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Board of Scientific Advice for India

for the year 1909-10

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3. The Superintendent, Industrial Section, Indian Museum;
4. Colonel S. G. Burrard, R.E., F.R.S.;
5. The Director, Geological Survey of India.

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ANNUAL REPORT FOR 1909-10.

ZOOLOGICAL
LIVORE

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ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

1909-1910.

SUMMARY OF PROCEEDINGS.

Eighteenth Meeting held at Simla on the 9th May 1910.

Correspondence forwarded under Government Endorsement between Government and the Inspector-General of Agriculture in which were embodied memoranda on the work in progress in plant breeding—particularly of wheat and tobacco—on Mendelian lines in the section of Economic Botany and on the investigation of soil gases and availability of plant food being conducted in the Chemical section of the Agricultural Research Institute at Pusa was read and recorded.

Correspondence forwarded under Government Endorsement in which were set forth the views of the Observatories Committee of the Royal Society of London on Meteorological work in India was read and recorded. The Observatories Committee expressed their satisfaction with the various lines of investigation conducted by the Meteorological Department.

The programmes for 1910-1911 of the various Departments were discussed and with minor emendations in several were accepted.

Nineteenth Meeting held at Calcutta on the 20th December 1910.

After considering correspondence forwarded under Government Endorsement between the India Office and the Director of the Imperial Institute, London, on the subject of furnishing the Indian Departments interested with the names of experts consulted by the Director of the Imperial Institute in scientific and commercial enquiries made on behalf of the Government of India the Board resolved to amplify their original resolution of the fifteenth meeting by explaining that they would be obliged if, in addition to the names of external referees consulted by the Director of the Imperial Institute, the names of officers of the Imperial Institute also would be furnished when asked for.

Correspondence under Endorsement from Government on the remarks of the Advisory Committee of the Royal Society of London regarding the work of the Geological Survey and Civil Veterinary Departments and embodying the revised arrangements concluded with the Royal Society in respect of the future functions of their Advisory Committee was read and recorded.

The Board then considered the draft Annual Report for 1909-1910. It was resolved that contributors to the Report should restrict their accounts to scientific work coming under the various headings of the Report, and should not deal with matters of departmental administration or detail. The advisability of combining the present separate accounts on chemical work into one section; of combining Botanical Survey with Forest Botany and Agricultural Entomology with Forest Entomology was discussed and the Secretary to the Board was authorised to communicate with the Departments concerned with a view to linking up those sections of the Report in future.

The question of whether a section of the Annual Report should in future be devoted to the subject of scientific Libraries in India was referred to Sub-Committee F (Libraries) for consideration and report to the Board at the next meeting.

INDUSTRIAL AND AGRICULTURAL CHEMISTRY.

BY

D. HOOPER, F.I.C., F.C.S.,

AND

J. W. LEATHER, PH.D., F.I.C.

This report is a review of the chemical work done during the year in connection with Indian industries and agriculture, and on Indian material examined in other countries. It indicates a vast amount of scientific activity of which the results are a useful contribution to our knowledge of indigenous products and their technical applications. For the purposes of the report the classification of last year has again been followed :—

i. Analytical methods.
ii. Industries based on mineral production.
iii. Chemistry and physics of soils and water manuring.
iv. Analyses of organic raw products and manufacturing processes connected with them.

1. Gums, resins and rubber.
2. Fixed and volatile oils.
3. Dyes and dyeing.
4. Tans and tanning.
5. Fibres and paper.
6. Flour, sugars, starch, foods.
7. Accessories to human food.
8. Spirits.
9. Drugs.

(i) Analytical Methods.

Temperature of reference for India.

The Committee appointed by the Asiatic Society of Bengal to collect evidence and opinions on the adoption of a temperature of reference suitable for India has published its report. The temperature of 30° C. has been recommended; 40 scientific workers in India out of 50 being in favour of this temperature for chemical and physical operations. India being only one of the countries of the tropics the matter has been considered of sufficient importance to

be referred to the Royal Society for submission to the International Association of Academies; for it is only in some such manner that other countries would have an opportunity of expressing their opinions.

The Chief Chemical Examiner, Ordnance Department, has supplied the following information with regard to experiments on explosives made in his laboratory.

Storage of explosives.

Much trouble has been experienced in storing explosives in India, as they are liable to decompose and eventually ignite in consequence of the high temperature of storage. Modern explosives are composed mostly of endothermic compounds, that is to say they can only be built up from their elements with absorption of heat. Such substances are necessarily unstable to a greater or less extent, and the rate of decomposition increases rapidly with the temperature. In the case of the two most important explosive compounds, gun-cotton and nitro-glycerine, the rate of decomposition is rapid enough even at a temperature of 140° F. to be quite easy to detect in the laboratory, and the rate is about doubled for every increase of 9° F. in the temperature. Moreover, the reaction is subject to autocatalysis, for the nitrous oxide and perhaps other products of decomposition, which accumulate in the course of time greatly increase the rate of decomposition. If these explosives therefore are stored for long periods at the temperatures prevailing in most parts of India, they are liable to decompose more and more rapidly, until finally the rate of decomposition becomes so great that it raises the temperature to the point of ignition and the explosive catches fire.

Hence the importance of keeping the magazines cool especially if the explosives are to be kept for some years before use. Various structural alterations are to be tried in the magazines of the Ordnance Department and the Fort Armaments with a view to reducing the temperature. In the larger magazines refrigerating machinery will probably be introduced to artificially reduce the temperature.

Records of the temperatures of all magazines are kept and the results tabulated. In order to have a ready means of comparing the records for different magazines or the same magazine in different years, a method has been worked out of plotting the figures for each month round the circumference of a circle and determining the position of the "specific gravity."

Carbon dioxide apparatus.

Manindra Nath Banerjee has described a convenient apparatus for the determination of equivalents of metals and the estimation of carbon dioxide both directly and indirectly. The equivalents of the following metals have been found by the apparatus: magnesium, zinc, aluminium and sodium.

Nitrites.

P. C. Ray in collaboration with students has continued his studies of the nitrites of mercury and other metals, in regard to which several papers have appeared during the year. On heating di-mercurammonium nitrite, it commences to decompose at about 140° and the change is complete at 250° C.; the chief products are mercury, mercuric oxide, mercuric nitrate, nitrogen and nitrous oxide.

Several double nitrites, namely, mercuric calcium nitrite, mercuric strontium nitrite and mercuric barium nitrite have been prepared by mixing the respective nitrites with mercurous nitrite, separating the precipitated mercury and evaporating in a vacuum.

(ii) Industries based on Mineral Production.

Indian Magnesite.

Mr. H. H. Davis in 1909 read a paper on The Indian Magnesite Industry. According to the writer, Dr. Macleod was the first person to suggest the possibility of starting a magnesite industry at Salem, Madras, in 1826. But work on a somewhat large scale has been begun only lately. From the analyses of samples of Indian magnesite by the author, as well as by other chemists, it was found that the mineral was of a very good quality, the percentages of lime, silica, iron oxide and alumina being exceptionally small.

The calcined magnesite which is of great commercial importance is prepared from the Indian mineral. The lightly calcined or caustic magnesia is largely used as an ingredient for cement. The dead-burnt or shrun magnesia is used as a refractory lining for furnaces, converters in the steel industry and for making refractory bricks.

The Indian magnesite industry is at present in its infancy, but with the erection of suitable plant it is expected to become a very profitable one.

Loss of sulphur in vitriol works.

Mr. Biraj Mohan Das has carefully calculated the amount of loss of sulphur in the manufacture of vitriol. All his experiments and observations have been made on the vitriol chambers of the Bengal Chemical and Pharmaceutical Works, Limited. The total loss has been sub-divided under the following heads :—

(1) As sulphur dioxide in the exit gas	1·5 per cent.
(2) As sulphur trioxide	1·0 ,,
(3) As sulphur by sublimation, and as sulphur oxides by premature condensation, etc. . . .	1·5 ,,

Total loss calculated as sulphur dioxide is 4 per cent. on the sulphur dioxide entering the chamber, whereas the best managed European works lose totally 1·5 per cent. to 2·5 per cent. on sulphur dioxide introduced.

Saltpetre.

In connection with saltpetre Babu Manindra Nath Banerjee has published a series of articles in the *Modern Review* on "The Nitre Industry in Tirhut." Analyses are given of the products and suggestions are made for the improvement of the manufacture.

(iii) Chemistry and Physics of soils and water.

Water requirements of crops.

The investigation of the amounts of water required by crops in India, which has been in progress for some years, (see Memoir of the Department of Agriculture, No. 8, Chemical Series, and this report for 1908-09, p. 12) has been continued both in the field and by pot-culture methods, the results of which are about to be published. The newer pot-culture tests were made in part in order to check previous work and in part to ascertain what effect, if any, the nature of the soil has on the transpiration ratio. Regarding the former section of the work, the check consisted in the employment of larger jars of soil and these substantiated previous tests in shewing that the larger the mass of soil employed, the lower is the transpiration ratio. The employment of different soils showed that, given a liberal water supply this factor has no influence on the transpiration ratio.

The field tests have been conducted for three cold weather seasons at Cawnpore and at Pusa and have resulted in showing that (i) the crop occasions a marked decrease of water concentration in the soil within the root range of some 7 to 9 feet, but that below this depth the water-concentration remains practically constant; (ii) that practically all the water assimilated by the plant or lost into the atmosphere by evaporation from the land surface is accounted for by this decrease of concentration; (iii) that a comparison of these data with the weight of crop gives a ratio closely approximating to that obtained by pot-culture methods and hence support them.

This work has also shown how very great a value would be possessed by an accurate method for the determination of the quantity of water which can move through soils under the influence of surface tension.

Drainage.

The records which have been maintained for some years at Cawnpore and Pusa on the amounts of water draining away from arable and from cropped land, and the amounts of plant food, more especially nitrogen-compounds which are at the same time removed, have been continued, and in respect of nitrates somewhat extended. It is proposed to publish these data shortly. In addition to providing a comparison with the Rothamsted data, they show the effect of crops both on the amount of drainage and its constituents; certain deductions are also possible in relation to the nature of drainage.

Soil gases.

Mr. W. H. Harrison has carried out a series of analyses of the gases which are evolved from paddy fields which have been green-manured. The work has not

been published, but Mr. Harrison has courteously intimated the following as a typical sample :—

CO_2	5·6 per cent.
O_2	·4 ,,
CH_4	20·2 ,,
N	73·8 ,,

Usar soils.

The examination of alkali lands in the United Provinces, to which reference was made in last year's report, is being continued. A new test has been devised for estimating the rate at which water can percolate through soils. By its aid the great difference between the physical state of some alkali lands and ordinary arable soil has been demonstrated, the former being only one-tenth down to one-hundredth part as permeable as the latter.

(iv) Analyses of Raw Products and Industries connected with them.

1. Gums, Resins and Rubber.—Five samples of rubber prepared from trees grown in the Government Experimental Gardens at Kullar and Burliar in the Nilgiri Hills have been analysed at the Imperial Institute. The percentage of caoutchouc is given as follows :—

	Caoutchouc.
No. 1 Ceara rubber (*Manihot Glaziovii*)	80 2 per cent.
,, 2 Castilloa rubber (*Castilloa elastica*)	62·7 ,,
,, 3 Do.	86·1 ,,
,, 4 Para rubber (*Hevea brasiliensis*)	92·0 ,,
,, 5 Do.	91·5 ,,

The values per lb. in London are given as : No. 1, 5*s.* 6*d.* ; No. 2, 3*s.* 2*d.*—3*s.* 4*d.* ; No. 3, 3*s.* 6*d.*—3*s.* 8*d.*; No. 4, 5*s.*—5*s.* 2*d.* ; No. 5, 5*s.* 4*d.*—5*s.* 5*d.*

Cotton seed oil.

2. Fixed Oils.—The Director-General of Commercial Intelligence has interested himself with regard to the utilisation of cotton seed oil and has supplied samples of the crude and refined oil to the Industrial Section of the Indian Museum for examination. The chief problems for solution were : (1) the proportion of stearin or solid fats present in the oil expressed from Indian grown seed ; (2) the nature and amounts of the acrid and colouring principle ; and (3) the practicability of using the oil for edible purposes. Samples of the oil obtained from American seed grown at Dharwar and expressed at Cawnpore were obtained for experiment. At the winter temperature of Calcutta (22°—24°C.) very little stearin is deposited by this oil, but by chemical methods 29·5 and 32·4 per cent. of solid white fats were separated

from two different samples. Previous investigators have found from 22·3 to 32·6 per cent. of solid fats in commercial cotton seed oil. Dr. Lewkowitsch quotes some recent analyses in which the proportions of solid fatty acids in American and Egyptian cotton seed varied from 20·9 to 24·4 per cent. From these results we may conclude that just as much, if not more, stearin could be obtained from Indian oil. The separation of the solid fat would of course not be so easy a matter in India as it is in temperate climates.

As regards the acridity of crude cotton seed oil it is evident that this is intimately associated with the reddish-brown colouring matter or bloom. No figures are available for showing the amount present in other oils, but the acid value of two kinds of oil from American seed from Dharwar gave respectively 7·5 and 9·7 per cent. By using an amount of alkali corresponding to these figures and subsequent washing, the colouring matter, bloom and acridity are entirely removed, and a refined oil obtained having the same yellow colour and other properties of the Egyptian refined oil. The objectionable features of Indian cotton seed oil are removed by this method with very little loss on the bulk of the oil. Most of the edible cotton seed oil made in Britain is prepared from Egyptian seed. Indian cotton seed oil is said to have a disagreeable flavour either due to the excess of fibre in the seed or the condition of the seed when it arrives at the factory; the refining of the Indian oil is also said to be more costly than Egyptian. From the above experiments it would appear that with very careful screening of the seed before crushing and by washing the oil thoroughly in the process of refining, a perfectly edible oil could be produced for local use.

Soy beans.

The interest that has lately been taken in Soy beans and its oil has prompted the Reporter on Economic Products to examine the beans grown in India. The Directors of Agriculture have supplied samples from the chief districts where they are grown. Ninety-one samples have been received from Burma, Naga Hills, Shillong, Kalimpong, Kangra, Simla, Kashmir, Patna, Nagpur, Poona and 37 villages of the United Provinces. The oil content ranged from 13·5 to 22·4 per cent., the Poona samples yielding the highest amount. As far as the yield of oil is concerned, Soy beans cultivated in India afford almost as much as is found in those from Manchuria and Japan. Only certain localities in India are suitable for growing *Glycine*, and these are upland situations in Burma, Assam and the lower valleys of the Himalaya.

Lesser known oils.

The testing of the lesser known fixed oils has been continued by Mr. Hooper with some interesting results. The first to be considered is that of *Celastrus paniculata*. Malkanguni seeds yield a reddish oil, depositing white fats on standing. The oil is reported to have peculiar medicinal properties and is given as a brain stimulant to students and pundits. The seeds are small, red and angular--a sample from Madras afforded 43·25 and one from the Punjab 44·7 per cent. of a thick reddish bitter oil. Seven samples of oil received from Burma, Garhwal, Barhaich, Dehra Dun and Gorakhpur, had the following constants: specific gravity at 50°C. ·942 to ·956; acid value, 34·7 to 101·0; saponification value, 218·0 to 246·7; iodine value, 75·5 to 100·8; Reichert-Meissl value, 41 to 42. The high saponification and Reichert-Meissl values agree with published analyses of the oil of the staff tree (*Celastrus senegalensis*) and spindle tree (*Euonymus europeus*) of the same natural order.

Pyinkado seed (*Xylia dolabriformis*).—The hard seeds of this tree, frequent in Burma, yield to ether 21·1 per cent. of a yellow non-drying oil melting at 22°. The constants were: acid value, 22·0; saponification value, 176·3; iodine value, 89·4. 31·6 per cent. of the mixed lead salts was insoluble in ether and the liberated fat acid melted at 69°, consisting probably of stearic acid.

Mimusops hexandra.—The tree is a native of the Deccan and is cultivated in Northern India. Kirni seeds yield a clear yellowish non-drying oil depositing a white fat at 30°. The specific gravity at 40° is 0·905 and acid value 25·5. The constants are: saponification value, 195·4; iodine value, 72·5; Reichert-Meissl value, 0·17.

Origanum vulgare.—The minute seeds of this labiate plant have been reported as oleaginous. A sample from Ramnagar, United Provinces, yielded to ether 27·3 per cent. of a drying oil. The oil had an acid value of 11·3, saponification value 194·9, and iodine value 190·5. The iodine value is, therefore, higher than that of linseed oil, and in this respect resembles the fatty oil of *Perilla ocimoides*, a labiate plant indigenous in India, China and Japan.

Prunus Puddum.—The seeds of the Bird Cherry growing in the Himalayas yield another peculiar oil remarkable for its siccative properties. The oil extracted by ether commenced to form a skin and absorb oxygen as soon as evaporation was complete. Under the circumstances it was difficult to estimate its iodine value. A small sample was crushed in a mill, and the oil treated at once by Hubl's solution showed a value of 172,

It dried to a skin in glass in two hours; boiled linseed oil required 4 hours. The pressed cake and seeds distilled with water afforded considerable quantities of hydrocyanic acid and benzoyl aldehyde (oil of bitter almonds).

Volatile Oils.—Experiments have been made with lemon grass from Jalpaiguri, Bengal, to see what effect the season has upon the yield and character of the oil. In July 1909 Mr. Burkill distilled grass before the flowering period, both locally and at Calcutta. Two months later in September he again distilled the grass before flowering. Finally the grass was cut while in flower and distilled, first the flowers were used and then for another experiment the leaves only. The samples were examined by Messrs. Schimmel & Co., but no differences of any importance were discoverable in the oil from the flowers and the leaves; the samples showed no material divergence from those prepared from herb before flowering and no such differences were observable among the various oils distilled before flowering. The oil from the leaves is a little richer in aldehydes and rather heavier than the oil from the flowers, but the few investigations do not admit of any final conclusions.

Lemon grass oil.

Experiments made by A. J. Ultie in Java have shown that manuring does not affect the oil content of lemon grass.

Palmarosa oil (*Cymbopogon Martini*).—Mr. Burkill has supplied further details respecting the distillation of this oil as practised in British India, and Messrs. Schimmel & Co., Leipzig, have reproduced in their report for April 1910 some excellent photographs of the process as conducted in the district of Khandesh. Samples of the oil collected by Mr. Burkill on the occasion of his visit have been chemically examined by Messrs. Schimmel & Co., and the results show the difference between the Motia and Sofia oils which occur in this district. The Motia (Palmarosa) oil has an average specific gravity of 0·891 and a geraniol content of 91·3, while the Sofia (ginger grass) oil has an average specific gravity of 0·941 and a geraniol content of 42·7. The Motia oil dissolves in 1·5 volumes of 70 per cent. alcohol and the Sofia oil requires 2 per cent. for solution. The Palmarosa grass is distilled in the low-lying situations and the ginger grass on the plateau of Akrani. Great credit is due to Mr. Burkill for having solved the mystery that has long surrounded the origin of these two commercial oils.

Palmarosa oil.

The essential oil of *Blumea balsamifera* has been investigated by R. Jonas. The brown oil from which a portion of the camphor (laevo-borneol) had been pre-

Blumea balsamifera.

viously removed had the following characters: specific gravity 0·950 at 15° C., acid value, 23·35; ester value, 1; acetyl value, 19·8. It contained cineol, limonene, borneol, laevo-camphor, sesquiterpenes and sesque terpene alcohols, and a phenol identified as phloracetophenonedimethyl ether, in colourless crystals melting at 32—33°C. It gives a deep red colour with ferric chloride. The oil from different sources varies considerably in composition. Messrs. Schimmel found in a sample of the oil received from Mr. R. S. Pearson, Dehra Dun, about 75 per cent. of l-camphor and only 25 per cent. of oil. The crude product showed a specific rotation of 46·26, its melting point being 175°. The borneol content of the Ngai camphor was calculated at 24·4 per cent.

Cinnamomum Tamala.

Oil of *Cinnamomum Tamala.*—The leaves contain an essential oil, a sample of which was distilled in the Industrial Section of the Museum and examined by Messrs. Schimmel & Co. with the following result. The oil was of a lemon yellow colour and had a clove-like, at the same time slightly peppery, odour. It possessed a phenol content of 78 per cent. consisting of eugenol. In respect to its high eugenol content it is closely allied to the ordinary oil from Ceylon Cinnamon leaves.

Ægle Marmelos.

Ægle Marmelos oil.—The leaves of the Bel or Bael tree yield about 6 per cent. of a faintly yellow coloured essence having the following constants: specific gravity at 25° 0·856, saponification number 10·6. The oil contained d-limonene and no aldehydes. The oil exposed to the air becomes cloudy and left to stand a considerable time, it again becomes clear, but assumes a viscous resinous condition. A resinous product was also obtained from the dried leaves by distillation (Ritsema, quoted in Schimmel's Report, April, 1910).

Dyes.

3. Dyes and Dyeing.—A. G. Perkin has continued his researches on the colouring matter of flowers and has lately investigated the flowers of *Gossypium herbaceum*, in which he finds three hitherto unknown glucosides. Quercimeritrin $C_{21}H_{20}O_{12}$, the main constituent, crystallises with 3 H_2O in small yellow plates m.p. 247—249°, dyes mordanted fabrics very similarly to quercetin and gives with lead acetate an orange-red precipitate. Isoquercitrin, $C_{21}H_{20}O_{12}$, consists of pale yellow needles m.p. 217—219° and is readily hydrolysed by acid with formation of quercetin and dextrose. With lead acetate it gives a bright yellow precipitate. The third glucoside, gossypitrin $C_{21}H_{20}O_{13}$ pale orange yellow needles, m. p. about 200—202°, when hydrolysed gives gossypetin and dextrose. It yields a

It dried to a skin in glass in two hours; boiled linseed oil required 4 hours. The pressed cake and seeds distilled with water afforded considerable quantities of hydrocyanic acid and benzoyl aldehyde (oil of bitter almonds).

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The essential oil of *Blumea balsamifera* has been investigated by R. Jonas. The brown oil from which a portion of the camphor (laevo-borneol) had been pre-

Blumea balsamifera.

viously removed had the following characters: specific gravity 0·950 at 15° C., acid value, 23·35; ester value, 1; acetyl value, 19·8. It contained cineol, limonene, borneol, laevo-camphor, sesquiterpenes and sesquiterpene alcohols, and a phenol identified as phloracetophenonedimethyl ether, in colourless crystals melting at 32—33°C. It gives a deep red colour with ferric chloride. The oil from different sources varies considerably in composition. Messrs. Schimmel found in a sample of the oil received from Mr. R. S. Pearson, Dehra Dun, about 75 per cent. of l-camphor and only 25 per cent. of oil. The crude product showed a specific rotation of 46·26, its melting point being 175°. The borneol content of the Ngai camphor was calculated at 24·4 per cent.

Cinnamomum Tamala.

Oil of *Cinnamomum Tamala.*—The leaves contain an essential oil, a sample of which was distilled in the Industrial Section of the Museum and examined by Messrs. Schimmel & Co. with the following result. The oil was of a lemon yellow colour and had a clove-like, at the same time slightly peppery, odour. It possessed a phenol content of 78 per cent. consisting of eugenol. In respect to its high eugenol content it is closely allied to the ordinary oil from Ceylon Cinnamon leaves.

Ægle Marmelos.

Ægle Marmelos oil.—The leaves of the Bel or Bael tree yield about 6 per cent. of a faintly yellow coloured essence having the following constants: specific gravity at 25° 0·856, saponification number 10·6. The oil contained d-limonene and no aldehydes. The oil exposed to the air becomes cloudy and left to stand a considerable time, it again becomes clear, but assumes a viscous resinous condition. A resinous product was also obtained from the dried leaves by distillation (Ritsema, quoted in Schimmel's Report, April, 1910).

Dyes.

3. Dyes and Dyeing.—A. G. Perkin has continued his researches on the colouring matter of flowers and has lately investigated the flowers of *Gossypium herbaceum*, in which he finds three hitherto unknown glucosides. Quercimeritrin $C_{21}H_{20}O_{12}$, the main constituent, crystallises with 3 H_2O in small yellow plates m.p. 247—249°, dyes mordanted fabrics very similarly to quercetin and gives with lead acetate an orange-red precipitate. Isoquercitrin, $C_{21}H_{20}O_{12}$, consists of pale yellow needles m.p. 217—219° and is readily hydrolysed by acid with formation of quercetin and dextrose. With lead acetate it gives a bright yellow precipitate. The third glucoside, gossypitrin $C_{21}H_{20}O_{13}$ pale orange yellow needles, m. p. about 200—202°, when hydrolysed gives gossypetin and dextrose. It yields a

bright red precipitate with lead acetate and dyes mordanted fabrics. The flowers yielded 1·86 per cent. of colouring matter, consisting of quercetin mixed with about 10 per cent. of gossypetin.

Andropogon dye.

In a paper on "A Natural Substantive Dyestuff" A. G. Perkin describes his having obtained evidence of the presence of santalin, the colouring matter of sandal wood, in the leaf-sheaths and stems of the great millet (*Andropogon Sorghum*). The principle is termed dura-santalin.

Azo dyes.

The relation between the chemical constitution of the mono-azo dyes and their fastness to light, has been the subject of investigation by Professor E. R. Watson in collaboration with his students. A preliminary classification of known dyes in respect of their constitution and fastness, indicated that the fading in light of these dyes is a property closely associated with the readiness with which that part of the molecule containing (CH) or (NH_2) groups suffers oxidation and that it should hence be possible to predict the fastness of dyes. On applying the theory to dyes which have not been tested for fastness to light, it was found that the theory does not hold at all universally, though certain compounds supported it.

Indigo.

Messrs. Bergtheil and Parnell are engaged in indigo research at Sirseah and a report for the year has been published. The work is being prosecuted on a new basis and valuable results may be expected.

Investigations in England on indigo have been concentrated on indirubin, a natural constituent of the commercial dye. Messrs. W. P. Bloxam and A. G. Perkin have studied its constitution and have devised methods for its estimation.

4. Tans and tanning.—

Pistacia galls.

The leaf gall of *Pistacia mutica* Fisch. et Mey. var. *cabulica* received from Baluchistan, were examined in the Indian Museum. Both the leaves and the galls are used for dyeing and tanning. A separate chemical examination was made of the leaf blades and the galls to see how the substance of the leaf had been changed by the aphid.

The leaves contained 12·85 per cent. of tannin and the galls 15·16. The leaves also contained more albuminoids and ash than the galls. It was shown that the insect had caused a deposition in the galls of resinous and tanning matter and carbohydrates at the expense of the albuminoids. The increase of tannin is not so great as would be expected from the composition of the galls of other species of *Pistacia*.

Canaigre root.

A specimen of the root of the American *Rumex hymenosepalus*, grown in Dharwar, Bombay Presidency, afforded 20·4 per cent. of tannin. This is a better result than was shown last year when the root contained 14·9 per cent. In North America this root at different seasons of the year yields from 16·7 to 28·2 per cent.

The bark of *Cleistanthus collinus*, a tan and fish poison of Madras, has been examined by J. Dekker who has separated saponin, tannin and a crystalline phytosterin.

5. Fibres.—Several samples of fibrous substances have been sent to the Indian Museum, Industrial Section, to ascertain their value for paper-making.

1. Coir refuse (*Cocos nucifera*) from Malabar.
2. Leaves of *Areca Catechu* from the Dooars.
3. Bark of a tree (*Bauhinia*) from the Central Provinces.
4. Stems of grass ("Elkora") from Assam.
5. Sacchi bark (*Aquilaria Agallocha*) from Assam.
6. Do. cleaned and peeled.
7. Do. polished.
8. Rags, raw material.
9. Do. bleached and washed, 2nd stage.
10. Do. do. do. 3rd do.
11. Do. do. do. 4th do.

Analyses of the above gave the following compositions :—

	Cellulose.	Water.	Ash.
1	27·9	10·7	32·9
2	31·9	...	...
3	48·4	10·5	6·6
4	50·4	7·8	3·5
5	41·8	9·3	10·7
6	53·1	10·2	5·2
7	55·1	9·8	6·1
8	57·2	6·4	11·0
9	65·2	8·0	15·0
10	72·8	5·9	8·5
11	78·7	6·4	2·3

The coir refuse is useless on account of the dark coloured coarse fibre and large amount of ash. The bark fibre and grass stems have a satisfactory cellulose content and little ash. The Sacchi bark is a natural paper of Assam, and it is interesting to compare the composition of the crude bark with that prepared for writing. The analyses of rags and the paper pulp made from them in four stages are instructive in showing the rise in the cellulose content in the prepared pulp. In addition to these materials 12 kinds of grasses were sent from Kathiawar for the determination of cellulose. This constituent varied from 31·8 to 43·9 per cent., while the ash content ranged from 4·4 to 14·5 per cent.

Samples of fibres from different parts of India have also been examined at the Imperial Institute and their values at the London market ascertained. The percentages of cellulose in most of them as well as their values are given below :—

	Cellulose.	Value.
Agavê rigida from Madras . . .	73·0%	£36—£38 per ton.
Agave americana from Madras .	77·0%	£27—£28 „ „
Furcroea sp. from Madras . .	72·0%	£26—£27 „ „
Manilla hemp from Kullar, Madras . .	70·5%	£23 – £24 „ „
Agave fibre from Assam . . .	...	£30 „ „
Agave sisalana from the Andaman Islands	76·6%	£24 „ „
Urena fibre	...	£12-10*s.* to £13 per ton.
Kapok (the seed-floss of *Eriodendron anfractuosum*) from Madras . . .	...	4½*d.* per lb.

6. Flours, sugars, starches, food.—One of the most important questions that has transpired in the East is the alleged connection between rice and the disease beri-beri. Drs. Fraser and Stanton of the Medical Institute for Medical Research of the Federated Malay States propounded the theory in 1909, and Dr. Hignet, the Chief Medical Officer of Siam, supported the conclusions arrived at. A series of experiments was carried out at the Institute on fowls, the result of which was that a large proportion of those fed on overmilled rice alone developed polyneuritis, while all those fed on partially husked paddy or undermilled rice containing a certain amount of the polishings that are removed in the cleaning process, remained healthy. Practical measures were taken in various outbreaks of beri-beri by both Dr. Fraser and Dr. Hignet on the lines suggested by these researches and previously by Dr. Braddon with the best results, and they quoted a large number of cases in which the disease disappeared almost immediately on the substitution of a less completely polished for a white rice diet.

Rice and beri-beri.

The Government of India have deputed Captain E. D. W. Greig, I.M.S., to investigate the subject of beri-beri in Bengal, and Mr. Hooper has been requested to assist in the matter of analysing samples of rice and grains consumed by beri-beri patients. The enquiry has shown a marked difference in the amount of phosphoric pentoxide between the polished and unpolished rice which points to a deficiency of nutrient quantities in the diet which predisposes the system to disease. Rice being one of the principal dietetics in parts of India, further analyses are being made and the albuminoids of the polished and unpolished grains are being studied in the light of the investigations of Rosenheim and Kajiura.

Wheat.

G. Evans has written a note on the annual variations in character of wheats of the Central Provinces (Dept., Agriculture, C. P., Bulletin No. 3, 1910) in which he shows that hard wheats contain more nitrogen than soft grains which seems to indicate that the commercial method of valuation on a basis of hard grain percentage is a very sound one. The facts have long been recognised in Europe. Further investigations on Indian wheats are being carried on and the results will be duly published by the Department of Agriculture.

Sugar-cane.

At the Sabour Agricultural station, Messrs. Taylor and Woodhouse are investigating the period of maturity of the indigenous canes of Bengal.

In connection with analytical tests of a sugar-cane crop, an opportunity was taken at Pusa last season, of estimating the error involved in taking samples of cane, the probable error being calculated by means of the usual formulæ. The test was too limited to admit of publication of the results and the work will be repeated, but it is obvious that a knowledge of how to take the smallest sample which will represent the average composition of a plot or field of cane would be most useful to those engaged on sugar-cane work.

Mahua flowers.

Bassia latifolia (Mahua) flowers were examined by A. H. Church in 1886 (*Nature*, XXXIII, 343-344). They have again been analysed by R. R. Bennett and J. D. W. Anklesaria who obtained 49·8 per cent. of invert sugar and 13·4 per cent. of cane sugar. The flowers also contained 18 per cent. of water, 2·6 per cent. of ash, and 0·7 per cent. of protein. Flowers from trees in the hilly districts contain more sugar than those grown in the plains. An infusion of the flowers fermented with

yeast yield on distillation a spirit with a strong odour; this may be removed by digesting the strong distillate with a potash and redistilling.

Phromnia marginella.

D. Hooper has examined the peculiar saccharine secretion deposited by *Phromnia marginella*, Olivier, on various species of Celastraceæ. The substance is found to be composed principally of dulcitcol or dulcite, an isomeride of mannitol or mannite found in commercial manna.

Butter-fat of Indian buffalo.

Messrs. E. R. Watson, Monohar Gupta and S. C. Ganguli have written an interesting note on the chemical examination of the butter-fat of the Indian buffalo. In a preliminary note on the subject by Watson (*Journ. Asiat. Soc. Bengal*, Vol. II, pp. 293-297) analytical figures were recorded which seemed to show that in Indian buffalo butter-fat the volatile fatty acids were almost entirely butyric. Further investigation recorded in the present paper has not confirmed this result, but has shown that the relative proportion of butyric to caproic acids is practically the same in the Indian buffalo butter-fat and in that of the ordinary cow. The processes of Henriques, Duclaux, Thorp, and Krishner were applied, and it is shown by several tests, illustrated in the paper by means of curves, that the ratio of butyric to caproic acid is practically 2 : 1, the same as in Danish butter-fat. The second section of the work showed that the proportion of volatile acids in Indian buffalo-fat is practically the same as in that of European cows.

Ghee.

A paper on "Analyses of ghee" by E. R. Bolton and C. Revis affords some useful constants of genuine ghee compared with those of samples adulterated with various vegetable fats.

7. Accessories to human food.—The year's contributions to the scientific work on tea include a bulletin by Dr. G. D. Hope intimating further investigations on behalf of the Indian Tea Association. The bulletin deals with experiments on the quality of tea.

Tea.

The effect of *climatic conditions* has been examined more particularly in respect of temperature and rainfall. A higher temperature is accompanied by a higher proportion of total soluble matter in the leaf; good rain produces a like effect, but excessive rain causes a reduction in this respect. The latter effect has been traced to absence of sunlight. Tea grown under artificial shade, as also under trees, contained less soluble matter than tea freely exposed. The same factor likewise occasions a reduction of tannin.

The recommendation is therefore made that where "green manures" are grown they should be restricted to moderate proportions. The *effect of manures* at the Heeleaka Experiment Station has been examined in respect of the total soluble matter in the leaf; artificial nitrogenous fertilizers tend to reduce somewhat the proportion of the total soluble matter at first, though this feature is of no serious moment if the fertilizers are employed in repeated small doses; a "complete" artificial manure has, however, advantages in this respect. Oil cakes do not act prejudicially on the total soluble matter.

In respect of the *manufacture of tea* the investigations had to do with the loss of essential oils during "firing," and it was ascertained that quick firing at a high temperature was accompanied by a smaller loss of these constituents than slow firing at a low one.

Alberkann has investigated a new substance named Assamin in Assam tea seed. These seeds are already known to contain a saponin.

8. Spirits.—During the year the question of the contamination of country liquors with copper salts has been reported on by the Director of the Central Excise Laboratory. In the case of Mahua spirit the cause of this contamination proved to be a copper "soap" produced by the action of organic acids on the still-worm; methods for preventing this action and for cleaning the still-worms by steaming have been proposed and found satisfactory. The limit amount for copper salts in liquors has been fixed at one quarter-grain per gallon, and a suitable test provided for the use of Excise officers which will detect amounts in excess of this limit.

The new *denaturants* for spirit which have been devised by Colonel Bedford have been now adopted throughout India.

A special investigation of toddy with regard to alcoholic strength at various stages and of other points of excise interest was conducted in Bengal and Eastern Bengal.

A report has been made to Government on the *increase of alcoholic strength* in casked spirits, which has been observed in certain parts of India.

A more accurate and rapid method for estimating true alcoholic strength of spirits in Custom Houses has been submitted to Government.

Extended tables for the reduction of spirits of any strength whose use will eliminate "shainkage wastage," and a "Technical Excise Manual" for the use of Excise officers in India by Colonel Bedford are under issue.

9. Drugs.—The question of a satisfactory test for samples of Indian hemp (*Cannabis sativa*) has again engaged the attention of the Director of the Central

Cannabis sativa.

Excise Laboratory. The case requires that the chemical method shall be closely correlated to results of physiological experiments, which latter have still to be made, and no satisfactory progress has been attained.

Peganum Harmala.

Before the Royal Society of Edinburgh last November Dr. James A. Gunn reported on "The Pharmacological Action of Harmaline." Harmaline is the more important of two alkaloids found in the seeds of *Peganum Harmala*, a plant which grows wild over a large area of Southern Europe, Egypt and Asia. The seeds were used medicinally by the ancient Greeks as they are to this day in India. Dr. Gunn finds that harmaline belongs to the group of protoplasmic poisons of which the best known alkaloid is quinine, and the actions of harmaline and quinine are practically the same, so that it is possible that harmaline may come to be used as a remedy for those diseases in which quinine is known to be effective.

Bassia longifolia.

An investigation has been made in the chemistry, biology and physiology of the soap-glucoside obtained from the seeds of *Bassia longifolia*. The results are communicated to the Journal of Bio-Chemistry, by B. Moore, S. C. M. Sowton, F. W. Baker-Young and T. A. Webster of the University of Liverpool. Mowrin is the name given to the bitter, irritant glucoside of the oil-cake. It is not poisonous to animals when eaten, but kills when injected. Hydrolysed with hydrochloric acid, it gives a gelatinous precipitate of mowric acid ($C_5H_8O_2$). Mowrin gave 3·1 per cent. of moisture, 14·4 per cent. of furfurol, 41·2 per cent. of dextrose and 40·1 per cent. of mowric acid. Injected into rats it causes paralysis of the limbs followed by respiratory failure resulting in death. The heart is not materially affected, there is nevertheless a fall in blood pressure. Mowrin is a powerful hemolytic agent.

Datura Metel.

The seeds of *Datura Metel*, a poisonous plant of the Punjab, have been examined by G. de Plato. The seeds are similar to those of tobacco, and while they contain, according to the author, neither alkaloids nor cyanogenetic glucosides, they contain allantoin.

Terminalia Arjuna.

The bark of *Terminalia Arjuna* is recommended in Hindu Materia Medica in heart disease, and Lal Mohan Ghosal of the Calcutta Medical College has submitted it to a chemical examination and physiological experiments. The drug contains sugar 17 per cent., tannin 12 per cent., a colouring matter, a body

glucosidal in nature, and 30 per cent. of ash most of which consisted of calcium carbonate.

The author, as the result of physiological experiments, proved that the drug is a cardiac stimulant, increasing the force of contraction and prolonging the diastole, at the same time it slows the heart, but it never acts as a complete cardial poison. It also acts as a powerful hæmostatic, the only drawback being the rise of blood pressure.

Boerhaavia diffusa.

The same writer has made observations chiefly of a physiological character on *Boerhaavia diffusa*, a herb largely used in Bengal in food and medicine. The author separated (1) an alkaloidal body, (2) an amorphous fat and (3) 15 per cent. of ash consisting of alkaline chloride and sulphates. It was shown that the active principle is a diuretic chiefly acting on the glomeruli of the kidney through the heart, increasing the beat and strength and raising the peripheral blood pressure in consequence. It has little or no action in respiration and on the liver its action is principally secondary.

Cucurbita Pepo.

Messrs. Power and Salway have examined the seeds of the common pumpkin (*Cucurbita Pepo*) which are regarded as an efficient and harmless tænifuge. The oil corresponded to 34·3 per cent. of the seed and consisted of the glycerides of linoleic, oleic, palmitic and stearic acids and a phytosterol. The seeds also yielded sugar, salicylic acid, resinous matter and a new monocarboxylic acid melting at 99°. Physiological experiments proved that the reputed remedial action of the seeds was not justified.

Cucurbita Citrullus.

The seeds of watermelon (*Cucurbita Citrullus* Linn.) have also been examined by Messrs. Power and Salway. The entire seeds yielded 19 per cent. of fatty oil consisting of the glycerides of linoleic, oleic, palmitic and stearic acids and a phytosterol. The seeds also contained soluble protein, resin, sugar and a new alcohol, cucurbitol. Physiological experiments with the resin showed that it was quite innocuous.

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FOREST CHEMISTRY, 1909-1910.

BY

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The following is the summary of the main results of the principal investigations conducted by the Chemical Department of the Imperial Forest Research Institute during the year under report.

Manufacture of Mangrove tannin extract. (*Rhizophera mucronata.*)

About three months of the year under report were taken up by the experimental manufacture of mangrove tannin extract, on a commercial scale at the Rangoon Tannin Factory. Besides the Assistant Forest Chemist's process for the decolorisation of mangrove extracts, three other processes were also tried in the factory and fairly large samples of the different extracts thus prepared were sent to some well-known European and American firms for practical trial. Out of the six reports received so far, four are fairly favourable. Some 15 more reports are awaited and it is expected that they will not only furnish the Research Institute with the required information regarding the exact market requirements, but will be of great help to the Forest Chemist in deciding the best method to be adopted for the treatment of mangrove bark.

Distillation of *Blumea balsamifera*, DC.

This investigation, which has been in progress for the last three years has been completed. The shade-dried leaves of Blumea balsamifera DC. of Burma were successfully distilled on a large scale in the Laboratory with the aid of the newly designed condenser referred to in the last year's report. The sample of the Blumea camphor thus extracted, was sent to Messrs. Schimmel & Co., Leipzig, through the Imperial Forest Economist for commercial valuation. The price quoted by them is so low that it would not be worth while to manufacture camphor from the *Blumea* of Burma as an industrial undertaking.

Distillation of *Rhusa* grass oil.

It has been found that steam distillation yields an appreciably larger percentage of the oil than the crude method of water distillation in vogue in the Central Provinces. Fairly large quantities of both the *Sofia* and *Motia* oils from both the varieties of the grass have been distilled in the Laboratory. Further investigation of the chemical composition of both the oils is in hand.

Mr. A. M. Arathoon, who owns a large shellac factory at Jhalda, Bengal, has evinced a considerable interest in the Assistant Forest Chemist's methyl alcohol process for the manufacture of shellac. He had a model shellac apparatus constructed according to the plan given in I. F. Memoirs, Vol. I, Part II, with a view to testing the economic value of the methyl alcohol process. The Assistant Forest Chemist was sent to Jhalda for a week in order to advise Mr. Arathoon on the working of the apparatus. Mr. Arathoon has expressed his opinion that he has no doubt regarding the commercial possibilities of the process and that it is of special use in the factory for the recovery of useful shellac from refuse lac.

Manufacture of shellac.

From the scientific reports on the samples of shellac manufactured by the methyl alcohol process, which have been received from England, it appears that this shellac is as good as if not better than the best shellac of the market. The commercial firms, however, report that the form* in which shellac was submitted to them was objected to by the trade, as the latter would appear to have taken a fancy to the extremely thin opaque cakes, similar to those in which the DC. brand of shellac is made up.

The commercial firms are thus of opinion that the shellac extracted with wood alcohol should be converted before export into such forms as are already well-known, otherwise it will have to be put on the market at considerably lower prices in the beginning than the best brands of shellac already exported from India.

A new model of apparatus for lac extraction is being constructed and it is proposed to make fairly large quantities of shellac in proper commercial form for exact valuation. In this apparatus use has been made of centrifugal force to separate by filtration dissolved lac resin from the sludgy impurities.

The analytical constants of shellac prepared by the methyl alcohol process, pure lac resin and lac wax were determined and a note embodying the results was communicated to the Society of Chemical Industry, London.

Shellac analysis.

The following table gives the constants for shellac, pure lac resin and lac wax as reported in the above note. The figures given in the table should be read for those given in the last year's report of the Board of Scientific Advice. The

A correction.

* The samples of shellac prepared in the Laboratory were in three forms: (1) fibrous of golden-yellow colour, (2) flakes of white to white-yellow colour produced by blowing air into the melted lac, and (3) thickish transparent cakes of yellow to brownish-yellow colour.

saponification values as reported last year are too high, owing to the use of a wrong factor by an oversight.

No.		Moisture.	Matter insoluble in hot alcohol.	Acid number A.	Saponification number B.	Ester number (B—A.)	Iodine absorption (Hubl.) after 18 hours action.	Endemann number.
		Per cent.	Per cent.					
1	Shellac from Kosum lac (Extracted by wood spirit.)	2·7	0·7	61·1	201·0	139·9	9·6	8·43
2	Shellac from Palas lac (Extracted by wood spirit.)	3·8	0·8	60·8	202·4	141·6	9·3	7·96
3	Shellac from Block lac (Extracted by wood spirit.)	3·9	1·1	63·1	201·6	138·5	8·2	9·16
4	Mirzapur Factory Shellac	2·0	0·6	64·4	203·6	139·2	8·6	7·39
5	Lac wax	...	...	22·1	79·2	57·1	8·8	...
		...	...	—24·3	—85·0	—60·7		
6	Lac resin (dessicator dry)	...	...	52·1	193·5	141·4	6·8	7·3
		...	...	—59·2	...	—134·3	—7·3	—8·2
7	Lac resin (melted and dried at 100° C.)	...	...	55·	190·0	135	10·6	...

Turpentine and Colophony.

The Turpentine oil produced in the Bhowali factory was not liked by the trade on account of the sticky residue left by it after evaporation. This defect was not completely remedied by the proposed partial redistillation of the oil. This can, however, be done by redistilling the whole of the first distillate, rejecting 20 per cent. of the total output of the crude oil. The loss thus incurred by the distillation is very heavy. The sticky residue in the oil, which is due to the presence of high boiling constituents in the latter could, of course, be easily obviated if the distillation of the oil were conducted at low temperatures under diminished pressure. But as this would have necessitated the use of costly vacuum apparatus, other devices had to be used for lowering the temperature of distillation. After various trials the Assistant Forest Chemist proposed to mix the crude oleo-resin

before distillation with a small proportion of low boiling medium such as acetic acid, methylated spirits, etc. He was sent to Bhowali in order to give his process a trial on a large scale. He succeeded in distilling the oil through methylated spirits at a considerably lower temperature than has been done hitherto. The greater portion of the oil was distilled below 100° C. According to the chemical analysis of the oil thus produced, it appears to be considerably superior to the oil hitherto obtained. The samples of the oil produced have been sent to different Indian firms for practical trial and their reports are being awaited. As regards the improvements in the manufacture of colophony, besides working out the processes of its decolorisation, a process of imparting to it a reddish tint as desired by certain shellac manufacturers has been successfully worked out. Samples of the articles thus prepared at Bhowali have also been sent to different Indian firms, for commercial valuation. Messrs. Hoare Miller & Co., of Calcutta, have reported very favourably on one of the samples, valuing it as equal to imported American colophony.

Canarium benga lense.

Attention was first drawn to this resin by the Reporter on Economic Products to the Government of India as an article of possible commercial value and it has been favourably reported on as a good shellac substitute by a London firm, provided its melting point could be lowered. A large sample of the resin received from the Forest Economist has been refined, and attempts are being made to produce samples with a sufficiently low melting point.

Camphor from *Cinnamomum glanduliferum*.

A sample of crude camphor distilled from *Cinnamomum glanduliferum* was received from the Forest Economist, which was refined and submitted to Messrs. Schimmel & Co., Leipzig, through the Forest Economist, for valuation. The sample has been favourably reported on by the said firm and is likely to fetch the same price as the Japan camphor. Further data as to the commercial possibilities of its distillation in India are being collected by the Imperial Forest Economist.

Refining of Koosam oil for soap-making.

A sample of Koosam (Schleichera trijuga *Willd*) oil sent in by the Imperial Forest Economist was refined for soap-making. The N.-W. Soap Co., which had reported unfavourably on the crude oil as a soap-making material, accepted the refined sample. Further data as to its commercial possibilities are being collected by the Imperial Forest Economist.

Publications.

PURAN SINGH . . Note on the Analytical Constants of pure Shellac, Lac resin and Lac wax. (Communicated to the Society of Chemical Industry, London, for publication.)

ASTRONOMY.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,
Director-General of Observatories.

Solar physics.—Researches in solar physics are carried on under the direct control of the Government of India at Kodaikánal, the Director being Mr. Michie Smith and the Assistant Director Mr. J. Evershed. The chief instruments are:—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is that of making photographs of the sun using the light emitted by one chemical element only. In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus, fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and shall so emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any desired wave length to pass through. In the Kodaikánal spectroheliograph the collimating and camera lenses, each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the

image of the sun while the secondary slit will move at an equal rate across the sensitised plate; and as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently 'reversed,' *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called 'flocculi'—of calcium vapour scattered about over the sun and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

(*b*) Two 6-inch refractors, with one of which an Evershed spectroscope has been used since November 1904. These are used for visual examination of the sun and for spectroscopic study of spots and prominences.

(*c*) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus. This is used with a 4-inch concave grating of 10-foot focus mounted on Rowland's plan, or a parabolic grating collimated to cure astigmatism, or a plane grating with collimator and camera lenses of 8-foot focus. A powerful spectrograph has also been erected in the spectro-heliograph room, using a 3-inch plane grating. It is employed in photographing the ultra-violet region in spot spectra and in studies on the line of sight movement of the chromospheric gases. Both spectrographs have been fitted with special occulting shutters for regulating exposures in spot spectrum work.

(*d*) A photoheliograph by Dallmeyer. With this a photograph of the sun in ordinary light is made daily when possible. Originals are sent to Greenwich for the use of the Solar Physics Committee for those days for which photographs are not available from Greenwich or Dehra Dun.

(*e*) An 18-inch silver-on-glass parabolic mirror (the property of the Assistant Director) has been mounted in front of the 12-inch

photovisual lens in the spectroheliograph building. It has been found to be very efficient for photographing spectra, particularly in the violet region. The mirror is mounted in a box upon rollers in such a manner that during the operation of the spectroheliograph and associated instruments it may be pushed to one side so as not to obstruct the light incident upon the 12-inch lens. To bring it into use for photographing spot spectra, etc., the mirror and its mounting are run into position in front of the lens, with the centre of the mirror in the axis of the beam of light coming from the heliostat, an operation requiring a few seconds only.

(*f*) A powerful spectrograph has been set up on piers erected near the large mirror, and has been fitted with special arrangements for rotating the sun's image on the slit plate and for accurate guiding during long exposures on sunspots. The new Michelson 6-inch grating has been employed in this instrument, which has been largely used for photographing spot spectra, and limb and centre comparison plates.

(*g*) The Littrow spectroheliograph for photographing the sun's disc in Hα light is still incomplete although some promising trial plates have been obtained with it. Two large 45° prisms have been recently received from the Poona Observatory and these have now been mounted in the spectroheliograph. It is hoped to begin regular photographic work shortly.

2. **Routine work.**—In addition to the use of the spectroheliograph and photoheliograph the routine work includes visual examination of sunspots and faculæ, observations of widened and displaced lines in sunspot spectra and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes bulletins and memoirs of the observatory are issued. Of the former 20 have appeared, while of the latter the first has been published.

Photographs of spot spectra are now made in which different exposures are given for the spot and for the adjacent photosphere so that equally dense images of both spectra may be obtained: these are then copied and enlarged with a special apparatus so as to bring out clearly the characteristic features of the spot spectrum. Arrangements have also been made by which the slit of the parabolic grating spectroscope can be replaced by a

negative lens and enlarged images of sunspots obtained on a scale of about one metre to the sun's diameter.

3. **The Solar constant.**—Numerous photographs have been obtained of extra focal images of the moon reflected from a quartz mirror and for comparison similar images of the stars Regulus, Procyon, Rigel, Sirius and Capella. The apparatus has worked well and this method of detecting variation in the solar constant seems to be a promising one. Unfortunately the essential condition of a uniformly clear sky has been realized only in three lunations out of thirteen, *viz.*, in January, March and April.

4. **Spectroscopic investigations.**—A large number of high dispersion photographs of spot spectra have been obtained with the new Michelson grating and with the Rowland 3-inch grating. With improved arrangements for guiding and for rotating the sun's image on the slit plate, it is now possible to give the comparatively long exposures required in high dispersion work, keeping the slit accurately bisecting a spot in any required direction during the exposure. This is an essential condition for the study of problems connected with the movement of gases in sunspots.

5. **Radial Motion in sunspots.**—A study of the plates obtained has amply confirmed the results of the preliminary investigations. The spectra of all the larger spots which have appeared have been photographed, and the systematic line displacements in these indicate an accelerating outward radial movement parallel to the sun's surface of the gases in the reversing layer in every case. The movement measured varies from 1·3 to 3 km. per second at the outer limits of the penumbrae where the motion is greatest. A small component of motion at right angles to the radial movement has also been measured in spots favourably situated for detecting horizontal movements, that is, when not very far from the sun's limb. This probably indicates a spiral movement of the gases flowing outwards from the umbra of a spot—a slow movement of rotation superposed upon the radial motion. In all, 6 spots have been investigated for this movement, 3 northern spots and 3 in the southern hemisphere, and all have shown a movement of this kind of the order of 0·3 km. per second. It is found that the direction of motion is opposite in the two hemispheres; if it is really a rotational movement as seems probable then the direction of rotation is with the clock in the case of the three southern spots, and the reverse in the three northern. The rotational movement cannot as yet be affirmed however for an easterly or a westerly drift on the north or south side of a spot would equally satisfy the observations. The research is a

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somewhat tedious one involving a large amount of the most accurate measuring work, but it is hoped that it may eventually throw light on the origin of the magnetic field in sunspots discovered by Hale.

6. **Radial motion in the Higher Chromosphere over spots.**—Photographs of the calcium lines H and K and of the hydrogen line C in spots have been made on all favourable opportunities. The central absorption lines of the broad bands H and K, and the hydrogen absorption line C in the solar spectrum are produced by absorption in the higher levels of the sun's atmosphere and it is of great interest to find that these lines are displaced systematically over sunspots in the opposite direction to the displacement of the lines of iron and other elements representing low levels. This shows that in the high levels there is a radial movement *inwards* towards the umbra from the outlying regions. The H and K lines are sufficiently well defined to admit of fairly accurate measures of the motion, which has been found to be of the same order of magnitude as the reverse movement of the low level gases. The average in 9 sets of measures is 1·83 km. per second near the outer limits of the penumbræ.

7. **Vertical movement in sunspots.**—When a sunspot is situated near the centre of the sun's disc the component in the line of sight of the horizontal radial motion becomes inappreciable. If, on the other hand, there is any vertical movement it is evident that the line of sight component will be near a maximum. With a view to detecting vertical motion measures are made of the lines in the spectra of all spots which have been photographed within 15° of the centre of the disc. The velocity of such motion is in all cases very small in comparison with the horizontal movements. Some preliminary results indicate a sinking movement in the umbræ of some spots amounting to 0·4 km. per second.

8. **Halley's Comet.**—During part of the months of April and May 1910, Halley's comet was very favourably placed for observation, and as photographs taken in India would fill a blank between those taken in America or Europe, it was considered advisable to take advantage of every opportunity to photograph the comet and its spectrum with such instruments as were available, or could be constructed in the observatory workshop.

The following is a brief summary of the results obtained with the different instruments:—

(1) A series of 45 plates was secured with a Grubb portrait camera permanently attached to the 6-inch equatorial in the north dome. These represent 23 days during the morning apparition

from April 18 to May 16 inclusive, and 6 days at the end of the month when the comet was an evening star.

(2) A series of 14 plates was obtained with a reflecting telescope fed by a cœlostat. They show the region of the comet's head and two degrees of the tail on a scale about twice that of the portrait lens. One plate only was exposed each morning so that 14 days are represented covering the period April 20 to May 16 inclusive.

(3) About 22 plates were obtained with small cameras from 5 inches to 11½ inches focal length, and show interesting features in the outer extensions of the tail.

(4) A series of 22 spectrum plates were obtained with a prismatic camera attached to the south equatorial between 18th April and 16th May inclusive. The main features shown in these are (1) a continuous spectrum due to the nucleus in which some of the Fraunhofer lines can be traced, indicating reflected sunlight; (2) A discontinuous spectrum of the gases surrounding the nucleus but not extending into the tail, and (3) a series of monochromatic images of the tail.

Extensive preparations were also made to observe the transit of the comet across the sun's disc on May 19 (civil time). Owing to the very great intensity of the cyanogen rays at wave-lengths 3281 and 3883 in the head of the comet it seemed probable that if the nucleus or coma could not be observed or photographed by ordinary methods on the sun's disc, it would appear as a dark absorption marking in spectroheliograph plates taken with the camera slit set on the line 3883. Unfortunately the weather was not very favourable for this work, but a few fairly good monochromatic photographs were obtained during the supposed time of transit of the comet. Neither these nor the direct photographs taken at the same time show any trace of the comet, nor could anything whatever be seen of the comet in the 6-inch telescope. The evidence as a whole although entirely negative is of importance in proving the extreme tenuity and transparency of the materials composing even the densest portion of the comet's head.

A bulletin has been issued (No. XX) giving detailed particulars of the work on Halley's Comet and the results of the measure of the lines in the spectrum plates. A more complete discussion of the spectrum has also been published in the monthly notices of the Royal Astronomical Society, Vol. LXX.

9. The observatory is now co-operating with the "International Union for Solar Research."

10. There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief portions of the equipment are :—

(*a*) A Foucault siderostat with an 8-inch image lens for use with a spectroscope which has recently been improved in England.

(*b*) An equatorial refractor with a Cooke 6-inch triple photovisual lens. This is provided with two 45° objective prisms, and a prominence spectroscope with a Thorpe transmission grating has been constructed locally for attachment to it.

(*c*) An equatorial reflector with a 20-inch mirror by Common. A focal plane ultraviolet spectrograph is now in complete adjustment and it is proposed to employ it for stellar spectra.

The twelve 'most widened' lines in sunspot spectra are observed daily and the results forwarded to Sir Norman Lockyer, and a close agreement is maintained with the observations made at South Kensington. The observatory is also co-operating with the International Union for Solar Research, and is observing the region 5300 to 5500 for all lines affected in sunspots.

11. **Solar Radiation.**—Of the three Angström pyrheliometers previously in use in Simla one was taken in January 1908 to the Solar Physics Observatory at Kodaikánal for employment there. The operation of these instruments in Simla and Kodaikánal is, however, difficult and intermittent on account of cloud and atmospheric dust.

METEOROLOGY.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

The Upper Air.—In continuation of Mr. Field's experimental work with recording balloons, the purpose of which was shortly described in last year's report, 17 balloons with instruments were liberated by him at Jhang during the monsoon months of June and July, and 7 in December 1909; of the first set more than half were recovered, but only one of those in December. The heights reached during the monsoon ranged up to 12 miles, with a lowest temperature of about —107°F. and the descents occurred at

short distances from Jhang; in several cases within 10 miles of the starting point. The balloons in December all travelled eastward and their horizontal velocities indicated very high winds a few miles above the ground surface. The one instrument recovered had only reached the 6 mile level, with a lowest temperature of —35°F., but it came down as far away as Lahore. It appears probable that the remaining instruments, which would in the ordinary course have reached much greater altitudes, were carried into the Himalayas or Tibet, and that, but for some defect in the balloon which touched ground in Lahore, no one of the seven instruments would have been heard of again.

A feature of the ascents in the monsoon was the liberation on two occasions of a pair of instruments together on the same balloon with a view of comparing their records and ascertaining to how great an extent the traces could be relied upon to represent actual conditions. This question had assumed some importance in consequence of doubts which had been expressed by scientists at home as to the capabilities of instruments constructed so lightly as these must necessarily be. One pair was recovered and the two independent records were found to agree satisfactorily.

Attention was paid throughout the year to the training of a native clerk who had shown aptness in this work, with a view of enabling him to calibrate the instruments and liberate the balloons with native help only, in order that continuous systematic balloon work might be carried on from Jhang. This work has now been begun by the liberation of a series of pilot balloons, observed by two theodolites, the ascents taking place about five times a week. After obtaining skill at this preliminary work with pilot balloons the staff at Jhang are to begin liberating balloons with recording instruments, of which it is proposed that two weekly should be sent up in addition to three or four pilots.

Electrical Condition of the Atmosphere.—Following on the work done by Dr. Simpson in 1908 in relation to the origin of thunderstorms, a second series of observations on the electricity of rainfall was undertaken during the year 1909 with a view to confirm or amend the previous conclusions of which a statement was given in last year's report. The results of examination of the new data were published by the Royal Society in their Proceedings, and have since been included in a Memoir of the Meteorological Department which deals with the combined work of the two years and includes a consideration of the electrical condition of snowfall.

The automatic apparatus for recording the potential gradient in the atmosphere near the earth's surface was in nearly constant use, and the

apparatus for recording earth-air current, to which a reference was made last year, had been put into working order by the time Dr. Simpson left Simla to join the new Antarctic Expedition. It is expected that on his return Dr. Simpson will resume this piece of work, which was promising well at the time of his departure.

Correlation in seasonal variations of weather.—The application of statistical methods had previously shown that causal relationships exist between the monsoon rainfall of June to September in India and a number of factors as to which information is available at the beginning of June; and it appeared desirable to publish an account of the method with tables of the data on which it is based. The publication has been issued, and contains also attempts on similar lines to construct a method for forecasting Nile floods and the summer monsoon rains of Australia. In the former case it is shown that out of the 14 occasions since 1865 on which a forecast (based on the pressure in South Africa, the rainfall of Zanzibar and the accumulation of snow to the west and north of India) would indicate a departure of 10 per cent. or over, the departure is of the right sign 13 times: and the correlation co-efficient of the calculated departure with the actual is ·6. This co-efficient has the same value in the case of India, using 4 factors (South American pressure, Mauritius pressure, snowfall and Zanzibar rain), and of Australia, with 3 factors (Australian pressure, Indian monsoon rainfall, and Mauritius pressure).

Data from logs of ships in the Indian Ocean.—The collection of these has been continued, but it has not been possible to do any work upon them during the year.

Publications.—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay and Madras, the Monthly Weather Reviews, the Annual Summary, and various administrative pamphlets the following memoirs have been published departmentally:—

Simpson, George C. .	On the electricity of rain and its origin in thunderstorms. (*Mem. Ind. Meteor. Dept., xx, Part VIII.*)
Walker, Gilbert T. .	On the meteorological evidence for supposed changes of climate in India. (*Mem. Ind. Meteor. Dept., xxi, Part I.*)
Ditto .	Correlation in seasonal variations of weather, II. (*Mem. Ind. Meteor. Dept., xxi, Part II.*)
Simpson, George C. .	Tables for the reduction of meteorological observations in India (*1910*).

TERRESTRIAL MAGNETISM.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Magnetic Observatories.—*Bombay* (*Alibag*).—The Bombay Observatory which was formerly maintained by the Local Government at Colaba was moved to Alibag in consequence of the introduction of electric trams into the city: it is now directly under the Government of India, the Director being Mr. N. A. F. Moos. The chief instruments are a set of magnetographs of the Watson pattern and a Schulze earth-inductor, in addition to ordinary magnetometers and dip circles. All have given satisfactory results through the year. A set of sight-reading instruments of Eschenhagen pattern has been ordered and will be used as a check on the Watson instruments as well as for special observations. The results of the sixty years of observations at Colaba are passing through the press.

2. *Dehra Dun, Kodaikánal, Barrackpore and Toungoo.*—These observatories were started as base stations in connection with the Magnetic Survey of India and are all equipped with Watson autographic instruments for declination, horizontal intensity and vertical force. Instead of dip-circles earth-inductors of the Schulze pattern have been set up at each place. Good results have been obtained through the year. At Dehra Dun, of the flooding of which mention was made last year, it is satisfactory to report that in spite of the heavy rain of this year, no break of record has occurred. The passage surrounding the magnetograph room was at one time flooded to a depth of 3 feet, but water was kept out of the room by a barrier at the door. In order to prevent this percolation of subsoil water the walls and floor of the observatory are now being plastered with portland cement.

3. The mean values of the magnetic elements for 1909 at the observatories are as follows:—

	Declination.	Horizontal force.	Vertical force.	Dip.
Bombay . .	1° 0′·3 E.	·36845	·16033	23° 30′·0
Dehra Dun .	2° 34′·8 E.	·33276	·31909	43° 48′·0
Barrackpore .	1° 0′·7 E.	·37300	·22099	30° 38′·7
Kodaikánal	0° 50′·1 W.	·37459	·02391	3° 39′·1
Toungoo .	0° 30′·0 E.	·38766	·16475	23° 1′·5

An error in the mean values of H. F. and Dip at Barrackpore for the year 1908 has been discovered owing to the wrong temperature having been taken for the correction of the measured ordinates. The correct mean values are ·37298 and 30°34′·6.

4. **Magnetic Survey.**—The general scheme was to execute a preliminary survey of the whole country and a detailed survey of those areas where, owing to local irregularities, further information was required. The preliminary survey was to consist of observations of declination, intensity and dip at about 1,100 stations, and measurements were to be made in successive years at about 22 'repeat' stations in order to effect the elimination o secular variation.

Field work was begun in November 1901 and up to the end of the year 1908-09 1,255 field stations had been occupied and 23 repeat stations established, in addition to 24 stations on the Seistan trade route where declination had been observed; observations had also been repeated at 57 old field stations. In the detailed survey 122 stations had been occupied.

During the field season under report four detachments were employed. Of these one worked in the outer ranges of the Himalayas from Naini Tal to Dalhousie, two re-observed at most of the old field stations in the area lying between Lat. 16°-19° and Long. 73°-78° where the secular change in H. F. appears to be particularly abnormal, and also examined a few small areas in detail, while the fourth was employed on detail survey in Central India.

5. The officer in charge, Captain R. H. Thomas, R.E., with his assistant Lieutenant H. T. Morshead, R.E., re-observed at all the repeat stations (with the exception of Port Blair) and also at a number of old field stations. Comparative observations were made at the four survey base stations and also at Alibag.

Full sets of magnetic observations were taken at 69 new and 71 detailed survey stations while 100 old field stations were re-occupied.

6. During the recess season the investigation of the question of instrumental differences in H. F. has been continued and has necessarily postponed the discussion of other results obtained during the working season. The investigation, however, is nearing completion and it is hoped that satisfactory results will be obtained.

The standard instruments are liable to some unknown change which produces an apparent drop in the moment of the magnet and an apparent change, usually an increase, in the value of the horizontal force. That this change is not a permanent one is indicated by the fact that in May

1908, immediately after a large drop in the moment of the Dehra Dun standard magnet, No. 17, the differences of all the field instruments from the standard dropped by about 20γ, while at the next comparison in October 1908 these differences had resumed their original values, and the base line of the Dehra Dun magnetograph, after rising suddenly in May, dropped rapidly during the next 4 or 5 months.

There also appears to be some evidence of personal error between observers. The clearest case of this is at Kodaikanal where one observer took over the duties of the permanent observer for three months. Immediately after this change m_o dropped 0·46 C.G.S. units and the base line 19γ, a rise of exactly the same amount occurring when the permanent observer returned. This was a simple case and can easily be allowed for, but in other cases of change of observers the evidence is not so clear and it is difficult to decide whether any correction should be applied.

In addition to this investigation the ordinary computation of the field work and the reduction and tabulation of the base station results for 1909 has been undertaken and is nearing completion.

7. For the next field season a magnetic survey of the Andamans and Nicobar Islands is proposed and also a detailed examination of the coal fields of Bengal. Besides this a number of old field stations will be permanently marked to admit of their re-occupation in the future.

GEOLOGY.

BY

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Late Officiating Director, Geological Survey of India.

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INTRODUCTION.

This report contains a summary of the operations conducted by the Geological Survey of India during the calendar year 1909. In certain cases the results of these operations have already appeared in the publications of the Department, and these are only briefly referred to here. The work still in progress in Rajputana and in Burma is, however, not yet completed, and is accordingly described in somewhat greater detail.

PETROLOGY.

Rocks from Gwalior and Alwar.

2. A large number of petrographical determinations have been made by Mr. Jones of the rocks collected by him in the Gwalior State, and by Mr. Heron of the Alwar rocks, but no types of particular interest have been found among them. A general account of these rocks is given in the section on Geological Surveys below (pp. 69, 70).

Rocks of the Aden Hinterland.

3. Mr. Vredenburg has worked out the petrology of the rocks collected by Captain R. E. Lloyd, in the hill country north of Aden (*see* below, p. 63). The assemblage of specimens from the older volcanic series, resembling that of the Upper Cretaceous formation in Baluchistan and Persia, together with their superposition upon the Jurassic rocks, leaves little doubt that they belong to the same period of volcanic activity as the Deccan trap. The acid varieties are represented by rhyolitic lavas, rhyolite breccias and ash beds, and there are also some doubtful andesites. Among the basic rocks there are dolerites with beautiful pleochroic augites of purple colour; a dolerite closely resembling many of the dyke rocks of Deccan trap age occurring in Baluchistan; ordinary basalts without olivine, also resembling the Deccan trap; basalts with olivine, and an abnormal rock made up of a base composed of small prismatic crystals of augite, iron ores, and serpentinous material, through which are scattered vacuoles filled with felspar and epidote; and olivine porphyry. Geodes of agate, chalcedony, jasper, etc., are extremely common in the basalts, and may be picked up in large quantities on the surface as in the Deccan trap areas in India. Mr. Vredenburg's notes are published in Vol. XXXVIII, Pt. 4 of the *Records*.

PALÆONTOLOGY.

Upper Jurassic fossils from the Aden Hinterland.

4. The collections of fossils made by Captain R. E. Lloyd in the hill country north of Aden have been examined by Mr. Tipper, whose notes on them are published in Vol. XXXVIII, Pt. 4 of the *Records*.

They consist of a Belemnite, *B.* cf. *tranganensis* Futterer; four species of *Perisphinctes;* an undetermined gasteropod closely resembling *Dicrolema* (*Piettia*) *seminudum* Heb. and Desl.; among lamellibranchs *Parallelodon egertonianum* Stol., and species of *Pinna, Trigonia, Pecten* (*Syncyclonema*) and *Cardinia ?*; and a species of *Pentacrinus.* Mr. Tipper considers that the fauna described possesses a distinctly Upper Jurassic facies.

Fusulinidæ from Afghanistan.

5. In a paper contributed to the *Records* (Vol. XXXVIII, pt. 3), Mr. Hayden has given a description of various *Fusulinidæ* collected by him in the limestones of the Bamian valley in Afghanistan. The material described consists chiefly of well-known forms and includes *Fusulina uralica* Krotow, *F. elongata* Shumard, *Schwagerina princeps* Ehr., *Neoschwagerina craticulifera* Schw. and *N.* (*Sumatrina*) *annæ* Volz. A new species, *Neoschwagerina primigena,* is described, intermediate between *Schwagerina* (*Doliolina*) *lepida* Schw. and *N. craticulifera,* and the last named fossil is shown to be dimorphic.

Mr. Hayden also made a critical examination of the nature of the shell of the *Fusulinidæ,* which he found to be composed of cryptocrystalline material identical in structure with the shell-substance of the *Porcellanea* and he pointed out that certain authors had mistaken the dark shell-wall for perforations and *vice versâ.* At the time of writing his paper, he had not seen the very important memoir by Professor Douvillé, which had previously appeared in the *Bulletin de la Société géologique de France;* he was not aware, therefore, that the latter author had come to the conclusion that the so-called perforations of *Fusulina* were in reality gaps in a net-work of varying degrees of fineness, and that this net-work was covered by a thin imperforate layer, to which attention had already been drawn by Girty. In Mr. Hayden's specimens the gaps in the net-work ('perforations') are frequently seen to traverse this outer layer, which therefore appears to be 'perforate.' It is of course possible that this may be due to the state of preservation of the specimens and, with a view to deciding this, Mr. Hayden is at present in correspondence with M. Douvillé on the subject.

Fossil fish teeth from Burma.

6. Mr. Murray Stuart has described and figured a number of fossil fish teeth, collected from various localities in Burma, in Vol. XXXVIII, Pt. 4 of the *Records.* The evidence afforded by these is in favour of the classification of the Tertiary strata in Burma put forward by him in the paper noticed below (p. 110).

Ostrea latimarginata in Burma.

7. Messrs. Vredenburg and Stuart describe in Vol. XXXVIII, Pt. 2 of the *Records* the occurrence of *Ostrea latimarginata*, a species characteristic of the Gaj groups of Kachh and Sind, in the Yenangyaung Stage of the Pegu System in Upper Burma. The fossil was discovered by Mr. H. J. Davies, Geologist to the Burma Oil Co., and throws much light upon the vexed question of the correlation of the Tertiary rocks in Burma. Mr. Stuart considers that the Kama clay, which occurs immediately above the zone of *O. latimarginata*, must represent a part of the 'Hinglaj beds' of Mekran, as defined by Mr. Vredenburg, and confirms the suggestion that a distinct unconformity separates this Kama clay from the base of the Irrawaddy System. This observation is of importance, as it accounts for the extreme divergence in the thickness of the Kama clay which, as recent surveys have shown, constitutes the main petroliferous horizon in Burma; whereas Dr. Noetling considered that at Yenangyaung the oil sands occurred at a lower horizon, *i.e.*, in the Lower Prome beds of Mr. Theobald (*see* below, p. 116).

Hippurite-bearing limestone in Seistan.

8. Mr. Vredenburg has described, in *Records*, Vol. XXXVIII, Pt. 3, two interesting species of *Hippurites* from a collection made in Seistan by Mr. T. R. J. Ward and Sir Henry McMahon, and gives in the same paper a geological sketch of the country. The two species of *Hippurites* described are *H. gosaviensis* Douvillé and a new species *Pironæa persica* Vred., and Mr. Vredenburg considers the beds to be most probably uppermost Turonian. A large ribbed bivalve, which Mr. Vredenburg was unable to identify at the time his paper was written, has since been shown by Dr. Emil Böse of Mexico to be a species of *Chondrodonta*, a genus distinguished by the peculiar interlocking chondrophores of the hinge and associated with shells of the Rudistæ in Europe and America. Mr. Vredenburg has consequently given the name of *Chondrodonta Bösei* to the Seistan species.

New Tertiary Mammalian genera and species.

9. As a result of the exploration of the Tertiary ossiferous deposits of India now being carried out by Dr. G. E. Pilgrim, with the assistance of Sub-Assistant M. Vinayak Rao, it has been found necessary to establish several new genera and species of mammals. A preliminary list of these is published to the present volume of the *Records*, Pt. 1, and full descriptions of those forms which have been determined up to the present are now in the press.

Trias of the Himalaya, Dr. C. Diener.

10. The examination of the Triassic fossils from the Himalaya collected at various times by the late Mr. C. L. Griesbach, the late Dr. A. von Krafft, Dr. Diener, Mr. Hayden and others has now been completed, and Dr. Diener has summed up the whole question of the distribution and correlation of the Triassic rocks in the four distinct areas from which the fossils have been obtained, *viz.*, Painkhanda, Spiti, Eastern Johar and Byans, and the exotic blocks between Malla Johár and Hundes, in an exhaustive paper which will shortly appear as Vol. XXXVI, Pt. 3 of the *Memoirs*.

The more recent researches of Hayden and von Krafft have shown that the Trias is not developed uniformly throughout the Himalaya, and that there is no 'type section' to which the development of the system in various localities can be referred. Thus the present memoir supersedes the summary of the Trias of Asia, so far as the Himalaya is concerned, published by Dr. Noetling in the *Lethæa Mesozoica* (Vol. I, 2, Stuttgart, 1905). The Triassic beds of the Himalaya were divided by him into ten cephalopod-bearing horizons thus :—

Upper Trias.	10. *Sagenites* beds.
	9. *Halorites* beds.
	8. *Hauerites* beds.
	7. *Tropites* beds.
	6. *Joannites* beds.
Middle Trias	5. *Ptychites* beds.
	4. *Robustites* beds.
Lower Trias	3. *Stephanites* beds.
	2. *Hedenstræmia* beds.
	1. *Prionolobus* beds.

The base of the Trias was drawn above the *Otoceras* horizon, which Griesbach considered to be a passage bed between the Permian and Trias. It is now shown, however, that *Oteceras* is confined to a thin layer at the base of the Lower Trias.

The sub-division of the whole system now adopted by Dr. Diener is shown in the following table, which also indicates the variations that occur in the three principal areas from which collections have been made :—

Spiti.	Thickness.	Painkhanda.	Thickness.	Byans.	Thickness.	Equivalents in the Eastern Alps.		
Megalodon limestone.[1]		Megalodon limestone.		Megalodon limestone.		Upper.		
Quartzite series (*Spirigera Maniensis*)	Feet. 300	Quartzite series (*Spirigera Maniensis*)	Feet. 250	Greenish black shales with sandy bands.	Feet. 1,000	Middle.	Noric Stage.	Upper Trias
Monotis beds (*Monotis salinaria*)	300	Anodontophora Griesbachi beds (Sagenites beds)	160					
Coral limestone (*Spiriferina Griesbachi*)	100	Limestone with *Spiriferina Griesbachi*	320					
Juvavites beds	500	Halorites beds, Nodular limestone with *Proclydonautilus Griesbachi*	200			Lower.		
Dolomitic limestone (*Lima* cf. *austriaca*)	300	Beds with *Halobia comata*.	800	Tropites limestone.		Tuvalic.	Carnic Stage.	
Tropites shales (*Tropites* cf. *subbullatus*)	600							
Grey beds. Higher beds with brachiopods and bivalves, near base *Joannites cymbæformis*	500			Grey, massive limestone.		Julic.		
Halobia limestone (*Halobia comata*)	150	Traumatocrinus limestone	25	*Ceratites Thuillieri* *Spiriferina Stracheyi*.		Cordovalic.		
Daonella limestone. Higher beds with *D. indica*, near base *D. Lommeli*	150	Passage beds of the Shalshal Cliff	10-20	Limestone with *Rhynchonella Griesbachi*. Near top *Sibirites spiniger*.	250	Ladinic stage.		Middle Trias
Daonella shales (*D. Lommeli*)	160							
Upper Muschelkalk (*Ptychites rugifer*)		Upper Muschelkalk (*Ptychites rugifer*)			...	Muschelkalk.		
Beds with *Spiriferina Stracheyi* and *Keyserlingites Dieneri*		Beds with *Spiriferina Stracheyi* and *Keyserlingites Dieneri*						
Niti limestone[2] Shaly bed with *Rhynchonella Griesbachi*	100	Niti limestone. Shaly bed with *Rhynchonella Griesbachi*	100					
Hedenstrœmia beds (*Flemingites Rohilla*).		Hedenstrœmia beds (*Flemingites Rohilla*)				Campil beds.		
Meekoceras beds (*Meekoceras Varaha*)	40	Meekoceras bed (*Meekoceras Markhami*)	...	Chocolate limestone.	150	Seis beds.		Lower Trias
Ophiceras bed (*Ophiceras Sakuntala*)	...	Otoceras beds (*Otoceras Woodwardi, Ophiceras Sakuntala*)	...					
Otoceras bed (*Otoceras Woodwardi*)	...							
Kuling shales	...	Kuling or Productus Shales		Kuling or Productus Shales.	...	Permian.		

[1] In the classification now employed by the Geological Survey of India, this term has been discarded for Stoliczka's original name "Para" (see Burrard and Hayden, Geology and Geography of the Himalaya, p. 239.

[2] "Nodular limestone" of the Geological Survey of India classification.

Fifteen cephalopod-bearing horizons are distinguished by Dr. Diener, as shown in the following table. Of these three are rather doubtful, No. 5

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Upper Muschelkalk (*Ptychites rugifer*)		Upper Muschelkalk (*Ptychites rugifer*)		Near top *Sibirites spiniger.*	...	Muschelkalk.		
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Niti limestone[2] Shaly bed with *Rhynchonella Griesbachi*	100	Niti limestone. Shaly bed with *Rhynchonella Griesbachi*	100					
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Meekoceras beds (*Meekoceras Varaha*)	40	Meekoceras bed (*Meekoceras Markhami*)	...	Chocolate limestone.	150	Seis beds.		
Ophiceras bed (*Ophiceras Sakuntala*)	...	Otoceras beds (*Otoceras Woodwardi, Ophiceras Sakuntala*)	...					
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being perhaps not an independent palæontological horizon, though *Rhynchonella Griesbachi* is confined to it; while from 9 only a single ammonite is known, *Joannites thanamensis*, and No. 15 is based on two fragmentary specimens of ammonites :—

	Spiti.	Painkhanda.	Byans.	Exotic blocks of Chitichun and Malla Johar.
Noric stage.	15. Horizon of *Trachypleuraspidites* aff. *Griffithi*. 14. Horizon of *Juvavites angulatus*.	15. Horizon of *Sageniles* sp. ind. 14. Horizon of *Halorites procyon*. 13. Horizon of *Proclydonautilus Griesbachi*.		
Carnic stage.	12. Horizon of *Tropites subbullatus*. 10. Horizon of *Joannites cymbæformis*. 9 Horizon of *Joannites thanamensis*.	12. Horizon of *Mojsvarites eugyrus*. 11. Horizon of *Juvavites tonkinensis* and *Hypocladiscites subaratus*. 10. Horizon of *Joannites cymbæformis*.	14. 13. 12. } Horizon of *Tropites subbullatus* and *Halorites sp. aff. procyon*.	12. 11. } Horizon of *Cladiscites crassistriatus*.
Ladinic stage.	8. Horizon of *Protrachyceras Archelaus*.			
Muschelkalk.	7. Horizon of *Ceratites Thuilleri* and *Ptychites rugifer*. 6. Horizon of *Keyserlingites Dieneri*.	7. Horizon of *Ceratites Thuilleri* and *Ptychites rugifer*. 6. Horizon of *Keyserlingites Dieneri*. 5. Horizon of *Sibirites Prahlada*.	7. Horizon of *Ceratites Thuilleri*.	6. Horizon of *Monophyllites Confucii*.
Lower Trias.	3. Horizon of *Hedenstræmia Mojsisovicsi* and *Flemingites Rohilla*. 2. Horizon of *Meekoceras Varaha*. 1. Horizon of *Otoceras Woodwardi*.	3. Horizon of *Hedenstræmia Mojsisovicsi* and *Flem. Rohilla*. 2. Horizon of *Meekoceras Markhami*. 1. Horizon of *Otoceras Woodwardi*.	4. Horizon of *Sibirites spiniger*. 3. Horizon of *Hedenstræmia Mojsisovicsi*.	3. Horizon of *Meekoceras Joharense*.
Permian	Horizon of *Cyclolobus insignis*.			

The Lower Trias and Muschelkalk are developed almost equally well in Spiti and Painkhanda, but in Byans both divisions are not so well represented. In this area, however, the topmost beds contain the fauna of the *Sibirites spiniger* zone, which is probably homotaxial with that of the Upper Ceratite Limestone of the Salt Range.

In the ladinic stage a strongly marked difference in the development sets in. It is much richer in fossils and of greater thickness in Spiti than in Painkhanda, and has not yet been traced further east.

The same difference is equally prominent in the carnic deposits, which are well developed in Spiti, but are almost insignificant in Byans.

The noric deposits are divided into three sets of beds—Quartzite series, Brachiopod beds and Cephalopod beds—of which the last named are locally very rich in fossils, but do not form a constant stratigraphical horizon. The lower noric beds of Byans show peculiar features, being made up of black shales of great thickness, wanting in the other districts. The upper noric beds consist everywhere of thick limestones which pass through beds of doubtful age into limestones of Middle Jurassic age, overlaid by the Upper Jurassic Spiti Shales. The base of these is marked by a very constant ferruginous oolitic layer of Kelloway age.

11. Dr. Diener appends to his memoir a discussion of the extension into other regions of the Indian Triassic province. He shows that the Triassic strata were deposited along the southern shore of the ancient ocean known as *Tethys*; that the fauna bears a quite distinct character which distinguishes it from those of the Mediterranean region; and that during the middle and upper Triassic periods Afghanistan was at the western limit of the province. Eastwards, on the other hand, the fauna of Himalayan type has been found in Yunnan, but that of Tongking points to a closer connection with the eastern Pacific region. To the south-east, however, the Indian marine Trias has been traced through the Malay Archipelago; and this region appears to have formed a connecting link between the Indian and Pacific provinces; while evidence of the extension of Himalayan elements to New Caledonia during this period has recently been obtained. So close that Dr. Diener states that "the Trias of this island can scarcely put in a claim for being separated from the Indian Triassic province as a special faunistic district."

The memoir concludes with a brief account of the evolution of the Triassic ammonites.

PHYSICAL GEOLOGY.

Himalayan glaciers.

12. During the year 1906 a number of glaciers in the North-West Himalaya were visited by officers of the Geological Survey and permanent marks were affixed to the rocks near their lower ends in order that observations on their secular oscillations might be made in future years.

Alukthang and Zemu glaciers in Sikkim.

This work was carried out at the instance of Mr. D. W. Freshfield, on behalf of the *Commission Internationale des Glaciers*, and has now been completed for the present by the demarcation of two of the glaciers descending from the Kinchinjunga Group in Sikkim. The observations recorded are published in Pt. 1 of the present volume of the *Records*. Marks have now been placed at, and plane table plans made of, the ends of 14 glaciers, extending from Kashmir through Lahaul and Kumaon to Sikkim.

Hassanabad glacier in Hunza.

13. An interesting letter has been received from Dr. Hunter Workman giving an account of a visit in June 1908 to the Hassanabad glacier in Hunza, one of those marked by Mr. Hayden in 1906 (*Records*, Vol. XXXV, Pt. 3, p. 135). One of the boulders marked No. 3 in Mr. Hayden's plan (op. cit. Pl. 38), had slipped down the hill some 50 or 60 feet from its former position, but Nos. 1 and 2 were *in situ*, and the inscriptions still bright and clear. Dr. Hunter Workman states that the tongue of the glacier had remained stationary since the plan was made, and had not altered appreciably in appearance.

Kashmir glaciers.

14. Dr. A. Neve, of the C. M. S. Mission, Kashmir, has sent us some interesting notes on the Murgisthang or Mongstong glacier in the Mustagh Range, and on the Machai (or Mechoi) glacier, near the crest of the Zoji La, on the road from Srinagar to Leh. The latter is one of the most easily accessible glaciers in Kashmir, but the ice is so buried in moraines on either side that it would be difficult to find spots on which permanent marks could be placed near the tongue. Dr. Neve thinks that there has been scarcely any change in it during the last 25 years.

The Khumdum glaciers.

15. The Khumdum glaciers are situated on the right bank of the Shayok river near its source, and were visited in 1908 and again in 1909 by Captain D. G. Oliver, I.A., accompanied on the latter occasion by Dr. T. G. Longstaff.

The chief interest of these glaciers, so far as the question of secular oscillation is concerned, lies in the fact that they all descend from lateral valleys to the bed of the river, along which runs an important trade route across the Karakoram Pass into Tibet. Thus any general retreat or advance of the ice can be easily recognised. Captain Oliver gives instances of floods caused by the advances of the glaciers completely across the bed of the river, the last occasion when this happened being 1903. The Aktash glacier also advanced in the same manner in 1905, but caused no flood, as the water percolated through sand in the river bed at this point.

Dr. Neve's and Captain Oliver's notes will shortly be published in the *Records*.

Lakes of the Punjab Salt Range.

16. While engaged on a traverse along the plateau of the Salt Range in the Punjab, for the purpose of ascertaining the probable extension of the coal seams beneath the Nummulitic limestone, I took the opportunity of surveying and taking soundings of the four permanent lakes found on the plateau. The basins of these lakes with the exception of the Jalar Kahar, were found to owe their origin to earth movements, that is to say, to a synclinal fold in the case of the Kabaki Kahar and to faulting in that of the Kalar and Son Sakesar Kahars respectively. The Jalar Kahar has been formed by erosion along the crest of an anticlinal fold in carboniferous limestone. All the lakes are very shallow and none of them has any visible outlet. Their present configuration is due to irregularities in the accumulation of wind-blown 'loess,' which collects in the original depressions. A full account of the lakes is published in Part 1 of the current volume of the *Records*.

Mud volcanoes of the Arakan Coast.

17. In a paper published in Vol. XXXVII, Pt. 3, of the *Records*, Mr. Coggin Brown brought up to date the accounts of the various eruptions of the mud volcanoes situated off the Arakan Coast that have taken place since 1893. There appears to have been a remarkable period of quiescence between the years 1886 and 1903, similar to that noted by Mr. Mallet between 1846 and 1878, but it is not certain that the apparent falling off in activity is not due to lack of evidence of eruption. Since 1903 five eruptions have been recorded and are described by Mr. Brown, one of which resulted in the formation of a new island, off Beacon Island, on the 15th December 1906. This island was still in existence in December 1908, but a great part of it had been washed away.

ECONOMIC ENQUIRIES.

Coal.

Revision of the map of the Raniganj coal-field.

18. The revision of the geological map of the Raniganj coal-field, undertaken in November 1908 in conjunction with a Committee appointed by the Mining and Geological Institute of India, has made fair progress, and it is hoped will soon be completed. The re-survey is being carried out on behalf of the Geoglogical Survey Department by Mr. H. Walker, who testifies to the general accuracy of the original maps, for a long time out of print, constructed by the late Dr. W. T. Blanford in 1858-1860 ; only minor corrections in the boundaries along the margin of the field, where dense jungle existed in Dr. Blanford's time, being necessary. The principal additions to our knowledge of this important area have been made with respect to the underground correlation of the coal seams and the more accurate mapping of faults and dykes in which work Mr. Walker and the Committee have received most valuable assistance from the owners and managers of the collieries, most of whom have placed their mining plans and boring records freely at their disposal.

Gilhurria, Rajmahal Hills.

19. A small patch of Damuda rocks at Gilhurria on the western flanks of the Rajmahal Hills, containing a seam of combustible carbonaceous shale, was examined by Mr. Stuart in the course of his examination of the area for china-clay and glass-making sands (referred to in last year's General Report) and is described in a short paper in Vol. XXXVIII, Pt. 2, of the *Records*. The occurrence is interesting, as it indicates the continuance of the Damudas of the Hura and Dhamni coal-fields beneath the trap, but the coal, which was being quarried by the natives, is of poor quality at the outcrop.

Punjab Salt Range, Shahpur District.

20. At the instance of the Railway Board, I was deputed to visit the coal mines being worked by native owners in that part of the Punjab Salt Range which lies in the Shahpur District, as application had been made for the construction of a branch line from Dhak station on the Sind-Sagar line to the foot of the range to serve the mines. At present the mines are worked entirely from the outcrop, and no attempt has been made to form a reliable estimate of the quantity of coal available. The present output is not more than 40 or 50 tons a day, and until more capital is spent on the development and equipment of the mines, it would be premature to discuss the question of constructing a branch line to the locality, unless there is a demand for building stone from the Range sufficient to supplement the coal traffic.

I also made a traverse along the Salt Range plateau and suggested that a series of borings should be put down through the Nummulitic limestones which cover the greater part of it, in order to ascertain whether coal exists in workable quantities beneath it at the horizon at which the coal seams crop out along the southern scarp. An experimental boring at Dandot was sanctioned for the purpose of estimating the cost of carrying out this scheme, and is now in progress.

Sikkim.

21. Reports of the discovery of coal in the valley of the Great Rangit River in Sikkim having been received, I visited the localities during my tour in that State. Several of the outcrops had been opened out sufficiently to show that the so-called coal is a dense black carbonaceous shale, so greatly crushed as to have assumed a nodular structure in which the nodules are surrounded by a thin glistening film of carbon, the appearance in bulk being that of a hard bright coal. It is so impure, however, that when placed on a fire it merely becomes calcined, and it will not support combustion. Some of the seams are as much as 6 feet in thickness, but none of the so-called coal is of any value as fuel.

Copper.

Sikkim.

22. On my way to the glaciers of Kinchinjunga I also visited the localities in Sikkim at which copper ores are known to occur, and are now being actively prospected under European supervision. The conditions under which the lodes occur, especially the intense folding and dislocations to which the rocks have been subjected, render it extremely difficult to form a definite opinion regarding the continuation of any particular occurrence of ore, but it is evident that in many cases the lodes, though perhaps originally continuous, have been broken up into a succession of small detached lenticles or pockets, and that the location of these would be a matter of great difficulty and expense. In a few instances, however, lodes of some persistence have been opened up, and may prove to be worth exploitation by modern methods.

Gwalior.

23. Traces of copper ores in the Bundelkhand gneiss of the Gwalior State were investigated by Mr. Jones (*see* below, p. 113), but were found to be of no economic importance.

Engineering Questions.

Building sites at Dalhousie.

24. At the request of General C. H. Powell, Commanding the Jullunder Brigade, I visited the Hill station of Dalhousie in September for the purpose of examining the sites proposed for the erection of a garrison church and other buildings. The cantonment is situated on a narrow spur known as the Balun spur which runs out to the north from the high ridges on which Dalhousie itself is built, at a considerably lower level than the civil station. This spur consists of slates which have a regular easterly dip, corresponding very closely with the slopes on the eastern side of the spur. The soil cap on this side, which is of great thickness, has therefore a constant tendency to creep downwards, as the toe of the slope is cut away by the stream at its base, and any heavy structures, either on the slope or near its crest, are liable to serious movement of their foundations. In fact every building already erected in such a position is severely cracked, and the eastern end of one of the barracks, which are exceedingly massive, had to be pulled down some years ago. These movements are, however, entirely confined to the soil cap, and all buildings erected not too near the eastern edge of the spur would be perfectly safe. Such a site was selected for the church and the other buildings to be erected.

Cauvery River Project, Coimbatore District.

25. In response to a request made by the Chief Engineer for Irrigation in Madras that the sites proposed for a dam on the Cauvery River in the Coimbatore District should be inspected and reported on by a Geologist, Mr. H. Walker was deputed on this duty in July 1909. Five sites in all were examined, situated on a straight reach of the Cauvery between Cauveripuram and the mouth of the Bhavani River, where it is bordered on either side by hills of crystalline rocks. Mr. Walker submitted a full report to the Local Government, and was able to recommend a site about 3 miles below the village of Sanpalli as the most suitable for the project, but details of alternative sites are given, the final choice depending upon economic and engineering considerations.

Fire clay.

Gwalior State.

26. Among the clay beds at the base of the Morar group in Gwalior State a thick bed of soft white clay near Raipur G. T. S. has been extensively mined for use as whitewash, but from its composition, and from tests made by Mr. H. C. Jones, it is considered that it would make good fire bricks.

Galena.

Gwalior State.

27. Mr. H. C. Jones examined some occurrences of galena in the Gwalior State at the request of the Durbar. Mere traces of the existence of the mineral were found, as described below (p. 70).

Petroleum.

Oil-fields Committee, Yenangyaung.

28. At the beginning of the season Mr. E. H. Pascoe was engaged in assisting the Committee appointed to enquire into the working of the Yenangyaung oil-field. An analysis of data regarding flash-points and specific gravities supplied by the Burma Oil Co., led to the following interesting conclusions :—

(*i*) That in each well the specific gravity decreases generally with the depth, especially near the surface.

(*ii*) That in each oil horizon the specific gravity is generally least at the crest and increases further down the flanks of the anticline. Wells therefore near the margin of the field may be expected to yield a heavier oil at any particular horizon than those nearer the crest.

A final attempt was made to correlate the various oil sands recorded in the boring logs of the Companies engaged in the industry, but was not successful.

Ramri Island. Mr. E. H. Pascoe.

29. The portions of Ramri Island, off the Coast of Arakan, examined were the northern area including the Minbyin oil-field (Yenandaung) and the oil-field of Ledaung. The island is evidently part of a raised archipelago and raised beaches are found all along the West Coast. The rocks consist of sandstone and clays with occasional thin bands of conglomerate. Calcite is abundant locally, but selenite was not found in the portions of the island visited. From Mr. Davies' find of nummulites near Pyade, some of the rocks appear to be of Eocene age. Mr. Pascoe was no more successful than Mr. Mallet in any attempt to divide the beds into distinctive series.

In all but one or two doubtful cases, the rocks are inclined steeply or vertically, and the hypothesis which fits in best with the facts is that there are several sharp contiguous folds which have been sufficiently denuded to leave an almost uninterrupted series of steep dips. Some of the folds are very sinuous, and the direction of dip and strike may vary enormously.

Mud volcanoes, gas vents and oil seepages are found throughout the island, except within a barren tract around the town of Ramri.

In the Minbyin field native workers have shewn themselves more enterprising than those at Yenangyaung, and have adopted a crude method of the rod-system used in Canada, learnt from Canadian drillers employed by the Australian and Baronga Oil Companies. The wells are cased for the first 18 to 20 feet only, and are never more than 500 feet deep. Some 200 wells have been put down here but most of these have been abandoned, less than 50 being worked at the present day. The total yield of the field amounts to something under 2 barrels (80 gallons) per day.

Between 15 and 20 wells have been drilled at Ledaung, about 24 miles south of Minbyin, and some are still producing oil.

Mr. G. deP. Cotter.

30. Two areas were surveyed by Mr. Cotter —one in the Minbu district and one in the Pakokku district.

Minbu District.

In the Minbu district, sheets 111 and parts of sheets 110 and 84 L/6, Burma Survey, 1″=1 m., were geologically mapped. The Pegu beds are found in the West of sheets 111 and 84 L/6, dipping very regularly east, except in the neighbourhood of Ngahlaingdwin where they are disposed as an anticline. Mr. Cotter was able to differentiate the Pegu beds into three groups which grade insensibly into one another. The upper group consists of shallow water deposits with current-bedded sandstones, selenite and shallow water fossils including *Cyrena crawfurdi* and *C. khodaungensis*. In the middle group, current-bedding is uncommon, the rocks are harder, the clay beds more sharply differentiated from the sands, and the fossils belong to the "laminaria" zone. The lower group resembles the middle, but the sandstones are coarser and harder and the limestone bands slightly more frequent. A species of *Heterostegina* and a nummulite, most probably of oligocene age, were found at an oil seepage 3 miles N.N.W. of Ngahlaingdwin. Another seepage occurs 3½ miles W.S.W. of the same village. The Ngahlaingdwin anticline is steeper on the west than on the east; and since it sinks rapidly southwards in the area mapped, Mr. Cotter is of opinion that it would be well worth while to examine the area to the north in sheet 84 L/5 before testing near Ngahlaingdwin.

Pakokku District.

In the Pakokku district the Myaing anticline was examined and surveyed with the aid of cadastral maps on a scale of 2″= 1 m. The anticline, consisting of Pegu and Irrawaddy beds, resembles that of the Gwegyo hills. The crest is

recognisable near Chaingzauk, but southwards has been faulted away by what Mr. Cotter considers to be probably a thrust-plane on the east. Fossils of the usual Pegu types were found together with selenite and fossil-wood, the latter being fairly common in the Pegu rocks. There are many gas pools, but Mr. Cotter considers the area unpromising for oil boring on account of the contortion and faulting.

Myingyan District. Sub-Assistant Sethu Rama Rau.

31. The following sheets of the Burma Survey 1″= 1 m. were mapped geologically: parts of 109 and 112, east of the Irrawaddy, the northern half of sheet 153, and the whole of 156.

In sheet 109 the eastern boundary of the Pegu inlier of Singu was mapped for the first time on this scale, as also was the northern part of the Gwegyo anticline and the southern extremity of the Pagan fold. Cone-in-cone structure was found in many places in the northern part of the Gwegyo anticline.

In sheet 153 the rocks east of the Popa area were found to be folded into successive sharp anticlinal and synclinal folds and consisted of Pegu strata. The crests of the anticlines usually occupy low ground, and their direction is about 40° W. of N. to 40° E. of S. Sandstones predominate over shales, and some contain many nodules of carbonised wood enclosed in pyritiferous sandstone. Fossil bands are plentiful, the commonest species being *Turritella simplex* and *T. acuticarinata*. Specimens of *Batissa* including *B. khodaungensis* were also obtained.

The country surveyed in sheets 156 and 112 (E. of the river) is that around and east of Magwe. In it was discovered the Pegu inlier of Ondwe on which a short note has already been published (*Records*, Vol. XXXVIII, Pt. 2, p. 152) and which is shortly to be tested for oil.

Possible oil-field in Las Bela and Southern Mekran.

32. Mr. Vredenburg in a recent paper in the *Records* (Vol. XXXVIII, Pt. 3, p. 206), has called attention to the possibility of petroleum being found in Las Bela and the Mekran district, in rocks belonging to the Hinglaj series which correspond with the oil-bearing strata of Burma. The structure is favourable for the storage of petroleum in large quantities underground should it exist, and though no oil seepages occur, the presence of mud volcanoes along the crest of some of the anticlinal axes is a favourable sign.

The other minerals found in southern Baluchistan were noticed in the General Report for 1906 (*Records*, Vol. XXXVIII, Pt. 1, p. 50), and are described in greater detail in Mr. Vredenburg's paper cited above.

Road-metal and Building Stone.

Road-metal for Rangoon.

33. Reference has been made in previous General Reports (*Records*, Vol. XXXIII, Pt. 2, p. 85, Vol. XXXV, Pt. 1, p. 30) to the question of an adequate supply of road-metal for Rangoon, the cost of importing such material from Bombay and Mauritius having become prohibitive in view of the rapid extension of the roads of the city and its surroundings and the great increase of traffic within the last few years. Formerly the Bombay basalt was brought in by ships in ballast and was collected at little cost to the Municipality, but the opening of direct steamship communication with foreign countries has cut off this source of supply. At the request of the Chief Engineer to the Government of Burma, Mr. P. N. Datta was deputed to examine the crystalline rocks of the Thatón District, Lower Burma, rendered accessible by the opening of the Pegu-Moulmein Railway, and his report, submitted in May 1909, shows that there is a practically inexhaustible supply of gneiss and granite to be obtained within easy reach of the line. These rocks, though perhaps not quite so durable as the Bombay basalt, will no doubt serve the purpose required at far less cost than the imported material.

Taungu stone quarries.

34. In the General Report for 1908 (*Records*, Vol. XXXVIII, Pt. 1, p. 46) reference is made to a visit by Mr. G. deP. Cotter to the stone quarries of Taungu, Lower Burma, in order to advise the Public Works Department, Burma, regarding the location of a Government quarry for the supply of building stone. Mr. Cotter's report, submitted in April 1909, shows that building stone of two qualities may be obtained in large quantities from these quarries—

(1) A yellow calcareous sandstone occurring in a bed from 200 to 300 feet thick, and extending for a mile along the strike. This is somewhat soft when freshly cut, but hardens on exposure to the air.

(2) Purple, sometimes pink, sandstone of medium grain, very slightly calcareous and considerably harder than the yellow sandstone. It occurs in layers averaging about 6 inches in thickness, but slabs of one foot thick might be obtained. Other localities in the neighbourhood were visited, but the stone was found to be of inferior quality.

Salt.

Salt manufacture. Myingyan District, Burma.

35. The relics of a once flourishing salt manufacturing industry in the Myingyan District, now moribund on account of the competition of imported salt, are described by Sub-Assistant Sethu Rama Rau. The inhabitants of one village, Sagyin, even now subsist chiefly on this industry, and a few others are still engaged in it. The salt is derived from springs and causes a saline efflorescence on the surrounding soil. After saturation as far as possible by repeated moistening with the water flowing from the springs and drying, the soil is lixiviated either in large conical wicker baskets or in rows of earthen pots, and the brine evaporated over a slow fire.

Water.

36. Many applications have been received from Local Governments and private individuals during the year for advice regarding the search for artesian water in various parts of India. Where these enquiries are concerned with the great expanses of alluvium that cover the valleys of the Indus, Ganges and Brahmaputra the advice of a Geologist is of little value, as the alluvial strata lie horizontally and information regarding the distribution of sub-soil water can be obtained only by actual experiment, that is to say by well sinking or boring. In hilly tracts on the other hand the possibility of obtaining artesian water depends entirely on local conditions and it is not often possible to ascertain these from a small scale geological map without personal inspection of the ground. The following is a summary of the work that has been done during the year.

Baluchistan : Mastung.

37. A boring was put down close to the Political Agent's house at Mastung to supply drinking water, and was carried to a depth of 510 feet without meeting with water under sufficient pressure to bring it to the surface. The rocks passed through, judging from the samples submitted, were Siwalik clays, with a bed of loam at 410 feet, from which water rose to between 13 and 17 feet below ground level. This water was found to be slightly brackish, but it is not clear whether the brackishness was not caused by a leak in the tube at a higher level.

Kulozai.

38. A boring put down to a depth of 410 feet near Said Hamid railway station (Kulozai) was not successful. It was proposed to make another attempt near Gulis-

tan, 8 miles further to the south, where the conditions are similar to those at Quetta, and there are some "karezes." A supply sufficient for drinking purposes might be obtained here.

Bengal: Borings for sub-soil water.

39. Considerable activity has been shown by the Agricultural Department in Bengal in sinking borings in search of sub-soil water, in accordance with the recommendations of the Irrigation Commission. From a note supplied to this Department, by Mr. W. R. Gourlay, Director of Agriculture, it appears that operations have been carried on in nine districts, both north and south of the Ganges, and that several of the District Boards have purchased sets of tools. The wells sunk are said to have been more successful in the districts to the south of the Ganges than to the north, as the former must be sunk to a greater depth before reaching a water-bearing stratum, and, therefore, the water rushes in with greater force. On the north side the sands lie at a shallower depth, and it will probably be found advisable to sink ordinary percolation wells in this area.

Proposed deep boring at Sitamarhi.

40. In April 1909 the District Engineer in Muzaffarpur, and more recently the Secretary to the Government of Bengal, Irrigation Department, requested our advice regarding the putting down of a deep boring at Sitamarhi, in order to ascertain whether water under pressure does not exist in the coarse gravel beds that presumably lie at the base of the Gangetic alluvium. In view, however, of the distance of Sitamarhi from the northern edge of the plains, whence the water would be derived; the slight elevation above the plains of the beds into which the water percolates from the hills; and the poor results obtained from the Lucknow boring, 1,336 feet deep, in 1889, I was compelled to reply that I did not think the prospects sufficiently good to warrant the expenditure of a large sum of money on a deep boring. I think that the salvation of this and neighbouring districts will consist in the deepening of existing wells, or the sinking of borings through them, in order to reach deeper water-bearing strata in the alluvium, which may keep them supplied in times of drought.

Raniganj.

41. Messrs. Balmer, Lawrie & Co. having reported that they experienced increasing difficulties in obtaining an adequate supply of water for their Paper Mills at Raniganj from the Damuda river owing to changes in its course, and that they contemplated boring for artesian water, Mr. H. Walker was

deputed to examine and report on the possibilities of the project. He found that there was no prospect whatever of obtaining an artesian supply in the vicinity, and recommended the sinking of a number of bore-holes in the alluvium bordering the river, by which means a sufficient supply may be obtainable from a band of gravel underlying a bed of clay in the alluvium, which appears to have a considerable extension horizontally.

Bombay: Borings in Gujarat.

42. After many delays, due to the difficulty of finding a suitable site, the experimental boring in Gujarat with the Calyx drill, lent by the Geological Survey Department, was at length started in the autumn of 1909, the site finally selected being near Sanand railway station, on the Ahmedabad-Wadhwan branch of the Bombay, Baroda and Central India Railway. A report on this boring has been furnished by the Engineer-in-charge, from which it appears that water was struck at a depth of about 300 feet from the surface, but not under artesian pressure. Pumping tests have proved that a discharge of about 5,000 gallons an hour is available, but the water is of inferior quality, and is not potable. In fact it is evident from the boring records that the water comes from a bed of sand in the alluvium, and is ordinary sub-soil water. It still remains to be proved, therefore, whether water under pressure can be obtained beneath the plains of Gujarat, but in places like Sanand the alluvium is probably too thick to be pierced by a boring of reasonable depth.

It is unfortunate that the site originally selected under the advice of this Department, to the north-east of Wadhwan, was found to be impracticable. Not only is the alluvium there probably much less deep than at Sanand, but there was a prospect of reaching the Tertiary strata which may underlie the alluvium, and which might have given a fair supply of artesian water.

Burma: Artesian water at Pegu.

43. At the request of the Local Government, Mr. P. N. Datta visited the town of Pegu for the purpose of advising the Chief Engineer regarding the possibility of obtaining a supply of drinking water from artesian wells. Two sources had already been tapped by tube wells of 120 and 305 feet deep, respectively, at the Ice Factory in the town, and the existence of a water-bearing stratum at a depth of 580 feet had also been proved. Mr. Datta was of opinion, however, that the supply from the higher beds would not be sufficient for the town, as a considerable portion of it is taken by the Ice Factory, but if the water-bearing strata are continuous it should be possible to obtain a large supply from them,

if several wells are sunk at such distances apart that they do not interfere with one another.

Central India: Trial boring at Shamgarh.

44. A trial boring for water at Shamgarh station on the Nagda-Muttra Railway proved unsuccessful, as the whole of the boring was in Deccan trap. It was thought that the trap-flow might be of small thickness, and that water might be found beneath it, but after boring to a depth of 217 feet the experiment was abandoned.

Eastern Bengal and Assam: Chittagong.

45. On his way to Upper Assam in November 1909, Mr. Hayden visited the tube wells at Chittagong which have been sunk by Messrs. Kilburn & Co. in accordance with the advice given by him after an inspection of the locality in 1906. In the first instance an experimental bore of $3\frac{3}{8}$ inches in diameter was put down to a depth of 700 feet. Three water-bearing bands were met with, one of 10 feet thick at 165 feet, the second of 40 feet thick at 215 feet, and the third of 92 feet thick at 335 feet from the surface, respectively. Below this no more water-bearing strata were found. The water from the band at 335 feet, that from the upper layers having been blocked off, rose to 8 feet below the ground level, and pumping tests showed that a constant yield of about 1,100 gallons an hour, capable of being largely increased with a more powerful pump, could be obtained from this band. It was then decided to sink two other tube wells of 6 inches diameter each, near the original boring, and these have now been drilled, but only one has been fitted with machinery for testing the yield. This is about 9,000 gallons per hour, and it is estimated that the two six-inch wells will give an ample supply for the town, the requirements being about 300,000 gallons a day. The water is derived from Tertiary sandstones which have their outcrop in a ridge of low hills lying to the south-west of the town and is therefore under artesian conditions, though the effective head, owing to the low elevation of the outcrop, is not sufficient to force the water above the orifice of the bore hole.

Jorhat.

46. Since the year 1906, the Public Works Department has been engaged in putting down a boring for artesian water at Jorhat in Upper Assam. Last year this boring reached a depth of 365 feet, and samples of the strata passed through were sent to this Department for determination. From these it appears that the boring has not yet reached the base of the alluvium, and no indications of water under pressure have been met with.

Punjab: Amritsar.

47. A boring was put down in the grounds of the Khalsa College at Amritsar in the hope of striking artesian water, but at a depth of 215 feet, operations were suspended through lack of funds. The boring records show that at this depth the alluvium had not been pierced, but the Principal of the College states that at 60 feet a practically unlimited supply of water was met with, though not under pressure. The distance of Amritsar from the edge of the plains, about 50 miles, is probably too great to hold out much prospect of reaching the base of the alluvium at a reasonable depth from the surface.

United Provinces: Bundelkhand.

48. The Government of the United Provinces has asked our advice regarding the sinking of artesian wells in the portion of Bundelkhand not occupied by Native States; but the greater part of the area specified consists either of metamorphic rocks or alluvium, while the narrow strips of Vindhyan rocks in the Lalitpur district are so disposed that there is no prospect of obtaining artesian water from them. It would be useless, therefore, to spend money on deep borings in this area.

Borings for sub-soil water.

49. The Department of Land Records and Agriculture in the same provinces has shown great activity in putting down shallow bore-holes as a preliminary to sinking percolation wells, with a very gratifying measure of success. During the official year ending in 1909, over 1,000 of these borings were made, and in certain cases samples of the beds passed through have been sent to this Department for determination. As a general rule, the borings are not over 100 feet in depth, being usually stopped at this point if water is not met with, and none of them appear to have been carried far enough to determine the thickness of the alluvium out in the plains.

GEOLOGICAL SURVEYS.

Aden.

Capt. R. E. Lloyd, I.M.S.

50. An interesting paper has been contributed to the *Records*, Vol. XXXVIII, Part 4, by Captain R. E. Lloyd, I.M.S., Surgeon Naturalist, Marine Survey of India, giving the geological results of a tour made by him in 1906 through the little known country to the north of Aden. Mr. F. R. Mallet had made a short expedition through this country in 1870, but was able to reach only the foot hills and determine the presence of fossiliferous limestones there.

Captain Lloyd was able to penetrate 40 miles into the hills, and ascended to Dala, which lies among hills of six or seven thousand feet in altitude. The rocks met with on the road were a sedimentary series of limestones and sandstones and a more recent igneous series, covering a much wider area than the sedimentary rocks, and separated into :—

(1) Massive lavas :—these occur above the others and form plateaus and pinnacles which give a characteristic appearance to the landscape ;

(2) Horizontally bedded lavas, consisting of alternating layers of compact black lava and amygdaloidal lava ;

(3) Beds of volcanic ashes of brightly variegated colours, dipping at pronounced angles, usually less than 30°.

It is not quite certain from Captain Lloyd's description, whether the dip of these beds is original and due to the presence of a centre of volcanic activity in this neigbourhood, or whether it is due to subsequent tectonic disturbance. As Mr. Vredenburg points out, the sedimentary rocks are similarly inclined, and he thinks therefore that there may have been a long interval between the deposition of the ash beds and the eruption of the undisturbed massive lava, which may be of quaternary age, like the Aden volcano.

The sedimentary rocks are older than the igneous series, but the uppermost beds show traces, in the presence of beds of volcanic fragments, pebbles of lava, etc., of the setting in of volcanic conditions. The limestones are highly fossiliferous and have been shown by Mr. Tipper to be of Upper Jurassic age (*see* above, p. 85).

The petrology of the rocks collected by Captain Lloyd has been worked out by Mr. Vredenburg (*see* above p. 85), and the results of his investigations, with those of Mr. Tipper on the palæontology are published in separate papers in the same part of the *Records*.

Burma.

51. Part of the survey work in Burma is described above under the heading of *Petroleum*, wherever the areas dealt with have been mapped during the course of the search for new oil-fields. A considerable amount of mapping has also been carried out in other areas and a distinct advance made in the correlation and description of the Tertiary deposits.

52. In addition to the special enquiry into the suitability of the crystalline rocks of the Thatôn district for road metal, Mr. P. N. Datta made a geological survey of the western parts of the district.

Thaton District, Lower Burma: Mr. P. N. Datta.

The rocks met with were:—

Alluvium.

Laterite.

Sedimentary rocks:—Sandstones and shales, more or less metamorphosed in places.

Crystalline rocks:—(i) Volcanic (probably rhyolitic); (ii) Granite, and (iii) Gneiss with mica and quartz schists.

A good section of the sedimentary rocks was found in the new cuttings for the railway at Martaban Station. Here some of the shales are highly carbonaceous and contain plant remains, too fragmentary to admit of identification, and bivalves, with casts of what appear to be *Orbiculoidea* and the wings of insects. None of these is sufficiently well preserved or characteristic to enable the exact age of the beds to be determined, but there is no doubt that they belong to the 'Moulmein Group' of Dr. T. Oldham, and are probably of carboniferous age.

Section at Martaban.

The crystalline rocks are of ordinary types and call for no special remark, but Mr. Datta thinks that the granites and rhyolites, which were included by Mr. Theobald with the gneisses in his 'Martaban Group,' are really intrusive, and may be of post-carboniferous age.

53. On his return from Kyaukphyu in February, Mr. Pascoe made an attempt to map the Pegu beds of Yenangyaung, but found that the conditions were such that no definite boundary lines could be drawn. At Yenangyaung the Pegu beds are of a shallow water type and extremely variable in thickness, so much so that it was found impossible to recognise the division made by Dr. Noetling, who separated the Pegu series into a lower or Prome stage, and an upper, or Yenangyaung stage. The question is of some importance, since if horizons of definite composition could be recognized in this enormously thick series of beds, it would render the mapping of the anticlines or domes beneath which petroleum is likely to be found, and the determination of faults, a much more simple matter than it is at present. Mr. Pascoe suggests that, instead of attempting to map the various groups of beds, which are constantly changing in composition, a better method would be to lay down each outcrop observed accurately on a large scale

Pegu beds, Yenangyaung.

Captain Lloyd was able to penetrate 10 miles into the hills, and ascended to Dala, which lies among hills of six or seven thousand feet in altitude. The rocks met with on the road were a sedimentary series of limestones and sandstones and a more recent igneous series, covering a much wider area than the sedimentary rocks, and separated into :—

(1) Massive lavas :—these occur above the others and form plateaus and pinnacles which give a characteristic appearance to the landscape ;

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51. Part of the survey work in Burma is described above under the heading of *Petroleum*, wherever the areas dealt with have been mapped during the course of the search for new oil-fields. A considerable amount of mapping has also been carried out in other areas and a distinct advance made in the correlation and description of the Tertiary deposits.

Thaton District, Lower Burma: Mr. P. N. Datta.

52. In addition to the special enquiry into the suitability of the crystalline rocks of the Thatôn district for road metal, Mr. P. N. Datta made a geological survey of the western parts of the district.

The rocks met with were :—

Alluvium.

Laterite.

Sedimentary rocks :—Sandstones and shales, more or less metamorphosed in places.

Crystalline rocks :—(i) Volcanic (probably rhyolitic) ; (ii) Granite, and (iii) Gneiss with mica and quartz schists.

Section at Martaban.

A good section of the sedimentary rocks was found in the new cuttings for the railway at Martaban Station. Here some of the shales are highly carbonaceous and contain plant remains, too fragmentary to admit of identification, and bivalves, with casts of what appear to be *Orbiculoidea* and the wings of insects. None of these is sufficiently well preserved or characteristic to enable the exact age of the beds to be determined, but there is no doubt that they belong to the 'Moulmein Group' of Dr. T. Oldham, and are probably of carboniferous age.

The crystalline rocks are of ordinary types and call for no special remark, but Mr. Datta thinks that the granites and rhyolites, which were included by Mr. Theobald with the gneisses in his 'Martaban Group,' are really intrusive, and may be of post-carboniferous age.

Pegu beds, Yenangyaung.

53. On his return from Kyaukphyu in February, Mr. Pascoe made an attempt to map the Pegu beds of Yenangyaung, but found that the conditions were such that no definite boundary lines could be drawn. At Yenangyaung the Pegu beds are of a shallow water type and extremely variable in thickness, so much so that it was found impossible to recognise the division made by Dr. Noetling, who separated the Pegu series into a lower or Prome stage, and an upper, or Yenangyaung stage. The question is of some importance, since if horizons of definite composition could be recognized in this enormously thick series of beds, it would render the mapping of the anticlines or domes beneath which petroleum is likely to be found, and the determination of faults, a much more simple matter than it is at present. Mr. Pascoe suggests that, instead of attempting to map the various groups of beds, which are constantly changing in composition, a better method would be to lay down each outcrop observed accurately on a large scale

map, and deduce the structure of the rocks from the series of strikes thus obtained. But the chief objection to this course would be the necessity of constructing a special map (on a scale of at least 8 inches to the mile) for each locality visited.

The volcano of Popa: Mr. E. H. Pascoe.

54. As a result of surveys carried on during the final months of two field seasons around the ancient volcano of Popa in the Myingyan district, more than half the area has been mapped. The northern part of the crater-wall is missing, and the rest is formed of breccia or agglomerate. There is a conspicuous parasitic cone on the west known as Taungkalat. A large part of the mountain is made of Irrawaddy sandstone, and a few small inliers of beds resembling the Pegu are observable in a few places. The oldest bed is an ashy tuff interbedded in the Irrawaddy sandstone. The lavas are mostly andesites, both hornblende and augite varieties being represented. An account of the volcano will be published as soon as the petrographical details of the rocks collected have been worked out.

Country south of Mt. Popa: Mr. K. A. K. Hallowes.

55. Mr. Hallowes was engaged in examining the country immediately south of Mt. Popa. The Kyaukpadaung Hills were found to be composed of altered silicified tuffs, with some interbedded altered rhyolites, associated with pumice and volcanic agglomerate. East of Leya altered tuff and rhyolite occur interstratified with Irrawaddy sandstones. The small hill of Taungnauk between Kyaukpadaung and Popa consists of altered silicified tuffs with some interbedded rhyolitic lava flows. The junction between the Pegu and Irrawaddy series south of Popa was found to be covered by an extensive sheet of hornblende-andesite. The crater of Mt. Popa itself, according to Mr. Hallowes, lies upon a fault. The hill known as Taungni was found to be composed of altered lavas and white flour-like tuffs, some of which have been highly silicified; it is probably an old tuff cone. Mr. Hallowes reports the discovery of tuffs interbedded in Pegu sandstones near Leya and elsewhere, indicating that volcanic activity in this area existed in pre-Pliocene times. East of the Kyaukpon hills is a large tract of Pegu rocks bent into more or less parallel anticlines striking about 30° W. of N. In these *Turritella acuticarinata* and *T. simplex* occur in great profusion. There are no good prospects of obtaining oil here.

Western Prome: Mr. M. Stuart.

56. The localities examined and mapped by Mr. Stuart during the season 1908-1909, were North-West Prome, South-West Thayetmyo, and Yenangyaung.

The results of these surveys have already appeared in Vol. XXXVIII, Pts. 2 and 4, of the *Records*.

The mapping made it evident that Theobald's classification of the Pegu system was the most suitable one, *viz.*:—

4. Kama clays.
3. Upper Prome series.
2. Lower Prome series.
1. Sitsayan shales.

and that Noetling's later suggestion to incorporate the Kama clays and the Upper Prome series into one series, which he called the Yenangyaung stage, and the Lower Prome series and Sitsayan shales into another series, which he called the Prome stage, could not be entertained.

It also became evident that the old method of classifying the fresh-water deposits as the Irrawaddy system and the underlying marine beds as the Pegu system could no longer be adopted, but that the division between the two systems must be made at the horizon of the unconformity which exists some distance below the base of the fresh-water beds. This unconformity is scarcely visible in any individual section, but on mapping the junction of the two systems is seen to be of considerable importance and extent. This brings a series of marine beds into the base of the Irrawaddy system, which series is represented in the district mapped by the beds on which the town of Prome is situated. This series of marine beds is described by Theobald as overlying the Kama clays, but is incorporated by him with the Pegu system. The Kama clays are therefore the highest beds of the Pegu system seen in the district.

It was also ascertained that there is a distinct unconformity between the base of the Pegu system (Sitsayan shales) and the Bassein system. The age of the topmost beds of the Bassein system which are seen in the district are of Eocene age.

Classification of Tertiary Strata.

57. The succession in the district is therefore:—

Irrawaddy system . . . . { Fresh-water series. / Marine series.

Unconformity.

3. Kama clays.

Pegu system . . . . 2. Prome beds . { Upper series. / Lower series.

1. Sitsayan shales.

Unconformity.

Bassein system.

58. Another point which was suggested by the detailed mapping of the district was that all the oil seepages in the district from the Pegu system come from the Kama clays, and that none occur in the system below this horizon. This observation is in direct conflict with Noetling's assertion that all the oil in the Pegu system comes from the Lower Prome series and Sitsayan shales (his Prome stage).

Oil horizon.

59. The structure of the Padaukpin and Banbyin area proved to be an anticline in marine Irrawaddy beds with the underlying Kama clays exposed in the crest of the anticline. Owing to the unconformity between the two systems there is not any definite anticlinal structure in the Kama clays, which are here several thousand feet thick. The marine Irrawaddy beds have a lower angle of dip in an easterly direction than the underlying Kama clays, and where the latter again crop out near Aukmanein, some ten miles to the west, only 1,200 feet of them are seen.

Structure.

In view of the discovery of this structure, the fossil evidence obtained from the oil-fields of Minbu, Yenangyaung, Singu, and Yenangyat was examined and was found to favour the view that in each case the structure was similar to that of the Padaukpin-Banbyin area, and that the Pegu beds exposed in the various oil-fields were an upper development of the Kama clays.

A separate investigation was carried out on the fossil fish teeth obtained and their evidence generally supported the above view.

Central India and Rajputana.

60. The first two months of the season Mr. Jones spent in putting the finishing touches to his last year's mapping in the neighbourhood of Rampura in the Indore State and in parts of Jaora. This work, which connects our present survey with the old work of Messrs. Hacket and Kishen Singh, has already been summarised in some detail in last year's General Report (*Records*, Vol. XXXVIII, Part 1, p. 62). Nothing fresh of any importance was found in the area with the exception of a few small inliers of Delhi rocks among the Deccan Trap at Dhorwara (24° 13′ ; 75° 10′) and Diknio (24° 10′ ; 75° 5′), and some ancient workings for iron (magnetite and hematite of poor quality) in the Suket shales at Pardha (24° 32′ ; 75° 13′).

Mr. H. C. Jones : Indore and Jaora.

Gwalior.

61. The area next taken up by Mr. Jones was that of Gwalior State near Gwalior town, at those interesting localities where the Gwalior representatives of the Bijawar series are found lying unconformably above the Bundelkhand gneiss, and the Upper Vindhyans in turn unconformably above both.

The whole of this area had already been mapped on the one inch scale by Messrs. Hacket and Kishen Singh; whilst the former had also given a short, but comprehensive account of its geological structure (*Records*, Vol. III, p. 33-42, with map and further notes in *Records*, Vol. X, p. 84). The aim of Mr. Jones' visit was primarily to examine some mineral occurrences which the Gwalior Durbar was anxious to have an opinion about. Incidentally, however, a re-examination of the general geological structure of the country was undertaken, and typical specimens of all the rock series were gathered and described in more petrological detail than was previously possible. Mr. Jones' report is very full and is illustrated by numerous very clear photographs and a few local sections. Much of it, however, is a repetition of observations already made by Hacket, expanded by further detail, and enlarged by more illustrative descriptions of local occurrences. The general stratigraphy of the area remains unchallenged. No better examples of the supposed corals (as recognised by Dr. Stoliczka) from the limestone bands of the Morar shales (see *Records*, Vol. III, p. 35) were obtained and Mr. Jones has been unable so far to improve upon the successional arrangement of the series of limestones, traps, felsitic rocks, shales, jasper, hornstone and clay bands belonging to the Morar series, in expansion of Hacket's section given at p. 36 (*loc. cit.*). They still appear very vaguely outlined as lying generally above the Par sandstone at uncertain positions, whilst the genetic relations of many of these remarkable petrological types have not been further enquired into (compare rocks of the same age and general composition in the Son valley; *Memoirs*, Vol. XXXI, Pt. 1, pp. 58-92). The following is a brief outline of Mr. Jones' results as obtained in his examination of sheets 365, 366, 383, 399, 400 and 401 of the Central India and Rajputana topographical survey, between latitudes 25° 45′ and 26° 15′ and longitudes 78° 0′ and 78° 45′.

Bundelkhand gneiss and quartz reefs.

62. Typical Bundelkhand gneiss with pegmatites and quartz reefs, agreeing in every way with the descriptions of Mallet (unpublished reports summarised in the *Manual*, 2nd Edn., p. 27), occupy the low ground in the south-east of the area, and Mr. Jones has given a number of particular descriptions from special localities, accompanied by microscopical

determinations. All appear to be varieties due to local concentrations, or particular mineral segregation, of one Archæan mass that cannot be further sub-divided.

Galena and Copper Ores.

63. It is in these rocks that trenches have been opened for galena at Ragonathpur (26° 4′ ; 78° 20′) at Bhilowa (26° 3′ ; 78° 20′) and kaolin quarries at Antri (26° 3′ ; 78° 17′). Specks of galena and some pyromorphite were found in the first, but nothing at Bhilowa. Traces of galena, malachite and azurite were also found 2½ miles west of Karhia (25° 54′ ; 78° 4′).

Scarcely any metallic minerals were found in the quartz reefs penetrating the gneiss. Small specks of copper pyrites, covellite and malachite are mentioned as present, but no gold. Assays of 4 of these veins were made in the Geological Survey laboratory by Mr. Blyth without any trace of gold or silver being obtained. The pure white variety of quartz from the reefs is used for the manufacture of glass at the Gwalior (Morar) works.

Trap dykes.

64. The trap dykes of the area, previously described by Mallet (*loc. cit.*) are identified by Mr. Jones as ophitic dolerites, consisting of pale brown augite, plagioclase felspar (labradorite), magnetite, and ilmenite frequently altered to leucoxene. Altered varieties occur containing saussuritised felspar, hornblende, epidote, quartz chlorite and hematite.

Bijawar Rocks and Upper Vindhyans.

65. A large number of notes on the Bijawar rocks of the area (Par sandstones and Morar group of shales) have been put together by Mr. Jones in amplification of Hacket's original description (*Records*, Vol. III, pp. 33-42). They constitute a set of isolated petrographical descriptions of specimens and sections from many localities, but as already remarked, their mutual relations and mode of origin have not as yet been further elucidated.

Interbedded traps.

66. The interbedded traps associated with the shales compose five main spreads, and have been determined as labradorite-augite-magnetite rocks.

Mr. A. M. Heron: Alwar State.

67. Mr. Heron, in his new survey of Alwar State, has contributed a very carefully coloured map and detailed report, illustrated with sections and an admirable array of photographs. The area treated of is chiefly in Alwar, with portions of Jaipur and Bharatpur States, as shown in sheets 286, 287, 288, 314, 315, 316, 339 and 340 of the Central India and Rajputana topographical survey.

General Results.

68. His results comprise a return to the original view of Hacket, (*Records*, Vol. X, Pt. 2, p. 85) as regards the rock succession, a matter which requires a few words of explanation. In the above cited reference, Hacket, after surveying the area in detail, arranged the formations as below :—

Arvalis { Mandan group of slates, schists and quartzites;
Ajabgarh ,, of slates, quartzites, horn-stone-breccia and limestone;
Alwar ,, of quartzites, conglomerates, schists and bedded trap;
Raialo ,, of limestone and quartzites;

and the small scale-map, illustrating that published report is coloured according to this scheme. Later, however, in consequence of work in other parts of Rajputana to the west, he formally abandoned this view (*Records*, Vol. XIV, Pt. 4, p. 281) and wrote :—

"In my description of a portion of this area, the Alwar hills, in a previous paper, I placed the Ajabgarh and Mandan groups at the top of the Arvali series above the Alwar quartzites. Upon further examination of the series in the country to the west, where the sections are less broken, I found that this was not the true interpretation of the section, but that both these groups were below the quartzites, in fact, representatives of the Raialo group. I was led into this error by the high dip of the rocks and by taking inversion for the normal sequence.

I also then included the Alwar quartzites with the Arvali series, but as in the western area the quartzites are found to constantly overlap the lower rocks; as also several cases of unconformity have been noticed it is necessary to separate these two series. As the quartzites extend up to Delhi and form the ridge there, I now propose to call the quartzites and their associates in the Mandsaur hills and elsewhere the Delhi series, retaining the name of the Alwar quartzites for the lower member of the series."

A small-scale map illustrating the above paper is also coloured according to the new view; whilst, what is of even more importance, the signed fair copies of the large-scale, 1″=1 mile, maps handed in by Mr. Hacket in 1882, and stored now in the map cases of the department were also coloured according to this later view and indexed thus :—

Delhi series (=Alwar quartzites).

Arvali series with limestone, hornstone breccia, and trap (=Ajabgarh series).

It should be noticed that this change of view of Hacket was made without his re-surveying the Alwar area, and without his supporting it by detailed sections, his paper in Vol. XIV of the *Records* being the last published account that Hacket wrote.

Hornstone-breccia and thrust-plane.

69. Mr. Middlemiss, on visiting the area for a few weeks in Mr. Heron's company during the latter's survey, was particularly struck by the peculiar appearance and lie of the hornstone breccia, which both he and Mr. Heron agreed in viewing as a fault-breccia due to an *in situ* smashing and tearing asunder of the beds at various horizons near those of the Kushalgarh limestone and the Ajabgarh shales. Mr. Middlemiss, believing it to be the record of a great thrust-plane, suggested to Mr. Heron that it might possibly account for the two opposite interpretations of the sequence held by Mr. Hacket at different times. Mr. Heron, however, in his report, whilst accepting the theory of it as a nearly horizontal plane of movement, does not accept this suggestion as accounting for the sequence observed, which he simply describes in full detail on the basis of the original (but since superseded) description of Hacket as given in Vol. X of the *Records*.

Although the full petrographical descriptions of Mr. Heron are very carefully worked out, and are a distinct advance on anything hitherto attempted, it is to be hoped that further work in adjacent areas will enable Mr. Heron to clear up this question categorically.

Mr. N. D. Daru: Partabgarh and Banswara.

70. Mr. Daru broke new ground in Banswara, continuing in a north and westerly direction the survey of that State already begun by Mr. Heron during the previous field season. In preparation for this, he, in the first instance, spent a short time in the neighbouring State of Partabgarh, accompanying Mr. Heron in a study of the rock groups there displayed along the junction of the old work and the new.

Area surveyed.

71. Mr. Daru was able to map geologically a considerable area within sheets 175, 176, 208 and 209 of the Central India and Rajputana topographical survey, the last two of which (begun by Mr. Heron) he has now completed.

In carrying out this he followed the delineation scheme of his predecessors as closely as possible. The outliers of Deccan Trap, which lie flatly in the usual, absolutely unconformable way above the older rocks, were continued into the newly explored ground, where they were found to occupy the higher hills and ranges. As regards the older systems, he was able to distinguish and separate from a general ground work of presumably Archæan gneisses and other crystalline rocks, a set of presumably much younger, metamorphosed sedimentary rocks, consisting of limestones, shales, slates or phyllites, garnet-quartz-biotite schists, boulder beds and

schistose conglomerates. These were found to be all highly inclined or vertical as to their dip, either forming comparatively large spreads or narrow and frequently interrupted strips with a general N. 30° W.—S. 30° E. alignment.

Difficulties of interpretation.

72. In spite of the wide areas of these rocks exposed in certain parts of Banswara, both Mr. Heron and Mr. Daru found difficulty in interpreting the depositional order of the various sediments which composed them. Their outcrops are certainly not wanting in continuity and parallelism over considerable tracts; but the chief difficulty seems to be their obscure junctions with the Archæan ground-work, and their steep dips; which latter, even where they occasionally give rise to anticlinal and synclinal flexures, nevertheless cause the younger series to appear as a whole more like parallel packets of strata thrust on edge amongst the Archæans than like outliers resting upon the same. Mr. Daru is disposed to accept a descending order agreeing with that given in the preceding paragraph, with the exception that the limestone bands appear at varying horizons.

Equivalents of Hacket's Aravallis.

73. Notwithstanding this, Messrs. Heron and Daru's work taken together comprises a detailed descriptive account and large-scale map covering their joint area which now become of value in discussing questions of correlation. The younger metamorphic series as a whole, and certainly as regards its larger spreads, must now be regarded as identical with the great group which has been classified by Hacket as Aravallis, and mapped by him in the sheets a little way to the north of the area now dealt with. It would also seem to be likely that the interrupted bands of crystalline limestone, quartzite, limonite-quartz rock, grünerite rock, etc., which appear in very narrow outcrops among the wide area of mixed gneisses, and which were last year temporarily included with the mixed gneisses, should also be considered as long extended outcrops connected with the younger series rather than with the older Archæan complex—or as outcrops owing their narrow interrupted state to the circumstance that they are the remnants of almost obliterated troughs of compressed folds. This last explanation at all events seems to be the only one capable of accounting for the very elongated strip of the Masania conglomerate (23° 57′; 74° 34′) which continues for many miles with a very narrow outcrop as an isolated band among the gneisses.

Conglomerates and Boulder beds.

74. The conglomerate mentioned above is composed of flattened lenses of quartz held together by an argillaceous, chloritic or sericitic cement, and roughly resem-

bling augen-structure; but another much coarser conglomerate or boulder bed, which Mr. Daru now thinks distinct from the former, is of considerable interest. It occurs prominently at Loaria (23° 46′; 74° 10′) and resembles that from Kusalgarh described by Mr. Heron, having a matrix of biotite schist, and contained boulders ranging up to the size of three times a man's head. These are sub-angular in shape, and consist of granite, gneiss, syenite and fragments of quartz, of felspar and of biotite rock. This remarkable bed is in direct connection with the schists and phyllites of one of the larger spreads of the younger metamorphic series.

Suggested resemblance to the Dharwars.

75. A boulder bed of the above nature, so aggressively significant of all that can be implied by a great unconformity, is nevertheless at variance with the peculiar position of the whole series, smothered as it appears to be by the surrounding gneissic system, and also at variance with other evidence of intrusive action both of quartz veins and granite among many members of the series. We are herein reminded of the similar paradoxical relations subsisting between the Dharwars and massive gneisses of South India, a resemblance which may even not be without value as an index of age.

In view of the position suggested by Mr. Daru for the conglomerate and boulder bed among the younger metamorphic Aravallis, it is difficult to correlate it with the somewhat similar boulder bed near Udaipur to the north. The latter is said to occur doubtfully at the base of the Alwar quartzite and between it and the older schists. (C. A. Hacket, MS. Report, 1886, quoted in the *Manual*, 2nd Edn., p. 68.)

Doubtful rocks.

76. Both Mr. Heron and Mr. Daru have, in addition to the above, recorded some compact quartzites and schists which they cannot definitely assign to the younger (Aravalli) series; whilst at the same time they consider them as unlikely to belong to the still newer Delhi series of Hacket. In these cases, as in all those involving narrow strips of rock types isolated by want of exposures or by alluvium, the coincidence of strike that obtains throughout all the rock complexes below the Deccan Trap, renders the sorting of every known outcrop exceedingly difficult.

Archæan complex.

77. No attempt was made to limit by definite boundaries and colours on the map the various members of the Archæan system among themselves. In this matter Messrs. Heron and Daru have both been compelled to follow the only feasible plan of indicating by one or two signs superposed

on one uniform wash of colour such marked lithological types as massive acid and basic intrusions, wherever such could be distinguished as exercising a predominating effect in the field. Thus the mixed gneisses are left in possession of the greater part of the area coloured Archæan, with here and there patches of granite, syenite, aplite, pegmatite and basic dyke rocks. This, though a superficial method, and one giving no clue to the genetic relationships of the rock masses to one another, is nevertheless a slight advance on the work of the older survey in neighbouring parts; but it would be premature at present to attempt any closer descriptive summary of results. This rock group may undoubtedly, as a whole, be correlated with the "gneiss" of Hacket in the area of the Aravalli Range to the north.

Punjab.

Dr. G. E. Pilgrim: Upper Tertiary Fresh-water strata.

78. In continuation of his survey of the ossiferous deposits of India, Dr. G. E. Pilgrim visited that portion of the Punjab, lying between the Jhelum and the Indus, known as the Potwar, the Salt Range and the Murree Hills Sub-Assistant M. Vinayak Rao was employed in collecting from the same district under Dr. Pilgrim's direction.

As the result of his investigations, Dr. Pilgrim has been able to arrive at certain definite and important conclusions regarding the divisions of the Tertiary fresh-water strata of the Punjab, and their correlation with the Siwalik formation in other parts of India.

A full summary of these conclusions with a revised classification of the Upper Tertiaries of India will appear in the *Records*.

Kuldana series of Fatehjang.

79. In the first place Dr. Pilgrim shows that the nummulites associated with the mammalian fauna of Fatehjang, near Rawalpindi, which led Lydekker to refer these beds to the eocene (Khirthar) period are not *in situ*, and that great unconformity really exists between these beds and the Khirthars. The presence of *Anthracotherium bugtiense*, *Brachyodus africanus*, and other Upper Nari forms, clearly denotes the age of these beds, which are identified with the Kuldana series of Middlemiss, and pass upwards into the Murree sandstones. These latter beds thin out rapidly towards the south and are not represented in the Salt Range, where the Kuldana beds are followed by a series of beds correlated with the lower Siwaliks of Sind and the Bugti Hills.

Middle Siwaliks of the Potwar.

80. One of the most important discoveries made by Dr. Pilgrim is the fact that the collections made by Mr. Theobald in the Potwar, from beds supposed to be on

the same horizon as those mentioned above, really belong to a horizon some 5,000 to 8,000 feet higher in the series. This fauna, to which Dr. Pilgrim restricts the term Middle Siwalik, is quite distinct from the lower one, the most striking features being the absence of *Dinotherium* and the abundance of *Hipparion*, Giraffoids and the large antelopes. Furthermore, Dr. Pilgrim has proved the passage of these Middle Siwalik upwards into beds containing a fauna identical with that of the Siwalik hills in the typical area. These latter beds had been traced by Medlicott and Theobald in practical stratigraphic continuity through Jammu and Kangra as far as the Pabbi Hills on the east side of the Jhelum, so that it now becomes possible to correlate the Siwaliks of the Siwalik Hills with the Upper Tertiaries of Western India..

Siwalik Hills.

81. Dr. Pilgrim also paid a visit to the Siwalik Hills in order to investigate a supposed bone deposit. This turned out to be merely a deposit of calcareous tufa; but he was able to re-visit several of the old localities, which appear to have been worked out by former collectors, and discovered the important fact that most if not all of these localities are near the top of the series. The whole series of beds form a perfectly conformable sequence, and the occurrence of *Dinotherium* and species identical with those of the lower Siwaliks of the Salt Range shows that lower horizons are also represented. This is the so-called Nahan stage. With the exception of these lowest beds, the rest of the series, including both Mr. Middlemiss' 'Siwalik conglomerate' and 'sand-rock' stages, corresponds both in thickness and lithological character with the Upper Siwaliks of the Pabbi Hills. The conclusion is therefore drawn that the middle Siwalik stage in the Siwalik Hills was characterised by a remarkably slow deposition, only a few hundred feet representing the 6,000 feet or so of the fossiliferous Middle Siwaliks of the Salt Range.

No reason whatever has been seen to doubt the propriety of separating the Dagshai and Kasauli series from the Nahans, or the identity of the two former with the Murree series of the Punjab.

Kashmir.

Mr. C. S. Middlemiss: District S. E. of Srinagar.

82. During the summer of 1909, Mr. Middlemiss re-visited Kashmir, and added considerably to the discoveries made the previous year, which have been described in Vol. XXXVII, Pt. 4, of the *Records* and in the General Report for the year, Vol. XXXVIII, Pt. 1, p. 69. A

full account of these later observations will appear in the current volume of the *Records*.

The area examined is a compact one about 36 miles long by 16 miles broad, lying to the south-east of Srinagar, embracing the area in the Vihi district examined in detail last year and sections along the Patarkul, Traal, Lidar, Arpat and Naubug Valleys, which, with a north-east—south-west trend, join the Jhelum Valley above Srinagar.

In his progress through this area, Mr. Middlemiss soon found that the old interpretation of the geological series as formulated by Lydekker (*Memoirs*, Vol. XXII) needed much revision as a sequel to the more recent detailed surveys, which since Lydekker's time have been made of the Tibetan watershed of Garhwal and Kumaon, and in Spiti. A new map was therefore produced of this very typical area, and a re-grouping of the fossiliferous marine sedimentary series from Silurian to Upper Trias was instituted.

83. A large and characteristic collection of fossils was made from many of the horizons as given in the table of formations below (arranged in descending order) :—

Geological sequence.	
(12) U. Trias	(not differentiated into sub-zones).
(11) Muschelkalk	*Ptychites* horizon. *Gymnites* do. Nodular limestone.
(10) L. Trias	*Meekoceras* horizon. *Ophiceras* do.
(9) Zewan or Permo-Carboniferous	*Spirifer Rajah* and *Marginifera* beds. *Protoretepora* limestone and shales.
(8) L. Gondwanas	*Glossopteris* horizon (Karharbari ?) *Gangamopteris* do. (Talchir ?)
(7) Volcanic flows.	
(6) Agglomeratic slate series.	
(5) M. Carboniferous	(?) *Fenestella* series.
(4) L. Carboniferous	*Syringothyris* limestone series.
(3) Muth quartzite.	
(2) U. Silurian.	*Orthis* shales.
(1) L. Silurian and Cambrian ?	(traces of fossils only).

Of these, the horizons of the Upper Silurian and Muschelkalk, for the first time during this visit, were identified by beds containing abundant

faunas and arranged in regular sequence with the other formations round an elongated anticlinal axis which pitches to the north-west in the neighbourhood of the Lidar Valley.

Age of the Panjal Traps.

84 Incidentally it will be observed that the removal of the so-called Panjal traps and conglomerates of Lydekker (Nos. 7 and 6 of the table) from a low position among the (?) Silurians of that author to a much higher level, immediately below the Permo-carboniferous and Lower Gondwanas, has been found to be necessary, as was tentatively announced in the account of the previous season's work on the Lidar Valley sequence (*op. cit.*, Vol. XXXVII, p. 322).

REPORT ON GEODESY

BY

COLONEL S. G. BURRARD, R.E., F.R.S.

PRINCIPAL TRIANGULATION.

Operations were carried on in the following localities :—

(1) Northern Baluchistan.
(2) Kashmir.
(3) Upper Burma (Bhamo and Myitkina districts).

In Northern Baluchistan and Kashmir the work was a continuation of that of 1908-09, while in Upper Burma an entirely new series, the "Upper Irrawaddy," was commenced.

(1) Northern Baluchistan.

The Northern Baluchistan series emanates from the base Zawa-Zibra of the Kalat Longitudinal Series; it trends in a northerly direction as far as the Northern boundary of Baluchistan, then turning east runs through Northern Baluchistan and closes on the Great Indus Series on the side Tounsa-Langawala, just north of Dera Ghazi Khan. Two figures of the series, both tetragons, were completed in 1908, and a pentagon had been commenced.

Mr. Tresham commenced work early in September, and, after completing the pentagon, carried the work eastwards by means of a tetragon and quadrilateral as far as meridian 68° 30′. Closing work here at the end of December he transferred his base of operations to Tounsa, and commenced to work eastward from the base Tounsa-Langawala. By means of four quadrilaterals he closed on the western portion of his work at the end of April, thus completing the series.

A two-microscope 12″ micrometer theodolite was used for the observations throughout the season's work.

The total length of triangulation executed by Mr. Tresham amounts to 230 miles covering an area of 6,000 square miles. The 24 completed triangles have an average triangular error of 0″·303.

Astronomical azimuths were observed at Gundak, Saleghar and Tounsa. The difference between the observed and geodetic azimuths at the first station is + 0″·06, at the second + 1″·08, and at the third + 11″·65.

The completion of this series closes the circuit, which starting from the base Gandpahar-Kharko of the Great Indus series includes 130 miles of the Kalat Longitudinal Series, the whole length, 340 miles of the North Baluchistan Series, and 340 miles of the Great Indus Series.

The closing errors on the side Tounsa-Langawala are as follows :—

	Value from Great Indus Series.	Value from North Baluchistan Series.	Discrepancy.
Side Tounsa-Langawala .	62,321·8 feet.	62,323·0 feet.	1·2 feet.
	° ′ ″	° ′ ″	″
Latitude of Tounsa .	30 41 51·59	30 41 51·63	0·04
„ Langawala . .	30 51 26·93	30 51 26·98	0·05
Longitude of Tounsa . .	70 41 27·31	70 41 27·55	0·24
„ Langawala . .	70 45 45·07	70 45 45·32	0·25
Azimuth at Tounsa of Langawala	201 07 42·87	201 07 45·89	3·02
Height of Tounsa . . .	593 feet.	580·5 feet.	12·5 feet.
„ Langawala . . .	500 „	484 „	16·0 „

The large error in height is probably due to the very long rays employed on the Kalat and North Baluchistan Series. Heights obtained from short rays are more reliable than those obtained from long rays.

(2) Kashmir.

It was mentioned in last year's report, that a new principal triangulation series had been commenced in Kashmir, emanating from the base Nerh-Khagriana of the North-West Himalaya Series. It was subsequently found, that it was impossible to build up any figure but that of a simple triangle on this base. As this is an unsatisfactory way of commencing a new series, connection was made with a second side of the North-West Himalaya Series, and the first figure of the series becomes a pentagon, of which two of the triangles are common to both series.

Owing to the high altitudes of the stations and the short period of the year available for observations, progress has necessarily been somewhat slow.

Mr. J. de-Gräaff Hunter, who has been the observer throughout both seasons of work, has extended the series north to a distance 90 miles from its base, covering an area of 1,600 square miles. The seven computed triangles have an average triangular error 0″·591.

During 1909 the instrument used for the observations was No. IV two-microscope 12″ micrometer theodolite; this has always been an unsatisfactory instrument, and has now been returned to the makers for improvement. In 1910 it was replaced by No. V 12″ micrometer theodolite; this theodolite has been provided with 3 microscopes in place of the two carried by the other instruments of this class, made by Messrs. Troughton & Simms for the Survey of India.

Mr. Hunter's value of the station Ismail-di-Dori which is common to the present Series and to Montgomerie's old work, differs in both latitude and longitude by 0″·03 from the values obtained by Montgomerie in 1856. The azimuth at Ismail-di-Dori of Manganawa differs from Montgomerie's by 1″·4.

The height of Choti-wala, the last station visited before closing work, is over 16,000 feet in height. It was with the greatest difficulty that the instrument could be got to the top of the hill; for 600 feet it had to be hauled up the steep slopes by men from above.

An astronomical azimuth was observed at Gangachoti. The difference between the observed and geodetic azimuths is—13″·72.

Mr. Hunter has intersected numerous snow peaks; like other experienced observers, he has found it impossible to identify peaks observed from different places; he hopes, however, to fix a large number by combining his computations with graphic methods.

Mr. Hunter, in addition to his triangulation equipment, took with him during the present season two mercurial barometers, two aneroid barometers and two hypsometers for the purpose of comparing their relative values as height measurers. The result show that at heights up to 13,000 feet the mercurial barometers gave sensibly the same readings, but the values of height deduced by Baily's formula were lower by about 200 feet than the triangulated values. The two aneroids were entirely unreliable even as regards relative heights. The hypsometers computed by the formula in the Auxiliary Tables invariably gave too high values, the excess increasing with the height. At 16,000 feet their error amounted to 600 feet.

Table of Meteorological Observations.

Stations.	Triangulated Height.	Mercury Barometers reduced to 62° F.						Aneroid Barometers.						Barometric Height.	Boiling Point.			Radiometer.		Temperature Range.			Remarks.
		Hicks 577.	No. of readings.	Range.	Cray 58.	No. of readings.	Range.	Hicks 5428.	No. of readings.	Range.	Hicks 5502.	No. of readings.	Range.		Temperature.	Air Temperature.	Calculated Height.	Temperature.	Air Temperature.	Max.	Min.	No. of readings.	
	Feet.	"		"	"		"	"		"	"		"		°	°	Feet.			°	°		
Nerh . .	6076	24·06	3	·07	24·00	3	·01	23·87	3	·08	23·75	3	·09	...	201·05	46·9	6119	Not	taken	55	43		
Kandi .	4375	25·14	2	00	24·96	2	·09	25 45	2	·04	25·56	2	·04	...	Not ta	ken.	Not	taken		87	64		
Gangachoti	9920·7	20·89	16	·16	20·83	16	·12	20·46	4	·03	20·77	15	·33	...	194·22	57·7	10339	133·0°	55·5°	62·5	34·0		
Kakwa-ka-Pahar.	12985·5	18·69	3	·05	18·69	3	·01	17·92	3	·05	19·00	3	·19	* 12670	189·11	57·0	13510	Not owing mist.	taken to	58·2	38·2		
Chotiwala .	16120 app.	16·59	6	·21	Brok en		...	15·60	6	·28	16·88	6	·55	* 15910	183·75	49·5	16747	134°	62·5°	65·5	24·0		

N.B.—(1) Heights marked thus * are deduced from these and simultaneous observations taken at Baramulla.
(2) Radiometer—only maximum readings obtained given.
(3) Range of Temperature—only maximum and minimum readings obtained given.

The table attached shows the results of Mr. Hunter's observations.

Mr. Hunter's advance parties have built stations as far north as Gilgit. Beyond the Nanga Parbat range the strength of the monsoon decreases considerably, and it has been possible for the builders to continue work, with only occasional interruptions from rain, throughout the period of the monsoon.

Simultaneously with the work of the principal series the work of inspecting and repairing the stations of Montgomerie's series has been carried out. In 1909 the stations south of Srinagar were repaired; this year those between Srinagar and Skardu have been taken in hand.

Mr. Abdul Hai, who has carried out this work this year, is now proceeding up the Indus Valley to visit and repair stations, from which it is hoped that the high peak of Teram Kangri, discovered by Dr. Longstaff, will be visible.

Next year it is proposed to send a detachment to observe Teram Kangri from these stations, or if necessary to extend the triangulation, so as to obtain a base from which it can be observed.

(3) Upper Irrawaddy Series.

For topographical reasons it was decided to stop work on the Great Salween Series for a season, and to initiate a new Series in Upper Burma through the upper Irrawaddy basin.

This Series emanates from the side Tangte-Lakar Bum of the Great Salween Series; it will follow the eastern and northern frontiers of Upper Burma.

Lieutenant Cardew commenced work at the beginning of December and carried the Series, by means of three quadrilaterals, 112 miles in a northerly direction, when further work became impossible owing to the dense haze. His eight completed triangles have an average triangular error 0″·381 and the triangulation covers an area of 2,900 miles.

An astronomical azimuth was observed at Kumtung Bum, the value of this differs from the geodetic value by 6″·68.

The observations were taken throughout by a two-microscope 12″ micrometer theodolite.

SECONDARY TRIANGULATION.

Up to the year 1909 all triangulation work executed by the Trigonometrical Branch has, with a few exceptions, been principal work, and the gaps between principal series have been filled in by Topographical Parties with a network of tertiary work. This latter though sufficing in accuracy

left few permanent marks on which a future survey could be based. Experience in other countries has shown that periodic re-surveys are necessary, and that these re-surveys are made on ever increasing scales. It was therefore decided that the trigonometrical triangulation party should initiate good secondary triangulation with the primary object of fixing permanent stations for future use.

In order, however, that this work might be utilised for current surveys the two series selected have been carried out in localities which are actually under topographical survey.

The Mawkmai Series.

This series is based on the side Letpataung-Suletaung of the Mandalay Meridional principal series ; it runs eastward to meridian 98°, then follows the Burma frontier, bends north on meridian 99°, and closes on the Monghsat Secondary Series.

The stations were built up to meridian 98° in the season 1908-09. During last season Mr. Collins with two other provincial officers of the Survey of India was employed in completing the building of the stations and taking the observations.

Owing to the bad weather experienced they were unable to complete the series, but in order to render their completed work available for topographical purposes the eastern portion of the series was closed provisionally on the Monghsat Series. There remains for work during the coming season a gap of some 20 miles in the middle of the series and an extension of the series to a more easterly base of the Monghsat Series. The length of the series when completed will be 220 miles covering an area of 2,400 square miles. The average triangular error of the 25 completed triangles is 1·99″. Except at the base stations all signals were non-luminous consisting of a pole stayed by means of ropes. The instruments used were two microscope 8″ micrometer theodolites.

The Khasi Jaintia Hills Series.

This series is based on the side Landou Modo-Mautherichan of the eastern frontier series. Mr. Smith carried the triangulation westward through the Khasi Hills up to the meridian 91°, the stations having been built the preceding field season.

Owing to dense haze it was found impossible to observe to non-luminous signals, and helios had to be employed throughout the observations. The length of the completed portion of the series amounts to 41 miles covering an area of 400 square miles. The average triangular error

of the ten completed triangles is 3·17″. Mr. Smith used a two-microscope 8″ micrometer theodolite.

The stations of the eastern frontier series on which the work is based are known to have been displaced by the severe earthquake of 1897; it has therefore been decided to continue the series westward through the Garo Hills during the coming season to close on Brahmaputra Meridional Series: the work will then be re-computed from the terminal side as the base.

While Mr. Smith was carrying out his triangulation, Mr. Wyatt completed the building of stations for the extension of the series eastward up to meridian 93°.

ASTRONOMICAL LATITUDES.

During the past field season astronomical latitudes were observed at 11 stations in the plains of Oudh, along a line running north from the Ganges, (south of Rae Bareli) to Bahraich and then east to Uska Bazar, north of Gorakhpur. The positions of the stations and the values of the deflection of the plumb-line are given in the table below :—

Table.

Name of station.	Latitude.	Longitude.	Height above mean sea-level.	Deflection of the plumb-line (A—G).
	° ′	° ′	Feet.	″
Sora T. S. . . .	26 17	81 12	400	+ 7·56
Pariaon „ . . .	25 50	81 22	346	+ 6·33
Parewa „ . . .	26 38	81 12	380	+ 7·44
Utiamao „ . . .	27 0	81 12	386	+ 4·54
Imlia „ . . .	27 19	81 8	428	— 1·07
Masi „ . . .	27 38	81 23	406	—10·38
Dadaura „ . . .	27 43	81 43	420	—14·82
Manichauk „ . . .	27 37	82 5	360	—19·23
Basadela „ . .	27 24	82 17	366	—12·53
Pathardi „ . . .	27 26	82 45	320	—18·66
Ghaus „ . . .	27 21	83 6	296	—16·74

A positive value in the last column denotes, that the plumb-line is deflected towards the south.

The values are in accordance with those previously found south of the Himalaya. The last 5 stations are all within sight of the Himalayas, the nearest, Manichauk, being about 18 miles distant.

In addition to the latitude work, an attempt was made by Major Crosthwait during the summer, to apply to India the method which Mr. J. Hayford has used in the United States to ascertain whether the condition known as isostasy exists. This involved the computation of the deflection of the plumb-line, in the meridian, due to visible masses up to a distance of 2,564 miles from each station. The deflection was computed for some 100 latitude stations and for 18 longitude stations (in the prime vertical). The details of this work will form the subject of a separate paper. Major Crosthwait's conclusions do not support the Hayfordian theory of isostasy.

The Pendulum Observations.

The pendulum operations of 1908-09 and 1909-10 were designed to determine the limits of the areas of high and low crustal density in Central India, the existence of which had been indicated by latitude observations; we particularly wished to discover whether the belt of high density corresponded to any extent with topographical configuration, that is to say, whether it was visible, or whether it lay concealed beneath the surface.

The operations for 1908-09 were confined to the south-western portion of the belt, to the area Ujjain, Dhulia in Khandesh, Amraoti, Hoshangabad. In 1909-10 the pendulums were swung by Captain Cowie in the region to the east of this, in the tract Saugor, Seoni, Bilaspur, and Sultanpur. The work of the two seasons thus covered the area between Lats. 21° to 24° and Longs. 75° to 82°.

The results of the season 1908-09 were communicated in the last report submitted to the Board of Scientific Advice. The stations visited by Captain Cowie in 1909-10 and the results obtained are given in Table 1.

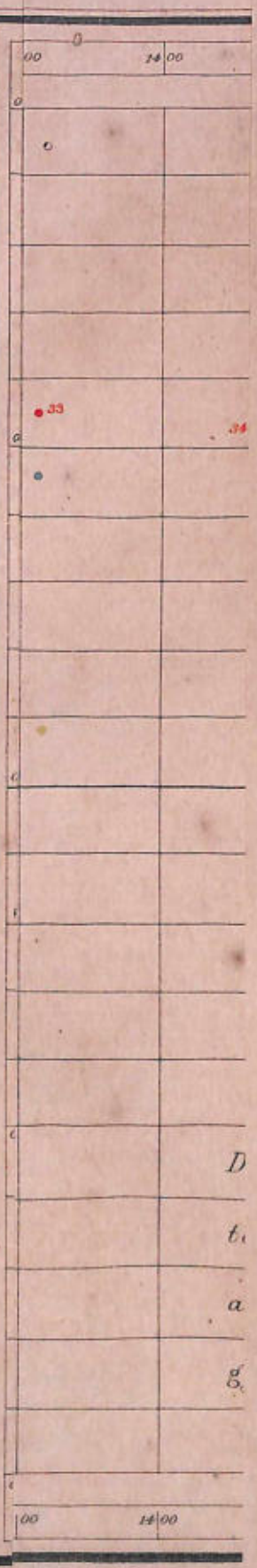
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Table 1.

Station.	Latitude.	Longitude.	Height.	Observed value of gravity.
	° ′ ″	° ′	Feet.	Dynes.
Saugor	23 51 47	78 48	1,757	978·731
Damoh	23 49 54	79 26	1,213	978·758
Katni	23 50 25	80 26	1,254	978·757
Umaria	23 31 37	80 54	1,499	978·740
Pendra	22 46 41	82 0	1,996	978·638
Bilaspur	22 3 53	82 12	878	978·681
Raipur	21 13 56	81 41	996	978·612
Amgaon	21 21 31	80 28	1,032	978·614
Seoni	22 5 29	77 29	2,032	978·622
Jubbulpore . . .	23 8 54	79 59	1,467	978·719
Maihar	24 15 38	80 48	1,161	978·784
Allahabad	25 25 55	81 55	288	978·943

The values of gravity given in this table are based on the value of g at Dehra Dun, 979·063 dynes.

The stations are given in the order in which they were visited. At each station four pendulums were swung, and as a rule, four complete sets of observations were made.

In Table 2 are given (i) the observed values of gravity, (ii) these values corrected for height of station, and (iii) for height of station and

mass interposed between station and sea-level according to Bouguer's formula, (iv) the theoretical values of gravity at sea-level, and (v) the comparison of these last values with the observed values reduced to sea-level by means of Bouguer's formula :—

Table 2.

Station.	Observed value of gravity $=g$.	g corrected for height $=g_o$	g corrected for height and mass $=g_o''$	Theoretical value of gravity at sea-level. $=\gamma_o$	$g_o''-\gamma_o$
	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.
Saugor . . .	978·731	978·895	978·834	978·850	—0·016
Damoh . . .	978·758	978·871	978·829	978·848	—0·019
Katni . . .	978·757	978·874	978·830	978·848	—0·018
Umaria . . .	978·740	978·880	978·830	978·827	+0·003
Pendra . . .	978·638	978·824	978·754	978·778	—0·024
Bilaspur . .	978·681	978·763	978·733	978·733	0·000
Raipur . . .	978·612	978·705	978·670	978·681	—0·011
Amgaon . .	978·614	978·710	978·674	978·689	—0·015
Seoni . .	978·622	978·811	978·744	978·735	+0·009
Jubbulpore . .	978·719	978·856	978·806	978·803	+0·003
Maihar . . .	978·784	978·892	978·851	978·877	—0·026
Allahabad . .	978·943	978·970	978·960	978·958	+0·002

In this table the theoretical values of gravity at sea-level have been calculated by Helmert's formula of 1884.

$$\gamma_o = 978{\cdot}000\ [1 + 0{\cdot}005310 \sin^2 \phi.]$$

The correctness of the Bouguer reduction having been recently questioned by Mr. Tittmann and Mr. Hayford of the U. S. Coast and Geodetic Survey, who uphold the theory of complete isostasy, an investigation has been commenced by Captain Cowie to see whether the gravity results of the Indian Survey support the views of the American Geodesists. This enquiry has progressed only so far as will allow us at present to consider the

masses within 100 miles of 42 stations. The quantities derived from this investigation are given in Table 3.

In reductions of the observed values of gravity to sea-level, the effect of masses situated between the level of the station and sea-level have hitherto been calculated by Bouguer's hypothesis and formula. This hypothesis assumes that in the earth's crust below sea-level there is everywhere a normal amount of matter and that all masses situated above sea-level are in excess of normal. Hayford's hypothesis is based on the theory that in every prism from the centre of the earth to the surface, at whatever distance from the centre that surface may occur, the amount of matter is normal, that is, that where masses are raised above the sea-level, thus constituting excesses of matter above that surface, there must be compensating deficiencies of matter below. Hayford's hypothesis is to the effect that this compensation of mass is everywhere complete and occurs within a stratum situated between the sea-level and a plane 113·7 kilometres below it. In the case of the quantities exhibited in the table, it should be noted that this compensation depth has been assumed to be 70 miles. The hypothesis of Bouguer is, thus, one of no compensation, while that of Hayford maintains complete compensation occurring within a depth of 70 miles below sea-level.

Table 3.

No.	Station.	Height in feet.	Helmert.	Bouguer.	Hayford.	$(g_o - \gamma_o)$ Bouguer.	$(g_o - \gamma_o)$ Hayford.
1	2	3	4	5	6	7	8
1	Chatra . . .	64	11	+ 2	− 1	+ 9	+12
2	Cuttack . . .	92	32	+ 3	− 3	+ 29	+35
3	Kisnapur . .	113	37	+ 4	+ 1	+ 33	+36
4	Ramchandpur . .	132	6	+ 5	0	+ 1	+ 6
5	Jacobabad . .	183	37	+ 6	− 3	+ 31	+40
6	Kesarbari . .	204	36	+ 7	−14	− 43	−22
7	Jalpaiguri . .	268	88	+ 8	−37	− 96	−51
8	Allahabad . .	288	12	+10	0	+ 2	+12

Table 3—contd.

No.	Station.	Height.	Helmert.	Bouguer.	Hayford.	$(g_o - \gamma_o)$ Bouguer.	$(g_o - \gamma_o)$ Hayford.
1	2	3	4	5	6	7	8
9	Dera Ghazi Khan .	397	74	+14	−10	− 88	−64
10	Multan . . .	404	31	+14	0	− 45	−31
11	Montgomery . .	557	22	+19	+ 6	+ 3	+16
12	Mortakka . .	576	14	+20	− 7	− 6	+21
13	Ferozepore . .	646	29	+23	+ 7	+ 6	+22
14	Gesupur . . .	691	4	+24	+ 8	− 20	− 4
15	Mian Mir . .	708	29	+25	+ 7	+ 4	+22
16	Meerut . . .	734	1	+26	+ 7	− 27	− 8
17	Jalgaon . . .	760	39	+27	− 2	+ 12	+41
18	Kaliana . . .	810	30	+28	− 2	− 58	−28
19	Ludhiana . .	835	19	+29	+ 5	− 48	−24
20	Roorkee . . .	867	78	+29	− 8	−107	−70
21	Bilaspur . . .	878	30	+30	+ 3	0	+27
22	Nojli . . .	879	65	+30	− 6	− 95	−59
23	Mukhtiara . .	926	3	+32	0	− 35	− 3
24	Raipur . .	996	24	+35	+10	− 11	+14
25	Hoshangabad . .	1,002	39	+35	0	+ 4	+39
26	Khandwa . .	1,014	73	+35	+ 6	+ 38	+67
27	Amgaon . . .	1,032	21	+36	+ 9	− 15	+12
28	Amraoti . . .	1,123	49	+39	+ 7	+ 10	+42
29	Maihar . . .	1,161	15	+41	+10	− 26	+ 5
30	Damoh .	1,213	23	+42	+ 8	− 19	+15
31	Katni . . .	1,254	26	+44	+ 8	− 18	+18

Table 3—contd.

No.	Station.	Height in feet.	Helmert.	Bouguer.	Hayford.	$(g_o - \gamma_o)$ Bouguer.	$(g_o - \gamma_o)$ Hayford.
1	2	3	4	5	6	7	8
32	Shahpur . .	1,284	40	+45	+ 3	− 5	+37
33	Ellichpore . .	1,314	55	+46	+ 8	+ 9	+47
34	Jubbulpore . .	1,467	53	+50	+11	+ 3	+42
35	Umaria . . .	1,499	53	+50	+12	+ 3	+41
36	Ujjain . . .	1,612	25	+56	+18	− 31	+ 7
37	Saugor . . .	1,757	45	+61	+23	− 16	+22
38	Mhow . .	1,903	34	+67	+33	− 33	+ 1
39	Pendra . . .	1,996	46	+70	+24	− 24	+22
40	Seoni . . .	2,032	76	+67	+25	+ 9	+51
41	Asirgarh . . .	2,077	84	+67	+38	+ 17	+46
42	Badnur . . .	2,103	79	+73	+27	+ 6	+52
	Mean positive . .	.....	36	.....	+13	+ 12	+28
	„ negative .	.....	43	.....	− 9	− 40	−33
	General mean . .	.....	17·5	+32·7	+ 5·7	− 15·2	+11·9

In this table the unit is the thousandth part of a dyne.

The Hayford method has been applied to masses within 100 miles of the station. An extension of this investigation to cover the whole surface of the globe would result in a small correction, negative in sign, but varying slightly in amount, being applied to two quantities in column 6.

The figures in columns 4, 5 and 6 of the Table all profess to represent the same quantity, the effect of masses in the neighbourhood of each station on the force of gravity. The first of the three columns gives the actual effects of these masses as derived from a comparison of the observed value of gravity, corrected for altitude of station only, with the theoretical value γ_o at sea level. The two succeeding columns give the theoretical effects based on the two hypotheses of Bouguer and Hayford.

The Hayford correction tends to increase the observed value of gravity. In a region, like the Sub-Himalayan, where large negative values of $(g_o - y_o)$ prevail, the Hayford correction does reduce the anomalies of column 7. But in a region, like the Indo-Gangetic plains, where positive values of $(g_o - y_o)$ have been found at all stations throughout a long zone, the Hayford correction serves only to intensify the anomalies.

Tidal Operations.

During the past year tidal registrations by automatic tide gauges have been taken at the ports of Aden, Karachi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair. The registrations at these ports have been satisfactory.

Levelling Operations.

The total outturn of double levelling of precision completed during the field season 1909-10 was 1,276 miles, in the course of which observations were taken at 16,944 stations. The bench-marks determined were 41 standard, 134 rock-cut, 1 interred, 7 engraved, 90 embedded, 343 inscribed, and 64 belonging to other departments.

The heights of 21 Principal and 3 Secondary triangulation stations were also determined by levelling as a check on the heights deduced by triangulation. The principal lines of levelling were carried on in the Bahawalpur State, the Punjab, Sind, the Sub-Himalayan tracts and in Burma; there were also short lines of levelling in other parts of India in connection with the standard bench-mark scheme.

The following are the Himalayan lines of levelling that were completed during the past field season :—

1. Lahore to Dharamkot, *viâ* Pathankot and Dharamsala.
2. Hardwar to Lansdowne, *viâ* Najibabad.
3. Bareilly to Naini Tal Brewery, *viâ* Kathgodam.
4. Siliguri to Tindharia.

BOTANICAL SURVEY.

BY

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Director, Botanical Survey of India.

Eastern India.—Work on the Catalogue of the non-herbaceous flowering plants cultivated in the Royal Botanic Garden, referred to in last year's report has been continued. The numerical index to the first 4,000 plants together with a new map of the Garden to serve as a key to the position of the plants therein is about to appear and another 4,000 numbers are ready for press.

Reference was made last year to the expedition then in progress of Messrs. Smith and Cave to the extreme north-west of Sikkim. The results of this tour have been elaborated by Mr. Smith in a paper that is now in the press and will appear as No. 5 of Vol. IV of the Records of the Botanical Survey. The following condensed account of the results is taken from Mr. Smith's manuscript. The expedition lasted during July and August of 1909, and the immediate result was some 6,000 specimens with about a score of species new to science. The Zemu and Llonakh valleys are the most distant from the main roads and most difficult of access on account of the dense Rhododendron jungle and high passes that cut them off from the rest of Sikkim. There are neither houses, roads, bridges nor even pony tracks. Botanically the Zemu area shows three regions—a temperate forest region from 8-11,000 feet, a sub-alpine shrub region from 11-14,000 feet and an alpine region from 14-17,000 feet. In the first region are found such genera as *Picea, Larix, Tsuga, Abies, Juniperus* with numerous species of *Berberis, Ilex, Euonymus, Acer, Rubus, Rosa, Spiræa, Pyrus, Ribes, Viburnum, Lonicera, Rhododendron, Corylus, Betula, Alnus,* etc. Towards the upper limit of the region Rhododendrons and Coniferæ prevail. At about 11,000 feet the tall Rhododendrons tend to disappear and are replaced by intermediate forms like *R. Wightii* and *R. campanulatum. Coniferæ* begin to thin off and the valley opens out. At about 12,000 feet most of the trees disappear and the floor of the upper valley is covered with straggling shrubs of *Berberis, Pyrus, Cotoneaster, Ribes, Lonicera, Rhododendron* and *Salix.* The herbaceous element is represented by species of *Meconopsis, Cardamine, Corydalis, Lychnis,*

Astragalus, Potentilla, Sedum, Epilobium, Heracleum, Angelica, Saussurea, Primula, Pedicularis, Salvia, Polygonum, etc. From 14-18,000 feet the prevailing genera are *Anemone, Corydalis, Draba, Potentilla, Saxifraga, Sedum, Cremanthodium, Saussurea, Leontopodium, Anaphalis, Primula, Androsace, Gentiana, Swertia, Lagotis, Pedicularis, Polygonum, Salix, Carex, Poa.* Taken as a whole the valley shows a transition from the moist prolific areas such as Jongri to the south, to the dry area beyond the Thé La. Generally speaking the vegetation of the Zemu has more affinity with that of Jongri than with that of Llonakh.

The Llonakh valley is a wide expanse of gently undulating ground in the midst of the highest peaks, with here and there huge moraines on the flanks. The flats show evidence of strong persistent winds, the vegetation being chiefly of the "tussock" type. The subsidiary valleys are characterised by a succession of flats and marshes, the upper ends of the valleys ending in cliffs and glaciers. The vegetation of the Llonakh valley as a whole may be divided into (1) the plants of the open flats and marshes, (2) the plants of the moraines and screes, (3) the extreme alpines of the upper cliffs. On the flats trees and shrubs are restricted to dwarfish specimens of Juniper, *Rhododendron lepidotum* and *R. Anthopogon, Berberis, Spiræa, Potentilla fruticosa, Lonicera, Hippophæ,* and an occasional *Salix.* Among the herbaceous species the hemispherie mounds of *Arenaria* are the most striking. On the moister areas flourish species of *Ranunculus, Caltha,* and *Pedicularis, Poterium filiforme, Saxifraga pallida, Primula sikkimensis,* and *P. tibetica.* On the drier flats were found species of *Delphinium, Hypecoum, Lepidium, Stracheya, Astragalus, Oxytropis, Saussurea, Artemisia, Campanula, Cyananthus, Urtica, Allium,* and such species as *Arabis glandulosa, Viola kunawarensis, Stellaria decumbens, Saxifraga flagellaris, Antennaria muscoides, Anaphalis xylorhiza, Androsace Selago, Lancea tibetica, Elsholtsia eriostachya,* etc. Amongst the screes in addition to the Junipers and dwarf Rhododendrons were species of *Anemone, Callianthemum, Draba, Saxifraga, Sedum, Trigonotis, Onosma, Picrorhiza, Eriophyton, Polygonum tortuosum.* On the higher cliffs the prevalent plants were *Meconopsis horridula, Draba, Braya, Thlaspi, Cochlearia, Potentilla macrophylla, P. fruticosa, Saxifraga imbricata, S. ranulosa, S. saginoides, Cortia, Allardia, Saussurea, Primula muscoides, Androsace, Selago, Myosotis Hookeri, Veronica lanuginosa, Polygonum nummularifolium, P. Hookeri, Rheum nobile, R. spiciforme.*

Considering the north-west corner of Sikkim as a whole and the vegetation above 11,000 feet, *Ranunculaceæ* are only moderately represented.

Berberis persists into the upper Llonakh valleys. *Meconopsis* is well represented in quantity. *Corydalis* is prevalent and rich in species. *Drabas* chiefly represent the Cruciferæ. *Lychnis, Stellaria* and *Arenaria* are strong in species and in numbers. *Impatiens* persists only as far as the lower Zemu. *Leguminosæ*—chiefly *Astragalus* and *Oxytropis*—are but moderately frequent in the upper regions. *Potentillas* are very conspicuous and abundant. *Saxifraga* is also a dominant genus, nearly all the Himalayan species being found in the area. *Umbelliferæ* are not particularly prominent. *Compositæ*, especially *Saussureas* are abundant. *Codonopsis* and *Cyananthus* are frequent. Rhododendrons abound but are not of many species. *Primulaceæ* are particularly common, as are species of *Pedicularis*. *Salix* prevails up to the melting snows. Rushes, sedges and grasses are poorly represented. In addition to the new species that are described in Mr. Smith's paper, nearly forty species have been added to the list of plants native to Sikkim.

In addition to his account of the vegetation of Llonakh, Mr. Smith has also described several new species of Eastern Himalayan plants from the collections made by Mr. J. C. White, C.I.E., late Political Officer in Sikkim. These will appear along with the Llonakh paper.

Collections from the lower and outer hills of the Eastern Himalaya have been contributed by the late Mr. R. Pantling, Assistant-Superintendent of the Cinchona Plantation, by Mr. G. E. Shaw, B.Sc., F.I.C., Government Quinologist, and by Mr. R. E. Cooper.

In Eastern Bengal and Assam collections were made by trained Lepcha collectors in the Terai of the Jalpaiguri district.

From Burma large accessions of material were received. Mr. J. H. Lace, F.L.S., Chief Conservator of Forests, sent a finely preserved collection of about 1,000 specimens that have helped largely to fill up gaps or to supplement species previously very imperfectly represented in the Calcutta Herbarium. Important contributions that include species hitherto undescribed were also received from Captain R. W. MacGregor, I.M.S., from the Southern Shan States and from the following Deputy Conservators of Forests: Mr. G. E. S. Cubitt of Bhamo, Mr. H. W. A. Watson of the Southern Shan States, Mr. A. Rodger of the Ruby Mines, and Mr. E. M. Buchanan of Myitkyina. Mr. D. W. Rae, Assistant Superintendent, Kachin Hills, forwarded a collection of ferns from Sinlumkaba. To all these officers the Botanical Survey is much indebted. From the Burma-Yunnan frontier a particularly fine collection

of over 1,000 sheets was obtained from Mr. G. Forest, well known for his botanical explorations in China.

A suggestive and most interesting account of Recent Plant Immigrants into Bengal has been published by Mr. P. J. Brühl, F.G.S., F.C.S., of the Indian Educational Service. His paper is divided into two parts, the first being concerned with the description and distribution of *Croton sparsiflorus* Morung, in Bengal. This species, a native of South America, appears to have been first imported into Chittagong, where it was collected in 1898, and thence have spread up the Megna and across to the mouths of the Hughli. It was observed at Diamond Harbour and other places down the Hughli river by Botanic Garden collectors in 1903 and in the following year was collected at Sibpur. Mr. Brühl gives an account of its present distribution as determined by himself in the neighbourhood of Sibpur and further afield, and points out how excellent an example of the dispersal of a species the further spread of *Croton sparsiflorus* will afford. The second and the larger part of Mr. Brühl's paper deals with those species found in Bengal and Behar that are known to be immigrants from other countries. It is pointed out how the agricultural conditions of Bengal and Behar favour the introduction and spread of foreign species. Mr. Brühl gives a list of 234 species of foreign origin now more or less established in the province, representing 166 genera and 58 orders, the names of some of the latter, however, by some slip having been omitted in the paper.

The immigrants hail from practically all quarters of the globe, from temperate Europe, Western Asia and Songaria; Japan, China and Indo-China, the Malayan Peninsula, Andaman Islands, and Ceylon; the Malayan Archipelago and the Philippines, Polynesia, Africa and the African islands, the United States, tropical and sub-tropical America in general, Mexico and Central America, the West Indies, the Andes region, Brazil, the La Plata region. Mr. Brühl gives a list of the species and the percentage of the whole contributed by each region. More than half the total of introduced species has been furnished by America, Asia (except the N.-W.) outside of India coming next, then Europe and Asia N.-W. of India with a considerable drop and last of all Africa. A list is given showing what orders have been enriched and to what extent by the immigrants. Mr. Brühl concludes that the immigrants furnish 12·4 per cent. of the Flora of Bengal and Behar. He suggests the way in which these species have been introduced by classifying them in detail according as to whether they are cultivated (field crops, garden plants, forest, avenue and hedge plants) or wild (field and garden weeds, weeds of grass plots, road-

sides and waste places, plants found in tanks and marshes). Mr. Brühl also indicates approximately the periods of introduction of the various species from before the arrival of the Portuguese in India in 1498 to after 1897. The dissertation ends with an account and classification of the Bengali names given to the introduced species, and a plea for the establishment of local herbaria in district centres.

Western India.—The outstanding feature of the year's work on this side of India is the appearance of the first volume of an illustrated Forest Flora of the Bombay Presidency and Sind by Mr. W. A. Talbot, F.L.S., late Conservator of Forests. The book is a large volume of over 500 pages, with 288 sketch figures in the text. The natural orders concerned are from *Ranunculaceæ* to *Rosaceæ*. The work affords the opportunity of comparing the number of arborescent species as they appeal to the Forest officer with the total number of species within the same ordinal limits as given in Dr. T. Cooke's Flora of the Presidency of Bombay, the first volume of which containing amongst others the same orders dealt with by Mr. Talbot appeared in 1903. From *Ranunculaceæ* to *Rosaceæ*, both included, 49 orders appear in the Flora with 303 genera and 769 species. In the Forest Flora there are ten orders fewer, while the genera drop to 207 and the species to 439. The ten dropped orders are *Nymphæaceæ*, *Papaveraceæ*, *Fumariaceæ*, *Cruciferæ*, *Polygalaceæ*, *Caryophyllaceæ*, *Portulacaceæ*, *Elatinaceæ*, *Hypericaceæ*, and *Zygophyllaceæ* with a total of 48 species. Of the orders common to both works those that show marked differences in the number of genera and species in the two works, being such as show a fair proportion or even a predominance of herbaceous species the difference between the generic and specific numbers in such orders roughly indicates the saving to the Forest Officer who desires to know the plants that more immediately concern him without first [illegible] to sort out the herbaceous species. The more important among [illegible]ders are *Capparidaceæ*, that in the Forest Flora are shorn of [illegible]era and [illegible]een species; *Malvaceæ* that are reduced from 16 genera [illegible] species in [illegible] Flora to eight genera and only 12 species in the Forest Flora; [illegible] genera and 24 species to 6 genera and 13 species; [illegible] with 5 genera [illegible] species in the Flora to 3 genera and 20 species in the Forest Flora; [illegible] with 23 species to 1 genus with 2 species. Absolutely, though not relatively, the greatest reduction occurs in the large order *Leguminosæ*, which is reduced from 81 genera with 284 species in the Flora to 49 genera with 136 species in the Forest Flora. A few other orders of minor importance

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shed a genus or a species or two. On the other hand one or two orders in the Forest Flora show an increase of species or genera over the numbers shown in the Flora. Thus the order *Guttiferæ* in the Forest Flora is credited with 11 species, while the Flora gives only ten. The difference in this case is due to Mr. Talbot raising a variety of *Garcinia spicata* in the Flora to specific rank in the Forest Flora. In the Forest Flora the order *Olacaceæ* shows an additional genus and species *Erythropalum populifolium* Mast. that is not given in the Flora. In Anacardiaceæ *Holigarna ferruginea* March., appears as an extra species in the Forest Flora, no mention being made of it in the Flora. In *Connaraceæ*, *Rourea Prainiana* and in *Celastraceæ*, *Gymnosporia konkanensis* new species are described in the Forest Flora. Mr. Talbot describes four distinct types of Forest Flora within the Presidency and Sind : (1) the evergreen tropical flora of distinct Malayan Peninsular origin, (2) the mixed deciduous and evergreen Konkan flora, (3) the mixed deciduous Deccan flora, and (4) the Sind desert flora. Evergreen tropical or Rain-forests are found with a rainfall of not less than 70 inches per annum in North Kanara, and further north in isolated patches into Dharwar. These forests are practically absent from the Deccan trap, and their total extent in the Bombay Presidency does not cover more than 500 square miles. The mixed deciduous and evergreen or Monsoon-forest extends in an irregular and interrupted belt about 500 miles long and about 40 miles wide from Bombay to North Kanara, and constitutes the bulk of the Konkan flora. It requires a rainfall of not less than 40 inches per annum. The mixed deciduous Deccan flora consists of an open formation of thorn-forest, a name that indicates one of its prominent features. A remarkable feature of the desert flora of Sind is the forest formation of *Prosopis spicigera* L. that occurs near the river Indus above the level of inundation.

Mr. G. A. Gammie, F.L.S., has given an account of the Orchids of the genera *Vanda*, *Saccolabium*, *Sarcanthus*, *Cleisostoma* and *Diplocentrum*. Two species of *Vanda*, *V. parviflora* Lindl. and *V. Roxburghii* R. Br. occur in the Presidency, while Mr. Gammie has described a new variety *Spooneri* of the latter species. Three species of *Saccolabium* are found, *S. Wightianum* Hook. f., *S. viridiflorum* Lindl. and *S. maculatum* Hook. f. The other three genera are represented by one species of each, *Sarcanthus peninsularis* Dalz., *Diplocentrum congestum* Wight and an unnamed species of *Cleisostoma*, materials of which were collected by Mr. Gammie in North Kanara previous to 1902, but were unfortunately lost by fire.

Two coloured plates accompany the descriptions, one of *Vanda Roxburghii*, the other of *Saccolabium Wightianum*.

Mr. L. J. Sedgwick, I.C.S., has published a first list of mosses from Western India. Altogether 35 species and 28 genera are represented, while three of the species are new to science.

The Rev. Father E. Blatter, S.J., has given a general account of the vegetation with a sketch map of the physical features, and a detailed list of the species of Panchgani, a small station about 12 miles east of Mahableshwar on the Western Ghats. He divides the station into four regions, each characterised by its flora. A list of some 368 species of flowering plants belonging to 89 natural orders, with the habitat within Panchgani of each species, and vernacular or English names in most cases is given. A list of 14 ferns belonging to ten genera is also appended.

Mr. W. Burns, B.Sc., Economic Botanist to the Government of Bombay, has collected in the Dharwar and Broach districts and has studied the plant life of certain limited areas in relation to environment. He has given attention to the genera *Mangifera* and *Tamarix* as they occur in the Bombay Presidency. Messrs. Chibber and Bhide, Assistants to the Economic Botanist, toured through various districts of the Presidency and made collections chiefly of grasses. About 1,000 sheets were added to the local herbarium.

Southern India.—The only work of systematic importance during the year has been done by Mr. C. E. C. Fischer, Deputy Conservator of Forests, Coimbatore, who has continued his researches on the flora of that part of India and has contributed several hundreds of excellently preserved specimens to the Calcutta Herbarium, that should be very useful in the ultimate working out of the flora of the Madras Presidency.

North-West India.—During the year Mr. J. F. Duthie, B.A., F.L.S., has forwarded the final instalment of manuscript of Volume II of the Flora of the Upper Gangetic Plain, and the whole of Volume II is now in type.

Mr. I. H. Burkill, M.A., F.L.S., Reporter on Economic Products to the Government of India, has given an account in the Records of the Botanical Survey, Volume IV, No. 4, of the vegetation of the route traversed by him in the end of 1907 when he visited Khatmandu, and has given a list of the species collected or observed on the way. His paper is accompanied by a map showing the route traversed. Mr. Burkill describes the belts of vegetation traversed by the road, the great Bhavar or Sal forest under the mountains, the waste grass lands of the Terai, the pine woods on the south

face of the foot-hills, the vegetation about the top of the foot-hills, the plants of the northern aspect of the same, and the forest on the outer face of the inner hills. A list of the plants of the tropical Forest belt is given, a brief account of the crops cultivated, and another list of wild plants of the cultivated belt. The vegetation of the temperate Forest belt is described and a list of the plants observed therein is given. The general conclusions arrived at by Mr. Burkill are that the Sal forests of the tropical belt are rather more eastern than western in character, that the pine forests on the south face of the forest hills are unrepresented in Sikkim although a few of their plants are distinctly eastern; that the Sal forests on the northern slopes of the foot-hills near Hettaunda are like the Sal forests of the lower Sikkim-Himalayan slopes; that the vegetation of the wet gorge of Bhainsa Duhan agrees closely with that of corresponding localities in Sikkim; that vegetation of the cultivation belt differs somewhat from the vegetation of the same belt in Sikkim; that the plants of the wet hill tops agree with those of similar places in Sikkim. The endemic species found by Mr. Burkill numbered five, possibly six. The total number of species of flowering plants enumerated is 584, belonging to 403 genera and 109 orders. In addition, 13 species of ferns belonging to 9 genera, a Lycopod and an Equisetum are recorded. Mr. Burkill's specimens have been presented by him to the Calcutta Herbarium.

Further west Mr. James Marten has given an account of the flowering plants in and about Mussoorie collected by him during 1908, with notes on the periods of flowering and uses. Excluding *Cyperaceæ* and *Gramineæ* and some smaller orders after *Araceæ* that Mr. Marten does not mention he enumerates 313 species belonging to 235 genera and 81 orders. The predominant orders are *Leguminosæ, Urticaceæ, Compositæ, Rosaceæ, Orchidaceæ, Euphorbiaceæ, Labiatæ, Tiliaceæ.*

From Kumaon considerable collections were contributed by Mr. N. Gill, F.L.S., Superintendent of the Government Gardens there, and from Simla and its neighbourhood by Mr. A. R. Tucker, late of the Revenue and Agricultural Department. Colonel C. J. Bamber, I.M.S., F.L.S., has continued his useful descriptive key to the plants of the Punjab, North-West Frontier Province and Kashmir, two more instalments having appeared during the year.

General.—The Rev. Father Blatter, S.J., has published the first of a series of articles on "The Palms of British India and Ceylon, indigenous and introduced." In his first paper Father Blatter gives a short history of the exploration of the Indian Palm-flora, and a general account of the

morphology and geographical distribution of the order. A list of palm genera is followed by an account of the distribution of palms in British India, and a bibliographical list. The paper is illustrated with a plate and a sketch map of the geographical distribution.

Mr. I. H. Burkill has given a general account with figures of the genus *Coptis* belonging to the natural order *Ranunculaceæ* and a detailed study of the origin of Coptis, a drug that is of some repute for its tonic properties. Three kinds of the root are imported into India, one sort from the Mishmi hills and two kinds by sea. Mr. Burkill's conclusions are that the supply of the drug obtained from the Mishmi hills in Assam is the product of *Coptis Teeta* Wall., that the plant cultivated in China as a source of the drug is a variety of *C. Teeta*, that in Japan another species *C. anemonæfolia* Sieb. & Zucc. both wild and in cultivation appears to yield a medicinal product, while still another species allied to the last but not yet satisfactorily discriminated would also seem to be employed as a curative agent. Mr. Burkill thinks it probable that one of the two sorts of Coptis brought to India by sea is the product of the Chinese variety of *C. Teeta* and that the other is yielded by *C. anemonæfolia* of Japan.

Mr. Burkill has also described two varieties of the grass *Cymbopogon Martini* Stapf. that occur in Berar, yielding two kinds of volatile oil. The two varieties are *Motia* and *Sofia*, the former distinguished by the absence of a strong smelling substance known as i-carvon, which is present in the latter. Botanically the varieties differ in their habitats and in the angles at which their leaves are set on to their sheaths.

Mr. A. W. Hill, M.A., F.L.S., of the staff of the Royal Botanic Gardens, Kew, has given an account of the genus *Myxopyrum* of the order *Oleaceæ*, in which he describes ten species of which two are Indian, the latter including a new species *M. serratulum* A. W. Hill, from Travancore and the Anamalai hills of Southern India. Mr. Hill expresses the opinion that the Indian species show greater affinity to the species of New Guinea and the Kei Islands than to the species of the Malayan Peninsula and Archipelago.

Mr. W. B. Hemsley, F.R.S., has cleared up the confusion that has hitherto existed regarding the species called *Cornus macrophylla* Wall. and has described some Asiatic species of the same genus. Mr. Hemsley distinguishes two new Indian species, *C. controversa* Hemsl. from the Eastern Himalaya and Manipur, and *C. Stracheyi* Hemsl. from Kumaon in the North-Western Himalaya, both of which have hitherto been confused with *C. macrophylla* Wall.

M. Beauverd has published descriptions of *Leontopodium Jacotianum* and *L. evax*, new species of *Compositæ* found in both Western and Eastern Himalaya. The same Botanist has also described the following new species of the genus *Cicerbita* :—*C. Duthieana, C. laevigata, C. violæfolia, C. decipiens, C. macrantha, C. Aitchisoniana*, mostly from the Himalayan region.

The following new species of the order *Compositæ* from the Eastern Himalaya have been described by Mr. J. R. Drummond, I.C.S. (retd.) :— *Anaphalis deserti, Leontopodium fimbrilligerum, L. paradoxum, Saussurea tanguensis.* A new species of *Corydalis* from the same region that had been named in the Calcutta Herbarium *C. spathulata* by Colonel Prain has been described by Mr. Craib.

Micholitzia obcordata, a new genus and species of the order Asclepiadaceæ from India, has been described by Mr. N. E. Brown, but its precise habitat within India was unknown at the time of description. It has, however, been collected by Mr. A. Meebold at Laimatak in Manipur. Mr. R. A. Rolfe has published a new orchid *Saccolabium platycalcaratum* from Upper Burma. Coloured plates of the following Indian species have appeared in the Botanical Magazine *Peliosanthes violacea* VAR. *Clarkei* Baker, *Pieris formosa* D. Don., *Scutellaria violacea* Heyne, *Iris Clarkei* Baker. From the Malayan Peninsula the following new species have been recorded and described :—*Eria ochracea* and *Acriopsis latifolia*, new orchids by Mr. Rolfe, *Derris Yappii*, a new Leguminous plant by Mr. W. G. Craib, *Vernonia Curtisii*, a new Compositæ by Messrs. Craib and Hutchinson, *Aristolochia Curtisii* and *A. minutiflora* by Mr. J. S. Gamble, the former of which had been named in manuscript by the late Sir George King and the latter by Mr. H. N. Ridley.

Mr. Gamble has also described six new species of *Cryptocarya*, ten new species of *Beilschmiedia*, ten new species of *Dehaasia* and three new species of *Endiandra* from the same region.

Selected list of Papers on the Botany of India published during 1909-10.

ADAMSON, R. S. . Note on the roots of *Terminalia Arjuna* Bedd. (*New Phyto., 1910, ix, 150.*)

BAMBER, C. J. . . Plants of the Punjab. (*Journ. Bomb. Nat. Hist. Soc., 1909-10, xix, 370, 683, 943.*)

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ECONOMIC BOTANY.

BY

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In accordance with the practice of previous years this report deals only with original contributions to the Economic Botany of India which have been published or are in course of publication during the year under review, in this case the year ending June 30th, 1910. The programmes of work in this subject are given in detail in the last issue of the *Proceedings of the Board of Agriculture in India* and an abstract is to be found at the end of the present volume. Under these circumstances all references to programmes have been omitted and only the results actually obtained during the year are discussed. A list of original and other papers published during the year is appended.

Wheat.—During the present year a large number of papers have been published on the improvement of the wheat crop. The large amount of work which has been done already throughout India on wheat is the direct result of the discussion which took place at the second meeting of the Board of Agriculture held at Pusa in 1906. At this meeting a scheme for the improvement of the wheat crop was adopted by the Board. Steps were also taken for the preparation of a monograph on the crop to include a botanical survey of the varieties grown, a digest of the scattered information on wheat both in India and other countries together with detailed suggestions for future work. The book, which is entitled *Wheat in India,*

has appeared during the year. The first section deals with the production of wheat in India and also contains a short summary of the various wheat experiments which have been carried out at the experimental farms. The materials from which this section was derived were found to be very widely scattered and quite inaccessible to the student of Indian Agriculture. The second section of the book deals with the diseases of wheat, while the last portion, which is, in the main, original, deals which the improvement of Indian wheat. This section includes a botanical survey of the wheats of India and the recent work which has been done at Pusa on the milling and baking qualities of the wheats of this country. It is hoped that the book will serve as a work of reference to all interested in Indian wheat.

A considerable amount of progress has been made during the year at Pusa on the testing of Indian wheats both in the field and also in the mill and bake-house. The results have been published in Pusa Bulletin No. 17 during the present year. The milling and baking tests have been carried out in England by Mr. A. E. Humphries, a former President of the Incorporated National Association of British and Irish Millers and a well-known authority on these questions; while the analytical work has been conducted, as formerly, by Dr. J. W. Leather, Imperial Agricultural Chemist at Pusa. The views published in a former paper (Pusa Bulletin No. 14) on this subject aroused a considerable amount of attention in India. It was stated in the earlier paper that some of the hard red wheats of the Punjab and especially those liked by the people, gave much better results in the mill and bake-house than the soft white kinds of the type of Mozaffernagar, the cultivation of which has been so consistently advocated since the publication of Messrs. MacDougalls' milling report in 1882. In addition, a Pusa selection (No. 6), originally grown from one plant, proved to be a much better milling wheat, much higher in nitrogen and with greater flour strength than anything previously grown in India. The recommendations in the paper in question were referred by the Director of Agriculture of the Punjab to the President of the Incorporated National Association of British and Irish Millers and the whole subject was considered by the Council of the Association. The result was that the recommendations in Pusa Bulletin No. 14, which were based on Mr. Humphries' report of 1908, were unanimously endorsed by the Council of the most important Milling Association of the Empire, while two of the largest Home millers (Messrs. Nicholls and Rank) proposed and seconded the motion that was adopted. The results obtained and published during the present year in Pusa Bulletin No. 17 more than bear out the

promise of the work of the previous year. Several of the Pusa selections proved superior to Pusa 6 and behaved in the mill and bake-house like Canadian and American Spring wheats which are the most valuable wheats imported into England. These results prove that the idea previously held that India can only grow weak wheats with moderate milling qualities, must be revised and that there is every hope that wheats with great strength and high milling qualities can be successfully produced on the alluvial plains of India. The Pusa selections referred to above, together with some of the new hybrids produced from them are now being tested on a field scale in several localities and the best of these will be distributed to the cultivators.

Progress has also been made in another direction with Indian wheat, namely, on the influence of the environment on the milling and baking qualities. This investigation is being conducted in collaboration with the Economic Botanist to the Government of the United Provinces, and the results obtained up to the present have been published as a memoir of the Agricultural Department. The same wheat, Mozaffernagar, has been grown at a large number of stations in the Indo-Gangetic plain under widely different circumstances as regards soil and irrigation. The samples were analysed, ground into flour and made into bread. The nitrogen percentage of the Cawnpore sample was over 80 per cent. higher than that grown at Aligarh, there were great differences in consistency, while Mr. Humphries considered there was a difference in money value of several shillings per quarter between the best and the worst. There was practically no difference in quality between the Pusa sample grown without irrigation and the Cawnpore sample grown under canal irrigation. This point is of considerable interest as indicating that canal irrigation does not necessarily injuriously affect the milling qualities of wheat. This supposition is further confirmed by the behaviour in milling of five Punjab wheats grown with canal water at Cawnpore. The samples were exceedingly uniform in texture and behaved very well in the mill. Evans has published a short paper on a somewhat related subject in connection with wheats of the Central Provinces where it has been found that excessive irrigation (nine waterings) softens the local wheats, especially the macaroni wheats. These results confirm the earlier work of Le Clerc in the United States on the same subject.

New ground has been broken in another direction with regard to the yield and quality of Indian wheat. It has been repeatedly observed at Pusa that hot weather cultivation of wheat lands leads to a greatly

enhanced yield in the following *rabi* season and, moreover, that the milling qualities of the grain are also improved. The Pusa results have been repeated at Cawnpore and it is believed that they will be of very general application throughout the Indo-Gangetic plain. The investigations recently carried out by Russell and his colleagues at Rothamstead appear to afford an adequate explanation of the increased fertility of the Indian alluvium after it has been exposed to the sun and air during the hot weather. Russell has found that sterilising the soil by heating or by poisons kills off the phagocytes which live on bacteria and also other soil organisms inimical to bacteria. At the same time the soil bacteria are killed off, but the spores remain which germinate and rapidly multiply when the soil is moistened. The new bacterial cultures increase at an enormous rate and the resulting nitrogenous food material becomes so great that plant growth is stimulated. It is not unlikely that the intense heat and dryness of the Indian hot weather has a similar sterilising effect on the soil organisms and that the luxuriant growth which follows weathering is the result of an alteration in the soil flora. Attention has been drawn to this subject in *Nature* and the field trials already completed at Pusa support the views put forward. It is satisfactory to note that the results obtained on this subject at Pusa and Cawnpore, have attracted a good deal of attention in the various Provincial Agricultural Departments and further evidence on the subject will no doubt be available shortly. It is believed that by a combination of hot weather cultivation and occasional green manuring the crop production of the Indo-Gangetic alluvium can be vastly increased and that no more promising field for future work has so far been discovered in the history of agricultural improvement in India.

During the year a large amount of culture work dealing with the extent of natural cross-fertilization in wheat in India has been completed at Pusa and the results are now in the press. It has been found that, under canal irrigation in the Punjab, cross-fertilization in wheat is exceedingly frequent and 226 cases were proved in one year at Lyallpur. Natural crossing in wheat at Pusa occurs rarely and the difference between the behaviour of the same crop in the Chenab Colony and in Bihar is entirely due to the difference in the water supply of the crop in the two cases. At Lyallpur, where wheat is grown entirely under canal irrigation, the crop is watered at least twice after sowing, the last watering taking place after the plants are in ear. Often before this last irrigation the supply of water in the soil is so small that the plants wilt during the hottest part of the day, the glumes open and the stigmas are exposed to the air. Under such

circumstances natural crossing is easy and frequent. At Pusa where wheat is grown without irrigation on high moisture retaining loams, the supply of water is more constant and this wilting does not take place. Consequently natural crossing is rare. These results are interesting from the scientific aspect in showing that environment may modify the usual pollination mechanism in a crop. On the economic side they show that wheat breeding will be difficult at Lyallpur and that the growth of pure wheat seed for distribution to the people is not such an easy matter as in other tracts of India.

The trade aspect of the wheat investigations in India referred to above has been emphasised by the Director of Agriculture of the Punjab and also by Sir James Wilson, K.C.S.I., formerly Financial Commissioner of that Province.

Cotton.—No important papers have been published on this crop during the year under review. At Lyallpur, Milne has described the cotton selection experiments in progress in the Punjab and in Madras, Wood has given an account of similar work at the Nandyal Experiment Station. In both cases the results are published in the Farm reports for 1908-1909.

Fibres.—Several papers on fibres have appeared during the year. Finlow, in the *Agricultural Journal of India*, discusses the work done on the "heart damage" of baled jute by Messrs. Cross & Bevan in London and outlines further work on the subject which it is desirable should be conducted in India.

Two papers on *San* (*Crotalaria juncea L.*) have been published. In the *Agricultural Ledger*, No. 7 of 1908-1909, an account is given of *san* hemp in the Pabna District where two kinds are grown, one called *chotna* for green manuring and the other *boran* for fibre. A short paper has been published in the Botanical Memoirs of the Agricultural Department on two distinct varieties of this crop. A tall, unbranched, fibre yielding kind is grown in the Central Provinces, while the local Bihar variety is much dwarfer, more branched and less suitable for fibre. Other different varieties have since been isolated. An improvement in the use of this crop for green manuring has also been worked out at Pusa. It has been found that the best results are obtained when the crop is sown early in a well cultivated soil and when the green crop is ploughed in during the first week in July. This enables the *san* to decompose thoroughly and to be incorporated into the soil before the end of the monsoon. In addition, there is ample time for the soil to take up a sufficiency of the monsoon rains for the succeeding *rabi* crop.

Fruit.—Continued attention is being paid to fruit culture in India, but only one paper on the subject has appeared during the year, namely, the second report on the Pusa fruit experiments. This paper deals with the results which have been obtained and a detailed account of peach growing in Bihar and of the fruit packing experiments at Pusa is given. Perhaps the most interesting result is that of the tillage experiment where the deleterious effect of grassing down has been even greater than that found in the case of apples at Woburn in England and since repeated at many other places.

Plant Breeding.—Two papers of general interest on this subject were completed during the year one of which has already appeared. Woodhouse has published a short sketch dealing with the possibilities of improving the crops of Bengal by the method of pure line culture. For some years the occurrence of natural cross-fertilization in the Indian crops has been studied at Pusa and the results obtained up to the present year are dealt with in a paper in the press. The experiments with wheat are referred to above under that crop. Other crops dealt with are tobacco, peas, *khesari* (*Lathyrus sativus*, L.), beans, tobacco, *Hibiscus cannabinus* L. and *H. sabdariffa* L., cotton, linseed, the cruciferous oil-seeds, opium poppy, safflower, castor, *Sesamum indicum* and *S. niger*. The results have an important bearing on the choice of the methods of plant improvement, on the testing of varieties, on the introduction of exotics and also on seed distribution.

Tobacco.—Two papers on the work done at Pusa on this subject have been published. Both have appeared in the Botanical memoirs of the Agricultural Department. The first relates to the types of *Nicotiana rustica* and to the occurrence of natural crossing in this crop. The second deals in detail with the botany of the Indian types of *Nicotiana tabacum*. These papers are introductory to the further study of this crop and to the tobacco breeding experiments in progress at Pusa which are now in the second generation. It is hoped to publish the first results on the inheritance of characters in this crop during the present year.

Miscellaneous.—Burkill has published an interesing paper on the plants used in the preparation of Indian pens in the *Agricultural Ledger* and this author has also contributed two papers of economic interest to the *Journal of the Asiatic Society of Bengal*. One refers to some of the oil grasses in the Central Provinces and Berar and the other to the drug known as *Coptis*. Hooper in the same Journal has given an account of tamarisk manna.

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MYCOLOGY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

Mr. MacRae, Officiating Imperial Mycologist, investigated a severe outbreak of blister-blight of tea in Darjeeling District. The disease has been known for many years, but was confined to North-East Assam, where it occasionally caused serious loss. The climatic conditions of Darjeeling appear to be more favourable to the parasite, and it spread with great rapidity after its first introduction in 1908. The life-history of the fungus (*Exobasidium vexans*) which causes it was fully studied by Mr. MacRae and experiments carried out to ascertain the best methods of checking it. The preliminary results were published by the Darjeeling Planters' Association in 1909, and fuller accounts have appeared in the Agricultural Journal of India, and as a Bulletin of the Pusa Institute in 1910.

The campaign against bud-rot of Palms in Madras Presidency was continued. Extension in the Godavari District has been checked but has progressed in Kistna, where the operations were started late. An account of the disease and of the results of the efforts made to stamp it out, was written by the Imperial Mycologist, and has appeared since the close of the period covered by this report

A serious disease of Areca palms, known locally as *Koleroga*, was investigated by Dr. L. Coleman, Mycologist and Entomologist to the Mysore Government. Spraying experiments carried out in 1909, demonstrated the

possibility of saving a great portion of the nuts at a low cost. With the exception of spraying for potato-blight which is practised to a limited extent in the Khasi Hills, this is probably the first successful application of this method of checking fungus diseases made in India on native crops. A full account of the disease and of the remedial measures adopted has since been published as a Bulletin of the Mysore Department of Agriculture.

The results of several years' investigation of the wilt disease of *tur* (pigeon-pea) were published by the writer early in the year. Incidentally it was shown that the fungus *Neocosmospora vasinfecta*, to which many similar diseases have been attributed is, at least in India, a harmless soil saprophyte.

Mr. MacRae visited Rangpur, Eastern Bengal, twice in connection with an enquiry into the cause and treatment of ginger-rot, a disease which the writer had found also to be prevalent in Gujarat. The fungus (*Pythium gracile*) which was noted as the probable cause of the disease in Gujarat was also found in the diseased plants at Rangpur. Attempts to cultivate it failed, so that absolute proof of its parasitism has not been obtained. An account of the disease with a description of the methods of treatment which have given successful results on the Burirhat Farm, is in the press.

Experiments in spraying potatoes with Bordeaux mixture as a protection against potato-blight were continued at the Upper Shillong Agricultural Station and the results are given in the Annual Report of the Agricultural Stations in Eastern Bengal and Assam for 1908-09. The profit resulting from spraying was less than in previous years, but still amply justifies the practice. Demonstrations were carried out on an extensive scale on cultivators' holdings in the Khasi Hills with very satisfactory results, and a separate report on them is promised in the near future.

Mr. Burns, Economic Botanist, Bombay, is continuing his work on wheat rust at several of the Bombay stations, particularly with a view to determining the conditions by which the disease is influenced. Some notes on the subject are given in the Report of the Ganeshkhind Botanical Station for 1908-09 and a fuller account has been submitted for publication. Experiments in treating jowar seed to prevent smut were made at the Dharwar Agricultural Station. Steeping in 2 per cent. copper sulphate for 10 minutes was found to prevent the disease entirely. Attempts to obtain a wilt-resisting variety of *tur* are being made at Kirkee and Dharwar.

Mr. Clouston, Deputy Director of Agriculture, Southern Circle, Central Provinces, has continued to test cottons, with regard to their comparative

susceptibility to wilt, at Akola. *Buri* cotton has proved immune to this disease so far and is being introduced on wilt-affected lands. The use of copper sulphate as a steep for jowar seed was demonstrated widely in the Central Provinces where smut causes great losses. The practice is said to be extending amongst the cultivators. Mr. Evans, Deputy Director of Agriculture, Northern Circle, Central Provinces, is endeavouring by hybridisation and selection to obtain a rust-resistant wheat at Hoshangabad and is also trying to get a wilt-resisting *tur*.

At the Samalkota Station in Madras the work of resuscitating sugarcane cultivation in the Godavari Delta where it was dying out from the ravages of red-rot, was continued. The success obtained so far has been considerable. In the Report of the Station for 1908-09 Mr. R. C. Wood, Deputy Director of Agriculture, Northern Circle, Madras, summarises the practical results already obtained, but calls attention to a disheartening outbreak of disease on the Farm in the previous year. It has since been ascertained by the writer and Mr. A. Hafiz Khan that this was probably not red-rot, but a new root disease which is under study.

Mr. MacRae visited the Wynaad in November 1909, in company with Mr. Anstead, Planting Expert to the South Indian Planters' Association, to make further enquiries into the pepper-vine disease of Malabar. Reports on the tour are given in the Planters' Chronicle, Vol. IV, No. 12, and a scheme of experimental measures for its control, drawn up jointly by the two officers, in Vol. V, No. 2 of the same journal.

Mr. Burns has contributed short notes on diseases of mango trees to the Poona Agricultural College Magazine.

The cocoanut-palm disease in Travancore continues to occupy the attention of the Agricultural Department of that State. In the Annual Report of the Department for 1908-09, Mr. N. K. Pillai outlines the scheme of experiments in the treatment of the disease which he has started, and gives further notes on the area affected and prospects of successful treatment.

Numerous short notes on fungus diseases of rubber, tea, coffee, pepper and other plants have been contributed to the Planters' Chronicle by Mr. Anstead.

The operations carried out in Coorg to limit the spread of spike disease of Sandal are reviewed by Mr. C. McCarthy, Deputy Conservator of Forests, in the Progress Report on Forest Administration in Coorg for 1908-09. Though the extension of the disease into the unaffected northern portion of the province has been checked, there is no appreciable lessening of its severity within the affected area.

An account of a suspected parasite of several important forest trees and palms was contributed by the writer to the Indian Forester. The fungus (*Fomes lucidus*) is a common tropical and sub-tropical species, but has hitherto been generally supposed to be harmless.

An important contribution to the little studied bacterial diseases of plants was published by Dr. Coleman in the Mysore Agricultural Bulletins. The disease is one which affects potatoes throughout Peninsular India and is known as "ring" or "*bangadi*" disease. The bacterium which causes it was isolated and successful inoculations obtained not only on potatoes but also on brinjals and tomatoes. Suggestions for checking its ravages are given.

List of Publications.

ANSTEAD, R. . . Numerous notes on fungus diseases of rubber, tea, coffee, pepper, etc. in *Planters' Chronicle, iv, v, 1909-10.*

BURNS, W. . . Notes on wheat rust in *Ann. Rep. of the Ganesh-khind Bot. Stat. for 1908-09, Bombay, 1909.*

BURNS, W. . . "A note on red rust of the Mango tree" and "Observations on diseases of the Mango tree" (*Poona Agri. Coll. Mag., i, Nos. 1 and 2, 1909-10.*)

BUTLER, E. J. . . *Fomes lucidus* (Leys) Fr., a suspected parasite. (*Ind. For., xxxvi, Sept. 1909.*)

BUTLER, E. J. . . The wilt disease of pigeon-pea and the parasitism of *Neocosmospora vasinfecta.* Smith. (*Mem. Dept. of Agric. in India, Bot. Ser., ii, No. 9, 1910.*)

CLOUSTON, D. . . in *Report on the Agricultural Stations in the Central Provinces for the year 1908-09, Nagpur, 1909.*

COLEMAN, L. C. . The Ring disease of Potatoes (*Bull. No. 1, Mycol. Ser., Dept. of Agric., Mysore State, 1909.*)

EVANS, G. . . in *Report on the Agricultural Stations in the Central Provinces for the year 1908-09, Nagpur, 1909.*

MCCARTHY, C. D.'A. Spike disease in Sandal (*Progress Report on Forest Administration in Coorg for 1908-09, Bangalore, 1910.*)

MACRAE, W. . . The Outbreak of Blister-blight on tea in the Darjeeling District in 1908-1909 (*Ag. Jour. Ind., v, 126, 1910.*)

MacRae, W. . . Report on the Outbreak of Blister-blight on tea in the Darjeeling District in 1908-09 (*Bull. A. R. I. Pusa, No. 18, 1910.*)

MacRae, W. . . Pepper-Vine disease (*Planters' Chronicle, iv, 352 and v, 13, 1909-10.*)

Main, T. F. . . in *Annual Report on the Experimental work of the Dharwar Agricultural Station for 1908-09. Bombay, 1909.*

Pillai, N. K. . Cocoanut palm disease in *Annual Report of the Department of Agriculture, Travancore, for the year 1908-09, Trivandrum, 1909.*

Wood, R. C. . . in *Scientific Report of the Samalkota Agricultural Station for 1908-09, Madras, 1909.*

FOREST BOTANY.

BY

C. M. McCRIE, F.C.H.,

Acting Imperial Forest Botanist.

I.—Work done at the Imperial Forest Research Institute.

Educational Work of Forest Botanist.

1. From July to October the Botanist gave the usual course of botanical instruction to students of the 3rd year, and in March 1910 he conducted the final examinations in Botany of the Ranger class.

Facilities for Research Work. (a) Herbarium and Collections.

2. The re-arrangement of the Saharanpur herbarium (now located at Dehra Dun) and its amalgamation with the herbarium of the Research Institute and College were continued during the year under report, and had been nearly completed by its close. Additions to the herbarium during the year numbered 512 sheets, including a valuable set of 174 duplicates received from Calcutta. A set of duplicates from Dehra Dun was sent to Calcutta in exchange for those received, and it is hoped that this system of exchange may be extended with other herbaria

in India. During the year 35 specimens were identified and named for Forest officers in all parts of India and Burma, and 6 for independent enquirers.

A start was made with a collection of specimens in the College to show type trees and plants of the main natural orders and sub-divisions of the vegetable kingdom. These are to be exhibited in glazed cases for convenience of reference by students and others, and are intended to comprise—

(i) a complete botanical specimen of the species,
(ii) a photograph of the tree or plant,
(iii) specimens of the fruit, seed, and bark.

By the close of the year specimens of 151 species had been collected in readiness for exhibit as soon as glazed cases are ready to receive them. A reference collection of seeds has also been started, in which 60 species are now represented.

(b) Botanical Library.

Two hundred and thirteen volumes were added to the Library during the year. A revised system of classification of the books was sanctioned, and a complete catalogue was drawn up in accordance therewith.

(c) Accommodation.

A botanical laboratory and a potting shed in the experimental garden were built during the year. With these additions the accommodation provided is sufficient for present purposes.

Research Work of Forest Botanist.

3. The following subjects were included in the programme of research for the year :—

(a) Study of the coppicing of Teak, and of its effect on the normal health and development of the tree.
(b) Study of forest grasses, with special reference to the effects produced by repeated firing.
(c) Study of the various species or forms of Grewia of economic importance.
(d) Study of Teak reproduction.
(e) Study of Sal reproduction.

As regards the first subject, the investigations begun last year on the effect of coppicing on the normal health and development of Teak were continued, but are not yet complete. A preliminary note on the best season for coppicing Teak was published during the year, giving the results of experiments conducted in the Jubbulpore Division of the Central Provinces.

These experiments indicate that the best months for coppicing this species are March and September, or, to put it more generally, that the *worst* period for such fellings is from the time when vegetative activity commences up to, and for a short time after, the full development of the foliage, while the *best* season is immediately before and after this period.

The results of the enquiry regarding forest grasses, commenced last year, were worked up during the year under report, and were sent to press for publication in the form of a Memoir. These results indicate that forest grass lands should as far as possible be classified as follows : —

(i) those which are required for grazing and for the production of fodder;

(ii) those which are not required for fodder production and which it is advisable to afforest.

The enquiry has shewn that the production of trees and that of grass are two distinct and more or less incompatible objects which require distinct methods of treatment.

As regards fodder supply, the work has shewn that where hygrophilous or coarse mesophilous grasses are dominant, early firing is as a rule decidedly beneficial, as it :—

(i) increases the supply of palatable fodder from these species at a time when fodder is scarce, and

(ii) tends to replace these coarse species by less vigorous and generally more valuable fodder grasses, either by direct injury to the coarser plants themselves, or by drying up the soil and thus rendering it less fit for the coarser species.

In those grass lands where valuable fodder grasses are already dominant, firing may tend to favour the spread of the less desirable species, and is not advisable.

As to afforestation, the enquiry has shewn that it is advisable to classify the local grass lands into :—

(i) those in which the vigorous growth of most woody plants is made impossible by frost, the latter being the factor of dominant importance;

(ii) those in which damage by frost is seldom or never severe.

In lands of the first class, only the most frost-hardy species such as *Acacia Catechu* and *Zizyphus Jujuba* can be introduced with any hope of success. In some cases it is possible that radiation might be decreased and the effects of frost diminished by (1) clearing lines through the surrounding

forest, and thus stimulating the circulation of air, or by (2) irrigating the soil and keeping it moist, which would increase the quantity of water vapour in the air.

As regards grass lands of the second class (*i.e.*, those not subject to severe frost) the investigations have indicated that, as a general rule, the species of grass dominant in each locality is an accurate indication of the prevailing conditions of soil and moisture, and thus points clearly to the tree species which can be introduced with the best prospect of success. Thus where *Saccharum ciliare* is dominant, the locality is generally suitable for dry miscellaneous forest species; where *Saccharum Narenga* prevails, the locality is usually suitable for Sal, and where *Erianthus Ravennæ* is dominant, moist miscellaneous forest species are indicated.

The study of the classification and description of the important tree species of *Grewia* was continued during the year under report, but could not be completed owing to the non-receipt of certain specimens from Baluchistan and the Shan States. This enquiry will be completed and the results published next year.

Observations were started in the experimental garden at Dehra Dun with the object of discovering the factors primarily responsible for the dying back of Sal and Teak seedlings. These observations are not yet complete, and require to be checked with the results of control experiments conducted in the forests. But so far as they go they appear to indicate that, under the local conditions of soil and climate, dying back is not a natural and inevitable incident in the life-history of the seedling, but is brought about by an insufficient supply of available moisture in the soil.

No touring could be done by the Botanist during the year. Mr. Hole was fully engaged at Head-quarters in working up the information and specimens collected during previous tours until he went on leave in the end of April 1910.

II.—Work done elsewhere.

4. Forest officers in all parts of India and Burma helped the Botanist with specimens required for his research work. A considerable number of botanical specimens were also collected for the Reporter on Economic Products to the Government of India, for the forthcoming Exhibition at Allahabad, and for other purposes. Investigations into matters connected with Forest Botany are in progress in several provinces, but none of these are in a sufficiently advanced state to be recorded at present. Interesting and valuable notes have, however, been collected by several officers (notably

in the Kheri and Bahraich Divisions of the United Provinces) on such subjects as the germination and development of seedlings of forest species, the times at which local species shed their leaves and put out new foliage, and the seasons of their flowering and fruiting. Experiments undertaken in the Gonda Division are reported to have shewn that Sal coppice shoots are capable of yielding perfectly fertile seed.

Mr. A. E. Lowrie, I.F.S., is preparing an illustrated list of trees, shrubs, etc., found in the Southern Circle of the Central Provinces, and Mr. D. O. Witt, I.F.S., was engaged on an illustrated list of the common grasses of the Berar Circle, which is expected soon to be ready for the press. Rai Sahib Upendranath Kanjilal, Extra Deputy Conservator of Forests, has revised his "Flora of the School Circle," and an enlarged edition of this work is now in the press.

5. The following publications of the year may be mentioned as dealing more or less directly with Forest Botany :—

NAYADU, S. . . The distribution and cultivation of *Acacia arabica* in Berar. (*Ind. For., xxxv, No. 9*).

LUSHINGTON, A. W. . The Genus *Citrus*, by A. W. Lushington. (*Ind. For., xxxvi, Nos. 6 and 7.*)

HOLE, R. S. . . Note on best season for coppice fellings of Teak (*Tectona grandis*). (*Forest Pamphlet No. 16.*)

SYLVICULTURE.

BY

R. S. TROUP, F.C.H.,

Imperial Sylviculturist and Superintendent of Forest Working Plans.

Measurements in sample-plots.

Hitherto measurements in sample-plots in typical forest crops have been carried out entirely by local Forest officers, the results being recorded at the Forest Research Institute. These measurements are concerned only with girth increments, and take no account of the volume of material produced per acre under different conditions. In order to calculate the girth increment of trees, with a view to fixing a girth limit for exploitation purposes and for estimating the rotation of the crop, these measurements are no doubt useful: for forming a correct idea of the productive capacity of the locality, however, they are of little value, since the girth increment of individual trees depends largely on the density of stocking of the crop, and though the several trees of the crop may show a rapid growth in girth, the volume increment per acre may be comparatively small.

This being so, it follows that in order to estimate the productive capacity of a forest area, and in order to classify localities according to productivity, it is necessary to carry out periodic volume measurements in typical fully-stocked crops and also to test the effect of thinnings of different degrees on the volume increment of the crop as a whole. This work will be carried out by the Sylviculturist, who has already selected a number of typical areas in the *sál* forests of the Siwalik, Garhwal and Kheri Divisions of the United Provinces. Actual measurements will commence forthwith, and will be pushed on as rapidly as time and staff permit.

Developments in sylvicultural systems: (*a*) Sál (Shorea robusta).

2. The question of introducing more uniform methods of working in *sál* forests continued to receive attention during the year. A block of *sál* forest about 7½ square miles in extent at Thano near Dehra Dun has recently been taken up as an experimental ground for the application of the system of successive regeneration fellings, and the Sylviculturist was engaged during the year in compiling a working-plan

for the forest in question, with a view to introducing the system experimentally.

(*b*) Teak (Tectona grandis in Burma).

3. It is some years since attention was first called to the adverse effects of continued fire-protection in some of the moister types of Teak forest in Burma worked under the selection system, and more recently a change of system has been suggested in order to ensure the adequate reproduction of Teak by utilizing the respective benefits of burning and fire-protection. This idea was strongly urged by Mr Beadon-Bryant in an article entitled "Fire Conservancy in Burma" in the *Indian Forester* of December 1907.

During the past year the matter has been under further consideration and a "Memorandum regarding prescriptions for improvement fellings in Teak working-plans in Burma, and the introduction of a more uniform system of working" was drawn up; this memorandum is printed in the *Indian Forester* of October 1909, page 584. A subsequent and more detailed memorandum, written after consultation with the Inspector-General of Forests, was read and fully discussed, and approved of with certain modifications, at a Forest Conference held at Maymyo in June 1910, and it is hoped that the system finally adopted by the Conference will shortly be applied as a tentative measure is some typical forest tract. Briefly stated, the system consists in concentrating improvement fellings and subsidiary operations over definite blocks throughout a period of 25 years, this being considered long enough to ensure the adequate establishment of Teak reproduction : this having been effected, other blocks will be taken in hand, the whole forest area being thus regenerated during one rotation, by successive regeneration periods. Although the system will tend towards the eventual formation of even-aged crops, this will not be accomplished during the first rotation, since it was decided by the Conference to be inadvisable as a general rule to fell under-sized teak trees in the interests of the future crop, even in blocks under regeneration.

Causes and effects of drought on *Sal* forests of Oudh.

4. A portion of the past season was spent in investigating the causes and effects of the drought of 1907 and 1908 on the *sál* forest of Oudh, and with the assistance of the local Forest officers a number of borings down to water-level were made in affected and unaffected areas to ascertain the effect of the sub-soil on the degree of damage done. This investigation is not yet complete, but it will be continued during the coming season.

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Statistical information on Burma Teak forests.

5. A note on some statistical and other information regarding the Teak forests of Burma was prepared during the year, and has gone to press. This note, compiled from all the Teak working-plans hitherto published in Burma and from the control forms showing the results of working, furnishes information regarding types of forest, rate of growth, density of stocking, yield and outturn, and other matters.

Germination of *Sal* seed.

6. Experiments are in progress in all the principal *sál*-bearing areas with a view to testing the germinative power of *sál* seed collected from trees of all sizes from the smallest to the largest, and from sound and unsound trees, respectively. Experiments of this kind can be carried out only in the neighbourhood of the forests concerned, because *sál* seed cannot be kept for more than a few days owing to its perishable nature : hence local Forest officers are giving their assistance in carrying out the necessary germinating tests. The results, when complete, should be of value in helping to elucidate problems concerned with the regeneration of *sál* forests.

Working-plans sanctioned during the year.

7. Three working-plans were sanctioned during the year, namely—

(1) **Working-plan for the Forests of the Nowgong Division, Eastern Bengal and Assam.**—By E. M. Coventry, I.F.S. The plan deals with an area of about 157 square miles, partly of *sál* and partly of miscellaneous forest. Working for 10 years is prescribed by improvement fellings, with the object of restoring the previously overworked and partially ruined *sál* forest to a better condition.

(2) **Revised working-plan for the Bori Range Forests, Hoshangabad Division, Central Provinces.**—By A. A. Dunbar-Brander, I.F.S. This plan deals with an area of some 42 square miles of forest in which Teak is the principal species ; the forest is one of the most important tracts of Teak in the Central Provinces, but was in former days much ruined by shifting cultivation. The plan prescribes improvement fellings including thinnings and the removal of over-mature trees, for a period of 10 years.

(3) **Working-plan for the Mawku Working Circle, Upper Chindwin Division, Upper Burma.**—By L. C. Davis, I.F.S.

The area concerned is some 309 square miles, of which 299 square miles are Teak-bearing. The system prescribed is the selection system with a rotation of 180 years and an exploitable girth of 7 feet. The possibility, based on enumerations extending over 24 per cent. of the Teak-bearing area, is estimated at 5,000 sound Teak trees per annum. Improvement fellings in the interests of Teak will be carried out as far as practicable. The period of the plan is 24 years.

List of Indian Publications, 1909-10.

BEST, HON'BLE J. W. . The effects of cattle-grazing in Bhandara Division, Central Provinces. (*Ind. For., xxxv, 610.*)

BEST, HON'BLE J. W. . The prevalence and utility of *Xylia dolabriformis* in the Central Provinces. (*Ind. For., xxxv, 677.*)

CACCIA, A. M. F. . Note dealing with the Progress made in Working-plans outside the Madras and Bombay Presidencies, up to the 31st December 1908, with special reference to the application of the various Sylvicultural Systems. (*Forest Pamphlet No. 9.*)

CACCIA, A. M. F. . Revised (Fourth) Edition of D'Arcy's "Preparation of Forest Working-plans in India."

COVENTRY, E. M. . Working-plan for the Nowgong Reserved Forests, Eastern Bengal and Assam.

DAVIS, L. C. . Working-plan for the Mawku Working Circle, Upper Chindwin Division, Upper Burma.

DUNBAR-BRANDER, A. A. Revised Working-plan for the Bori Range Forests in the Hoshangabad Forest Division, Central Provinces.

MCCRIE, C. M. . The Mixed Teak Forests of the Saugor Division, and their Treatment. (*Ind. For., xxxv, 553.*)

REBSCH, B. A. . The Bamboo (*Dendrocalamus strictus*) Forests of the Ganges Division, United Provinces. (*Ind. For., xxxvi, 202.*)

TROUP, R. S. . Memorandum regarding Prescriptions for Improvement Fellings in Teak Working-plans in Burma,

and the Introduction of a more Uniform System of Working. (*Ind. For., xxxv, 584.*)

TROUP, R. S. . . The Practical Determination of the Girth Increment of Trees, with Tables.

ECONOMIC FOREST PRODUCTS.

BY

R. S. PEARSON, F.L.S.,
Imperial Forest Economist.

1. **Economic Museum.**—The work of the year commenced with the re-arrangement of the Forest Economic Museum. The foundation of this Museum was laid by Sir Dietrich Brandis in 1881. It was consolidated and improved by Mr. Gamble during his tenure of the office of Deputy Director and afterwards Director of the Dehra Dun Forest School.

The Museum, as constituted by those officers, was partly of a Botanical, and partly of an Economic character. On the inauguration of the Forest Research Institute it was decided to form a Museum entirely of Economic Forest Products and to hand over all purely Botanical specimens to the Forest Herbarium.

Besides the Economic specimens available in the old Museum, a large number of specimens were obtained from the Franco-British Exhibition of 1908, and from the Nagpur Exhibition, while others were collected by Forest officers in India and Burma, and by the students of the College. In this way the total number of exhibits available amounted to 1,350.

The classification and arrangement of the Museum was completed during the rains, and a descriptive catalogue prepared which is now in the press.

2. **Educational Work.**—It was found possible to reduce the educational work formerly entrusted to the Imperial Forest Economist, thus giving him more leisure to carry out his programme of research work. A course of lectures in Utilization was delivered to the senior students during the rains term, while the 3rd year class was given work in laboratory. A course of Surveying and Engineering was also given to the latter students during September and October.

3. **The Match Industry.**—The enquiry into the Match Industry was completed in 1908-09, the results of which have been recorded by Mr. Troup in his recently published memoir on the subject.

The position of the industry in India is as yet not altogether satisfactory. From the enquiry made into this business it was found that want of expert help, as also of a sustained annual yield of suitable wood for match sticks and boxes are the greatest difficulties to be overcome.

4. **Antiseptic treatment of Timber.**—A considerable amount of attention was paid to the antiseptic treatment of timber during the year. The enquiry naturally falls under two heads. The first portion of the enquiry consisted in treating specimens of timber with a variety of antiseptics on a laboratory scale, by which the amount of absorption and mode of penetration of the various preservatives was studied and estimates made as to the cost of each process. The pieces so treated were afterwards placed in the ground and kept under observation. The second part of the enquiry consisted in making arrangements for treating five thousand railway sleepers of five different species of timber by the Powell process, which when ready are to be laid down on one of the main railway lines and kept under observation. It is hoped to gradually extend this enquiry by treating fairly large numbers of railway sleepers with other antiseptics, as the results of past trials and the present laboratory experiments indicate that this is desirable.

So far as the results obtained by treating timber according to the open tank have come to hand, it is evident that whatever preservative is used the harder Indian timbers will require a longer period of immersion in a fluid, heated to a higher temperature, than is necessary for most of the European timbers. Various antiseptics have been given a trial, amongst which may be mentioned *Arenarius Carbolineum, Jodelite, Atlas solution, Coal-tar, Pine-tar, Solignum, Green-oil, Bellit* and a mixture of chloride of zinc and sodium-fluoride, while 147 specimens of various species treated by the Powell process have also been kept under observation. Up to the present nearly all these processes have given good results, even with the softest woods, on the other hand all the specimens have been laid down within the last two years, an insufficient period from which to draw conclusions. Time only can prove their respective merits, while the value of the various solutions must largely depend on how far they are retained by the timber after heavy rainfall or on exposure to excessive heat. Theoretically speaking those substances which have a low boiling point are unsuitable as antiseptics, while solutions

containing heavy oils with a high boiling point, such as are yielded by the distillation of tar more closely fulfil the necessary conditions for good preservatives.

5. **Utilization of oil seeds yielded by forest trees.**—This enquiry has been going on for several years. The most useful result obtained was, with the oil from the seed of *Schleichera trijuga*, which was stated by a large factory to be most suitable for soap-making. At first a slight difficulty was experienced by the presence of ammonia salts in the oil, which was, however, overcome without much trouble. It is now hoped that it will be possible to work this oil on economic lines in connection with the manufacture of soap. Attempts were made to place the seed of *Prunus eburnea*, *Mesua ferrea*, *Hydnocarpus Wightiana*, *Bombax malabaricum*, and *Diospyros montana*, on the market, in most cases with fair success.

6. **Wood and Bamboo Pulp.**—One of the most important subjects under investigation was in connection with the possibility of manufacturing wood and bamboo-pulp. A commencement was made by visiting three of the largest existing paper mills in India, and discussing the position of affairs with the Managers. Further, many of the likely bamboo areas on the West Coast of India were visited, with a view to the collection of data as to the possible outturn from any one locality, cost of extraction, labour supply and to fix on possible factory sites. In order to ascertain the percentage of pulp yielded by the various timbers and bamboos, arrangements were made to carry out laboratory tests with the raw materials, and also to have tests made on a large commercial scale with 100 tons of bamboos and twenty varieties of timber. It is proposed to complete this enquiry by visiting the forests of Burma and Arakan.

7. **Investigation into the physical properties and seasoning power of Timber.**—By the courtesy of the Principal of the Civil Engineering College, Sibpur, the writer was allowed to use the testing machine at that Institute and to carry out experiments as to the relative strength of plantation and natural grown Teak from Burma. The timber on which the experiments were carried out came from the Zigon Division of the Pegu Circle. The results obtained shewed that as regards transverse strength the natural grown Teak was slightly stronger than the plantation grown timber, while the reverse was the case when crushing and shearing stress came into play. On the other hand the differences shown by each set of tests were so trifling that for all practical purposes both classes of timber were found to be of equal value. The experiment further demonstrated that the percentage of moisture in the timber is a very important factor so that

unless the percentage of moisture in two sets of specimens is very approximately equal, no reliable deduction can be made as to their relative strength. Another set of experiments is being carried out as to the liability of timber to split while seasoning. It is a well-known axiom that by retarding the process of seasoning the liability of timber to split is reduced. Working on this assumption, a substance known on the market as "Ligno," which is a thick brown paste, was applied to the ends of the short butts of green timber with a view to retarding the process of seasoning. The logs selected for treatment were taken from species known to be liable to split while seasoning and were laid down about a year ago and kept under observation. Untreated butts, cut from the same stems, were kept together with the treated specimens, so as to allow of comparison one with another. So far the results have shown that in some cases the treatment has been most beneficial, while in all cases it has tended to stop splitting. The moisture tests carried out to ascertain the relative rates of seasoning, however, showed that the untreated pieces are in many cases practically seasoned, while the treated specimens still contain a high percentage of moisture. The final results as to the value of this substance will not be available until the treated pieces are completely seasoned.

8. **Minor Investigations.**—A great number of minor investigations were carried out during the year, chiefly at the instance of Indian firms. Certain timbers were tested as to their suitability for pencil-making, of which *Cupressus torulosa* proved excellent, while the timbers of *Podocarpus neriifolia*, *Cedrus Deodara*, *Wrightia tomentosa*, *Wrightia tinctoria* and *Pinus longifolia* were also considered suitable, especially that of the two first mentioned species.

Sonneratia apetala was passed as suitable for packing-cases; *Taxus baccata* for bows; *Gmelina arborea* for mallet-handles; *Pterospermum acerifolium*, *Podocarpus neriifolia* and *Gmelina arborea* were considered (provisionally) suitable for mathematical instruments, such as set squares. Walnut "burrs" sent from the Panjab to a European firm, were considered to be little inferior to Persian "burrs" for the purpose of cutting veneers; *Holoptelea integrifolia* proved excellent for handles and that of *Diospyros Kurzii* and *Diospyros Melanoxylon* as suitable for brush-backs; while the results of the trials to be made on timbers being tested for cotton-mill rollers, knife and razor handles, fruit crates, paving-blocks, tea-boxes, cricket-bats, tool-handles, etc., are as yet not available.

9. **Botanical and other specimens.**—A large number of wood and botanical specimens, samples of seed and minor forest products, were

collected by the Forest Department and supplied to the Reporter on Economic Products; the Imperial Institute, London; the Imperial Forest Research Institute, Dehra Dùn; the Agricultural Research Institute, Pusa; the Imperial Bacteriologist, Muktesar; the Madras Museum; the Deputy Commissioner, Mianwali; South Africa; Austria; the Chemical Examiners, Lahore; the Lahore Technical School; the Bureau of Science, Manila; Philippines; Professor Percy Groom of the Royal College of Science, South Kensington, London; and to a number of firms and private persons both in India and Europe. The officers of the Forest Department also took great pains to collect a large number of wood-specimens which were missing in the wood collection of the Forest Research Institute, thus helping to complete this already extensive collection of Indian timbers.

Publications.—The following is a list of some of the important publications and articles brought out during the year and which deal with subjects of economic interest :—

Fibre producing plants in India (*Ind. For. October 1909, 561-569.*)

RAIT, WILLIAM . . A note on new fibres for paper (*Ind. For. Jan.-Feb. 1910, 34-36.*)

SINDAL, R. W. . . Bamboo for paper-making.

TROUP, R. S. . . . Note on Burmese Leza wood (*Lagerstroemia tomentosa*). Forest Pamphlet No. 10, Economy Series, No. 3.

TROUP, R. S. . . . Note on Carallia wood (*Carallia integerrima*). Forest Pamphlet No. 11, Economy Series, No. 4.

TROUP, R. S. . . . Note on Petwun or Trincomali wood (*Berrya Ammonilla*). Forest Pamphlet No. 12, Economy Series, No. 5.

TROUP, R. S. . . . Note on Burmese in wood (*Dipterocarpus tuberculatus*). Forest Pamphlet No. 13, Economy Series, No. 6.

TROUP, R. S. . . . Note on Burma Padauk (*Pterocarpus macrocarpus*). Forest Pamphlet No. 14, Economy Series, No. 7.

TROUP, R. S. . . . Note on the Fissibility of some Indian woods. Forest Record, Vol. II, Part II.

TROUP, R. S. . . . Indian Forest Memoir, Vol. II, Economy Series, Part I. Note on the Prospects of the Match Industry in the Indian Empire, with particulars of proposed match factory sites and woods suitable for match manufacture.

INDIAN ZOOLOGY

with special reference to the work of the Indian Museum.

BY

N. ANNANDALE, D.Sc., C.M.Z.S., F.A.S.B.,

Superintendent of the Indian Museum.

I.—Work in the Indian Museum.

Since my last report was submitted, the scientific staff of the Natural History Section has been reorganized and augmented by the appointment of two additional Assistant Superintendents, Mr. S. W. Kemp, formerly a member of the scientific staff of the Irish Fishery Board, and Mr. F. H. Gravely, formerly Lecturer on Zoology in the University of Manchester. These changes should render it possible to augment the practical utility of the Museum in several directions, especially as a centre of instruction for higher studies in zoology and scientific questions connected with fisheries. Applications are now being received from students who have passed through the ordinary courses in biology and desire instruction in methods of zoological research, and two such students have already worked in the Museum under Mr. Gravely.

Mr. Kemp, who has been appointed Senior Assistant Superintendent, has as yet devoted the greater part of his time in this country to a study of the Indian Decapod and Stomatopod Crustacea considered from a systematic point of view. He has a lengthy report on the latter nearly completed and has already published a revision of the Indian species of the genus Gennadas. He has also undertaken on behalf of the Museum an inquiry as to the cause of the death of fish in certain tanks in the Murshidabad district of Bengal. With adequate funds at its disposal the Museum would now be able to increase its work in such directions to a very considerable extent.

Mr. Gravely has commenced an investigation into the structure, life history and taxonomy of certain groups of Arachnida and Myriapoda, and has published several preliminary papers on the subject in the "Records of the Indian Museum" and "Spolia Zeylanica."

The systematic study of the freshwater fish of India and the surrounding countries has been undertaken by Mr. B. L. Chaudhuri, Assistant Superintendent, who has prepared a report on a large collection obtained from Tirhut through the generous assistance of Mr. M. Mackenzie, Circle Officer, Hathwa Raj, Saran, and another on a collection from Lake Tali Fu in Yunnan made by Mr. J. Coggin Brown of the Geological Survey of India. Mr. Chaudhuri has also identified a considerable number of fish from different parts of India which feed on mosquito larvæ. At least one of the species is new to science.

Mr. E. Brunetti, whose fruitful work on Indian Diptera must shortly come to an end through lack of funds, has been engaged for some time on a volume on the *Tipulidæ*, *Mycetophilidæ*, *Psychodidæ* and several other smaller families of *Nemocera* for the official "Fauna of British India," the large additions recently made to our collection of Diptera by himself and others having made it possible to undertake this important work, which could not have been contemplated elsewhere than in Calcutta.

I have myself continued my work on the fauna of stagnant water and have completed the manuscript of a volume of the "Fauna" on the sponges, polyps and polyzoa of fresh water. It is gratifying that at any rate two volumes of this series, of which about a dozen other volumes are now being prepared in Europe and America, should be written in India by authors with access to fresh material and to the collections preserved in this country.

A healthy sign of progress in the zoological work of the Museum is the interest shown in the collections by members of the non-gazetted staff, to whom we are indebted for the gift of several valuable collections of insects and other animals made while they were on leave or holiday. The collections

have also been widely extended by the exchanges with European and American Museums. Commanding as the Indian Museum does the supply of Indian specimens of several of the more important and obscure groups of animals, it is not difficult to fill in many blanks in the collection by this method, although it is of course much less satisfactory than that of collecting the specimens ourselves.

It is satisfactory to report that several distinguished zoologists from abroad have made use of our laboratories during the year. I may mention in particular the names of Sir Charles Eliot, Vice-Chancellor of Sheffield University, who examined certain Nudibranch Molluscs, and Mr. C. William Beebe, Curator of Birds in the New York Zoological Gardens, who prepared a full list of the collection of pheasants and their allies.

II.—Work elsewhere in India.

Zoological work has this year by no means been confined in India to the Museum. Text books for the use of Indian students have been prepared in Calcutta by Captain R. E. Lloyd, I.M.S., Professor of Biology in the Calcutta Medical College, and in Bombay by Dr. A. Powell, Professor of Biology in the Grant College. The former work is the more elaborate of the two and lays great stress on theory, in which the author expresses the views of an influential school of English zoologists without neglecting the more practical side of instruction. Captain Lloyd has also published a paper on Indian rats (Records, Indian Museum V.) in which fresh evidence is adduced as regards variation in the common species. In Lahore Major J. Stephenson, I.M.S., Professor of Biology in the Government College, has continued his researches on aquatic worms, while in Madras Dr. J. R. Henderson, Professor of Biology in the Christian College and Officiating Superintendent of the Government Museum, and his assistant Mr. G. Matthai have written a memoir on the freshwater prawns of South India which will be shortly published in the "Records of the Indian Museum." In the same periodical a revision of the Indian genera of Anopheline mosquitoes by Major S. P. James, I.M.S., will be issued immediately. Major James has also described a new genus of mosquitoes from material belonging to the Museum in the new journal "Paludism", which is devoted to the study of Malaria.

The Bombay Natural History Society has issued in its "Journal" a number of valuable papers, many of which have been illustrated in a manner that no other private society in the East could undertake.

III.—Work on Indian Zoology in Europe and America.

Perhaps the most important work on general lines published abroad during the year is Dr. P. Sarasin's paper on the geographical distribution of the fauna of Ceylon, its interest being by no means confined to that island.

Lieutenant-Colonel A. W. Alcock, F.R.S., has continued in England the work he inaugurated in India, by writing an account of the Indian freshwater crabs (*Potamonidæ*), which has been published as fasciculus 2, part I of the Catalogue of Decapod Crustacea in the collection of the Indian Museum. He has in this fascicule proposed many new characters whereby the species, genera and sub-genera of the *Potamonidæ* may be distinguished from one another and has added considerably to our knowledge of the distribution of the freshwater fauna of the Oriental Region. Dr. R. Koehler of the University of Lyons has added a fresh part to the Catalogue of the Echinoderms of the Indian Museum to which he and his colleague Dr. Vaney had already contributed four parts. The fifth part consists of a description of the shallow-water starfishes and is illustrated by a number of plates in which a large proportion of the Indian species are figured in a very clear manner by reproductions of photographs.

Two volumes of the "Fauna of British India" have appeared under the editorship of the new Editor, Dr. A. E. Shipley, F.R.S., one on the earwigs by Dr. Malcolm Burr and one on certain families of Lamellicorn beetles by Mr. G. J. Arrow.

References to other work will be found in the following list of papers, etc., published during the year and having a direct reference to Indian zoology. The list has been compiled by Mr. B. L. Chaudhuri, Assistant Superintendent, Indian Museum.

List of papers and books having a special reference to Indian Zoology recently published.

Memoirs published in India.

GENERAL.

In the *Records of the Indian Museum*. Contributions to the fauna of Yunnan, Introduction, by J. Coggin Brown, B.Sc., F.G.S., Assistant Superintendent, Geological Survey of India, Vol. v, 1910, 193.

Independent works. *Report on the Marine Zoology of Okhamandal in Kattiawar*, Part I, by James Hornell, F.L.S., with Supplementary Reports on (1) a new species of Pinnoteres, (2) the Anomura of Okhamandal, (3)

Alcyonarians of Okhamandal, and (4) the Nudibranchs of Okhamandal. 1909.

Lessons on Practical Biology for Indian Students. By Arthur Powell, B.A., M.Ch., Professor of Biology, Grant College, Bombay, 1910.

Porifera (Sponges).

In the *Records of the Indian Museum.* Notes on Freshwater Sponges, No. XI, by Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Superintendent, Indian Museum. Vol. iii, 1909, 275.

Notes on Freshwater Sponges. No. XII. Description of a new species from Cape Comorin. By the same author. Vol. v, 1910, 31.

Sponges from Yunnan. By the same author. *Ibid.*, 197.

Cœlenterates.

In the *Records of the Indian Museum.* Branchiocerianthus imperator von der Küste von Oman und Baluchistan. By E. Stechow, München. Vol. iii, 1909, 296.

The Hydroids of the Indian Museum. No. 1. The Deep-sea Collection. By James Ritchie, M.A., B.Sc. Vol. v, 1910, 1.

Annelida.

In the *Records of the Indian Museum.* Studies on the aquatic Oligochæta of the Punjab. By Major J. Stephenson, M.B., D.Sc., I.M.S., Vol. v, 1910, 59.

Note on Polychæte worms. By the same author. *Ibid.*, 82.

Myriapoda.

In the *Records of the Indian Museum.* On a sub-species of Scutigerella unguiculata, Hansen, found in Calcutta. By F. H. Gravely, M.Sc., Assistant Superintendent, Indian Museum. Vol. v, 1910, 157.

The distribution of the Oriental Scolopendridæ. By the same author. *Ibid.*, 161.

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The rate of growth in two species of barnacles. By the same author. *Ibid.*, 295.

Description of a new species of Scalpellum from the Andaman Sea. By the same author. Vol. v, 1910, 115.

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Two barnacles of the genus Dichelaspis new to Indian seas. By the same author. *Ibid.*, 213.

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Notes on the Trichoptera in the collection of the Indian Museum. By C. Betten. *Ibid.*, 231.

Descriptions of three new Cicindelinæ (Coleoptera) from Borneo. By Dr. Walther Horn, Berlin. *Ibid.*, 259.

The Hemipterous family Polycteniidæ. By Dr. P. Speiser. *Ibid.*, 271.

Field notes on Indian Insects. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Superintendent, Indian Museum. *Ibid.*, 293.

Description of a minute Hymenopterous insect from Calcutta. By the same author. *Ibid.*, 299.

The Insect Fauna of Tirhut. No. 1. By H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S., Imperial Entomologist. *Ibid.*, 301.

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The Indian species of Papataci Fly (Phlebotomus). By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S. *Ibid.*, 35.

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Notes on the larvæ of Toxorhynchites immisericors. By C. A. Paiva, Assistant, Indian Museum, *Ibid.*, 187.

Cockroaches as predatory insects. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Superintendent, Indian Museum. *Ibid.*, 201.

Note on Ædeomyia squammipenna. By C. A. Paiva, Assistant, Indian Museum. *Ibid.*, 202.

Named specimens of Chrysomelidæ in the Indian Museum. By S. Maulik, Temporary Assistant, Indian Museum. *Ibid.*, 202.

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In the *Journal of the Bombay Natural History Society*. The butterflies (Rhopalocera) of the Nimar District, Central Provinces. By D O. Witt, I.F.S., Vol. xix, 1909, 564.

Biological Notes on Oriental Hemiptera, No. 4. By J. C. Kershaw and G. W. Kirkaldy. *Ibid.*, 571.

Descriptions of Indian Micro-Lepidoptera. By E. Meyrick, B.A., F.R.S., F.Z.S. (X—Eucosmidæ). *Ibid.*, 582. (XI—Oecophoridæ). Vol. xx, 1910, 143. (XII—Gelechiadæ). *Ibid.*, 435.

The Common Butterflies of the plains of India (including those met with in hill stations of the Bombay Presidency). By T. R. Bell, I.F.S. (continued from p. 439 of Vol. xix), with plates. Sub-family—Nymphalinæ. *Ibid.*, Vol. xix, 635 and 846; *Ibid.*, Vol. xx, 1910, 279.

Descriptions of new genera and species of Indian Ichneumonidæ. By P. Cameron, *Ibid.*, 722.

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AGRICULTURAL ENTOMOLOGY.

BY

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Imperial Entomologist.

The study of the insect pests of crops was continued at the Pusa Research Institute, and by the Assistants in Provincial Agricultural

Departments. The life-histories of injurious species were worked out at the Pusa Insectary, the further study made on the Pusa Farm and in the district. The more important of which the life-history was done were the:—

Palm Weevil (*Rhynchophorus ferrugineus*).
Rhinoceros Beetle (*Oryctes rhinoceros*).
Army Worm (*Cirphis unipuncta*).
Rice Swarming Caterpillar (*Spodoptera mauritia*).
Deccan Grasshopper.
Wheat Stem Borer (*Sesamia uniformis*)
Pink Bollworm (*Gelechia gossypiella*).
Indigo Leaf Webber (*Ypsolophus ochrophanes*).
Dusky Cotton Bug (*Oxycarenus lactus*).
Wheat Weevil (*Calandra oryzae*).
Rice Grain Moth (*Sitotroga cerealella*).

A study is being made of the White Ant (*Termes obesus*) and methods of checking it are being tested in conjunction with the Deputy Director of Agriculture, Northern Circle, Central Provinces. In collaboration with the Imperial Agricultural Chemist, an enquiry was made into the amount of dessication required to inhibit weevil in wheat. The investigation of the food of birds was completed by Mr. C. W. Mason. Insecticides sent in for trial were tested and a new insecticide of indigenous manufacture has been adopted and recommended, all imported ones being too costly. The question of Apiculture is being considered and attempts made to ascertain if bees can be profitably kept in the plains.

Investigation into Eri silk has been limited to the study of disease, in collaboration with the Imperial Agricultural Bacteriologist, and to the question of hybridising. Hybrid races of Eri (*Attacus ricini*) and of the wild form (*Attacus cynthia*) have been obtained and are being propagated; these may have an important influence on eri cultivation as the strains are hardier and less liable to disease. In regard to mulberry silk, enquiry has been directed mainly to the question of producing better multivoltine races by hybridising univoltine European with multivoltine Indian races and this will be continued. In lac, an attempt is being made, in conjunction with the Forest Department, to obtain material for discriminating the number of distinct races or species of the lac-insect, which is at present wholly unknown. Cultivation of lac is done on a small scale at Pusa and an attempt is being made to introduce and grow babul lac, an apparently distinct race which might be very extensively cultivated on waste lands on existing babul trees.

The work of Provincial Assistants has been mainly field-work with insects destroying the crops and local investigation into the occurrence of pests. In Madras, the work is very advanced and in almost every district the occurrence of pests has been investigated, as a preliminary to systematised campaigns to check them. Special attention has been paid to the Hairy Caterpillar pest of South Arcot (*Creatonotus albistriga*, Wlk.) and to the Deccan Grasshopper (a *Pyrgomorphid* of undescribed genus). The latter has also been studied in Bombay, and remedial measures for the Potato Moth (*Phthorimæa operculella*) carried out. In the Central Provinces, the work against Potato Moth was continued and work begun against the White ant (*Termes obesus*). In the United Provinces the work against the Cane Grasshopper (*Hieroglyphus furcifer*) has been continued. In the Punjab some experimental work has been done with bee-keeping in the hills and with sericulture.

The work in progress with biting flies, as affecting cattle, has made little progress owing to the absence of the Second Imperial Entomologist.

In Mysore, the Mycologist and Entomologist, Mr. L. C. Coleman, has studied the general pests of the State and especially the Deccan Grasshopper and the Dusky Ground Beetle (*Opatrum* spp.). Mr. R. D. Anstead, Scientific officer of the United Planters' Association of Southern India, has investigated methods of checking the green Bug and brown Bug of coffee and the pests generally occurring on coffee, tea, rubber, pepper, etc., in South India. Mr. C. B. Antram, Entomologist to the Indian Tea Association, has continued his work against the tea Mosquito (*Helopeltis theivora*).

The issue of coloured plates illustrating the life-histories of injurious and beneficial insects has been continued and these have been very largely circulated and used by Provincial Agricultural Departments. Publications in Agricultural Entomology during the year are few, the most notable being "Fasaler Poka," a revision in Bengali (with 20 coloured plates) of Indian Insect Pests. The record of advance in this subject grows smaller as the practical applied work absorbs the attention of the available workers, and while the practical applied work is yearly growing as the value of Agricultural Entomology becomes more generally recognised, the staff for both enquiry and practical work remains the same. The position is growing less and less favourable for the prosecution of any careful research or investigation, though the need for research grows as the subject expands.

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C. C. GHOSH . . Fasaler Poka (Bengali Revision of Indian Insect pests.)

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VOL. II, No. 8, H. MAXWELL-LEFROY . Life-histories of Indian Insects. Coleoptera I.

Bulletins.

H. MAXWELL-LEFROY . Vernacular Names. (In the press).

Leaflets.

Instructions for rearing Eri silk-worms. (In English, Hindi, Bengali) Eri seed exchange.

Other Contributions.

H. MAXWELL-LEFROY . Weevil in Wheat. (*Indian Trade Journal, Vol. XV, No. 190*).

Bulletins of the Indian Tea Association.

No. 1 of 1910, C. B. Antram. The Mosquito Blight of Tea.

FOREST ENTOMOLOGY.

BY

V. SUBRAMANIA IYER, M.A., F.L.S.,

Forest Zoologist.

This branch of the Research Institute was engaged in the investigations of:—

(*a*) Sal-insect pests of the United Provinces and Central Provinces.

(*b*) Insect pests of the Himalayan Coniferæ.

(*c*) The damage done to Babul plantations in Berar by rats and a longicorn borer.

(*d*) The Life-histories of the predaceous and parasitic insects of the Lac-scale.

(*e*) The classification and cataloguing of the insects collected during the last 10 years for the College and the Institute by the officers of the Department.

(*f*) Damage to one-year old Sal-seedlings owing to an attack by caterpillars of *Pammene Theristis*, Meyr. on the roots in the Dechouri Range of the Kumaon Division, United Provinces. The investigation was started towards the end of February last, but little progress was made in the study of the Life-history of the moth which was, however, successfully bred out in the Laboratory at Dehra Dun and was subsequently identified by Mr. Meyrick as *Pammene Theristis*, Meyr. It is proposed to continue the investigation of this subject during 1910-11.

(*g*) The Casuarina insect pests of Madras (East Coast). This investigation was undertaken during May and June last in Nellore, North and South Arcot, Districts of the Presidency of Madras and the report which will shortly be submitted for publication deals with the Life-history of *Arbela tetraones* (Moore) and other insects that infest Casuarina on the East Coast of Madras.

During the year under review the time of the Zoologist was also taken up with:—

(*a*) Identification of insects for the benefit of Forest officers and others interested in Forest Entomology.

(*b*) Furnishing of information regarding the Life-history of known insect pests with suggestions of remedial measures for their eradication.

(*c*) Setting up of Show-cases of Injurious Forest insects for the benefit of the students of the Imperial Forest College.

List of Publications.

1. STEBBING, E. P. . Second monograph on some undescribed Scolytidæ (*Indian Forest Memoirs, i, Part ii.*)
2. STEBBING, E. P. . Note on some Insect pests of the Himalayan Oaks. (*Indian Forest Records, ii, Part i.*)
3. STEBBING, E. P. . Scolytus major. (*Leaflet No. 4, Forest Zoology series.*)
4. STEBBING, E. P. . Polygraphus major. (*Leaflet No. 5, Forest Zoology series.*)

VETERINARY SCIENCE.

BY

MAJOR F. S. H. BALDREY, I.C.V.D.,
Officiating Imperial Bacteriologist.

The output of various products at the Imperial Bacteriological Laboratory, Muktesar, will be observed from the following table:—

NAME.	Quantity prepared, doses.	Quantity issued, doses.
Anti-Rinderpest Serum	409,078	446,981
Hæmorrhagic Septicæmia vaccine . . .	8,320	9,960
Anti-Anthrax Serum	12,168	12,404
Charbon Symptomatique Pillules . . .	20,350	20,900
Mallein	9,515	10,137
Tuberculin	444	469
Strangles vaccine and serum (on trial) . .	5,753 c.c.	2,583 c.c.

Rinderpest.—The output of serum has been considerably increased by the application of the Peritoneal Washing method. This technique has been improved and rendered of practical benefit so that the amount of inoculable material for hyper-immunisation purposes has been increased. This in spite of the fact that the number of animals obtained has been less in weight and numbers than heretofore. The success of this method is a matter for congratulation.

Further experiments are now being conducted in other methods of increasing material by incubation, etc.

Hæmorrhagic Septicæmia.—Experiments have lately been conducted in the methods of contagion and natural immunisation by feeding, etc. A series of observations will also shortly be made as to the feasibility of obtaining a sensitised vaccine for this disease. The whole will form the subject of a special Memoir.

Anthrax.—There are some hopes that a vaccine which is harmless and has lately been tried in the Laboratory may prove in a measure successful, but it is too early to say anything definite. The serum prepared is a powerful one and gives immunity for about five weeks.

Surra.—A series of observations have been conducted as to the method of fly infection. This will form the subject matter of a special paper. The successful treatment by arsenic has been confirmed and the following cases have been treated and cured.

In our hands we have been able to cure about 80 per cent. of cases treated. The treatment was subjected to the most severe test it is possible to apply.

Twenty ponies from the Transport Corps were sent to the Laboratory in October 1909. These ponies had contracted Surra on the Kathgodam road. They were in the last stage of the disease, entirely emaciated, and hardly able to walk. They were aged ponies, most of them well over sixteen years. Out of these twenty ponies, two died from colic not attributable to the treatment and two died from cerebritis. Nine were returned to work at end of January 1910, having been under observation three months from the termination of treatment. Seven others were returned to the Transport at the end of March 1910.

These also were kept under observation for three months. Further experiments have been made in the treatment of camels by the use of adventitious drugs with Arsenic.

A report will be submitted on this method.

Charbon Symptomatique.—A serum was prepared with a view to its use in actual outbreaks where the use of vaccine is attended with danger. This serum has been tested in the Laboratory but not yet used in the field.

Lymphangitis, Contagium of cattle.—An organism causing symptoms similar to those described by Colonel Raymond in the Journal of Tropical Veterinary Science has, during May, been investigated and is the subject of a paper.

A List of Publications contributed during the year 1909-10 from the Imperial Bacteriological Laboratory.

BALDREY, F. S. H. . Annual Report of the Imperial Bacteriological Laboratory for the year 1909-10.

BALDREY, F. S. H. . Some Original Notes on the Comparative immunising Properties of Vaccine and Agressions in Schweineseuche. (*Jr. of Trop. Vety. Sci. v, No. 1, 46.*)

BALDREY, F. S. H. . Notes and observations on the Evolution of T. Lewisi in the Rat Louse, *Hæmatopinus spinulosa.* (*Jr. of Trop. Vety. Sci. v, No. 1, 101.*)
Also *Archiv für Protistenkunde.*

HOLMES, J. D. E. . Further Experiments on the Treatment of Surra with Atoxyl and other preparations of Arsenic. (*Jr. of Trop. Vety. Sci. iv, No. 3, 286.*)

HOLMES, J. D. E. . The Treatment of Surra in Horses, by means of Arsenic and its Derivatives. Thirty-two cases of Successful Treatment. (*Jr. of Trop. Vety. Sci. v, No. 1, 1.*)

A List of Papers published during 1909-10 bearing on such diseases.

ARGYLE, CAPT. E. P. . Some Notes on Equine Filariasis. (*Jr. of Trop. Vety. Sci. v, No. 1, 96.*)

CLELAND, J. B. . Trypanosomiasis and other Diseases of Camels with Experiments in connection with the former. (*Jr. of Trop. Vety, Sci. iv, No. 3, 316.*)

CORNWALL, J. W., & KESAVA PAI, M. The Diagnosis of Rabies in Inoculated Animals. (*Jr. of Trop. Vety. Sci. v, No. 1, 149.*)

CORNWALL, J. W., & KESAVA PAI, M. — The Measure of Immunity against Rabies in Animals. (*Jr. of Trop. Vety. Sci. v, No. 1, 156.*)

CORNWALL, J. W., & KESAVA PAI, M. — Negri Bodies. (*Jr. of Trop. Vety. Sci. v, No. 1, 162.*)

DAWSON, W. O., & GAIGER, S. H. — *Trichorrhexis nodosa* in the Horse. (*Jr. of Trop. Vety. Sci. iv, No. 3, 307.*)

DEY, D. . . . — *Coenurus serialis* in a Goat. (*Jr. of Trop. Vety. Sci. iv, No. 4, 556.*)

EVANS, G. H. . . — "Elephant Surra" Trypanosomiasis in the Elephant. (*Jr. of Trop. Vety. Sci. v, No. 2, 233.*)

EVANS, G. H., & RENNIE, T. — Notes on some parasites in Burma, III. (*Jr. of Trop. Vety. Sci. v, No. 2, 240.*)

FRASER, H. . . — Surra in the Federated Malay States. (*Jr. of Trop. Vety. Sci. iv, No. 3, 345.*)

FREER, G. W. . . — Ephemeral Fever or Three Days' Sickness in Cattle. (*Jr. of Trop. Vety. Sci. v, No. 1, 145.*)

GAIGER, S. H. . . — Contribution to the study of Hæmorrhagic septicæmia. (*Jr. of Trop. Vety. Sci. iv, No. 4, 501.*)

GAIGER, S. H. . . — *Filaria Osleri* in India. (*Jr. of Trop. Vety. Sci. iv, No. 4, 525.*)

GAIGER, S. H. . . — *Linguatula tænioides* (*Jr. of Trop. Vety. Sci. iv, No. 4, 528.*)

(I) Treatment of Camel Surra.

(II) An Extraordinary case of Resistance to Camel Surra in the Dog.

(III) Some attempts at Treatment of Surra in the Dog. (*Jr. of Trop. Vety. Sci. iv, No. 4, 546.*)

GAIGER, S. H. . . — Contagious Gastro-Enteritis in Dogs. (*Jr. of Trop. Vety. Sci. v, No. 1, 52.*)

GAIGER, S. H. . — A Preliminary Check List of the Parasites of Indian Domesticated Animals. (*Jr. of Trop. Vety. Sci. v, No. 1, 65.*)

GAIGER, S. H. . .	Rabies. (*Jr. of Trop. Vety. Sci. v, No. 2, 277.*)
GIBSON, ADAM . .	A Method of dealing with Rinderpest in the Field. (*Jr. of Trop. Vety. Sci. v, No. 1, 93.*)
HAJI, S. G. . .	The Australian Camel Trade and Trypanosomiasis. (*Jr. of Trop. Vety. Sci. v, No. 1, 27.*)
JOWETT, W. . .	Biliary Fever or Malignant Jaundice of the Dog. (Canine Piroplasmosis.) The Drug Treatment. (*Jr. of Trop. Vety. Sci. v, No. 2, 257.*)
LEESE, A. S. . .	The Normal and Abnormal Temperatures of the Camel, with a Note on Normal Pulse and temperature. (*Jr. of Trop. Vety. Sci. iv, No. 3, 300.*)
LEESE, A. S. . .	Note on Tapeworms in Punjab Camels. (*Jr. of Trop. Vety. Sci. iv, No. 3, 305.*)
LEESE, A. S. . .	Summary of first series of Experiments on Treatment of Surra in Camels. (*Jr. of Trop. Vety. Sci. v, No. 1, 57.*)
LEESE, A. S. . .	Filariæ in Vitreous Chamber of the Eye of a Camel, Ophthalmia. (*Jr. of Trop. Vety. Sci. v, No. 1, 89.*)
MITTER, S. N. . .	A case of generalised tuberculosis in a Macacus. (*Jr. of Trop. Vety. Sci. v, No. 2, 281.*)
MITTER, S. N. . .	Gnathostomum spinigerum in a Domestic Cat. (*Jr. of Trop. Vety. Sci. v, No. 2, 284.*
NUTTALL, G. H. F., & HADWEN, S.	The Successful Drug Treatment of Canine Piroplasmosis. Together with Observations upon the effect of Drugs on Piroplasma Canis. (*Jr. of Trop. Vety. Sci. v, No. 1, 106.*)
OLD, J. E. S. . .	Contributions to the study of Trypanosomiasis and to the Geographical Distribution of some of the Blood-sucking Insects, etc. (*Jr. of Trop. Vety. Sci. iv, No. 3, 395.*)
PRATT, H. C. . .	Distribution of certain Biting Flies in the Federated Malay States. (*Jr. of Trop. Vety. Sci. iv, No. 3, 390.*)

PEASE, H. T. . . *Trypanosoma Theileri* (Laveran) and Galziekte. (*Jr. of Trop. Vety. Sci. iv, No. 4, 532.*)

RAYMOND, F. . . Some Notes on Rabies (*Jr. of Trop. Vety. Sci. iv, No. 3, 275.*)

RAYMOND, F. . . Infectious Lymphangitis in Cattle. (*Jr. of Trop. Vety. Sci. v, No. 2, 213.*)

RUEDIGER, E. H. . A Reduction in the Cost of Anti-Cattle Plague Serum. (*Jr. of Vety. Sci. iv, No. 3, 312.*)

RUEDIGER, E. H. . Filtration Experiments on the Virus of Cattle-Plague with Chamberland Filters "F." (*Jr. of Trop. Vety. Sci. iv, No. 4, 573.*)

REMLINGER, P. . . Rabies in the Street Dogs of Constantinople. (*Jr. of Trop. Vety. Sci. iv, No. 4, 561.*)

THIROUX, H., & TEPPAZ, L. Contribution to the study of Epizootic Lymphangitis of Equidæ in Senegal. (*Jr. of Trop. Vety. Sci. iv, No. 4, 567.*)

THOMPSON, C. G. . Report on the Animal Industry of Indo-China. (*Jr. of Trop. Vety. Sci. v, No. 1, 135.*)

VALLADARES, I. F. . A case of *Trypanosoma Theileri* in Madras. (*Jr. of Trop. Vety. Sci. iv, No. 4, 544.*)

PROGRAMMES OF WORK FOR 1910-11.

PROGRAMMES OF WORK OF THE VARIOUS SCIENTIFIC DEPARTMENTS FOR THE YEAR 1910-11, AS APPROVED BY THE BOARD ON THE 9th MAY 1910.

1.—Department of Economic Products, Calcutta, and Imperial Institute, London.

1. **Turpentine.**—The chemical investigation of the hydrocarbons of Indian turpentine at present in hand at the Imperial Institute will be concluded there.

2. **Fragrant Gums.**—The examination and identification of the plants yielding the various trade forms of myrrh, frankincense, mastic, byssabol and other like products from the Gulf of Aden, Arabia and the Persian Gulf will be continued. The gums are further being examined chemically so that the subject is under study as a whole both from the botanical and from the chemical standpoint.

3. **Lac.**—The study of the chemical constants of various forms of lac will be continued. This investigation is connected with a study of the effect of adulterating shellac with resin.

4. **Dyes.**—As a sequel to the publication of the Agricultural Ledger No. 2 of 1908-09 on dyes from Indian flowers, came an offer of assistance in the investigation of the subject from Professor A. G. Perkin. Very gladly the offer was accepted, and material for a chemical study of such flowers as are used and have not been investigated is being forwarded to him. The minor investigation on the dyeing properties of *Baccaurea sapida* is still in hand.

5. **Oils.**—The minor investigation on the utility of the oil of "Tannoom" (*Chrozophora verbascifolia*) will be completed if material can be obtained and so will that on the variability of the oil of *Amoora Rohituka*. The important survey of Indian fixed oils will be brought to a finish by the publication of descriptions, characters and classification of those that are known.

6. **Citronella Oil.**—The results of work to date will be published, and the publication will serve as a link between the work of the Reporter on Economic Products and that of the Forest Department.

7. **Fibres and Paper.**—Work on jute-selection will be continued conjointly with the Fibre Expert to the Government of Eastern Bengal and

Assam. A few analyses are to be made of "Sabai" grass from various sources. Indian papers are being examined from the point of view of their composition.

8. **Food Grains.**—An attempt will be made to complete the review of the Indian races of juar (*Sorghum vulgare*) and an index of literature on races of rice in India will be published.

9. **Dioscorea.**—Indian Yams.—During the year, the monograph on these plants will be completed. It will comprise the classification of the genus, descriptions and figures of the species, notes on the cultivated races, on the jungle and famine foods derived from various species, and on their food value.

10. **Pulses.**—The work on Indian pulses will be prosecuted. The survey of those of Burma is being carried out conjointly with Mr. J. MacKenna, Director of Agriculture, Burma, under whose instructions many are being cultivated for better observation. The work on the Soy bean—*Glycine Soja*—consists of a botanic study of the races in India together with chemical examinations by Mr. D. Hooper. The work of "Khessary" comprises the cultivation for the purposes of observation of many samples, which have been sown in the Royal Botanic Gardens, Calcutta, by the kindness of Major A. T. Gage. The study of "San" hemp has involved some special examination of material collected in Eastern Bengal.

11. **Caraway.**—All the material available for study here has been lent to the Royal Botanic Gardens, Kew: so that the botanic investigation named in earlier programmes is still proceeding, but in England instead of in the Indian Museum.

12. **Turmerics, Curcumas and other Scitamineæ.**—The investigation is proceeding on two main lines, (*i*) the study of such plants as yield starch, and (*ii*) the collection of an index series of roots to serve as standards for the identification of the several belonging to the *Scitamineæ* which are sold as drugs. The amount of starch, oil and colouring matter in the various roots will be estimated.

13. **Gentians.**—The identity of all medicinal bitters derived in Eastern Asia from this group of plants is being established.

14. **Aconites.**—The study of the chemistry and physiology of our Indian Aconite roots is in progress in the hands of Professors Dunstan and Cash.

15. **Hemp Drugs.**—It is proposed to assist Professor C. R. Marshall of Dundee in any way possible in his enquiry upon the chemistry of the active substances in "Charas."

16. **Solanaceous Alkaloids.**—The study of these is in progress in the hands of Professor Dunstan.

17. **Colchicum luteum.**—A physiological and chemical study of the roots of our small Indian Colchicum is in progress on material sent by the Reporter on Economic Products to Cambridge.

18. **Peganum Harmala.**—A chemical study of the seeds of this drug is in progress at Manchester on material supplied by the Reporter on Economic Products to Professor J. F. Thorpe.

19. **Thalictrum foliolosum.**—A chemical study of the roots of this medicinal plant is in progress in the hands of Professor Dunstan on material supplied by the Reporter on Economic Products.

20. **Saponin.**—Professor Schaer of Strasburg is endeavouring by work on material supplied by the Reporter on Economic Products to ascertain how many forms of Saponin are in the vegetable kingdom.

21. **Indigenous Drugs.**—The work of the Indigenous Drugs Committee will be continued. The full programme cannot yet be given but one important piece of work will be a further examination of the effect on its efficiency of digging *Podophyllum Emodi* at different stages of maturity.

22. **Poison to Stock.**—The collection of information on plants poisonous to horses, cattle, etc., is in progress, and botanic specimens will be collected as far as possible and sent to the various military institutions requiring them for teaching purposes.

Of the above, the following are new investigations or parts of investigations :—

(*i*) Index to the literature on rice.
(*ii*) Estimation of the amount of oil in the Soy bean in India.
(*iii*) Chemical investigation on dyes from flowers.
(*iv*) Turmerics, etc.
(*v*) *Peganum Harmala.*
(*vi*) *Thalictrum foliolosum.*

The following are in hand at the Imperial Institute, Nos. 1, 2 and 4 being conducted on material supplied by the Reporter on Economic Products :—

1. Completion of the work on Indian Daturas.
2. Examination of the constituents of the Indian Aconites.
3. Examination of Indian opiums.
4. The completion of the determination of the hydrocarbons of Indian turpentines.

2.—Meteorological Department.

Meteorology.

1. **Sounding balloons.**—It is proposed to make a series of ascents throughout 12 months, beginning as soon in 1910 as the necessary instruments have been completed, probably at the end of March. Two balloons will be liberated weekly, each carrying an instrument to record temperature, pressure and humidity during ascent and descent, while the vertical and horizontal velocities of the balloons will be found, and their paths plotted, from observations taken in the ordinary way by theodolites at the two ends of a measured base line. As far as possible the days chosen in each month by the International Commission will be observed, in order that India may contribute to the data of simultaneous upper air conditions which are now being rapidly accumulated. This work will be carried out at Jhang in the Punjab where the experiments with such balloons have hitherto taken place.

2. **Kites.**—The work with balloons will, it is believed, tax the department as far as is practicable, and it will not therefore be possible to supplement that work by the use of kites.

3. **Atmospheric electricity.**—Continued observations will be made of the chief factors of atmospheric electricity. These are :—The electric potential gradient; ionization, conductivity and radio-activity of the air; the earth-air current, and the quantity of electricity carried down by rain and snow.

4. **Seasonal variations of weather.**—It is proposed to continue the search for relationships between these variations in different parts of the earth, and to try to find physical explanations in certain cases.

Astronomy : Solar Physics.

5. **Photographing the sun in ordinary light.**—This will be continued as in former years.

6. **Record of sunspots.**—As before.

7. **Record of prominences.**—As before.

8. **Sunspot spectra.**—These will be studied both visually and photographically as before.

9. **Halley's Comet.**—It is proposed to take as complete a series as possible of photographs of this comet, while it is suitably situated for observation, with the camera attached to the Lerebour and Secretan equa-

torial and with a smaller camera attached to the same instrument. Attempts will also be made to photograph the spectrum with a prismatic camera and with a slit spectrograph used in connection with the 18-inch silver-on-glass mirror.

10. **Variations in the quantity of radiation emitted by the sun.**—Photographs of extra-focal images of stars and of the moon reflected from a convex quartz surface will be continued with a view to detecting variations in the solar constant and variations in relative emissive power in different regions of the spectrum.

11. **Photographing the sun in monochromatic light.**—The routine work with the spectro-heliographs will be continued, and in addition photographs in H light will be taken with the new auto-collimating grating spectro-heliograph.

12. **Spectra of sunspots :—**

(*a*) Studies in the radial movement in spots will be continued.

(*b*) Attempts will be made to detect vertical movements in the umbræ.

(*c*) Displacements of lines due to pressure effects in spots will be studied.

13. **Displacements of lines at the sun's limb.**—It is proposed to continue the research into the cause of the shift of the lines towards the red at the sun's limb, using a series of high dispersion spectra of limb and centre already secured with the Michelson grating. Particular attention will be given to the shifts of the lines which are most and least affected by pressure.

Seismography.

14. The three Omori seismographs, two in Simla and one in Bombay, and the Milne seismographs at Calcutta, Kodaikanal and Bombay will be kept in use during the year.

3.—Survey of India (Scientific Research Work).

Gravimetric Survey.—Pendulum operations in Rajputana in the area between Latitudes 24° and 27° and Longitudes 79° and 82°.

Magnetic Survey.—Colaba Observatory under the Meteorological Reporter and the four Observatories under the Surveyor General will continue to work. Observations will be taken at repeat stations and at certain selected old field stations and detailed surveys of disturbed areas will be continued.

Latitude Operations.—Latitude observations south of the Himalaya of Central and Eastern Nepal on the N. E. Longitudinal series up to Sonakhoda and commencement on the North Maluncha and North Parasnath Meridional Series.

Solar Photography.—Photographs of the sun will be taken daily at 10 A.M. and 4 P.M., at Dehra Dun, as has been done since 1879 in conjunction with Greenwich.

4.—Geological Survey.

Part A.—*Subjects undertaken during previous years to be continued.*

(1) Geological Survey of Upper Burma.
(2) Revision of the Survey of Central India and Rajputana.
(3) Investigation of samples of salt from Rajputana and the Punjab Salt Range.
(4) Mapping of unsurveyed areas in the Central Provinces.
(5) Survey of oil-bearing regions in North Eastern Assam.
(6) Economic Survey of the Dhalbhum Estate.
(7) Survey of the Idar State in the Bombay Presidency.
(8) Search for mammalian remains in the Siwalik rocks of Jammu and Kangra, and revised classification of freshwater Tertiary strata.
(9) Palæontology of (*a*) the Liassic beds of Baluchistan, (*b*) the Cretaceous and Tertiary systems of Tibet, (*c*) the Indian Tertiary mollusca, (*d*) Jurassic brachiopoda from the Northern Shan States, and (*e*) study of the Siwalik vertebrates.

Part B.—*New questions.*

(10) The examination of the Lonar Lake salts.
(11) Survey of the oil-bearing strata of the Rawal Pindi district.
(12) Artesian water-supply in Gujarat and other places.
(13) Sulphide ores in the Punjab Salt Range.
(14) Palæontology of (*a*) Silurian fossils, (*b*) Permo-Carboniferous and Triassic fossils, and (*c*) Gondwana plants from Kashmir.

5.—Botanical Survey.

Work already in progress.—The Superintendent of the Royal Botanic Garden will continue the compilation of a catalogue of the non-herbaceous plants cultivated in the Royal Botanic Garden, Calcutta.

The Curator of the Herbarium will finish his account of the botanical results of the expedition to Lonakh in the North-West of Sikkim.

An account of the botanical results of Mr. Meebold's tour through Manipur and Burma will be elaborated for publication.

Mr. I. H. Burkill's account of his trip into Nepal will appear.

New work.—Two Indian Assistants will be trained to Herbarium work in the first instance and, if possible, field work also. A commencement will be made in forming photographic records on a suitably large scale of typical views of Indian vegetation and of typical Indian plants.

The Curator of the Herbarium will be deputed to study in the field the flora of the South-Eastern area of Sikkim in the same way that he has done the North-Western area of the same province.

Signor Beccari's account of the genus *Dæmonorops* of climbing palms will, it is hoped, appear during the year.

Work by associated officers.—The Director of the Botanical Survey has been informed that there is little prospect of the Government Botanist, Madras, being able to do any systematic botanical work.

The Economic Botanist to the Government of Bombay states that he is to undertake the collection and identification of flowering plants from all parts of the Bombay Presidency. He proposes to make a special study of the genus *Tamarix* and to make a catalogue of the hosts of certain parasites, chiefly *Loranthus* and *Cuscuta*.

No botanical work bearing on the Botanical Survey of India is to be undertaken by the Economic Botanist to the Government of the United Provinces.

6.—Agricultural Department.

I.—Agricultural Research Institute, Pusa.

The scientific work of the Institute for the coming year is indicated under the programmes of the different sections.

The Prospectus of the Institute and College, as revised by the Board of Agriculture, 1909, and finally approved by the Government of India, has been published and the courses given in the several sections will be on the lines indicated therein.

For the benefit of *boná fide* agriculturists and the subordinate staff of the Agricultural Departments, specially short courses of a simple and practical nature have been instituted and instruction in these subjects will be continued.

II.—Agricultural Chemistry.

1. The work on the availability of plant food in soils will be continued, the immediate aim being the more correct ascertainment of the composition

of the aqueous solution in the soil. Included in this section of investigation are naturally the amounts of nitrate in soils and temperatures. It is intended to co-operate, if possible, in relation to this subject with the Imperial Bacteriologist.

2. The investigation on soil moisture and water requirements of plants is being continued on lines which have been sufficiently indicated in the memoirs.

3. A joint investigation with Mr. Burt, Deputy Director of Agriculture, United Provinces, is being conducted into the causes of infertility in a tract of land in the Mainpuri District.

4. The effect of soil and manure on the composition of crops is a branch of study which is engaging the attention of a number of investigators and is one on which I have already obtained some information. It will be developed at Pusa during the coming year.

5. Two points in relation to the Indian saltpetre manufacture, in respect of which it seems possible that an improvement can be suggested, will be investigated.

6. **Education.**—This requires no special comment; it will be conducted according to the lines laid down.

III.—Economic Botany.

1. **Training.**—The training of advanced students in this section will be continued on the lines laid down in the prospectus of the Institute. The course on fruit-growing will be given as usual in the cold weather.

2. **Plant breeding and plant improvement.**—During 1910 the following crops will be studied:—Wheat, tobacco, barley, oilseeds and fibre plants.

(*a*) **Wheat.**—The botanical survey of the wheats of Baluchistan will be completed. The production of improved varieties by selection and hybridization will be continued. The co-operative experiments on the effect of environment on the milling and baking qualities of Indian wheats, which are being conducted in collaboration with Mr. H. M. Leake, Economic Botanist to the United Provinces, and of which the earlier results are now in course of publication, are being continued on an extended basis. The above experiments include the effect of weathering on the quality of the wheat crop and the Imperial Bacteriologist has agreed to undertake the study of the bacteriological aspect of this subject.

(*b*) **Tobacco.**—The production of new varieties by selection and hybridization will be continued as well as the testing and curing of the varieties already isolated. The investigations on the influence of environment on the stability of the type and on the quality will be continued.

(*c*) **Oil-seeds.**—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) **Fibres.**—The isolation and testing of pure races of fibre plants of India will be continued.

(*e*) **Fruit.**—The fruit experiments will be continued on the lines laid down in the First Fruit Report.

(*f*) **Minor Investigations.**—The study of the varieties of cassava will be completed and the investigation on the inheritance of sex in ganja continued.

IV.—Mycology.

1. **Research and Experimental work.**—Owing to the opportunity for co-operation afforded by the appointment to Pusa of the Imperial Bacteriologist, it is proposed to resume the work on soil fungi which was temporarily abandoned two years ago.

The work on the wilt disease of crops, especially of indigo and cowpea, and if opportunity occurs, of cotton and gram, will be continued.

The investigation of sugarcane disease is being continued and the new results regarding red-rot will be published. The Supernumerary Mycologist is investigating the life history of sugarcane smut.

Assistance will be given on the campaign against the bud-rot disease of palmyra palms in the Godavari. An account of the parasite and a review of the work undertaken to prevent its spread will be published.

It is proposed to publish a preliminary account of the soft-rot disease of ginger based on the work of the last two years.

The study of some anthracnoses of leguminous crops, specially of *val* (Dolichos) and cowpea, will be begun.

2. **Training.**—The training of students in Mycology will be continued and the advanced course of Mycology will be given to those already in training; assistance will be given to Provincial Colleges in providing notes and material for Mycological instruction.

3. The collection and identification of Indian parasitic fungi will be continued. If possible a complete list of the ascomycetes in the Pusa Herbarium will be published and the text of the book of Indian Plant Diseases finished.

V.—Entomology.

1. **Research and Experimental Work.**—The work of the past year in studying and advising on crop pests will be continued. Assistance will be given, where desired, in directing the work of Provincial Assistants and in coping with any outbreaks of pests that may occur. So far as possible, all specimens of insects sent in will be identified and work in connection with the reference collection of insects of the plains will be continued. The issue of coloured plates of injurious and beneficial insects will be continued. Enquiries in progress on insecticides and spraying machines, fumigation, the danger of the importation of injurious insects and the value of parasites as checks on crop pests, will be carried on as time permits. The staff of the Second Imperial Entomologist will continue work in progress on mosquitos, biting-flies and fruit-flies. The cultivation of lac at Pusa will be continued and so far as possible assistance will be given to those wishing to start cultivation in agricultural areas. Eri silk cultivation will be continued as the basis of a possible cottage industry in several parts of India and assistance will be given so far as possible in starting the industry in new localities. The cultivation of mulberry silk will be continued chiefly with a view to giving advice to those who require it and to testing the possibilities of this industry in new localities. Tassar silk rearing will not be continued.

2. **Training.**—It is uncertain if any students will present themselves for the course of advanced entomology. If they do, this course will continue as before. Short courses in eri silk and lac cultivation will be given if required as also a course in sericulture. If possible, instruction in dealing with insects injurious to live-stock will be given as part of the course in cattle-breeding.

Publications.—A revision of the Indian Insect Pests in Bengali is being published; if time permits, the full revision of the text of Indian Insect Pests will be taken up.

VI.—Agricultural Bacteriology.

The Biological aspects of tillage in Indian soils.

This will involve investigations extending over a prolonged period, the basis of which would include a general investigation of the bacterial content of Indian soils.

Concurrently with this general investigation special observations will be made with the intention of determining the biological factors under-

lying certain problems of agricultural interest such as those connected with the custom of embanking wheat lands. They will also include enquiries into :—

1. The biological aspects of the availability of plant food in soils.
2. The biological factors concerned in the decomposition of organic matter in Indian cultivated soils.
3. Biological aspects of :—
   (*a*) Green manuring in India.
   (*b*) " Weathering " of soils.
   (*c*) Effect of ploughing land when too wet, before sowing.

No. 1 will be carried out in collaboration with the Imperial Agricultural Chemist, No. 2 in collaboration with the Imperial Mycologist and No. 3 in collaboration with the Imperial Economic Botanist.

VII.—Agriculture.

1. **Permanent Experiments.**—The permanent manurial and rotation experiments and the pasture experiments will be continued.

2. **Extension of Botanical Work.**—The growth of selected varieties of wheat will be taken up in extension of the work now being done by the Imperial Economic Botanist. This work will be carried on in consultation with and under the botanical surveillance of the Imperial Economic Botanist.

3. **Cattle-breeding.**—The local herd has been transferred to the Bengal Agricultural Department and the Montgomery herd will now be considerably increased. Improvements of this breed by selection based principally on milk tests will be the chief object in view. It is also intended to start a dairy.

4. **Sheep.**—The crossing of local and Bikanir ewes with Dumba rams will be continued.

5. **Poultry.**—Poultry breeding and distribution will be continued.

6. **Training.**—Courses in the practice of agriculture will be given as heretofore.

VIII.—Imperial Cotton Specialist.

I.—To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

II.—By special invitation of the Department of Agriculture, Central Provinces, to make detailed investigations throughout the whole of the

cotton tracts of that Province in co-operation with the Deputy-Directors of Agriculture; a continuation of this research would probably have to be carried into Khandesh and Bengal; also to investigate into the distribution of superior varieties in the rich cotton tracts of the Nizam's Dominions especially those which lie along the Godavery river.

III.—As Bourbon and Buri Cottons appear to be two superior varieties most suitable for what are at present non-cotton-producing tracts, namely, those with a sandy or red soil or with a rainfall heavier than can be borne by indigenous varieties, it is proposed to carry out experiments with these, on lands furnished by the owners, in parts of Rajputana, near the Western Ghats, and perhaps Mysore. I understand that the officers of the Madras Agricultural Department are to undertake investigations into the Bourbon cultivation in the red soils of their Presidency.

IV.—The re-establishment of superior varieties in Kathiawar and other parts which substituted inferior drought resisting cottons during the famine year of 1899-1900.

IX.—Provincial Departments of Agriculture.

The programmes for 1910-11 generally follow those described in 1909-10. The following are, however, important additions :—

Bengal.—The Sabour College will likely be opened in November 1910. As a consequence, much of the time of the Principal, the Economic Botanist and the Agricultural Chemist will be occupied in the laying out of the Farm, the Botanical Garden, College grounds and the fitting up of the College Laboratory. Manurial and other varietal experiments with paddy, jute, sugarcane, wheat and maize will be continued. For the revival of sericulture industry in the Province, pure and disease-free seed will be supplied to silk-worm rearers from model nurseries under the control of the Department. Well-boring operations have been undertaken in Behar and will be continued as they indicate a possibility that very large supplies of water may be obtained from deep borings in South Behar. The work of classifying the different types of sugarcane in the Province will be continued in co-operation with the Economic Botanist. The experiments on the chemical selection of the canes are also being continued. At the Indigo Research Station, Sirsiah, attempts are being made to improve the indigo plant by selection and to study the causes which lead to the production of indican with a view to evolving some method of stimulating its production.

United Provinces.—The opening of Experimental Farms at Attara and Benares has been deferred owing to financial pressure. The principal crops

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United Provinces.—The opening of Experimental Farms at Attara and Benares has been deferred owing to financial pressure. The principal crops

under study have been wheat, cotton and sugarcane. It is intended to carry on the classification of the wheats of the Province based upon the observation of the growing plant. Co-operative experiments on the effect of environment of the milling and baking qualities of Indian wheats are being extended, in collaboration with Mr. Howard, the Imperial Economic Botanist. Pure Indian types of wheat will be tested on a field scale at Cawnpore. Selection experiments with types of wheat best suited to Bundelkhand conditions as regards power of resistance to rust will be carried on at Orai. Pure selected Muzaffernagar wheat is being propagated at Cawnpore for distribution. Experiments with indigenous cottons will be carried on at Aligarh and attempts will probably be continued to establish American cotton on a commercial scale. Trials are being made to establish lac on dhak trees, *Butea frondosa*, growing on usar land. A study of alkali soils in a canal irrigated area has been taken up to determine the nature and distribution of the alkali salts, their variation laterally and vertically and with season and such other connected questions.

Punjab.—The site for the second Agricultural Station has been acquired at Gurdaspur and the laying out of the land for experimental purposes will be pushed on. The distribution of American cotton seed will be continued mainly in the Canal Colonies. A staff of well-borers will be organised for extension of well-irrigation where possible. Attempts to introduce the labour saving machinery tested by the Department will be continued. The Lyallpur Agricultural College has been opened and much time will necessarily be occupied in organising the teaching work. The Agricultural Chemist will investigate, as time permits, the whole question of the alkali lands of the province. The breeding of poultry will be taken up with a view to develop a cross between an English and indigenous breed to suit local conditions. The present condition of date-cultivation in the province will be investigated, the possibilities of its improvement and extension will be studied and a certain number of selected varieties will be planted. The experiments with cassava, flax and jute will be continued to determine whether they could be profitably introduced into the province. Further work on the classified wheats of the province will be undertaken to discover which of the selected varieties are best suited to the natural conditions of particular districts. Sericulture, apiculture and lac-culture have been taken up.

Bombay.—Cotton will continue to receive the major share of attention. The methods for improving cotton consist of (*a*) hybridization, (*b*) selection, and (*c*) trial of varieties in addition to experiments in manuring, irrigation,

tillage and the like. The cultivation of tobacco under shade is being investigated to determine the effect upon the texture of the leaf. As Nadiad tobaccos are markedly weak in potash, a suitable site in the same tract is being tested for laying out special experiments with potash manures on the recommendation of the Director of the Imperial Institute, London. The potato-moth will continue to receive special attention both in the field and in the store. A farm has been opened at Sukkur to introduce new crops, chiefly cotton, pulse and leguminous crops, into Upper Sind. The Agricultural Chemist proposes to study the method of dealing with the salt lands of the Nira Valley and other salt tracts in the Deccan. He will also investigate the sources and amount of loss in the manufacture of *gur* with a view to ascertain how they can be avoided and the bye-products utilised. The Economic Botanist proposes to study the varieties of the important local fruit crops with a view to description, classification and selection. Among new lines of work proposed to be undertaken by him are the study of (1) the possibility of extracting and using plantain fibre in a profitable manner, (2) the variations of the cotton leaf as indicated by Mr. Leake's leaf-factor, (3) the effects of crossing mango varieties, (4) comparison of budding and grafting the mango, (5) the pruning of the mango, and (6) the comparison of European and Indian methods of grape culture.

Madras.—The lands on the Farm at Bezwada recently taken over by Government will be brought to a condition fit for experiment. As the demand for Mauritius sugarcane in the Godaveri delta is practically over, their further distribution afield is being taken up. The Barbados cane, No. 208, introduced by the Department on the Samalkota Agricultural Station, having been a marked success, efforts will be made to spread it as rapidly as possible. At Palur, exotic and other varieties of groundnut are being tested and compared with the variety grown locally. Rotation and mixed cropping experiments of groundnuts and cereals will be continued to determine which has the best effect on the succeeding groundnut crop. In the ceded districts, where there is a much greater mixture of cotton varieties, the pure white-seeded variety called white "Northerns" is the most promising. Forty-five acres of land have, therefore, been taken up for growing seed of this variety for distribution. The cultivation of Karungani variety in Tinnevelly is being pushed. In the same district, arrangements have been made by the Department to bring into extensive use the method of sowing cotton with a drill, a practice previously unknown. Village depôts for the sale of seed will be extended to new

centres. The experiments on the water requirements of irrigated garden crops will be continued at Coimbatore. The diseases affecting the pepper vine will be investigated by the recently appointed Mycologist of the province.

Central Provinces.—Implement depôts of the type already existing in Nagpur and Hoshangabad have been started on a small scale at Akola and Raipur. At Jubbulpur, a small plot under a Government Irrigation work is to be taken up to demonstrate, after experiment, the most economical use of irrigation water in the crops and soils of the district. A similar plot will be taken up at Damoh in land embanked by the Irrigation Department to teach people how to use much of the land which, at present, lies fallow. A small plot is also to be taken up at Nimar to demonstrate the possibility of growing better varieties of cotton in that district. The various experiments with cotton as regards hybridizing, plant to plant selection, etc., carried on at Akola will be continued. An important experiment has been undertaken at Hoshangabad to test the double-cropping of embanked land on typical heavy soils. At Raipur, an experiment will be made to test the value of wild lucerne (*Melilotus alba*) both as a fodder crop and as a soil renovator for land which grows rice continuously without manure, as it is likely to be of great help in solving the manure and fodder question for Chhattisgarh. Demonstrations will be pushed on in the backward tracts of Chhattisgarh to extend transplantation of rice, irrigation of wheat and cultivation of cane and groundnut.

Burma.—The crops under investigation are paddy, wheat, cotton, jute, jowar and maize. As the area under groundnuts is increasing, experiments in their yield, percentage of oil to kernel and of kernel to whole seed have been begun in addition to varietal experiments. If the Hmawbi Farm is opened during the year, work there will consist in laying out operations. In the event of this farm not being opened, some initial experiments will be attempted with flood resisting paddies, a site being obtained in one of the flooded areas. The extent of damage done to cocoanut trees by the Rhinoceros Beetle will be investigated, with a view to evolve a scheme to check its ravages.

Eastern Bengal and Assam.—The principal crops under study are rice, jute, sugarcane, tobacco and groundnut. At Rajshahi, Upper Shillong and also at Haflong (in the North Cachar hills), attempts will be made to raise potato seed for distribution in connection with the efforts which are being made to promote the cultivation of Naini Tal and Darjeeling

potatoes. The experiments at Rajshahi having indicated that potatoes can be grown there successfully without irrigation, steps will be taken to popularise this crop in the district. Further work on tobacco at Burihat will depend upon the results of a flue-curing experiment which is being tried for the first time this year. Poultry-breeding will be commenced on a small scale at Dacca with Chittagong and Langshan fowls. An enquiry will be made as to the desirability or otherwise of introducing a new and superior polyvoltine race of silk-worm said to have been bred by Messrs. Anderson, Wright & Co. of Berhampur by crossing the Italian with the local "Nistri" worms. At Shillong, the experiment with the European univoltine silk-worms, which have proved successful for six years in succession, will be continued. If time permits, the Fibre Expert proposes to study the retting of jute and Sunn-hemp from the Chemical and Bacteriological point of view.

7.—Forest Department.

Programme of work to be carried out at the Imperial Forest Research Institute, Dehra Dun, during the three Forest years 1910-11 to 1912-13.

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute.*

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
1	The conversion of an irregular Sâl forest into a regular Sâl forest, experiment to be carried out on a practical scale, a careful working scheme being prepared for the Thano experimental area.	Sylviculturist and Superintendent of Working Plans.	Thano Experimental area, Dehra Dun District, U. P.	It is recognized that owing to the prevalence of frost in the Thano forest, it will be necessary to extend the experiment to other localities, where more favourable climate conditions exist, in order to obtain conclusive results.

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
2	Experiments to ascertain the best methods of ensuring natural regeneration of Sâl; severity of cuttings to bring it about, and the degree to which young Sâl will stand shade.	Sylviculturist and Superintendent of Working Plans.	Thano Experimental area, Dehra Dun District.	.....
3	Methods of artificially cultivating Sâl and assisting natural reproduction to be tested, and experiments made.	,,	Thano Experimental Station, Dehra Dun, U. P.	The experiments under this head being carried out in Kheri Division, U. P., and elsewhere, will be visited and the results obtained there will be tested in Thano, as well as such other experiments as may suggest themselves. Other experimental stations may also eventually be started in Sâl localities where special difficulties are being encountered.
4	The effect of age of tree on fertility and abundance of seed; the frequency of seed years; the effect of environment on the same.	,,	,,	Notes will be collected from all Sâl forests visited, and reliable information obtained from other sources will be utilized.
5	Sâl coppice experiments and fertility of coppice seed.	,,	Gorakhpur Division, Gonda Division and other U. P. Sâl coppice areas.	.....

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
6	Investigation of effects of drought, fire, frost and grazing.	Sylviculturist and Superintendent of Working Plans.	For drought and fire: Kheri Division, United Provinces. For frost: Siwalik Division. For grazing:—Bahraich Division.	.....
7	Rate of growth of Sâl:—			
	(i) Rate of girth and height increment in high forests.	,,	(i) Siwalik Division	It will be impossible to obtain data applicable to the Sâl region as a whole and consequently it is considered that (i) at any rate should be left to local officers to investigate in areas in which the sylviculturist is unable to take the initiative. The investigation as regards (ii) should be undertaken by the sylviculturist.
	(ii) Yield tables for Sâl high forest and coppice.	,,	(ii) Gorakhpur Division.	
8	Thinnings in uniform Sâl crops; the age at which they should be commenced; their intensity, and the proper density to be maintained in crops of different ages.	,,	Wherever uniform crops are found in the United Provinces.	.....
9	Effect of subterranean water level and of geological formation (and soil drainage) on Sâl development.	,,	Kheri Division .	It is hoped that this investigation in the Central Provinces, especially as regards geological formation, will be undertaken by local officers.

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
10	Collection of notes and information regarding other matters relating to Sâl, including the companions associated with it in natural forests.	Sylviculturist and Superintendent of Working Plans.	Kheri Division .	.....
*11	The pollination of the flowers and distribution of the seeds of Sâl. Description and illustration of fruit, seed, process of germination and the seedling.	Botanist .	Most of these investigations will be carried out at the Research Institute, short tours being arranged as required.	*Note.*—The items marked with an asterisk will first be taken in hand.
*12	Study of the conditions favourable and unfavourable for successful germination and early development. This will include among other things the determination of the most suitable physical conditions of the soil.	,,	.....	For the purposes of these investigations analysis of soils selected by the Botanist will be carried out by the Chemist The method of analysis to be adopted in each case will be decided by the Botanist and Chemist in consultation.
*13	The dying back of seedlings and its causes. How does dying back interfere with the normal development of root and shoot, and does it induce decay in the mature stem?	,,	.....	.....

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
*14	Study of grasses characteristic of Sâl forest with special reference to— (*a*) Preparation of descriptions and illustrations, enabling the various species to be easily recognised. (*b*) Their relation to Sâl, their competitive action, excretion of poisonous substances, increasing damage by frost, etc. (*c*) Their value as indicators of soil suitable or unsuitable for Sâl. (*d*) Their economic value in preventing erosion, as fodder plants and in other ways. (*e*) Effect of fire and grazing upon them. (*f*) Best method of propagating or increasing the proportion of the more valuable species.	Botanist .	.....	This investigation is in progress.
15	Study of the diseases of Sâl whether caused by fungi or otherwise.	,,	Wherever found in Sâl forests.	.....

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
16	Technical properties of wood— (*a*) To carry out experiments with regard to the shearing, crushing and bending strength of wood of seedling and coppice origin, respectively; seasoned and green— (i) Grown in the hills. (ii) Grown in the plains. (*b*) To test the fissibility of wood of seedling and coppice origin, grown in the hills and plains, seasoned and green— (i) Vertically and tangentially. (ii) Vertically and radially. (iii) Horizontally and tangentially. (iv) Horizontally and radially.	Economist .	Research Institute and Sibpur Engineering College.	It is proposed to send the wood to Sibpur for testing, provided the Sibpur authorities can undertake the work.

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
	(*c*) The time taken for Sâl to season under various conditions, and the best methods of seasoning, with special reference to the liability of the timber to crack, warp and shrink. (*d*) The specific gravity of timber of (i) seedling, (ii) coppice origin, grown at various altitudes and on different soils and aspects. (*e*) The relative properties of wood when felled at different times of the year.			
17	Durability— . . Investigations regarding— (*a*) The life of Sâl timber when used (i) under cover; (ii) in the open; (iii) under water. (*b*) The life of Sâl sleepers. (*c*) The effects of iron fastenings on Sâl sleepers.	Economist .	.....	

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
	(*d*) The effect of various antiseptic solutions on Sâl timber.			
18	Uses to which the products of Sâl can be put—	Economist .	.....	
	(*a*) Major, *e.g.*, timber.			
	(*b*) Minor, *e.g.*, resin, oil, bark tanning extracts and fibre.			
19	The calorific value of wood when used as (i) fuel, (ii) charcoal.	,,	.....	
20	Supply of market for Sâl—	,,	.....	
	(*a*) Enquiry as to the actual annual outturn of Sâl timber—			
	(i) from Government forests.			
	(ii) from private forests so far as the principal markets are concerned.			
	(*b*) General note on past and present prices of Sâl timber.			

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
	(*c*) The time taken for Sâl to season under various conditions, and the best methods of seasoning, with special reference to the liability of the timber to crack, warp and shrink. (*d*) The specific gravity of timber of (i) seedling, (ii) coppice origin, grown at various altitudes and on different soils and aspects. (*e*) The relative properties of wood when felled at different times of the year.			
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Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
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	(i) from Government forests.			
	(ii) from private forests so far as the principal markets are concerned.			
	(*b*) General note on past and present prices of Sâl timber.			

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—concluded.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
	(*c*) The available annual supply of Sâl sleepers and the past and present prices of the same. (*d*) Past and present prices of minor products, and possibility of improving the demand. (*e*) Forecast of the Sâl trade.			
21	The study of all insects which cause serious damage to, or which are beneficial to the Sâl tree or its timber.	Zoologist .	.....	*Note.*—With regard to Sâl *insect pests* a considerable series of investigations have already been undertaken, and the results have been published or are under publication. The Botanist and Sylviculturist will be able to render considerable assistance in this study.
22	A special enquiry into Sâl bark tanning extracts.	Chemist .	.....	

Note.—It is recognised that the general restriction during the next three years of investigations regarding the Sâl to the United Provinces may not be advantageous from the point of view of acquiring data applicable to this species throughout India, but, owing to the paucity of the staff sanctioned for the Sylvicultural branch of the Institute, it is considered that this cannot be avoided at present. As soon as the necessary staff is forthcoming investigations should be extended to Bengal, Eastern Bengal and Assam and the Central Provinces.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
1	The Uniform and Group methods of working forests. Enquiries will be made as to the suitability of these two methods, or modifications of them, in Indian forests.	Sylviculturist and Superintendent of Working Plans.	Forests under these methods of treatment, or which it is proposed to put under them, may be visited, *e.g.*, the Chir forests of the United Provinces, the Teak forests of Burma (Tharrawaddy and Mohnyin) and Sâl forests of the Kumaon Division, United Provinces.	
2	Compilation of statistics of plantations of various species and enquiries, if necessary, into any difficulties met with in the propagation of any particular species, including an enquiry as to the best density to be maintained at different periods. This is in progress for several species, but before anything reliable can be published visits to many of the plantations concerned will be found necessary.	„	The United Provinces.	

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
3	Investigation into the best methods of cutting and working bamboos. Detailed experiments will be carried out in specially demarcated plots.	Sylviculturist and Superintendent of Working Plans.	Siwalik and Ganges Divisions, United Provinces.	
4	The cultivation of trees for the growth of lac experiments, which have been commenced, will be continued with reference to the best methods of (i) preparing trees for the reception of lac, and (2) working prepared trees in rotation.	,,	Siwalik Division, United Provinces.	This will be carried out in conjunction with the Economist.
5	Sylvicultural Notes on various species. The collection and collation of statistical and other data regarding the chief Indian trees and types of forest, commencing with deodar, *Pinus excelsa* and *Pinus longifolia*. The preparation of yield tables and the collection of data for fixing the exploitable size and age as well as the possibility in forests under the different sylvicultural systems.	,,	The United Provinces.	The progress of this enquiry must depend to a great extent on information communicated by local officers.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
6	Study of teak, including the factors favouring the rapid germination of the seed and the development of the young plant; the dying back of seedlings, the mode of origin of coppice shoots, the structure of young and old seedling and coppice plants and pollination of the flowers.	Botanist	.....	A quantity of plants of various ages and of coppice shoots collected in various forests in the Central Provinces are now in hand. A preliminary pamphlet on teak coppice is in the Press and others will follow as the material collected is worked up. Germination experiments have also been commenced.
7	Detailed systematic study and description of all forms of forest plants of economic value, when such is required, owing to the commercial importance of the species and to the fact that the existing classification and description are unsatisfactory and confusing.	,,	.....	
8	The study of the fungoid diseases affecting the blue pine in the Punjab and the Casuarina in Madras. Also of the spike disease of sandal in Madras.	,,	.....	
9	An experimental botanical garden will be laid out and maintained in good order.	,,	Dehra Dun, United Provinces.	

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute– continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
10	Wood, bamboo and grass pulp— (*a*) Woods, bamboos and grasses suitable for the manufacture of pulp, and the available supply. (*b*) Suitable sites for factories. (*c*) The financial aspect of the business.	Economist .	India and Burma generally.	
11	To keep under observation and encourage the match business in India, which is already started but which is still not firmly established.	,, .	.....	
12	Antiseptic treatment of woods— To carry out experiments with various antiseptic processes, with special reference to the use of important inferior species for railway sleepers.	,, .	.....	
13	Investigations into the physical properties and seasoning powers of various woods.	,, .	.....	For details see items 16 and 17 in Part I.
14	Enquiry as to the use of and the possibility of putting certain gums, resins and oleo-resins on the European markets.	,, .	.....	In communication with the Reporter on Economic Products.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
15	Investigations to be carried out with regard to the disposal of products obtained from the destructive distillation of woods.	Economist .	.....	In conjunction with the Chemist.
16	Enquiry as to the commercial value of certain oil-seeds.	„ .	.....	In communication with the Reporter on Economic Products.
17	Investigations regarding woods suitable for— (i) Packing cases. (ii) Tea boxes. (iii) Opium chests. (iv) Paving blocks. (v) Railway rolling stock. (vi) Carriage building. (vii) Harbour construction. (viii) Other miscellaneous purposes, such as pencils, pipes, hair brushes, fishing rods, veneers, coopérage, etc.	„ .	.....	
18	Description of the woods at present little known in the market— Yearly a number of woods will be examined and information collected on each species likely to prove of commercial importance, with a view to bringing them to public notice.	„ .	.....	This work will be in continuation of a series of articles already published.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigation will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
19	Resin tapping of conifers and enquiry into the possibility of improving the present system of distillation.	Economist .	.....	In conjunction with the Chemist.
20	Enquiry into the subject of useful fibres.	,, .	.....	
21	Enquiry as to the use, if any, of *Strobilanthes Spp., e.g.*, the flowers contain an oil.	,, .	.....	
22	Enquiry as to the suitability of various tan barks, especially *Terminalias* and Oaks.	,,	.....	In conjunction with the Chemist.
23	Enquiry into the best method of disposing of resin, including the preparation of a list of the industries in which it is used, with the names of the firms engaged in these industries.	,, .	.....	
24	Enquiry into the most profitable method of disposing of lac.	,, .	.....	In conjunction with the Chemist.
25	Preparation of a satisfactory reference collection of insects for the Research Institute.	Zoologist .	.....	This collection should be confined to insects of practical importance from a Forest point of view.
26	Investigation regarding the lac insect.	,, .	.....	This investigation will be carried out in conjunction with the Agricultural Research Institute at Pusa.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
27	Rusa grass oil, to study the causes of differences between the two varieties, Motia and Sophia, and the possibility of the conversion of Sophia-oil into Motia-oil.	Chemist .	.. ...	In communication with the Reporter on Economic Products. *Note.*—These investigations will be carried out chiefly in the laboratory of the Imperial Forest Research Institute.
28	The commercial possibilities of the manufacture of shellac by various processes. (In hand).	,, .	.....	In conjunction with the Economist.
29	Distillation of *Blumea balsamifera* on a commercial scale (in hand); and of *Cinnamomum glanduliferum*.	,, .	.....	
30	Oil-yielding forest seeds, their oil value and the determination of the constituents of various oils.	,, .	.. ...	In conjunction with the Economist, and in communication with the Reporter on Economic Products.
31	Destructive distillation of Indian woods including the manufacture of Ethyl Alcohol.	,, .	.. ...	
32	Manufacture of decolourised Mangrove extract on a commercial scale.	,, .	.. ...	
33	Decolourisation and clarification of Indian Colophony. (In hand.)	,, .	.....	

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—concluded.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
34	Distillation of miscellaneous fragrant grasses, *e.g.*, khas oil, and the investigation into the properties of the essential oils obtained from them.	Chemist .	.....	
35	Examination of the resins of the principal conifers in connection with the production of turpentine.	„ .	.....	
36	Investigation regarding the best season for the collection of myrabolams so as to obtain the greatest yield of tannin.	„ .	.....	
37	Enquiry regarding collection and utilization of the milk of *Dichopsis elliptica*.	„ .	.....	

8.—Natural History Section, Indian Museum.

The programme for the Natural History Section of the Indian Museum must again be a provisional one, as two of the three new Assistant Superintendents have not yet reached Calcutta. The work noticed in last year's programme will, however, be continued, special attention being paid to blood-sucking Diptera of the families *Muscidæ* and *Psychodidæ* and to fresh-water fish.

9.—Civil Veterinary Department.

By the Imperial Bacteriologist :—

(1) *Anthrax.*—To continue the investigations laid down in the programme of the previous year.

(2) *Surra.*—To continue experiments in methods of treatment and prophylaxis.

(3) *Rinderpest.*—Investigations as to possibility of preparing serum for buffaloes; and also the use of other than hill bulls for the preparation of serum for bovines.

(4) Further tests of serums and vaccines prepared during the past two years.

By the Officer investigating Camel diseases :—

(1) Investigations into Surra in the field.

(2) The study of Filariasis in the camel.

(3) Treatment of Surra in the camel.

By the Provincial Staff.—Punjab Veterinary College Laboratory :—

(1) Treatment of Surra.

(2) Study of Hæmorrhagic Septicæmia.

By Provincial Superintendents :—

Collection of information and the mapping out, as opportunity occurs, of the incidence of Surra, Piroplasmosis, Hæmorrhagic Septicæmia and Anthrax.

APPENDIX.

APPENDIX.

REPORT ON SCIENTIFIC AND TECHNICAL INVESTIGATIONS CONDUCTED FOR INDIA AT THE IMPERIAL INSTITUTE DURING THE YEAR ENDED 30TH SEPTEMBER 1910.

The scientific and technical investigations which have been in progress at the Imperial Institute for the Government of India during the year ended the 30th September 1910, are as follows :—

(1) **Opium**.—The examination of the constituents of a large number of specimens of opium collected at the instance of the Government of India in the various districts of India has been in progress. Over 100 samples in all have been submitted for complete investigation and the work is now approaching completion.

(2) **Solanaceous** plants.—In connection with the examination of Indian Solanaceous plants, a report on the leaves and seeds of *Datura Metel* was completed during the year. Further specimens of *Datura Metel* and of *Hyoscyamus niger* were also under examination.

(3) **Aconites**.—The investigation of Indian aconites has been in abeyance owing to the requirements of the Indian opium enquiry. It is hoped to be able to resume this investigation, which promises interesting results, during next year.

(4) **Tobacco**.—Samples of tobacco grown experimentally at the Government Burirhat Farm at Rangpur, Eastern Bengal and Assam, and at the Nadiad Agricultural Station in the Bombay Presidency, have been examined and reported on. The nature and composition of the tobacco was ascertained and expert opinions obtained regarding its quality and value. Recommendations were made in the reports for the improvement of the tobaccos.

(5) **Lac**.—Specimens of lac prepared by a special process by the Imperial Forest Chemist were examined and submitted to technical trials. It appeared that the lac was rather darker than the best shellac and that there would be considerable prejudice against the form in which it was prepared. Larger samples for further technical trials were, however, requested.

An examination of lac from the "rain tree" (*Pithecolobium Saman*), forwarded from Baroda, showed that the material was of fair average quality.

(6) **Monazite sand.**—Samples of monazite sand from Travancore have been examined and reported on. The opportunity was taken of referring to analyses of other specimens of the same sand previously received at the Imperial Institute.

In addition to the above-mentioned investigations a large number of products received from the Officiating Reporter on Economic Products and other Indian officials have been examined and reported on during the year. These have included cotton, jute and other fibres, cotton-seed oil and ghi, lemon grass oil, foodstuffs and minerals.

The facilities offered by the Imperial Institute for obtaining independent and trustworthy information respecting the intrinsic and market values of Indian commercial products are being more generally recognised, and a great deal of such information has been supplied to numerous Government officials in India, and to merchants and firms in India as well as in the United Kingdom.

In this connection it may be mentioned that several reports have been drawn up at the request of the Government of Mysore on the subject of the production and the commercial prospects of sandalwood, with special reference to the present and future market for the Mysore wood.

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Departmental Publications.

I.—Department of Economic Products.

(1) The Agricultural Ledger—a series of papers on Economic Products issued as ready and priced according to the number of pages.
(2) Commercial Circulars printed for circulation but not on sale.
(3) Annual Report of the Industrial Section, Indian Museum.

II.—Meteorological Department.

Government of India Office.

(1) The India Daily Weather Report and Chart.
(2) The Weekly Rainfall Summary.
(3) The Monthly Weather Review.
(4) The Annual Summary.
(5) The Rainfall of India.
(6) Indian Meteorological Memoirs.

Bengal Office.

(1) Bengal Daily Weather Report and Chart.
(2) Monthly Rainfall tables and Summaries of the chief features of the weather of the month over Bengal.

Bombay Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Rainfall tables (*Madras Gazette*).

Allahabad Office.

(1) Monthly Weather Summaries (*United Provinces Gazette*).
(2) Annual Summary.
(3) Monthly Rainfall tables (*United Provinces Gazette*).

Lahore (Simla) Office.

(1) Monthly Summary } of Punjab weather.
(2) Annual Summary }

III.—Geological Survey.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XXXVIII, including the larger papers on geological subjects.

Records, Vol. I—XL, including the shorter papers and Annual Reports from 1868 to 1910 sold in parts, price one rupee each.

Manuals, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhi Road, Calcutta. Indexes to the Genera and Species described in the Palæontologia Indica up to 1891; to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

IV.—Survey of India.

(1) Annual General Report.
(2) Professional Papers.

V.—Botanical Survey and Royal Botanic Garden, Calcutta.

(1) Annual Report of the Botanical Survey of India.
(2) Records of the Botanical Survey, Vols. I—III, Vol. IV, Nos. 1—4 and Vol. V, No. 1.
(3) Annual Report of the Royal Botanic Garden, Calcutta.
(4) Annals of the Royal Botanic Garden, Calcutta, Vols. I—XII.

A list of the contents of the Records and of the Annals with prices of the numbers and volumes still available can be obtained by applying to the Superintendent, Royal Botanic Garden, Calcutta.

VI.—Department of Agriculture.

(1) *Annual Report.*—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology, and the like).

(2) *The Agricultural Journal of India.*—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in Agriculture.

(3) *Scientific Memoirs of the Department of Agriculture.*—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.

(4) *Bulletins.*—An occasional publication containing information on agricultural matters of a temporary nature.

(5) *Leaflets.*—Short notes of practical instruction in agricultural matters, dealing mainly with entomological subjects.

VII.—Forest Department.

(1) *Review of Forest Administration in British India* by the Inspector-General of Forests (issued annually).

(2) *Annual Progress Report of Forest Administration in each Province.* —Issued by the Local Governments annually.

(3) Indian Forest Records.

(4) Indian Forest Memoirs.

(5) *The Indian Forester.*—A monthly Journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal, published monthly.

(6) Bulletins are published from time to time.

VIII.—Zoological Department.

(1) The Annual Report—8vo.

(2) The Records of the Indian Museum, 8vo. Containing short papers on Indian zoology. One or two volumes issued annually in quarterly parts.

(3) The Memoirs of the Indian Museum, 4to. Containing monographs and other important papers. Published at irregular intervals.

(4) Descriptive Catalogue of Indian Decapod Crustacea, 4to. Parts published at irregular intervals.

(5) Descriptive Catalogue of Indian Echinodermata, 4to. Parts published at irregular intervals.

IX.—Civil Veterinary Department.

(1) Annual Report.

III.—Geological Survey.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XXXVIII, including the larger papers on geological subjects.

Records, Vol. I—XL, including the shorter papers and Annual Reports from 1868 to 1910 sold in parts, price one rupee each.

Manuals, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhi Road, Calcutta. Indexes to the Genera and Species described in the Palæontologia Indica up to 1891; to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

IV.—Survey of India.

(1) Annual General Report.
(2) Professional Papers.

V.—Botanical Survey and Royal Botanic Garden, Calcutta.

(1) Annual Report of the Botanical Survey of India.
(2) Records of the Botanical Survey, Vols. I—III, Vol. IV, Nos. 1—4 and Vol. V, No. 1.
(3) Annual Report of the Royal Botanic Garden, Calcutta.
(4) Annals of the Royal Botanic Garden, Calcutta, Vols. I—XII.

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(1) Annual Report.

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Board of Scientific Advice for India

for the year 1910-11

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1912

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for the year 1911-12

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Members of the Board of Scientific Advice.

Name.	Appointment.
The Hon. Mr. E. D. Maclagan, C.S.I., I.C.S.	Secretary to the Government of India (Department of Revenue and Agriculture) and *ex-officio* President, Board of Scientific Advice.
G. T. Walker, Esq., C.S.I., M.A., D.Sc., F.R.S.	Director-General of Observatories.
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Colonel S. G. Burrard, C.S.I., R.E., F.R.S.	Surveyor-General of India.
Colonel H. T. Pease, C.I.E., M.R.C.V.S.	Principal, Punjab Veterinary College.
Morris W. Travers, Esq., D.Sc., F.R.S.	Director of the Indian Institute of Science.
F. Beadon-Bryant, Esq., C.S.I.	Inspector-General of Forests to the Government of India.
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Surgeon-General the Hon'ble Sir C. P. Lukis, K.C.S.I., M.D., F.R.C.S., I.M.S.	Director-General, Indian Medical Service.
Major A. T. Gage, I.M.S., M.A., M.B., B.Sc., F.L.S.	Director of the Botanical Survey of India and Secretary, Board of Scientific Advice.

List of Sub-Committees.

Sub-Committee A.—(*Meteorology, Terrestrial Magnetism and cognate subjects*).

1. The Surveyor-General of India (Chairman);
2. The Director-General of Observatories;
3. The Director, Geological Survey of India.

Sub-Committee B.—(*Agricultural Products*).

1. The Director, Botanical Survey of India (Chairman);
2. *Vacant.*
3. The Inspector-General of Agriculture.

Sub-Committee C.—(*Soils and Manures*).

1. The Inspector-General of Agriculture (Chairman);
2. The Director, Geological Survey of India;
3. The Inspector-General of Forests.

Sub-Committee D.—(*Forest Products*).

1. The Inspector-General of Forests (Chairman);
2. *Vacant.*
3. The Director, Botanical Survey of India.

Sub-Committee E.—(*Veterinary Subjects*).

1. The Inspector-General, Civil Veterinary Department (Chairman);
2. The Inspector-General of Agriculture;
3. The Superintendent of the Indian Museum.

Sub-Committee F.—(*Libraries*).

1. Morris W. Travers, Esq., D.Sc., F.R.S. (Chairman);
2. The Director-General of Observatories;
3. The Surveyor-General of India;
4. The Director, Geological Survey of India.

ANNUAL REPORT FOR 1911-12

B 2

ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

1911-12

SUMMARY OF PROCEEDINGS.

Twenty-second Meeting held at Simla on the 13th May 1912.

The programmes of work of the various scientific departments were discussed. The Board resolved to accept the programmes as submitted, and to recommend that those departments which so far had not differentiated between more and less important investigations should in future do so and should frame their programmes accordingly. The Board also resolved that in view of the new arrangements regulating the relation of the Imperial Institute to the various scientific departments of Government, future reports on work done and programmes of work to be done at the Imperial Institute on behalf of the Government of India should be sent by the Director of the Imperial Institute direct to the Secretary to the Board of Scientific Advice to the Government of India.

It was also resolved that the individual contributions to the chapters of the Annual Report of the Board concerned with (*a*) Applied Chemistry, (*b*) Economic Botany and (*c*) Economic Entomology should be indicated by separate sub-headings.

Twenty-third Meeting held at Dehra Dun on the 9th November 1912.

The Board considered proposals submitted by their Secretary for securing earlier publication of the Annual Report of the Board. The Board after discussion decided that it was unnecessary to publish in future the programmes of the various scientific departments, but that programmes should be sent to the Secretary to the Board not later than the 15th April for consideration by the Board at the meeting in May and for submission to Government thereafter. It was further resolved that contributions to the Annual Report of the Board should be sent to the Secretary not later than the 1st September, for discussion by the Board at a meeting to be held in October or November.

The draft Annual Report for 1911-12 was then discussed. The Board resolved to accept the report after the omission from it of mere criticisms and expressions of individual opinion as distinct from records of fact. The Secretary was directed to request contributors to the report to append to their respective contributions a list containing the titles of such publications only as have a direct bearing on Indian conditions.

The distribution list of the Annual Report of the Board and new applications for copies were read. The Board resolved to grant the new applications and to authorise the Secretary (*a*) to distribute copies to such officers of the various agricultural departments as might apply for them, (*b*) to increase the number of copies distributed to the public press by ten copies.

The question of whether seismographic observations should be placed under the control of one department was referred by the Board to Sub-Committee A for discussion and report at the next meeting of the Board.

APPLIED CHEMISTRY.

PART I.—ECONOMIC AND INDUSTRIAL CHEMISTRY.

BY

D. HOOPER, F.I.C., F.C.S., F.L.S.,
Economic Botanist, Botanical Survey of India.

This is a review of the chemical work performed during the year apart from that undertaken by the Agricultural and Forest Departments of India. In a few educational institutions the professors and their students have prosecuted a certain amount of research not directly connected with industrial chemistry; it is considered desirable that this work should be recorded, and the titles of the papers in which such work has been published have been included in the bibliography. With the appointment of Professors of Tinctorial Chemistry at Madras and the Sibpur Engineering College, Calcutta, research should be developed in this branch of knowledge. Analyses of economic minerals are carried on by the Geological Survey and private companies, and little has been published during the year on the subject of inorganic chemistry. The present report consequently deals almost exclusively with substances of vegetable origin examined in India and Europe. Since many of these articles are consumed as food and drugs, a knowledge of their actual chemical composition is important in enabling analysts to recognise the genuine products and to detect adulteration. The report records an increased amount of analytical work in connection with economic products and substances having a possible future in the industries and commerce. The material has been arranged according to the following classification:—

1. Natural exudations: rubber, resins and gums.
2. Fixed and volatile oils.
3. Dyes and tans.
4. Fibres and paper.
5. Food substances: flour, sugars, starch.
6. Accessories to human food.
7. Drugs.

I.—Natural Exudations.

The following notes on the examination of indigenous rubbers and resins are taken from the report of the laboratory of the Industrial Section of the Indian Museum.

India-rubber.—Few commercial products have been brought to light by the Abor Expedition, but a sample of rubber obtained by Mr. Burkill from the Galong Abors is of interest. The rubber is in the form of balls, weighing, on an average, half a pound. It is scrap rubber of fair quality and elasticity, and its composition, recorded below, is similar to that of *Ficus elastica* Roxb.

		Dry rubber.
Moisture	3·2	...
Caoutchouc	76·5	79·0
Resins	12·9	13·3
Albumen	2·6	2·7
Ash	4·8	5·0
TOTAL	100·0	100·0

The sample corresponds in analysis and appearance with some hill rubber received in 1904 from Nazira, Sibsagar.

Ceara rubber.—About nine years ago plants of ceara rubber (*Manihot Glaziovii* Muell.-Arg.) were planted out in farm land at Nahpa in the Northern Shan States. In three years they attained a height of 15—20 feet and girths of from 18 inches to 2 feet. Last year the trees were 2 to 3 feet in girth, and had grown vigorously. The latex was collected by tapping the trees by the herring-bone method in September, and about 2 lbs. of dry smoked rubber per tree was obtained at a cost not exceeding Re. 1 per tree. The cultivation thus promises to be very profitable in large areas such as the worked-out Taungyas at 2,400 feet

and below. A cake of the prepared rubber had the following composition :—

	—	Dry rubber.
Moisture	5·20	...
Caoutchouc	70·48	74·3
Resins	6·90	7·3
Albumen	13·62	14·4
Ash	3·80	4·0
TOTAL	100·00	100·0

This is fair average composition; the high amount of albumen is peculiar to ceara rubber.

Euphorbia gum.—The latex of the Euphorbias yields an inferior caoutchouc or gutta-percha, and samples are occasionally submitted for valuation. The coagulum obtained by heating the milk of *E. neriifolia* L. which had been preserved in a bottle for some years, had the following composition :—

	—	Dry.
Moisture	17·30	...
Caoutchouc	7·23	8·7
Resins	71·90	87·1
Albumen	1·87	2·2
Ash	1·70	2·0
TOTAL	100·00	100·0

A substance of this character, containing so much resinous substance, would have very little commercial value.

Mulberry gum.—The gum of the Indian Mulberry (*Morus indica* L.) has been noticed by a few observers, but no account of its properties or uses appears to exist in the literature of Indian products. A sample of the dried latex was received from the Tista Division in 1909.

When washed in hot water, a soft, white, plastic, gutta-like substance was left. It consisted largely of amorphous and crystalline resins soluble in alcohol according to the following proportions:—Moisture 4·7, resins 87·6, gutta 7·7.

Calophyllum resin.—A greenish resin is exuded by various species of *Calophyllum*, and the Indian Museum possesses two specimens from Burma and one from Madras, the production of *C. Inophyllum* L. This resin is supposed by some authorities to be East Indian Tacamahac or the "Tacamahaca orientale" of early writers, but there is no evidence that the resin is a commercial article at the present time. The resin is not known to have any industrial use, but as it is occasionally collected by the natives it is probable that they attribute to it some medicinal virtues.

The crude resin is usually mixed with pieces of bark and wood, and the purified resin is greenish, transparent and sticky, having a peculiar odour of melilot or coumarin. Two samples of the refined resin had the following constants:—Acid value, 190·9, 194·3; saponification value, 204·3, 206·7; iodine value, 148·8, 165·2.

Mesua resin.—The iron wood tree (*Mesua ferrea* L.) belongs to the same natural order as *Calophyllum*, and yields a resinous juice when the bark is bruised. A tenacious resin also exudes from the base of the young fruits and in time completely covers them. The resin is at first soft but hardens on exposure to the air; it is pleasantly aromatic. The soft resin had the following constants:—Acid value, 121·3; saponification value, 143·4; iodine value, 124·8. 61 per cent. of a hard brown acid resin was separated from the total; this had an acid value of 190. The unsaponifiable portion was fluid and balsamic.

Tibetan lac.—Dr. G. D. Hope, of the Indian Tea Association, presented to the Museum a sample of brown resin from Kalimpong having the properties of crude lac. According to Tibetans the incrustation is produced on the branches of trees of which one is "Siris" (*Albizzia Lebbek* Benth.). They boil the resin with water and prepare a red dye which they use for dyeing their clothes. The residue is pressed into cakes or sticks and sold in the bazaars. It is called "Laha" in Kalimpong, and is used for various purposes, such as fastening khukri handles and other articles. The lac is also brought in by Bhuteas to the annual cold weather fairs at Dananga and Subankhata in the north of the Kamrup district. Similar cakes are known in Manipur where they are called "Cha." The resin had the characteristics of crude lac with 10·5 per cent. of insoluble impurities.

Messrs. Hoseason and King have contributed to the Society of Chemical Industry a preliminary note on the examination of various samples of stick lac and shellac from Calcutta.

Sterculia gum in tragacanth.—The substitution and adulteration of powdered tragacanth with a substance known to trade as Indian gum has of late assumed large proportion, and enquiries have been made as to its occurrence. True tragacanth is a product of Turkey, Asia Minor and Persia and is exported from Beirut and the Persian Gulf ports. Mr. H. C. Fuller has shown that *Sterculia urens* Roxb. is the source of the substitute for tragacanth, and is supplied from India, where it is used in place of tragacanth in the hospitals in Bombay. The spurious article forms a nearly transparent jelly with water, and the aqueous solution is decidedly acid to litmus paper. It is unaffected by iodine solution which becomes blue in the presence of tragacanth, and it does not give a yellow colour when boiled with alkali. Indian gum reacts in a peculiar manner with borax. Tragacanth gives a smooth creamy mixture, while the substitute gives a thick slimy mass, often so gelatinous that it will not pour out of the container. Another important property of the new gum is the separation of volatile acids, largely acetic, on boiling with mineral acids. The amount of acid given off by specimens of Sterculia gum is quite constant and the acidity of a sample under examination will furnish a very reliable figure for estimating the amount present.

W. Schirmer of Strassburg has investigated the gum of *Anogeissus latifolia* Wall. and *Odina Wodier* Roxb., received from the Indian Museum, and has studied the products of their hydrolysis. Anogeissus gum contains half its weight of Arabo-galactan in which araban predominates. Odina gum contains half its weight of Arabo-galactan in which galactan predominates. Anogeissus gum yields 0·95 per cent. of nitrogen, and the Odina gum 0·78 per cent.

II.—Fixed and Volatile Oils.

Bassia seeds.—Samples of these seeds were forwarded to the Imperial Institute by the Reporter on Economic Products and have been examined by Mr. R. G. Pelly. *B. butyracea* Roxb. seeds are richer in fat than those of either *B. longifolia* L. or *B. latifolia* Roxb.: *B. butyracea* yields 61·2—66·9 per cent.; *B. longifolia* 55·3—57·8 per cent.; and *B. latifolia* 33·0—46·0 per cent. of fat.

The fats of *B. longifolia* and *B. latifolia* are of similar character, but they differ widely from the fat of *B. butyracea*. This is confirmed

by the results of the investigation of the fatty acids, which, stated briefly, are as follows. The fats of *B. longifolia* and *B. latifolia* consist of glycerides of stearic, palmitic and oleic acids, and in the case of *B. longifolia* of linoleic acid, whilst the fat of *B. butyracea* contains glycerides of palmitic and oleic acids only. The fat of *B. butyracea* is of firmer consistence, and this fact, together with the superior yield obtainable, indicates that the seeds of this species are of greater value than those of other species if it is found that supplies can be obtained in sufficient quantity for the European market.

Marotti fat.—In 1911 it was recorded that several poisoning cases had occurred in Germany through the consumption of margarine made from "Marotti" or Maratti" fat or "Cardamom" oil imported from India. An investigation made at the Hamburg Hygienic Institute showed that the fat is very similar to that yielded by *Hydnocarpus Wightiana* Bl. and *H. venenata* Gaertn. of South India and by *Taraktogenos Kurzii* King, the Chaulmugra of North-East India. This discovery has been the subject of numerous reports and enquiries. All these fats contain chaulmoogric and hydnocarpic acids, which are now shown to be physiologically active, causing nausea and vomiting and producing irritation of the mucous membrane of the stomach.

Gynocardia oil.—The rancidity, judged by the high acid value of commercial samples of Chaulmugra oil, is attributable to the decomposed state of the seeds before they are pressed. A much superior oil, it is presumed, would be obtained from fresh seeds or seeds preserved after careful drying. In order to test the property of the oil from newly collected and carefully picked seeds, some seeds of *Gynocardia odorata* Br. or False Chaulmugra were forwarded by Mr. Burkill from Kobo, the base of the Abor Expeditionary Force. The acid value of the ether extracted oil was 3·23, that of the expressed oil 3·09. We may compare these figures with those of Power and Barrowcliff obtained on the oil of the same seeds collected in the ordinary way and examined after a long sea voyage. The determinations recorded are—Acid value of ether extracted oil, 5·0; expressed oil, 4·9. The acid values of the oil of the fresh seeds are not much below those determined in England, but they are lower than all the published acid values of Chaulmugra oil of commerce, and the results tend to prove the desirability of using seeds fresh as possible for oil extraction.

Chilgoza nuts.—The seeds of Chilgoza or Neoza pine (*Pinus Gerardiana* Wall.) form one of the great trade products exported from the district of Khost and the Kuram Valley to India. Large quantities also

pass through Leh to Yarkhand and Lhassa. They are sold all over Northern India, and are available in the Calcutta market in the dry weather. The nuts form a nutritious article of food, and the oil is sometimes expressed and used for edible purposes. The nuts contain about half their weight of oil which is almost neutral in reaction and possesses slightly drying properties.

Thevetia seeds and oil.—Under the name of "Kaneer" the Chemical Examiner of the United Provinces forwarded some seeds which had been used in cattle poisoning. They were identified as the seeds of the yellow Oleander (*Thevetia nereifolia* Juss.). All parts of the plant are known to be poisonous, and the active principle, thevetin, has been shown to resemble digitalis in its action. In addition to their morphological characters the seeds are easily distinguished by giving a blue colour with hydrochloric acid.

The seeds are very oleaginous, and a sample from Dacca had the following composition:—

Moisture	3·5
Oil	59·8
Albuminoids	16·5
Carbohydrates	17·1
Fibre	·4
Ash	2·7
TOTAL	100·0

The oil is perfectly liquid at ordinary temperatures and has a specific gravity of 0·9148 at 25° C. Oudemans found it to consist of 63 per cent. triolein and 27 per cent. tripalmitin and tristearin.

Prinsepia utilis Royle.—The seeds of this shrub, known as "Bhekul," yield an oil by expression which is used in the North-West Himalaya for food, illuminating, and occasionally in medicine. It is said to be exported in small quantities from the forests of Garhwal and Kumaon. There are two samples in the Indian Museum: one from the Kangra Valley, of a bright green colour, and the other from Bushahr in the Punjab, opaque and light brown in colour. In specific gravity, iodine value and melting point of the insoluble fatty acids, the oil resembled that derived from cotton seed.

An Agricultural Ledger on fixed oils has been published during the year by Mr. Hooper. It deals with the sources, properties, uses and value of vegetable fats and oils available in British India.

Cinnamomum glanduliferum Meissn.—The "Nepal Sassafras" or "Nepal Camphor" occurs as a large tree in Assam, where it is called "Gonserai." The oil of the wood examined by Mr. S. S. Pickles is pale yellow and possesses an odour resembling safrole. The yield obtained from the dried ground wood by steam distillation was 4·16 per cent. An exhaustive examination showed the oil to consist mainly of safrole, myristicin and elemicin. Other constituents present in small quantities are palmitic acid, esters of the lower fatty acids and traces of phenols.

Cinnamomum Parthenoxylon Meissn.—This yields the Martaban camphor wood or Selasian wood. An oil distilled from the chips at Buitenzorg gave the following constants:—Density 1·067, optical rotation – 1° 3′, saponification value 8·4, ester value after acetylation 11·8.

Meriandra bengalensis Benth.—The leaves of this labiate plant are used in Eritrea as a popular remedy for similar purposes as those of sage, and the oil bears some resemblance to sage oil. The raw material yields 1·5 per cent. of a pale brown oil with an odour of sage and rosemary. The density was 0·9513, acid value 3·7 and ester value 14·8. It was soluble in two volumes and more of 70 per cent. alcohol. Placed in a freezing mixture or submitted to fractional distillation dextrorotatory camphor was separated.

Ocimum sanctum Linn.—The statement that the oil of the Holy Basil of India contains methylchavacol has been confirmed. Brooks, who has recently investigated the product in the Philippines, found between 50 and 60 per cent. of methylchavacol, besides cineole and linalool.

Strobilanthes lupulinus Nees.—A fragrant acanthaceous shrub very common on the ghats near Bombay is collected for its perfume. The oil distilled from the flower buds possesses a very strong and pleasant odour. The constants are: Density 0·9648, optical rotation 16° 30′, saponification value 1·7, and ester value 25·7.

Indian turpentine oil.—In continuation of the remarks made on this oil in last year's report, Mr. H. H. Robinson has examined by fractional distillation and analysis genuine samples of the oil of *Pinus longifolia*. One fraction, amounting to about one-third of the whole, was of a much lower boiling point and was found to be l-pinene. From the remaining two-thirds sylvestrene was obtained as a hydrochloride. It is thought very possible that the sylvestrene is not present as such in the original oil, but that a terpene is there contained which unites with hydrogen chloride to form sylvestrene dihydrochloride, just as pinene

yields a hydrochloride from which camphene is obtained when the hydrogen chloride is removed.

Toddalia aculeata Pers.—A camphor-like compound melting at 96·5° to 97° has been obtained by Mr. B. T. Brooks from the oil. The leaves yield ·08 per cent. of oil by steam distillation. On freezing, the oil deposited 18 per cent. of a white crystalline compound, very volatile, and having an odour closely resembling that of camphor. The oil had an odour suggesting a mixture of camphor and lemon grass. Sp. gr. at 20°, 0·9059. The oil is largely linalool, since the fraction between 195° to 200° yielded citral on oxidation with chromic acid mixture.

Indian Wintergreen oil.—The parent plant of this oil is *Gaultheria fragrantissima* Wall., a bush occurring gregariously over tracts of the Nilgiri Hills and the Palni and Travancore Hills. It differs markedly from the American Wintergreen (*G. procumbens* L.) which is a small creeping shrub. The oil consists chiefly of methylsalicylate, and that distilled locally is wholly restricted to home consumption. It would, however, be possible to extend the industry seeing that there is abundance of the raw material available.

III.—Dyes and Tans.

Cedrela Toona Roxb.—These flowers which constitute an Indian dyestuff of minor importance yield, according to Mr. A. G. Perkin of Leeds, a minute amount of a red colouring matter identical with the nyctanthin obtained by Hill in 1907 from the flowers of *Nyctanthes Arbor-tristis*. This melts at 285—287°. In dyeing and other properties it closely resembles, but is not identical with, the bixin of annatto (*Bixa Orellana*). The presence of quercetin contaminated with a trace of an allied colouring matter as glucoside and of a sugar have also been detected, and to the former the main dyeing properties of the flowers appear to be due.

Red Sandal Wood.—Santalin, the colouring principle of Red Sandal Wood (*Pterocarpus santalinus* Linn. f.), has been examined by Messrs. Cain and Simonsen. Santalin is a red micro-crystalline powder melting at 276°, and having the formula $C_{15}H_{14}O_5$. It contains a methoxy and two hydroxy groups. With hydroxylamine it forms an oxime, and on oxidation with potassium permanganate yields veratric and anisic acids. The authors isolated a colourless glucoside from the sap of the plant, from which santalin is probably produced in the plant by the action of an oxidase.

Assam dye wood.—The root of the "Napoo" (*Fibraurea Trotteri* Watt), an extensive climber common in the forests of Manipur, is used as a yellow dye in Assam. The root is soaked in water, cloth is steeped in the infusion for twenty-four hours, and the colour is fixed by means of the fruits of "Heibong" (*Garcinia pedunculata* Roxb.). An authentic sample of the root was analysed and found to contain 1·89 per cent. of the alkaloid, berberine.

Mangrove bark.—A large quantity of the wood of the "Goran" (*Ceriops Candolleana* Arn.) is brought from the Sunderbans into Calcutta for fuel. The bark is a valuable tanning material, but it is said to vary according to the age of the tree from which it is taken. In order to determine the distribution of tannin in the older and younger bark, a tree about 12 feet in height was cut down and divided equally into four parts, the first representing the thicker and older bark at the base of the stem, and the fourth representing the thinner and younger bark at the top. The bark from each portion was separately dried and analysed with the following results:—

	Moisture.	Ash.	Extract.	Tannin.
No. 1	11·3	9·5	37·2	26·2
No. 2	11·0	9·0	36·7	24·6
No. 3	10·5	8·8	35·4	23·8
No. 4	10·5	8·9	34·7	22·8

This experiment exemplifies the greater tanning value of the older and thicker bark of the mangrove tree compared with the younger portion.

IV.—Fibres.

Rhea.—At least two processes for cleaning rhea fibre (*Boehmeria nivea* Hook. & Arn.) in India have been devised during the year. A Calcutta merchant submitted samples along with samples of the fibre prepared in Germany for favour of comparison with that prepared locally. In appearance they were equally good and in strength they were about the same. On testing them by chemical methods, there was found to be a very little difference in their composition. A cheap and suitable plant for cleaning the fibre on a large scale is still desirable.

Hental leaves.—An enquiry has again been made as to the value of the leaves of "Hental" (*Phœnix paludosa* Roxb.), the wild date palm of the Sunderbans. The leaves contained 28·6 per cent. of cellulose. Some years ago a large quantity of the leaves was sent to a paper mill

for experiment, and the manager reported that the yield of fibre was only 25 per cent., and the material was therefore too expensive to use.

The bark of "Bhola" (*Hibiscus tiliaceus* L.), a plant of the Sunderbans, yielded 30 per cent. of fibre. The bark of *Sterculia villosa* Roxb. affords 49·85 per cent., a much better return.

V.—Food Substances.

Amorphophallus tubers.—The corms or tubers of *Amorphophallus campanulatus* Bl. are cultivated throughout India in rich moist soils. In Bengal the plants are known as "Ol," and the roots, containing much starch, are considered nutritious and wholesome, and are cooked like potatoes by boiling or roasting. The wild roots are acrid and irritating, which property is removed by thorough washing and boiling. The acrid principle is partly, if not entirely, due to the presence of needle-shaped crystals or raphides, which causes troublesome irritation in the mouth and fauces. Four samples of fresh tubers of the following descriptions were analysed to ascertain their nutritive value:—

(1) "Deshi Ol," cultivated, with fingers; (2) "Chit Ol," a wild small tuber; (3) "Deshi Ol," large, cultivated; (4) "Bombai Ol," large, cultivated.

The dried and powered tubers contained from 0·7 to 1·2 per cent. of fat, 6·7 to 9·6 per cent. of albuminoids, 80·3 to 85 per cent. of carbohydrates, 2 to 3·8 per cent. of fibre, 4·7 to 7·5 per cent. of ash, and 0·55 to 0·75 per cent. of phosphoric anhydride.

The samples were examined microspically and raphides were found most abundant in the wild variety (No. 2) containing the largest amount of ash. The largest quantity of lime as acid soluble ash was also present in this tuber.

Bamboo seed.—Owing to the phenomenal flowering last May of the Mulī bamboo (*Melocanna bambusoides* Trin.), in Assam, the large pear-shaped fruits have attracted attention. Dr. Stapf has described the fruit in the Trans. Linnean Society, 1901-5, VI, 409. They are said to be edible, but no chemical analysis has so far been made of them. A sample was sent by Messrs. Shaw, Wallace & Co. from one of their estates in Sylhet. The edible portion or seed is quite palatable and had the following percentage composition:—

Moisture 10·20, fat ·65, albuminoids 14·62, carbohydrates 65·23, fibre 1·40, ash 7·90, phosphoric anhydride ·69.

Salep.—There being very few recorded analyses of salep, the dried corms or tubers of species of orchids, a sample of the large ovoid roots obtained from Lahore bazaar in 1908 was examined. The powder had the following composition:—

Moisture 9·65, albuminoids 8·62, carbohydrates 77·73, fibre 1·15, ash 2·85, phosphoric anhydride ·56.

VI.– Accessories to Human Food.

Tea.—Dr. G. D. Hope and his assistants have continued their investigations into the various problems affecting the tea industry, and the results have been published in special reports and in the new Quarterly Journal of the Scientific Department. In a paper on the "Firing of Tea" (No. 1 of 1911 of the Indian Tea Association) Messrs. Hope and Carpenter describe the results of experiments carried out at the Heeleaka Experimental Station. Changes in the amount of tannin, total soluble matter and oxidisable volatile matter in the leaf as the result of firing under different conditions are recorded, and the inference is drawn from the indications afforded by the experiments that it is most detrimental to the successful retention of essential oil, tannin and total solids to fire it at a high temperature during the early stages of the process, particularly if the leaf is surrounded during that time by an atmosphere highly saturated with water vapour. It appears more desirable to effect the drying in as short a time at a lower temperature by means of an increased air draught and the leaf thinly spread on the trays of the machine. There are indications of chemical changes taking place at the later stages of, and after firing, which may profoundly influence the flavour of the product.

In the second Quarterly Journal of the Department there is an interesting article on caffeine, describing the distribution of the alkaloid in the organs of the tea plant, the amount present in teas of various kinds and the combination of caffeine and tannin in the infusion.

Abor tea.—In May last Mr. A. J. Harrison of Dibrugarh, Assam, sent to the Indian Museum some specimens of leaves which the Abors call tea, and from which they make an excellent drink. The plant is about 5 feet high, and grows near the villages. The plant has been identified as *Actephila excelsa* Muell., a plant of the *Euphorbia* family. The leaves contain no alkaloid and are without any special aroma. They are extremely mucilaginous. A small quantity of tannin was present

and a white crystalline neutral principle. They would appear to constitute a harmless drink.

Bee-food.—The flowers of certain species of *Strobilanthes* growing in the Bombay Presidency and in Burma are visited by the large Indian bee (*Apis dorsata*) for collecting honey and wax. The flowers are aromatic, and the sticky sweetly scented buds of *S. ixiocephalus* Benth. are sent to Bombay from Kathiawar as a perfume. Some of the dried flower heads of *S. foliosus* T. Anders. were sent to the Museum for examination, to ascertain if the resin could be put to any commercial use. In addition to 9 per cent. of a fragrant oleo-resin, the heads afforded 3·18 per cent. of wax and 0·5 per cent. of sugar. The wax and sugar, no doubt, contribute largely to the bee-food found in the jungles in the Bombay Presidency.

Alcohol.—Mr. R. L. Jenks, formerly of the Central Excise Laboratory, Kasauli, has in the press a report on the method of spirit valuation for revenue purposes, and has devised a suitable pycnometer for taking the specific gravity of alcohol in the tropics at 60° F.

VII.—Medicinal Products.

Camelthorn root.—A sample of the root of camelthorn (*Alhagi camelorum* Fisch.) was sent from Cawnpore to the Indigenous Drugs Committee for examination and report, it having been pronounced to be a specific in malaria. The root contained a wax, resin, tannin, tannin anhydride, organic acid, sugar, quercetin, and colouring and mucilaginous matters. It yielded no alkaloid. Its properties being mildly astringent, the root would appear to have no recommendation as a febrifuge.

Belladonna leaves.—The acclimatisation of medicinal plants is a subject worthy of further study in this country. It is intended to prepare a statement of those that are cultivated for the Medical Stores and compare their composition with plants grown in Europe. A sample of leaves of *Atropa Belladonna* L. grown in Kashmir and sold by a Calcutta druggist was sent for valuation. The leaves contained 0·27 per cent. of alkaloid, an average yield compared with the European drug.

Belladonna root.—The Superintendent of the Kumaon Government Gardens forwarded for opinion the roots of Belladonna plants grown at Jeolikote—No. 1 sample was from one-year old plants, and No. 2 sample was from two-year old plants. They afforded respectively 0·40 and 0·45 per cent. of alkaloid. A sample from Kashmir also gave 0·45 per cent. The valuation of European root is from 0·2 to 0·6 per cent. of

alkaloid; the cultivated Indian root is, therefore, of average medicinal quality.

Coptis root.—The two sources of this root procurable in India are the Mishmi Teeta from the Mishmi Hills, north-east of Assam, and the root imported in Bombay from Japan. The former is considered a superior drug and commands a higher value in the market. A description of the two kinds known in this country and the result of their comparative analysis has been published as a supplement to Mr. Burkill's work on the botany of *Coptis*.

Croton bark.—It has been reported that the bark of *Croton Tiglium* L. is one of the ingredients of the Abor arrow poison. The bark is intensely acrid, and when applied to the arm in a fresh state it causes irritation and raises pustules. Two preparations were made from the bark, one a watery extract, and the other an alcoholic extract. The extracts were examined by Major J. W. D. Megaw, I.M.S., of the Medical College, Calcutta, with a view to finding the minimum lethal dose on guinea-pigs. 0·63 gram of the watery extract inserted in a pocket under the skin produced marked local irritant symptoms and caused death in five days. 0·2 gram of the alcoholic extract injected subcutaneously caused death in four hours. 0·1 gram caused death in 28 hours. Both cases were attended with marked local irritation. The extracts are of a comparatively low degree of toxicity for guinea-pigs, but the experiments prove that the fresh bark contains a poison of distinctly virulent type.

Gardenia gum.—The Deputy Conservator of Forests, Ramnagar, Garhwal Division, United Provinces, sent last June some samples of a white incrustation taken from trees of *Gardenia turgida* Roxb. The exudation occurred after longitudinal cuts had been made in the upper part of the stem, and did not form at the base of the tree. The gum was white, brittle and sweetish to the taste, and on testing its solubility and melting point it was found to contain mannite. The occurrence of manna in this genus is remarkable since other species of *Gardenia* are known to yield a yellow fragrant resin, called Dikamali resin.

Ginger.—In testing some samples of cultivated ginger root it was necessary to traverse the statement made by S. J. Riegel in 1891 that East Indian ginger yields 8 per cent. of oleo-resin, and that Jamaica ginger contains about 5 per cent. It was found that on estimating the pungent resinous principle by means of alcohol, either of 90 per cent. strength or absolute, the dried extract contained sugar and other matters soluble in water. The amount of washed oleo-resin would therefore be a more accurate criterion of the value of the root. A few Museum samples,

and recently dried samples from the local market, were extracted with strong alcohol, and the extracts washed with water. The following results were obtained :—

	Alcoholic extract.	Washed resin.
Punjab	11·1	8·1
Rough, Calicut	9·3	7·0
Bleached, Calicut	6·0	4·0
Unbleached, Calcutta	5·7	5·1
Bleached, Calcutta	5·1	4·6
Freshly dried, Geoukhali	8·4	3·9
„ „ Hooghly	7·9	4·3
„ „ Rungpur	11·8	5·1
„ „ „	9·3	4·7

From these few examinations there is seen to be a great variation both in the amount of extract and oleo-resin. The freshly dried samples also contain a smaller proportion of resin in the extract than the Museum samples of dried ginger.

An interesting experiment was made in the Kumaon Government Gardens to ascertain if ginger increased in value by being left longer in the ground. The root is usually harvested in December, and for purposes of the trial a sample was collected that month, another portion of the crop was lifted in February, and a sample of the original "Soont" from which the younger roots had grown was also taken. These were analysed :—

	Harvested in December 1911.	Harvested in February 1912.	Original "Soont."
Extract	6·4	8·3	14·0
Washed resin	3·0	3·5	4·1
Ash	6·5	6·8	7·2
Moisture	11·1	10·4	9·7

These results demonstrate that young ginger develops more oleo-resin the longer it is allowed to grow.

Saffron.—The Revenue Commissioner in Baluchistan forwarded during the year to the Reporter on Economic Products a sample of stigmas and anthers of *Crocus sativus* L. cultivated experimentally in Quetta. The stigmas, which constitute the true saffron of commerce, were of excellent quality, both in aroma and tinctorial properties.

Indian blistering beetles.—*Mylabris cichorii* Fabr. and other species of this beetle have been used for many years as a substitute for European cantharides, and are official in the Indian and Colonial addendum to the British Pharmacopœia. The beetles are collected for commercial purposes at Gwalior, and are supplied to all the Medical Store Depôts. K. Dieterich in 1901 found these beetles to contain from 0·73 to 1·92 per cent. of cantharidin, while the Spanish flies yielded on an average 0·7 per cent. Eldred and Bartholomew in 1908 recorded the occurrence of 1·24 and 1·36 per cent. in Mylabrideæ. During the year samples have been obtained from the principal Medical Store Depôts and submitted to analysis. The following figures were obtained:—

	Cantheridin.	Ash.	Moisture.
Calcutta	1·47	8·7	11·0
Bombay	1·02	5·7	10·2
Lahore	1·26	5·3	7·7
Madras	1·12	7·2	10·5

This result is satisfactory in showing that the drug used in India contains over 1 per cent. of cantharidin. The dried beetles do not appear to lose their active principle on being stored. The sample from Calcutta was marked as "old stock, 1910," yet it contained the largest amount of active principle.

There is evidence that the amount of vesicating principle depends upon the species of beetle employed. A sample of *Cantharis hirticornis* from the Murree Hills, Punjab, yielded as much as 2·02 per cent. of cantharidin.

Indian hemp.—Messrs. C. R. Marshall and J. K. Wood have submitted to the Therapeutic Sub-Committee of the British Medical Association a report on the standardisation of Indian hemp (*Cannabis sativa* L.). This is an investigation of the value of the acetyl number

which a previous research had indicated as likely to offer the basis of a chemical and physical standard. Many acetyl numbers were determined, but it was found that there is a marked divergence between the pharmacological activity and the acetyl number which indicates that this method, like the iodine value reported on last year, cannot be used as a substitute for physiological standardisation.

Ægle Marmelos Corr.—Mr. J. C. Shenstone has recorded the interesting observation that bael fruit contains starch granules of a peculiar shape. It is unusual to find starch in a fruit which develops rapidly to ripeness and then decays. The starch may be deposited to provide nourishment for the fruit in the final effort of ripening.

Andrographis paniculata Nees.—By extracting the leaves of this bitter medicinal plant with alcohol, M. K. Gorter has isolated a lactone, $C_{20}H_{30}O_5$, named andrographolide. It is converted into salts of andrographolic acid by boiling with caustic alkalis.

Cæsalpinia Bonducella Fleming.—The seeds yield an alkaloid for which Babu K. Bhaduri suggests the name "natin." The oil has a density at 27° of 0·9132, iodine value 96·1, and saponification value 292·8.

Cinchona.—During the past year in the Bengal Cinchona Plantations 853,638 lbs. of bark were worked up in the factory and yielded 48,393 lbs. of sulphate of quinine and other products. The plantation-grown bark yielded 3·4 per cent. of quinine and the imported Java bark yielded 5·7 per cent. To obtain a rough idea of the future yield of the Munsong Cinchona, 27 trees gave 324 lbs. of dry bark, equal to 12 lbs. per tree. The stem bark yielded 5·25 per cent., root bark 4·92 per cent. and branch bark 2·89 per cent. of sulphate of quinine or an average of 4·71 per cent.

In the Madras Cinchona Plantations in the Nilgiris 755,900 lbs. of bark were worked up in the factory and yielded 30,489 lbs. of quinine sulphate or 4·03 per cent. against 3·63 per cent. in the previous year.

In connection with this subject a translation has been published in the form of an Agricultural Ledger of Dr. K. W. Van Gorkom's administration of the Java Cinchona Estates during the period from 1872 to 1907.

Daturas.—Mr. A. E. Andrews has studied the active constituents of Indian solanaceous plants. It was found that in *Datura Stramonium* L. the percentage of total alkaloid in the stems was 0·25; in the leaves 0·41 and 0·45; and in the fruits 0·46; with one exception this alkaloid consisted of hyoscyamine either alone or associated with a small proportion of scopolamine. The results indicate that the Indian plant bears

favourable comparison with the European and Egyptian plants as regards the amount of total alkaloid, but the presence of scopolamine in some of the Indian samples appears to be a point of difference.

In *D. fastuosa* L. the total alkaloid varied from 0·1 in the roots to 0·2 in the fruits, and scopolamine was found to be the predominant alkaloid. In these respects the Indian plant closely resembles the European plant.

In *D. Metel* L. the seeds and the leaves contained 0·25, and the capsules 0·12 per cent. of total alkaloid. On comparing the results with those recorded for the European species it appears that in the Indian plant the amount of total alkaloid in the seeds and in the leaves is only about one-half what it is in the European plant, but with one exception the samples resemble the latter in so far that scopolamine is almost unaccompanied by other mydriatic alkaloids.

Nerium Oleander L.—Further investigations by A. Leutier confirm the existence in all parts of the plant, except in the latex, of the glucoside previously reported. This is probably the substance named "neriin" by Schmiedeberg who examined the plant in 1883 and isolated, besides this, the alkaloid oleandrine, and another glucoside, neriatin. On account of its strong affinity to strophanthin, neriin is now re-named "laevostrophanthin." A solution of a few crystals of the glucoside in strong sulphuric acid is coloured violet by contact with bromine vapour or nitric fumes. It is very poisonous, the toxic dose ranging from 2 to 6 mgm. per kilo for the dog. The latex contains another distinct crystalline glucoside.

Vernonia anthelmintica Willd.—The seeds contain a glucoside to which Babu K. Bhaduri has assigned the name "Shomerajin." The oil has density at 25° of 0·9731, iodine value 91·7, saponification value 305·7.

PART II.—AGRICULTURAL CHEMISTRY.

BY

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Usar Soil.—A long investigation which has been in progress in collaboration with officers of the Agricultural and Irrigation Departments for several years was brought to a conclusion during the past year. In the

United Provinces "alkali spots" occur in cultivated lands over a very large area. These spots are more or less infertile, frequently quite sterile, patches of land of a few square yards in area. Sometimes they lie so close to the margin of an usar plain that the relationship of the one to the other is apparent, but often such connection is absent. They occur alike within canal-irrigated and well-irrigated lands. Sometimes complaints are made that an extension of these alkali spots has occurred and it was due to such a case of complaint that the series of investigations now referred to were instituted.[1]

The first questions raised were to what extent do the usar salts move either vertically during changes of season, or laterally. It has been generally accepted as an established fact that the obnoxious soda salts of alkali lands are brought to the surface by the evaporating water during dry weather and are carried into the sub-soil during wet weather; that in fact such a movement is not only to be expected on theoretical grounds, but that such a periodical displacement applies to a large proportion of the saline ingredients in the soil. It is also certain that such salts will spread laterally into any soil which contains a less quantity, not that there is necessarily any movement of water, but the laws of diffusion of salts demand that this must be so.

But whilst the principles involved are readily defined, the practical effect on the land will depend on the amount of such movement in a given time. If it is great, as writers on alkali soils usually depict, the effect will be marked; on the other hand it may be so small as to be of no importance.

The tests which were made in order to estimate the amount of such movement of salts were carried out in the Mainpuri District near Bhadan by the late Babu Subodh Chandra Kar, second assistant to the Imperial Agricultural Chemist, under instructions from Mr. B. C. Burt and Dr. Leather, and the results went to show that the variation at any one time in the quantity of these salts from point to point in a horizontal plane in the soil was so great that it would only be possible to detect a seasonal movement of salts if this were considerable. The tests were conducted over a whole cold-hot weather season, November 1909 to May 1910, and necessitated the examination of the soil at each succeeding 6 inches from the surface down to either the water-level or to 9 ft. It was shown that no measurable movement of the alkali salts occurred in these soils towards the surface during the dry season. There was also no indication of any

[1] See "Investigations on usar land in the United Provinces" (*in the press*).

saline layer, so often spoken of as a characteristic of alkali lands in general, in the sub-soils at any time. The salts included the very destructive sodium carbonate, and bicarbonate, together with generally smaller amounts of chloride and sulphate; the amount of alkali though small was sufficient to account for the infertility of the soil. Records of the amount of water present throughout the season showed that there was a far smaller loss of this constituent than would occur in good arable land.

These soils were at the same time examined with regard to another characteristic, namely, their permeability to water, or the rate at which water moves through them. It was known in a general way that many of these alkali soils are much less permeable to water than ordinary agricultural land, but for the end in view a quantitative measurement became essential. There being no recognised method of making such a measurement, a new test had to be devised. This was done at the Pusa laboratories. The test consisted in first packing the soil into cylinders fitted with a "false" bottom by the aid of a specially designed machine, and then allowing water to percolate through it. It proved of the utmost service and showed that the permeability of these alkali soils to water was far less, one-hundredth or one-thousandth part, than in good arable soil.

This feature of the soil provided the true explanation of the facts which had been observed in regard to the salts. The movement of the salts is dependent, excepting in respect of diffusion, on the movement of water through the soil. If this is small, so will be the amount of salts which can move through a given stratum of soil in a given time. The soils were in fact so highly impervious to water that there could be no material movement either downwards during wet weather or upwards during the dry season, and there was consequently no "saline sub-soil layer" during the monsoon, nor accumulation of salts on the surface in the hot weather. The *appearance* of these lands gives the impression that such changes do occur, because in dry weather the salts dry on the surface and become visible, but in point of fact they are merely carried by rain about an inch or so into the soil where they remain practically stationary until the dry season sets in.

Subsequently to the above-mentioned investigation, a large number of alkali spots were examined (1910-11) through a stretch of about 20 miles of country in the Muttra and Etah Districts with a view to ascertain whether any difference exists in the nature of these alkali spots in well-irrigated and canal-irrigated tracts respectively. The first 10 miles

consists of country which has never been canal-irrigated but always well-irrigated; the second 10 miles has been under canal-irrigation for many years. In addition to general appearances and the character of the crops, samples of the soils were drawn, as had been done in Mainpuri District, for each succeeding six inches from the surface down to 9 ft. and examined with respect to the nature and amount of salts present and their physical properties. The results showed very conclusively that there is no difference between these alkali spots which are found under the two systems of irrigation; in every respect they were similar. They are not therefore the creation of canal-irrigation. They consist of "blocks" of an irregular shape both below and on the land surface; in superficial area they measure a few square yards, in depth rarely more than 9 ft. but usually more than 5 ft.; the side is often apparently nearly vertical but also commonly slopes away; nodular kankar frequently occurs in them but is probably not a necessary constituent, since it was apparently absent in some cases. The soil is highly impervious to water; the amount of salts is usually small, but the pernicious sodium carbonate is always present. No ordinary system of drainage could hope to affect such soil. Approximate calculation showed that if 2 ft. depth of water were constantly maintained on the surface of such land, the time required for it to percolate through 5 ft. would be from 6 months to 5 years according to the exact nature of the land.

The experiments which have been in progress on usar land at Aligarh for a long time were also examined. There the land is a compact alkali plain, the soil of which has the same general chemical and physical characteristics as have been described above, though the depth of the impervious soil is often only small, such as 3 to 4 ft. The imperviousness explains much of the small success which has attended these experiments. For example the salts had been regularly scraped off the surface of one plot for nine years, until but little saline matter accumulates on the surface soil during the hot weather. The land is however still quite sterile and the analysis showed that it contains in the sub-soil practically as much salts as it did formerly. The effect of the annual scraping has been to remove that portion of the salt which was always quite near the surface and which could be brought up annually by the evaporating water, but the greater part of the salts lies too far off to come out and remains permanently buried. Another and still more interesting case is situated at Mr. Keventer's dairy farm. For many years now useful fodder crops have been grown successfully, with the aid of very liberal applications of manure and water, on land which was formerly some of the worst usar.

To the visitor this land appears to be quite reclaimed. Examination of the soil however showed that although the upper 12 to 18 inches have been rendered fertile, the soil below is as impervious and saline as at first. The cultivation is in fact carried on purely with the help of about a foot of soil. It follows therefore that irrigation must be just as frequent as would be the case were there solid rock below.

In one instance gypsum, which was applied in very liberal quantity 14 years ago, has worked its way throughout the impervious stratum and having not only destroyed the sodium carbonate but also at the same time made the soil pervious to water, this patch has been entirely changed to fertile soil, but at a cost which is quite prohibitive.

At Pusa experiments were made with pot-cultures to ascertain the effects of alkali and imperviousness when acting separately. To this end in one set of tests the alkali was almost neutralised by gypsum without however affecting the impervious character, whilst in another set the soil was rendered permeable to water by the addition of sodium chloride, used in such quantity as not to affect plant growth; the alkali would of course remain. These tests went to show that of the two characteristics of this class of alkali soil, the sodium carbonate is the more severe on plants, though the impervious state was sufficient to practically prevent plant development.

In another set of experiments, also at Pusa, soil is maintained in a very wet state at 20 inches from the surface. The option has been expressed that good arable land becomes alkali under conditions of excessive canal-irrigation which commonly implies a high water-level. For the purposes of the test some soil was dug out of two fields where crops were growing, the adjacent land being usar, the idea being that such land would be more likely to become affected than land remotely situated from alkali patches. It was packed into large stone-ware jars and water has been added to the base so as to maintain the bottom soil in a permanently wet state. At the end of two years an examination of these soils showed that one was free from any sign of becoming usar, whilst the result with the other was doubtful. This experiment is being continued.

Soils—Regur.—A very interesting addition has been made to our knowledge of the cause of the black or dark brown colour of *regur* (black-cotton) soil by Messrs. Harrison and Ramaswami Sivan.[2] They confirm the observations of Leather[3] that the black colour is only in part accounted

[2] Memoirs, Dept. Agri. India, Chemical Series, Vol. II, No. 5
[3] Agri. Ledger, No 2, 1898, p. 26.

for by the presence of organic matter, and that it is largely due to mineral matter, and they confirm also the observation of Annett[4] that these soils contain a titaniferous magnetite. At the same time an examination of regur from many parts of the Madras Presidency as well as from the Bombay Deccan and the Central Provinces showed that these soils in Madras often contained only very small proportions of magnetite or none at all, but that all these soils contained another class of dark coloured mineral.

Separations were at first made by the aid of cadmium borotungstate and Thoulet's solution, but with these it was found that the dark coloured substance was liable to disintegration, and acetylene tetrabromide (sp. gr. 2·9) diluted with absolute alcohol, proved to be more suitable. The dark coloured material was found to consist of compound particles. Its amount in these soils is considerable, varying from one-third to one-half of the coarser portion of the soil; the finest portion being excluded.

This dark coloured material has a low specific gravity. Under the microscope it is seen to consist of transparent or semi-transparent grains cemented together by a dark coloured substance. The latter is readily stained by methyl violet and is colloidal. These compound particles are readily disintegrated by pressure. They are comparatively stable in contact with strong reagents; concentrated hydrochloric acid and caustic alkali have little effect on them, though the former dissolves much iron and aluminium. On the other hand, after ignition treatment with hydrochloric acid renders them colourless. Hot concentrated sulphuric acid, however, discharges the black colour entirely, and the residue is now found to consist of white compound particles similar in shape and size to the original. The black material when wetted forms a clayey mass which dries to hard lumps. The fact that concentrated hydrochloric acid, although dissolving large quantities of iron and aluminium from the unignited material, does not remove all the black colour, indicates that this is in part at least due to organic matter. This view is also supported by the following behaviour. Treatment of the unignited material with hydrofluoric acid results in a dark coloured residue, the colour of which is not discharged by either concentrated hydrochloric acid or alkali, but it is destroyed by either hot concentrated sulphuric acid or by ignition. The authors, whilst expressing no very decided opinion, raise the question whether the cementing substance is not an organic compound of iron and aluminium.

[4] Memoirs, Dept. Agri. India, Chemical Series, Vol. I, No. 9.

Regarding the origin of regur soil the authors consider that, since these soils are found overlying not only trap, as in the Deccan, but gneisses, shales, limestones and kankar beds, and having regard to the fact that the dark colour is largely due to a cementing substance, the materials of which they consist have been derived originally from a variety of rock formations and not exclusively from trap.

Assam Tea Soils.—Results are published[5] by Dr. G. D. Hope, of a number of mechanical analyses of tea soils which have been recently carried out in the Calcutta laboratory of the Scientific Department of the Indian Tea Association according to a method which approximates to that of A. D. Hall. The mechanical composition of soils taken from different localities in the North-East Indian tea districts is described.

The soils differ so much that generalisations are difficult to make, but these analyses show that on the whole they contain commonly high proportions of clay.

Some instances are quoted which show how the proportion of fine silt in a soil is correlated to its mechanical properties and the class of cultivation required.

Indigo.—Experiments on the chemical selection of indigo (*Indigofera arrecta* Hochst.) has been continued at Sirseah, although under very great difficulties, arising from both floods and pests. Mr. Bergtheil's recent report[6] shows that the Java plant, as at present cultivated, includes two, a high and a low, indigotin yielding plants and possibly two intermediate varieties. Among other indigotin yielding plants which are being studied are *Strobilanthes flaccidifolius*, *Indigofera longiracemosa* and *Wrightia inctoria*. The two first named, both high yielding plants, are probably too delicate to offer much hope of successful cultivation on the large scale, but *Wrightia tinctoria* grows well and may prove of practical importance. In relation to manufacture, experiments have been made in shipping the indigo in the form of paste instead of dried cubes.

Milk.—A second Memoir on milk has been published by Messrs. Meggitt and Mann,[7] the subject now being the milk of Indian buffaloes of the Surti, Delhi, Deccani and Jaffarabadi breeds. The conclusions which the authors make may be summarised as follows:—

(*i*) The mixed milk from a herd of these cattle contains from 6·5 to 8·0 per cent. fat in the morning and from 7·5 to 8·5 per cent. in the evening, that is, they find the evening milk to

[5] Quarterly Journal, Indian Tea Association, Part I, 1912.
[6] Report of the Indigo Research Station, Sirseah, for 1911-12, by Cyril Bergtheil.
[7] Memoirs, Dept. Agri, India, Chemical Series, Vol. II, No. 4.

be the richer by about 1 per cent., a difference which is similar to what was found by these authors for cow's milk at Poona. The milk of the Surti breed was found to be somewhat richer than the others.

(*ii*) During the monsoon period the percentage of fat decreases somewhat, but otherwise the changes due to climate are nominal.

(*iii*) The solids-not-fat in the milk of the Surti breeds varies from 9·5 to 11·5 per cent., the variation for three-fourths of the samples being from 10 to 11 per cent. There is no variation in these constituents between the morning and evening milk.

(*iv*) The ratio of milk sugar : proteids : mineral matter was found to be 6 : 5 : 1; which is the same as was found formerly by Leather.

(*v*) There seems little relationship between the composition of milk of individual animals of the *Surti* breed and the yield, except that the milk becomes *slightly* richer at the extreme end of the period of lactation. Apart from this, the milk yielded by a single buffalo does not seem to vary according to the amount of milk it is giving.

(*vi*) There is very great variation in the composition of the milk of individual animals of one breed, and also between the same buffalo at various times. This last variation in the quality yielded by one animal is much greater than that previously found for Indian cows. The variation in the content of "solids-not-fat" with one animal is practically as wide as for the whole of the animals examined.

(*vii*) The average length of the period of lactation for the *Surti* buffaloes is 53 weeks, but this varies very much, from 32 weeks to 67 weeks.

(*viii*) The yield of milk from a buffalo during the lactation period rises to a maximum almost at once, and remains almost constant for about the first two-fifths of the period. After this there is a regular and steady decline to the end of the period.

(*ix*) There is no relationship between the composition of the milk given by a buffalo and the period of the lactation except when the animal is rapidly becoming dry.

PART III.—FOREST CHEMISTRY.

BY

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Forest Chemist.

The following is a brief account of the more important work carried out by the Chemical Department of the Forest Research Institute during the year under report:—

Conifer Resins.—*Pinus longifolia* resin has been the subject of a detailed investigation both at Dehra Dun and at the Imperial Institute, London, and the results obtained are embodied in the form of a report which is now in press. The turpentine obtained from *Pinus Merkusii* having been already pronounced by Professor Armstrong to be similar to that derived from *Pinus Khasya*, the latter alone has been examined at the Forest Research Institute. *Pinus Gerardiana* occurs at such altitudes that its exploitation for the distillation of turpentine oil would not be commercially possible, hence no effort was made to obtain samples of its resin. The only two species, therefore, left for consideration were *Pinus excelsa* and *Pinus Khasya*. The resins from these two species have been thoroughly examined and samples of turpentine oil have been distilled from them in the laboratory. From the chemical tests of these oils carried out by the Forest Chemist, it is clear that both of them are high grade oils similar in all their properties to the high grade American oil. Samples of both these oils have been sent to the Imperial Institute, London, for commercial valuation. The data for a complete report on the subject are ready but the subject is kept pending till the receipt of the Imperial Institute Report.

Myrabolams.—Nine specimens of myrabolams, half ripe, nearly ripe and perfectly ripe, received from the Forest Economist, were examined for their tannin value. It ranged between 44 per cent. to 53 per cent. from October to March in half ripe fruits and between 42 per cent. to 50 per cent. in nearly ripe fruits and between 48 per cent. to 52 per cent. in ripe fruits. From these results the writer in his Note on the best season for collecting myrabolams for tannin material, published in the "Indian Forester" of September 1911, concluded that the longer the fruit is allowed to remain on the tree, the higher is its tannin value, and he recommended that myrabolams should be collected when they are perfectly ripe. In order to support this conclusion, it was proposed to analyse a greater number of specimens from different localities. This

work could not be taken up this year, as no more samples of myrabolams were received. It is hoped that a good number of specimens will be collected for examination from November 1912 to March 1913 and the investigation will be continued next year.

Tan barks and woods.—This investigation was started in 1911 and will be continued to the end of the year 1913. The results obtained so far go to show that the percentage of tannin in air-dried barks does not suffer any appreciable decrease, while in the case of barks exposed to atmospheric changes, as is already well known, the tannin is rapidly oxidised.

Catechin.—An interesting observation has been made on the total loss of Catechin that the old wood of *Acacia Catechu* undergoes, probably by alternate oxidation and anhydration. In a specimen of *Acacia Catechu* wood 40 years old, it was found that the whole of its Catechin had changed into Catechu red. Another specimen obtained from the Siwaliks, which in its fresh condition in 1907 gave 10·9 per cent. of Catechin, 13·7 per cent. of alcoholic extract and 21·8 per cent. of aqueous extract, gave in 1911 only about 8 per cent. alcoholic extract and 8 per cent. of watery extract and Catechin *nil*. Most of its tannin had also oxidised into Catechu red. This wood was lying in the laboratory exposed to changing climatic conditions for four years, being roughly used for various purposes in the laboratory.

Canarium bengalense resin.—The resin of *C. bengalense*, received from the Forest Economist, was refined and then samples were prepared by mixing 8 per cent. and 16 per cent. of bee's-wax to lower its melting point with a view to make the resin serviceable as a shellac substitute in the manufacture of crape, etc. These samples were sent to the Imperial Institute, London, for commercial valuation. The Institute submitted these samples to a firm of crape manufacturers for technical trials with the result that the sample of the resin mixed with 8 per cent. of bee's-wax was pronounced to be most likely to be serviceable, as its clearing properties were superior to those of the refined resin and the one mixed with 16 per cent. of bee's-wax. It was impossible, however, to obtain as stiff a finish with this resin as with shellac. For a soft finish, however, there seemed to be a likely demand. The results of the trial indicated that this resin mixed with 8 per cent. of bee's-wax might find a restricted application in finishing crape. Further work to improve the quality of this resin as a shellac substitute was given up as the tendency of the lac consumers to seek substitutes had ceased, owing to the low price of lac.

Boswellia serrata gum-resin.—Attempts were made this year to refine the *Boswellia serrata* gum-resin and to prepare the different products from it. A gum resembling in its properties gum Tragacanth, a resin similar to *Canarium bengalense* resin and an essential oil which has already been reported by Professor Dunstan as consisting of l-pinene and other terpenes were experimentally prepared. It is hoped that the gum mentioned above might probably form a substitute of gum Tragacanth in calico printing, etc., and the resin may find some useful application in the varnish industry and as an adulterant of shellac, but all this has yet to be tested on a commercial scale. The oil seems to be a valuable one inasmuch as it may serve as a base for the preparation of some of the artificial perfumes, perhaps camphor, and it might be useful as a soap perfume. The investigation will be continued next year.

Podophyllum Emodi resin.—Three samples of *Podophyllum Emodi* were received from the Forest Economist for analysis with a view to ascertaining the best season for collecting the herb. These samples were collected in May, September and November 1910. From the results obtained, it was seen that the younger the rhizome, the greater is the percentage of resin that it contains. The sample collected in May gave about 14 per cent. of resin, which diminished in September to 8 per cent. and in November to 7 per cent. On the other hand, the percentage of Podophyllotoxin increases with age from 35·34 per cent. in May to 37·07 per cent. in September and to 49·77 per cent. in November. The older root though poorer in resin than the younger root is richer in Podophyllotoxin and consequently more active medicinally. The conclusion arrived at was that the rhizome should be collected in May about the time when the plant is in flower and not in the autumn as has been suggested.

Seventeen samples of Podophyllum roots have been examined at Dehra Dun from time to time during the last four years in order to determine the variation in the percentage of resin contained in the plant. It was found that excepting a sample of rhizome obtained from Kalatop, Chamba, which contained 19·5 of resin, the percentage of resin in the other sixteen samples varied from 8·60 to 16·82 in the rhizome and from 3·9 to 13·94 in the hair-roots. From the results obtained, which have been published in the form of a Forest Bulletin, it would be safe to assert that an average quality of the Indian plant will contain as a rule twice as much of the active principle as the American, and the variation in its physiological properties, as determined in England from time to time on samples sent from India, is accounted for

by the fact that the percentage of the resin in the root as well as the medicinal activity of the Indian plant differs not only with the season of its collection, but also with the locality where grown. In another paper on *Podophyllum Emodi*, contributed by the Forest Chemist to the "Indian Forester," it was suggested that *Podophyllum Emodi* of standard quality could be produced by artificial cultivation and by collecting the rhizome in one particular season.

Sandalwood oils.—Ten specimens of Sandalwood have been examined this year for their oil value. A specimen received from the Divisional Forest Officer, Belgaum, Bombay, consisting of wood taken from trees grown on very poor soil covered with sandstone boulders at an elevation of 2,500 feet gave 4·44 per cent. of oil by steam distillation. Four samples of Sandalwood were analysed for the District Forest Officer, North Coimbatore, Madras. Five specimens of Sandalwood were sent by Mr. S. M. Lushington, Conservator of Forests, Central Circle, Madras, taken from the trees grown at the Kodur plantations, East Cuddapah Division, at an elevation of 800 feet only. He suggested that the analysis of these roots should prove of great value as it is usually supposed that at a low elevation the tree does not produce wood of any real value. As the tree has been introduced at low elevations both in the Northern and Central Circles of Madras on a fairly extensive scale, it is important to decide whether there should be any further advance in this direction. The results of the examination of these five specimens show that they contain 4—6 per cent. of oil. These results indicate that the Sandalwood derived from the trees grown at low elevation are quite as rich in oil as the other highly prized ones.

As mentioned in the last year's Report of the Board of Scientific Advice, a preliminary Note on the oil value of Sandalwood from trees grown in rich as well as poor soils, received from Madras, was published last year, but as suggested by the Editor, "Chemist and Druggist," London, a greater number of samples of Sandalwood should be examined to confirm the conclusion arrived at in the said Note. The investigation proposed by Mr. Lushington in the same connection to determine the oil value of Sandalwood grown at low elevation is also an important one. The Forest Chemist, therefore, proposes to include the determination of the oil value of Indian Sandalwood in his next triennial programme in order to investigate more definitely the factors which determine this value by examining at least one hundred specimens taken from trees grown at different localities, different elevations and in different soils.

Nickel tannates.—While estimating tannin by means of nickel hydroxide, it was noticed that tannic acid combines chemically with

nickel hydroxide. In order to investigate the chemical composition of the salt formed by the interaction of these two substances, a preliminary investigation was made, which shows that tannic acid combines with nickel hydroxide in different proportions under different conditions of precipitation and formation of the salt. The best method to make these salts consists in precipitating nickel hydroxide dissolved in ammonia and ammonium salts by means of tannic acid solution. In this way a series of salts is formed containing less NiO when the solution of nickel hydroxide in ammonium salts is completely precipitated by an excess of tannic acid solution and more NiO when it is fractionally precipitated.

(1) The solution of nickel hydroxide in ammonium chloride was precipitated fractionally by means of Kahlbaum's "extra pure" tannic acid solution, and the nickel tannate thus formed was first washed by decantation and then in a funnel connected with a filter pump till the washings were free from chlorides. It was then dried in a desiccator in partial vacuum. The desiccator-dry salt was taken both for nickel determination and for the moisture determination at the same time. In this salt, NiO found = 28·5, calculated on the dry salt.

(2) The same as in No. (1), but the nickel hydroxide solution was completely precipitated by an excess of tannic acid solution. NiO found = 8·96 per cent. calculated on the dry salt.

(3) The solution of nickel hydroxide in ammonium acetate was fractionally precipitated by means of tannic acid solution. Further treatment of the salt as in No. (1). NiO found = 23·76 per cent.

(4) The same as in No. (3). The solution was completely precipitated by means of tannic acid solution. NiO = 8·61 per cent.

When freshly precipitated, these salts are amorphous and greyish white in appearance, and on exposure to air gradually oxidise to a darkish brown powder. The salts which are completely precipitated, are more stable than the fractionally precipitated ones and they change their colour but little and that only superficially. They are insoluble in water, alcohol in ether, but dissolve in alkalis, making a dark brown solution out of which they can be precipitated by means of alcohol. The action of caustic soda is somewhat drastic on the salt. Ammonia is the best alkali for the purpose of making salts by precipitation.

In presence of excess of ammonia, the addition of tannic acid does not precipitate nickel tannate from the solution of nickel hydroxide in ammonia. After the addition of tannic acid solution in excess to the ammoniacal solution of nickel hydroxide, the nickel tannate can be

precipitated by the addition of an excess of alcohol. The nickel tannate prepared by precipitation with alcohol from the ammoniacal solution of nickel hydroxide gave 9·95 per cent. of NiO, being the average of two estimations. The composition of this salt very closely agrees with the formula where two molecules of tannic acid enter into reaction with one molecule of nickel hydroxide as shown in the following reaction :—

$$(C_{14}H_{10}O_9)_2 + Ni\ (OH)_2 = (C_{14}H_8O_9)_2\ Ni + 2H_2O.$$

The theoretical percentage of NiO required according to this formula is 10·65. The difference between the value found and the theoretical is 0·7 per cent. But considering that even "Kahlbaum's extra pure" tannic acid cannot be taken to be quite pure, it is clear that the theoretical salt of the above composition is formed by adopting the above process.

This investigation had to be left over for want of time and the Forest Chemist hopes that he will be able to continue it next year.

Lemon grass oil.—At the request of Dewan Tek Chand, I.C.S., Deputy Commissioner, Gujranwala, Punjab, a sample of lemon grass oil grown in his garden at Dehra Dun was examined. It contained 74·1 per cent. of moisture and 0·52 per cent. of oil or 2 per cent. on the dry grass.

Saussurea Lappa oil.—A sample of the roots of *Saussurea Lappa* (Kuth) of Kashmir was sent to the Forest Chemist by Rai Bahadur Pundit Keshwanand, E.D.C., for the determination of its oil value. The roots gave 13·23 per cent. of moisture or loss at 100° C. and 2·78 per cent. of oil. Messrs. Gildmeister and Hoffman in their "Volatile Oils" give 0·8 to 1 per cent. of oil. This percentage seems to be very low, it may be that the specimens examined were rather old. It would be interesting to analyse more samples of this valuable root. Accordingly Rai Bahadur Keshwanand is trying to obtain more specimens and the Forest Chemist hopes to continue this work next year. This investigation has an economic importance as the oil obtained from these roots is used as an adulterant of the perfume of violets in Europe and it would be worth while to inquire into the methods of its artificial cultivation, the percentage of oil in samples drawn from different localities, and the commercial possibilities of the oil.

Bamboo paper pulp.—Mr. William Raitt, F.C.S., Cellulose Expert, attached to the Forest Research Institute, Dehra Dun, has issued an important report on his investigation on bamboo as material for paper-pulp. This is now available in the published form in the

Indian Forest Records, Vol. III, Part III. Mr. Raitt's report gives valuable information on the chemistry of bamboo paper-pulp and he has for the first time removed various erroneous ideas on the subject that had resulted from the conflicting nature of the results of a considerable number of trials and experiments by pulp and paper-makers carried out in a somewhat unsystematic manner.

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ASTRONOMY.

BY

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Solar physics.—Researches in solar physics are carried on under the direct control of the Government of India at Kodaikánal, the Director being Mr. J. Evershed and the Assistant Director Mr. T. Royds. The chief instruments are:—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is to take photographs of the sun using the light emitted by one chemical element only. In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus, fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and so shall emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any desired wave length to pass through. In the Kodaikánal spectroheliograph the collimating and camera lenses each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate; and as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic

light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently 'reversed,' *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called 'flocculi'—of calcium vapour scattered about over the sun, and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

(*b*) An autocollimating spectroheliograph built in the observatory workshop. This is attached to the side of the Cambridge instrument and shares in the very perfect transverse movement of the latter. It is designed for photographing the sun's disc in the hydrogen line C. A large grating is used to obtain the highly dispersed spectrum which is necessary in photographing with this line.

(*c*) A high dispersion spectrograph mounted on piers in the spectroheliograph room. This is fitted with special arrangements for rotating the sun's image on the slit plate, and for accurate guiding during long exposures on sunspots or prominences. A special device has also been added for photographing simultaneously the spectrum of an electric arc on either side of a solar spectrum. A grating by Rowland with $3\frac{1}{4}$-inch ruling is usually employed.

(*d*) An 18-inch parabolic mirror (the property of the Director) is mounted in the spectroheliograph room immediately in front of the 12-inch photo-visual lens. It is used to form the solar image on the slit plate of the high dispersion spectrograph. The mounting is on rollers and the mirror can either be moved into position in front of the lens with its centre in the axis of the beam of light coming from the heliostat, or it can be pushed to one side so as not to obstruct the light incident on the lens during employment of the spectroheliograph and associated instruments.

(*e*) An 8-inch visual achromatic lens from the Maharajah Takhtasinji Observatory, Poona, temporarily mounted in the

spectroheliograph room on a pier near the Foucault siderostat. It is used for forming a solar image on the spectrograph slit specially for sunspot work.

(*f*) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus. This is used with a $3\frac{1}{3}$-inch concave grating of 10-foot focus mounted on Rowland's plan. A 2-inch parabolic grating can be substituted for the concave grating, and a collimating lens may be employed with either grating to cure astigmatism.

(*g*) An equatorial refractor, with an Evershed spectroscope attached, used for the spectroscopic study of sunspots and prominences by visual methods.

(*h*) A 6-inch equatorial refractor with a photo-visual object glass (this lens is also from the Maharajah Takhtasinji Observatory, Poona). A large camera has been attached and the whole instrument adapted for taking direct photographs of the sun. It will supersede the Dallmeyer photoheliograph previously employed for this purpose.

Routine work.—In addition to the daily records obtained by the two spectroheliographs and the photoheliograph, the routine work includes visual examination of sunspots and faculæ, observations of intensified or weakened lines in sunspot spectra, and of bright lines or displaced lines in spots and prominences. The position angles and forms of the prominences are also recorded. A monthly article describing the solar activity is contributed to the "Monthly Weather Review" while for more technical purposes bulletins and memoirs of the Observatory are issued; of the former 25 have appeared while of the latter the first has been published.

The solar constant.—No progress has been made in the method of estimating changes in the solar radiation by photographic comparisons between moonlight and first type stars on account of the difficulty in obtaining suitable apparatus for measuring the plates. It is hoped that satisfactory results may be obtained with a Hartmann photographic photometer which has been recently acquired by the Director.

Spectroscopic investigations.—Researches connected with the radial movements of the gases over sunspots discovered here in the year 1909 have been continued, but owing to the very small number of spots available for study during the year very little progress has been possible.

A considerable number of prominence spectrum plates have been obtained and measured for determining the velocities in the line of sight of eastern and western prominences due to the solar rotation. The results so far obtained are of great interest in that they indicate a much higher angular speed of rotation than the value derived from sunspot observations. The hydrogen of the chromosphere is known to be rotating faster than the general body of the sun from the spectrographic researches of Adams, and the prominences arising from the chromosphere and extending outwards into space appear to be forced round at a yet faster angular speed than the chromosphere. Individual prominences show large variations of velocity however and the results referred to are the mean velocities of about 60 prominences. The research will be continued whenever favourable opportunities occur with a view to verifying this preliminary result.

The completion of the electric installation early in the year 1912 has greatly enlarged the general scope of the spectroscopic work and terrestrial comparison spectra of the electric arc or spark can now be photographed side by side with the solar spectrum, the lines of the iron spectrum forming very convenient standards of reference for determining absolute velocities in the sun. As a test of the accuracy of the measurements of motion in the line of sight, as well as of the correctness of the adjustments of the spectrograph, comparison spectra of the sun and the electric arc were obtained with the sun at widely differing hour angles. The first plate was exposed at about 6 P.M. on March 27 and the second at 9 A.M. on March 28. In each plate there is shown a shift of the solar lines towards the red compared with the arc lines. This shift is made up of three components: (1) a shift due to a recession of the earth from the sun amounting at this date to 0·486 km. per second; (2) a shift due to the component of the earth's rotation movement in the direction of the sun, which is a motion of approach in the morning and recession in the afternoon; and (3) a shift of most of the solar lines towards the red and varying from line to line, which is supposed to be due to pressure in the sun's reversing layer.

The shifts due to (1) and (3) are constant for the two photographs, so that the difference of shift shown by the morning and evening plates should give (2). Measures of only 12 lines in the two plates gave a mean result from which is derived the value 0·52 km. per second for the earth's equatorial rotation velocity, or omitting four rather discordant lines 0·46 km. per second. The true value is 0·464 km. per second, a very satisfactory accordance considering the minuteness of the line displacements, which are of the order of 0·01 mm. on these plates.

With regard to the shift of the solar lines supposed to be due to pressure an excellent set of plates of the spectrum of the iron arc in air and the centre of the sun's disc has already been obtained. These will be measured for estimating the amount of the shift in different iron lines. A further set of photographs will be obtained in which the centre of the sun's disc is compared with the arc in vacuo. The measurement of these plates after correcting for the components (1) and (2) will give the values of (3), and these will be compared with known shifts due to pressure and with the relative shifts which the solar lines show when the centre of the disc is compared with the limb.

METEOROLOGY.

BY

J. H. FIELD, M.A., B.Sc.

Experimental work.—Owing to the absence on medical leave of the Director-General throughout the year and to the great shortness of scientific staff practically no new experimental work was possible during the year. A short series of pilot balloons was sent up in the early morning at Simla during a part of the monsoon, and their results have been worked out for publication with previous ones.

Publications.—These were of a routine nature only; no memoirs were published for the reasons which rendered impossible any progress under paragraph 1.

TERRESTRIAL MAGNETISM.

BY

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Director-General of Observatories.

Magnetic observatories.—*Bombay (Alibag).*—The Bombay Observatory, formerly maintained by the Local Government at Colaba, was moved to Alibag in consequence of the introduction of electric trams into the city: it is now directly under the Government of India, the Director being Mr. N. A. F. Moos. The chief instruments are a set of magnetographs of the Watson pattern, a set of sight-reading instruments of Eschenhagen pattern, a Schulze earth-inductor, and ordinary magnetometers and dip-circles. A careful study by means of daily absolute measurements of all elements has shown that while the base line values of the self-registering instruments for declination and horizontal force were constant or varied uniformly within the limits of error, the base line values of the vertical force instrument varied irregularly from day to day, and the mean value of vertical force for a month as derived from weekly measurements, duly corrected from the magnetograph traces, might differ by as much as ·00010 C. G. S. from the mean as derived from daily observations. The examination of the matter is still in hand.

Dehra Dun, Kodaikánal, Barrackpore and Toungoo.—These observatories were started as base stations in connection with the Magnetic Survey of India, and are all equipped with Watson autographic instruments for declination, horizontal intensity and vertical force. Instead of dip-circles, earth-inductors of the Schulze pattern have been set up at each place. Good results have been obtained through the year except for three weeks at Dehra Dun in May 1912; the records were then lost owing to dismantling of the instruments in order to permit of the carrying out of the repairs to which reference was made in last year's report.

The mean values of the magnetic elements for 1911 at the observatories are as follows:—

Observatory.	North Lat. and East Long.	Declination.	Horizontal force.	Vertical force.	Dip.
Alibag	18° 38′ 72° 52′	0° 54′ 43″ E.	C. G. S. ·36856	C. G. S. ·16250	23° 47′·1
Dehra Dun	30° 19′ 19″ 78° 3′ 19″	2° 29′·2 E.	·33238	·32136	44° 2′·0
Barrackpore	22° 43′ 29″ 88° 21′ 39″	0° 49′·9 E.	·37337	·22220	30° 45′·5
Kodaikánal	10° 13′ 50″ 77° 27′ 46″	1° 0′·2 W.	·37515	·02536	3° 52′·0
Toungoo	18° 55′ 45″ 97° 27′ 3″	0° 19′·3 E.	·38853	·16532	23° 3′·0

Magnetic Survey.—The general scheme was to execute a preliminary survey of the whole country and a detailed survey of those areas where, owing to local irregularities, further information was required. The preliminary survey was to consist of observations of declination, intensity and dip at about 1,100 stations, and measurements were to be made in successive years at about 22 'repeat' stations in order to effect the elimination of secular variation.

Field work was begun in November 1901, and up to the end of the field season 1909-10, 1,324 field stations had been occupied and 23 repeat stations established, in addition to 24 stations on the Seistan trade route where declination had been observed; observations had also been repeated at 142 old field stations, of which 15 have been re-occupied on two occasions. In the detailed survey 193 stations had been occupied.

During the field season 1910-11 three detachments were employed on field work, one under the officer in charge (Captain R. H. Thomas, R.E.), and two under provincial officers; a fourth detachment was employed on office duties at head-quarters.

Two detachments were employed on detail survey in Central India and Hyderabad State, where the Deccan trap area exhibits considerable abnormalities. These detachments also observed at repeat stations and permanently marked field stations in the vicinity of their areas. The officer in charge inspected the four survey base stations, re-adjusting the instruments where required. Comparative observations were made at each base station and at Alibag to determine the differences from the survey standard. Observations were also made at repeat stations and permanently marked old field stations. During the season full sets of magnetic observations were made at 78 detail stations, while 56 old field stations and 18 repeat stations were re-occupied.

The detachment at head-quarters was utilized in initiating the reduction of the declination data of the survey. A simpler empirical formula for the correction for diurnal variation has been devised by Mr. de Graaf Hunter, M.A.: the correction is based on the results of one, two, three or four base stations according to the numbers available at the date of any given field observations.

During the recess the reduction of the base station results for 1911 were completed and those for 1912 taken in hand. The computation of the field work carried out in the field season will shortly be completed.

The investigation of the instrumental differences in H. F., to which reference was made in last year's report, was continued.

The 'chronograph' comparisons of 1911-12 have but served to confirm the view expressed in last year's report, *viz.*, that the observed discrepancies are to be attributed in the main to personal error in the vibration experiment, and the investigation has therefore practically resolved itself into the determination of the probable personal errors both of the field instruments and the survey base station instruments for the period 1903-09 during which the chronograph was not used.

This investigation will, it is hoped, be shortly completed, when the reduction of the H. F. observations can be put in hand.

Programme for 1912-13.—During the next field season, three field detachments will be available. Two will be employed on continuing the detail survey while the third under the officer in charge will visit the base stations and as many repeat stations as possible.

A fourth detachment will continue the reduction of the declination data, remaining at head-quarters.

GEOLOGY.

BY

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MINERALOGY AND PETROLOGY.

1. Mr. Tipper continued his examination of the monazite-bearing sands of Travancore, and, in addition, has been able to detect the presence of this mineral in small quantities in very widely separated localities. It has been proved to occur in small quantities in the sands near Tinnevelly and also in the cemented dunes of that district, in the Vizianagram district, in concentrates from the Sabarmati river at Golwara in Idar State, and recently in tin concentrates from Southern Burma. Thanks to the kindness of Mr. H. P. Herbert, Manager, Morgan Crucible Company's Mines in Travancore, and Mr. E. Masillamani, State Geologist, specimens of the monazite-bearing pegmatites of that State have been carefully examined. The monazite is undoubtedly a primary accessory mineral, but, like many other accessory minerals, it

does not follow any particular order in crystallization. Some of these pegmatites are very rich in monazite. In spite of this, the conclusion to be drawn from a study of the sands is that the bulk of the mineral is derived, not from the pegmatites, but from the denudation of the charnockites and granulites in which the monazite probably occurs in small quantities.

2. During the course of his survey of Idar State, Mr. Middlemiss met with a rock of unusual type and one of considerable interest. It occurs as a band at the junction of the Idar biotite granite with the Kawa dyke of olivine-dolerite (gabbro) at one mile north-west of Kawa. Microscopically it is a coarse, dark and light rock, with large poikilitic patches of biotite. It is composed of a fairly large amount of orthoclase, occasionally porphyritic as in the Idar granite, abundant lath-shaped plagioclase (albite-oligoclase) and quartz, a considerable amount of pyroxene in rather small idiomorphic and hypidiomorphic grains, often gathered together into clusters and showing here and there change to uralitic hornblende, a large amount of biotite in great ophitic plates and, as accessories, iron ores and rather much apatite. Mr. Middlemiss regards this rock as a composite or "hybrid" one, due to chemical reactions between the two rocks now found on either side of it, *viz.*, the Idar granite and the younger intrusive Kawa dyke of olivine-dolerite. He concludes that owing to the basifying of the granite consequent on this intrusion, the quartz and orthoclase of the former have remained unaltered, but all the usually dominant microcline has disappeared, its place being taken by abundant plagioclase (albite-oligoclase); at the same time both the biotite and apatite of the granite have been largely reinforced. Or, regarding the reaction from the point of view of the basic rock, the more basic plagioclase (labradorite) has disappeared, as also has the olivine, whilst the pyroxene has persisted in more or less patchy groups. Except on the supposition of a commingling of material and chemical re-arrangement having taken place, it is difficult to classify a rock of such abnormal mineral constitution among the ordinary igneous rocks, and Mr. Middlemiss considers that all the conditions of its occurrence point to its being a hybrid.

3. During a course of study leave spent at Cambridge, Mr. Pascoe made a detailed examination of the lavas from Mount Popa in Upper Burma, and was able to confirm the conclusions of previous observers that these consist exclusively of andesites. He recognises two types, one a hornblende-andesite in which the hornblende phenocrysts show strong absorption borders and much alteration to magnetite, and the other a porphyritic augite-andesite with small rounded grains of olivine.

PALÆONTOLOGY.

4. **Lamellibranchs and gastropods from the Spiti shales.**—Amongst the collections from the Spiti shales sent to the late Dr. Victor Uhlig for description, there were a number of lamellibranchs and a few gastropods; these were handed over by Dr. Uhlig to Dr. Karl Holdhaus, whose description of the material has now been received and will shortly be published in the *Palæontologia Indica*. Dr. Holdhaus states that his examination of the bivalves tends generally to confirm the conclusions already arrived at by Dr. Uhlig from his study of the ammonites. At the same time the fauna seems to represent a very special and individualised facies, since, with the exception of certain species of *Astarte*, Dr. Holdhaus has been unable amongst 37 species to find a single one that is truly identical with similar species from other regions; he has thus unfortunately been compelled to create a number of new species and one new genus. The gastropods are few in number, poorly preserved and of no particular importance.

5. **Himalayan Ordovician and Silurian fossils.**—A very important work on Himalayan palæontology has just been completed by Mr. Cowper Reed, namely, a description of the Ordovician and Silurian fossils of Spiti and Kumaon. The material described includes Salter's duplicates of Strachey's original collections, Stoliczka's collections from Spiti, Griesbach's from Kumaon, Krafft's and mine from Spiti and Bashahr and various small collections made by Messrs. Hughes, La Touche and others. Mr. Cowper Reed has been able to recognise definitely both Ordovician and Silurian faunas, of which the most remarkable feature is the striking American stamp of the Ordovician. Thirty-four species are closely related to American forms, but "while the affinities of so many species are remarkably close, yet scarcely any or perhaps even none are absolutely identical"; Mr. Reed attributes this to "a certain amount of modification having taken place in the course of their long migration from America." Equally remarkable is the absence from the Ordovician fauna of any European affinities, a fact which is the more striking in view of the very marked European character of the Ordovician of the Northern Shan States. The Silurian fauna on the other hand, although showing distinct American affinities in the corals, is on the whole rather European, although the strong European facies found in the Shan States is not developed.

6. **Triassic fossils from Kashmir.**—Dr. Diener has completed, for publication in the *Palæontologia Indica*, a description of the collections of Triassic fossils made by Mr. Middlemiss in Kashmir during the last few years. Amongst these Dr. Diener recognises representatives of

the Lower Trias, Muschelkalk, and carnic stage of the Upper Trias. The lowest horizon of the Lower Trias, which is found at Pastannah, corresponds fairly closely with the Otoceras zone of Spiti and Kumaon. The genus *Otoceras*, however, has not been found in it, but *Ophiceras* and *Xenodiscus* predominate. An interesting feature of this fauna is the close connection that has been proved between these two last-named genera, the intermediate forms being comprised among Mr. Middlemiss' specimens. The lamellibranchs, however, are more important than the cephalopods, and include large numbers of *Pseudomonots* (*Claraia*), of which four species are particularly interesting as representing isolated elements of Mediterranean origin, but all leading forms of the Werfen beds of the Alps. A younger Lower Triassic fauna containing *Flemingites* and *Meekoceras* is attributed to the Hedenstrœmia stage of Spiti and Kumaon. A fairly rich fauna was obtained from this horizon in the Guryul ravine, and a similar collection from Mandakpal. The marked resemblance between the Lower Trias of Kashmir and that of Spiti and Kumaon is in decided contrast to the absence of resemblance, indeed to the dissimilarity, of the Muschelkalk. Throughout those more easterly parts of the Himalaya, the physical characters of the Muschelkalk are practically invariable, and the steep cliff of the nodular limestone always forms a characteristic feature which cannot be mistaken. This, however, appears to be quite absent from Kashmir. So far as the fauna is concerned, Dr. Diener confirms Mr. Middlemiss' view as to the absence of Lower Muschelkalk forms from all the collections hitherto made, whilst every fossil that can be assigned to the Muschelkalk appears to belong to the Trinodosus zone of other parts of the Himalaya. The only upper Triassic fossils in Mr. Middlemiss' collections consist of lamellibranchs and brachiopods, which, although marked by certain Upper Muschelkalk affinities, are regarded by Dr. Diener as, on the whole, indicative of a carnic age.

7. **Fossil plants from Afghanistan.**—Professor Seward has completed a detailed critical study of the plants collected by Mr. Griesbach and by me in Afghanistan. Mr. Griesbach's collections, which come chiefly from Chahil and Shisha Walang to the north of the Kara Koh (Afghan-Turkistan), are regarded by Professor Seward as perhaps as old as lias or rhætic, whereas my collections, chiefly from the country to the south of the Kara Koh (Saighan and Kahmard), he regards as Middle Jurassic (Inferior Oolite). This rather tends to confirm the suggestion (*Memoirs, Geological Survey of India*, XXXIX, page 77) that the volcanic Doab series of Saighan is represented in Afghan-Turkistan by the estuarine and shallow-water

marine deposits which contain *Halobiæ* of Upper Triassic affinities. Professor Seward also confirms the view that the affinities of the Afghan Jurassic flora are with that of the provinces of Fergana and Syr Darya, that is to say, of Angaraland rather than of Gondwanaland.

8. **Fossil plants from the Assam coal-measures.**—By the kindness of Mr. G. E. Harris, Agent and General Manager of the Assam Railways and Trading Company, Professor Seward has also been enabled to examine certain specimens of the Tertiary flora associated with the coal-seams of Margherita in Upper Assam. Good specimens are rare as the shale rapidly disintegrates on exposure to the atmosphere. In the present instance, however, Mr. Harris had obtained a large fossiliferous block, which he immediately varnished, thus preserving it for some time from the effects of the atmosphere. The fossils consist chiefly of dicotyledonous leaves, which Professor Seward has described under the name *Phyllites kamarupensis*. They are unfortunately not sufficiently distinctive to warrant any statement as to geological age.

ECONOMIC ENQUIRIES.

Asbestos.

9. **Idar State.**—During the course of his survey of Idar State Mr. Middlemiss discovered in the hills to the south-east of Dev Mori (23° 39′: 73° 28′) a deposit of asbestos, which appears to be of excellent quality. It occurs in large rod-like masses, which, when soaked in water and dried, come out as long silky masses of beautifully white fibre. The mineral is the amphibole variety and is long in staple, some fibres being as much as eight inches in length. The deposit is being opened up by the local authorities and, if it proves to be of any size, should be well worth exploiting.

Coal.

10. **Assam.**—During his investigation of the oil-fields of Assam, Mr. Pascoe took the opportunity of visiting the valley of the Namchik river to the north-east of Margherita. Here he discovered a fine seam of coal, some sixty feet thick. The results of his investigation have already been published in the *Records of the Geological Survey* (Vol. XLI, page 214).

11. **Punjab.**—The proposed borings for coal on the Dilwal plateau of the Salt Range were put down during the latter part of the year, at

Tothral and Arar. These villages lie well back from the southern scarp of the range and are separated from one another by a distance of about $2\frac{1}{2}$ miles. If, therefore, there was a coal-field of any considerable extent below the nummulitic limestone of the plateau, evidence of its presence should be found below Tothral and Arar. No coal, however, was found at Arar, and a seam only a few inches thick at Tothral; at the latter place, the boring was carried to a depth of over 112 feet below the coal into the Olive series, and the general sequence proved to be similar to that at Dandot. The Arar and Tothral sections are given below, and that obtained from the previous boring at Dandot is added for comparison:—

	Arar.	Tothral.	Dandot.
Surface soil, débris and nummulitic limestone . . .	99′ 3″	117′ 0″	127′ 0″
Variegated shales . . .	10′ 6″	10′ 6″	11′ 6″
Limestone with some calcareous sandstone	131′ 9″	156′ 0″	140′ 6″
Alum shale	27′ 6″	24′ 2″	30′ 0″
Coal-seam	...	1′ 4″	1′ 10″
	Pink marl.	Grey shale.	Dark grey shale.

The persistence in character and thickness of the variegated shales lying between the two bands of nummulitic limestone is very marked, as also is the uniformity of the lower limestone. The results of these borings lead to the inference that the coal-seam is thinner under the Dilwal plateau than in the neighbourhood of Dandot, that is to say, that it thins out and disappears towards the north. The data are of course insufficient to admit of any definite statement to that effect, but they give us no encouragement to expect that the seam under the Dilwal plateau will ever be appreciably thicker than that along the scarp, whilst the results of these investigations hold out no inducement towards further borings on the other plateaux of the Salt Range.

Copper.

12. With a view to the preparation of a memoir on the copper deposits of India, Dr. L. L. Fermor was deputed to Sikkim to examine the ore-bodies of that State. The most important are those of Bhotang and Dikchu. Both deposits occur interbedded with the associated rocks,

being of the nature of interbedded replacement deposits; but whereas the Bhotang deposit is in a comparatively unmetamorphosed form of the Daling series, the Dikchu deposit occurs in the belt of highly crystalline mica-schists with associated gneisses, forming a boundary zone between the Daling series and the Sikkim gneiss. In both cases, the copper-ore is chalcopyrite, the chief associated sulphide being pyrrhotite. But, especially at Bhotang, galena and blende are also of somewhat common occurrence. Dr. Fermor finds the origin and mode of occurrence of these ores to be similar to those of the Singhbhum copper-lodes. In each area the lodes are interbedded in the Archæan rocks (Dharwars in Singhbhum and Dalings in Sikkim, the garnetiferous rock of Dikchu being probably a highly metamorphosed form of the Dalings); in each area the bodies of copper-ore have been formed by the metasomatic replacement of the associated rocks; and in each area the copper-bearing formations are close to large masses of granitic rocks, from which, one may conjecture, the copper-bearing solutions were derived. In Singhbhum there are numerous basic (epidioritic) dykes associated with both the granites and the Dharwar rocks (schists, quartzites, etc.), and, as an alternative to the derivation of the copper-bearing solutions from the granites, it is possible to suppose them to be closely connected with the basic dykes. The disposition of the Singhbhum copper deposits as an aureole in the Dharwars following the curvature of the Dharwar-granite boundary is, however, in favour of the former suggestion, which, as it happens, is also more suitable for explaining the derivation of the ores of Sikkim, where basic igneous intrusions are scarce.

13. Although the deposits of Sikkim are similar in mode of origin to those of Singhbhum, they differ from them remarkably in the diversity of their mineral contents which frequently include chalcopyrite, pyrite, pyrrhotite, blende and galena; in Singhbhum, on the other hand, the copper-lodes show, as a rule, only two sulphide minerals, chalcopyrite and pyrite—with traces of chalcocite at higher levels, probably representing a zone of secondary enrichment. In both Sikkim and Singhbhum, azurite, malachite, chrysocolla and chalcanthite are found in the oxidised zones of the lodes, but in Sikkim where the slopes are very steep and denudation under the influence of a moist climate and heavy rainfall is very rapid, the oxidised zones are much less predominant than in Singhbhum. In Sikkim the sulphide minerals may crop out at the surface in the fresh condition, but this practically never happens in Singhbhum, where one might doubt the existence of copper deposits, were it not for the presence of numerous ancient outcrop workings stained with green and blue oxidised copper minerals.

Engineering Questions

14. **Darjiling landslips.**—During the early part of October, a committee was convened to discuss the safety of the hill-sides surrounding Darjiling. Attention was chiefly centered on the Happy Valley slip, which was examined in detail; various suggestions were made with a view to preventing further landslips, but final measures were postponed pending a detailed geological survey on a large scale of the whole hill-side from the Court-house to the Jail. It is proposed to undertake this in the summer of 1912. Incidentally it should throw much-needed light on the nature and origin of the Darjiling gneiss, which in the Happy Valley appeared to be derived largely from the metamorphism of a pre-existing sedimentary series of slate and quartzite.

Galena.

15. **Simla Hill States.**—A visit was paid to Basantpur in Bhajji State, the site of the head-works of the Simla hydro-electric installation, where galena and stibnite were said to occur. Specimens said to represent deposits of each had been sent previously to the Geological Survey Laboratory, but had proved to be only galena, no ore of antimony occurring among them. The latter was said to have been found on the left bank of the Nauti Khad just above the flume, and two mule-loads of ore were said to have been taken away. In spite of careful search no trace of ore of any kind could be found at this locality; it would appear that the whole deposit had been removed.

A few lumps of galena and a considerable amount of slag are found in the alluvium of the stream running from Basantpur to join the Nauti Khad. The quantity noticed was, however, small and is probably derived from the small veinlets and clusters of galena to be seen here and there in the metamorphic limestone which occurs in large quantity in the neighbourhood. Similar occurrences of galena are common throughout the Simla Hill States and are not as a rule of any economic importance.

Gold.

16. **Mong Long State.**—On his return from leave, Mr. Coggin Brown was deputed to examine, on behalf of the Sawbwa, the gravels of the Möng Lông Sub-State in Hsipaw, where gold was said to occur in payable amounts. Mr. Brown found that the gravels, although rich in places, occurred in too small quantity to hold out any hopes of successful dredging operations and recommended that the deposits be

left to the Shans to work. A detailed report on the subject has been published.

Petroleum.

17. The oil-fields party consisted, in addition to Mr. Cotter, of Mr. K. A. K. Hallowes and Sub-Assistant Sethu Rama Rau. During the early part of the year, Mr. Hallowes was posted to Yenangyaung, but, after the monsoon, resumed field-work in the Pakokku district, where he has been engaged on a survey of the volcanic area in the northern part of the district. Sub-Assistant Sethu Rama Rau was engaged in mapping the area included in sheets 113 and 157 (Burma Survey, 1″ = 1 mile) covering parts of the districts of Minbu, Thayetmyo and Magwe. Three anticlines were noted in this area, *viz.*, (1) the Migyaunge-Kyundaw anticline, (2) the Tagaing-Sinmadaung and (3) the Mindegyi-Kyawdo. Of these the first is approximately symmetrical, and has shallow dips ranging from 10° to 25°, the Pegu beds being continuous with those of the Minbu oil-field. The conditions are regarded as favourable for the storage of oil. The Tagaing-Sinmadaung anticline is asymmetric on the north and symmetrical on the south, but the dips are very high, and the economic possibilities of the area are regarded as poor. The Mindegyi-Kyawdo anticline is a symmetrical one with shallow dips ranging from 10° to 25°. The Pegu beds here are the continuation of those exposed near Yenaman and Thabyemyaung, where seepages are numerous; the area is therefore regarded as decidedly promising.

Steatite.

18. **Idar State.**—Reference has already been made to the asbestos found by Mr. Middlemiss in Idar State. It occurs among, and is closely associated with, large quantities of steatite. The latter is found between Dev Mori and Kundol (23° 40′: 73° 28′) and also at Ghánta (23° 36′: 73° 26′). The steatite is of very fair quality and occurs in enormous quantity, Mr. Middlemiss having calculated that at the first locality alone there are over two million tons in sight and within easy reach. A note on the subject has been published in the *Records of the Geological Survey*, Vol. XLII, page 52.

Tin.

19. **Nurunga, Hazaribagh district.**—In July, Dr. Fermor visited the Nurunga tin locality, already noticed in *Records of the Geological Survey of India*, Vol. XXXIII, page 235 (1906). The deposit was found to be of a very unusual character, consisting of a thin

band, some 6 inches thick at most, of cassiterite-granulite, forming an interbedded layer in a considerable thickness of microcline granulite: in addition to the band mentioned above—which often contains a very high proportion of cassiterite, as much as 30 to 50 per cent.—cassiterite is also found in sparsely scattered granules in the microcline-granulites, especially close to the cassiterite-granulites. Samples of the country-rock have not yet been analysed, but it seems unlikely that the amount of included cassiterite is sufficient to render the whole mass of rock worth treating as an enormous deposit of low-grade tin-ore. The specimens collected have not yet been thoroughly studied, but the mode of occurrence of the tin suggests that the cassiterite-granulite is a basic segregation from the acid granulites with which it is associated.

See also under *Wolfram*.

Water.

20. At the request of the Local Government, it was arranged that a traverse should be made across the Irrawadi valley from the western foot of the hills of the Southern Shan States to the outer ranges of the Arakan Yoma, with a view to ascertaining the possibility of obtaining supplies of water under artesian conditions. The work was undertaken by Mr. P. N. Datta, who made a complete traverse along the latitude of Pyawbwe. On the whole, the result was not very encouraging, but Mr. Datta indicated various spots at which artesian water might be found.

Wolfram.

21. **Burma.**—At the request of the Local Government, Mr. Page was again posted to Tavoy and Mergui with a view to assisting the local officials with advice in matters relating to tin and wolfram-mining. Owing to the great rush for wolfram concessions in Tavoy and to the complete absence of reliable maps, he found that there was great difficulty and delay in connection with the issue of prospecting licenses. Matters, however, are being gradually reduced to order and it is hoped that before long all pending applications will have been dealt with.

GEOLOGICAL SURVEYS.

Assam.

22. **Naga Hills: Mr. E. H. Pascoe.**—Having been deputed to Assam for the field-season 1910-11, Mr. Pascoe was permitted to accompany a column that left Kohima early in January for a visit to Makwari on the Assam-Burma border. The greater part of the traverse,

which was some 85 miles in length, lay over a monotonous sequence of Disang shales and slates with little to relieve it save occasional lenticles of quartz. Among the Disang beds, between Dimapur and Kohima, was recognised the Naogaon sandstone of Mallet forming the peaks of Kadiuba and Siwenuchika. In the extreme east of the area, occurrences of serpentine were observed corresponding to the band mapped by Mr. R. D. Oldham in Manipur. A thick massive conglomerate was another interesting feature of this part of the traverse. The serpentine has been derived from gabbro and peridotite, pieces of which rocks are common in the streams.

23. **Abor Hills.**—The despatch of an expedition to the Abor country offered an opportunity for exploration of a tract of which the geological conditions were entirely unknown and it was therefore decided that a member of the Geological Survey should be attached to the force. Mr. Coggin Brown was selected for the purpose and joined at Kobo early in December. Mr. Brown has been able to add largely to our knowledge of this part of the Himalaya and he deserves great credit for the energy and perseverance with which he pursued his work in the face of the many difficulties inseparable from an expedition of the kind. It was anticipated that the general sequence of strata recognised at different times in the outer zone of the Eastern Himalaya would be more or less followed in the Abor hills, and this proved to be the case. From Kobo northwards the flat alluvium was found to stretch to the foot of the hills as far as Pasighat. In every direction it is covered with dense forest and the luxuriance of the vegetation entirely masks the ground. North of Pasighat the road soon commences to rise over pleistocene deposits lying on a core of Siwalik rocks, and at Janakmukh there is a raised terrace section of pleistocene gravels 150 feet in thickness, the top of which is 350 feet above the present level of the Dihong.

24. The Siwaliks were crossed on the line of march between Pasighat and Rammidumbang, forming the outer lower-lying foot-hills which flank the higher ground to the north; they were found to consist of great thicknesses of various kinds of sandstones, the softer micaceous varieties often containing nests of bright lignite, undoubtedly the remains of waterlogged drift-wood deposited during the formation of the rocks. Landslips are very common in this zone and from the high Abor "jhums" (clearings) the light-coloured Tertiary strata show up well against the dark green of the Sub-Himalayan rainy forest which covers the hills.

25. The Siwaliks dip into the hills and have the customary appearance of being overlain by the Himalayan Gondwanas, the next series met with. Unfortunately no actual contact of the two systems was seen, but there is no doubt that it is the same here as elsewhere. The commonest rock types in this series are white and greyish-white indurated sandstones and quartzites, reddish ferruginous shales, black carbonaceous shales, often with clay-ironstone septarian nodules, hardened, greyish-blue shales in which a schistose structure has been developed, and coal-seams. Owing to the intense crushing to which they have been subjected the seams have been squeezed into lenticular patches and the coal itself rendered powdery and friable. It is believed that these coals are of no economic value. Near Renging bands of decomposed volcanic rock begin to make their appearance, interbedded with the Gondwanas, and further north there is a great development of trap-like rocks which have given rise to the peculiar physical character of the narrow gorge-like course of the Dihong through the lower Abor hills. These rocks have been named the Abor Volcanic series, but at present, mainly owing to the want of continuous exposures, it is not possible to fix their exact age, though in the presence of palagonite tuffs they bear a striking resemblance to the Rajmahal traps. This series is followed higher up the valley by metamorphic rocks which in general appearance and position appear to correspond partly with the Daling series of Sikkim.

Bombay, Central India and Rajputana.

26. Messrs. Middlemiss, Jones, Heron and Daru were engaged in the survey of parts of Bombay, Central India and Rajputana, together with a few connected areas in the Punjab and United Provinces which border the part of Rajputana worked by Mr. Heron.

27. **Mr. Middlemiss: Idar State.**—Mr. Middlemiss began work in Idar State, and spent from January to April there investigating a portion of the country new to the Geological Survey, but lying immediately south of Hacket's and La Touche's surveyed areas in Rajputana and north of Kishen Singh's mapped areas in parts of Bombay. He completed a well-defined area of about 729 square miles, lying centrally within sheets 118 to 120 and 144 to 146 of the Bombay 1″=1 mile survey. The banded and bedded formations represented are a folded (N.N.E.—S.S.W.) complex of Aravalli calc-gneisses and other schists, Delhi quartzites—coming apparently above and folded with the latter,—Ahmednagar sandstone series and recent deposits. The most common form of the first of these,

occurring in limited exposures among vast spreads of alluvium, is a thoroughly crystalline aggregate of much calcite with varying amounts of quartz, microcline, plagioclase, diopside and sphene, and occasionally with much biotite or with wollastonite, scapolite, garnet and zoisite. Among it ramify innumerable small granitic veins of aplite, graphic granite, and pegmatite, which seem to be as old as the folding of the rocks among which they appear. There are also later intruded, rugged and grotesque, large masses of Idar granite (biotite and hornblende granite) and of quartz-porphyry bursting irregularly through the region regardless of the older series. Long sinuous dykes of vein-quartz (ultra-acid differentiation products of the Idar granite?) and one or two examples of a basic dyke (olivine-gabbro or dolerite), together with a contact, composite or hybrid rock, between the latter and the Idar granite, were also identified and mapped.

Of these intrusive rocks, Mr. Middlemiss specifically identifies the Idar granite with the Siwana and Jalor granites, and the quartz-porphyry with the Malani rhyolites of Western Rajputana (see La Touche, *Mem. Geol. Survey of India*, Vol. XXXV, pt. 1, pages 25 and 90—91) and the olivine-gabbro and dolerite with a very similar one also in Western Rajputana, described by Sir T. Holland (*loc. cit.*, page 91). But there are further resemblances between the two areas in the nearly horizontal Ahmednagar Sandstone series, which appears as cappings on the hills or in the deeply-cut rivers under the alluvium, and which probably represents the Barmer sandstone of Western Rajputana as well as the Lathi group of Jaisalmir and the Umia of Kathiawar.

28. **Economic.**—No minerals of sufficient importance to notice here have as yet been found, but the sandstone quarries at Ahmednagar yield an excellant free-stone, whilst marble and granite can also be obtained in any quantity.

29. **Mr. Jones: Gwalior.**—Mr. Jones spent a full season, from November to the middle of May, in the Amjhera and Ujjain districts, continuing the revision of the geological maps of the area and the investigation of the mineral resources of the State. The area is contained on sheets nos. 212 to 215 and 242 to 247 of the Central India and Rajputana survey (1″ = 1 mile). Of this the Bag area to the south took him to the interesting localities already surveyed generally by Messrs. Blanford and Wynne (*Mem., Geol. Survey of India*, Vol. VI, pt. 3) and later again in more detail by Mr. Bose (*Mem., Geol. Survey of India*, Vol. XXI, pt. 1).

30. Although Mr. Jones was primarily concerned with the possibility of finding ores of manganese in the crystalline rocks, he has incidentally contributed a newly coloured map of most of the Bag area in even greater detail as regards delineation of boundaries than the already detailed work of his immediate predecessor Mr. Bose. A feature of special interest in his report of this area, where the sequence of beds comprising Nimar sandstone, Nodular limestone, Coralline limestone, Lameta and Deccan Trap lie almost horizontally above the steeply dipping Bijawars or still older gneissic and metamorphic series, is the beautiful set of photographs which he has taken in illustration of this and other physical features. His report may generally be considered as a further study in a number of detailed and well-illustrated sections taken at points of special interest of the area already liberally treated by Bose. A further addition to the fossils, of about cenomanian age, collected especially from the Nodular limestone and the Deola and Chirakkan marl has also been made by Mr. Jones. Among these Mr. Tipper has specifically recognised *Hemiaster similis*, *Placenticeras mintoi* Vredenburg, and *Namadoceras scindiæ* Vredenburg. As before, no fossils were obtained from what have been called Lameta beds at the base of the Deccan trap, so that the points in debate with regard to that formation remain as they were.

31. **Economic.**—No manganese nor anything of special economic importance was found. In the Bijawar rocks near Bag, however, Mr. Jones found promising slates, and he has suggested that pits be opened in them to determine their quality and suitability for roofing, writing slates, etc.

32. **Mr. Heron: Rajputana, Punjab and United Provinces.**—From the middle of November to the first week in May Mr. Heron spent a full season in continuation northwards, eastwards and south-eastwards of his work in Alwar of the last two seasons. The formations exposed constitute isolated hill groups, gradually dying out in the Indo-Gangetic alluvium to the west of the Jumna, during which process they spread out from Rajputana (whence the work of determination originated) into the neighbouring areas of Delhi and Gurgaon districts of the Punjab, and Agra and Muttra districts of the United Provinces of Agra and Oudh. This large area is included in Atlas of India sheets 49 and 50 (1″=4 miles), and standard sheets (1″=1 mile), Punjab Survey nos. 321 to 325, Central India and Rajputana Survey nos. 283, 284, 312, 313, 337 to 341, 360 to 362, and United Provinces Survey no. 23, all of which are now completely surveyed.

33. The rock systems include those of the Alwar State already described in previous reports by Mr. Heron, namely, Aravallis (schist

series of Hacket), above these the Alwar quartzite series, which in the Biana hills becomes split up into several groups, and above these the Ajabgarh (Mandan) series of slates, shales, etc. Besides these, in the area surveyed there are examples of Hacket's "Gwaliors" of Hindaun (thinly laminated cherts with jasper layers) and the Bhander and Rewa sandstone stages of the Upper Vindhyans, which are not found in Alwar.

34. Notwithstanding the large surface covered, practically only one sheet (Central India and Rajputana no. 341) presents any variety of geological feature. This is embodied in the hilly mass of Alwar quartzites north-west of Biana and the Upper Bhander scarp to the south. The rest of the sheets comprehend long tailing-out ridges or hill-masses of either the Alwar series and Ajabgarhs with a few pegmatite veins, or of the Rewa and Bhander stages in monotonous regularity, the greater part of the structure of the country and all geological boundaries being hopelessly buried under the all-pervading alluvium.

35. With reference to the Biana hills in sheet 341, it is to be noticed that Mr. Heron upholds Hacket's sub-divisions of the Alwar series into five groups (*Rec., Geol. Surv. India*, X, 87, and XIV, 298), with one unconformity and several conglomerates indicating breaks in the succession. Near the middle of the lowest group (the Nitahars) there are two bands of volcanic rocks, traps and tuffs, the former of which Mr. Heron has determined as a dolerite in which the plagioclase has been replaced by quartz and muscovite or kaolin, and the augite by chlorite.

The "Gwalior" cherts of Hacket, Mr. Heron thinks may belong to the schist series and not to the true Gwaliors.

36. **Economic.**—Impure graphite and a tradition of gold at Sohna, some old copper workings west of Nitahar and the kaolin of Kasampur have long been known and are mentioned in the *Manual of the Geology of India*, Vol. III. Nothing further of importance has been found by Mr. Heron in connection with them. He describes, however, an excellent band of slate at present being worked by the Kangra Valley Slate Company near Kund railway station. Building stone from the long-celebrated Upper Bhander sandstone quarries in Bharatpur State is of excellent quality.

37. **Mr. Daru: Banswara and Dungarpur.**—Mr. Daru spent only a very short field-season engaged in the above survey, namely, the months of March and April. During the first fortnight of this he was occupied in Banswara, the completion of the survey of which left him free to pass northwards and westwards into new ground

in Dungarpur, where he surveyed 250 square miles in the extreme north-east of that State (sheets 175 and 176 of the Central India and Rajputana Survey). Mr. Daru describes the area as being entirely of Aravalli rocks, with igneous intrusives and a few patches of recent alluvium, most of the country being a continuation north-west along the strike of the formations as found in Banswara.

38. The Aravallis are of the "argillaceous" type, generally biotite schist, occasionally with garnet and staurolite, sometimes too with a large proportion of magnetite. This passes locally into quartz-schist. There is also found hard shale, phyllite, graphitic shale, muscovite schist, hornblende schist and apatite schist. Boulder beds preponderate in one area east of the Sabla chain of hills. Limestone is comparatively rare, such outcrops as occur being extensions from the Banswara area. Two bands of ferruginous cherty quartzite are found, also in extension of the Loaira rock from Banswara.

39. The intrusives in these consist of aplite, graphic granite and muscovite pegmatite, occasionally with tourmaline; and there are also quartz-felspar rock and vein-quartz, the latter being in both large and small veins and regarded as extremely acid representatives of the pegmatites. Granite, gneissose granite, syenite and diorite are also found. In two or three bands there are also examples of "interbanded quartz-hornblende schistose intrusives."

Burma.

40. The work of the Burma party has already been referred to under *Petroleum* and *Water*. In addition to the systematic survey being carried out in the oil belt, a survey was begun by Mr. Datta of the country lying along the western foot of the Shan Hills from Kyaukse southwards. Work was begun only just before the end of the year and there is therefore but little to report. Mr. Datta finds that the country in the neighbourhood of Kyaukse consists of an altered sedimentary series, now consisting of argillite, quartzite, micaceous schist and marble, associated with biotite granite to which the metamorphism of the sedimentary rocks is probably to be attributed.

Central Provinces.

41. It was decided this year to form a new field party, in addition to those already at work in Burma and Central India, the new party being for the systematic survey of the Central Provinces on the scale of 1″=1 mile. Previous work in this province has been carried out on a variety of scales, and much of the province is practically unsurveyed.

The party has been placed under the charge of Dr. Fermor, and, as constituted for the field-season of 1911-12 includes also Messrs. H. Walker and C. S. Fox, Assistant Superintendents, and M. R. Ry. Vinayak Rao, Sub-Assistant. Babu Bankim Bihari Gupta, recently promoted from the post of Museum Assistant to one of the newly sanctioned posts of Field Collector, was also sent with this party in order to collect a typical series of Chhindwara rocks. The first area selected for survey comprises, on the northern line, the districts of Betul and Chhindwara as far north as the Satpura coalfields and the districts of Seoni and Mandla as far north as the district boundaries, and, on the southern line, the districts of Nagpur, Bhandara and Balaghat as far south as the Bengal-Nagpur Railway line. This area has the advantage of being, as far as is known, a homogeneous geological entity including a large proportion of unmapped country and the whole of the Central Provinces manganese-ore deposits with the exception of those of Jubbulpore. Maps on the 1″ scale are available for the whole of this area with the exception of the Nagpur district, of which the largest maps available are on the scale of 1″=2 miles. The Surveyor-General has, however, kindly modified the programme of work of the Survey of India party now engaged in preparing new maps of the Central Provinces and Berar so as to issue the topographical sheets of this district within the next two or three years. Meanwhile, work was commenced during the current field-season (1911-12) on the northern line of districts. The Betul district has been assigned to Mr. Walker, whilst the remainder of the party accompanied Dr. Fermor to the Chhindwara district in order to become familiar with the rock formations, the study of which was commenced as long ago as 1903 (Fermor, *Records*, XXXIII, pages 159—218, 1906). Sub-Assistant Vinayak Rao has since been sent to Seoni to commence mapping in that district on the lines established at Chhindwara, whilst Messrs. Fermor and Fox propose to survey the Chhindwara district jointly, as it contains a large area of varied Archæan rocks and gives a section across the Satpura Hills from the 1,000-ft. Nagpur-Balaghat plain on the south, across the Chhindwara plateau (2,200-ft.) in the middle, to the Mahadeo Hills bounding the southern edge of the Narbada valley on the north and frequently rising to elevations of over 3,000 feet. It is expected that a detailed survey of this district will furnish the key to the structure both of the Satpura Hills, which traverse the northern line of districts, and of the Archæan plains comprising the larger portion of the southern districts.

42. **Deccan Trap.**—In the short portion of the current field-season falling within the year under review, the only work carried sufficiently

far for report here is the detailed mapping of some 70 square miles of Deccan Trap lying on the 2,200-ft. plateau round the villages of Linga and Lahgarua, to the south of Chhindwara town. Dr. Fermor began detailed work on this area with the object of determining, in the first place, whether it would be possible to break up the Deccan Trap formation into divisions sufficiently well-marked to be easily mapped, or whether it would be necessary, as seemed probable, to colour the whole of this formation with one tint. Incidentally he wished to study in some detail the inner relationship of the vast succession of lava-flows, especially as to origin. Mr. Harker has expressed the view in his *Tertiary Igneous Rocks of Skye*, that the columnar doleritic flows interbedded in the Tertiary basic lavas of that island are sills intruded between the flows of extrusive basalts. To ascertain whether or not any such explanation could be applied to the Deccan Trap, it was decided to map, flow by flow, a selected area in which the existence of dolerite had been ascertained. Dr. Fermor and Mr. Fox first mapped a portion of the area jointly, determining the existence of four distinct flows; they then separated, Mr. Fox carrying the boundaries to the northern and western edges of the selected area and Dr. Fermor to the southern and eastern. The results of their work are of considerable interest. Each flow—except the uppermost, the surface of which has been denuded away—shows a vesicular, more or less amygdular, surface; and between each pair of flows there is usually an 'intertrappean' layer. This sometimes takes the form of a silicified sedimentary stratum a few feet thick—in some cases of limestone, and still frequently containing abundant silicified fossils, *Physa*, *Paludina* and *Lymnæa* (?)—whilst in others the intertrappean layer consists of a green clay, the 'green earth' of Indian geologists, sometimes associated with brownish and cream-coloured clays. The origin of this green earth seems to vary; in some cases, it has undoubtedly been formed by the alteration of the underlying lava surface, but in other cases the origin is doubtful. Sometimes both green earths and sedimentary intertrappeans occur together, the green earth usually overlying the sedimentary rocks. Mr. Fox has collected for careful study a series of specimens of green earths and green jaspers, both from these intertrappean layers and from the lava flows themselves.

43. The flows are numbered serially 1 to 4 from below upwards, flow 1 being the true basal flow in this area, as it rests directly upon the Chhindwara granite. With the exception of flow 2, all have normally the texture of basalts, but any flow may be exceptionally more coarse-grained, *i.e.*, doleritic. Flow 2 is, however, usually a crystalline dolerite,

and if any flow were to prove intrusive, it would be this one. Several other doleritic flows were discovered later in the season on the edge of the ghats fringing the Kanhan valley, but nowhere was any evidence of intrusive relations detected. On page 259 of the *Manual of the Geology of India*, second edition, the existence of phenocrysts of olivine in the Deccan Trap is referred to, but it is probable that the phenocrysts of plagioclase, so abundant in the basalts, have been mistaken macroscopically for olivine, for none of the officers working on the Deccan Trap formation of recent years have been able to detect this mineral in thin sections under the microscope, although serpentinous patches are commonly seen, representing in some cases, perhaps, original olivine. It is interesting to record, therefore, that both Dr. Fermor and Mr. Fox independently discovered olivine in flow 2, in which it appears to be a normal constituent, although frequently altered completely to serpentine, and rarely quite fresh. The separate flows do not rest on each other with horizontal surfaces, and by the judicious use of the aneroid, frequent surprisingly high variations of a particular flow from one point to another have been detected. Marked dips of several degrees have been noticed in many places. As it was uncertain whether any or all of these dips were to be regarded as due to tectonic disturbances or were to be attributed to the flows adjusting themselves to the irregularities in the surface of the underlying Archæan peneplain, Mr. Fox returned to the area at the end of the field-season when nearly all the streams were dry and the crops cut, so that the outcrops could be easily followed; as the result of this he has obtained evidence supporting the former supposition, and has succeeded in tracing out the position of gentle synclines and anticlines striking north by west and south by east. The probable truth of the explanation of these dips as due to post-Deccan Trap tectonic disturbances is supported by several marked dips observed by Dr. Fermor on descending the edge of the Deccan Trap plateau by the Ramakona ghat. It is not unlikely, however, that when the observations obtained are carefully worked out, some of the irregularities will prove to be due to the adjustment of the flows to the underlying Archæan peneplain.

44. The result of this work has been to show the possibility of mapping the Deccan Trap in detail, although it has proved exceedingly difficult and slow work; but, unfortunately, it will not be possible to continue this detailed work owing to limitations of time, although it is evident from the discovery of the gentle folds in the Deccan Trap referred to above that further detailed work might yield valuable results from the tectonic point of view. Further, this work indicates that there is no practicable grouping of the flows in this area suitable for mapping.

45. **The Shikarpur "craterlets."**—Whilst carrying out the detailed survey of the Deccan Trap lavas referred to above, Dr. Fermor discovered a series of remarkable, more or less circular, depressions in the surface of flow 1 in the Kulbehra river opposite to the village of Shikarpur. There are in all some 20 of these depressions varying from 3 to 23 feet in internal diameter. Some of them are beautifully circular, and, where filled with water, look as if they had been drawn with a pair of compasses, whilst others are oval or somewhat irregular in shape. Almost invariably these depressions have a raised rim (1 to 3 feet high) separating them from the surrounding lava surface. Whilst the material composing these rims is a compact, comparatively non-vesicular lava, that composing the main surface of the flow is vesicular and amygdular, as also is the lava occupying the interior of these depressions, where seen. The exact nature of these depressions is difficult to understand, but Dr. Fermor is inclined to regard them as vents formed on the surface of flow 1 as outlets from that flow only, probably for steam and gases, and perhaps also in some cases to release lava from still molten pools within the body of the partially solidified flow. There is some evidence of lava piled up by the side of one of these depressions. It is proposed, therefore, to call them 'craterlets,' in the absence of any better name. Nothing in the least like them is known anywhere in the Deccan Trap formation, except the gigantic Lonar Lake crater in Berar, which must have been formed after the close of the Deccan Trap extravasations; whilst these Shikarpur craterlets must have been formed before the erruption of flow 2 in the Chhindwara district and have been exposed by subsequent denudation.

Punjab.

46. The survey of the Tertiary rocks of the outer Himalaya in Kangra and the Simla Hill States was continued by Dr. G. E. Pilgrim, who was accompanied by Sub-Assistant Vinayak Rao. Dr. Pilgrim's general conclusions were referred to in last year's report and need not be recapitulated here. A considerable area was mapped on a scale of $1'' = 1$ mile.

Sikkim.

47. During his visit to Sikkim, Dr. Fermor took the opportunity of travelling as far north as Lamteng in the Lachen valley, in order to obtain an idea of the nature of the crystalline rocks lying between that place and Gangtok, and especially to examine the crystalline limestones (*Mem., Geol. Survey of India*, XXXVI, page 18) for purposes of

comparison with those of the Chhindwara district, Central Provinces (*Records*, XXXIII, pages 195—206, 1906). Until larger-scale topographical maps of Sikkim are prepared, it will not be desirable to map the geology in greater detail than is shown on Mr. P. N. Bose's map in *Records, Geol. Survey of India*, XXIV, which may be accepted as roughly correct. This map shows a large shield-shaped area of Dalings with the point of the shield to the north; the eastern edge of the shield has a north-north-west trend, corresponding with a similar strike of the Dalings and a general east-north-east dip under the crystalline complex which extends from this boundary right up to the Teesta, Lachen and Lachung valleys. This crystalline complex comprises both igneous and sedimentary rocks, the former consisting chiefly of varieties of biotite-gneiss, and the latter principally of limestones, calciphyres, mica-quartz-schists and quartzites. A large-scale map would show these para-schists as long strips striking north-north-west parallel to the strike of the ortho-gneisses, and Dr. Fermor advances the tentative view that these strips, which are presumed to be of sedimentary origin, represent portions of the Daling series folded in with the ortho-gneisses and rendered at the same time thoroughly crystalline. The Dalings may well be the equivalents of the Dharwars of the Peninsula (*Mem., Geol. Survey of India*, XXXVI, page 66), and in this case we may regard the associated gneisses as the foliated forms of post-Dharwar granites intrusive with regard to the Dalings. In support of this view of the nature of these para-schists, it is interesting to notice that the slates of the Daling series become more crystalline—phyllitic—as the gneiss boundary is approached.

GEODESY.

BY

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PRINCIPAL TRIANGULATION.

Since the submission of the last report to the Board of Scientific Advice, principal triangulation has been carried on in Bengal and Kashmir.

Bengal.

Chota Nagpur Division. The Sambalpur Series.

For the purpose of establishing well-fixed points to serve as base stations for secondary triangulation in the tracts between the meridians of 82° and 86°, south of latitude 24°, a principal meridional series has been commenced, emanating from the side Bhursu-Hariharpur of the Calcutta Longitudinal Series at a mean longitude of 85°, and extending southwards with a view to junction with the East Coast Series in about longitude 84°.

The tentative scheme of triangulation framed before the observers took the field included the extension of the new series from the side Birpokar-Turer of the Calcutta Longitudinal Series, in longitude 84° 7′.

Examination of the country over which the triangulation would have to be carried, however, showed that it was impossible to lay out well-proportioned figures with unobstructed rays. Reconnaissances were made, both to the east and west, but until longitude 85° had been reached the same unfavourable conditions were found to exist. Plateau succeeded plateau, each thickly wooded, on which mutually intervisible stations at suitable distances apart were difficult to locate and where, without the construction of tower stations, grazing rays could not be avoided. The topographical conditions place this region among the most difficult, from the triangulator's point of view, that India has to offer.

The deflection by 1° of longitude of the new series from its ruling meridian of 84° was held to be less objectionable than the adoption of an expensive scheme of tower stations and accordingly the new series

broke off from the Calcutta Longitudinal Series in longitude 85° and, as soon as possible, was bent towards the west to regain the 84th meridian.

By the middle of April 1912, the series had reached latitude 22° and consisted of four quadrilaterals and one pentagon with a central station, the two southernmost figures lying astride the meridian of 84°. This triangulation, 112 miles in length, covers an area of 2,570 square miles.

The mean triangular error of 21 triangles is 0″·473, the observations being taken with a 12″ two-microscope theodolite.

An astronomical azimuth was observed at Bhursu H. S. of the Calcutta Longitudinal Series, latitude 23° 16′, longitude 84° 44′. The value of the difference (Astronomical – Geodetic Azimuth) being –6″·07.

Kashmir.

The Kashmir Principal Series.

At the time of submission of last year's report this series had been carried as far as Gilgit, and Lieutenant Bell, R.E., and Mr. Wainright had commenced reconnaissances to the northwards, the former of the Sakiz Jarab Range and the latter of the Hunza Valley, with a view to framing a scheme of triangulation connecting the Kashmir Principal Series with Russian triangulation on the Pamirs.

As regards the feasibility of establishing stations on the Sakiz Jarab Range, Lieutenant Bell reported that the main chain of peaks was inaccessible and that the hills immediately to the south, only a little less difficult to negotiate, were useless for his purposes as the view from them to the south was obstructed by high inaccessible peaks. He then explored and found impracticable the valley from Darkot to Garmush, 20,564 feet, and later ascended a peak to the south of the Darkot-Askuman Pass. From this point he obtained a view of the summits of the Sakiz Jarab Range. He reports, "the whole range consists of nothing but extremely sharp and precipitous peaks, while south of it, between the Yasin and Karambar valleys, there are many high peaks." This country, just to the east of the Darkot Pass, was thus found to be impossible of triangulation, and an examination was made of the Karambar valley. It was found that triangulation could probably be carried as far as Harmot or Imit, but that northwards from this place the valley becomes very narrow between precipitous hills and the further progress

of a triangulating party was impossible. The normal difficulties were increased by the flooded condition of the river and further reconnaissance in this district was abandoned for the time being with a view to its resumption when the river subsided. In the meantime, however, a feasible route had been found up the Hunza Valley and the whole efforts of the detachment have since been devoted to carrying triangulation northwards along that line. The connection of the Russian triangulation by principal work in this locality has therefore been abandoned.

SECONDARY TRIANGULATION.

Bengal.

Chota Nagpur Division. The Ranchi Secondary Series.

One hundred miles of secondary triangulation were completed in the neighbourhood of Ranchi. The series emanates from the South Parasnath Series at about latitude 23°, on the meridian of 85°, and following this parallel closes on the new Sambalpur Principal Series in longitude 84°. The triangulation covers an area of 988 square miles and numbers 13 triangles with an average triangular error of 2″·17. An 8″ micrometer theodolite was used.

Central India.

Hyderabad. The Bhir Secondary Series.

This series connects the Khanpisura Series with the Great Arc, following the 19th parallel. It has a length of 176 miles and covers 2,764 square miles.

Twenty-six stations were visited, forming a chain of twenty-four simple triangles. The observations were made with an 8″ micrometer theodolite and show a mean triangular error of 0″·9.

Madras.

Districts of South Arcot and Salem. The Villupuram Secondary Series.

A secondary series was completed along the parallel of 12°, extending from the Great Arc in longitude 77° 50′ to the South-East Coast Series in longitude 79° 20′. Its length is 99 miles and the 18 triangles composing it cover 1,106 square miles. The observations were made with an 8″ micrometer theodolite and give an average triangular error of 1″·77.

District of Madura. The Madura Series.

This series, of which only the building of stations has so far been accomplished, will be observed as a secondary series. It lies along the parallel of 10° between the Great Arc and the South-East Coast Series.

Bombay.

Bombay City. Triangulation network.

To serve as an adjusting framework for a large scale survey of Bombay City, a network of triangulation is being gradually extended over the Island. It is based on a pentagonal figure, with sides some seven miles in length directly connected with the Bombay Longitudinal Series. The completed triangulation covers an area of 75 square miles.

Kashmir.

Russian connection. Hunza Valley.

Mr. Wainright followed the course of the Hunza and Kilik rivers from Gilgit to the Kilik Pass. He found that the carrying of operations up this valley to points from which a junction with the Russian triangulation could be effected, though difficult, was feasible.

He reported that the pathway, good as far as Hunza, became very difficult in places between that place and Misgar, sometimes hung precariously on the face of precipices, sometimes crossing glaciers much serrated and crevassed.

The Hunza Valley having been found to be practicable, Lieutenant Bell's detachment has been occupied this hot weather in carrying a series of triangles along it from the head of the Kashmir Principal Series, towards either the Kilik or the Mintaka Pass. The latest information received points to Lieutenant Bell with one provincial officer having been at work in the neighbourhood of Misgar during the early part of July, while other officers of his detachment were occupied lower down the valley between Gilgit and Hunza.

Since writing the above I have learned with deep regret of Lieutenant Bell's death beyond the Kilik Pass.

Teram Kangri.

At the time of submission of last year's report only preliminary values could be given of the position and height of Teram Kangri, the peak discovered by Dr. Longstaff in 1909.

These preliminary values were based on Mr. Collins' plane table work and an aneroid barometer. The triangulation, carried by him up to his stations of observation, has been now computed, giving the following results:—

Teram Kangri. Lat. 35° 34′ 37″. Long. 77° 07′ 31″. Height 24,489 ft.

ASTRONOMICAL LATITUDES.

During the season 1911-12, latitude observations were made at eleven stations; one being in the Siwalik hills south-east of Dehra Dun, and the remainder on two triangulation series extending northwards from the line Ranchi-Lohardaga.

The reason for the selection of this locality was to attempt to define the position of the hidden chain of high density, the existence of which has long been suspected.

The values of the deflections of the plumb-line are as follows, the stations shown in italics having been observed at previously.

Name of station.	Latitude.	Longitude.	Height.	Deflection of the plumb-line.
	° ′	° ′	Ft.	″
Mahwari	23 26	84 54	3,153	+4·32
Bulbul	23 38	84 26	3,352	+8·81
Chendwar	23 57	85 26	2,814	+3·07
Hurilaong	24 2	84 22	1,378	+10·75
Teona	24 35	84 10	740	+10·82
Mahar	24 44	85 10	1,606	+10·24
Behar	25 12	85 31	391	+13·22
Mednipur	25 5	84 22	335	+8·33
Nuaon	25 35	84 14	251	+7·70
Dubauli	25 40	85 20	189	+6·76
Jalalpur	26 4	84 23	232	+6·14
Pahladpur	26 4	85 27	175	+6·23

A positive sign denotes a southerly attraction of the plumb-line.

Neglecting for the present the value at Bihar, the deflections north of latitude 24° decrease regularly, and though it may seem somewhat surprising to find southerly deflections at Jalalpur and Pahladpur within 100 miles of the outer Himalaya to the north, with flat plains stretching to a greater distance southwards, such deflections have been found before in similar localities and form the main evidence of the existence of the hidden chain of high density to the south, and the trough of low density under, or near the foot of, the Himalaya.

The small deflections at Mahwari and Chendwar seem to show that these stations are near to, and probably south of, the crest of the hidden chain, the comparatively high value at Bulbul being explained by its position on the extreme north edge of high ground. Latitude observations on the new series of triangulation now being executed south of Mahwari towards Sambalpur should prove of great geodetic interest.

The deflection at Bihar is the largest southerly deflection as yet discovered in India (that at Teona being the second) and the position of the station on a low hill rising only some 200 feet above the Gangetic plain precludes the possibility of a large correction for local topography such as exists at Bulbul. It seems likely, therefore, that the range of hills 12 to 15 miles south are of very great density, though unfortunately it was not possible to visit them.

Pendulum observations were made over the same area as the latitudes, and the results, which are dealt with elsewhere, show that gravity is probably in excess south of latitude 25°.

The station in the Siwalik hills, Khajnaur, is situated on a spur running north from the main range and the deflection found is somewhat less than at the four stations visited the previous year. This result seems somewhat contradictory, as in the last report the deflections on the crest and northern edge of the Siwaliks were stated to be larger than on the southern slopes. The deflections given therein were, however, provisional and the correct values are as given below:—

Station.	Latitude.	Longitude.	Height.	Deflection of the plumb-line.
	° ′	° ′	Ft	″
Lachkua	30 4	78 2	2,674	−28·90
Bullawalla	30 7	77 59	2,432	−28·97
Hatni	30 13	77 52	3,096	−29·59
Shorpur	30 14	77 58	2,916	−29·13
Khajnaur	30 16	77 53	2,576	−26·93

Until local topography has been allowed for it is idle to discuss these results, but in view of the fact that the deflection at the east end of the Dehra Dun base, some four miles north of Shorpur, is $-30''{\cdot}37$, the statement that the mass of the Siwaliks is probably not very great and of low density is probably correct.

PENDULUM OPERATIONS.

During the season 1911-12 measurements of gravity were made at 12 stations in Bihar, Chota Nagpur and the extreme eastern portion of the United Provinces. The results are shown in the table.

The last seven stations are in the Gangetic plain and gravity is everywhere found to be in defect, the residuals $(g_o''-\gamma_o)$ increasing in the usual manner as the Himalayas are approached. At the first five stations gravity is more nearly normal, but, except at Daltonganj, has not been found to be in excess. A study of the deflections of the plumb-line observed in this area and referred to elsewhere in this report would, however, seem to show that the chain of high density has been crossed between Ranchi and Sasaram* and we should therefore have expected to find gravity considerably in excess at Japla, Daltonganj and Gaya.

The values of $(g_o''-\gamma_o)$ depend, of course, on the corrections for height and mass that we apply to the observed value of g. The correction for height is definite and unalterable and allows for the increased distance of the station from the centre of the earth. The correction for mass, however, depends entirely on the assumption of the existence or non-existence of isostasy. The corrections in the table are computed on Bouguer's hypothesis, that surface masses are not compensated by deficiencies of density. The corrections based on the theory of underground compensation have not as yet been computed for all the stations, but the following are the values of $g-\gamma$ that have been found at present:—

Station.	$g-\gamma$ dynes.
Ranchi	+0·054
Daltonganj	+0·050
Japla	+0·027
Gaya	+0·028
Sasaram	+0·033
Monghyr	0·000
Arrah	−0·003

* *Vide* deflections found at Mahwari, Teona and Mednipur under heading Astronomical Latitudes.

These values seem to fit in well with the theory of the hidden chain of high density, but discussion would be premature until the isostatic corrections for mass have been computed for more stations.

In the report for 1909-10 a table was published showing the values of $g-\gamma$ computed on Hayford's hypothesis, *i.e.*, that of underground compensation. These corrections were only computed up to a distance of 100 miles from the station, time not having been available for more than this; and to show that the values of $g-\gamma$ there exhibited will be sensibly altered when the correction is computed for the whole earth, it is only necessary to state that the correction beyond 100 miles from the stations already computed varies from 0·012 at Ranchi to 0·029 at Monghyr.

Summary of results, 1911-12.

Station.	Latitude.	Longitude.	Height above M. S. L.	Observed g.	Correction for height.	Correction for mass.	Correction for terrain.	g_o = g. corrected for height only.	g_o'' = corrected for height, mass and terrain.	γ_o.	$g_o - \gamma_o$ dynes.	$g_o'' - \gamma_o$ dynes.
	° ′ ″	° ′	Ft.									
Ranchi . . .	23 23 5	85 19	2,167	978·691	+0·202	−0·076	0	978·893	978·817	978·818	+0·075	−0·001
Daltonganj . .	24 2 5	84 4	707	978·827	+0·066	−0·025	0	978·893	978·868	978·861	+0·032	+0·007
Japla . . .	24 31 58	84 0	474	978·856	+0·044	−0·017	0	978·900	978·883	978·895	+0·005	−0·012
Gaya . . .	24 47 42	85 0	361	978·884	+0·034	−0·013	0	978·918	978·905	978·913	+0·005	−0·008
Sasaram . . .	24 57 21	83 59	340	978·903	+0·032	−0·012	0	978·935	978·923	978·925	+0·010	−0·002
Moghalsarai . .	25 17 3	83 6	257	978·919	+0·024	−0·009	0	978·943	978·934	978·947	−0·004	−0·013
Monghyr . . .	25 22 53	86 28	154	978·909	+0·014	−0·005	0	978·923	978·918	978·954	−0·031	−0·036
Arrah . . .	25 34 10	84 39	188	978·918	+0·018	−0·007	0	978·936	978·929	978·967	−0·031	−0·038
Buxar . . .	25 34 42	83 59	207	978·933	+0·019	−0·007	0	978·952	978·945	978·968	−0·016	−0·023
Muzaffarpur . .	26 7 5	85 25	179	978·934	+0·017	−0·006	0	978·951	978·945	979·006	−0·055	−0·061
Majhauli Raj . .	26 17 46	83 58	219	978·928	+0·020	−0·008	0	978·948	978·940	979·019	−0·071	−0·079
Gorakhpur . .	26 44 58	83 23	257	978·936	+0·024	−0·009	0	978·960	978·951	979·052	−0·092	−0·101

TIDAL OPERATIONS.

During the year tidal registrations by automatic tide-gauges have been continued at the following ports, with satisfactory results:—

Aden, Karachi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein, and Port Blair.

LEVELLING OPERATIONS.

During the year 1911-12 the following lines of precise levels were run:—

(*a*) *In the Punjab.*

Shahpur to Sargodha.
Sargodha to Lahore.
Sargodha to Multan.

(*b*) *In Assam.*

Dumpep to Sylhet.
Sylhet to Karimganj.
Karimganj to Silchar.
Karimganj to Comilla.

(*c*) *In Burma.*

Minbu to Salin.

Salin along both sides of the Salin Chaung to the canal works.

Prome *viâ* Henzada and Maubin to Rangoon.

The line Magwe to Prome had been included in the programme, but it was not found possible to complete it. This line would have completed the first circuit formed in Burma. It is now intended to complete it in 1912-13.

In addition to the above lines of precise levelling some 235 miles of single levelling were carried out in the neighbourhood of Delhi, both as an aid for the surveying of contours for a map of Delhi and for the fixing of heights for engineering purposes.

I.—BOTANICAL SURVEY.

BY

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Eastern India.—Since the publication of the last report two more fasciculi—comprising over 7,000 numbers—of the numerical list of non-herbaceous flowering plants cultivated in the Royal Botanic Garden, Calcutta, have appeared. This nominally completes the first volume of the catalogue, which contains over 13,400 numbers. These numbers indicate individual plants or groups only. The number of different species is much smaller. In the numerical list there are many blanks so far, of which palms constitute the large proportion. During the year, however, a fairly representative collection of specimens from the palms cultivated in the garden were sent to Dr. Beccari, the distinguished Italian botanist and authority on palms, and he has kindly identified them, so that it will be possible in the second volume to fill in many of the blanks. Considerable progress has been made in elaborating the materials for the second or systematic volume of the catalogue.

In the Eastern Himalaya collections were made on behalf of the Botanical Survey by Mr. B. J. Gould, I.C.S., Mr. W. R. Jacob of the Forest Department, Mr. R. S. Lister of Pashok Tea Estate, Mr. W. W. Smith, lately Curator of the Herbarium of the Royal Botanic Garden, Calcutta, and by Mr. G. H. Cave, Curator of the Lloyd Botanic Garden, Darjeeling. Mr. Gould's collections numbering about 400 sheets were made about Gyantse. Messrs. Jacob and Lister collected in Bhutan, the former contributing over 200 and the latter over 100 specimens of interest. Messrs. Smith and Cave's collections were made in Sikkim and the Darjeeling district, and supplemented by the collections made by the Lepcha collectors of the Lloyd Botanic Garden, Darjeeling, they totalled about 1,400 sheets. Mr. A. Meebold also presented the Calcutta Herbarium with a small collection from the outer hills of the Darjeeling district. J. F. Duthie has described the following new species of *Boraginaceæ* from the collections made in the Eastern Himalaya and the Tibetan tableland beyond by several officers during the Mission to Lhasa and by Calcutta Botanic Garden collectors:—*Paracaryum trinervium*,

Eritrichium densiflorum, Microula pustulata, M. Younghusbandii, Onosma longiflorum, O. Waltoni, O. Waddellii.

Mr. J. S. Gamble has cleared up the confusion hitherto existing as regards the differences between the different species of *Arundinaria* bambcos found on the hills of Sikkim, and has separated off as a new species—called *Arundinaria Maling*—a species that has hitherto been confounded with *A. racemosa*. Mr. Gamble has given a key to the 10 species of *Arundinaria* he recognises as occurring in Sikkim.

M. R. Hamet has described under the name of *Sedum Karpelesæ* a new species of *Crassulaceæ* collected by Major H. J. Walton, I.M.S., in the neighbourhood of Lhasa. Herr E. Koehne has described two new species of *Rosaceæ, Sorbus arachnoidea* and *S. Wenzigiana* and a new variety of *S. rufopilosa* from the Eastern Himalaya. From the same region Herr Herter has described a new species of Club moss as *Lycopodium sikkimense*, and Mr. H. N. Dixon a new moss, *Pogonatum papillosulum*. Messrs. Burkill and Finlow have described a new variety of the common jute plant *Corchorus capsularis* L. occurring in Eastern Bengal. In Assam Mr. I. H. Burkill while officiating during the hot weather of 1911 as Director of the Botanical Survey, toured in the Khasia Hills, accompanied by Mr. S. C. Banerji of the Botanical Survey Department. Their tour resulted in an accession to the Calcutta Herbarium of over 800 specimens. Towards the end of 1911, Mr. Burkill was deputed as botanist to accompany the Abor Expedition. Despite the unfavourable conditions, seasonal, climatic and otherwise, that greatly hampered botanical work, Mr. Burkill returned with over 2,000 specimens, which with his notes will serve to add very materially to our knowledge of the vegetation of that little known frontier region. Mr. Burkill has under preparation a detailed account of the botanical results of the expedition, which will appear in the Records.

Meanwhile the following extract from a general account of the Abor flora which was read by Mr. Burkill at the recent assembly of the British Association may serve to indicate the general characteristics of the vegetation.

"Forest is the natural clothing of the Abor hills, where it obliterates the clearings of man quickly; and where woody plants, following herbs, invade the less inviting spots (1) as epiphytes securing places in the tree-tops, (2) slowly spreading on to the rivers' sterile sandbanks, and (3) invading the river-beds between their June level and their January level. The lecturer used his time chiefly in studying the constitution of the different types of forest met with, and these three intrusions,

The Plains forest is in a way a northward extension of the vast forests of Malaya. Like all tropical rain-forests, it has a great variety of foliage. It has three layers—(1) the layer of the wind-dispersed, relatively small-leaved, giant trees; (2) the layer of the animal-dispersed, large-leaved lesser trees not growing beyond the still air; and (3) the layer of the ground vegetation wherein the plants are not large-leaved except in the alleyways of the forest. The second and third layers are separated by a light-diffusion space.

In their relation to creepers the trees of the forest differ in interesting ways: some thrive by outgrowing the creepers in annual spurts; some thrive by smothering them.

The Lower Hill forest is of two kinds. On the south slopes it is not unlike the Plains forest; but on the north slopes rules a most distinct and characteristic forest composed chiefly of a tree called by the Abors 'Shingkeng.' There is little variety in the foliage of a Shingkeng forest. Above the base of the hills oaks appear, and rule in places. On very steep slopes a giant bamboo rules. The Upper Hill forest has very uniform foliage, and is rather of two layers than three.

Grasses, as in the Sikkim forests, are very rare in the whole countryside; it is only where the very copious rain is drained away to an unusual extent that they can exist: thus, the very steep slopes harbour the giant bamboos; Abor clearings on hill-crests enable *Saccharum* to exist for a while; very well trodden paths in the immediate vicinity of villages allow two species to grow; sandbanks grow grasses; one invades the river-bed, clinging to rocks; and the gravel-beds at the foot of the hills after cultivation become covered with *Phragmites*.

Elsewhere grasses, even on clearings returning to jungle, do not exist. The clearings after the crop is removed are seized on by *Ageratum*, *Bidens*, *Blumea*, *Gnaphalium*, *Triumfetta*, *Viola*, etc. Then follow shrubs out of which a *Calophyllum* and a *Macaranga* gradually come to rule, the foliage getting larger as the height of the scrub increases, until finally it passes back to the true forest.

The river's clearings are sandbanks. Grass, first of all, takes possession of them; then slowly trees invade them, those which come first being the most deciduous species of the countryside.

The fall of the River Dehong in the hills is 50 to 60 feet. Of terrestrial plants, a moss ventures furthest into the exposed river-bed; not quite so far ventures a *Jungermannia;* a fern, an *Equisetum*, a *Polygonum*, and the curious Euphorbiaceous *Homonoia* descend to a

limit which has a longer period above the flood; another *Equisetum*, two other ferns, and *Rhabdia* of the Boraginaceæ descend half-way; the grass already mentioned, a *Lactuca*, a *Blumea* (Compositæ), *Viola Patrinii*, a *Ficus*, and some other plants occupy in increasing degree the upper part of the banks. The grass makes such a dense mat of roots as to resist the wash of the current and to hold a soil. The *Homonoia* is a tree with a trunk buried in the shingle.

Humid all the year round, it is only on the bluffs and south slopes of the Abor hills that trees bare after their leaf-fall for more than a month are found. Where bare trees stand, the epiphytes of the upper layers of the forest can be seen easily; they are more commonly in considerable aërial gardens than solitary, for the presence of one plant enables another to get a footing. As with the forest trees, the larger-leaved epiphytes are rarely in the topmost layers of the forest, but live a little below.

Mosses and film-ferns are abundant on the tree-trunks; neither store water, but both withstand desiccation. Two film-ferns were sent alive to Kew in a letter—a matter of a month in post-bags—without any protection against desiccation, and are now growing there.

Epiphytic figs are common in the forest, where the crown of one attains a greater span than other trees, and its roots find their way to the soil more than one hundred feet below.

The forest attains a height of 120 to 180 feet. Phanerogamic parasites are common in it, showy mistletoes living in the tree-tops, and leafless parasites being common on the ground, such as the coral-red *Balanophora dioica* and brown *Rhopalocnemis phalloides* (Balanophoraceæ) and dark blood-red *Sapria bengalensis* (Cytinaceæ), which live on the giant vines, where these, running through the tree-tops, make the light on the ground below too dim for foliage plants."

From Mr. Meebold's previous Manipur and Naga collections, M. C. deCandolle has described the following new species of *Piper*:—*P. phalangense*, *P. lainatakanum*, *P. kapruanum*, *P. aurorubrum*, *P. makruense*, *P. Meeboldii*, *P. nagaense*. From the same collections, a new species, *Raphidophora manipurensis*, has been described by Dr. Engler and Herr Krause, while from the same region but from Sir George Watt's collections Herr Krause has described *Sorbus Wattii* as a new species. Mr. W. W. Smith has described *Craibiodendron Mannii* as a new species from the Jaintia Hills.

In Burma Captain S. M. Toppin, R.G.A., made a botanically important journey in company with the Khampti Long Mission during

December 1911 and January and February 1912. The route was from the confluence of the Mali Hka and N'mai Hka rivers to form the Irrawaddy, northwards along the region west of the Mali Hka to Patau, thence north-eastwards to the Nam Tamai or upper waters of the N'mai Hka, the easterly of the two rivers that unite to form the Irrawaddy. The area covered lies roughly between 26° and 28° N. Lat. and 97° and 98° E. Long. Captain Toppin's collections are now being worked out. In addition to the collections much interesting information has been furnished by Captain Toppin in his notes. An account of the botanical results of both his journeys will be published as soon as opportunity permits, but a few of Captain Toppin's notes may be given here. The area west of the Mali Hka, between 26° and 27° N. Lat., consists of low ranges of hills running from west to east, covered with evergreen forest mostly composed of species of oaks and *Castanopsis*, with an undergrowth of prickly palms, bamboo thickets, plantains, and an abundance of *Strobilanthes* and *Impatiens*. Begonias also were common. Further north the hills are higher but the general aspect of the vegetation not markedly different. The species of oaks appeared to be different and a Rhododendron was found. There was practically a complete absence of Balsams and but few *Strobilanthes*. No coniferæ were seen. North of 27° 15′ N. Lat. and west of the Nam Kiu tributary of the Mali Hka is the grassy plain of Khampti Long. This plain is at an elevation of 1,100 to 1,200 feet and is completely covered with tall thatch grass, the trees being confined to edges of ravines that run from west to east, and to a few isolated knolls. Captain Toppin's collections on this journey were therefore from three distinct areas, (*a*) the part of the Kachin region that occupies the west side of the valley of the Mali Hka; (*b*) the Khunnong area around the headwater of the Mali Hka and N'mai Hka, being east of the Nam Kiu tributary of the Mali Hka and north of 17° 15′ N. Lat.; (*c*) the Khampti Long plain, north of 27° 15′ N. Lat., and west of the Nam Kiu tributary of the Mali Hka. Captain Toppin's explorations cover the area to the west of the region explored by Lieutenant Pottinger, R.A., in 1897, the explorations of the latter having been mostly confined to the eastern side of the N'mai Hka valley, which as is now known—although it was unknown at the time of Lieutenant Pottinger's expedition—does not come within the proper Kachin Hill area.

In Lower Burma Mr. A. Meebold explored part of the district of Mergui in the spring of 1911, and in the end of 1911 and beginning of 1912 made a tour in the districts of Thaton and Salween, travelling beyond

Papun in the latter district. From the three districts mentioned Mr. Meebold has contributed some 2,500 sheets to the Calcutta Herbarium. Smaller collections were contributed by Captain R. H. Phillimore, R.E., from the Southern Shan States, and by Mr. C. G. Rogers, Conservator of Forests, from Pegu. Amongst them and previous collections made in Assam and Burma quite a number of new species have been discovered, though all have not yet been published. Descriptions of the following have, however, appeared:—*Paradombeya multiflora*, *Elæocarpus Robertsoni*, *Lespedeza sessilifolia*, and *Beilschmiedia Robertsoni*, all from the Southern Shan States by Mr. Gamble; *Gentiana Hesseliana*, originally collected by Parish at Moulmein by Herr Hosseus; *Bulbophyllum congestum* from the Kachin (Maru?) hills by Mr. Rolfe; *Hibiscus Watsoni*, *Hedyctis glauca*, *Styrax Lacei*, *Staurogyne shanica*, *Didymocarpus Burkei*, *Craibiodendron Mannii* (all from Assam or Burma) by Mr. W. W. Smith; *Fimbristylis Lacei* (Burma) by Mr. Turrill. Mr. J. S. Gamble has continued his work on the Flora of the Malayan Peninsula, a region which comes within the area treated in the "Flora of British India," and during the year there has appeared an account of the families *Nyctaginaceæ*, *Amarantaceæ*, *Polygonaceæ*, *Aristolochiaceæ*, *Chloranthaceæ*, *Lauraceæ* and *Hernandiaceæ*, all being worked up by Mr. Gamble, except *Polygonaceæ*, the account of which was contributed by the writer of this report. M. Casimir deCandolle has published in the Records of the Botanical Survey diagnoses of the following new species of *Peperomia* and *Piper* from the Malayan Peninsula:—*Peperomia kotana*, *P. Maxwellana*, *P. Wrayi*; *Piper bipedale*, *P. collinum*, *P. connibaccum*, *P. curtipetiolum*, *P. Curtisii*, *P. dindingsianum*, *P. erecticaule*, *P. eucalyptolimbum*, *P. febrifugum*, *P. filipes*, *P. flavibaccum*, *P. flavimarginatum*, *P. flavispicum*, *P. globulistigmum*, *P. gymnocladum*, *P. gymnophyllum*, *P. kotanum*, *P. Kunstleri*, *P. larutanum*, *P. longamentum*, *P. longibracteum*, *P. longicaule*, *P. magnibaccum*, *P. malaccense*, *P. Maxwellanum*, *P. minutistigmum*, *P. mucronatum*, *P. muricatum* forma *peninsulare*, *P. pilistipes*, *P. nigrantherum*, *P. obovantherum*, *P. paucistigmum*, *P. pentandrum*, *P. polygynum*, *P. protractum*, *P. puberulirameum*, *P. ramipilum*, *P. varispicum*, *P. Ridleyi*, *P. rufibracteum*, *P. rufispicum*, *P. Scortechinii*, *P. selangorense*, *P. semangkoanum*, *P. subalbicans*, *P. subfragile*, *P. subrubrispicum*, *P. subsessililimbum*, *P. velutinervium*, *P. xanthocarpum*. Other species from this region described since last report include *Wikstræmia Ridleyi*, *Henslowia monticola*, *H. Ridleyi*, *H. Wrayi*, *Scleropyrum Ridleyi*, by Mr. Gamble; *Strychnos pseudo-tieute* by Mr. A. W. Hill; *Lecanorchis Ridleyana* by Herr R. Schlechter.

Southern India.—Mr. C. E. C. Fischer, Deputy Conservator of Forests, has been the main support of Botanical Survey work in the peninsula. He has contributed over 1,200 specimens collected in various parts of the Madras Presidency, such as the Pulney and Anamalai Hills and in Coimbatore district. Mr. Fischer's large and excellently preserved collections will prove of great value when the Flora of the Madras Presidency comes to be written. Dr. C. A. Barber, D.Sc., Government Botanist, has given as much of his time to systematic work as his other engrossing duties permitted. The following is quoted from his report as Government Botanist for 1911-12:—

"*Systematic Botany.*—A considerable amount of attention was devoted to this section during the year because of the decision on the part of the Government to have a flora of the Madras Presidency prepared, and numerous reports were forwarded on the subject. There was practically no special touring for the collections of plants, but substantial additions were made to the collections of peppers and *Loranthaceæ* by the Government Botanist while on other tours and a few local expeditions were made by fieldmen. Much progress was made in getting the large accumulation of plants, collected in previous years by the Government Botanist named, although this work was still hampered by lack of staff and the absence of suitable herbarium cases. Some 7,700 sheets were finally written on and added to the special collection of Madras plants. Eighty duplicate sheets were received from the Calcutta Herbarium. A small herbarium of 250 species of plants was given to the Presidency College for teaching purposes and about 50 sheets were distributed to other correspondents. The whole collection of *Dioscoreas* was sent to the Reporter on Economic Products and named and returned by him. The valuable collection of *Grewias* remained with the Kew authorities throughout the year. An important addition was made to the illustrations of the Madras flora in the form of 513 pen and pencil drawings of plants. On investigation these turned out to be the originals of the plates in Wight's, Beddome's and other authors' published works on the Madras flora. They were received in an extremely dilapidated condition, but every effort is being made to preserve them in a series of specially prepared atlases. About 200 plants were named by the Assistant for various correspondents. The collection of 1,143 sheets of Madras peppers was overhauled by the Government Botanist and numerous dissections and drawings made. The specimens were sorted, arranged and named where possible and notes were drawn up for the information of the writer of the flora. A summary note on this work was prepared and forwarded for filing at Kew. The seed collection

was overhauled and it was found necessary to reject a large number on the ground of insufficient naming. About 280 new species were, however, added, so that the number at the end of the year was 600."

The following new species from this area has been published during the year:—*Decaschistia rufa* (*Malvaceæ*) by Mr. W. G. Craib.

Western India.—Although there is not now so much scope for exploration on the western as on the eastern side of the Indian Empire, there is abundant opportunity for study of the vegetation from the standpoint of particular orders, genera or species as distinct from the study of the vegetation of any definite geographical area. Both aspects of study are comprehended in Mr. W. H. Talbot's Forest Flora of the Bombay Presidency and Sind, the second volume of which—comprising descriptions and distribution of the forest species of the families *Rhizophoreæ* to *Gramineæ*—has appeared during the year. In this volume 526 species belonging to 247 genera and 51 orders are described. The richest orders are *Euphorbiaceæ* with 66, *Rubiaceæ* with 48, *Urticaceæ* with 36, *Acanthaceæ* with 34, *Convolvulaceæ* with 28, and *Apocynaceæ* with 24 species. The flora of Aden has been made for some years the subject of thorough study by the Rev. Father E. Blatter, S.J., who has now made ready for publication an exhaustive account of the vegetation, comprising the history of the botanical exploration of the region, the physical aspects of Aden, a statistical account of the vegetation, its general aspects, adaptations, flowering season and climate, geographical relations, origin, dissemination, together with a synopsis of the families and descriptions of the species. Altogether 250 species are described, nearly thrice as many as were mentioned by Anderson in his "Florula Adenensis" published about half a century ago. Arrangements have been made for the Botanical Survey Department to publish during the coming year this valuable contribution to the botany of the Indian Empire.

Mr. G. A. Gammie has issued a further instalment of his description of the *Orchidaceæ* of the Bombay Presidency, comprising the species of the genus *Peristylus*.

Mr. R. K. Bhide, Assistant Economic Botanist, Bombay, has published description of the following new species of grasses found in the Bombay Presidency:—*Danthonia Gammiei*, *Andropogon Paranjpyeanum*, *Enteropogon badamicum*, *Tripogon Roxburghianum*. The following new species or varieties of *Piper* collected by Mr. Meebold in Western India have been described by M. Cas. deCandolle:—*Piper*

crenulatibracteum (North Kanara), *P. nigrum* L. var. nov. *mysorensis* (Mysore), *P. hymenophyllum*, form. nov. β (Mysore), *P. Talbotii* (Matheran). Mr. S. A. Watson, I.A., of of the 67th Punjabis has presented collections made by himself in the neighbourhood of Kach in Baluchistan. Mr. H. N. Dixon has described a new genus and species of moss *Bryosedgwickia Kirtikarri* from the Bombay side.

Northern India.—Colonel J. C. Bamber, I.M.S., has issued another part of his key to the flora of the Punjab, North-West Frontier and Kashmir. Lady Douie presented the Calcutta Herbarium with collections made by herself and by Mr. K. S. Imam-ud-din of the Forest Department in Kulu and Pangi respectively. Mr. J. H. A. Ivens has studied and recorded the general seasonal and altitudinal aspects of the flora of the vale of Kashmir. From the North-West Himalaya the following new species have been described:—*Leontopodium Evax*, *L. Jacotianum* by M. Beauverd; *Corydalis Onobrychis* (from Gilgit) by M. Fedde; *Sorbus Wenzigiana* (from Kumaon), and three new varieties of *S. cashmiriana* Hedbund by Herr Koehne; *Lespedeza dubia*, *L. indica*, *L. Meeboldii* by Herr Schindler; *Cynanthus cordifolius* by Mr. J. F. Duthie; *Lindbergia longinervis* (a new moss) by Mr. H. N. Dixon. The area of distribution of *Philonotis seriata* Mitten, a moss hitherto supposed to be confined to Europe and North America, has been extended by the recognition of its occurrence in the North-West Himalaya.

Additions to the known Flora.—During the year over a hundred hitherto undescribed species have been added to the number known to occur within the area covered by the "Flora of British India."

General systematic.—The Rev. Father Blatter, S.J., has compiled a very useful bibliography of the Botany of British India and Ceylon. The compilation is in two parts—(I) a general bibliography containing the titles of publications that treat of the Botany of India in general or of a greater part of India, (II) a regional bibliography that enumerates the books and papers dealing with the botany of smaller areas included wholly or partly in one of the botanical regions at present recognised in India. In all over 1,500 books and papers are cited. Parts V and VI of the same botanist's account of the palms of British India and Ceylon, indigenous and introduced, have appeared during the year, the species described belonging to the genera *Corypha*, *Nannorhops*, *Licuala*, *Livistona*, *Pritchardia*, *Washingtonia*, *Sabal*.

Considerable progress has been made towards the publication of the supplement to Doctor Beccari's account of the species of the genus *Calamus* of climbing palms. The same author has published a classification of the

palms of Indo-China. Mr. J. R. Drummond, I.C.S. (retd.), has published an elaborate and valuable critique of the Indian species of *Grewia* as understood, described or mentioned by Roxburgh. M. Gagnepain has revised the classification of the Asiatic species of *Buddleia*. Sir David Prain has critically revised the history, classification and distribution of the species of *Erythrococca* and *Micrococca*. His review is of importance to students of Indian botany from the occurrence of species of the latter genus in India. Herr Schottky has published an account of the oaks and allied genera of Eastern Asia and their geographical distribution. The Asiatic species of *Aponogeton*, *Paspalum* and *Panicum* have formed the subject of papers by M. Camus. The distribution and use of *Erythrina indica* Lamk. in Indo-China has been discussed by MM. Dubard and Eberhardt.

Mr. S. T. Dunn has published an account of *Primula bellidifolia* King and its allies, with a key to the group formed by that species and nine others. Papers of a more general systematic character, that in part directly or indirectly have a bearing on the botany of India, are mentioned in the list of publications at the end of this article.

Anatomical and physiological.—Professor Bower of Glasgow University has based one of his recent studies in the Phylogeny of the Filicales, *viz.*, "On *Lophosoria* and its relation to the *Cyatheodeæ* and other ferns," partly on material supplied by the Calcutta Botanic Garden. The same Garden supplied in part the material for an investigation by Mr. R. C. Davie into the structure and affinities of *Peranema* and *Diacalpe*, two Eastern Himalayan forms. Mr. I. H. Burkill has recorded a series of observations on the polarity of the bulbils of *Dioscorea bulbifera* L. as regards the sprouting of shoots. Mr. W. Burns has described a second year's growth of a plantain inflorescence.

Other investigations on anatomical or physiological lines with more or less application to Indian botany are mentioned in the list of papers appended.

A list of papers containing references to the Botany of India published mostly during 1911-12.

BAMBER, C. J. . . Plants of the Punjab, IX. (*Journ. Bomb. Nat. Hist. Soc., xxi, No. 1, 1911, p. 203-228.*)

BEAUVERD, G. . . Sur la distribution géographique des genres *Leontopodium* Cass. et *Cicerbita* Wallr. Emend. Beauv. (*Bull. Murithienne, xxxvi, 1911, pp. 44 and 77.*)

BEAUVERD, G. . Nouvelles especes eurasiatiques du genre *Leontopodium*. (*Bull. Soc. Bot. Genève, 2nd Ser., i, p. 185-196, 1909.*)

BECCARI, O. . Classification des Palmiers d'Indo-Chine. (*Bull. Mus. Nat. d'Hist. Nat., 1911, No. 3, p. 148-160.*)

BENOIST, R. . Les genres *Lepidagathis* et *Lophostachys* sonts-ils distincts? (*Notulæ Systemat., ii, No. 5, 1911, p. 139-144.*)

" Contribution à la flore des Acanthacées asiatiques. (*Notulæ Systematicæ, ii, No. 8, 1912, p. 238-240.*)

BHIDE, R. K. . New and revised species of *Gramineæ* from Bombay. (*Journ. Asiat. Soc. Beng., vii, No. 8, 1911, p. 513-520, with 4 plates.*)

BLATTER, E. . A Bibliography of the Botany of British India and Ceylon. (*Journ. Bomb. Nat. Hist. Soc., xx, No. 5, 1911, p. lxxix-clxxxv.*)

" The Palms of British India and Ceylon, Indigenous and Introduced, V and VI. (*Bomb. Nat. Hist. Soc. Journ., xxi, Nos. 1 and 2, 1911-1912, p. 66-86 and 343-391, with 15 plates.*)

BONAVENTURA, C. . Ricerche anatomiche súl fiore delle Orchidee. (*Nuovo Giorn. Bot. Ital., xix, 1912, No. 2, p. 167-293, with 4 plates.*)

BOWER, F. O. . Studies in the Phylogeny of the *Filicales*. *Lophosoria* and its relation to the *Cyatheoideæ* and other ferns. (*Ann. Bot., xxvi, 1912, No. 102, p. 269-323, with 7 plates.*)

BURKILL, I. H., & FINLOW, R. S. *Corchorus capsularis* var. *oocarpus*, a new variety of the common jute plant. (*Journ. Asiat. Soc. Beng., vii, 1912, No. 8, p. 465-466.*)

BURKILL, I. H. . Polarity of the bulbils of *Dioscorea bulbifera* L. (*Journ. Asiat. Soc. Beng., vii, 1912, No. 8, p. 467-469.*)

" The Forest of Kobo. (*Kew Bull., 1912, p. 159.*)

BURNS, W. . Second year's growth of a plantain inflorescence. (*Journ. Bomb. Nat. Hist. Soc., xxi, 1912, No. 2, p. 706-707.*)

CAMUS, A. . . Note sur les éspeces asiatiques du genre *Aponogeton*. (*Notulæ Systematicæ, ii, 1912, No. 7, p. 202-204.*)

,, Note sur les *Paspalum* de l'Asie orientale. (*Not. System., ii, 1912, Nos. 7 and 8, p. 216-226.*)

,, Notes sur quelques *Panicum* de l'Asie orientale. (*Notulæ Systematicæ, ii, No. 8, 1912, p. 246-253.*)

CANDOLLE, DE, C. . *Piperaceæ Meeboldianæ* Herbarii Vratislaviensis. (*Repert. spec. nov. Reg. Veget., x, 1912, Nos. 266-270, p. 518-523.*)

,, Piperaceæ novæ a Peninsula Malayana. (*Rec. Bot. Surv. Ind., vi, 1912, p. 1.*)

COLOZZA, A. . . Contributo allo studio anatomico delle *Burmanniaceæ*. (*Bull. Soc. Bot. Ital., 1910, p. 106-115.*)

CRAIB, W. G. . *Decaschistia rufa*. (*Kew Bull. No. 1, 1912, p. 35.*)

DAUPHINÉ, A., & HAMET, R. Contribution à l'étude du genre *Kalanchoe*. (*Ann. Sc. Nat. 9, Ser. Bot., xiv, 4-6, p. 195-219.*)

DAVIE, R. C. . . The structure and affinities of *Peranema* and *Diacalpe*. (*Annals of Botany, xxvi, No. 92, April 1912, p. 245-268, with 2 plates.*)

DISMIER, G. . . Sur la presence du *Philonotis seriata* Mitten en Asie. (*Bull. Soc. Bot. de France, lix, 1912, p. 175-177.*)

DIXON, H. N. . . *Bryosedgwickia*, novum genus *Entodontacearum*, with further contributions to the Bryology of India. (*Journ. Bot., l, No. 593, 1912, p. 145-156, with 1 plate.*)

DOMMEL, H. C. . Ueber die Spaltöffungen der Gattung *Euphorbia*. (*Ber. deutsch. bot. Ges., xxviii, 3, 1910, p. 72-77, with 1 plate.*)

DRUMMOND, J. R. . The Grewias of Roxburgh. (*Journ. Bot., xlix, Nos. 587 and 588, 1911, p. 329-337 and p. 357-363.*)

DUBARD, M. . . Remarques sur la classification des Sidéroxylées. (*C. R. Acad. Sc. Paris, cvii, 1911, p. 390-393.*)

DUBARD, M., & EBERHARDT, PH. — *L'Erythrina indica* Lamk. en Indo-Chine. (*Bull. Mus. Nat. Hist. Nat.*, *1910, No. 6, p. 333-337.*)

DUNN, S. T. . — *Primula bellidifolia* King, and its allies. (*Notes from the Roy. Bot. Gard. Edinburgh, No. xxiii, 1911, p. 61-64, with 1 plate.*)

DUTHIE, J. F. . — Diagnoses of new Indian species. (*Kew Bull. No. 1, 1912, p. 37-41.*)

ENGLER, A., & K. KRAUSE. — *Raphidophora manipurensis.* (*Bot. Jahrbüch, xlv, 5, 1911, p. 659.*)

ESENBECK, E. — Ueber die Systematik der Gattung *Melampyrum.* (*Mitteil. bayr. bot. Ges. Erforsch. heim. flora, ii, 4, p. 239.*)

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II.—ECONOMIC BOTANY.

Part I.—AGRICULTURAL BOTANY.

BY

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The present report deals with the progress of Agricultural Botany in India during the year ending June 30th, 1912, and is confined to the results actually obtained. All references to current programmes of work are omitted as these are to be found in the *Proceedings of the Board of Agriculture for 1911*, which has already been published. In the present paper, the subject of seed distribution in India has been dealt with in a separate section, in order that the significance of the great progress made in this direction by the Agricultural Department may be appreciated. A list of papers published during the year is appended.

I. SEED DISTRIBUTION.

Since the foundation of the Agricultural Department of India in 1905, a considerable amount of attention has been paid to the improvement of the cultivated plants of the country. New crops have been introduced and better varieties of existing staples have been brought to the notice of the people, coupled often with improved methods of cultivation. The success of these efforts has in turn raised the question of the best means of maintaining and distributing pure seed of improved varieties of crops and this matter was one of the subjects discussed at the recent meeting of the Board of Agriculture held at Pusa in November 1911. The report of the Committee, which was adopted by the Board, is published in the *Proceedings of the Board of Agriculture for 1911*, and deals with the methods of obtaining improved varieties, the testing of varieties, the maintenance of pure types, the distribution of seed to cultivators and with the marketing of the produce. In this work stress was laid on the importance of natural cross-fertilization in crops like cotton and also on the maintenance in pure culture, by the Botanist in each Province, of a collection of the improved types introduced by the local Department. This collection will serve both as a source from which pure seed can be obtained for re-stocking the seed farms and also for the use of investigators in other Provinces. In the distribution of

seed to cultivators it was recommended that the following main principles should guide the work of the Agricultural Department:—

1. The desirability of concentrating the efforts of the Department on one or two well-defined problems at a time rather than wasting its resources on indiscriminate seed distribution.

2. The desirability of confining the work of seed distribution in any one tract as far as possible to one sort and of systematically replacing existing mixtures by this pure type. This is particularly necessary in the case of cross-fertilized plants where degeneration through vicinism is of such great importance. The distribution of one sort only has the further advantage of creating large supplies of one particular type and thus forming a trade centre for this produce and attracting buyers.

3. The necessity of utilizing to the utmost the present staff and resources of the Department and of supplementing this by enlisting the assistance of leading agriculturists in the work of seed growing and seed distribution in the tracts concerned.

This discussion of the general subject of seed distribution in India by the Board of Agriculture by no means implies that nothing useful in this direction has been accomplished. On the contrary, the results already obtained are most gratifying and the present opportunity is taken of drawing attention to the most important. The crops in which most progress has been made are cotton and wheat and these are dealt with in the following paragraphs.

Cotton. The distribution of improved seed of a crop like cotton, in which natural cross-fertilization is common, in such a manner that the improvement in the staple can be maintained permanently is a problem of the greatest interest in agricultural science. On this account the efforts of the Agricultural Department in this direction are described in some detail. It is clear that if this work is to be of lasting benefit to India the present cottons in any tract must be entirely replaced by one kind, which breeds true to type, in order that the results of vicinism may be prevented and the mixing of seeds at the ginneries rendered impossible.

The improvement of the cotton crop in Madras is one of the chief features of the work of the Provincial Agricultural Department. Not only have selection methods been applied successfully to the local cottons, but an exotic cotton, known as Cambodia, has been widely taken up by the cultivators.

In the selection work the results obtained by Mr. Sampson with Karanganni cotton in Tinnevelly are the most interesting and the most

important. This work was commenced at the Koilpatti farm some years ago and the area now under the improved cotton is upwards of 80,000 acres. The methods first adopted in the improvement of Karanganni cotton come under the term mass selection, that is to say, the culture was started from several plants. These were selected for their shape and bearing power from the general farm crop. In the third year, the seed was issued to contract growers who cultivated it under instructions from the Department. The whole crop was then sold back to the Department, who ginned the *kapas* and next year distributed the seed to depôts in the black cotton soil villages where it was sold to cultivators. These depôts are selected every year and the depôt is moved to a fresh place as soon as Karanganni cotton has been established as a pure crop. In this way the whole area suited to this cotton will be worked over and the existing cottons will be replaced by the improved kind. Recently the methods of selection have been improved at Koilpatti and at the present time the cultures are started from one plant. Such pure line cultures have already reached a field scale and during the present year one of these will be grown on a seed farm. The method of conducting the pure line cultures is as follows: In the second year culture the crop from each plant is collected separately and the lint is examined for twist, evenness, length and fineness and the ginning percentage is also determined. The best and most even plants only of this culture are taken for seed and these are grown as a field crop on a plot one-tenth of an acre in area so that the behaviour of the selection under ordinary field cultivation can be estimated. If the crop is even and suitable in the third year it is planted on an acre plot, after which the cotton is sampled and tested, and, if suitable, carried on to a seed farm. At each stage selections which prove undesirable are discarded and an approximation to a pure culture is obtained in this way and cross-fertilization is to a great extent prevented. Mr. Sampson states that cross-fertilized plants disclose themselves by the following characters: by increased vigour; by increased length of the staple; by increased difficulty in ginning—a selection in which there is difficulty in removing the lint from the seed is always open to suspicion. Variation in the colour, shape and fuzziness in the seed of the progeny of a selection is also a useful indication of natural crossing. The area of the seed farms in Tinnevelly under Karanganni in 1910-11 was 574 acres which gave seed enough for 11,200 acres and it was sold for Rs. 10 per 250 lbs. There was great competition for the seed and it is interesting to note that the Tuticorin Chamber of Commerce states that the improvement in the quality of this cotton is still maintained. As the selection methods at the Koilpatti farm progress there is little doubt that

still better cotton will be produced for the seed farms and in this way successive waves of cotton will proceed outwards from the agricultural station resulting in the establishment of a definite improvement.

In the Northern Circle of the Madras Presidency similar methods of selection and seed distribution with cotton have been started, the preliminary results of which appear to be of considerable promise.

In the case of Cambodia cotton the results obtained in Madras are, on the whole, not so satisfactory as with Karanganni. Cambodia cotton, which is grown only on irrigated garden lands, continues to spread and in the south of the Presidency the crop is estimated at 80,000 bales as against 33,000 bales the previous year. In addition it has been tried further north in Bellary, Kurnool and other Districts and has been a success everywhere. Over 31,000 lbs. of seed were sold by the Department last year and a still larger stock will be held in future. The yield per acre is as good as ever but the price has dropped to the level of Tinnevelly or even lower. This is said to be due not only to the fact of the cheapness of long stapled American, with which Cambodia competes, but also to a deterioration in quality of which most of the mills complain. The subject has received the careful attention of the Director of Agriculture who states that this deterioration is due to some extent to fraudulent admixture with country cotton, but mainly to the carelessness of the ryot who sows mixed seed and who will not trouble to eradicate the country cotton plants from his Cambodia crop. Some of the deterioration may be due to fraudulent admixture with country seed by the private growers who are growing the Cambodia mainly for seed purposes. The Madras experience with Cambodia is not surprising considering the rapidity of the spread of this cotton by private agency and the fact that most of the seed supply was not controlled by the Agricultural Department. It is a valuable lesson to all concerned with the establishment of high quality cotton in India. To bring about any permanent improvement in such cottons it is necessary to replace systematically all the existing cottons in a tract by one type as is being done in Tinnevelly. This replacement to be effective must obviously be controlled by the Agricultural Department and it is clear that this will take time, especially when the size of the staff and the means of the Department are considered. There must always be a risk of fraudulent adulteration of seed if the seed supply is not under strict control and it would seem to be better to work in one or two Districts at a time in future than to allow the cotton to spread itself. Only in this way can the consequences of natural crossing, of mixing of seed at ginneries and of fraudulent admixture be prevented.

In the Central Provinces, the chief centre of cotton seed distribution is situated at Akola in the middle of the cotton tract, where the work has been organised by Mr. Clouston, Deputy Director of Agriculture, Southern Circle. The principal types distributed have been obtained by selection from the Berar *Jari* and high quality long stapled cottons like *Buri* are distributed only to rich village lands and in those areas where cotton is generally affected by wilt. The selected constituents of the *Jari* mixture are short stapled cottons, characterised by high yield, high ginning percentage and robust growth under ordinary conditions and it has been found that these types pay the cultivator best. From the Akola farm as a centre, a system of seed distribution has been developed by Mr. Clouston on the following lines. Leading landowners, who are also members of the Agricultural Associations, are selected as suitable men to look after the local private seed farms and at the beginning the Government guaranteed to these men to make up any loss resulting from the improved methods of cultivation and the growth of seed which the Agricultural Department recommended. The selected seed from the Akola farm is sold to these private seed farms and the owners themselves arrange for its sale and distribution. The supervision of the Agricultural Department is confined to cultivation, ginning and advertising the seed in the monthly vernacular journal, which has a circulation of about 6,000 copies. The chief difficulty experienced has been that of getting the seed ginned at the proper time and of preventing mixture of kinds during the process. The number of these seed farms in 1911 was 42, and it is estimated that upwards of 250,000 lbs. was distributed through their agency. The number of farms has since been increased to 120, and it is expected that 600,000 lbs. of seed will be distributed when the present crop is picked. The Akola farm, which supplies the private seed farms, was inspected by Mr. Arno Schmidt, Secretary of the International Federation of Master Cotton Spinners' and Manufacturers' Associations, in 1911, who stated:

"The whole farm, in consequence of its sound management, does not only act as a nucleus for the other seed farms and as a demonstration to the many farmers who visit it, but it also realises a very handsome profit. I cannot recommend the farm too highly as an example well worth emulation in other Provinces; it certainly is the best and most effective seed and demonstration farm I have seen in India."

A similar system of seed distribution of the Akola cottons is being developed in the Nimar District of the Central Provinces by Mr. Evans.

It will be seen that the methods of cotton seed distribution in the Central Provinces and Madras have one important difference. In Madras,

the seed is grown for the Agricultural Department under contract and comes back every year to stock the village depôts. In the Central Provinces, private seed farms are supplied from the Government farm and the work of seed distribution is in the hands of the seed growers themselves. It will be interesting to watch the progress of these two systems and to see which is the more effective in bringing about a permanent improvement in the cotton crop.

In the Bombay Presidency, the distribution of improved cotton seed has not made the same progress as in the case of Madras and the Central Provinces. In Guzerat, the improved cottons obtained by the Agricultural Department are not markedly better than those already grown by the cultivators. Some types however have been obtained which the trade is prepared to purchase at a premium of five per cent. over the prevailing bazar rate for local Broach cotton. The distribution of these improved cottons is being arranged for through the Bombay Cotton Trade who have formed a syndicate to buy up at a premium of 5 per cent. all the seed cotton which is produced by cultivators in the Surat District from seed supplied by the Agricultural Department. The syndicate also provides facilities for the separate ginning of this seed cotton under departmental supervision and the return of the seed to the Agricultural Department for redistribution. The seed is then given out to groups of villages where only this kind is grown and the harvest is taken over by the ginneries as described above. In the present season arrangements have been made to distribute sufficient seed to sow 10,000 acres.

In Dharwar, Broach cotton has been found to do well, but after a time the seed deteriorates, so that the best arrangement has been found to be to import fresh seed from Guzerat each season for the cultivators. This can be done at a price of Rs. 2 per maund compared with Rs. 1-4 for local *Kumpta* cotton seed.

In Sind, under present irrigation conditions, the efforts of Mr. Henderson, the Deputy Director of Agriculture, in improving the local cotton are confined to the growth on a large scale of American Upland. Arrangements have been made to sow 4,000 acres of this cotton and a Bombay syndicate has been formed to finance the growth, to erect gins and to sell the product as graded American Upland. This cotton is worth 25 per cent. more than the local staples and will be grown largely in a part of Sind in which cotton is not at present cultivated. There will, in these tracts, be no possibility of admixture or crossing with local kinds.

In the United Provinces, progress has been made in cotton seed distribution by Dr. Parr, from the Aligarh farm. From the local cotton

a white flowered type has been isolated which is characterised by a high yield of *kapas* and a ginning percentage of 40 per cent. The staple however is somewhat shorter and coarser than the local yellow flowered kind. This disadvantage in character of lint is however more than made up for by the increased yield and high ginning percentage. About two thousand acres of the white flowered cotton are being sown this year and the crop will be purchased by Government so that the seed will be available to sow 30,000 acres next year. A great demand for seed has arisen and there is every prospect that this cotton will be established in the neighbourhood of Aligarh.

A beginning has also been made at Cawnpore by Mr. Burt where a new farm has been started for the supply of cotton seed. The white flowered cotton from the Aligarh farm is being grown for distribution to cultivators. About 1,500 acres of land round Cawnpore have also been sown with Dharwar American cotton, which will be bought by a Cawnpore mill at a premium.

During the past year the report of Mr. Arno Schmidt, Secretary of the International Federation of Master Cotton Spinners' and Manufacturers' Associations, on his visit to the cotton growing tracts of India, in December 1911 and January 1912, has drawn pointed attention to the work on the distribution of the seed of improved cottons in India. The report, considering the short period of the Secretary's visit and the many-sided aspects of the subject dealt with, is a very valuable one and is certain to lead to good results. The Secretary was particularly impressed by the seed distribution arrangements at Akola and recommended that "The system adopted by the Central Provinces of having two or more 'nucleus' seed farms owned by Government and a large number of smaller seed farms owned by intelligent cultivators, spread all over the Province, is to my mind the most essential means for improving the staple and of increasing the yield. Such seed farms are especially required in the Bombay Presidency, in the Punjab and the United Provinces." In considering this recommendation it must be borne in mind that the chief cotton distributed from Akola is a short stapled heavy yielding kind with a high ginning percentage which has been found suitable for the tract in question. *The improvement aimed at is one of yield and no question of quality is involved.* Consequently admixture of this cotton with other kinds and a certain amount of natural crossing are not so important as in the case of the distribution of selected Karanganni in Tinnevelly, of Cambodia in South Madras or of improved Broach in Guzerat. In all these latter quality of the fibre is the main consideration and mixing at ginneries and natural crossing are far more

important. The object at Akola is not the same as in the other tracts referred to and a system of seed distribution that suits the short staple cotton of the Central Provinces may not be the best in Madras. It may be much the best policy for Madras in the long run to control the seed distribution till the whole of the existing cottons of particular tracts are replaced by one improved kind. If the seed of improved long staple kinds is grown by private seed farms it is possible that adulteration will be practised and the degeneration of the staple will only be a question of time—a state of things which apparently has already begun in Madras with Cambodia. Another matter in connection with seed distribution mentioned by Mr. Arno Schmidt refers to the establishment in India by the English spinners of agencies for the buying, ginning and export of long stapled cotton. This is considered to be unnecessary as it is stated that the same result can be more easily achieved by co-operation with the Indian mill-owners. It is pointed out that long stapled cotton grown in India need not necessarily be purchased by Lancashire. Any of this cotton sold will naturally go to the highest bidder and whether it is consumed by Lancashire, India, Japan or the Continent does not matter as a corresponding amount of American cotton will be set free. In the whole report the work done by the Indian Agricultural Department on cotton is dealt with with great fairness and full credit is given for what has already been done. The Committee of the International Federation of Master Cotton Spinners' and Manufacturers' Associations considered Mr. Arno Schmidt's report at a meeting held at Salzburg on May 13th and 14th, 1912, and referred to the work on cotton of the Indian Agricultural Department in their second resolution as follows:—

> "This Committee expresses its high appreciation of the work undertaken by the various Agricultural Departments in India and respectfully urges on the Secretary of State the absolute necessity of strengthening the European staff in every Province if the measures for the extension of cotton cultivation that have been introduced are to have any prospect of success."

Wheat. In the case of this crop, in which self-fertilization is the rule, the question of seed distribution does not present the same difficulties as have to be overcome in the case of cotton. It is only in irrigated tracts like the Punjab, where the air is dry, that natural cross-fertilization in wheat is of sufficient importance to be considered in the work of seed distribution. Admixture of kinds in wheat at threshing time can be to a great extent prevented by using a separate threshing floor for each kind or by the use of pucca floors which can be swept clean

between the kinds. Even when admixture takes place the cultures can be started afresh from a single plant and a large quantity of pure seed is very soon obtained. Further, the amount of seed per acre in wheat is relatively large so that the area of the seed farms is not so large as in the case of cotton. The only problem in wheat distribution in India after the best wheats for any tract have been obtained is the question of grades. To accomplish the greatest possible improvement in wheat production in India it is necessary to establish definite grades of wheat of known quality in the various tracts, so that these grades may become well known in the markets of Europe. The position of Canadian wheats on the Home market is largely due to the grades which have been established and which are maintained by the assistance of Government. To establish such grades in India it will be necessary to confine seed distribution in the various tracts to wheats of one or two grades and to replace the existing crop by these grades. Such wheats should be suitable for the export trade and also for local consumption and it will be necessary to operate with a very small number of wheats which would fall into two grades at the most.

In the wheat growing areas of the northern portion of the Central Provinces progress has been made by Mr. Evans in improving the grade of soft white pissi wheat which has been for some years a feature of this tract. The improvement consists in extending the cultivation of selected white pissi and keeping it free from red and other impurities. The work is directed from the Powarkhera farm near Hoshangabad which supplies forty private seed farms in the Northern Circle. These seed farms are grouped round some important market and the growth, threshing and storage of the wheat is supervised by the Agricultural Department. One essential condition for each private seed farm is the provision of a separate threshing floor for this wheat. The Government has the first refusal of any seed not required by the grower and it is proposed to re-stock all the seed farms every fourth year from Powarkhera. In this way it is expected that a grade of improved white wheat, practically free from admixture, will be established in this tract to the benefit both of the cultivator and the trade.

A beginning has been made in the distribution of the strong wheats of high yielding power produced at Pusa. These were tried last year on a large number of estates in Bihar and about 1,500 acres were grown. The results were so satisfactory that seed farms, 500 acres in extent, under the supervision of the Imperial Economic Botanist have been started on three estates. The seed is being grown by the Planters concerned under directions from Pusa and the farms will be re-stocked from

time to time from Pusa. As soon as sufficient seed is available for the market a grade of superior strong white wheat will be offered to the trade. In the various Provinces where Pusa wheats have been tried with success the distribution of seed will naturally be in the hands of the Provincial officers concerned. Thus in the United Provinces Mr. Leake is growing large quantities of seed at Cawnpore and Aligarh and in the Central Provinces Mr. Clouston is developing the work from Tharsa and Raipur. The investigations at Pusa will be confined to the production of new kinds and to the growth of sufficient seed for re-stocking periodically the various seed farms in Bihar and other Provinces.

Besides wheat and cotton a considerable amount of seed of some of the other cultivated crops of India has been distributed from the various Government farms, but the quantity has not been beyond the means of these farms and in no case has it been necessary to establish special seed farms as in the case of cotton and wheat.

II. INVESTIGATIONS.

Sugarcane. The present position of the Indian sugar industry has been the subject of considerable discussion during the year. The steady increase in the yearly imports of foreign white sugar into India, combined with its low price, has resulted in the decline of the area under cane and in the decrease of the number of sugar mills and refineries in the most important sugar tracts of India. In the quinquennial period ending 1889, the import of foreign white sugar was 79,638 tons while at present it is over 700,000 tons per annum. Attention was called to the subject at the meeting of the Imperial Legislative Council in Calcutta in March 1911, and at the recent Agricultural Conference held at Allahabad. In consequence, the present position of the Indian sugarcane industry and the means by which it can be improved were exhaustively discussed, at the instance of the Government of India, at the recent meeting of the Board of Agriculture in India, and a detailed programme of future work was prepared.

From the botanical point of view the main recommendation of the Board of Agriculture related to the establishment of an acclimatisation and cane-breeding station in Madras which it was suggested, should be placed under an Imperial officer. This proposal was subsequently adopted by the Government of India and sanctioned by the Secretary of State and a large grant for the purpose has been placed at the disposal of the Government of Madras under whose direction the station has been placed. It is proposed to found the sugarcane breeding station at Coim-

batore, and, although final orders have not as yet been issued, a certain amount of preparatory work has been accomplished by Dr. Barber. About 90 kinds of cane have been collected for comparison and these have been somewhat exhaustively studied. The attempt to raise seedling canes in India has been renewed and the reasons for former failures in this respect have been investigated. It has now been discovered that these failures are almost entirely due to the fact that most of the indigenous canes, as far as examined, do not form fully developed stamens, the rest of the flower being apparently normal. One native cane and two introduced ones have, however, been thus far found to contain a number of open anthers in the flowers and, acting upon this clue, a considerable number of cane seedlings have been already produced. It is anticipated that there will be no further difficulty in this matter, once the sugar station is sanctioned. As might have been anticipated, these seedlings vary considerably among themselves even when of the same parentage, and the next step in the enquiry will be the far more difficult work of selection and the discovery of criteria by which unprofitable forms may be eliminated before too much time is spent upon their study. A more detailed description of the work thus far done has been prepared for the *Agricultural Journal of India*. The lines on which it is proposed to conduct the station are as follows:—

(1) The collection of all canes growing in India, their comparison and classification, (2) a study and comparison of the cane-growing tracts of India, with special reference to climatic conditions and agricultural practices, (3) such study of the anatomy and physiology of the sugarcane plant as circumstances may demand, (4) the introduction of as many canes from other countries as possible, with special reference to the requirements of Northern India, (5) the raising of cane seedlings and the selection of such as appear to be of value in the same tract, (6) the study of the flowers, growth and life-history of the wild Saccharums of India.

Progress continues to be made in Madras in the successful introduction of new canes. In the South Arcot District the Red Mauritius variety continues to make rapid progress. Here, as in the Godavari delta, the local canes have disappeared, no less than 96·2 per cent. of the area under cane in South Arcot last year being Red Mauritius. The Director of Agriculture of Madras writes: "From experience gained in South Arcot it may now be stated confidently that, with the superior canes now available, and good cultivation and management, India can produce

refined sugar at a price capable of competing with Java sugar. Large areas of suitable land with an ample supply of subsoil water being available, we may expect to see South Arcot become the leading centre of the sugar-industry in Southern India." As an example of the spread of Red Mauritius cane among the Madras cultivators the following figures showing the progress in the vicinity of Nellikuppam speak for themselves:—

				Acres.
1907	(Red Mauritius canes from Melrosapuram)			...
1908	Do.	do.	do.	145
1909	Do.	do.	do.	409
1910	Do.	do.	do.	876
1911	Do.	do.	do.	2,250

In the United Provinces the *Saretha* variety (a thin cane), which has done best at Aligarh, is being distributed to the cultivators and around the same centre some of the thick Mauritius canes are replacing the local varieties of thick cane grown for chewing purposes.

In selecting new canes for tracts like the alluvium of the Indo-Gangetic plain, where the monsoon is followed by cold weather of considerable intensity, the recent work of Mr. Somers Taylor at Sabour is of great interest and value. This observer, in a recent paper published in the *Agricultural Journal of India*, has drawn attention to the consequences of the great difference in growth conditions between tropical islands like the West Indies and Java and sub-tropical regions like the plains of India. In the former, both growth and ripening are practically continuous and there is, as it were, no hurry for the canes to ripen. In tracts like Bihar however the cold season cuts short growth and in many cases interferes with the ripening process. What is wanted under such conditions are canes which can ripen properly in the available growth period and for this rapidly maturing varieties are essential. These investigations also show the need of chemical control in variety trials of canes in India and the discovery of some easy method of determining when the canes are at their best.

At Sabour, Mr. Woodhouse has made some interesting observations on the flowering of the sugarcane. While many varieties flowered in 1911, in only one case were the anthers observed to dehisce and even here no seedlings were observed.

Wheat. Progress continues to be made in wheat investigations in India and during the year several papers have been written which are now in course of publication.

In the United Provinces, Mr. Leake has summed up the results of his experiments with this crop at Cawnpore in a paper now in the press. At this station it has been found that under canal irrigation high grain quality is easily produced provided the preliminary cultivation is thorough and care is taken in the regulation of the water supply. Further, crops of as much as 2,500 lbs. to the acre have been grown with much less water than is used by the cultivators. These results are of the greatest value as they show that high quality in wheat is possible in the alluvium with canal irrigation and that a considerable saving of canal water can be made in the growth of this crop.

An important stage has been reached in the experiments on the influence of environment on the quality of wheat and the results, which include the crop of 1911, have been submitted for publication. In these experiments wheats of widely different quality, including strong free milling wheats, have been grown at many stations in the plains and also on the black soils of Peninsular India. The circumstances under which the wheats have been grown have differed widely and the range of conditions have been as great as would occur if the same wheat were grown by the best and the worst cultivators. It has been found that the weak wheats have always remained weak but their milling and baking qualities have been improved to some extent by cultivation. Strong wheats with good milling qualities have, on the other hand, been found to retain their strength and free milling nature both under canal irrigation in the alluvium and also as a dry crop on the black soils of Peninsular India. Even when grown after rice the same year and with inadequate cultivation the strongest of the wheats grown always showed its superiority in the milling and baking tests. These results are important in the improvement of the wheat crop in India as they indicate vast scope for progress in the future even after the highest possible yield has been realised. Where the limit of yield has been reached there will still remain the question of quality. These experiments also throw light on the relations between yield and quality in wheat. It was found in the case of any particular wheat that the conditions which produce the highest yield are those which also produce the best quality. Further in the same wheat high yield and high quality can be combined. A cultivator therefore, who wishes to obtain the greatest financial return for his labour, should grow to perfection a wheat which combines high yield and good grain qualities. When this is accomplished Indian wheats will be second to none in the markets of the world. During the investigations of the relation between yield and quality two adverse factors in wheat production in the alluvium were investigated—water-

logging during the monsoon and late cultivation. Both influenced the yield and to some extent the quality. Waterlogging for a month only reduced the yield about fifty per cent. while late cultivation was responsible for a diminution of about one-third the total crop. Another interesting fact arose out of these experiments, namely, the change of consistency in the same wheat when grown in different places and under different conditions. In general the consistency of the wheats grown varied greatly with environment. A few hard wheats however showed a tendency to remain hard while several soft wheats always remained soft and never hardened. It is possible that these constant soft wheats are always characterised by poor milling qualities, a point which is now being investigated.

In the wheat breeding experiments at Pusa, an account of which is now being published, several interesting results have been obtained. The wheats employed in this work, which was stated in 1906, have been throughout pure line cultures, that is to say, the parents were originally grown from a single ear. In this way only is there any prospect of obtaining results of permanent value in hybridization work. In addition the number of plants used in the second generation has often been over one thousand in number. The results confirm and extend those obtained at Svalöf and show that such apparently simple characters as colour of grain, presence of awns, felted chaff and resistance to rust are often exceedingly complex and involve the existence of several factors. The number of these inheritable factors in wheat is considerable and this fact explains the very large numbers of different types met with in cultivation. In breeding new forms it is essential that the gametic constitution of the parents should be known and the number of factors determined. Indeed the subject is so complex and the number of plants necessary is so large that it is desirable to restrict all hybridization work in the Agricultural Department to a few centres in India where the requisite facilities and supervision can be provided. It is doubtful whether any useful results will ever be obtained unless these conditions are fulfilled.

During the past year the wheats produced at Pusa and the methods of cultivation for this crop worked out at this station have been tried at many centres in India. The detailed results of this work have already been brought to the notice of the Government of India in the writer's last annual report so they need not be repeated here. It is sufficient to state that the results obtained in Bihar, the United Provinces, the Punjab and the Central Provinces have been most satisfactory and that the demand for seed which arose from these trials could not be met.

Fruit. Considerable attention is now being paid to the improvement of Indian fruit—an important matter in a country like India with such a large vegetarian population. In Bombay, Mr. Burns has devoted a considerable amount of attention to various questions relating to fruit growing at Ganeshkhind near Poona and also at Bassein in the Konkan. The methods of pollination of the mango are being investigated and it appears that the flowers set under bag without the intervention of insects. In the case of the papaya the work done so far indicates that parthenogenesis occurs in this crop. Several other questions relating to fruit are being taken up which promise to yield interesting results.

At Saharanpur, Mr. Hartless has devoted attention to several questions relating to the mango crop. The well thrown deleterious effect of damp and rainy weather at flowering time on the setting of the fruit is said to be due to the influence of humidity on the pollen. Hence early and late flowering kinds should always be grown so as to increase the chances of successful pollination. In connection with the work on polyembryony in mangoes, observations on this subject have also been made at Saharanpur. So far as the observations go the Indian grafted mangoes show no polyembryony although this condition has been found in seedlings.

In the Punjab, Mr. Milne has devoted attention to the culture of dates which is being started by the Provincial Agricultural Department from Multan and Muzaffargarh as centres. A detailed paper giving information on the cultivation and the conditions requisite for success has been issued.

At Quetta, a new fruit experiment station, 25 acres in extent, has been started during the year and considerable progress has been made in laying this out and in providing buildings and an artesian water supply. During this preliminary work attention has been paid to the best methods of packing fruit for long journeys under Indian conditions. Returnable packages have been found impracticable for long distances on account of the cost of the return journey and of the frequent overcharges made by the Railway Company. Loss by thefts in transit are common, but it should be possible to put an end to these practices if the staff concerned with these packages are made jointly responsible. Cheap light non-returnable packages have been found most useful and a large number of these were put on the market at Quetta during the present summer. Over one thousand peach boxes have been sold, many of which have been purchased by the Indian dealers. A bulletin is in preparation on this subject as it is felt that great improvements in the transport of

fruit are immediately possible in India without waiting for cold storage vans.

Cotton. Attention is being paid to the inheritance of flower colour in cotton at the Dharwar and Surat farms in the Bombay Presidency. An account of this work is to be found in the recent reports issued from these stations. At Cawnpore, Mr. Leake has continued his important investigations into the inheritance of characters in cotton and considerable progress has been made in the isolation of new kinds. A detailed account of these researches was given in the last report. Recently another paper has been published at this centre dealing with the characters and classification of the cottons obtained from Persia and Eastern Asia. A beginning has also been made in cotton breeding work at Coimbatore and the Madras Government proposes to appoint an Assistant Economic Botanist who will be employed, to a large extent, with the improvement of this crop.

Miscellaneous. Messrs. Finlow and Burkill have published an account of their investigations on the inheritance of the red colour in the common jute plant, *Corchorus capsularis* L., and state that self-fertilization is the rule in this species in India. Under the most favourable conditions for crossing the amount is said not to exceed two per cent., while in ordinary circumstances it may be much less and may not exceed 0·2 per cent. It seems probable that the colour factors in jute are not simple, as the authors suppose, but complex and the published figures point to the existence of two red factors at least. At Coimbatore, Dr. Barber has paid some attention to the types of *Hibiscus cannabinus* and the fibre of the various varieties has been compared. An account of the last year's working of the flax experiment at Dooriah in Bihar has been published by Mr. Vanderkerkhove in Pusa Bulletin No. 30. A profit of Rs. 63 per acre was obtained, but in spite of this satisfactory result planters are not inclined to take up the growth and manufacture of the fibre. Mr. Coventry, in an introduction to this paper, states that the disinclination of the planters to embark in this industry "seems chiefly due to the large amount of expert knowledge and capital required on the industrial side which are not easily commanded by the grower and there is, therefore, a difficulty in combining the two undertakings." In future, the growth of the flax and the factory aspects will be kept separate. Dr. Barber has published an interesting account of the sensitive plant (*Mimosa pudica*) in Coorg, where it is regarded as a dangerous weed. The methods of eradication are discussed and an account of various experiments for destroying the weed, including spraying with sodium arsenite, are given. A new coffee experiment station for the

investigations are already in progress. An account of the Italian millet (*Setaria italica*) in Bengal, in which the pollination mechanism and the occurrence of natural crossing have been worked out, has been published by Mr. Woodhouse and Babu A. C. Ghosh.

PART II.—FOREST BOTANY.

BY

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Œcology of sal.—This work was continued on the lines indicated in last report, publication having been deferred in order to include the results of observations made in the Dehra Dun sál forests by the Botanist during the year and the soil analyses and water determinations carried out by the Forest Chemist in connection therewith. The results will shortly be sent to press, but it may be mentioned that the work done shows that sál seedlings die when the moisture-content of the soil in contact with their roots falls below 1 per cent. and 9 per cent. respectively in sand and heavy loam. It was pointed out in a previous report that the species of grass dominant in a particular locality is frequently an accurate indicator of the prevailing conditions of soil and moisture, and that where *Saccharum Munja* is dominant the locality is suitable for dry-miscellaneous-forest species, whereas the dominance of *Saccharum Narenga* indicates soil and moisture conditions suitable to sál. In connection with this it is interesting to note that a series of soil samples selected during the year in local grass-lands of these two species in June, (*i.e.*, in the critical period before the break of the rains), showed a moisture content at the depth of 1′ 6″ (which is the average depth reached by the roots of sál seedlings in their first year) of 0·8 to 1·6 per cent. in the case of the former species and 16 to 19 per cent. in case of the latter. This clearly indicates the *primâ facie* unsuitability of grasslands of *S. Munja* for the growth of sál. The work done up to date will be shortly published and an extended series of experiments has been arranged for the further study of soil-moisture and light and the effect of these factors on the healthy development of sál.

Forest Grasses.—The study of Forest Grasses has been continued on the following lines:—

(1) The publication of descriptions and illustrations of the species likely to be most valuable, on account of their known

economic value, on account of their dominance over large areas, or because they occur constantly in admixture with valuable species and are likely to be confused with them. The first object of such publication is to focus attention on the more valuable species and to facilitate their identification.

(2) The determination of the best treatment to apply to forest grasslands with the object of realising, on the one hand, the best economic return from the grasses and, on the other hand, of facilitating the afforestation, with valuable trees, of those grasslands not required for the production of grass.

(3) The determination, in collaboration with other specialists, of the economic value of the species dealt with for fodder, paper-pulp and other purposes.

During the year descriptions and illustrations of the following species were published:—*Saccharum spontaneum* Linn., *S. Munja* Roxb., *S. Narenga* Wall., *Erianthus Ravennæ* Beauv., *Imperata arundinacea* Cyrill., *Triraphis madagascariensis* Hook. f., *Aristida cyanantha* Steud., *Andropogon monticola* Schult. The principal taxonomic and œcological results included in this publication have been briefly noted in the reports of previous years. The study of the following species on similar lines to the above was commenced during the year:—*Anthistiria gigantea* Cav., *Eragrostis cynosuroides* Beauv., *Phragmites Karka* Trin., *Arundo Donax* Linn., *Ischæmum angustifolium* Hack. and *Vetiveria zizanioides* Stapf.

Development of culms.—The importance of studying the life-history and development of the various species is shown by the fact that in some of the larger species which are likely to be most valuable for paper-pulp, *e.g.*, *Saccharum Munja* Roxb., the culms, instead of being annual, require 2 years for their full development and consequently such species must be worked on a rotation and not cut annually, if a full and regular yield is required. In addition to this, the liability of a species to damage, *e.g.*, by fire, depends on the period required for the development of the culms and on the condition of growth at the season when fires usually occur. It is obviously of importance, therefore, to discover a method by which the period required for development can be readily ascertained by an inspection of the culm and it has been found that there is a definite relation between the number of nodes and leaves produced by the culm and the number of months constituting its period of growth,

although this varies in different species. During the year a detailed study in this connection was made of the development of the culms of wheat (*Triticum sativum*) which is a convenient type of an annual grass and the results will be published next year. Notes also on this point have been given regarding the species mentioned above, of which descriptions have been published during the year and it is hoped that a generalisation on this point will soon be possible, covering (1) annuals, (2) perennials with annual culms with one period of growth, (3) perennials with annual culms with two periods of growth and (4) perennials with biennial culms. It may be noted incidentally that this point is not only of importance in the management of grasslands, but has a direct bearing on the question of selecting suitable types of an agricultural cereal, such as wheat, for cultivation in tracts with a particular climate and length of growing season.

Distribution of species and possible yield.—From an economic point of view it is essential to obtain accurate information regarding the distribution of the chief dominant forest grasses and of the approximate area occupied by them, seeing that, apart from other important points, the yield and possibility of establishing an industry, *e.g.*, for the manufacture of paper-pulp, depends on this. With the object of facilitating the collection of such information the Botanist has identified a number of grasses, which have been sent in by local forest officers, amounting to 150 specimens during the year. A direct result of this work is that local officers in the United Provinces are now preparing maps showing, in each Division, the approximate area occupied by the chief dominant grasses. The map for the Ramnagar Division has already been received and it is hoped that others will shortly follow and that this work will be taken up also in other Provinces. The information supplied by these maps will obviously be of the greatest value in such questions as the determination of the best sites for paper-pulp factories, or for extensive fodder operations, in addition to indicating the chief types of grassland which require separate study by the Botanist.

Value for paper-pulp.—With the object of determining the value of the chief dominant species in North India for paper-pulp, specimens of 22 carefully identified species were submitted to Mr. Raitt during the year for analysis. Those species were especially selected which promised to be of most value on account of their occurring dominant over large areas or constantly in mixture with other valuable species. Mr. Raitt was unfortunately unable to do more

than make a preliminary examination of this material based on simple tests. This examination, however, indicated that 14 of the species, including the very common and widespread *Kans* (*Saccharum spontaneum*), were likely to yield a high-grade pulp and to be of considerable value for the manufacture of high-class paper. Towards the close of the year, however, Mr. Raitt was again able to take up this work and it was then decided to prepare a detailed analysis and report dealing with 10 principal species and a less detailed report regarding 8 subsidiary species. Special attention is being paid to the point as to whether the value of the former is likely to be greatly diminished by an admixture of the latter, the principal and subsidiary species often growing together in nature. It is hoped that this work will be complete by October next.

Burmese Kaing grass.—An interesting point taken up during the year was the identification of the so-called Burmese *Kaing* grass. Specimens sent under this name had been previously examined by Mr. Raitt, who reported that it would form an excellent material for the manufacture of paper-pulp and its correct identification was therefore of importance. Through the kindness of Mr. J. H. Lace, Chief Conservator of Forests, Burma, numerous specimens of *Kaing* were sent to the Forest Botanist during the year which proved that at least 15 species, belonging to the genera *Saccharum*, *Andropogon*, *Anthistiria*, *Arundo*, *Phragmites*, *Rottbœllia*, *Coix*, *Triraphis*, *Thysanolæna* and *Polytoca*, passed under the name of *Kaing*. It is therefore clear that this is merely a general term given in Burma to all large grasses growing in savannahs and swamps, a descriptive epithet often being attached, such as *Paung Kaing*, *Sit Kaing* and so on.

Value for Fodder.—Various experts in India, Europe and America were addressed during the year as to the possibility of devising a system of analysis which could be trusted to indicate the relative fodder-value of our forest grasses. Unfortunately no such method is at present known and the only satisfactory procedure appears to consist in feeding experiments which it is hoped may perhaps be arranged for in co-operation with Pusa.

Miscellaneous Notes.—Miscellaneous notes of interest in connection with the grass specimens sent in by Forest Officers to the Botanist during the year are:—

(*a*) The discovery of *Erianthus elephantinus* Hook. f. by Mr. P. H. Clutterbuck in the Haldwani Division, United Provinces. This species has hitherto only been known with certainty from Assam.

(*b*) The discovery of an *Arundinella* (vern. *tadhodia*) by Mr. T. Carr, Divisional Forest Officer, Haldwani, which, although allied to the ordinary Indian form of *A. brasiliensis* Raddi (vern. *phurkia*), differs from it considerably and is possibly a distinct species. Further specimens have been asked for with the object of cultivating the grass at Dehra.

(*c*) Aromatic specimens of *Andropogon intermedius* Br. sent by Mr. J. Whitehead, Divisional Forest Officer, Gorakhpur, United Provinces, showed that there is practically no character to separate this species from *A. odoratus* Lisboa, except only that glume I of the latter is pubescent. It is probable that the latter is merely a variety of the former.

(*d*) The discovery of *Cymbopogon Schœnanthus* Spreng. in Goalpara, Assam, by Mr. Atulananda Dass, Extra Assistant Conservator of Forests. This species has hitherto not been reported east of the Punjab.

(*e*) The discovery by Mr. Witt, Deputy Conservator of Forests, Central Provinces, of an *Iseilema* allied to *I. laxum* Hack. but possibly distinct. The grass has been sown at Dehra and will be described in detail if it proves sufficiently distinct.

Systematic work. Xylia.—Through the kindness of local forest officers, a number of specimens of *Xylia* were received during the year from Burma and India. A preliminary examination of this material revealed the remarkable fact that, whereas all the specimens from Burma (Katha, Pyinmana, Toungoo, Zigon, Henzada and Ataran Divisions) showed no glands upon the anthers, all the specimens from India (from North Thana and North Kanara in Bombay, from South Malabar in Madras and from Balaghat and Bhandara in the Central Provinces showed a large and perfectly distinct stipitate gland on the anthers. It appears probable, therefore, that the Indian tree will have to be distinguished as *Xylia xylocarpa* Roxb. while the Burmese pyinkado will stand as *Xylia dolabriformis* Benth. Further study, however, is necessary to settle this and other points. A paper detailing the results obtained to date and indicating what specimens are still required for the adequate description of the Indian and Burmese forms of this genus was contributed to the *Indian Forester* at the close of the year.

Grewia.—The study of this genus was continued but, not being of first-class importance, had frequently to give way to more important work during the year. It is hoped, however, that publication will be

completed next year. There is probably only one other known genus (*viz.*, *Eucalyptus*) in which similar complications are met with on account of the occurrence of adventitious shoots and in *Grewia* the complications are increased by the fact that such twigs commonly bear, not only leaves, but also flowers and fruit which often differ widely from those of normal twigs. Consequently it is impossible to work on sound lines unless it is known whether the material dealt with is adventitious or not. The patient collection and study of suitable material in this case, therefore, requires much time and unusual labour.

Identification and local forest floras.—The collection of material for the study of the genera *Saccharum Cinnamomum* and *Anogeissus* was continued as far as possible. Seeds of the various forms of Babul, *Acacia arabica*, were obtained and sown at Dehra for the purpose of testing their constancy. Owing to the fact that local forest officers are frequently ignorant of the names of the species which occur in their forests, it is at present very difficult, or impossible, to obtain accurate information regarding the distribution of species of economic importance or to calculate the yield available in different localities of the economic products yielded by them. The creation and extension of industries depending on these products is consequently delayed and hampered. The preparation of local Floras and Lists which would enable any one of average ability to quickly identify the important species found in his forests is therefore a work of considerable economic importance. Owing to the necessity of encouraging this work and to the fact that the Botanical Library and Herbarium at Dehra Dun have now become fairly efficient, it was decided during the year that the Botanist ought to undertake the identification of specimens for Forest Officers, as a part of his regular duties. Owing to the fact that the Botanist has no Assistant and is obliged to do this work himself, it is clear that it can be carried out only on a small scale at present, as otherwise the progress of research work would be seriously hampered. During the year under report, however, the Botanist identified 246 specimens, whereas in previous years the total number of specimens identified has not exceeded 50.

New species.—Incidentally this work has resulted in the discovery of a new species of *Albizzia* from the Tinnevelly district of Madras. This was found by Mr. H. A. Latham, Deputy Conservator of Forests, and a full description of the same under the name of *Albizzia Lathamii* was sent to press during the year. A *Terminalia* new to Burma has been received from Tavoy, a description of which will shortly be published,

and a *Litsæa* from the Tista Division of Bengal which will also probably prove to be new.

Exotics.—A considerable amount of time and money has been spent in the past by Forest Officers in India on the cultivation of exotics. In order to realise the maximum benefit from the work which has been done, it is proposed to systematically collect and publish all the information available regarding those exotics which distinctly promise to be of forest importance in India, with notes on the conditions under which they have been found to thrive and their economic uses. A paper on this subject dealing with *Prosopis juliflora* DC. was sent to press during the year. Future publications will deal with *Eucalyptus* species and others. It is also hoped that, in future, it will be possible to arrange for more precise information, than has usually been available in the past, regarding valuable exotics and the conditions most likely to suit them, from foreign correspondents to whom seeds of our indigenous species are supplied.

Tree diseases. Spike-disease of Sandal. Trametes Pini.—Arrangements were made at the close of the year for the collection of all the available literature and information regarding the spike-disease of Sandal, the study of which will be commenced by the Botanist in Coorg next year. The results of the preliminary investigation regarding the attack of *Trametes Pini* on *Pinus excelsa* in the Punjab will it is hoped be issued early next year.

6. In addition to the specimens noticed in the above report many were collected as usual by local officers and sent to the Imperial Mycologist, Pusa, Calcutta Botanical Gardens, Reporter on Economic Products to Government of India, and others. The formation of a local forest herbarium was commenced by the Chief Conservator of Forests, Burma, during the year and collections for the local forest herbarium, Sind Circle, were continued. Mr. A. Rodger continued his work on the preparation of a list of species for the Ruby Mines Division. Mr. D. O. Witt published his illustrated list of the grasses of the Berar Circle, Mr. W. A. Talbot published the second volume of his *Forest Flora of Bombay* and Mr. Rama Rao an account of the host plants of the Sandal tree. Further details are given under the Botanical Survey and Mycology sections of the report.

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CHAUDHURI, N. C. . Commercial rices of Bengal. (*Bengal Quarterly Jour., v, 194, 1912.*)

CLOUSTON, D. . . Cotton seed distribution. (*The Agr. and Co-operative Gazette, viii, 1912.*)

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FINLOW, R. S., & BURKILL, I. H. Note on the inheritance of red colour and the regularity of self-fertilization in *Corchorus capsularis*, Linn., the common jute plant. [*Mem. of the Dept. of Agr. of India (Bot. Series), iv, No. 4, 1912.*]

GRAHAM, R. J. D. . A note on the uses of *Cleistanthus collinus* in the Nagpur Division of the Central Provinces. (*Agr. Jour. of India, vi, 424, 1911.*)

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BOTANY.

III.—MYCOLOGY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

I.—Plant Pathology.

The work of the Mycological Section at Pusa, which was completed during the year, includes investigations on sugarcane diseases, *Rhizoctonia* and *Phytophthora Colocasiæ*.

The chief diseases of sugarcane investigated were red-rot and an undescribed disease caused by a species of *Cephalosporium*, which presents many points of resemblance to red-rot and is frequently confused with it. The actual channels by which the parasites gain entrance to the cane have been determined by a large series of inoculation experiments. It is hoped that the result of the work, an account of which is being prepared for publication, will be to improve the methods by which serious injury from these diseases may be prevented.

Mr. Shaw, Supernumerary Mycologist, has in the press an account of his researches during the past two years into the morphology and parasitism of *Rhizoctonia*, a soil-dwelling parasite with a wide range of victims. Jute, cotton, ground-nut, cowpea, potato and sesame are amongst the plants attacked. Two species are distinguished, *R. Solani* Kühn, of which the perfect fruiting stage is not yet certainly known, and a species with larger sclerotia, of which the fruiting stage is the Basidiomycete, *Corticium vagum* B. & C. For the last, the old name *R. violacea* Tul., ordinarily used to cover both forms, is proposed to be retained. The beginnings of the formation of specialised races on individual hosts can be observed in *R. Solani*, as the race on jute cannot infect cotton, ground-nut or cowpea, while the forms on these last three hosts can pass freely from one to another. No cereal crop has, so far, proved susceptible to the attacks of these parasites and in a proper attention to rotation probably lies the best means of lessening their ravages.

A disease of the country vegetable, *Colocasia antiquorum*, caused by *Phytophthora Colocasiæ* Rac., has been under study by the writer for some time past. The fungus was obtained in pure culture last year and this has permitted of rapid completion of the investigation, the

results of which will be published shortly. The disease resembles in many respects the well-known potato blight caused by *Phytophthora infestans*, especially in persisting from year to year in the tubers and in only forming a true sexual stage in artificial culture. A second species of *Phytophthora*, on castor, is being studied by Mr. J. F. Dastur, First Assistant, and these two researches have added considerably to our knowledge of the genus.

Mr. Burns has published the concluding account of his three years' experiments in the treatment of grape-vine mildew (*Oidium*) in the Bombay Presidency. The results are considered to demonstrate conclusively the usefulness of the treatment. The spray used was Bordeaux mixture of the 6-4-50 formula (6 lbs. copper sulphate, 4 lbs. freshly burnt quicklime and 50 gallons water) to which was added soft soap at the rate of 5 lbs. The latter was intended to make the spray effective against insects and to increase its adhesiveness. Five sprayings are recommended, one about the middle of May, a second about the middle of August, a third about the middle of October, a fourth about the beginning of December and a fifth about the beginning of January. The last two should be at half strength of the mixture. The result of the treatment has been to reduce the number of attacked bunches from 100 to 21 per cent. and of attacked fruits per bunch from 22 to 1 per cent. The cost is estimated as Rs. 22 initial (cost of sprayer, etc.) and about Rs. 40 per acre annual (cost of materials).

Mr. Anstead has published a detailed account of the work done in Southern India in checking "pink" disease of Hevea rubber, caused by *Corticium salmonicolor* B. & Br. He recommends cutting out the affected parts, where the disease has already appeared, and painting the trees with Bordeaux mixture in May or June as a preventive. The formula recommended is 4-4-45 and resin is added to aid the mixture to stick to the trees. The cost is about a pie per tree or not more than Rs. 2 per acre. The results have been very encouraging and experiments are being continued to perfect the methods.

The writer described two diseases of wild vines, one of which is also known to attack the cultivated species. Neither of these diseases occurs in Europe, where, if introduced, they might become serious pests. Both are caused by rust fungi of unusual types.

Mr. Ajrekar has submitted for publication a note on the rust of Castor (*Melampsorella Ricini*). This fungus is known only in the uredo stage. None of the varieties of castor ordinarily grown in Bombay is

immune. The disease is severe in the southern part of the Presidency only.

Mr. G. S. Kulkarni has given a preliminary account of the red-rot of sugarcane in Bombay, in a paper in which the characters of the disease are described, the methods of treatment indicated and a number of interesting field observations recorded. He has also, in conjunction with Mr. Ajrekar, commenced experiments with a view to checking the *Koleroga* of betelnut in North Kanara, where it is responsible for damage estimated at nine lakhs of rupees annually. Further work on the prevention of the same disease, in continuation of that reported last year, was carried out by Dr. Coleman, who issued a vernacular leaflet on the subject.

II.—Systematic Mycology.

Two parts of the descriptive list of Indian fungi, which is being issued by Messrs. H. & P. Sydow in conjunction with the writer, were published during the year. These included the *Ascomycetes* and *Exobasidiaceæ* of the Pusa Herbarium, together with additions to the lists of *Phycomycetes*, rusts and smuts previously published. The total number of additional species recorded was 316, distributed in 108 genera, of which 1 genus and 115 species were new to science. A large proportion of the remainder consisted of species new for the Indian flora. Of the new species the majority (72) were *Ascomycetes*, a group which has received little attention in India, 26 were rusts, 11 smuts, 2 *Phycomycetes* and 4 *Exobasidia*.

The writer described a remarkable aquatic fungus found at Pusa and Poona, assigning to it a position in the family *Leptomitaceæ*. It is an aberrant member of the family, inasmuch as it has a completely segmented thallus. Reasons are given for considering the *Leptomitaceæ* to be a more primitive group than is usually admitted, and for holding them to be derived, through forms resembling *Monoblepharis*, from the *Siphoneæ* amongst the green Algæ.

Mr. Ajrekar has worked out the life-history of *Cystopsora Oleæ* Butl. This rust consists of æcidial and teleuto stages only, the uredo being omitted. The whole life-cycle is passed on the one host, *Olea dioica*.

Mr. Kulkarni has discovered the conidial stage of the *Sclerospora* which is parasitic on jowar and considers that it presents sufficient differences from this stage of *Sclerospora graminicola* to warrant its separation as a distinct species.

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BOTANY.

IV.—AGRICULTURAL BACTERIOLOGY.

BY

C. M. HUTCHINSON, B.A.,

Imperial Agricultural Bacteriologist.

Soil Bacteriology.—The work of the Bacteriological Section at Pusa during the year has been mainly directed towards ascertaining what factors determine biologic activity in Indian soils, and to the measurement of the changes resulting therefrom under various conditions. The main problem so far dealt with has been the supply of available nitrogen as provided by the biolysis of such substances as green manures, root residues, and organic manures. No work has been done upon nitrogen assimilation by Legume bacteria or such organisms as Azotobacter, Clostridium, or Rhizobium.

The method of determining the biologic activity of a soil by plate counts has been abandoned in favour of methods depending upon measurement of the physiological activity of the soil organisms. By the use of such methods biological analyses of soils may be carried out which will provide indications as to their relative capabilities for dealing successfully with organic manures. Far more valuable information, however, is also obtained by such analyses. By the use of fairly large portions of soil, it is perfectly feasible to set up and maintain conditions of moisture and æration comparable with those in the field, and to determine in the laboratory for any particular soil under what conditions of water supply, tillage, and addition of lime or manures either natural or artificial the greatest amount of ammonification and nitrification will result.

It has been ascertained by numerous experiments that the rate of formation of carbon dioxide in a soil is directly proportional to the biologic activity of that soil, and that conditions unfavourable to the latter will also adversely influence the former. A simple method of measuring the rate of formation of carbon dioxide in soils under various conditions has been devised and by this means it is possible to determine what moisture content of any particular soil is the optimum for bacterial activity; this has been found to vary from as high as 37 per cent. in one case to as low as 16 per cent. in another. By the same method, the effect of the addition of various manures, organic or mineral, may be observed, and it

has been found possible in this way to prescribe the addition of certain substances, such as lime or superphosphate, to a soil in order to promote the decomposition of green manures, oil cake, or cattle manure buried in it. Similarly by determining the optimum moisture content, recommendations can be made as to variations in field practice which would tend to dry out the soil in one case or to conserve moisture in another; a very large number of observations have been made as to the conditions under which ammonification and nitrification take place in Indian soils. It has been found that important differences exist between the biological changes taking place in the latter and those which have been observed in the soils of Europe; these differences appear to be due to the high average temperatures of Indian soils and their consequently high relative rate of bacterial action. In soil at temperatures between 15° C. and 18° C. the process of ammonification, which is the natural and necessary predecessor of nitrification, takes place at such a rate as to allow the latter to proceed *pari passu;* in many Indian soils, however, it has been found that at the higher temperatures, 25° C. to 30° C. which obtain in them for many months in the year, ammonification may proceed with such rapidity as to produce a concentration of ammonia in the soil water sufficiently high to interfere with nitrification or even to inhibit it altogether. Where large quantities of nitrogenous organic matter are turned into the soil and put under intensive cultivation much nitrogen may be lost in the form of ammonia, and experiments have shewn that biolysis of organic nitrogenous material requires very careful investigation from this point of view.

In particular, it has been found that temperature plays an important part in deciding whether ammonification will proceed at such a rate as to allow of concurrent nitrification; thus organic nitrogenous matter in soil at a temperature of 20—22° C. may be completely nitrified, whereas at 28—30° C. large quantities of nitrogen are lost as ammonia. It is evident that this fact must be taken into account in selecting the time of year for applying organic manures, along with other considerations depending on local meteorological conditions and the optimum moisture content of the soil.

Further experiments have demonstrated another source of loss of nitrate nitrogen. It has been shewn that where intense bacterial action is taking place in soil any nitrates present may be reduced without the occurrence of anærobic conditions; it appears probable that the nitrate is utilized as a source of nitrogen by the bacteria. It was found, for instance, that in Pusa soil the optimum moisture content for nitrification

is 16 per cent., whereas general bacterial action is intense up to 25 per cent. and at the latter figure rapid reversion of nitrate to the proteid form takes place. This would help to explain observations made in field practice both at Pusa and in the Punjab, that excess of soil moisture produces nitrogen starvation of the wheat crop; the importance of biological analysis of irrigated soils by such methods will readily be realized.

A special enquiry has been carried on and is still proceeding, to determine the conditions under which bacterio-toxins are formed in soils and their effect in inhibiting bacterial action. The work of Greig Smith of N. S. Wales on this subject has demonstrated its importance, and experiments at Pusa have fully confirmed his views. Mr. Meggitt, Agricultural Chemist, Eastern Bengal and Assam, has carried out a series of investigations on similar lines, but the enquiry is not sufficiently complete for detailed report.

An investigation as to bacterial action in rice soils was carried out at Coimbatore by the Agricultural Chemist to the Government of Madras. It was found that in puddled soil the anærobic conditions prevailing prevented the formation of nitrate, confirming the conclusions of previous workers that the rice plant obtains its nitrogen in the form of ammonia; further experiments in the field showed that for the same reason the use of nitrate of soda or of potash as a paddy manure, resulted in loss of nitrogen by denitrification.

Plant Pathology.—A bacterial disease of tobacco at Rangpur was investigated and found to be due to an infection of *B. Solanacearum*. The strain isolated was found to be also pathogenic to *Solanum Melongena*, Tomato, *Datura*, and Potato. The incidence of the disease at Rangpur and Burirhat was not apparently associated with any insect attack or specially unfavourable soil conditions, and was not heavy enough to cause apprehension as to future spread. The parasitism of the causative organism as isolated from diseased plants in the field was found to be insufficiently strong to attack healthy plants, although by passage through several individuals or by artificial culture on Potato it could be raised to a high degree of virulence. For this reason the practice of leaving the plants in the ground for a second cutting should be avoided in infected areas.

B. Solanacearum was also found attacking potatoes by Coleman in Mysore.

A bacterial disease of wheat in the Punjab locally known as "Tannan" or "Tandu" was investigated; this was found to be due

to the attack of a bacillus closely resembling *Ps. Hyacinthi* which invests the opening ear with a sticky growth causing deformation and stunting and preventing ripening of the grain. The attack is confined to small badly drained areas and can probably be avoided by proper cultivation; its distribution is limited and it is probably of no economic importance.

Disease of Eri Silkworms.—A disease of eri worms resembling "flacherie" was found to be associated with the presence of bacteria in the intestine. Investigation showed that the immediate cause of disease was improper dieting leading to indigestion; this was aggravated by a thickening of the peritrophic membrane due to invasion of the latter by bacteria, and resulting in impairment of digestion by suppression of secretion of the digestive fluids.

Experimental infection with cultures of bacteria isolated from the intestine did not produce results sufficiently conclusive to warrant the assumption that these bacteria were an immediate cause of the disease. Enquiries made in various districts in Assam where the disease is well known, confirmed the conclusion that improper diet is its immediate cause.

List of Publications.

HUTCHINSON, C. M. . Studies in Soil Bacteriology. No. 1. (*Mem. Dept. of Agriculture in India, Bacteriological Series, No. 1, 1911-12.*)

" " Rangpur Tobacco Disease. (*Mem. Dept. of Agriculture in India, Bacteriological Series, No. 2.*)

" " A Disease of Eri Silk Worms. (*Mem. Dept. of Agriculture in India, Bacteriological Series, No. 3.*)

" " A Bacterial Disease of Wheat in the Punjab. (*Journ. of Agricultural Science, Vol. V.*)

FORESTRY.

I.—SYLVICULTURE.

BY

R. S. TROUP, F.C.H.,

Sylviculturist.

Statistical work in typical forest crops.—Good progress was made during the year in the collection of statistics by measurements in sample-plots laid out in typical forest crops in the United Provinces, 53 permanently demarcated plots and 43 temporary plots having been laid out and measured. The principal species dealt with were *Shorea robusta, Cedrus Deodara, Pinus excelsa, Pinus longifolia, Quercus incana, Quercus dilatata* and *Quercus semecarpifolia*. The objects of these measurements are the ultimate compilation of yield-tables giving the average rate of development of forest crops, of different types and qualities, in girth, height and volume, and the determination of the frequency and intensity of thinnings which will produce the maximum volume increment per acre per annum. The want of such statistics has rendered it impossible hitherto to ascertain the most profitable rotations on which to work forest crops of different kinds in India: without some accurate forecast of the kind there is no alternative but to go by guess work, a proceeding which may involve heavy financial loss. The value of accurate statistical work is well recognised in European forestry, the result being the highest possible return on the forest capital and a maximum net annual yield per acre. Although the general application in India of all the scientific methods known to economic forestry in Europe is at present out of the question, there are nevertheless many types of forest where these principles could be applied, and the extension of statistical work, with this end in view, is greatly to be desired. This work is, so far as present conditions admit, now almost completed in the United Provinces, and it is proposed to extend it to other Provinces during the coming season.

The sal tree (Shorea robusta).—The sylviculture of the *sál* tree continues to be the subject of special investigation, and various experimental plots in the forest, dealing with the natural reproduction of the tree, are under observation. Some preliminary tests were carried out throughout the principal *sál* tracts of India with a view to ascertaining to what extent the fertility of *sál* seed is influenced by the size, condition and environment of the seedbearers. The results tend to show that neither the size of the trees, nor their degree of soundness,

nor the locality, soil, aspect, and type of forest in which they grow, have any appreciable effect on the fertility of the seed produced by them.

Financial results of plantations.—Ever since its initiation the Forest Department has been engaged in planting operations in various parts of India. Some of these plantations have been formed after due consideration, and with the idea of yielding good financial returns: on the other hand there can be no doubt that much loss has been incurred through haphazard planting operations without sufficiently accurate financial forecasts. There are now sufficient *data* available, with respect to many of the more important plantations of India, for affording means of gauging their financial success or otherwise, and ascertaining the factors contributing towards success or failure. With the co-operation of the Divisional Forest Officers concerned a commencement has been made with this important work, a large number of measurements having been carried out in the Eucalyptus plantations of the Nilgris and in the teak plantations of South Malabar: the statistics collected are under compilation, and will be published when complete.

Teak forests of Burma.—An examination of the statistics contained in all existing working-plans for the natural teak forests of Burma has been made, and the results were published during the year. In the 6,105 square miles of teak-bearing forests dealt with it is a striking fact that the three forests richest in teak trees 3 feet in girth and over are on flat alluvial land, the richest of all being the Mohnyin Reserve in the Katha Division, containing 707 such trees per 100 acres. There are five forests with over 400, and nine with from 300 to 400 such trees per 100 acres. In no case does the average percentage of teak trees 3 feet in girth and over in teak-bearing forests exceed 33 for whole reserves, while in some cases it falls as low as 6; in the Mohnyin Reserve the percentage is probably higher than 33, though the absence of enumerations of species other than teak makes it impossible to substantiate this. In individual sample-plots the enumerations naturally show far greater richness: the plot richest in large sized teak trees, one of 52 acres situated in the Taungnyo Reserve of the Zigôn Division, contained at the time of enumeration no fewer than 689 trees 7 feet in girth and over per 100 acres, while in a plot 20·4 acres in extent in the Mohnyin Reserve 5,560 teak trees 3 feet in girth and over were enumerated.

The beneficial effects of concentrated working on the natural regeneration of teak are strikingly exhibited by the enumerations in the Pegu Yoma forests of the Pyinmana Division, Upper Burma. These forests

were heavily overworked before the British occupation, and the percentage of large trees is small; aided, however, by the openings made in the overwood, the constant breaking down of bamboos by working elephants and the wounding of the soil during extraction, natural regeneration of teak has sprung up in great profusion, the figures showing that in the eight reserves in question in no case does the crop of young trees under 3 feet in girth average less than 768 plants per 100 acres, a result attained in only two other reserves in Burma.

In true teak-bearing forest of the recognised types the average rate of growth is found to be fastest in alluvial forest of the "lower mixed" type and slowest in dry "upper mixed" forest, an average tree 7 feet in girth varying in age from 110 to 190 years. The fastest and slowest rates of growth recorded for individual trees are ages of 42 years and 357 years for trees 7 feet in girth, representing mean annual girth increments of 2·00 and ·240 inches respectively. The average age of a 7 feet tree throughout the whole of Burma is 155 years: here the mean annual girth increment declines steadily from ·621 inches at an age of 58 years, representing a girth of 3 feet to ·542 inches at an age of 155 years. The actual rotations fixed in working-plans vary from 120 to 200 years, after allowance has been made for the time taken for a seedling to establish itself. So far as the results of actual felling operations under the working-plans are concerned, it is found that only in the richest forests does the average yield of marketable teak trees, spread over a series of years, exceed 10 trees of 7 feet girth and over per square mile per annum (that is, per square mile of total teak-bearing forest, not of forest actually worked over). The highest average yield has been furnished by the Mohnyin forest, which has yielded 24 such trees per square mile per annum. The statistics given above exhibit the comparatively small proportion of teak in the natural forests of Burma, and point to the advisability of increasing that proportion as far as is sylviculturally possible and desirable. Measures likely to effect this object were indicated in the report on Sylviculture for 1909-10.

Developments in Sylvicultural Systems.

(a) Teak (Tectona grandis).—A decided advance in sylvicultural methods in Burma has been made by the application of a modification of the system of successive regeneration fellings to the Mohnyin working circle under Mr. H. R. Blanford's working-plan, issued during the year. This is the first time this system has been substituted for the selection system hitherto universally applied to the Burma teak forests. The forest in question is of somewhat abnormal type, consisting as it does to a great extent of almost pure stretches of large sized teak with

little or no regeneration. Experiments extending over several years have shown that regeneration can be induced in abundance by opening the canopy thoroughly and burning the undergrowth, the young crop resulting from these operations being assisted by repeated weedings. The exploitable girth is fixed at 8 feet, and the rotation corresponding is calculated to be 180 years; this rotation is divided into nine regeneration periods of 20 years each. The fellings will take the form of clear fellings over successive small areas until the whole periodic block has been regenerated: it thus differs from the group system and the usual system of successive regeneration fellings in that only one felling, and not a succession of fellings, will be carried out over any given patch dealt with.

(b) Deodar (Cedrus Deodara).—Forest Officers in the Punjab have for some time past been confronted with the fact that the selection system has by no means proved a satisfactory one for the working of deodar forests, since this species, from its habit of regenerating freely, and in masses, only if the overwood is drastically opened out, is better adapted for regeneration under the group system than under the selection system. The application of the group system to deodar forests was the subject of discussion at a recent Forest Conference at Lahore: as a result of the discussion it was resolved to await the experience derived from carrying out the prescriptions of recently framed working-plans dealing with that system, before deciding on further details regarding its application.

Mr. C. G. Trevor's working-plan for the Upper Ravi Forests, Chamba State, prescribes the working of deodar under the group system: the rotation is fixed at 140 years, divided into five regeneration periods of 28 years each. The number of successive fellings has been provisionally fixed at four for the period, the interval between them being 7 years.

(c) Blue pine (Pinus excelsa).—The same working-plan prescribes the working of blue pine under the group system; the rotation is fixed at 100 years, divided into four regeneration periods of 25 years each. Three successive fellings are considered sufficient to effect regeneration.

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CHANNER, F. F. R.	. Working-plan for the Terai and Bhabar Government Estates Protected Forests, United Provinces.
HOPWOOD, S. F.	. Working-plan for the Ahlaw Working Circle, Upper Chindwin Division, Upper Burma.
MAITLAND-KIRWAN, J. D.	The Coppicing Powers of *Babul* (*Acacia arabica*). (*Ind. For., xxxvii, 430.*)
OSMASTON, A. E.	. Experiments on Coppicing *Sál* in the Gorakhpur Forest Division, Eastern Circle, United Provinces. (*Ind. For., xxxvii, 434.*)
STEVENS, E. R.	. The Uniform System for *Sál* Forest. (*Ind. For., xxxvii, 605.*)
TRAFFORD, F.	. Working-plan for the Forests of the Sundarbans Division, Bengal.
TREVOR, C. G.	. Working-plan for the Upper Ravi Forests, Chamba State, Punjab.
TROUP, R. S.	. A Manual of Forest Mensuration.
,, ,,	. A Note on some Statistical and other Information regarding the Teak Forests of Burma. (*Ind. For. Rec., iii, Pt. I.*)
,, ,,	. A Glossary of Technical Terms for Use in Indian Forestry—*revised edition.* (*For. Bull., No. 4, 1911.*)
,, ,,	. A Note on some Germination Tests with *Sál* Seed (*Shorea robusta*). (*For. Bull., No. 8, 1912.*)
,, ,,	. The Calculation of the Yield by Number of Trees under the Selection System. (*Ind. For., xxxviii, 75.*)
,, ,,	. Working-plan for the Thano Forest, Siwalik Division, United Provinces.

FORESTRY.

II.—ECONOMIC FOREST PRODUCTS.

BY

R. S. PEARSON, F.L.S.,

Forest Economist.

1. **Technical properties of *sal* timber.**—Specimens of hill and plains-grown *sál*, of seedling and coppice origin, obtained from the United and Central Provinces were sent to Sibpur to be tested. The results obtained so far are not conclusive, so that further specimens are being sent in order to obtain definite results as to the transverse strength and resistance to crushing and shearing of the various varieties of *sál* timber.

Sál logs of the above-mentioned varieties were laid down to season under different conditions, and the percentage of moisture in the timber was recorded. They will be inspected from year to year until completely seasoned. At the time when these experiments were commenced, and before the logs were laid down to season, specimens were cut from them to determine the specific gravity of the timber when green and after it had seasoned, and also with which to carry out splitting tests. The splitting tests with green timber were carried out during the year, those on dry timber will be carried out when the timber is thoroughly seasoned.

2. **Outturn, uses, durability and prices of *sal* timber.**—Figures of outturn of *sál* from Government and Private forests were collected during the year and also data as to the average annual number of *sál* sleepers purchased by the various railway systems of India. The Public Works Department officials and others furnished most detailed information on the uses and durability of *sál* timber when used in the open, under cover, in water and when buried in the ground, while the Railway officials furnished details as to the durability of *sál* sleepers, and their resistance to the cutting action of the rail and as to the tendency of the spike to shake loose. Information has also been collected regarding the past and present prices of *sál* timber and sleepers.

3. **Minor products obtained from the *sal* tree.**—The necessary information for a complete Note on the Minor Products obtained from *Shorea robusta* was collected, such as outturn and prices of *sál*

damar, the bark in connection with tanning, and the use of the fibre and leaves.

4. **The match industry.**—The Economist visited several districts in Oudh and after carrying out enumerations, reported on the available supply of suitable timber for match making. The amount available was found to be sufficient to work one or more match factories. Samples of timber from the Sunderbans and Madras were sent to an expert to be tested, and in several instances were found to be most suitable for match-making.

5. **Bamboo paper-pulp.**—This enquiry, which has been in progress for nearly three years, is now practically completed. Many bamboo areas have been inspected on the West Coast in Bombay and Madras, in Burma and Arakan. During the year a further area was inspected by the Economist in Cachar, large quantities of bamboo of different species have been converted into pulp on a commercial scale, and it has been found possible to make a good quality of paper within a working limit of cost.

6. **Antiseptic treatment of woods.**—(*i*) The experimental powellized sleepers, numbering 2,929 in all, have been handed over to the North-Western, Oudh and Rohilkhand and the Eastern Bengal State Railways, and laid down on the lines in order to note their behaviour. The above number of sleepers was made up of 860 *Terminalia tomentosa*, 435 *Dipterocarpus tuberculatus*, 121 *Dipterocarpus alatus*, 704 *Pinus excelsa* and 809 *Pinus longifolia*.

(*ii*) Another experiment has been carried out by treating 2,000 sleepers of the above-mentioned species with *Avenarius Carbolineum* oil. The two species of pine sleepers which were treated by the Economist have been handed over to the North-Western Railway, those treated in Bombay and Burma will be handed over to the Railway authorities in the near future.

(*iii*) An experiment to treat a third set of sleepers by a mixed impregnation method is now in hand.

7. **Tea-boxes.**—The Economist toured in several districts of Assam in order to ascertain the difficulties under which the tea-box industry is carried on in that province. The chief difficulties are the want of accessible timber and the liability of the timber to the attack of insects. Experiments to protect the timber were carried out during the year.

8. **Gums and resins.**—Experiments were carried out to ascertain the best method of tapping *Boswellia serrata*, with indifferent results. It was thought that the hot weather was not a suitable season in which

to carry out tapping operations, so that it is proposed to carry out further experiments during the cold weather of 1912-13.

Many enquiries were received from Europe on the Burmese wood-oil of *Melanorrhœa usitata* and information collected as to the local uses and method of preparing the varnish in Burma.

9. **Miscellaneous uses of woods.**—Samples have been supplied to, and experimented with, by makers of matches, pencils, tool-handles, weaving looms, cement barrels, wood veneers, musical instruments, packing cases, etc., while specimens of canes were sent to a firm and found suitable for cricket-bat handles.

10. **Tan barks.**—Figures of outturn and cost f. o. r. of seven species of tan barks were collected from the various provinces. After ascertaining that one or more of these barks are available in large quantities and at reasonable rates, it is proposed to prepare fair-sized samples of tan extracts for valuation.

11. **Economic and wood museums.**—A large number of specimens were collected for both museums, especially wood specimens. A complete collection of teak specimens from all parts of India and Burma was commenced, the number collected so far being 79. It has not been found possible to arrange the fine collection of timber and minor products received from the Allahabad Exhibition, all that it is possible to do is to house the specimens until the new Research buildings have been erected.

12. **Botanical and other specimens.**—A number of botanical and other forest product specimens were supplied by the Forest Department to various Government Departments, private persons, firms and institutions in India, England, Germany and Australia.

List of Publications.

BATEMAN, E. . . A visual method for determining the penetration of inorganic salts in treated wood. (*U. S. Dept. of Agr. Cir. No. 190.*)

BOND, FRANCIS M. . Progress Report on wood-paving experiments in Minneapolis. (*U. S. Dept. of Agr. Cir. No. 194.*)

BRAND, C. J. . . Crop Plants for Paper-making. (*U. S. Dept. of Agri. Cir. No. 82.*)

CLINE, MCGARNEY . Strength values for structural timbers. (*U. S. Dept. of Agri. Cir. No. 189.*)

PEARSON, R. S. . . Note on the Antiseptic Treatment of timber in India with special reference to railway sleepers. (*Ind. For. Rec., Vol. III, Part II.*)

PEARSON, R. S. . . Commercial Guide to the Forest Economic Products of India.

PURAN SINGH . . Note on the Preparation of Tannin Extracts. (*Ind. For. Rec., Vol. III, Part IV.*)

PURAN SINGH . . Method of distinguishing the powellized and the unpowellized wood. (*Ind. For., October 1911, p. 567.*)

PURAN SINGH . . *Podophyllum Emodi.* (*Ind. For., April 1912, p. 156.*)

RAITT, W. . . Report on the Investigation of Bamboo as Material for Production of Paper-pulp. (*Ind. For. Rec., Vol. III, Part III.*)

TEESDALE, C. H. . Volatilization of various fractions of Creosote after their injection into wood. (*U. S. Dept. of Agr. Cir. No. 188.*)

VINCENT, HARRY . Bamboo-pulp as the paper material of the future. (*Ind. For., November 1911, p. 627.*)

WOOLSEY, THEODORE S. Turpentining in Florida on an American National Forest. (*Ind. For., June 1912, p. 280.*)

ZOOLOGY.

I.—ZOOLOGICAL SURVEY.

BY

STANLEY KEMP, B.A.,

Officiating Superintendent, Indian Museum.

As explained in the introduction to last year's report, this brief account of the zoological research undertaken during the year is drawn up with special reference to that carried out in the Indian Museum, though, with the exception of that of Departments which themselves submit reports to the Board, other work which has a direct bearing on the Fauna of the Indian Empire is not neglected.

Field work.—Most of the field work effected during the year has been carried out on the lines indicated in last year's report. The survey of the fresh-water fauna of the Indian Empire has been continued and results of considerable value have been obtained; it was in work of this nature that Dr. Annandale interested himself during a month's leave in Ceylon in October 1911.

Dr. Annandale in company with Mr. F. H. Gravely visited Purulia in February and Puri and Cuttack in March; on each occasion extensive collections were made and the latter tour resulted in the discovery of *Caridinicola*, a new and very curious flat-worm of the order *Temnocephaloidea*, living on fresh-water shrimps of the family *Atyidæ*. In April, Mr. F. H. Gravely in company with Mr. S. P. Agharkar, Lecturer on Biology in the Elphinstone College, Bombay, spent three weeks in the Western Ghats and Konkan. This tour, which was undertaken with the object of again finding the fresh-water Medusa, *Limnocnida*, first discovered by Mr. Agharkar during the previous year, proved eminently successful: the Medusa was found in considerable numbers and valuable observations were made on its habits. Mr. B. L. Chaudhuri paid two visits to Chota Nagpur, chiefly with the object of obtaining specimens of fresh-water Chelonia and information regarding them. Considerable collections were made in this and in other groups.

In November 1911, Mr. S. W. Kemp left on deputation to accompany the Abor Expeditionary Force as Zoologist and Anthropologist, taking with him Mr. Hodgart, Museum Collector, as his assistant. About four months were spent in the Abor country and extensive collections were

made during this period. The most interesting animal obtained is *Peripatus*, a primitive arthropod which was not hitherto known to exist within the limits of the Indian Empire. The zoological results of this expedition are being published in a separate volume of the "Records of the Indian Museum" and it is believed that among them material will be found which will add very considerably to our knowledge of the inter-relationships of the faunas of the various regions of N. E. India.

On previous military expeditions where any biological work, other than of a private character, has been accomplished, it has been effected by a "Surgeon-Naturalist." This is the first time that a separate officer has been deputed for the purpose and it is hoped that the results obtained will be held to justify the deputation of an officer of the Museum on any similar occasion that may arise.

In November and December 1911, Mr. F. H. Gravely visited Tennasserim passing across the Amherst district to the Burmo-Siamese frontier. This tour was principally undertaken in order to obtain information regarding certain *Arachnida* and *Coleoptera* of this little known region: in this respect the results proved most successful and large collections in other groups were also made. The results of this expedition will, wherever possible, be incorporated with those obtained in the Abor country. The existence of a strong Burmese element in the latter region cannot be doubted and additional information regarding the fauna of Tennasserim will certainly have great interest from a comparative point of view.

It is unfortunate that Captain R. B. Seymour Sewell, I.M.S., Surgeon-Naturalist to the Marine Survey, was recalled to Calcutta two months after the survey season had commenced. During the period when he was on board the 'Investigator' he was employed in continuing his observations on the floating fauna and his introduction of a tow-net of exceptionally large size for obtaining extensive samples of plankton from any depth has produced results of a most satisfactory nature. There can be little doubt, however, that if funds were available for the purpose, the provision of some of the specially designed apparatus now used in this type of research in home waters would render the work still more efficient. No officer was appointed to act for Captain Sewell during the remaining five months of the survey season, but seven trawls were made in deep water producing results of considerable interest.

Mr. C. A. Paiva, late Entomological Assistant in the Museum, spent several months in the Almora district, where he made collections of

insects. The loss of this officer's services is seriously felt in the Entomological sub-section.

As in previous years we are under considerable obligation to a number of private collectors, thanks to whose energy a large number of specimens have been acquired for the Museum. His Excellency Lord Carmichael, Governor of Bengal, is taking great interest in the work of the Zoological Section and arrangements have been made for the sorting and, as far as possible, the identification in the Museum of the large collections which he is making in the Darjiling district. It is already evident that his offer to present specimens of any species not hitherto represented in the Museum is a most valuable one.

Laboratory work.—During the past four months of the year under review the greater part of the time of the officers belonging to the Zoological Section has been spent in the transference of the reserve collections and library to their new quarters. This work, though laborious, has not been entirely unproductive for it has been found possible in the course of the transference to give more space for the accommodation of the collections and to rearrange the majority of them according to a uniform scheme and thus facilitate in a very great degree their accessibility to students engaged in research. The increase in laboratory accommodation has proved a great benefit, but it is already evident that this increase is none too great for our requirements. At the moment the four spare laboratories which are available are occupied by the Professor of Biology at the Medical College, the Deputy Director of Fisheries, Bengal, the Surgeon-Naturalist to the Marine Survey and by Major A. C. MacGilchrist, I.M.S., officer on special duty in connection with the *Stegomyia* Survey, Port of Calcutta.

A considerable amount of work has already been done in the determination of the collections from the Abor country and it is satisfactory to be able to record that quite a substantial number of groups are being dealt with by specialists in India. As far as work within the Museum is concerned, Dr. Annandale completed exhaustive reports on the *Reptilia* and *Batrachia* prior to going on leave and Mr. Gravely, who has finished his account of the *Scolopendridæ*, is now undertaking the examination of certain other groups with which he is acquainted. The identification of the fish, which has been entrusted to Mr. Chaudhuri, is far advanced, and Mr. E. Brunetti has completed a lengthy report on the *Diptera*. Mr. Kemp's paper on the *Crustacea Decapoda* is almost ready for the press. Mr. E. A. Andrews has determined a considerable part of the large collection of *Hemiptera*, and Mr. C. A. Paiva has identified the *Anthophila*.

Several important papers dealing with the fresh-water fauna of the Indian Empire have been published during the year while others are in course of preparation. Dr. Annandale has completed two papers on the aquatic *Chelonia* and has described the fresh-water *Medusa* from the Western Ghats. Mr. Chaudhuri has continued his studies of Indian fresh-water fish; he has published a paper on the species of sting-rays inhabiting the middle and upper Ganges, their range and breeding habits, and has finished an account of new species of fish from Northern India. Mr. Kemp has published a few short papers on fresh-water Crustacea and done some preliminary work on the Indian fresh-water shrimps of the families *Palæmonidæ* and *Atyidæ*. Of other papers which have appeared during the year or are in preparation special interest attaches to the series which Dr. Annandale has named Fauna Symbiotica Indica, which deals with the taxonomy and more particularly the bionomics of Indian animals found living together in a manner which implies something more than fortuitous occurrence, and to his notes on the fauna of the Parésnath Hills. Mr. Kemp's memoir on the group *Stomatopoda* is now in the press and that by Mr. Gravely on the *Passalid Coleoptera* is almost completed. Mr. Gravely is continuing his work on the Indian *Pedipalpi*.

Captain R. B. Seymour Sewell, who in December was appointed Acting Professor of Biology in the Medical College, has continued his studies on *Copepoda* and a report which, in addition to the taxonomy of the group, comprises some most interesting observations on growth stages and development is now in the press. In collaboration with Mr. B. L. Chaudhuri, Captain Sewell has published a semi-popular brochure on certain fresh-water fish which eat mosquito-larvæ. The importance of this subject from the point of view of public health need not be emphasized.

Mr. E. Brunetti, continuing his fruitful work on *Diptera*, has now completed his volume in the "Fauna of India" series on the *Nemocera* other than *Culicidæ*, *Chironomidæ* and *Cecidomyidæ*. Among the papers which he has recently published special reference must be made to his Revision of Oriental Tipulidæ and to his Supplement to the Catalogue of Oriental Mosquitoes. The descriptions of hitherto unknown species which he has completed during the year under review (both published and in manuscript) amount to over 400.

Captain T. L. Bomford, I.M.S., Acting Surgeon-Naturalist to the Marine Survey, has been occupied since his arrival in Calcutta in the identification of part of the collections recently made by the R.I.M.S. "Investigator."

Mr. T. Southwell, Deputy Director of Fisheries, who is now engaged in reorganising the fishery departments of Bengal and of Bihar and Orissa is in occupation of one of the Museum laboratories. Such time as he is able to spare from administrative duties has been devoted to an enquiry into Cestode parasites with special reference to those of fish. It is hoped that arrangements to publish his more purely scientific papers in the "Records of the Indian Museum" will shortly be completed.

Bombay Natural History Society.—The publications of the Bombay Natural History Society have maintained their high standard. The survey of the mammals of India which was inaugurated last year has been prosecuted with vigour as may be seen by reference to the various papers on the subject which have recently been published. It is to be hoped that funds for the continuance of this useful work will be forthcoming. Among the papers of a more popular nature which have appeared in the Society's Journal special reference must be made to Mr. E. C. Stuart Baker's monograph of the game birds of India, Burma and Ceylon and Major F. Wall's treatise on the common Indian snakes. These memoirs are serial in form and both are well illustrated by coloured plates. Work of a more purely scientific nature is not neglected. Important papers such as those of Mr. Rowland E. Turner on Wasps, Mr. E. Meyrick on *Micro-Lepidoptera* and of Sir George Hampson on *Heterocera* will go far to confirm the scientific reputation of the Society at home. As in previous years the Journal abounds in biological notes of great interest.

Other work.—As regards other work which has been accomplished during the year, attention may be drawn to the descriptions of new Cestodes by Mr. J. Hornell of the Government Fishery Bureau, Madras, to the two papers on *Oligochæta* by Major J. Stephenson, I.M.S., Professor of Biology in the Government College, Lahore, and to Captain W. S. Patton's researches on the development of *Herpetomonas donovani* in two species of *Cimex*.

Work done in Europe and America.—During the year Dr. W. W. Fowler's volume in the Fauna of India series has appeared. It comprises a general introduction to the *Coleoptera* and descriptions of the Indian *Cicindelidæ*, *Paussidæ*, *Rhysodidæ* and *Cupedidæ*. The introduction occupies about half the book and, including as it does synoptic tables and a detailed account of all the families of beetles which are known to occur in India, is certain to prove most useful to those engaged on the study of Coleoptera in this country.

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Among other works reference to Colonel Alcock's 'Entomology for Medical Officers' must not be omitted. The book deals primarily—and always in the most lucid manner—with those Arthropoda that are known to influence public health. There can be no doubt that it will admirably fulfil the purpose for which it was written, while even the specialist in entomology will find in it much information that he will value.

In the Indian Museum publications the long memoir on Crinoids by Mr. Austen H. Clark is now ready and Prof. Bezzi's monograph of the Dipterous family *Trypetidæ* is approaching completion. Miss Ricardo has published two important papers on *Tabanidæ* and mention may also be made of Prof. Camerano's paper on Gordiid worms and of Mr. Preston's Catalogue of the Naiades in the Indian Museum collection. The latter is a preliminary work undertaken prior to the completion of an account of the fresh-water Mollusca for publication in the "Fauna of India" series.

List of Publications with special reference to Indian Zoology, prepared by B. L. Chaudhuri.

GENERAL.

ANNANDALE, N. . . Notes on the Fauna of Parésnath Hill, Western Bengal. (*Rec. Ind. Mus., vii, 33.*)

,, ,, . . Fauna Symbiotica Indica. (*Ibid., vii, 123, 147 and 243.*)

ANNANDALE, N., & KEMP, S. Observations on the Invertebrate Fauna of the Kumaon Lakes, with special reference to the Sponges and Polyzoa. (*Ibid., vii, 129.*)

HARTLEY, C. . . An exploration of the Beligal-ge, near Balangoda. (*Spolia Zeylan., vii, 197.*)

HICKS, F. C. . Forty years among the Wild Animals of India.

JENKINS, J. T. . . Observations on the shallow water fauna of the Bay of Bengal made on the Bengal Fisheries steam-trawler "Golden Crown," 1908-1909. (*Rec. Ind. Mus., vii, 51.*)

MANDERS, N. . . An investigation into the validity of Mullerian and other forms of Mimicry with special reference to the Islands of Bourbon, Mauritius

and Ceylon. (*Proc. Zoo. Soc., Lond., 1911, 696.*)

PEARSON, J. . Biological Survey of Trincomalee Harbour. (*Spolia Zeylan., viii, 30.*)

,, ,, . The growth of Marine Organisms in Colombo Harbour. (*Ibid., viii, 68.*)

STEBBING, E. P. . Game Sanctuaries and Game Protection in India. (*Proc. Zoo. Soc., Lond., 1912, 23.*)

PROTOZOA.

ANNANDALE, N. . Occurrence of *Trichodina pediculus* on the manubrium of *Limnocnida indica*. (*Rec. Ind. Mus., vii, 256.*)

PATTON, W. S. . The development of *Herpetomonas donovani* in *Cimex rotundatus* and in *Cimex lectularius*. (*Sc. Mem., Med. and Sanit. Depts., Govt. Ind.*)

PORIFERA (SPONGES).

ANNANDALE, N. . Notes on Freshwater Sponges. (*Rec. Ind. Mus., vii, 99.*)

,, ,, . Systematic and Geographical Notes on the Sponges of Kumaon Lakes. (*Ibid., vii, 137.*)

,, ,, . Freshwater Sponges and Polyzoa. (*Spolia Zeylan., viii, 133.*)

CŒLENTERATES.

ANNANDALE, N. . Preliminary Description of a Freshwater Medusa from the Bombay Presidency. (*Rec. Ind. Mus., vii, 253.*)

,, ,, . Note on a Freshwater Medusa from the Western Ghats. (*Journ. Asiat. Soc., Beng., vii, cxiii.*)

ECHINODERMATA.

CLARK, A. H. . On a small collection of recent Crinoids from the Indian Ocean. (*Rec. Ind. Mus., vii, 267.*)

VERMES.

ANNANDALE, N. . . Caridinicola, a new type of Temnocephaloidea. (*Rec. Ind. Mus., vii, 243.*)

,, ,, . . A Leech parasitic on the Hard-shelled Pond Tortoise of Ceylon. (*Spolia Zeylan., viii, 134.*)

CAMERANO, L. . . Gordiens du Musée Indien. (*Rec. Ind. Mus., vii, 215.*)

HORNELL, J. . . New Cestodes from Indian Fishes. (*Rec. Ind. Mus., vii, 197.*)

KHAN, M. . . Notes on the rearing of leeches in Mawai, Bara Banki District, United Provinces. (*Rec. Ind. Mus., vii, 206.*)

LLOYD, R. E. . Some disputed points in the anatomy of a common Indian earthworm. (*Journ. Bomb. Nat. Hist. Soc., xxi, 289.*)

POWELL, A. . . Note on above paper. (*Journ. Bomb. Nat. Hist. Soc., xxi, 291.*)

SOUTHWELL, T. . A description of ten new species of Cestodes Parasites from Marine Fishes of Ceylon, with Notes on seven other species from the same region. (*Ceylon Marine Biol. Repts., i, 259.*)

STEPHENS, J. W. . The Liver-Fluke of the Indian Pariah Dog. (*Ann. Trop. Med. and Parasit., Ser. T. M., vi, No. 1, B., 117.*)

STEPHENSON, J. . On a new species of *Branchiodrilus* and certain other aquatic Oligochæta, with remarks on cephalization in the Naididæ. (*Rec. Ind. Mus., vii, 219.*)

,, ,, . . Earthworms of Yunnan based on collections made by J. Coggin Brown. (*Rec. Ind. Mus., vii, 273.*)

CRUSTACEA.

HENDERSON, J. R. . Description of a new species of freshwater crab from Southern India. (*Rec. Ind. Mus., vii, 111.*)

KEMP, S., & SEWELL, R. B. S. — Notes on Decapoda in the Indian Museum with special reference to the species obtained by the R.I.M.S. "Investigator" during 1910-1911. (*Ibid., vii, 15.*)

KEMP, S. — Notes on Decapoda in the Indian Museum. (*Ibid., vii, 113.*)

" " — *Apus* from the United Provinces. (*Journ. Asiat. Soc., Beng., vii, cxi.*)

PEARSON, J. — Notes on the Alpheidæ. (*Spolia Zeylan., vii, 169.*)

WALTON, H. J., & KEMP, S. — Notes on the occurrence of *Apus* in Eastern Asia. (*Rec. Ind. Mus., vii, 310.*)

ARACHNIDA.

GRAVELY, F. H. — Mimicry of a Mutillid by a spider. (*Rec. Ind. Mus., vii, 87.*)

" " — Notes on Pedipalpi in the collection of the Indian Museum. (*Ibid., vii, 110.*)

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ZOOLOGY.

II.—ECONOMIC ZOOLOGY.

Part I.—AGRICULTURAL ENTOMOLOGY.

BY

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Pusa Research Institute.—The study of the life-histories and habits of injurious and beneficial insects was continued at the Pusa Research Institute, the following species being specially studied:—

1. "Bherwa" (*Schizodactylus monstrosus*, Dr.).
2. Indigo Psylla (*Psylla isitis*, Buck.)
3. Fish Insect (*Lepisma* sp.).
4. White-ants (*Termes* spp.).
5. Grain and Flour Beetles (1. *Rhizopertha dominica*, Fabr.).
   (2. *Tribolium ferrugineum*, F. & T.).
   (3. *Lœmophlœus testaceus*, F.).
6. White Weevil (*Myllocerus maculosus*, Dasbr.).
7. Green Weevil (*Astycus lateralis*, Fabr.).
8. Cotton Stem Weevil (*Pempheres affinis*, Fst.).
9. Small Rice Grasshopper (*Oxya velox*, Fabr.).
10. Green Surface Grasshopper (*Atractomorpha crenulata*, Sss.).
11. White-banded Grasshopper (*Epacromia dorsalis*, Thunb.).
12. Mango Leafhopper (*Idiocerus*) 3 species.
13. *Ascalaphus* sp.
14. *Rhogas lefroyi*, Ashm. Ms.

Work on fruit flies was continued by the staff of the Imperial Pathological Entomologist.

In addition to the above some important field observations were made on the Sugarcane Fly (*Pyrilla lycoides*, Wlk.) and the Sugarcane Mealy Wing (*Aleurodes barodensis*, Mask.). Observations have also been recorded on pests occurring generally in India and a minute record kept of those occurring on the Pusa Farm.

At the request of the Bihar Planters' Association, an enquiry into the *Psylla* disease of indigo was taken up and is being continued. The experiments on the preservation of wood and other materials from the attacks of Termites (White-ants) are still in progress, and the efficacy of various preparations and the relative immunity of different kinds of wood is being tested. A new process was devised and proved effectual; it is the only wood treatment yet found wholly to resist White-ant attack. Some experiments with White-ants, which attack wheat and sugarcane crops, were also conducted. In conjunction with the Department of Agriculture, Bihar and Orissa, active part was taken in combating the "Surface Caterpillar" pest (*Agrotis ypsilon*, Roth.) which did enormous damage annually to "rabi" crops in the Mokameh Tal lands; and as a result of the remedial measures adopted the loss this year has been considerably reduced. The Andres-Maire system of trapping has been of great value in this campaign; it is still uncertain where this pest passes the monsoon period. Assistance was given to the Department of Agriculture, Punjab, in checking an outbreak of the Cotton Bollworm (*Earias insulana*, Boisd.) in that Province. It was anticipated that the cold winter of 1910-11 would be followed by a bollworm outbreak, and that parasites would be absent; the parasite was accordingly introduced and the measures adopted were attended with great success, the parasite, *Rhogas lefroyi*, Ashm. Ms., of the Cotton Bollworm being introduced, established and spread throughout the affected areas. Fuller information has been gained of this Cotton Bollworm and its parasites during the course of this campaign.

The experiments in crossing multivoltine and univoltine races of Mulberry Silkworms to secure a superior silk-producing multivoltine race have been continued; up to the present it has been impossible to produce a stable multivoltine race of worms, but progress has been made and the problem is narrowed down and more likely to be solved. Acclimatized univoltine races were successfully reared on pruned tree mulberry, wild mulberry and bush mulberry and arrangements have been made to distribute eggs of these univoltine races for rearing in

October. The cultivation of the eri silkworm was continued and experiments with crossing *Attacus ricini* and *A. cynthia* were performed with a view to obtain a hardy race of worms which will successfully stand the climatic conditions of Bihar. After repeated trials it has been found that the crosses are influenced in the same way as pure eri worms, and do not show any special advantage over the latter. It has been necessary to show the commercial possibilities of eri silk and a part of the energies of this Section is devoted to designing superior fabrics as models for those who have taken up the industry.

Experimental work in Lac-culture and the collection of the races of lac insects, in collaboration with the Forest Department, were continued. It is hoped that the material collected by Forest Officers will enable the problem of lac races to be solved.

Investigations into Apiculture have been continued. In November 1911 two colonies of American-Italian bees were imported and these have proved very successful; but so far all attempts to obtain fertilised queens for multiplying the colonies have failed, apparently on account of the activities of bee-eating birds which are common at Pusa. The yield per hive was high, but it has been impossible to get fertile queens, these being destroyed on the marriage flight; if queens can be imported this difficulty will be overcome. Trials have been made with the common Indian bee (*Apis indica*, F.) and success has been achieved in adapting the modern bar-frame hive to its requirements.

Provincial Departments.—In Madras experiments were continued for the control of the Deccan Grasshopper (*Colemania sphenarioides*, Bol.). Special attention has also been paid to the observations and rearing of the natural enemies of this grasshopper. Considerable damage having been caused to Cambodia cotton in the Coimbatore District by the attack of the Stem Weevil (*Pempheres affinis*, Fst.), a considerable amount of work has been done on its life-history with a view to control, but no satisfactory method of dealing with it has been found as yet. Some research work on Termites was carried out and in the course of this it was noted that the open-chambered termitaria found at Coimbatore regularly harbour numerous specimen of Sand-flies (*Phlebotomus minutus*) which probably breed in the débris collected in the galleries of the mound.

In Bombay experiments were carried out to devise best means of checking the ravages of two insect pests which considerably damage some valuable crops in Ahmedabad and Kaira Districts. These insects are (1) Katra (Hairy Caterpillars of which *Amsacta moorei*, Butl. is most prominent) and (2) the White-ants (*Termes* sp.).

In Baroda the campaign against "Katra" (*Amsacta* spp.) was continued.

From the Central Provinces the parasite *Rhogas lefroyi* was issued to the Punjab and Pusa. The cultivation of Eri Silkworms was experimentally tried and the work in connection with the mound-building Termites was continued at Hoshangabad.

In the North-West Frontier Province very successful spraying experiments against the Peach Aphis were conducted; and the efficacy of Maize as a trap crop for the Sugarcane Borer (*Chilo simplex*, Butl.) was tested.

In the Punjab vigorous measures were adopted to check an outbreak of the Cotton Bollworm (*Earias insulana*, Boisd.).

In the United Provinces methods of controlling the Potato Moth (*Phthorimæa operculella*, Zell.) were demonstrated, and also active measures were taken against *Hieroglyphus furcifer*, Serv., a serious pest of Sugarcane, in the Province. One Deputy Collector has been put on special duty at Shahjehanpur to work up the Eri Silk industry.

In Bihar and Orissa the campaign against the Surface Caterpillar pest (*Agrotis ypsilon*, Rott.) of the Mokameh Tal lands was continued and great success has been achieved in reducing the extent of damage done by the pest. Successful demonstrations of the methods of controlling the Potato Moth were given at the several Exhibitions and Shows which were held during the year under review, in the Province. Eri Silk cultivation was also taken up and some progress has also been recorded in this direction.

In Bengal several investigations were undertaken including "Ufra" disease of Rice, the Rice Ear-cutting Caterpillar (*Cirphis unipuncta*, How.) and the Mango Hairy Caterpillar (*Cricula trifenestrata*, Helf.).

In Burma, experiments to control the Peach Fly (*Dacus ferrugineus*, Var.) and to destroy the mound-building species of White-ants were conducted. The cultivation of Eri Silkworms was also experimentally taken up at Mandalay, without success.

In Mysore the Entomological staff of the Department of Agriculture was mainly occupied in the supervision of the extensive bagging operations against the Deccan Grasshopper (*Colemania sphenarioides*, Bol.) and the Rice Grasshopper (*Hieroglyphus furcifer*, Serv.) on both of which pests bulletins were issued. The investigations of the Kumblihula pest (*Amsacta albistriga*, Wlk.) have, with the end of this year, been

completed and the more important results have been embodied in a preliminary report issued in June this year. In the Insectary, work was mainly confined to various store pests and to experiments in devising remedies against them. The free living *Bruchid* and the Thogari Pod Fly have also been studied. Further rearing of *Opatrum depressum* has yielded very interesting results. Other insects of minor importance have been studied:—*Episomus lacerta*, *Orthacris acuticeps*, *Cryptophlebia carpophaga*.

Indian Tea Association.—The Entomologist to the Indian Tea Association investigated the question of damage done to Tea-chests by boring Beetles and the best means to prevent it. An enquiry into the injury to Tea seeds by the Tea Seed Bug (*Pœcilocoris latus*, Dall.) and the study of Mosquito Blight in the Duars were also taken up.

II.—ECONOMIC ZOOLOGY.

Part II.—FOREST ENTOMOLOGY.*

BY

A. D. IMMS, B.A., D.Sc., F.L.S.,
Forest Zoologist.

A.—Sanctioned Programme.

The sanctioned programme of research work consisted of the following items:—

(1) The study of all insects which cause serious damage to, or which are beneficial to the *sál* tree or its timber.

(2) Investigations regarding the lac insect.

(3) The preparation of a satisfactory reference collection of insects for the Research Institute.

(1) **Sal investigation.**—The writer toured in the *sál* forests of the Siwalik and Kheri Forest Divisions, United Provinces, during December 1911—March 1912.

* Mr. R. S. Hole officiated as Forest Zoologist from July to October 1911, after which period the present writer was appointed.

A good many insects likely to have economic importance have been collected and information relating thereto is being recorded in the research files. The longicorns *Æolesthes holosericea* and *Hoplocerambyx spinicornis* are the only widely distributed insects at present found to cause any lasting damage to the mature *sál*, and special attention is being devoted to the life-history of the first-mentioned species. From affected *sál* logs collected in the Siwalik forests during the cold weather of 1911-12 the mature beetles emerged in breeding cages in Dehra Dun from 13th April to 7th May 1912. Both *Hoplocerambyx spinicornis* and *Æolesthes holosericea* have been found to occur plentifully in the United Provinces and have been recently bred out in considerable numbers from one and the same tree.

Several dead *sál* trees containing larvæ of *Æolesthes holosericea* were felled at Thano, Siwalik Forest Division, United Provinces, and some parasitic Hymenoptera were bred out of these. The specimens were sent to Mr. P. Cameron, a leading authority, for identification, and have been identified by him as *Paroligosthenus trichiopthalmus*, gen. et sp. nov. Parasitic Hymenoptera collected from *sál* leaves at Kaluwalla, Siwalik Forest Division, have proved to belong to two new species of the genus *Iphiaulax* and have been described by Mr. Cameron as—

(1) *Iphiaulax sál*, sp. nov.

(2) *Iphiaulax Immsii*, sp. nov.

Their descriptions along with those of others bred out of lac, are being published as a Forest Record.

So far as at present ascertained, the *Monophlebus* scale and the *Pammene* moth larva are much more local pests. Specimens of the *Monophlebus* scale were received from the Pilibhit Forest Division of the United Provinces, and among them were discovered a large number of the larvæ of a species of Coccinellidæ (genus *Vedalia*), which, on their receipt, were found to have devoured a considerable proportion of the scale insects.

Some lepidopterous larvæ defoliating *sál* leaves were also received from the Pilibhit Forest Division. Three moths (family *Bombycidæ*) were bred out of these, and are at present awaiting identification.

Specimens of caterpillars and moths defoliating *sál* leaves were received from Mr. A. E. Osmaston, Divisional Forest Officer, Gorakhpur Division. The moth was identified as *Ingura subapicalis*, Walker. The other specimens being larvæ could not be identified with any amount of

certainty. From this Division specimens of a beetle (family *Curculionidæ*) attacking *sál* fruits were also received. The specimens have been sent to Mr. Marshall who is at present working at the Fauna of India volume on the family.

Caterpillars of the Noctuid moth *Ingura subapicalis*, Walker, were reported as doing damage to *sál* coppice forests of Chakia Range in the Bahraich Forest Division.

(2) **Lac investigation.**—Specimens of stick lac were received from the Sylviculturist and numerous parasitic insects were bred out of these. A large number of parasitic Hymenoptera, new to science, were bred out. These have been named and described by Mr. P. Cameron as follows:—(1) *Chalcis tachardiæ*, sp. nov., (2) *Cyclopleura claripennis*, gen. et sp. nov., (3) *Eurytoma pallidiscapus*, sp. nov., (4) *Brasema annalicaudis*, sp. nov., (5) *Lissencyrtus troupi*, gen. et sp. nov., (6) *Copidosoma? clavicornis*, sp. nov., (7) *Hadrothrix purpurea*, gen. et sp. nov., (8) *Bracon tachardiæ*, sp. nov., (9) *Ectadiophatnus tachardiæ*, gen. et sp. nov., (10) *Apanteles tachardiæ*, sp. nov.

Their descriptions are being published as a Forest Record.

Specimens of *Butea* stick lac were received from various Divisional Forest Officers of the Central Provinces, and the parasites are being bred out therefrom. A special study is being made of these parasites and their bearing on the production and propagation of lac.

In consequence of the fact that much of the literature at present available contains numerous errors relating to this insect, and very little first hand information, a study is being made of the structure and biology of the lac insect with special reference to Butea lac.

(3) **Reference collection.**—During the year 40 parcels of specimens were despatched to various specialists in Europe and America for identification. Among the specimens identified, the following new species, in addition to those mentioned above, have been described:—

(*a*) Cicadidæ by Mr. W. L. Distant—(1) *Khimbya immsi*, sp. nov., (2) *Dunbulia helena*, sp. nov., (3) *Quintilia pomponia*, sp. nov., (4) *Meimuna cassandra*, sp. nov.

(*b*) Dermaptera by Dr. Malcolm Burr—*Pseudisolabis immsi*, sp. nov.

(*c*) Staphylinidæ by Dr. Max Bernhauer—(1) *Medon immsi*, sp. nov.

(*d*) Hymenoptera by Mr. P. Cameron, F.E.S.—(1) *Centrochalcis ruficaudis*, sp. nov. (Chalcididæ), (2) *Cylopleura fumipennis*, gen. et sp.

nov. (Chalcididæ), (3) *Caloteleia rufipes*, sp. nov. (Scelionidæ), (4) *Immsia carinifrons*, gen. et sp. nov. (Scelionidæ), (5) *Lophyrus indicus*, sp. nov. (Tenthredrinidæ), (6) *Salius dehraessis*, sp. nov. (Pompilidæ), (7) *Liris nitidus*, sp. nov. (Sphegidæ), (8) *Trypoxylon ornatipes*, sp. nov. (Sphegidæ), (9) *Icaria annulipes*, sp. nov. (Vespidæ), (10) *Megachile stirostoma*, sp. nov. (Apidæ).

B.—Investigations outside the Sanctioned Programme.

1. **Major Subjects.**—(*a*) A species of Coccid attacking Chir pine in the Naini Tal Forest Division. The attack has been found to be both serious and widespread. The life-history of the Coccid is under investigation, and the writer has toured through Kumaon during May and June 1912 in this connection.

(*b*) A study of the various species of Termites found in Indian forests. Specimens of white-ants and notes relating to the damage wrought have been received from nearly all parts of India. Professor Dr. F. Silvestri of Portici, Italy, has undertaken to do the work of identification.

(*c*) Scolytidæ attacking Blue pine (*Pinus excelsa*) and Chir pine (*Pinus longifolia*) in the Chakrata Forest Division, reported by the Divisional Forest Officer.

2. **Minor Subjects.**—(*a*) The beetles *Xylotrupes gideon* from *Poisiana regia* trees, and *Baladiva walkeri*, Waterh., received from the Divisional Forest Officer, Meiktila Division, Burma.

(*b*) A Chrysomelid beetle, reported as devouring *Boswellia serrata* leaves, from the Poona Forest Division.

(*c*) *Monophlebus tamarindus*, Green, found on *Tamarix* and *Prosopis*, received from the Sukkur Forest Division, Sind.

(*d*) Bruchid beetles attacking seeds of *Albizzia amara* and *Albizzia Lebbek*, received from the Bellary Forest Division, Madras.

(*e*) *Trilocha varia*, Walker, defoliating *Ficus elastica* leaves, received from the Conservator of Forests, Northern Circle, Madras. There is no previous record of this moth attacking *Ficus elastica*.

(*f*) The longicorn beetles *Epepeotus uncinatus*, Gahan, and *Haplohammus punctifrons*, Gahan, attacking rubber plants in the Lakhimpur Forest Division. There is no previous record of these beetles attacking rubber plants.

(*g*) Scale insects (probably a new species of *Pulvinaria*) attacking Nim trees in Mayo College, Ajmer. The Noctuid moth *Eublemma scitula*, Rmbr., parasitic on the scale insects, was bred out at the Research Institute.

(*h*) Two species of Bostrichid beetles, *e.g.*, *Sinoxylon anale*, Les., and a larger species closely allied to, or likely only a variety of, *Sinoxylon crassum*, Les., attacking shisham logs in Dehra Dun.

(*i*) Scolytid beetles attacking Padauk logs in the Andamans.

(*j*) Hepialid (?) larvæ, reported as boring into the stems of teak saplings, from the South Malabar Forest Division, Madras.

(*k*) The larvæ of the Noctuid moth *Ingura* (*Abrostola*) *subapicalis*, Walk., defoliating *sál* coppice forests of Chakia Range, Bahraich Forest Division.

(*l*) Curculionid beetles attacking *sál* fruits in the Gorakhpur Forest Division.

(*m*) Some caterpillars and the Noctuid moth *Ingura subapicalis*, Walk., reported as defoliating *sál* leaves from the Gorakhpur Forest Division.

The insects bred out of seeds of *Cassia fistula*, *Albizzia Lebbek*, *Dalbergia paniculata* and *Bauhinia malabarica*, sent by the Sylviculturist, mentioned in last year's report, were identified as follows:—

(1) Out of *Cassia fistula* seeds—*Caryoborus gonagra*, Fabr., *Trachylepidia fructicassiella*, Rog.

(2) Out of *Albizzia Lebbek*—*Stathmopoda basiplectra*, Meyr., sp. nov.

(3) Out of *Dalbergia paniculata*—*Bruchus theobramæ*, L.

(4) Out of *Bauhinia malabarica*—*Caryoborus gonagra*, Fabr.

From among the insects bred out of sundri wood mentioned in last year's report the longicorn beetles and parasitic Hymenoptera have been identified as follows:—

Longicornia (1) *Diorthus simplex*, White, (2) *Derolus discicollis*, Gahan.

Parasitic Hymenoptera (3) *Centrochalcis ruficaudis*, Cam., gen. et sp. nov., (4) *Paroligosthenus trichiopthalmus*, Cam. gen. et sp. nov.

The Buprestid beetles bred out of this wood have been sent to Dr. Ch. Kerremans of Brussels for identification.

3. **Miscellaneous.**—The following are the only additions to the Museum collection during the year worth mentioning:—

(*a*) Mounted specimens of rats and hares damaging Babul seedlings in the Buldana Division.

(*b*) Ants' nest, received from Mr. A. J. Butterwick, Burma.

(*c*) Termites' nest, received from the Haldwani Forest Division, United Provinces.

Specimens have been contributed during the year to the British Museum, Indian Museum, Pusa, and to several specialists.

About 1,600 research files have been opened and the information relating to each insect has been recorded therein.

A Card Index Catalogue of all insects recorded up to date as being injurious to the more important Indian forest trees has been prepared and completed.

Help in the identification of various insects has been generously given by Sir George Hampson, Mr. G. J. Arrow, Mr. Gahan, Mr. C. Morley, Dr. Malcolm Burr, Dr. Max Bernhauer, Professor F. Silvestri, Mr. W. L. Distant, and Dr. W. W. Fowler.

List of Publications on Economic Zoology.

BAINBRIGGE FLETCHER, T. Weevil and Dry Wheat. (*Agri. Journ. Ind., October 1911.*)

,, ,, A simple Honey-Extractor. (*Agri Journ. Ind., October 1911.*)

,, ,, The Wax Moth. (*Agri Journ. Ind., October 1911.*)

,, ,, The Cabbage White Butterfly. (*Agri. Journ. Ind., January 1912.*)

,, ,, The Moth-borer in Canes. (*A pamphlet published by the Dept. of Agri., United Provinces.*)

COLEMAN, L. C. *The Rice Grasshopper. (*Mysore Entomological Bull. No. 1.*)

,, ,, *Jola or Deccan Grasshopper. (*Mysore Entomological Bull. No. 2.*)

* Publications which were mentioned in the last year's report but issued during the year under review.

COLEMAN, L. C. . . "Kumblihulas" attacking crops in Mysore (*Amsacta albistriga*, Wlk.). (*Mysore Entomological Bull. No. 3.*)

DE, M. N. . . Grasserie in Silkworms. (*Agri. Journ. Ind., July 1911.*)

DEPARTMENT OF AGRICULTURE, BENGAL. Leaflet in Bengali on the Rice Ear-cutting Caterpillar (*Cirphis unipuncta*).

DEPARTMENT OF AGRICULTURE, BIHAR AND ORISSA. Leaflets in English and Hindi on the Surface Caterpillar pest (*Agrotis ypsilon*) of Mokameh Tal lands.

" " Leaflets in Bengali and Ooriya on the Potato Moth (*Phthorimœa operculella*).

DEPARTMENT OF AGRICULTURE, BURMA. Leaflets in English and Burmese on:—

1. The Common Hairy Caterpillar (*Diacrisia obliqua*).
2. Fruit Flies.
3. The Spotted Bollworm of Cotton.
4. The Brown Coccid on Cotton.
5. Field Crickets.

DEPARTMENT OF AGRICULTURE, MADRAS. Leaflets in English on:—

1. Light traps.
2. Bambachu (*Leptocorisa varicornis*) and how to combat it.
3. Cocoanut Beetles.

DEPARTMENT OF AGRICULTURE, PUNJAB. Leaflets in English, Urdu and Gurmukhi on the Cotton Bollworm.

DEPARTMENT OF AGRICULTURE, UNITED PROVINCES. Short articles in Urdu on:—

1. Cut Worms in Tobacco, Potato and Poppy fields. (*Mufid-ul-Muzarain, January 1912.*)
2. Termites. (*Mufid-ul-Muzarain, February 1912.*)
3. Rice Grasshopper. (*Mufid-ul-Muzarain, March 1912.*)

DUTT, H. L. . Insect Pests of Jute. (*Bengal Quarterly Journ. Agri., October 1911.*)

" " Swarming Caterpillars on Paddy at Sabour. (*Bengal Quarterly Journ. Agri., January 1912.*)

GHOSH, C. C. . .	*Life-Histories of Indian Insects, III. The Rhinoceros Beetle and the Red Palm Weevil. (*Mem. Dept. of Agri., India, Entomological Series, ii, No. 10.*)
HOLE, R. S. . .	Note on the Bark-boring beetle attack in the coniferous forests of the Simla Catchment Area. (*For. Bull. No. 12.*)
INDIAN TEA ASSOCIATION.	Damage by Beetles in Tea Chest Woods. (*Pamphlet No. 1, 1912.*)
IYER, V. S. . .	Note on some Casuarina Insect Pests of Madras. (*For. Bull. No. 11.*)
KHAMPARIA, R. R.	Moth-borer in Sugarcane, Juar and Maize. (*Agricultural Gazette of Cent. Prov., July 1911.*)
MACKENNA, J., & SHROFF, K. D.	The Rhinoceros Beetle and its ravages in Burma. (*Burma Agri. Dept. Bull. No. 4, 1910.*)
MAXWELL-LEFROY, H.	Bulletin No. 23 on Insecticides, 2nd edition, revised by T. Bainbrigge Fletcher.
MAXWELL-LEFROY, H., & GHOSH, C. C.	*Eri Silk. (*Mem. Dept. of Agri., India, Entomological Series, iv, No. 1.*)
MISRA, C. S. . .	Cotton Bollworms, an Article in Urdu. (*Mufid-ul-Muzarain, March 1911.*)
NOWROJEE, D. . .	*Life-Histories of Indian Insects, II. Some Aquatic Rhynchota and Coleoptera. (*Mem. Dept. of Agri., India, Entomological Series, ii, No. 9.*)
STEBBING, E. P. .	Note on some Insect Pests of the Himalayan Coniferæ (*Pinus longifolia*). (*For. Mem., Vol. ii, Pt. ii.*)
,,	The Blue Pine Tomicus Bark-borer. (*For. Bull. No. 5.*)
,,	Note on the Bark-eating and Root-boring beetles of Babul. (*For. Bull. No. 10.*)
WOODHOUSE, E. J. .	The "Potato Moth" in Bengal. (*Bengal Quarterly Journ. Agri., January 1912.*)

* Publications which were mentioned in the last year's report but issued during the year under review.

VETERINARY SCIENCE.

BY

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The following table shows the output and issue of the various products at the Imperial Bacteriological Laboratory at Muktesar:—

Name.	Quantity prepared.	Issued.
	Doses.	Doses.
Anti-Rinderpest Serum	1,052,500	698,100
Anthrax Serum	28,722	6,070
Hæmorrhagic Septicæmia Vaccine	33,700	33,700
Anti-Hæmorrhagic Septicæmia Serum	30,845	28,970
Charbon Symptomatique Vaccine	60,000	15,350
Mallein	20,644	16,480
Tuberculin	519	577
Anti-Streptococcic Serum	1,294	2,298

Rinderpest.—Major J. D. E. Holmes, M.A., D.Sc., M.R.C.V.S., has been chiefly employed during the year in studying the new method of preparing Anti-Rinderpest Serum which was reported last year. With a view to improving the technique for this purpose he has investigated the potency of serum taken after natural recovery from plains cattle and buffaloes and from hill cattle; the comparative value of serum taken at repeated bleedings and also the most suitable volume of virus for injection purposes. The system of preparation noted last year has been adopted as a routine method for India. It has proved to be far superior to the older method. Plains cattle and buffaloes which yield a far larger amount of serum than hill bulls can be utilized and consequently a very much larger quantity of serum can be prepared at less expense and labour.

We are now free from the incubus of the hill bull problem to a great extent and the necessity for a new serum laboratory does not exist

as the quantity of serum which it is possible to prepare at Muktesar is sufficient to meet the requirements of the country for some years to come.

Captain R. C. Cochrane, A.V.C., has been engaged in the immunization of military cattle against Rinderpest by the simultaneous method and has published a very valuable contribution to our knowledge of the effect of the use of the serum in the field. The special value of the report lies in the fact that as the cases were under observation continuously correct records were kept and consequently the information is reliable. The lowest dose for plains cattle at present is 5 c.c. per 600 lbs. body weight, the calculation being made at $\frac{1}{18}$, the dose required to protect the most susceptible bovine in India, *i.e.*, the hill bull, but Cochrane considers the calculation for plains should be not $\frac{1}{18}$ but $\frac{1}{5}$ or thereabouts, giving a standard plains dose of 20 c.c. This is the dose fixed by the Conference on Anti-Rinderpest Inoculation for military dairy cattle. It seems probable that it would be fair to issue at a minimum dose of 10 c.c. per 600 lbs. body weight and that a dose of 20 c.c. should be used in dairy cattle or at the beginning of an outbreak. Captain Cochrane's report fixes the average susceptibility in plains cattle at the old estimate, *i.e.*, 30 to 40 per cent. of mortality in untreated cases and 60 to 70 per cent. of considerable immunity. If Anti-Rinderpest serum is used early in an outbreak when the more susceptible animals have to be protected a dose of 20 c.c. is necessary. When the operations are undertaken late, the more susceptible animals have been attacked and only the resistant remain. In such cases a smaller dose suffices, and probably 10 c.c. is the safest.

Owing to the increased output of serum the restrictions in regard to its issue and the prohibition of sale to outside countries have been removed and a larger amount has been issued during the year.

A charge of two annas per dose has been imposed: this is borne by Provincial Governments in all Provinces except the Punjab where a charge is made to the peasant.

Hæmorrhagic Septicæmia.—During the winter at Bareilly, Major Holmes made experiments regarding the vitality of the Hæmorrhagic Septicæmia virus outside the animal body and the means by which infection is retained and disseminated. The investigations are not yet complete and are being continued.

Recent observations at Hissar point strongly to the fact that the bacterium is not communicated by means of an invertebrate intermediary

host, but is purely soil-borne and remains alive for a very long time in wet soil, in fact that it can live as a saprophyte as is generally supposed.

Mr. S. H. Gaiger collected a considerable amount of information regarding the connection of outbreaks of the disease with rainfall and has proved conclusively that although the disease is more prevalent after rain it occurs quite independently of it.

Major F. S. H. Baldrey in collaboration with Dr. P. Hartley records experiments regarding a sensitised vaccine for the disease, the sensitising being accomplished by means of a heated specific serum to avoid bacteriolysis. The vaccine thus prepared appears to give immediate immunity thus obviating the objectionable negative phase. Such a vaccine would be very valuable in India as it would supplant serum which is of very doubtful value as a means of dealing with the disease in the field.

Major G. K. Walker submitted a short report on observations of the use of the serum in the field. The issue is at present only in an experimental stage.

Anthrax.—Major J. D. E. Holmes reports that during the winter at Bareilly, further experiments were carried out regarding the value and practical application of sero-vaccination against Anthrax by means of a combined injection of serum and virus or serum and a vaccine and that the experiments are being continued.

The serum manufactured is chiefly issued to Eastern Bengal and Assam for use against actual outbreaks. The disease does not appear to be very prevalent in other places.

Surra.—Major Holmes has treated a few more naturally acquired cases in equines on the old lines, the result being 68 per cent. of recoveries. The treatment of Surra by this method may be relied on to give from 50 to 60 per cent. of recoveries when the conditions are favourable. The cases must be got pretty early, placed in a good climate, be rested and well fed during the treatment, otherwise the results are disappointing and do not justify the expense.

Experiments have been made in the treatment of Surra in the dog by means of Salvarsan, but the drug does not appear to be a satisfactory one for the purpose.

Mr. A. S. Leese, M.R.C.V.S., the officer investigating camel diseases, has continued his investigations into the curative treatment of Surra in the camel. Early in the year it had been recognised that cures had been obtained by the use of judicious combinations of Atoxyl

or Soamin, Tartar emetic and Sodium arsenate or Arsenious acid. The more recent experiments have been attended by considerable success, 30 camels cast from camel corps have been cured and a percentage of 50 to 62 obtained—a very great advance.

This officer made a long tour in Sind and a short one in Baluchistan for the purpose of collecting information regarding the prevalence of the disease in those Provinces and has submitted a report on the subject.

Kumri.—Major Holmes reports that he is investigating this disease in collaboration with Professor Mott, F.R.S., who is carrying out the pathological portion. No definite results have so far been obtained.

Spirochætosis.—Spirochætosis of fowls is a very fatal and widespread disease in India. In view of the fact that expensive English fowls are being imported into the country and as they are specially susceptible, Mr. Leese made experiments with a view to finding a cure. He reports that Soamin in $\frac{1}{4}$ to $\frac{1}{8}$ of a grain according to size of the fowl will, if injected into the breast muscles, cure a case.

Piroplasmosis.—Mr. S. H. Gaiger has published a paper on the experiments made in the Punjab Veterinary College regarding the treatment of canine piroplasmosis by means of Trypanblau. His experiments appear to confirm Patton's observations regarding the presence of two species of piroplasms in the dog in India, one destroyed by Trypanblau and the other unaffected by it.

Considerable success has been obtained in Madras by Major Symons, I.M.S., and Captain Patton in the treatment of the disease by Salvarsan.

Filariasis.—Mr. A. S. Leese has continued his studies into camel filariasis as it occurs in India and has published a paper describing the parasite, the effects of the embryos on the host, the duration and course of the disease produced and discussing the probable agent of infection. The paper is a valuable contribution to our knowledge of the subject.

Parasites.—Mr. Leese reports the occurrence of Bilharziosis in the camel. *Thelazia leesei* (Raillet & Henry) has also been described as an extra ocular nematode of the camel.

The same author reports on the probable connection between Linguatula larvæ and Peritonitis in the camel.

Mr. S. H. Gaiger records the occurrence of a new extra ocular filaria of the dog, which has been named *Thelazia callipæda* (Raillet & Henry).

The same observer has found a new nematode in sheep and cattle. The parasite belongs to a new sub-genus and a new species and has been named *Gaigeria pachyscelis*.

Some investigations have been made regarding the percentage of infestation of the dog and the treatment of parasitism.

A List of Papers published during the year 1911-12 bearing on Indian diseases.

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APPENDIX.

REPORT ON THE SCIENTIFIC AND TECHNICAL INVESTIGATIONS CONDUCTED FOR INDIA AT THE IMPERIAL INSTITUTE DURING THE YEAR ENDED 30TH SEPTEMBER 1912.

BY

W. R. DUNSTAN, M.A., LL.D., F.R.S.,

Director, Imperial Institute.

The scientific and technical investigations which have been in progress at the Imperial Institute for India during the year ended the 30th September 1912 are as follows:—

Opium.—In connection with the chemical investigation of Indian opium which has been conducted at the Imperial Institute, it has been found necessary to devise a new method of estimating codeine in opium, and a paper on the subject has been communicated by Mr. A. E. Andrews of the Scientific Staff of the Imperial Institute to the Society of Public Analysts, and published in the "Analyst" (1911, Volume 36, page 489).

A series of botanical specimens of the varieties of poppy cultivated in India for the preparation of opium was forwarded from the Imperial Institute to Kew for identification. It was found that all the specimens represented varieties of the true opium poppy, *Papaver somniferum*, Linn.

Samples of Indian medicinal opium have been supplied by the Imperial Institute to a London hospital for practical trial in comparison with Turkey opium, but the results of the experiments are not yet available.

Solanaceous Drugs.—A paper giving the results of special scientific interest obtained in the course of the work on Solanaceous drugs, alluded to in previous reports, has been communicated by Mr. A. E. Andrews of the Imperial Institute Staff to the Chemical Society of London and published in the Society's Transactions (1911, Volume 98, page 1871).

Tobacco.—In continuation of previous investigations, two further samples of tobacco from the Government Farm at Burirhat were received

for examination and valuation. Both samples were found to be of marketable quality as pipe tobaccos, whilst one of them might be suitable for use as a cigar "wrapper." A London firm of tobacco merchants expressed a desire to be placed in touch with exporters of this tobacco in India, and were referred to the Director General of Commercial Intelligence at Calcutta, who had forwarded the specimens.

During the year the Imperial Institute procured for the Director of Agriculture at Dacca typical samples of various tobaccos marketed in London, to be used as standards of quality at Burirhat.

Tanning Materials.—A sample of *Acacia Catechu* extract prepared experimentally in Gwalior was found to contain a low percentage of tannin, due to the extract having been insufficiently concentrated. Suggestions for the improvement of the extract were made in the report.

Essential Oils.—Lemongrass oil. In continuation of the action previously taken, a second small consignment of this oil, distilled from four varieties of lemongrass grown at Wahjain, was forwarded to the Imperial Institute for examination and sale in London. The greater part of the consignment was disposed of to a firm of soap-makers at 4*d.* per oz., and the remainder at the same price to a dealer in essential oils who wished to have a small quantity for submission to customers. This dealer subsequently informed the Imperial Institute that he was able to place orders for the oil, and was put into communication with the Director of Land Records and Agriculture in Assam with a view to obtaining consignments of the oil from native distillers.

A consignment of cuscus roots (*Vetiveria zizanioides*) from Trichinopoly was examined in order to determine their value as a source of vetiver oil. The roots were found to be of inferior quality, giving a low yield of somewhat abnormal oil, so that it was doubtful whether they would be readily saleable at good prices in Europe.

The chemical examination of the oil of "Nepal sassafras" or "camphor wood," *Cinnamomum glanduliferum*, was completed during the year, the results being of considerable scientific interest. A paper on the chemistry of the oil by Dr. S. S. Pickles of the Imperial Institute has been communicated to the Chemical Society of London and published in that Society's Transactions, 1912, Volume 101, page 1433. The commercial value of the oil was under investigation at the end of the year.

Turpentine Oil.—Two samples of crude and rectified turpentine oil, prepared from the oleo-resin of *Pinus longifolia* by the Forest Chemist at Dehra Dun, were examined. The rectified oil appeared to be

quite suitable for paint and varnish-making, but it differed considerably in composition from the best American and French turpentine oils. It would therefore have to be marketed on its own merits as Indian turpentine oil, and in this case it might be expected to realise a price equal to or rather higher than that of good Russian turpentine oil.

Apart from the examination requisite for determining the commercial value of the oil, the study of its chemical constituents has been pursued by Mr. H. H. Robinson of the Imperial Institute, and a preliminary note has been communicated to the Chemical Society of London and published in that Society's Proceedings, 1911, Volume 27, page 247.

Oilseeds.—Samples of five oil-seeds, forwarded by the Director of Agriculture at Dacca, were examined and valued. Four of the varieties, *viz.*, "Raina," "Nahar," "Panang" and "Taramani" seeds, would probably find a ready market in the United Kingdom, but, in the case of the first three, technical trials will be necessary to determine their exact value; a larger supply of these seeds was requested in order that this further investigation might be conducted. The "Taramani" seed (*Eruca sativa*) is already known in the United Kingdom and is used as a source of oil.

A consignment of Margosa seed from the United Provinces was found to yield a fat of dark colour and very unpleasant odour. The dark colour, which was due to the fermentation of the seed during transit, could be avoided, and if the odour can be removed by a simple process the fat could be utilised for soap-making. The matter is being further investigated at the Imperial Institute.

A memorandum was furnished to the Officiating Reporter on Economic Products on the composition of Hydnocarpus fats, including that of *H. Wightiana* ("Moratti" seed) from India, showing that these fats are unsuitable for edible purposes.

A paper giving an account of the scientific results obtained in the course of the work on Indian Bassia seeds has been communicated by Mr. R. G. Pelly of the Imperial Institute Staff to the London Section of the Society of Chemical Industry and published in that Society's Journal, 1912, Volume 31, No. 3, February 15th.

Cotton.—Samples of cotton from Trichinopoly, Akola (Berar) and Eastern Bengal and Assam were examined during the year. The samples from Akola were of exceptionally high quality, and it was recommended that their cultivation should be encouraged.

Fibres.—Samples of Sisal hemp, Sida fibre and Sisal tow, forwarded by the Fibre Expert at Dacca, were found to be of good quality, and similar fibres could probably be sold in large quantities in the United Kingdom. A small consignment of the Sida fibre was subsequently forwarded by the Fibre Expert and was sold in London at £27 per ton. The fibre was however valued at £28 to £30 per ton (July 1912) if shipped in commercial quantities.

A sample of wild plantain fibre from Burma was clean, soft, and lustrous, and would be readily saleable in the United Kingdom; it was suggested that a small consignment should be forwarded to the Imperial Institute for trial sale.

Minerals.—Samples of china clay, bauxite, sandstone, red ochre and other minerals were examined and reported on.

Miscellaneous official enquiries.—In addition to the foregoing reports, information was furnished during the year to Government officials in India on a variety of subjects, including the following:—

The analysis of feeding-stuffs.

The utilisation of rat-skins.

The commercial value of fish oils, fish stearin, and vegetable oils.

Bamboo pulp as a paper-making material.

The marketing of sandalwood.

The preparation and storage of compressed fodder.

The marketing of barley.

The commercial value of dried bananas.

The determination of prussic acid yielded by beans.

The cultivation of peas and beans in Burma.

Coal prospecting in Gwalior.

Rosa grass distillation in Gwalior.

A number of other miscellaneous enquiries, received from commercial firms and private individuals in the United Kingdom, India and elsewhere, were also dealt with during the year, information being furnished to the enquirers on Indian oil-seeds, tanning materials, minerals, foodstuffs and other subjects.

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