

Journal of the
Bombay Natural History Society

Vol. 63, No. 2

Editors

H. SANTAPAU, S.J.,
ZAFAR FUTEHALLY, & J. C. DANIEL



AUGUST 1966

Rs. 15

NO.

1

VOLUME 63, NO. 2—AUGUST 1966

Date of publication : 27-3-1967

CONTENTS

AN ANNOTATED LIST OF THE BUTTERFLIES OF DELHI, INDIA. By Julian P. Donahue. (With two maps, a text-figure and three plates)	235
AESTIVATION OF PERIANTHS OF <i>Areca catechu</i> LINN. FRUITS. By T. A. Davis and Abantika Kundu. (With three figures)	270
A REPORT ON TICKS COLLECTED FROM BIRDS AND SMALL MAMMALS IN NORTH ARCOT AND CHITTOOR DISTRICTS, SOUTH INDIA. By M. J. Rebello and Rachel Reuben	283
CHILKA LAKE: A PILOT SURVEY FOR BANDING POSSIBILITIES. By K. S. Lavkumar	290
TRANSPORT OF THE FRY AND FINGERLINGS OF THE MILK FISH <i>Chanos chanos</i> (FORSKÅL). By T. A. Mammen	298
STUDIES ON THE INSECT POLLINATORS OF <i>olitorius</i> AND <i>capsularis</i> JUTE. By S. K. Ghose. (With two figures)	315
NOMENCLATUREL NOTES ON SOME FLOWERING PLANTS. By N. P. Balakrishnan	327
STUDIES ON INDIAN COPEPODS—8. OBSERVATIONS ON THE DIURNAL VERTICAL MOVEMENTS OF PLANKTONIC COPEPODS IN THE GULF OF MANNAR. By A. N. P. Ummerkutty. (With a map and seven text-figures)	332
AN ACCOUNT OF THE WEEDS OF CENTRAL RESEARCH FARM, JODHPUR, RAJASTHAN. By Y. Satyanarayan and S. K. Saxena	344
INDIAN WOOD-DESTROYING TERMITES. By M. L. Roonwal, sc.D. (Cantab.) F.N.I. and O.B. Chhotani, M.Sc. (Hons.). (With two plates and an Appendix)	354
THE BIRDS OF NEPAL, Part 12. By Biswanoy Biswas. (With three plates and five figures)	365
RE-USE OF CELLS AND BROTHER-SISTER MATING IN THE INDIAN SPECIES <i>Stenody- nerus miniatus</i> (SAUSS.) (VESPIDAE : EUMENINAE). By S. D. Jayakar and H. Spurway. (With a plate)	378
LIFE HISTORY OF THE INDIAN CUCKOO, <i>Cuculus micropterus micropterus</i> GOULD, IN THE SOVIET UNION. By I. Neufeldt. (With four plates)	399
MORE NEW RACES OF BIRDS FROM THE ANDAMAN AND NICOBAR ISLANDS. By Humayun Abdulali	420
REVIEWS :	
1. The Behaviour of Arthropods. (R.R.)	423
2. The Company of Animals. (J.C.D.)	424
3. The Physical Geography of the Oceans. (T.S.S.R.)	425
4. Budongo. (J.C.D.)	426
5. Handbook of Waterfowl Behaviour. (J.C.H.)	427

MISCELLANEOUS NOTES :

1. Calcium Deprivation and Osteomalacia in a Slender Loris, *Loris tardigradus* (Linnaeus). By Donald E. Carey and Edward E. Carey (With a plate) (p. 428).
2. Authorship of the name *Presbytis geei* (Mammalia : Primates). By Biswamoy Biswas (p. 429).
3. Some observations on the Hairyfooted Gerbille *Gerbillus gleadowi* Murray, in the Rajasthan desert. By Ishwar Prakash and K. G. Purohit (With a textfigure and a photograph) (p. 431).
4. An out-size Elephant (With a note on measuring elephants). By Duncan Hay (p. 434).
5. The Short-tailed or Red-billed Tropic-Bird (*Phaethon aethereus indicus* Hume) at Kihim on the Maharashtra coast. By Rauf Ali (p. 437).
6. Notes on Indian birds 10—Occurrence of the Chinese Grey Duck Spotbill (*Anas poecilorhyncha zonorhyncha* Swinhoe) in India. By Humayun Abdulali (p. 438).
7. The Pinkheaded Duck [*Rhodonessa caryophyllacea* (Latham)] again. By Laliteshwar Prasad Singh (With a plate) (p. 440).
8. Aggressive behaviour of a Spotted Owlet [*Athene brahma* (Temminck)]. By K. K. Gupta (p. 441).
9. Occurrence of the Wire-tailed Swallow (*Hirundo smithii* Leach) in Northern Ceylon : A first record. By Mrs. E. M. Wynell-Mayow (p. 442).
10. Behaviour mimicry by the Large Racket-tailed Drongo [*Dicrurus paradiseus* (Linnaeus)]. By J. C. Daniel (p. 443).
11. Recovery of ringed birds. By Editors (p. 444).
12. Occurrence of the toad *Bufo fergusonii* Boulenger, in Hyderabad, Andhra Pradesh, India (Anura : Bufonidae). By Julian P. Donahue and J. C. Daniel (p. 447).
13. An insect's persistent vitality. By Thomas Gay (p. 447).
14. Record of *Paraclipsis praedatrix* Harding, 1924 (Annelida : Hirudinea), from a new host, *Natrix piscator* (Schneider), the Checkered Keelback (Reptilia : Serpentes). By Mahesh Chandra and S. S. Saha (p. 448).
15. Intertidal Entoprocta and Ectoprocta (Bryozoa) of Bombay. By B. F. Chhapgar and S. R. Sane (With one plate) (p. 449).
16. Correct name for *Ventilago calyculata* Tulasne. By G. M. Oza (p. 455).
17. A new Synonymy in Umbelliferae. By D. B. Deb (p. 455).
18. Floral variations in three species of *Cestrum* Linn., viz. *C. diurnum* Linn., *C. elegans* Schlecht., and *C. nocturnum* Linn. By G. L. Shah and B. Suryanarayana (p. 456).
19. *Utricularia minutissima* Vahl : A new record for North India. By V. C. Abraham (p. 459).
20. Two interesting orchids from N. W. Himalayas. By N. C. Nair (p. 461).
21. *Eleocharis fistulosa* Schult : A new record for the Upper Gangetic Plain. By V. Singh & Y. S. Murty (p. 462).
22. Distribution of *Spinifex littoreus* (Burm. F.) Merr. along Indian coasts. By T. Ananda Rao and P. G. Shanware (p. 463).
23. A new species of *Hydrogonium* from the Western Himalayas. By J. N. Vohra (With a plate) (p. 464).
24. Occurrence of *Streptonema trilobatum* Wall. at Raipur, Madhya Pradesh. By K. Sankaran Unni (p. 465).

ANNUAL REPORT OF THE BOMBAY NATURAL HISTORY SOCIETY FOR THE YEAR 1965-66	.. .. .	466
STATEMENT OF ACCOUNTS OF THE BOMBAY NATURAL HISTORY SOCIETY	.. .. .	473
MINUTES OF THE ANNUAL GENERAL MEETING	.. .. .	484
GLEANINGS	.. .. .	486

JOURNAL
OF THE
BOMBAY NATURAL
HISTORY SOCIETY



1966 AUGUST

Vol. 63

No. 2

An annotated list of the Butterflies
of Delhi, India¹

BY

JULIAN P. DONAHUE²

(With two maps, a text-figure and three plates)

ABSTRACT

A collection of over 5600 butterflies from Delhi, India, obtained from 1961 to 1965, contained 72 species. An additional five species have been reported in the literature or are represented by specimens in the Indian Agricultural Research Institute, New Delhi.

For each species the following information is given: habitat preference, flying time (seasonal), total number of specimens, number of specimens of each sex, the sex ratio, maximum and minimum sizes observed in the material examined (given as the length of one forewing), variation, and the distribution of the species in India.

Two diverse habitats were heavily collected: the xerophytic Reserved Forest on the Ridge, a low prolongation of the Aravalli Hills; and the mesophytic Sundar Nagar Nursery. The Nursery, and other parts of the cities of Delhi and New Delhi, have been so heavily irrigated that they differ radically from arid native habitats, such as the Ridge.

The development of the mesophytic urban habitat perhaps accounts for the presence of 14 species found in mesic areas east of Delhi, but not found in the arid land west of Delhi. Conversely, three species of *Colotis* plus the hesperiid *Pelopidas thrax thrax*, which are characteristic of arid land west of Delhi, occur on the Ridge but do not occur

¹ The major part of a thesis submitted to Michigan State University in partial fulfilment of the requirements for the degree of Master of Science. Publication approved by the Department of Entomology.

² Department of Entomology, Michigan State University, East Lansing, Michigan 48823, U.S.A.

east of Delhi. Finally, *Pieris canidia indica*, *Colias electo fieldi*, and possibly *Argynnis hyperbius*, appear to be visitors from the Himalaya.

The greatest numbers and variety of butterflies are found during the monsoon season, from July through September, and afterwards through early November. The wet season form, in those species which have seasonal forms, usually occurs during the monsoon. But in at least six species (*Anapheis aurota*, *Cepora nerissa*, *Eurema hecabe*, *Colotis etrida*, *Ypthima inica*, *Precis almana*, and possibly *Precis orithya*) the colour pattern characteristic of the wet season appears as early as mid-April or May, two of the warmest, driest months of the year. This indicates that environmental factors other than humidity may be influencing the seasonal forms of these species.

The two female colour forms of *Colotis fausta faustina* are seasonal: the white form occurs during the monsoon; the salmon-coloured form occurs at other times of the year.

Gongylus gongylodes (Orthoptera: Mantidae) is reported as a predator of *Colotis fausta*, and *Telenomus (Aholcus) talaus* (Hymenoptera: Scelionidae) is recorded as an egg-parasite of *Papilio demoleus demoleus* or *P. polytes romulus*.

The 'cyrus' female form of *Papilio polytes*, usually considered rare, is relatively common in Delhi.

The subspecies *minuta* Evans, originally ascribed to *Euchrysops pandava*, is merely the dry season form of *E. parrhasius parrhasius*, and is therefore a new synonym.

A list of 32 species which may occur in Delhi is included.

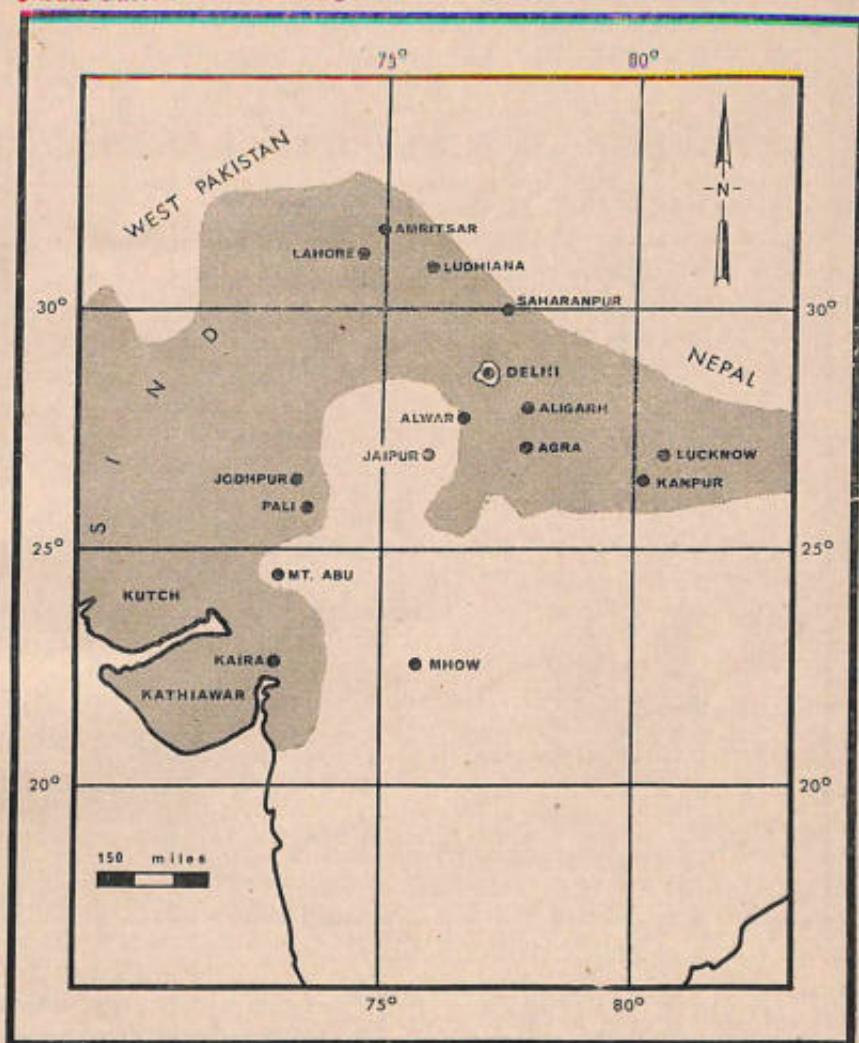
It is indeed surprising that no one has published a list of the butterflies of India's capital city, but the hot, arid climate of the north Indian plains has never been famous for inspiring the pursuit of Lepidoptera. Consequently, the only list of Delhi butterflies is a partial list of 21 species that Longstaff (1912) collected there in November 1903. Otherwise, no complete list is available for any locality nearer to Delhi than 250 miles.

DESCRIPTION OF THE STUDY AREA

Delhi is a Chief Commissioner's State of 574 square miles, wedged between the States of Punjab and Uttar Pradesh, on the Indo-Gangetic Plain at lat. 28° 40' N., long. 77° 10' E. (Maps 1 & 2).

Although it was not possible to survey the entire State, large collections were made in two diverse habitats: the Sundar Nagar Nursery (Map 2, Plate I, figs. 1 & 2), a lush area between the Zoological Park and Humayun's Tomb, on the south-east side of the State; and the 'Ridge' (Map 2, and Plate II, figs. 3 & 4, Plate III, figs. 5 & 6), a low (200-300 feet) prolongation of the Aravalli Hill Range that gradually disappears as it extends north-east to the Jumna River, which flows from north to south on the east side of Delhi. Unless otherwise stated, specimens collected on the Ridge were obtained in a Reserved

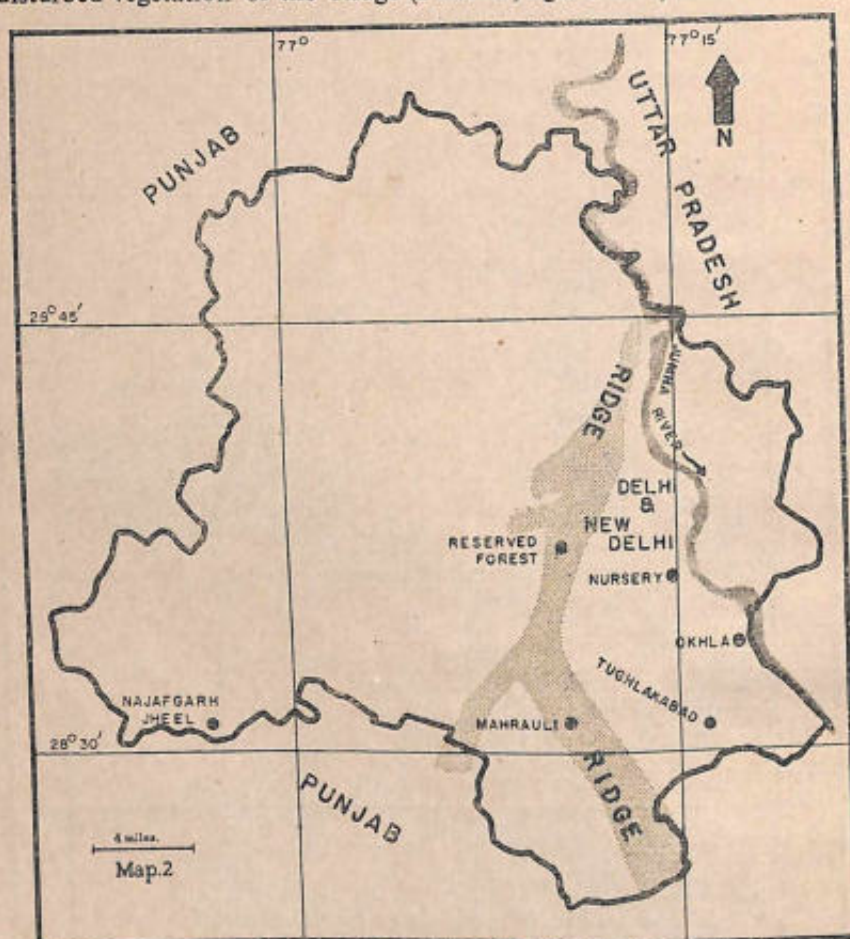
Forest west of the Ashoka Hotel, on either side of Link Road between Sardar Patel Road and Ridge Road (Map 2).



Map 1. Outline map of north-western India and West Pakistan, showing major collecting sites referred to in text. Approximate extent of Indo-Gangetic Plain is shaded.

The Nursery approaches a mesophytic habitat because of extensive irrigation throughout the year. Although flowers and shrubs are cultivated in much of the area, native grasses, shrubs, and trees occur in many parts of the Nursery (Plate I, figs. 1 and 2). Some Delhi butterflies, such as *Leptosia nina*, *Euploea core*, and, to a great extent, *Ypthima inica*, have been found only in restricted parts of this area.

Mukherjee (1953) has classified the essentially native and little-disturbed vegetation of the Ridge (Plate II, figs. 3 & 4, and Plate III,



Map 2. Outline map of Delhi, India

figs. 5 & 6) into two categories: (1) the permanent vegetation, which occurs throughout the year; and (2) the ephemeral vegetation, which consists of annuals growing chiefly during the rainy season. He states: 'The permanent vegetation is xerophytic in ecological peculiarities due to the rigorous climatic and edaphic conditions and gives an appearance somewhat like a thorn scrub or bush jungle. But the number of plants is somewhat fewer than in other scrub jungles of India.' According to Mukherjee (1953), the most characteristic trees on the Ridge include *Azadirachta indica*, *Salvadora persica*, *S. oleoides*, *Prosopis spicigera*, *Acacia modesta*, *A. senegal*, *A. leucophloea*, *Cassia fistula*, *Ehretia laevis*, *Tecomella undulata*, *Balanites roxburghii*, and *Butea monosperma*. The

more numerous thorny shrubs on the Ridge include *Zizyphus nummularia*, *Grewia betulaeifolia*, *Capparis aphylla*, *C. sepiaria*, *Celastrus senegalensis*, *Calotropis procera*, and *Carissa spinarum*. Mukherjee (1953) lists 178 species of plants, representing 44 families, that occur on the Ridge.

Reference should be made to Maheshwari (1963) for a complete analysis of the flora of Delhi.

In addition to the two major collecting sites above, small collections have been made in xerophytic situations at Tughlakabad Fort, eight miles SSE. of New Delhi, and at Okhla, the origin of the Agra Canal on the Jumna River, five miles south-east of New Delhi. A few specimens have also been collected near the Najafgarh Jheel, a large, shallow-water lake surrounded by open cultivated land 18 miles WSW. of New Delhi. With the few exceptions noted later, these localities have produced nothing unusual.

CLIMATE AND SEASONAL ABUNDANCE

The climate of Delhi can be characterized as semi-arid, but there are marked seasonal changes. It is cool and dry from October to February, hot and dry from March to early June, and hot and humid during the monsoon from mid-June through September. The precipitation and temperature data are given for each month in Table 1, along with the number of species that have been collected in each month.

TABLE 1

MONTHLY RAINFALL AND TEMPERATURES IN DELHI, INDIA (SOURCE : SOHONI 1953),
WITH THE NUMBER OF SPECIES OF BUTTERFLIES RECORDED FOR EACH MONTH

Month	Rainfall (inches)	Temperature (°F.)		No. Spp. Collected
		mean daily max.	mean daily min.	
January	0.99	70.5	43.3	26
February	0.83	74.7	49.2	32
March	0.51	85.0	57.1	38
April	0.33	96.6	67.7	31
May	0.52	104.8	78.8	26
June	3.03	102.4	82.5	13*
July	7.03	95.3	80.1	41
August	7.23	93.0	78.4	53
September	4.84	93.5	75.5	47
October	0.40	92.5	64.3	31*
November	0.10	83.2	51.8	55
December	0.43	73.7	45.0	38

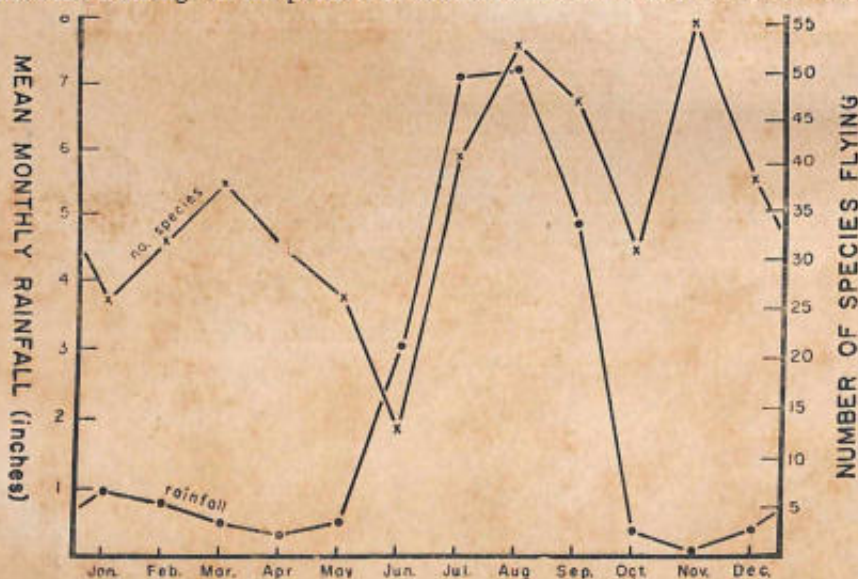
* June and October were relatively poorly collected. A fairly low number of species is expected in June, but over 50 species should be expected in October.

Of the mean annual rainfall of 26.24 inches, 84% occurs during the monsoon from June through September. The dry conditions prevailing

from October to May dictate the arid nature of the native vegetation. During the monsoon, however, the vegetation flourishes. Most plants produce lush new growth at a rapid pace, and almost overnight the land is green where leafless trees and hard bare ground had been but a few weeks earlier (see Plate II, figs. 3 & 4, and Plate III, figs. 5 & 6 for examples of the changes). The pronounced change in the vegetation during the monsoon has been studied in Gujarat by Saxton (1924).

The activity and abundance of the butterflies are strongly correlated with the climatic events in Delhi. Most species occur only during the monsoon, or are most common at that time (Table 1, and text-fig.). Butterfly numbers then decrease from mid-November to February, when specimens are scarce. Some species become extremely abundant during the hot season (*Anapheis aurota* and *Colotis fausta*, for example), but the variety of species on the wing gradually declines to a low point in June. About two weeks after the monsoon breaks (the onset is variable, but is usually in late June) the air is once again filled with butterflies.

The graph of monthly precipitation and the number of species occurring in a given month (text-fig.) demonstrates the time lag between a change in the pattern of rainfall and a change in the number



Text-figure. Number of species of butterflies recorded each month in Delhi, correlated with mean monthly rainfall.

of species flying. No attempt has been made to estimate relative numbers of butterflies during the different months, although the number of species collected was usually directly related to the number of individuals flying.

Donahue : Butterflies of Delhi



1. Uncultivated lowland area on north side of Nursery (Zoo in background). *Ypthima inica* most abundant in tall grass in centre of photograph. 1 July 1962.
2. Native grasses and thorn shrubs and trees in Nursery, looking south from the area in 1, towards Humayun's Tomb (right centre background). 1 July 1962.

(Photos : Julian P. Donahue)

Donahue : Butterflies of Delhi



3. Dry season aspect of vegetation in Reserved Forest on the Ridge, 9 May 1962. 4. Wet season aspect of same area as 3, on 14 Aug. 1962. Note change in the ground cover, in foliage of trees, and in vine in foreground.

(Photos : Julian P. Donahue)



SEASONAL VARIATION

Many species of Delhi butterflies have two well-marked seasonal forms, associated with the wet and dry seasons. Wet season specimens are usually larger and more conspicuously patterned than dry season specimens, while the seasonal forms of some species even have different wing shapes. *Eurema hecabe* is an exception, in that the dry season form is heavily marked on the underside, while the wet season form is almost immaculate on the underside.

Previous authors have implied that the wet season form occurs only during the monsoon, but this certainly is not true in Delhi. In at least six species (*Anapheis aurota*, *Cepora nerissa*, *Eurema hecabe*, *Colotis etrida*, *Ypthima inica*, *Precis almana*, and possibly *Precis orithya*), the colour pattern characteristic of the wet season appears in all specimens as early as mid-April or May—two of the hottest, driest months of the year—and lasts until sometime after the monsoon, depending on the species. These pre-wet-season forms may be smaller than wet season specimens, but in their facies (and wing shape, in *P. almana*) they are identical to wet season individuals.

The factors responsible for the appearance of the seasonal forms have been the subject of some experimentation and much speculation. Marshall (1901) and Dixey (1902) concluded, after a series of experiments, that the seasonal forms were influenced by both temperature and humidity. Apparently no modern, more sophisticated, research has been conducted into the problem, but Sevastopulo (1944) believes that three factors operate, either separately or in conjunction, to influence the form of a butterfly: (1) condition of the food; (2) effect of atmospheric humidity on the larva; and (3) effect of atmospheric humidity on the pupa. He further believes that the nature of the food or relative humidity alone are not the complete explanation of the phenomenon.

The appearance of the 'wet-season' form of some Delhi species in the dry season, mentioned earlier, indicates that some factor other than humidity may affect those species, although the majority of the Delhi wet-season specimens appear to be restricted to the monsoon season. It is quite possible that the factors affecting the form of a butterfly are different for different species.

METHODS OF COLLECTING

The butterfly collector in Delhi has poor success with special collecting methods—such as baits, models, or locating butterflies swarming on stream-banks—which are often successful in a moist forest habitat. Collecting butterflies at flowers, stalking them (especially *Precis*), or

chasing the fast-flying species are the only methods which have produced results in Delhi. Some species, such as *Leptosia nina* and *Mycalesis perseus*, must be beaten from the grass, while low-flying species (*Eurema*, *Zizeeria*, etc.) can be obtained by gentle sweeping. During warm weather it is advisable to do the bulk of the collecting before 10 a.m., while the butterflies are attracted to flowers and before they begin flying more rapidly. A warm day on the Ridge can be most exhausting, since the butterflies seldom pause in their headlong flight through the scrub, and many were the times when both collector and net became snagged and torn on the thorns.

No mass movements ('migrations') of butterflies have been observed in Delhi, although this phenomenon has been reported elsewhere in India for species which occur in Delhi. But some species, such as *Colias electo* and *Pieris canidia* probably emigrate to Delhi from the Himalaya, although so few specimens reach Delhi that it would be difficult to detect the movement.

METHOD OF STUDY

The list which follows is the result of the examination of 5611 mounted specimens, representing 72 species, collected by the author from May 1961 to August 1962, and by Roy L. Donahue and Reed C. Finrock from 1962 to 1965. A few additional specimens were purchased from Miss Nirmala of Delhi, who provided specimens collected by 'Venu', Leela R. Menon, and herself. All these specimens form a part of the collection of Indian butterflies deposited in the Entomology Museum at Michigan State University (MSU). Five additional species that were not examined have either been reported from Delhi in the literature or are represented by single specimens in the collection of the Indian Agricultural Research Institute (I.A.R.I.), New Delhi.

The total number of specimens examined is given for each species, followed by the number of specimens of each sex and the sex ratio (given as the percentage of males). With only a few exceptions (such as *Hypolimnas misippus*, *Ixias pyrene*, *Papilio polytes*, and *Colotis fausta*), males could not be distinguished from females in the field, so the sex ratio as given should reflect the relative abundance of the two sexes under field conditions at the time of collecting, although it is well known that behaviour and other ecological factors generally make the females of some species very difficult to find. The relationship between the sex ratio observed in the field and the actual sex ratio of a species can only be derived from rearing experiments and studies of predation, parasitism, and behaviour. The sex was determined by

examining the abdomen of all specimens, even of those species which are sexually dichromic.

To simplify the presentation of data on seasonal occurrence, each month has been divided into quarters, designated by Roman numerals as follows: I = 1-7; II = 8-14; III = 15-21; and IV = 22-end of the month. Because of the probability that a given species was not collected during every week it was flying, and because most Delhi butterflies appear to be continuously brooded in all except the winter months, the flying time is assumed to be continuous if the interval between collection records is four quarters or less. For example, if a given species was collected in the first and fourth weeks of October, and again in the third week of November, the flying time will be presented as October I to November III. June, October, and, to some extent, September have been poorly collected, and it is to be expected that additional records from these months may alter the known flying time of a species. The precise date of each capture is given if twelve or fewer specimens of a species have been collected.

The size of specimens, given in millimetres, is the length of one forewing from base to apex.

The species included in this paper were identified according to the following references: Evans (1949)—Hesperiidae; Talbot (1939)—Papilionidae, Pieridae; Cantlie (1962)—Lycaenidae; Evans (1932)—Nymphalidae; and Talbot (1947)—Danaiidae, Satyridae. Monographs of certain groups have been referred to whenever possible. The names used in this paper follow the above authors, unless subsequent investigations have shown other names to be more appropriate. The arrangement of species follows the above authors, while the arrangement of families follows dos Passos (1964). The figures in Wynter-Blyth (1957), Seitz (1927), and in various volumes of LEPIDOPTERA INDICA (Moore, 1890-1900; Swinhoe, 1905-1913: volumes V and VI were not consulted) were occasionally consulted for the clarification of a description. Terminology of the genitalia follows Klots (1956).

'Form' names are avoided whenever possible, especially for seasonal forms, since these names have no taxonomic validity. Some species, however, have distinct forms which, for the sake of recognition, are occasionally referred to by name.

Frequent reference is made in this paper to lists of butterflies published for other localities in north-western India and West Pakistan. The nearest localities and their distances from Delhi are as follows (see Map 1): Lucknow, Uttar Pradesh, 250 miles SE. of Delhi (de Rhé-Philipe 1902, 1905); Kanpur, U.P., 240 miles SE. of Delhi (partial list, Sevastopulo 1948); Lahore, West Pakistan, 250 miles NW. of Delhi (de Rhé-Philipe 1917); Amritsar, Punjab, 250 miles NW. of Delhi (partial list, Sevastopulo 1948); Fatehgarh, Punjab, 140 miles

NNW. of Delhi (partial list, Peile 1911); Jodhpur, Rajasthan, 300 miles WSW. of Delhi (MacPherson 1927); and Lyallpur, West Pakistan, 300 miles NW. of Delhi (partial list, Sevastopulo 1948).

Other, more distant localities (Map 1) whose lists have been consulted include Sind (the southern portion of the Indus Valley), West Pakistan, about 400 miles west to about 600 miles WSW. of Delhi (Swinhoe 1887; Menesse 1950); Kutch (region), Gujarat, about 600 miles SW. of Delhi (Nurse 1899); Kathiawar (region), Gujarat, about 600 miles SW. of Delhi (Mosse 1929); Mount Abu, Rajasthan, 380 miles SW. of Delhi (MacPherson 1927); Kaira District, Gujarat (near Ahmedabad), 580 miles SSW. of Delhi (Aldrich 1946); and Mhow, Madhya Pradesh, 420 miles SSW. of Delhi (Swinhoe 1886).

The terms used in this paper for the relative abundance ('common', 'rare', etc.) are the terms used by the above authors to indicate the status of species in their respective areas.

To clarify the range of certain species, occasional reference is made to specimens in the Michigan State University collection from the following localities (Map 1): Saharanpur, Uttar Pradesh, 90 miles NNE. of Delhi; Aligarh, U. P., 70 miles SE. of Delhi; Agra, U. P., 110 miles SSE. of Delhi; Ludhiana, Punjab, 170 miles NNW. of Delhi; Siliserh, Rajasthan (5 miles south of Alwar), 90 miles SSW. of Delhi; Jaipur, Rajasthan, 140 miles SW. of Delhi; and Sumerpur, Rajasthan (45 miles SSW. of Pali), 340 miles SW. of Delhi.

The following abbreviations are used in the text :

Wing surfaces

UPF—	upper side (dorsal surface) of the forewing.
UPH—	do. do. hindwing.
UNF—	underside (ventral surface) of the forewing.
UNH—	do. do. hindwing.

Seasonal forms

WSF—	wet-season form
DSF—	dry-season form

Collectors

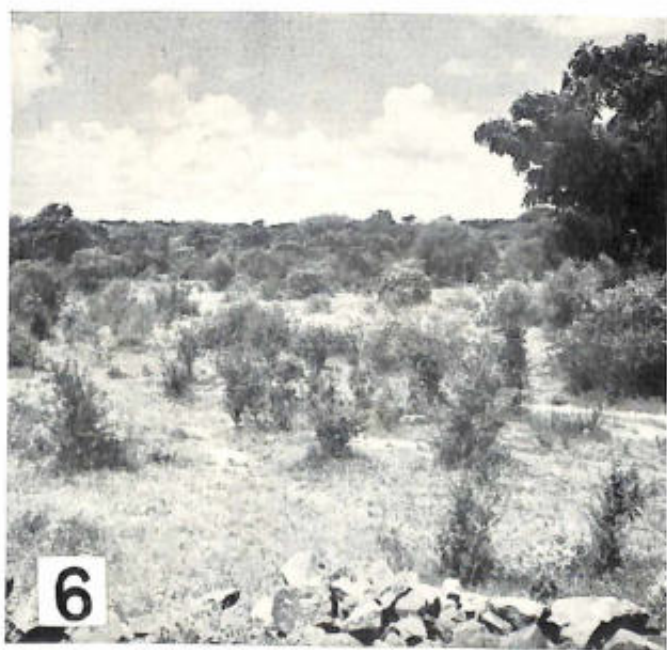
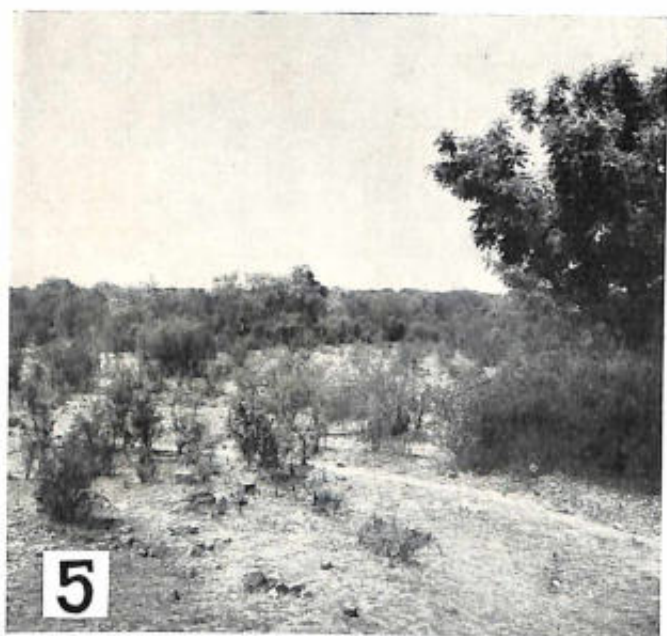
JPD—	Julian P. Donahue.
RLD—	Roy L. Donahue.
RCF—	Reed C. Finrock.

AFFINITIES OF THE DELHI BUTTERFLY FAUNA

The butterfly fauna of Delhi is poor compared to that of the montane, mesophytic habitats of the Western Ghats or the Himalaya. With the exception of *Colias electo*, *Pieris canidia*, and possibly *Argynnis hyperbius*, which are presumably immigrants from the Himalaya, all Delhi butterflies are characteristic of the populations of peninsular India, rather than of the adjacent Himalaya.

On the Indo-Gangetic Plain, a deep alluvial tertiary deposit between the Himalaya and peninsular India, the number of species decreases as

Donahue : Butterflies of Delhi



5. Dry season aspect of vegetation in another portion of Reserved Forest on the Ridge. 9 May 1962. 6. Wet season aspect of same area as 5, on 14 Aug. 1962. Note the marked increase in grasses. Large tree on right is *Azadirachta indica*.

(Photos : Julian P. Donahue)

one goes west. The annual precipitation also decreases as one goes west to the Great Indian Desert where, in some years, there is no precipitation at all. Conversely, the hill ranges of India generally receive a great amount of precipitation and have a rich butterfly fauna.

The 77 species of Delhi butterflies represent seven families (Table 2). For comparison with other localities on the Indo-Gangetic Plain, 84 species have been recorded south-east of Delhi in Lucknow District, U.P. (de Rhé-Philippe 1902, 1905); 54 species north-west of Delhi in Lahore, West Pakistan (de Rhé-Philippe 1917); and 51 species WSW. of Delhi in Jodhpur, Rajasthan (MacPherson 1927).

TABLE 2

FAMILY REPRESENTATION IN DELHI

<u>FAMILY</u>	<u>NUMBER OF SPECIES</u>
Hesperiidae	.. 11
Papilionidae	.. 4
Pieridae	.. 20
Lycaenidae	.. 22
Nymphalidae	.. 13
Danaidae	.. 4
Satyridae	.. 3
Total	.. 77

Extensive irrigation and the introduction of a multitude of exotic trees and shrubs have apparently altered the environment of the cities of Delhi and New Delhi to the point where the shaded residential areas have a lower temperature and a higher humidity. The cities are verdant oases set in a parched land, and several species of butterflies are virtually restricted to the irrigated city. Were it not for the creation of this mesophytic habitat, there is little doubt that fewer species would occur in Delhi.

The diversity of the two major habitats in Delhi perhaps explains the occurrence in Delhi of 20 species of butterflies which appear to be on the periphery of their known ranges (Table 3). The majority of these are more or less restricted to the mesophytic city habitat and have not been reported west of Delhi, where the climate becomes even more arid. Some of these species may occur in the Great Indian Desert, but collections have apparently not been made there.

Four of the remaining peripheral species are characteristic of the arid land west and south-west of Delhi, but have not been recorded east of Delhi, while two species appear to be stragglers or strays from the Himalaya.

In the Delhi area, as is true wherever man goes, the native vegetation must have been considerably altered when land was cleared, crops

were planted, and livestock were turned loose to overgraze the land (see Donahue 1962c). The vegetation on the Ridge probably represents only a portion of once-extensive thorn forests.

Beirne (1947a, 1947b) has noted that, at least in the British Isles, the net result of the activity of man and his animals is the decline and disappearance of populations of many species of Lepidoptera, while relatively few species become more numerous. Apparently no studies of the population ecology of Indian butterflies have been undertaken, but this list of species could well form the foundation for such an investigation in Delhi itself.

TABLE 3

DELHI BUTTERFLIES THAT APPEAR TO BE ON THE PERIPHERY OF THEIR KNOWN RANGES

<u>Species</u>	<u>Periphery</u>
<i>Spialia galba galba</i>	.. western
<i>Suastrus gremius</i>	.. do.
<i>Parnara naso bada</i>	.. do.
<i>Borbo cinnara</i>	.. do.
<i>Graphium nomius nomius</i>	.. do.
<i>Leptosia nina nina</i>	.. do.
<i>Dellias eucharis</i>	.. do.
<i>Ixias marianne marianne</i>	.. do.
<i>Ixias pyrene sesia</i>	.. do.
<i>Rapala iarbus ssp.</i>	.. do.
<i>Charaxes fabius fabius</i>	.. do.
<i>Euthalia nals</i>	.. do.
<i>Mycalopsis perseus tabitha</i>	.. do.
<i>Ypthima intica</i>	.. do.
<i>Pieris canidia indica</i>	.. south-western
<i>Colias electo fieldi</i>	.. do.
<i>Pelopidas thrax thrax</i>	.. eastern
<i>Colotis calais amata</i>	.. north-eastern
<i>Colotis vestalis vestalis</i>	.. do.
<i>Colotis fausta faustina</i>	.. do.

ACKNOWLEDGEMENTS

Were it not for the munificence of The Ford Foundation, which financed the transportation of the author and his gear to India, this study would not have been possible. My primary debt of gratitude is therefore tendered to this great organization.

To my father Dr. Roy L. Donahue and to my good friend Reed C. Finfrock I am deeply indebted for the several thousand specimens of butterflies they collected in Delhi after my departure. My strict instructions to collect every lycaenid and hesperiid they encountered, to the

neglect of larger species, bore fruit: not only was I swamped with tremendous series of common species, but they found several species which I myself had failed to collect in Delhi. To Mrs. Evelyn Jackson, who had the hideous task of mounting all that exiguous material, I am grateful for a job well done.

I further wish to thank Mr. T. G. Howarth and Mr. G. E. Tite, of the British Museum (Natural History), for assistance with taxonomic problems and for examining some Delhi specimens in their care; and Dr. M. G. Ramdas Menon of the Indian Agricultural Institute, New Delhi, for allowing me to examine some of his Delhi butterflies in that institution's collection.

Sir Keith Cantlie was most generous in allowing me to borrow his copy of the rare first edition of THE IDENTIFICATION OF INDIAN BUTTERFLIES by W. H. Evans, without which it would have been more difficult to properly assign names to the nymphalids.

To Dr. Irving J. Cantrall, of the University of Michigan, and C.F.W. Muesebeck, of the U.S. National Museum, go my thanks for identifying a mantid predator and hymenopterous parasites, respectively, of Delhi butterflies.

This study was partially supported by a National Science Foundation Cooperative Graduate Fellowship, and a grant-in-aid from The Society of the Sigma Xi and RESA Research Fund.

ACCOUNT OF SPECIES

HESPERIIDAE

Several of the 11 known species of skippers from Delhi are very similar in appearance. Although there are many characters to separate the groups, such as tibial spines, genitalia, and antennae, only the salient features of the facies of each species are listed here. Complete keys and figures of male genitalia will be found in Evans (1949).

Gangara thyrsis, *Hasora chromus*, and *Badamia exclamationis* are large species, all of which are figured by Wynter-Blyth (1957). *Spialia galba*, a small species with many white spots, is also figured by Wynter-Blyth. *Telicota colon* is the only orange skipper so far recorded from Delhi (figured in Wynter-Blyth as *Astychus augias*). *Gegenes nostrodamus* is a very pale brown species, whose male has no spots on the upperside, while *Suastrus gremius* is the only Delhi species with black spots UNH. Both these latter species are also figured by Wynter-Blyth.

The remaining four species have spotted UPF and are very similar in appearance. *Parnara naso* has no spot in space 1b UPF and no male stigma; *Borbo cinnara* has no spot in the cell UNH, has no male stigma

UPF, and usually does not have two spots in the cell UPF. The two species of *Pelopidas* which can be identified only after genitalic examination, have male stigmas, two spots in the cell UPF, and one spot in the cell UNH. The combinations of these characters will separate the species that have been recorded from Delhi, but additional skippers undoubtedly occur and should be looked for.

Because of recent taxonomic changes and the recognition of new species in this family, published records of the distribution of some species cannot be considered totally reliable.

***Hasora chromus chromus* (Cramer)**

The Common Banded Awl is, as the name implies, the most common and widespread *Hasora* in India, although only five specimens have been collected in Delhi. I collected two males on *Lantana* flowers in the Nursery (26 Aug. and 21 Sept. 1961), while Leela R. Menon collected two males and a female in Delhi (Oct. 1962). These last records indicate that the species may be locally common in suitable habitats. A large skipper, probably this species, was observed on *Lantana* in the Nursery, 4 Nov. 1961, but was not collected.

SIZE: The specimens range in size from 17 mm. to 22 mm.

DISTRIBUTION: This subspecies occurs throughout India (Evans 1949; Wynter-Blyth 1957), and has been recorded as far west as Karachi (Menesse 1950), where it is very rare.

***Badamia exclamationis* (Fabricius)**

Only two males have been examined, both of which were collected by JPD in the Nursery. The first (23 mm.) was taken on 20 July 1962 as it fed on a white-flowered *Lantana* at midday. A second specimen (26 mm.) was collected the following day on *Lantana*, and another was seen but not secured. A few days later RCF obtained three specimens, which remain in his personal collection.

DISTRIBUTION: The Brown Awl occurs rather locally throughout India (Wynter-Blyth 1957), but the British Museum (N.H.) has no specimens west of 'North India' (Evans 1949). It has been recorded from Lucknow (de Rhé-Philipe 1902), where the eggs and larvae were found on *Bignonia gracilis* (de Rhé-Philipe 1905). It has also been recorded from Mount Abu, but not in Jodhpur, by MacPherson (1927); Kutch (Nurse 1899); and Kathiawar (Mosse 1929). It is very rare in Karachi (Swinhoe 1887; Menesse 1950), which is apparently the westernmost record for the species.

***Spialia galba galba* (Fabricius)**

The Indian Skipper, a small but distinctive species, has been collected only sporadically in Delhi. In the Nursery, a female was taken on 15 July 1961 (JPD), and another was collected on 18 November 1962 (RLD). On the Ridge, a male was obtained on 26 Feb. 1963 (RCF), while a female was collected on 9 August 1962 (JPD). In addition, two males and a female were collected in Delhi by Venu, Dec. 1962.

SIZE: Males and females range from 8 mm. to 11 mm.

DISTRIBUTION: This subspecies occurs throughout India, west to Kutch and Sind, east to Assam (Evans 1949). It has not been reported from Jodhpur (MacPherson 1927), is apparently rare in Lahore (de Rhé-Philippe 1917), but is fairly common to common in Lucknow (de Rhé-Philippe 1902), Kutch (Nurse 1899), Kathiawar (Mosse 1929), and Sind (Swinhoe 1887; Menesse 1950). This species may be near the western limits of its range at the latitude of Delhi.

***Suastus gremius gremius* (Fabricius)**

Only five males of the Indian Palm Bob have been collected in Delhi. Two came from the Nursery (25 Sept. 1961, JPD; 17 Nov. 1962, RCF), while Leela R. Menon collected three in Delhi in Nov. 1962. These last records would imply that this species may be more common on the north side of Delhi where the food plants, various species of palm, are more common.

SIZE: The forewings are from 11 mm. to 12 mm. long.

DISTRIBUTION: This distinctive subspecies occurs in south and central India, the north-west Himalaya, and Bengal, Sikkim, and Assam (Evans 1949; Wynter-Blyth 1957). It is the most common hesperiid in Lucknow (de Rhé-Philippe 1902), though it is uncommon in Lahore (de Rhe-Philippe 1917), rare in Kutch (Nurse 1899) and Kathiawar (Mosse 1929), very rare in Karachi (Menesse 1950), and apparently absent from Jodhpur (MacPherson 1927). This species appears to be near the western limit of its range at the latitude of Delhi.

***Gangara thyrasis thyrasis* (Fabricius)**

The only Delhi record of this species is a single specimen in the British Museum (N.H.) from the Godman-Salvin collection [B.M. No. 1913-2] (T.G. Howarth, pers. comm.: specimen cited in Evans 1949, p. 325).

This subspecies of the Giant Redeye occurs from south India to Bombay and Calcutta, and again from Kangra (Punjab Himalaya) to Sikkim, Assam, and farther east. The specimen from Delhi, assuming

no labelling error, is apparently the only record from the Indo-Gangetic Plain, and should be substantiated with additional material. This huge skipper is crepuscular, and should be looked for near various species of palms, the food plant. Beating the bushes during the day-time may dislodge a resting specimen.

***Telicota colon colon* (Fabricius)**

The Pale Palm Dart, the only orange skipper so far recorded from Delhi, has been collected from Sept. IV to Nov. IV, a period during which most of the Delhi hesperiids make their appearance. This species reportedly feeds on sugarcane, so it may be locally common in the parts of Delhi where this crop is grown. Miss Nirmala collected three males in Delhi in Nov. 1962, but all the rest of the specimens examined were taken in the Nursery: one male on 25 Sept. 1961 (JPD), one male on 3 Nov. 1962 (RCF), two males on 4 Nov. 1961 (JPD), a male and a female on 17 Nov. 1962 (RCF), and one male on 25 Nov. 1962 (RCF).

The only hesperiid collected in Delhi by Longstaff (1912), 7-12 Nov. 1903, was probably this species.

SIZE: The specimens range in size from 14 mm. to 16 mm.

DISTRIBUTION: Evans (1949) records specimens in the British Museum (N.H.) from south and central India, Kathiawar, Kumaon, and from the U.P. to Sikkim. Two other subspecies occur in Ceylon, the Andaman Islands, and Assam.

Distributional lists published prior to the appearance of Evans's CATALOGUE (1949) are unreliable, since there appears to have been a considerable amount of confusion and misapplication of names in the two similar genera of *Potanthus* and *Telicota*. Specimens on which earlier lists were based should be re-examined in the light of the recent taxonomic changes before they can be included in our present knowledge of the distribution of the species. An examination of the genitalia, which are figured in Evans (1949), is virtually essential for the proper identification of most species.

This species is described and figured as *Astychus augias* (Linnaeus) in Wynter-Blyth (1957), who omits reference to two other species of Indian *Telicota*.

***Gegenes nostradamus* (Fabricius)**

Only nine males of this arid-land skipper have been collected in Delhi, all from the Nursery: 26 June 1961, 20 July 1962 (3 specimens), 21 and 31 July 1962 (JPD); 3 and 9 Sept. 1962 (RLD); and 4 Nov. 1962 (RCF). Darker specimens occur from late July (when light speci-

mens also occur) to November. The genitalia of all specimens were examined, but *G. pumilio* (Hoffmansegg) was not found, although it has been recorded as far east as the Punjab and Kulu (Evans 1949). This latter species was omitted by Wynter-Blyth (1957).

SIZE: The specimens range from 13 mm. to 14 mm.

DISTRIBUTION The Dingy Swift has been recorded east to Sind; Kutch; Deesa, Gujarat; NW. Frontier Province; and the Punjab, then becomes rare through the U.P. to Bengal (Evans 1949). Longstaff (1912) took it in Lahore, although de Rhé-Philipe (1917) failed to find it there; Aldrich (1946) records it from Kaira District; Menesse (1950) and Swinhoe (1887) have collected it in Sind; and Nurse (1899) took it in Kutch. There are two additional specimens in the Michigan State University collection from Ludhiana, Punjab (12 Sept. 1961).

Parnara naso bada (Moore)

This is the only white-spotted brown skipper so far recorded from Delhi which does not have a spot in space 1b UPF or UNF. Only six specimens have been collected in Delhi, all of which came from the Nursery, Aug. IV to Nov. IV: one male on 26 Aug. 1961 (JPD); one female on 21 Sept. 1961 (JPD); one female on 4 Nov. 1961 (JPD); a male and a female on 4 Nov. 1962 (RCF), and a male on 22 Nov. 1962 (RCF).

SIZE: The forewing is from 14 mm. to 15 mm. long.

DISTRIBUTION: This butterfly occurs in India from Ceylon north to Kashmir and east to Sikkim and Assam (Evans 1949). Wynter-Blyth (1957) apparently included this species with *P. guttatus mangala* (Moore), which is only known to occur in the Himalaya from Chitral to Sikkim and Assam (Evans 1949). *Parnara naso bada* has been recorded from Mount Abu (MacPherson 1927), but other authors have failed to report its occurrence in localities nearer Delhi. There is an additional specimen in the MSU collection from Aligarh, U.P., 17 Nov. 1962 (RLD). Delhi appears to be the westernmost locality recorded for this species at this latitude.

Borbo cinnara (Wallace)

This species is similar to *Pelopidas* females, but can be separated with the characters listed in the introduction to the family. It has been collected only in the Nursery from July III to Nov. IV. 41 specimens: 20 males (49%), 21 females.

SIZE: The forewing length of males and females varies from 14 mm. to 17 mm.

VARIATION: In one female (28 Aug. 1961, JPD) the subapical spots

UPF are almost indiscernible, and the spot in space 1b UPF is absent. The other spots UPF are smaller than usual.

DISTRIBUTION: Although the British Museum (N.H.) has many specimens from India, there appear to be none from west of 'Central India' (Evans 1949). *B. cinnara* has also been recorded from Mount Abu (MacPherson 1927) and Kathiawar (Mosse 1929) as *Baoris colaca* (Moore), a synonym. Previous authors may have confused this species with *Borbo bevani* (Moore) which, though not yet collected in Delhi, has been reported from Lahore (de Rhè-Philippe 1917) and Karachi (Swinhoe 1887). All these records should be re-examined in the light of the revisional work by Evans (1949).

Pelopidas thrax thrax (Hübner)

This species is very similar to *P. mathias*, but it is less common. The males can be distinguished by the position of the stigma UPF: in *P. thrax* the posterior end of the stigma is under the origin of Cu_1 , while in *P. mathias* the posterior end of the stigma is well proximal to the origin of Cu_1 . The male and female genitalia of all Delhi *Pelopidas* have been examined.

The females of these two species are very similar, and only an examination of the genitalia can separate them.

Among the Delhi *Pelopidas*, two types of female genitalia were found: (a) the less common type of female has a lateral, linear, well-defined sclerotized signum on both the right and left sides of the bursa copulatrix; (b) the more common type of female has only a diffuse, indistinct signum on the left side of the bursa copulatrix.

Since no copulating pairs of *Pelopidas* have come into my possession, there is still some doubt as to which type of female to associate with which species. I have arbitrarily assumed that the more common female, type (b), is associated with the more common male, *P. mathias*. Conversely, the type (a) female has been associated with *P. thrax*.

Pelopidas thrax is usually encountered in the Nursery, where it flies with *P. mathias*, but five specimens have been collected on the Ridge. It is probably more frequent on the Ridge than the records indicate, but the dearth of attractive flowers makes this fast-flying species difficult to collect. It has been collected in February IV and March II (Ridge), from July II to November IV (Nursery), and in December IV (Ridge). 35 specimens: 23 males (66%), 12 females.

SIZE: Males and females range from 15 mm. to 17 mm.

DISTRIBUTION: The only Indian record of this western subspecies in the British Museum (N.H.) is a single male from Kutch (Evans 1949), although Evans (1949) and Menesse (1950) report that this species is

common in Sind. Evans (1949) also records two males of a second subspecies, *P. t. masta* Evans from Sikkim. There appear to be no other published records of this species from India, but earlier authors may have confused it with other species. Wynter-Blyth (1957) has omitted it from his book, on which many collectors rely. The author has also collected two males 15 miles south of Saharanpur, U.P., 8 May 1961.

***Pelopidas mathias mathias* (Fabricius)**

The most common Delhi skipper, numerous on *Lantana* during and after the monsoon. It has been collected in most habitats, March I and IV, and from July III to December I, although it is most frequently collected in the Nursery. 100 specimens: 69 males (69%), 31 females.

Although the males can be distinguished from the preceding species by the position of the stigma and by examining the genitalia, the only sure way to separate the females is by examining their genitalia.

SIZE: The males and females range in size from 14 mm. to 16 mm., averaging only about 1 mm. smaller than *P. thrax thrax* from Delhi.

DISTRIBUTION: Evans (1949) records specimens in the British Museum (N.H.) from virtually throughout India, including Punjab, Sind, and U.P. It has also been recorded from Lucknow (de Rhé-Philipe 1902), Jodhpur (MacPherson 1927), Lahore (de Rhé-Philipe 1917), and Sind (Menesse 1950). There is a male in the MSU collection from Aligarh, U.P. (17 Nov. 1962, RLD).

PAPILIONIDAE

***Polydorus aristolochiae aristolochiae* (Fabricius)**

Although the specific name of this species was upheld by Opinion 265 in 1954 (rather than supplanting it with *ascanius* or *diphilus*, see Talbot 1947, p. 491), the generic name is still being debated. Munroe (1961) has placed this species in the genus *Pachlioptera* Reakirt, but Kent H. Wilson (pers. comm.) believes that it will come to rest in *Parides* Hübner. For the time being the arrangement of Talbot (1939) will be followed.

Only four Delhi specimens have been examined: a male collected by JPD in the Nursery on 27 Sept. 1961 (46 mm.), two males collected in Delhi in Oct. 1962 by Leela R. Menon (both 48 mm.), and a male collected in Delhi in Nov. 1962 by Miss Nirmala (48 mm.). The fact that three specimens were collected on the north side of Delhi in a two-month period may indicate that the species is more common there.

Longstaff (1912) reported that he saw 'many' in Delhi, 7-12 Nov. 1903.

DISTRIBUTION: The Common Rose is widespread throughout India (Talbot 1939; Wynter-Blyth 1957), and has been recorded as far west as West Pakistan (Menesse 1950).

Papilio polytes romulus Cramer

This swallowtail, the subject of a great deal of study because of the mimetic colour patterns of the females, is not very common in Delhi. It has been collected on the Ridge only once (Feb. IV), and at scattered times in the Nursery: March I and IV; May I; and July II to Nov. I. 31 specimens: 13 males (42%), 18 females, of which two (11%) are form '*romulus*' Cramer, a mimic of *Polydorus hector* (Linnaeus), which has not been recorded in Delhi; seven (39%) are form '*cyrus*' Fabricius, which has the same facies as the male; and nine (50%) are form '*stichius*' (Hübner), whose model is *Polydorus aristolochiae*; a species which appears to be less common in Delhi than its mimic.

The '*cyrus*' form of the female has been observed ovipositing on lime bushes (*Citrus*) on two occasions: on 21 Aug. 1962; and on 6 Sept. 1961, when one laid nine eggs (one egg to a leaf) on a single lime bush before the specimen was collected.

The larvae of both *P. polytes* and *P. demoleus* may be found on the *Citrus* bushes in the Nursery, but only one male was reared: the larvae pupated on 5 Sept. 1961, and the adult emerged 14 Sept. 1961.

On 27 July 1961 an egg of either *P. polytes* or *P. demoleus* was collected from a lime bush in the Nursery (the egg was about 3 mm. from the edge, on the underside of the leaf). On the evening of 28 July 1961 a hymenopterous parasite was observed emerging from the egg, and by the next day three parasites had emerged. They have been identified as *Telenomus (Aholcus) talaus* Nixon (Scelionidae) by C.F.W. Muesebeck of the U.S. National Museum, where all three specimens are deposited. The type series of this parasite was described from the eggs of *Graphium agamemnon* (Linnaeus) in Malaya.

SIZE: ♂♂ 38 mm. (7 March 1964, RLD) to 50 mm. (several); ♀ form '*stichius*' 46 mm. (15 July 1961, JPD) to 53 mm. (28 Aug. 1961, JPD); ♀ form '*cyrus*' 44 mm. (26 Aug. 1961, JPD) to 52 mm. (22 July 1961, JPD); ♀ form '*romulus*' 51 mm. (2 May 1963, RLD) and 52 mm. (13 Aug. 1962, JPD).

VARIATION: *Papilio polytes* is one of the classic examples of polychromic mimicry. Goldschmidt (1945) proposes hypothetical genotypes for all forms of this species, and includes a good bibliography on the subject.

Annandale & Dover (1921) have summarized the relative abundance of the three female forms in India. In general, the most common is 'stichius,' followed by 'romulus' and 'cyrus.' The 'cyrus' form is considered to be absent or rare in many localities. In north India, including Delhi, the 'romulus' form becomes less common, where its model, *Polydorus Hector*, apparently does not occur.

Sevastopulo (1947, 1956) reared 175 *P. polytes* from eggs in Calcutta. Of the 95 females he obtained, 68% were 'stichius,' 19% were 'cyrus' and 13% were 'romulus.' Sanders (1955), however, found that the 'cyrus' form was only very rarely collected in Calcutta.

The most important point concerning the Delhi female forms is that the male-like 'cyrus' form is relatively common, perhaps because there is little natural selection for the two mimetic forms when the models are uncommon (*P. aristolochiae*) or absent (*P. Hector*) in Delhi.

DISTRIBUTION: The Common Mormon is found throughout India (Talbot 1939; Wynter-Blyth 1957). In Lucknow the 'stichius' female is most common, 'romulus' is rare, and 'cyrus' has not been found (de Rhé-Philippe 1902). In Jodhpur the 'cyrus' female has not been recorded (MacPherson 1927). It is interesting to note that MacPherson (1927) found *Polydorus Hector*, the model for the 'romulus' form of *P. polytes*, in Jodhpur in 1924, which is apparently the northernmost record for the species.

Papilio demoleus demoleus Linnaeus

The Lime Butterfly is the most common Delhi swallowtail, and is usually found in the Nursery where its foodplant, *Citrus*, is cultivated, although specimens are occasionally encountered on the Ridge. It has been recorded in March II (Ridge) and May IV, from July I to Sept. IV, and Nov. I. The poor representation of some months may be because the species is so common and easily recognized that it is not collected. 48 specimens: 28 males (58%), 20 females. Females have only been collected from July I to Sept. IV.

A copulating pair was collected on 13 July 1961 (JPD), and a female was observed ovipositing on young basal leaves of *Citrus* on 15 July 1961. Several larvae, which are very similar to the larvae of *P. polytes*, were collected from *Citrus*, and four were reared through to adults. The pupation dates were 1 Aug., 2 Sept., 2 Sept., and 3 Sept. 1961. The emergence dates were 16 Aug. (?), 13 Sept., 14 Sept., and 14 Sept. 1961, respectively.

See the comments under *P. polytes* for notes on egg parasites of *P. demoleus* or *P. polytes*.

SIZE: ♂♂ 33 mm. (4 Aug. 1962, JPD) to 47 mm. (15 July 1961, JPD). ♀♀ vary only slightly, from 44 to 50 mm. Assuming that 'expanse' is

twice the length of one forewing, the small male cited here is about the same size as the smallest *P. demoleus* (? sex) cited by Crawford (1930).

DISTRIBUTION: This species is common throughout India (Talbot 1939: Wynter-Blyth 1957).

Graphium nomius nomius (Esper)

The only known Delhi specimen of the Spot Swordtail was collected at midday in the Nursery on 20 July 1962 as it fed on a white-flowered *Lantana*. The specimen, a female, is virtually perfect (the left tail is missing), and the forewing is 40 mm. long.

DISTRIBUTION: The distribution given by Talbot (1939), 'Ceylon, Southern India to the Sikkim lowlands,' leaves much to be desired. According to Wynter-Blyth (1957) this species occurs in the Himalaya from Simla east, and in peninsular India north to Madhya Pradesh and southern Bihar, west to Saurashtra and Lucknow. At first de Rhé-Philippe (1902) considered it rare in Lucknow, but later he (1905) reported that it was regular in July and August. It was observed at Mahuva, on the west coast of the Gulf of Cambay, Gujarat, by Mosse (1929), and has been taken on Mount Abu (MacPherson 1927). Delhi appears to be the westernmost record of this species in the Indo-Gangetic plain north of Gujarat.

PIERIDAE

Leptosia nina nina (Fabricius)

The Psyche is rare in Delhi: it has been found only in moist, shaded portions of the Nursery, where it may be flushed by beating the grass. Its habitat is essentially the same as that of *Euploea core*. The three specimens were collected on 26 Aug. (♀, 17 mm.), 25 Sept. (♀, 14 mm.), and 4 Nov. 1961 (♂, 18 mm.).

Longstaff (1912) found this species in Delhi, 7-12 Nov. 1903.

DISTRIBUTION: This fragile butterfly occurs more or less throughout India, but the western limits of its range are not well defined (Wynter-Blyth 1957; Talbot 1939). It is very local in Lucknow (de Rhé-Philippe 1905), but it has not been reported south-west or west of Delhi. Despite Wynter-Blyth's (1957) statement that it occurs in Sind, Menesse (1950) and Swinhoe (1887) have failed to record it from that region. Delhi, therefore, appears to be the westernmost record of this species in India.

***Delias eucharis* (Drury)**

This species was first observed feeding on *Lantana* in the Nursery on 5 Nov. 1961, and another specimen was observed flying over the Nursery the next day, but the first specimen was not collected until 23 Nov. 1961, when a worn female was caught on *Lantana* in the Nursery. The only other Delhi specimen examined was another worn female collected by RLD in the Nursery on 21 March 1965.

SIZE: The forewing of both specimens is 38 mm. long.

DISTRIBUTION: The Common Jezebel occurs from the lower slopes of the Himalaya south to Ceylon (Talbot 1939), although it is less common in the north-western part of its range. It is seasonally common in Lucknow (de Rhé-Philippe 1902) and Fatehgarh (Peile 1911), but is apparently rare in Jodhpur (MacPherson 1927), Lahore (de Rhé-Philippe 1917), and Kanpur, U.P. (Sevastopulo 1948). Delhi appears to be near the western periphery of the range of this species, since there are no records from West Pakistan.

***Cepora nerissa phryne* (Fabricius)**

The Common Gull occurs from July II to May I in all habitats, although it is more frequently collected in the Nursery. It is uncommon from December through May, a period in which the females are more frequent than males. Longstaff (1912) found only males of this species in Delhi, 7-12 Nov. 1903. 126 specimens: 65 males (52%), 61 females.

SIZE: ♂♂ 20 mm. (25 Dec. 1962, RCF) to 29 mm. (31 July 1962, JPD). ♀♀ 18 mm. (26 Feb. 1963, RCF) to 29 mm. (17 Aug. 1962, JPD).

VARIATION: Males and females from mid-April to mid-November are larger and darker, with the veins UNH prominently blackened, while dry-season specimens are smaller, with the UNH ground colour a paler yellow, with the veins blackened faintly or not at all.

DISTRIBUTION: Throughout peninsular India (Talbot 1939), at least as far west as Jodhpur (MacPherson 1927) and Lahore (de Rhé-Philippe 1917). It has not been recorded from Sind (Menesse 1950).

***Anapheis aurota aurota* (Fabricius)**

The Pioneer is one of the most common Delhi butterflies, occurring in all habitats throughout the year: abundant from March to May, then becoming less frequent until November, when it becomes common again. Uncommon in January. 362 specimens: 205 males (57%), 157 females.

Longstaff (1912) says this species was 'abundant at flowers' 7-12 Nov. 1903, and saw 'countless crowds' at Mahrauli (8 miles SSW. of New Delhi).

The sex ratio of field-collected specimens varies markedly: 46% males April II (20 specimens); 53% males for the month of March (166 specimens); 73% males in a series of 41 specimens collected at Tughlakabad, 10 Nov. 1962 (RCF); and 84% males May I (25 specimens).

Four copulating pairs have been collected: 24 March 1963 (2 pairs, RLD); 10 April 1962 (JPD); and 13 April 1962 (JPD, male very worn). On 2 May 1962 a cluster of four pupae and nine pupal cases was found on a thorny twig on the Ridge. Adults emerged from three of the pupae the next day (the fourth was preserved before emergence). Nurse (1899) has also observed over a dozen pupae on a single twig, in Kutch. Two larvae were also collected on 2 May. One was lost, but the second pupated on 4 May and emerged (σ) on 10 May 1962.

Adults were observed on Neem flowers (*Azadirachta indica*) on 2 May 1962. This species has also been observed attracted to light in Delhi (Donahue, MS. in preparation).

SIZE: $\sigma\sigma$ 18 mm. (2 May 1962, JPD; 16 June 1964, RCF) to 27 mm. (many specimens throughout the year). ♀♀ 18 mm. (14 Nov. 1963, RLD) to 29 mm. (11 March 1963, RLD; 10 Nov. 1962, RCF).

VARIATION: The seasonal forms are difficult to characterize, but specimens collected from May to August generally have less black suffusion on the veins and a paler ground colour UNH than dry season specimens. Three males collected in March (RCF) and May (JPD) have the spot at the end of the cell UPF detached from the costa, as opposed to most specimens, which have the spot connected to the costa with a dark band.

DISTRIBUTION: The Pioneer is common in India, extending west to Palestine and Africa (Talbot 1939).

Appias libythea libythea (Fabricius)

The Striped Albatross is the least common of the large Delhi 'whites'. It occurs on both the Ridge and in the Nursery, August IV (Nursery only), Nov. I to Dec. III, and Feb. IV (Ridge, one male). The females have only been collected in Aug. IV and again in December. This butterfly may be more frequent in Delhi, but it is possibly overlooked because of its general resemblance to several other pierids (*Cepora nerissa*, *Catopsilia* spp., *Anapheis aurota*). A copulating pair was collected on 28 Aug. 1961 (JPD). 20 specimens: 15 males (75%), 5 females.

SIZE: $\sigma\sigma$ 22 mm. (1 Dec. 1962, RLD) to 29 mm. (29 Aug. 1961, JPD). ♀♀ 21 mm. (25 Dec. 1962, RCF) to 24 mm. (28 Aug. 1961, JPD).

VARIATION: The August specimens are largest. The four August males have darker markings on the apex and margin UPF than dry season specimens; the only August female is darker on the upperside than the December females, e.g. UPH with large marginal spots, a discal band, and streaks connecting the spots with the band.

DISTRIBUTION: Peninsular India to the Punjab (Talbot 1939). It is rare in Lucknow (de Rhé-Philipe 1902, 1905, who identified it as *A. paulina*, which does not occur in north India) and on Mount Abu (MacPherson 1927). It has also been recorded from Lahore (de Rhé-Philipe 1917), and southward in peninsular India. There is also a female in the MSU collection from Siliserh, Rajasthan, 19 Nov. 1963 (RLD). This species is apparently uncommon but widely distributed in India.

Pieris canidia indica Evans

The Indian Cabbage White is one of the butterflies whose occurrence in Delhi came as a surprise. Only five specimens have been collected: a male from the Nursery on 28 March 1963 (RLD), 26 mm., and four specimens from the Ridge—a female on 21 Feb. 1963 (RCF), 25 mm.; two females on 12 April 1963 (RCF), 22 and 23 mm.; and a male on 13 April 1963 (RCF) 23 mm. There is also a single specimen in the I.A.R.I. collection, obtained in Delhi by M. G. Ramdas Menon, 6 March 1958.

DISTRIBUTION: This subspecies is normally confined to the Himalaya, where it is very common (Wynter-Blyth 1957; Talbot 1939), but it has been reported south of the hills several times. Sanders (1930) found it 15 miles NE. of Amritsar, Punjab, on 23 Feb., and again in late March, when it was present in 'considerable quantities.' Sevastopulo (1948) also reports that it is 'common at Amritsar before the weather gets hot,' and de Rhé-Philipe (1902) captured a single faded female in Lucknow in April. Although de Rhé-Philipe (1917) failed to record it from Lahore, he did observe *P. brassicae* there in Nov., Jan., and Feb. *Pieris brassicae* is also reportedly common in Fatehgarh in the early spring (Peile 1911).

Delhi is apparently the south-western most record of this subspecies.

Ixias marianne marianne (Cramer)

The White Orange Tip, like many other Delhi butterflies, is rare in the cold months of January and February, and again in the hot dry months from April to early July. It is common during the monsoon, but the population tapers off again in December. Although more frequently collected in the Nursery, it also occurs on the Ridge where

it is occasionally numerous. It has been recorded in Delhi from July I to Jan. I, and Feb. II to May II. 210 specimens: 118 males (56%), 92 females. The sex ratio of field-collected specimens appears to remain fairly constant.

Longstaff (1912) collected this species at Mahrauli (10 Nov. 1903) and in Delhi (7-12 Nov. 1903).

SIZE: ♂♂ 19 mm. (23 March 1963, RCF; 21 Feb. 1963, RCF) to 28 mm. (28 Aug. 1961, JPD). ♀♀ 21 mm. (several August specimens) to 27 mm. (29 Aug. 1961, JPD).

VARIATION: Wet season specimens of this variable species tend to be more heavily marked. Three of the females examined had none of the usual black spots in the orange subapical band UPF (13 April 1963, RCF; 25 Sept. 1961, JPD; and 24 Nov. 1962, RCF). In the dry season form of the female, which occurs from early November through May, the dark band bordering the proximal edge of the orange subapical band UPF is absent.

DISTRIBUTION: This handsome species is endemic to India, and occurs from the Punjab, U.P., and Nepal south to Ceylon (Talbot 1939; Gabriel 1943). Wynter-Blyth (1957) adds Saurashtra and Bengal to this range. It is common in Lucknow (de Rhé-Philipe 1902); apparently absent from Jodhpur, although it is common on Mount Abu (MacPherson 1927); and very rare in Lahore (de Rhé-Philipe 1917). It appears to be absent from Kutch, but it is common in adjacent Kathiawar (Mosse 1929). The MSU collection contains specimens from 15 miles south of Saharanpur, U.P. (8-9 May 1961); Aligarh, U.P. (17 Nov. 1962, RLD); and Amber, Rajasthan (7 miles north of Jaipur, 15 Nov. 1963, RLD). Delhi may be near the western periphery of the range of this species, since the specimen from Amber is the only record from northern or central Rajasthan known to the author.

Ixias pyrene sesia (Fabricius)

There is still some doubt surrounding the subspecies to which the Delhi population should belong. According to Talbot (1939), Delhi specimens would belong to *I. p. kausala* Moore, since the female is often white. But Gabriel, who revised the genus in 1943, ascribes white female forms to both *I. p. sesia* and *I. p. kausala*, and only gives Himalayan localities for the distribution of the latter. A careful examination of the descriptions in Talbot (1939) and Gabriel (1943), an examination of the figures in Swinhoe (1905-1910), and a comparison of Delhi specimens with *I. p. sesia* from south India led to the conclusion that the Delhi population is probably referable to *Ixias pyrene sesia* (Fabricius).

The Yellow Orange Tip is less common in Delhi than *I. marianne*, and occurs from Aug. III to Sept. IV, and again from Nov. I to May II. There are no records from June, July, or October, although this may be due to incomplete sampling. This species is common in March, and apparently common from the wet season through December. 86 specimens: 62 males (72%), 24 females.

Longstaff (1912) found the Yellow Orange Tip in Mahrauli (10 Nov. 1903) and in Delhi (7-12 Nov. 1903), when he saw only two specimens.

SIZE: ♂♂ 19 mm. (29 March 1964, RCF) to 27 mm. (3 Sept. 1962, RLD). ♀♀ 19 mm. (26 Feb. 1963, RCF) to 27 mm. (17 Aug. 1962, JPD).

VARIATION: Both seasonal and sexual dichromism are conspicuous in this species. The wet-season form, characterized by its larger size and wide marginal band UPH, occurs in August and September. Wet-season females are further characterized by the wide discal band UPF, which is more or less uniform in width to the tornus. Transitional forms with a macular margin UPH occur in early November, but the dry-season form appears in late November and flies until May. Most dry-season specimens have no trace of the marginal band UPH, and the females have only a narrow line connecting the bar at the end of the cell UPF with the tornus.

Two colour phases of the female occur: ground colour white or greenish white, with a slightly darker subapical band UPF; and ground colour pale yellow or greenish yellow, with the subapical band UPF of the same colour or pale orange. Both forms are about equal in frequency, fly together, and are apparently not associated with a particular season as are the female forms of *Colotis fausta*.

DISTRIBUTION: The Yellow Orange Tip appears to be uncommon in the arid plains of north-western India. The male is common in Lucknow, but the female has not been taken there (de Rhé-Philipe 1902); it is absent from Jodhpur but common on Mount Abu (MacPherson 1927); and apparently rare in Fatehgarh (Peile 1911). Menesse (1950) never observed this species in Sind, so it would appear that Delhi is near the western edge of the range at this latitude.

Colotis calais amata (Fabricius)

This is a small version of *C. fausta* but, unlike that species, it is found almost exclusively in the Nursery—there are only two records, Feb. IV and March II, from the Ridge. It occurs from July III to May IV (no June records). 175 specimens: 113 males (65%), 60 females, 2 unsexed. Infrequent from January to March, and in September and October (insufficient collecting?).

Longstaff (1912) found this butterfly 'abundant alike in the Kudsia gardens and close to the hotel . . .', in Delhi, 7-12 Nov. 1903. He also noted that one specimen was 'very small'.

SIZE: ♂♂ 13.5 mm. (22 Nov. 1962, RCF) to 20 mm. (26 Aug. 1962, RLD). ♀♀ 15 mm. (29 May 1962, JPD) to 21 mm. (29 Aug. 1961, JPD).

VARIATION: Specimens collected from July III through March are generally larger and darker than specimens collected in April and May. This is an unusual distribution of seasonal forms, since the forms do not correlate well with precipitation patterns. But April and May are two of the warmest months of the year, so temperature or insolation may be the dominant environmental factors affecting the appearance of the forms. There are no records from June, which is another of the warmest months.

DISTRIBUTION: This subspecies of the small Salmon Arab occurs from Bombay north to Sind, Baluchistan, and U.P., west to Iran and Syria (Talbot 1939). It has not been reported from Lucknow (de Rhé-Philippe 1902), but it is fairly common in Jodhpur (MacPherson 1927), common in Lahore (de Rhé-Philippe 1917), and common in Sind (Fraser 1911; Menesse 1950). Two additional specimens are in the MSU collection from Agra, U.P. (21 Nov. 1957). Delhi appears to be near the north-eastern edge of the range of this species.

Colotis vestalis vestalis (Butler)

The White Arab, like its relative *C. calais*, is found exclusively in the Nursery, where it is very common during the monsoon, although it has been collected there every month of the year. 167 specimens: 102 males (61%), 65 females.

SIZE: ♂♂ 15 mm. (29 May 1962, JPD) to 20 mm. (several specimens collected during the monsoon). ♀♀ 14 mm. (30 April 1963, RLD) to 21 mm. (two specimens, 31 July 1962, JPD).

VARIATION: The seasonal forms are not well differentiated, except that specimens flying during the monsoon are brighter yellow on the underside.

DISTRIBUTION: This species occurs from the Persian Gulf east to Sind, Baluchistan, and the U.P. (Talbot 1939). It is common in Sind throughout the year (Fraser 1911; Menesse 1950); 'exceedingly abundant' during all months except May and June in Lahore (de Rhé-Philippe 1917); common in Lyallpur, W. Pakistan (70 miles west of Lahore: Sevastopulo 1948); and common during the fall and winter months in Jodhpur (MacPherson 1927). It has not been recorded from Lucknow (de Rhé-Philippe 1902). The author obtained several specimens in Agra, U.P. (21 Nov. 1957).

Delhi is apparently near the north-eastern edge of the range of this species.

Colotis fausta faustina (C. & R. Felder)

The Large Salmon Arab, the most striking of the Delhi *Colotis*, was not found until the first trip to the Ridge, to which it is restricted and where it is abundant virtually throughout the year, Nov. I to Dec. IV, and Feb. III to Sept. IV. Cold weather may account for its absence in January, but it should occur in October. 214 specimens: 146 males (68%), 68 females.

The sex ratio varies somewhat, although probably not significantly. On 14 Aug. 1962, 27 specimens were collected, of which 22 (81%) were males. On 20 Aug. 1962, 18 specimens were obtained, of which 12 (68%) were males. Only the white form of the female occurs in August and, since they are not frequent, they were collected in preference to the males—hence the actual percentage of males flying was probably greater than indicated by the figures above. On 18 Nov. 1962, when the salmon-coloured females could not be distinguished from the males, 27 specimens were collected (RCF), of which 19 (70%) were males.

VARIATION: The females occur in two forms: a form with a white or salmon-white ground colour on the upper- and undersides, which flies from Aug. II to Nov. I (no October records); and a salmon-coloured form, indistinguishable from males, which flies from Nov. I to Dec. IV and from Feb. IV to July I. Previous authors have failed to observe that these two colour phases are seasonal—the white or salmon-white form flying in the wet season, the salmon form flying in the dry season. Both forms fly together in the first week of November, and may also be found to occur together in October.

The dry-season form of both sexes (Nov. I to July I) is also characterized by being smaller and having the black markings on the upperside reduced: the black apical markings UPF are less extensive, and the black margin UPH is reduced to separate spots, a very narrow line, or is entirely absent.

One symmetrically aberrant male (15 Feb. 1964, RCF) has a rounded apex on both forewings, quite unlike the apex of normal specimens. The black apical markings UPF are consequently more reduced than usual for the DSF.

PREDATOR RECORD: On 20 August 1962 a specimen was observed being eaten by a praying mantis, identified as a nymph of *Gongylus gongyloides* (Linnaeus) (Orthoptera: Mantidae) by Dr. Irving J. Cantrall of the University of Michigan.

DISTRIBUTION: This subspecies is reported as 'not rare' from the Punjab to Sind and Karwar, Mysore. The nominate subspecies occurs

as far west as South Arabia, Turkey, and Egypt (Talbot 1939). Published records of this species are sparse, perhaps due to its very local occurrence. The only records near Delhi are a few sight records in Jodhpur (MacPherson 1927), a single specimen collected in Lahore in October (de Rhé-Philipe 1917), a female in the MSU collection from Pali, Rajasthan (4 Oct. 1961), and a male from Siliserh, Rajasthan (19 Nov. 1963, RLD). This species is more common in Kutch (Nurse 1899) and Kathiawar (Mosse 1929), but Aldrich (1946) records it as 'not rare' in Kaira District. It is reportedly rare in Sind (Fraser 1911; Menesse 1950).

Delhi is apparently the north-easternmost record of this species in India.

Colotis etrida etrida (Boisduval)

The Little Orange Tip is the only *Colotis* which is common in all Delhi habitats. It occurs from Nov. I to Sept. I, but appears to be uncommon (or poorly collected) in January, June, September, and October. 322 specimens: 192 males (60%), 130 females.

Longstaff (1912) found it 'in abundance, flying close to the ground' in Mahrauli, 10 Nov. 1903.

SIZE: ♂♂ 13 mm. (3 March 1963, RCF) to 19.5 mm. (9 Aug. 1962, JPD). ♀♀ 11 mm. (9 May 1962, JPD) to 20 mm. (17 Aug. 1962, JPD).

VARIATION: Wet-season specimens are usually larger and darker on the upperside than dry-season specimens. The wet-season form, which flies from April through September, is almost immaculate UNH, but males have marginal black spots UPH. The dry-season form, which occurs from November through March, has a considerable amount of black dusting UNH, while the males have almost no trace of the marginal spots UPH.

Two extreme wet-season females (9 Aug. 1962, JPD) have the apical black UPF so extensive that only a trace of the orange band shows. The underside of these specimens is more yellow than usual.

DISTRIBUTION: This species occurs from peninsular India to the Himalaya (Talbot 1939). It is rare in Lucknow (de Rhé-Philipe 1902); fairly common in Jodhpur (MacPherson 1927); common in the Hardoi District, 190 miles SE. of Delhi (de Rhé-Philipe 1902); common in Lahore (de Rhé-Philipe 1917); and common in Sind (Fraser 1911; Menesse 1950). Additional specimens from Siliserh, Rajasthan (19 Nov. 1963, RLD) and Agra, U.P. (21 Nov. 1957) are in the MSU collection.

Genus *Catopsilia* Hübner

There is a strong belief by many workers that *C. crocale* and *C. pomona* are conspecific, and that *C. florella* and *C. pyranthe* are also

conspecific (see Sevastopulo 1950; and Talbot 1939 and 1947, p. 493, for a summary of current thinking). The four 'species' are treated as entities in this paper merely because they can be easily separated. No endorsement, expressed or implied, is intended concerning the conspecific or distinct status of these four 'species'.

Catopsilia crocale crocale (Cramer)

The Common Emigrant has been collected only in the Nursery, from July II to Nov. I (no October records). 38 specimens: 23 males (61%), 15 females, of which 10 (67%) are form '*jugurtha*' (Cramer), 3 (20%) are form '*crocale*' (Cramer), and 2 (13%) are form '*jugurthina*' (Godart). The '*crocale*' and '*jugurthina*' forms have only been collected in July. The male forms '*alcmeone*' (Cramer) and '*flavescens* Frühstorfer are considered together, since there is some overlap in the colour pattern.

SIZE: ♂♂ 29 mm. (15 July 1961, JPD) to 37 mm. (13 July 1961, JPD). ♀♀ 24 mm. ('*jugurthina*,' 15 July 1961, JPD) to 39 mm. '*crocale*,' 14 July 1961, JPD).

DISTRIBUTION: 'Very common' throughout India (Wynter-Blyth 1957; Talbot 1939). It has been recorded as common in Lucknow (de Rhé-Philipe 1902), Lahore (de Rhé-Philipe 1917), Jodhpur (MacPherson 1927), and Sind (Menesse 1950).

Catopsilia pomona (Fabricius)

The Lemon Emigrant is apparently the rarest of the four 'species' of *Catopsilia* in Delhi. Less than 4% of the *Catopsilia* specimens are referable to this 'species'. The rapid flight of *Catopsilia* makes them difficult to collect, so this 'species' may be more common than the records indicate. All ten specimens are from the Nursery, except for a male collected on the Ridge, 23 April 1963 (RCF), 36 mm. Males were collected in the Nursery on 15 July 1961 (JPD), 37 mm.; 28 Aug. 1961 (JPD), 31 mm.; and 29 Aug. 1961 (JPD) 32 mm. The female form '*hilaria*' (Stoll) has been collected on 5 Jan. 1963 (RLD), 27 mm.; 6 Jan. 1963 (RCF), 31 mm.; and 21 July 1962 (JPD), 28 mm. The female form '*catilla*' (Cramer), usually considered 'not rare', has been collected in the Nursery on 14 July 1961 (JPD), 36 mm.; 31 Aug. 1961 (JPD), 35mm.; and 28 Oct. 1962 (RLD), 29 mm.

DISTRIBUTION: As for *C. crocale*, except that *C. pomona* is uncommon in Jodhpur (MacPherson 1927) and Sind (Menesse 1950).

Catopsilia pyranthe pyranthe (Linnaeus)

The Mottled Emigrant is confined to the Nursery, with the exception of three males from the Ridge in August. It has been collected April IV, May IV, and from July II to Nov. III. Females have only been collected between April IV and Sept. IV. Copulating pairs have been collected on 20 July 1962 (JPD) and 29 Aug. 1961 (JPD). 109 specimens: 64 males (59%), 45 females.

SIZE: ♂♂ 22 mm. (3 Sept. 1962, RLD) to 32 mm. (11 Aug. 1962, RLD). ♀♀ 19 mm. (29 May 1962, JPD) to 32 mm. (31 July 1962 and 26 Aug. 1961, JPD).

DISTRIBUTION: As for *C. crocale*.

Catopsilia florella gnoma (Fabricius)

The African Emigrant is less common and more scattered throughout the year than *C. pyranthe*. It has been collected in July III and IV, from Sept. I to Jan. I, and from Feb. III to April IV. Further collecting may produce specimens from May, June, and August, the months for which there are no records. Specimens have been collected on the Ridge only in the last weeks of February, March, and December. Only four specimens have been collected in Delhi during the monsoon season, when *C. pyranthe* is most abundant, thus lending support to Talbot's (1939) belief that *C. florella* is a dry-season form of *C. pyranthe*.

SIZE: ♂♂ 23 mm. (1 Dec. 1962, RLD) to 31 mm. (29 March 1964, RCF). ♀♀ 21 mm. (30 April 1963, RLD) to 31 mm. (3 Sept. 1962, RLD).

DISTRIBUTION: As for *C. crocale*.

Eurema brigitta rubella (Wallace)

The Small Grass Yellow is the least common Delhi *Eurema*. It is found in all habitats from Aug. II to Jan. I, and again in Feb. III and IV (Ridge). It is most frequently collected in August (10 specimens), September (12 specimens), and November (23 specimens). Females have only been collected from Aug. II to Dec. IV. 57 specimens: 39 males (68%), 17 females, 1 unsexed.

SIZE: ♂♂ 14 mm. (several, Nov. & Dec.) to 19 mm. (29 Sept. 1961, JPD). ♀♀ 15 mm. (20 Aug. 1962, JPD; 18 Nov. 1962, RCF) to 19 mm. (several, late Sept. to early Nov.).

VARIATION: The marginal band UPH is continuous and broad from Aug. II to early November, after which it becomes reduced and macular. Wet season females (Aug. to Oct.) have a considerable amount of black scaling on the upper and undersides.

DISTRIBUTION: Throughout India, while other subspecies occur west to the Ethiopian Region (Talbot 1939). It is reportedly scarce in Lucknow (de Rhé-Philipe 1902), uncommon in Jodhpur (MacPherson 1927), and occasionally abundant, though usually uncommon, in Lahore (de Rhé-Philipe 1917). There are additional specimens in the MSU collection from Ludhiana, Punjab (11-12 Sept. 1961), Siliserh, Rajasthan (19 Nov. 1963, RLD), and Agra, U.P. (21 Nov. 1957).

Eurema laeta laeta (Boisduval)

The Spotless Grass Yellow is more common on the Ridge, but it occurs in all habitats from Aug. II to April II. 103 specimens: 61 males (59%), 42 females.

SIZE: ♂♂ 13.5 mm. (26 Feb. 1963, RCF) to 18 mm. (18 Nov. 1962, RCF). ♀♀ 14 mm. (20 Aug. 1962, JPD) to 19 mm. (29 Sept. 1961, JPD).

VARIATION: The wet season form '*venata*' (Moore) occurs from Aug. II to Sept. IV. DSF '*laeta*' (Boisduval) occurs from Oct. IV to April II. There are no records from early October, when both forms or a transitional form should occur. The dry season form is so pale that it appears almost white in flight.

DISTRIBUTION: Throughout India (Talbot 1939). A few specimens, of form '*laeta*' only have been reported from Lahore (de Rhé-Philipe 1917), but it is common in Jodhpur (MacPherson 1927). It has not been recorded from Lucknow (de Rhé-Philipe 1902). There are additional specimens in the MSU collection from 15 miles south of Saharanpur, U.P. (8-9 May 1961), Siliserh, Rajasthan (19 Nov. 1963, RLD), and Pali, Rajasthan (9 May 1961).

Eurema hecabe simulata (Moore)

The Common Grass Yellow is, appropriately, the most common *Eurema* in Delhi, flying from June IV to May III in all habitats, although it is more frequently collected in the Nursery. It is apparently rare from January to June. A copulating pair was collected on 25 Sept. 1961 (JPD). 247 specimens: 156 males (63%), 91 females.

The sex ratio of field-collected specimens varies considerably, with the percentage of males increasing from Aug. IV to Sept. I, then decreasing to Nov. IV: 64% males Aug. IV (47 specimens), 88% males Sept. I (16 specimens), 69% males Nov. I (32 specimens), 53% males Nov. III (17 specimens), and 47% males Nov. IV (19 specimens).

SIZE: ♂♂ 15 mm. (26 Feb. 1963, RCF) to 22 mm. (18 Nov. 1962, RCF; 7 Sept. 1962, RLD). ♀♀ 15 mm. (22 Nov. 1962, RCF) to 22 mm. (2 specimens, 28 Aug. 1961, JPD).

VARIATION : The dry-season form of this species is more heavily marked than the wet-season form. The DSF, which flies from about early November to late April, has conspicuous rusty markings on the underside and a prominent rusty subapical patch UNF. The WSF is poorly marked on the underside, does not have the rusty subapical patch UNF, and usually has no trace of the two cell spots UNF—the often-used key character for the species. The 'dogface' pattern UPF is more pronounced in the WSF than in dry-season specimens, and in dry-season specimens the black margin UPF is occasionally reduced to a narrow border somewhat as in *E. brigitta* (although there are some males from Oct. IV and Nov. I with the reduced margin).

Because many specimens are poorly marked, the genitalia of all males were examined, but no specimens of the similar *E. blanda silhetana* (Wallace) were found. Despite the statements in Talbot (1939) and Wynter-Blyth (1957) that *Eurema blanda* occurs from Ceylon and peninsular India to Sikkim, Assam, and eastward, I have collected it only in Ceylon, the Western Ghats, and north-eastern India. If it does occur on the Deccan Plateau or the Gangetic Plain it must be very local.

Because *Eurema hecabe* is so very variable in both size and coloration, it is my opinion that at least some of the Indian subspecies are not valid, but Talbot (1939) will be followed until more work can be done on the genus.

DISTRIBUTION : *E. hecabe* occurs throughout India, with *E. hecabe simulata* presumably restricted to Ceylon, peninsular India, and the Central Provinces (Talbot 1939). *E. hecabe fimbriata* (Wallace) is said to occur from the Punjab to Chitral and Kumaon (Talbot 1939), but all the records cited indicate that this is a Himalayan subspecies, hence the assignment of the Delhi population to *E. h. simulata*. The species is common throughout the Indo-Gangetic Plain, and extends westward to Africa (Talbot 1939).

Colias electo fieldi Ménétries

As with *Pieris canidia*, the occurrence of this hill species in Delhi was unexpected. RLD has collected the only five Delhi specimens, which are identical to several large series I have collected in the Himalaya. A female was collected in the Nursery on 3 March 1963, and on 24 March 1963 a male and a female were obtained. A male and a female were also obtained on the North Ridge, near I.A.R.I., on 29 March 1964.

SIZE : The two males measure 19 mm. and 20 mm., while the females are 23 mm., 25 mm., and 25 mm.

DISTRIBUTION : The Dark Clouded Yellow occurs throughout the Himalaya (Talbot 1939), but it has also been recorded from the following localities on the plains, where it is presumably a non-breeding straggler in the winter and spring : 15 miles NE. Amritsar, Punjab, in late March [Sanders 1930, who also found *C. erate erate* (Esper) there in late Feb. and late March] ; Amritsar (Sevastopulo 1948, who also collected *C. erate*) ; Lahore, in the 'early cold weather months' and again in Feb. and March (de Rhé-Philipe 1917) ; Fatchgarh (Peile 1911) ; and Lucknow, in the winter, and also in Feb. near Goshainganj, 130 miles SE. of Lucknow (de Rhé-Philipe 1902). Delhi appears to be the south-westernmost record of this species.

(to be continued)

Aestivation of perianths of *Areca catechu* Linn. fruits

BY

T. A. DAVIS AND ABANTIKA KUNDU
Indian Statistical Institute, Calcutta

(With three figures)

INTRODUCTION

Data are presented in the following pages on the different ways the six perianths of the female flowers/fruits of the areca palm (*Areca catechu* Linn.) are arranged. It is customary to describe the sepals (outer whorl of perianth) as well as the petals of areca flowers as being imbricately arranged (Hooker 1894; Murthy & Bavappa 1960a; Raghavan & Baruah 1956). But critical examination of a large number of fruits reveals that the sepals always imbricate leading to a spiral arrangement. In about half the number of fruits, the spiralling is clockwise, and in the rest, the converse. The petals have four distinct kinds of aestivation. In *c.* 20% of the fruits, all the petals regularly contort. About half of them have clockwise and the rest counter-clockwise contortion. In the remaining *c.* 80%, the petals imbricate like the sepals (both directions). The leaves of areca palm are spirally arranged, and a palm may be considered either a left-hander or a right-hander. The foliar asymmetry is not correlated with the aestivation of either the sepals or petals. Examination of the foliar spirals of seedlings raised from known fruits suggests that there is no correlation existing between the aestivation of the petals of a fruit and the foliar spiral of the seedling which develops out of it.

MATERIAL AND METHODS

A total of 4203 areca palms from four Indian States (Kerala, Mysore, West Bengal, and Assam) were examined for their foliar asymmetry in 1965. About four thousand fruits of 24 palms from Calcutta were examined for the arrangement of the perianths (some of them including the bracteoles) during 1964 and 1965. As some knowledge on the gross morphology of the flowers/fruits may help

to interpret the results better, a brief account of the areca flowers is given below.

Areca catechu Linn. bears unisexual flowers on the same infrafoliar, highly branched spadix, enclosed by a single glabrous spathe which is covered by the sheathing base of the subtending leaf almost up to the stage of the bursting of the spathe. The main rachis of the spadix is stout and compressed, producing several branches, some of which further branch and re-branch. The ultimate filiform spikes bear more or less distichous minute male flowers. The female flowers are solitary or, less frequently, in pairs at the bases and axils of the branches. Rarely one or two male flowers are seen at the base of a female flower. The spathe, corresponding to the fourth bract (younger to the largest spathe) of the coconut, although absent in most areca spadices, can be made out if very young spadices are examined. Barring the contributions of Blatter (1926), Juliano & Quisumbing (1931), Menon & Pandalai (1958), Patel (1938), and Venkata Rao (1959), the floral biology of palms has not been studied appreciably.

At the base of every female areca flower, a minute bract is visible which is more pronounced just at the time the spathe ruptures and the spadix emerges. Each female flower has two small scaly bracteoles (prophylls) just outside the sepals; of them the outer one sometimes grows almost half the size of a sepal. The outermost sepal, which partially overlaps the remaining two sepals, is located opposite and equidistant from the two bracteoles. When viewed from behind the spike on whose axil a female flower is produced, if the outermost sepal is located to the right of the observer, the bigger prophyll will be on the left. In another, the positions are just interchanged.

The male flowers are small triangular or ovate bodies measuring *c.* 4.5 mm. \times 3.0 mm. There are three minute sepals which are largely imbricate (critical large scale examinations not made); they alternate the inner whorl of three valvate petals which enclose six stamens, and the pistillodes in the centre consist mostly of the reduced trifold stigma. The female flowers are much larger, measuring *c.* 18 mm. \times 10 mm. at the time of receptivity. The perianths of the outer whorl representing the sepals are always imbricately arranged (one completely out, another partially covered by the outer sepal and partially covering the inner, and the third is completely in). Though the sepals are described as boat-shaped, they are more or less triangular, concave within, and fit tightly on the petals which are also triangular, convex outside, and slightly bigger than the sepals. The perianths being arescent grow with the fruit. A thin ring of six staminodes is seen between the petals and the ovary. The ovary has a dome-shaped trifold stigma formed by the three styler projections.

RESULTS AND DISCUSSION

100 fruits from a spadix were examined to determine the position of the outer sepal relative to the axis on which the fruit is borne. The fruit is viewed from behind the axis, and the results given under.

Fruits with outer sepal to left of axis	..	47
Fruits with outer sepal to right of axis	..	44
Fruits with outer sepal opposite to axis	..	2
Fruits where positions could not be made out	..	7
Total	..	100

Four distinct types of petal-arrangement are observable on areca fruits. All the petals in a flower may regularly rotate, i.e. contort (one half of each petal remaining out and the other half being overlapped by the succeeding or preceding petal) either clockwise or counter-clockwise. When a flower is viewed from the stigmatic end downwards, if the outer free portion of the petal twists clockwise, the flower is considered a left-hander, and vice versa if the petal twists counter-clock-

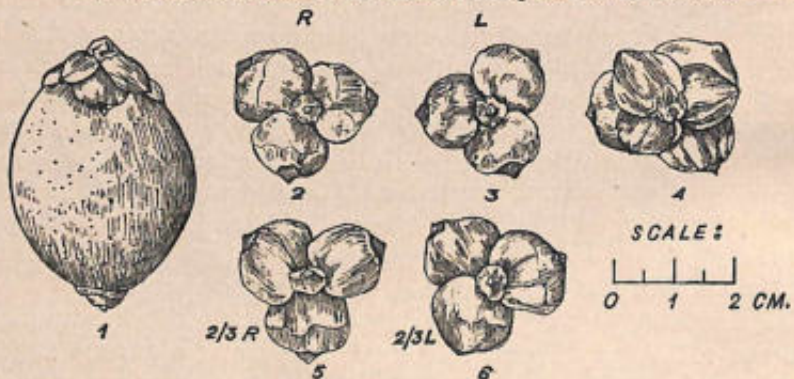


Fig. 1. 1. Areca fruit (side view); 2-3. Corolla regularly twisting to right (2), to the left (3); 4. Six perianths intact (top view); 5-6. Right- and left-handed imbrications of Corolla.

wise. In Fig. 1 the two middle drawings in the upper row represent the two kinds of regular petal-twist, the two lower drawings the two situations when the petals imbricate. In a flower where the petals are imbricately aestivated, depending on the arrangement of the middle petal, a flower is considered $\frac{2}{3}$ -left-hander (illustration 6 of Fig. 1) or $\frac{2}{3}$ -right-hander. In the $\frac{2}{3}$ -left-handed condition, (starting from the outermost one) the three petals spiral clockwise. The arrangement of the petals is reversed in a $\frac{2}{3}$ -right-hander.

The proportion of flowers having their petals regularly contorting

and those with imbricate aestivation was about one to five for a population of 762 fruits examined in 1964 (Davis 1964a). In Table 1 data are given on a little over three thousand fruits from 15 areca palms sampled in Calcutta.

TABLE 1
Areca catechu: AESTIVATION OF PETALS

Petal-twist	No. of fruits	Percentage
Left	320	10.53
Right	275	9.05
½-Left	1,225	40.31
½-Right	1,219	40.11
Total	3,039	100.00

The proportion of flowers having contorted petals to those with imbricate ones in the new population altered slightly (1:4). Since the earlier data were also collected from Calcutta, the variation in the two sets of observations may suggest that the proportions differ with individual palms or seasons, and warrants the need for much larger samples.

The petal arrangement on the fruits of six other palm species was also studied and the data together with those for *Areca catechu* appear in Table 2.

TABLE 2
AESTIVATION OF PETALS ON FRUITS OF 7 PALM SPECIES

Species	Lefts	Rights	½-L	½-R	Total
<i>Areca catechu</i>	320	275	1,225	1,219	3,039
<i>Areca triandra</i>	9	6	182	206	403
<i>Borassus flabellifer</i>	25	38	143	143	349
<i>Cocos nucifera</i>	25	16	208	186	435
<i>Phoenix paludosa</i>	42	19	62	61	184
<i>Phoenix sylvestris</i>	384	253	1,083	961	2,681
<i>Ptychosperma macarthurii</i>	0	1	1,195	1,128	2,324
Total	805	608	4,098	3,904	9,415

Flowers with contorted corolla in *Areca triandra* constitute only 3.7% of the population sampled. The corresponding figures for *Cocos nucifera*, *Borassus flabellifer*, *Phoenix sylvestris*, and *P. paludosa* are 9.4, 18.0, 23.8, and 33.7 respectively. In *Ptychosperma macarthurii*, however, with the exception of a single flower, a population of 2324 flowers showed only imbricate petals. The mechanism which regulates the aestivation of the corolla varying with species is not yet known. As the number of foliar spirals varies with the species, the foliar arrangement may have some influence on the aestivation.

Calyx-corolla relationship

As already mentioned, the calyx in *Areca catechu* is always imbricate, $\frac{2}{3}$ left or $\frac{2}{3}$ right and, under each situation, the four types of petal-aestivation occur (Fig. 2, L_1 - L_4 , R_1 - R_4). In only a single exceptional flower, the sepals contorted clockwise. 2277 flowers were examined for the arrangements of sepals and petals, and the data are presented in Table 3.

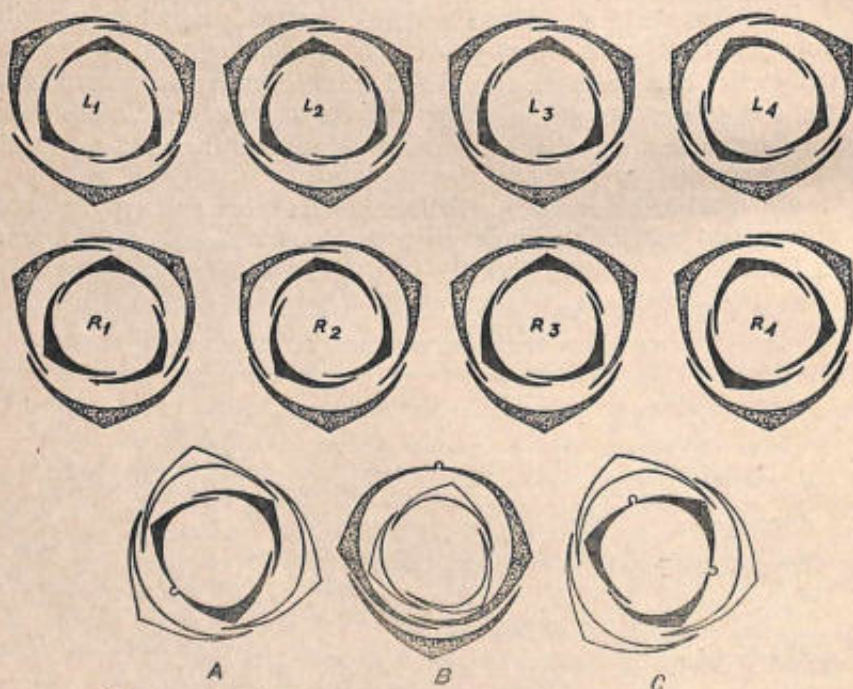


Fig. 2. Aestivation of perianths in *Areca catechu*. Top row: The four possible petal-arrangements when sepals imbricate to left. Middle row: Petal arrangements same as top row but sepals imbricate to right. Bottom: A. Flower with a double sepal; B. Another with a double petal; C. Flower with three petals united.

The number of flowers with left-handed sepal-imbrication does not differ significantly from that of their counterpart. Flowers whose sepals as well as petals are left-handed form slightly over 50% of the population sampled (584 : 526). Among flowers with left-handed sepals, those with left as well as right-spiralled petals are distributed equally. But among flowers with right-handed sepals, those bearing left-handed petals

TABLE 3
Areca catechu: DISTRIBUTION OF FRUITS ACCORDING
TO AESTIVATION OF PERIANTHS

Sepals	P e t a l s				Total
	Left	Right	$\frac{2}{3}$ -L	$\frac{2}{3}$ -R	
Left	—	—	1	—	1
Right	—	—	—	—	—
$\frac{2}{3}$ -L	124	124	460	468	1,176
$\frac{2}{3}$ -R	116	101	458	425	1,100
Total	240	225	919	893	2,277

are more. The slight excess of left-handedness in the aestivation of *Areca catechu* perianths is in conformity with the situations met with in some species of Malvaceae and Bombacaceae by Davis (1964b ; 1965), Davis & Ghoshal (1966), Davis & Kundu (1965), and Davis & Selvaraj (1964) and in the coconut by Davis (1962).

In order to see whether the proportions of the different groups of flowers vary significantly between individual trees, 1670 young fruits from 12 trees were examined at Calcutta, and the data presented in Table 4.

All the trees bore fruits having the eight different types of perianth arrangement. The aestivation is not influenced by the foliar spirality of a palm. Another point of interest is that 22.14% of the fruits bore twin sepals, and the twins always happened to be the younger two calyx components of a flower (Fig. 2, B). The outermost sepal which is completely exposed is just opposite the twin sepal. This may confirm that all the three members of the calyx whorl are not formed simultaneously, although the time-interval between the second and third sepals is very small when it exists.

Some spikes bore more than two flowers each, and an examination of those flowers suggested that the left- and right-handed flowers are distributed randomly on a spike.

The areca palm has five rows of leaves placed at $\frac{2}{3}$ -distances of the circle, giving a phyllotaxy of five-ranked or 'pentastichous' with an

TABLE 4
Areca catechu : AESTIVATION OF PERIANTHS ON FRUITS OF INDIVIDUAL TREES

Tree and spiral	Sepal-petal combinations										Fruits with twin sepals	Total
	IL/L	IL/R	IL/IL	IL/IR	IR/L	IR/R	IR/IL	IR/IR				
1 R	4	4	19	18	4	5	21	18			6	99
2 L	1	4	18	10	2	1	12	18			10	76
3 L	5	8	10	23	2	4	25	14			3	94
4 R	3	7	15	17	7	6	19	15			5	94
5 R	5	4	20	24	4	6	36	13			20	132
6 L	1	9	14	33	8	3	23	13			6	110
7 R	1	4	9	18	9	1	17	9			105	173
8 L	4	9	38	33	11	5	27	21			33	181
9 R	15	4	25	13	4	3	11	21			5	101
10 L	16	7	42	33	7	15	38	42			12	212
11 R	8	19	20	21	8	4	27	21			17	145
12 L	7	10	20	29	1	3	14	11			158	253
Total	70	89	250	272	67	56	270	216			380	1,670

N.B. L = regularly left-spiralled ; R = regularly right-spiralled ; IL = imbricate left ; IR = imbricate right.

angular divergence of 144° (Murthy & Bavappa 1960b). Thus, the sixth leaf will stand over the first with a genetic spiral of two circles and the eleventh leaf over sixth with a similar spiral. Since there are only about eight leaves present on the crown of a palm at a time and because of the fairly long internodes, the above details on the leaf-arrangement are not easily observable. As the leaves appear to be 'alternate', it is easier to conceive that they are arranged in a single spiral running clockwise or counter-clockwise. A tree is considered as having a clockwise (left-handed) foliar spiral if the younger of any two consecutive leaves (or inflorescences) is located nearer the vertical drawn from the middle of the older leaf towards the right-hand side of the observer, and as right-handed if it falls on the opposite side. This definition conforms to the coconut spirals (Davis 1962). In a population, the two kinds of trees are distributed in almost equal proportions as may be seen from Table 5.

TABLE 5
Areca catechu: DATA ON FOLIAR SPIRALS

Locality	Lefts	Rights	L+R	L-R
Palode (Kerala)	541	540	1,081	1
Vittal (Mysore)	544	505	1,049	39
Calcutta (W. Bengal)	155	162	317	-7
Jalpaiguri (N. Bengal)	382	323	705	59
Gauhati (Assam)	538	513	1,051	25
Total	2,160	2,043	4,203	+117

As the leaves are arranged spirally, the perianths also show spiral mechanism. The sepals of all the fruits and petals of about 80% fruits are arranged one after another (from the outermost) in spiral form. From data given in Table 3, it is seen that, only in just a little less than half the fruits, both the sepals and petals are arranged along the same direction (left- or right-spiralled). In the rest, the whorls of calyx and corolla are oppositely arranged, and this situation is more difficult to explain in view of the fact that the leaves in a palm always veer either clockwise or anti-clockwise.

Even in fruits where the sepals and petals veer in the same direction, the outermost petal which is to develop in continuation of the last sepal does not always seem to be doing so because of its varying positions as detailed below.

Of the 2277 fruits examined, the sepals imbricate in all except an odd case of contortion. On account of this situation a fruit bears one

sepal which is completely exposed. The sepals in a flower either twist right-handed or left-handed. The three petals can be arranged in four different ways (two types of contortions and two imbrications). Six different types of aestivation are possible when only the two kinds of petal-imbrications are considered in relation to the outermost sepal. Therefore, for the two types of sepal arrangements twelve kinds of imbrications are possible. With the left- and right-handed regular contortions for each calyx type, there are altogether sixteen different arrangements of perianths possible. Fig. 3 depicts 12 such combinations and the four combinations where the petals contort are seen in Fig. 2.

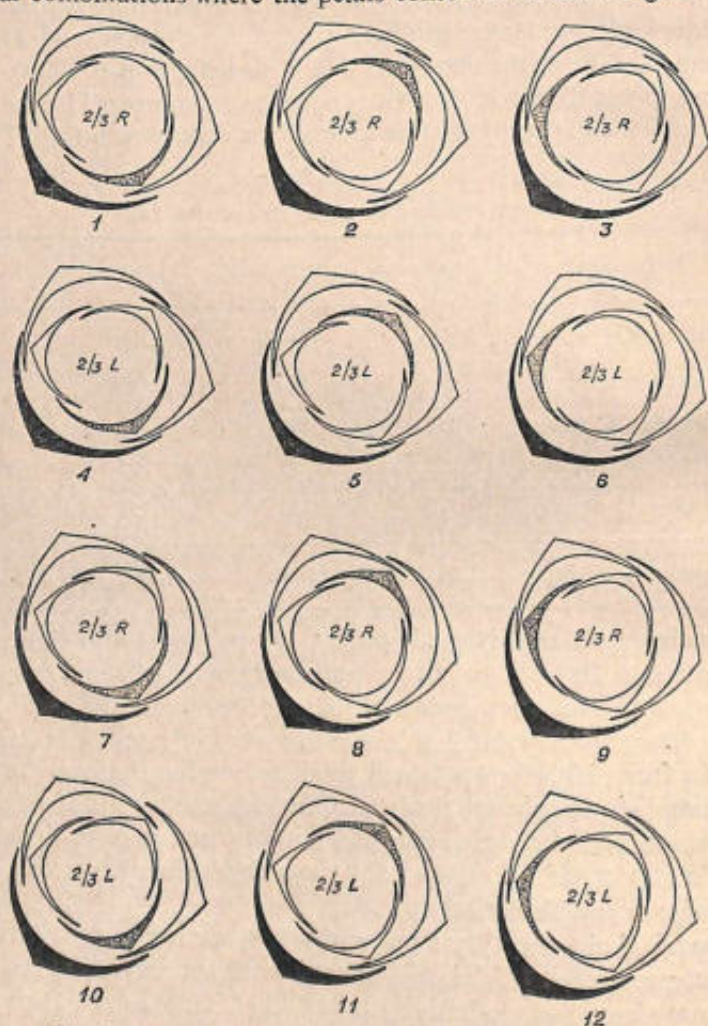


Fig. 3. Drawing to show relative positions of outermost sepal and outermost petal in areca fruits. Sepals in flowers 1-6 imbricate to left, in 7-12 to right. Petals in 1-3 and 7-9 imbricate to right, and in 4-6 and 10-12 to left.

When viewed from the middle of the outermost odd sepal, one petal will be seen just on its opposite side, one to its right and the other left. Any one of these can be the outermost petal. (Where the corolla is contorted, all the petals are similarly arranged.) In flowers where the petals imbricate right-handedly, the outermost petal can be in three positions in relation to the outermost sepal (vide Nos. 1-3 of Fig. 3), and when the petals imbricate left-handedly, a further three combinations are possible (vide Nos. 4-6 of Fig. 3). The six figures in the lower two rows show right-handed rotation of the calyx as opposed to the left-handed rotation of those in the top two rows. The numbers of fruits falling under the 16 sepal-petal combinations collected from three trees are given in Table 6.

In 26.26% of the entire fruits examined, the outermost petal was located opposite the outermost sepal, in 26.27% to its left, and in 23.10% to the right. The proportion of fruits having both the sepals and petals imbricating left-handedly and having the outer petal located to the left of the outer sepal is slightly greater than those of the other perianth-combinations relating to the left-handed sepals. Similarly, flowers having right-spiralled calyx and corolla and the outer petal located to the right of the outer sepal are slightly in excess of the other situations.

Aestivation of fruit and foliar spiral of subsequent seedling

One thousand ripe areca fruits collected from ten palms growing at the premises of the Indian Statistical Institute, Calcutta, were sown in a special nursery in December 1964, after separating them into four groups according to the aestivation of the petals. An examination of the foliar arrangement in the seedlings did not show that a fruit with a particular kind of aestivation gives rise to a seedling having a particular foliar spiral. In each group, left-handed and right-handed seedlings were observed.

Abnormalities

While examining the spadices from many areca palms, the following abnormalities were met with. A single flower having regularly contorted sepals and those bearing twin sepals have already been mentioned. In the two other flowers, the younger two petals fused to about three-fourths of their lengths (Fig. 2, A). In yet another flower, all the three petals remained united, but the corolla was free at one region where the margins overlapped each other clockwise (Fig. 2, C). The sepals of this flower, however, were free and imbricate. One flower had only 2 sepals and 2 petals as the one already described by Bavappa & Murthy (1961). Hermaphrodite flowers were noticed in five trees, a spadix bearing 2 to 22 such abnormal flowers. The size of the bisexual flowers ranged between the sizes of normal male and female flowers.

TABLE 6
Areca catechu: CALYX-COROLLA RELATIONSHIP

		Tree 1:	Tree 2:	Tree 3:	Total:	% on g. total
A. Sepals: Imbricate: $\frac{1}{2}$-Left-handed						
Petals	} Twisting regularly to the Left Twisting regularly to the Right	4	8	7	19	6.01
		4	19	10	33	10.45
} <i>Outer petal to outer sepal</i>						
} Imbricate $\frac{1}{2}$ -Left	(a) Opposite	4	5	8	17	5.38
	(b) To the Left	12	9	5	26	8.23
	(c) To the Right	3	6	7	16	5.06
} <i>Outer petal to outer sepal</i>						
} Imbricate $\frac{1}{2}$ -Right	(a) Opposite	7	8	12	27	8.54
	(b) To the Left	7	5	12	24	7.60
	(c) To the Right	4	8	5	17	5.38
Total:		45	68	66	179	56.65
B. Sepals: Imbricate: $\frac{1}{2}$-Right-handed						
Petals	} Twisting regularly to the Left Twisting regularly to the Right	4	8	1	13	4.11
		5	4	3	12	3.80
} <i>Outer petal to outer sepal</i>						
} Imbricate $\frac{1}{2}$ -Left	(a) Opposite	13	7	6	26	8.23
	(b) To the Left	5	13	2	20	6.33
	(c) To the Right	3	7	6	16	5.06
} <i>Outer petal to outer sepal</i>						
} Imbricate $\frac{1}{2}$ -Right	(a) Opposite	6	6	1	13	4.11
	(b) To the Left	5	6	2	13	4.11
	(c) To the Right	7	9	8	24	7.60
Total:		48	60	29	137	43.35
Grand Total:		93	128	95	316	100.00

Each flower bore six or less fully or partially developed stamens. The ovary developed conspicuously in flowers which resembled the female flowers. Similar condition was recorded in the coconut by Davis *et al* (1954) and Rao (1948) and in the arecanut by Bavappa & Murthy (1961) and Raghavan & Murthy (1954). One young areca fruit bore a single horn-like structure developing from one of the staminodes like the ones described by Davis (*in press*) and Murthy & Bavappa (1959).

SYNOPSIS

Of the six perianths on a fruit of *Areca catechu* Linn., the outer three (sepals) are always imbricately aestivated. The two wings of the innermost sepal are overlapped by the outer sepals while those of the outermost one are exposed. A wing of the middle sepal is overlapped by the outer sepal and, depending on the position of its exposed wing, a fruit may be regarded as left- or right-handed. In a large sample, fruits with the two kinds of sepal-arrangement are distributed in almost equal proportions. The inner whorl of three perianths (petals) either contorts (twists regularly) or imbricates like the sepals. The petals of about 20% of the fruits sampled twist regularly, and in the rest they imbricate. In about 50% of the fruits having either contorted or imbricate aestivation, the petals veer clockwise, and the rest counterclockwise. The data supplied show that the outermost sepal and outermost petal of a fruit are related to each other in sixteen different ways. The aestivation of the petals of a fruit is not correlated with the foliar spiral of either the mother palm or the seedling that develops out of it.

REFERENCES

- BAVAPPA, K. V. A. & MURTHY, K. N. (1961) : Floral abnormalities in arecanut. *Arecanut J.* 12 : 185-190.
- BLATTER, E. (1926) : Palms of British India and Ceylon. Oxford University Press, London.
- DAVIS, T. A. (1962) : The non-inheritance of asymmetry in *Cocos nucifera*. *J. Genet.* 58 : 42-50.
- (1964a) : Possible geophysical influence on asymmetry in coconut and other plants. *FAO Tech. Working Party on Coconut, Colombo 2* : 59-69.
- (1964b) : Aestivation in Malvaceae. *Nature* 201 : 515-516.
- (1965) : Floral structure and stamens in *Bombax ceiba*. *J. Genet.* 59 : 294-328.
- (in press) : Morphology of horns in exceptional fruits of palms. *Phytomorph.* 16(4).
- & GHOSHAL, K. K. (1966) : Variation in the floral organs of *Hibiscus rosasinensis* Linn. *J. Indian Bot. Soc.* 65 : 31-43.
- & KUNDU, A. (1965) : Floral structure and stamens in *Ceiba pentandra*. *J. Bombay nat. Hist. Soc.* 62 : 394-411.
- & SELVARAJ, J. C. (1964) : Floral asymmetry in Malvaceae. *J. Bombay nat. Hist. Soc.* 61 : 402-409.
- , ANANDAN, A. P. & MENON, K. P. V. (1954) : Hermaphroditism in *Cocos nucifera* L. *Indian Coconut J.* 7 : 133-142.
- HOOKE, J. D. (1894) : Flora of British India. VI. L. Reeve & Co., Ltd., Kent.
- JULIANO, J. B. & QUISUMBING, E. (1931) : Morphology of male flower of *Cocos nucifera* Linn. *Philipp. J. Sci.* 45 : 449-58.
- MENON, K. P. V. & PANDALAI, K. M. (1958) : The coconut palm, a monograph. Indian Centr. Coconut Cttee., Ernakulam.
- MURTHY, K. N. & BAVAPPA, K. V. A. (1959) : Abnormalities in arecanut. *Arecanut J.* 10 : 97-107.
- & BAVAPPA, K. V. A. (1960a) : Floral biology of Areca (*Areca catechu* Linn.). *Arecanut J.* 11 : 51-55.
- & BAVAPPA, K. V. A. (1960b) : Morphology of Arecanut palm—the shoot. *Arecanut J.* 11 : 99-102.
- PATEL, J. S. (1938) : The Coconut, a monograph. Govt. Press, Madras.
- RAGHAVAN, V. & BARUAH, H. K. (1956) : On certain aspects of the morphology of arecanuts (*Areca catechu*). *Arecanut J.* 7 : 21-28.
- & MURTHY, K. N. (1954) : Occurrence of bisexual flowers in an arecanut palm. *Sci. and Cult.* 20 : 239.
- RAO, G. T. (1948) : A note on the occurrence of a hermaphrodite flower in coconut (*Cocos nucifera* L.). *J. Indian Bot. Soc.* 27 : 208-211.
- VENKATA RAO, C. (1959) : Contribution to the embryology of palmae II. Ceroylineae. *J. Indian Bot. Soc.* 38 : 46-75.



A report on Ticks collected from Birds and small Mammals in North Arcot and Chittoor Districts, South India

BY

M. J. REBELLO AND RACHEL REUBEN

Virus Research Centre, Poona¹

Early knowledge about ticks in south India was very scanty and based mainly on collections made by veterinarians on domestic animals. Sharif published a key in 1928 and Sen summarised the existing knowledge about tick ectoparasites of wild mammals and birds in 1938. Subsequently the Virus Research Centre (VRC) has built up a large body of information on the subject based on collections made in several parts of India.

The present report is intended to place on record information on ticks collected from an area mainly in North Arcot District, Madras State, not covered by any of the previous surveys made by the VRC. The extensive studies made by the VRC in another part of south India, Mysore State, are being separately reported by the workers concerned (Trapido *et al.* 1964a and 1964b; Rajagopalan, V. R. C. unpublished data).

METHODS

During 1963 birds were mist-netted weekly in each of two villages in North Arcot District. Japanese mist-nets, 3 to 4 feet off the ground, were used among bushes and trees near houses. The birds caught were searched for ticks and other ectoparasites, banded, and released. They were also bled for virological studies. During the course of the study many released birds were recaptured and found to have more ticks. The method adopted for searching for ticks was to lift each feather gently and to remove with a pair of forceps any ticks attached beneath. Special attention was paid to the head region, where the great majority of the ticks were found attached. After one of the authors (R. R.) had

¹ The Virus Research Centre is jointly maintained by the Indian Council of Medical Research and The Rockefeller Foundation. The Centre also receives a grant of PL-480 funds from the National Institutes of Health, USA, through the Indian Council of Medical Research.

removed as many ticks as she could find, the bird was searched by a second person, and then handed back to her for a final check. The efficiency of this method is discussed later.

Some birds were also brought in by local trappers from forested areas in North Arcot District. These were the Grey Partridge, *Francolinus pondicerianus* (Gmelin), and the Painted Spurrow, *Galloperdix lunulata* (Valenciennes). They were kept in the laboratory over trays of water and the engorged ticks collected from time to time as they detached and dropped in the water.

The small mammals were collected mainly from the villages where the birds were captured. They were captured in standard Sherman traps, brought to the laboratory, and transferred to cages which were kept over trays of water for the fed ticks to detach. A few collections were made in Ootacamund, Nilgiri District, and some in Chittoor District, Andhra State.

RESULTS

Birds

Over the period of the study 590 birds belonging to 55 species were examined. Of these, 136 birds belonging to 16 species were found to be positive for Ixodid ticks (Table 1). Only three species of ticks were collected, of which *Haemaphysalis intermedia* Warburton & Nuttall, 1909, was the most common species. Its predominance in the collections is a reflection of the fact that birds were almost all netted in and around villages, since *Haemaphysalis intermedia* is a common cattle tick.

The following species of birds were negative for ticks: *Ardeola grayii* (Sykes) (2), *Accipiter badius* (Gmelin) (5), *Turnix suscitator* (Gmelin) (3), *Streptopelia senegalensis* (Linnaeus) (1), *Psittacula krameri* (Scopoli) (20), *Clamator jacobinus* (Boddaert) (2), *Eudynamis scolopacea* (Linnaeus) (2), *Rhopodytes viridirostris* (Jerdon) (3), *Athene brama* (Temminck) (2), *Caprimulgus asiaticus* Latham (2), *Halcyon smyrnensis* (Linnaeus) (20), *Merops orientalis* Latham (21), *Upupa epops* Linnaeus (10), *Megalaima haemacephala* (P.L.S. Müller) (2), *Dinopium benghalense* (Linnaeus) (16), *Lanius vittatus* Valenciennes (3), *Lanius schach* Linnaeus (1), *Dicrurus adsimilis* (Bechstein) (1), *Dendrocitta vagabunda* (Latham) (1), *Corvus splendens* Vieillot (4), *Corvus macrorhynchos* Wagler (6), *Coracina melanoptera* (Rüppell) (6), *Pericrocotus cinnamomeus* (Linnaeus) (3), *Aegithina tiphia* (Linnaeus) (4), *Pycnonotus luteolus* (Lesson) (4), *Muscicapa latirostris* Raffles (1), *Terpsiphone paradisi* (Linnaeus) (1), *Anthus trivialis* (Linnaeus) (2), *Motacilla maderaspatensis* Gmelin (5), *Nectarinia zeylonica* (Linnaeus) (17), *Nectarinia lotenia* (Linnaeus) (1), *Nectarinia asiatica* (Latham) (4), *Passer domesticus* (Linnaeus) (97), *Petronia xanthocollis* (Burton) (30), *Ploceus philippinus* (Linnaeus) (28),

Lonchura striata (Linnaeus) (1), *Lonchura malacca* (Linnaeus) (19). The number in brackets represents the number of birds examined.

The method of removing ticks has already been described. Its efficacy was tested on a few occasions. Two birds were killed after being searched in the field and five birds were kept alive in the laboratory. Thrice a single tick was collected in the laboratory after the original field examination, and on four occasions no more ticks were recovered. The field method was thus reasonably thorough and it seems likely, therefore, that the majority of the ticks collected on recaptured birds represented fresh infestations, and were not merely ticks which were missed by the naked eye the first time the bird was examined. Indian Pittas and Greyheaded Babblers were frequently recaptured infested with ticks after an interval of a week from the original examination.

Small mammals

The collections made from small mammals in Chittoor and North Arcot Districts are summarised in Table 2. It is interesting to find that many rodents harboured the immature stages of the genus *Hyalomma*, the commonest collected in this study being *H. brevipunctata*. The predominant genus, however, was *Rhipicephalus*, particularly *R. haemaphysaloides*. At present three species of *Rhipicephalus* are recognised in India (Sharif 1928; Dhanda, to be published). These are *Rhipicephalus sanguineus* (Latreille), *Rhipicephalus haemaphysaloides* Supino, and *Rhipicephalus ramachandrai* Dhanda. Two species of *Rhipicephalus* showing distinct differences from the known species were collected during this study from rodents and shrews. These species have been designated as *Rhipicephalus* species 4 and 5 for the present. These species require careful study to determine their taxonomic status. Most of these ticks were collected as fed nymphs and subsequently reared in the laboratory.

A few miscellaneous collections made in North Arcot District have been included in Table 3.

Two *Rattus rattus wroughtoni* and four *Suncus murinus* were collected in Ootacamund, Nilgiri District. Two larvae identified as *Ixodes ceylonensis* were collected, one from *Rattus rattus wroughtoni* and the other from *Suncus murinus*. This is of special interest since it is the first record of this species in India outside the Kyasanur Forest disease area in the forests of Shimoga District, Mysore State.

ACKNOWLEDGEMENTS

We would like to express our thanks to Dr. T. Ramachandra Rao, Director, Virus Research Centre, for his invaluable help and advice, and to the Bombay Natural History Society for checking on identifi-

cations of birds and mammals and to Dr. P. K. Rajagopalan who checked on the identification of *I. ceylonensis*.

REFERENCES

- ELLERMAN, J. R. (1947) : A key to the Rodentia inhabiting India, Ceylon and Burma, based on collections in the British Museum—Part II. *J. Mammal.* 28 : 357-388.
- DHANDA, V. (to be published) : *Rhipicephalus ramachandrai* sp. n. (Acarina : Ixodidae) from the Indian Gerbil *Tatera indica* (Hardwicke, 1807) (Rodentia : Muridae). *J. Parasit.*
- SHARIF, M. (1928) : A revision of the Indian Ixodidae, with special reference to the collection in the Indian Museum. *Rec. Indian Mus.* 30 : 217-344.
- SEN, P. (1938) : A check and host-list of Ixodoidea (Ticks) occurring in India. *Ind. Jour. Vet. Sci.* 8 : 133-147.
- TRAPIDO, H., GOVERDHAN, M. K., RAJAGOPALAN, P. K., & REBELLO, M. J. (1964a) : Ticks ectoparasitic on monkeys in the Kyasanur Forest Disease area of Shimoga District, Mysore State, India. *Am. J. Trop. Med. Hyg.* 13 : 763-772.
- , VARMA, M. G. R., RAJAGOPALAN, P. K., SINGH, K. R. P., & REBELLO, M. J. (1964b) : A guide to the identification of all stages of the *Haemaphysalis* ticks of South India. *Bull. Entom. Res.* 55 : 249-270.

TABLE 1
TICKS COLLECTED FROM BIRDS EXAMINED IN NORTH ARCOT DISTRICT FROM JANUARY TO DECEMBER, 1963

Host (Species found negative not included)	Total birds examined	Total birds positive for ticks	<i>Haemaphysalis</i>						<i>Hyalomma</i>			Total	
			<i>intermedia</i>			<i>bispinosa</i>			<i>marginalatum</i> <i>isaaci</i>				
			L	N	M	F	L	L	L	N	N		
1 <i>Fracolinus pondicerianus</i> (Gmelin) (Grey Partridge)	11	6	19	2	3	1	—	—	—	—	—	—	25
2 <i>Gallopodix lunulata</i> (Valenciennes) (Painted Spurfowl)	2	2	4	6	—	—	—	—	—	—	—	—	10
3 <i>Cacomanitis merulinus</i> (Scopoli) (Indian Plaintive Cuckoo)	1	1	1	—	—	—	—	—	—	—	—	—	1
4 <i>Pitta brachyura</i> (Linnaeus) (Indian Pitta)	9	7	57	21	—	—	1	—	—	—	—	—	79
5 <i>Mirafra assamica</i> Horsfield (Bush Lark)	1	1	6	1	—	—	—	—	—	—	—	—	7
6 <i>Lanius cristatus</i> Linnaeus (Brown Shrike)	4	1	2	6	—	—	—	—	—	—	—	—	8
7 <i>Dicurus leucophaeus</i> Vieillot (Grey Drongo)	4	1	1	—	—	—	—	—	—	—	—	—	1
8 <i>Sturnus pagodarum</i> (Gmelin) (Brahminy Myna)	35	17	35	8	—	—	—	—	—	—	—	1	44
9 <i>Acridotheres tristis</i> (Linnaeus) (Common Myna)	11	5	16	4	—	—	—	—	—	—	—	—	21
10 <i>Tephrorrhis pondicerianus</i> (Gmelin) (Common Wood Shrike)	9	5	10	1	—	—	1	—	—	—	—	—	12
11 <i>Pycnonotus cafer</i> (Linnaeus) (Redvented Bulbul)	22	1	2	—	—	—	—	—	—	—	—	—	2
12 <i>Turdoides affinis</i> (Jerdon) (Whiteheaded Babbler)	66	57	840	114	—	—	3	1	—	—	—	—	958
13 <i>Orthotomus sutorius</i> (Pennant) (Tailor Bird)	9	2	2	1	—	—	—	—	—	—	—	—	3
14 <i>Acrocephalus dumetorum</i> Blyth (Blyth's Reed Warbler)	13	5	11	1	—	—	—	—	—	—	—	—	12
15 <i>Copsychus saularis</i> (Linnaeus) (Magpie-Robin)	4	3	17	11	—	—	—	—	—	—	—	—	28
16 <i>Saxicoloides fulvicata</i> (Linnaeus) (Indian Robin)	26	22	48	31	—	—	—	—	—	—	—	—	79
Total ..	227	136	1071	207	3	1	5	2	1	—	—	—	1290

NOTE.—4 nestling Little Cormorants, *Phalacrocorax niger* (Vieillot), and 9 nestling Grey Herons, *Ardea cinerea* Linnaeus, were examined, and 61 *Ardea* larvae were collected from one Little Cormorant and five Grey Herons.
L = larva; N = nymph; M = male; F = female.

TABLE 2
TICKS ON SMALL MAMMALS FROM CHITTOOR DISTRICT, ANDHRA PRADESH, AND NORTH ARCOT DISTRICT, MADRAS STATE (1962-63)

Host	Total No. examined	No. +ve for ticks	Ticks												Total								
			Hya or lomna evipunctata			Haemaphysalis intermedia		Haemaphysalis leachi group		Rhipicephalus haemaphysalis physaloides			Rhipicephalus haemaphysalis sp. no. 4			Rhipicephalus haemaphysalis sp. no. 5			Hyalomma sp.?		Rhipicephalus sp.?		
			L	N	M	F	N	N	M	F	N	N	M	F	N	N	M	F	L	L			
<i>Suncus murinus</i> (Linnaeus)	56	7	1	2			1	16							16	2	1				11		50
<i>Vandeleuria oleracea</i> (Bennett)	3	1	13	43	9	17													1				10
<i>Mus platytrix</i> Bennett	81	46	1				1																194
<i>Mus booduga</i> (Gray)	4	1	2	5	1	1																	3
<i>Millardia melitana</i> (Gray)	24	15	2	5	1	1																	85
<i>Tatera indica</i> (Hardwicke)	42	9	2	6	5	3																	79
<i>Rattus rattus rufescens</i> (Gray)	109	17	2	6	5	3																	72
<i>Rattus rattus wroughtoni</i> Hinton	19	9																					11
<i>Rattus rattus</i> subspecies unknown*	3	1	6																				6
<i>Rattus blanfordi</i> (Thomas)	6	1	1																				1
<i>Rattus cutchicus</i> (Wroughton)	3	2																					3
<i>Bandicota bengalensis</i> (Gray & Hardwicke)	4	0																					0
<i>Funambulus tristriatus tristriatus</i> (Waterhouse)	53	12	1	31	4	10	3																51
TOTAL	407	121	26	88	23	39	3	1	225	21	41	7	29	7	10	1							565

* This was a white-bellied form with tail too long for inclusion in *R. r. wroughtoni*. Since all three specimens were immature males, subspecific identification could not be made with certainty.

TABLE 3
MISCELLANEOUS ECTOPARASITIC COLLECTIONS

—	Total No. examined	No. +ve for ticks	<i>Hyalomma brevipunctata</i>		<i>Hyalomma a. anatolicum</i>		<i>Haemaphysalis intermedia</i>			<i>Haemaphysalis salis leachi</i> (Group)			<i>Rhipicephalus haemaphysaloides</i>			Total
			F	M	L	N	M	F	L	N	M	F	N	M	F	
<i>Canis aureus</i> Linnaeus	2	2					13	28	8	17				2	1	69
<i>Herpestes edwardsi</i> (Geoffroy)	2	2									5	1				6
<i>Lepus nigricollis</i> Cuvier	1	1					30	27	17	25						99
Domestic pig	3	2			3									1		4
Bats	5	nil														
Ground drag	6	6	1				189	49	2	8			1	1	251	
Human	2	2											3		3	
TOTAL	21	15	1	3	3		232	104	27	50	5	1	6	1	2	432

Chilka Lake: A Pilot Survey for Banding Possibilities

BY

K. S. LAVKUMAR

Rajkumar College, Rajkot

The Bombay Natural History Society's Party detailed to survey the Chilka area for banding possibilities was rather hurriedly composed in the month of December 1965 and consisted of Shekar of the Society's staff, Kishore Kadiwar a young and enthusiastic naturalist from Rajkumar College taken along by me, and myself. We assembled a few minutes before departure time of the Secunderabad Express at Victoria Terminus. Somehow, our enterprising travel agents got us the necessary seats and the last of the gear was stowed away just as the train pulled away from the platform. It was Christmas Day and the rush of people considerable at this otherwise normally crowded station.

The train journey from Bombay to Poona has always been my favourite; the clean and efficient electric engines make it a habit of speeding across the low coastal plain to the foot of the Western Ghats. The mountain section is slow but not at all trying as an everchanging panorama of escarpments and deep forested gorges provide a thrilling and everchanging view. It was good to once again see the arrogant curve of the 'Duke's Nose' rising above Khandala and momentarily I was transported to its top as I thought of the time two years previously when I had sat on the very edge of the proud profile.

From Lonavla to Poona the countryside assumes a typically Saurashtrian appearance so characteristic of the Black-cotton soil areas and I listed many of the common birds familiar at Rajkot as we speeded past the small farmsteads and groves of trees. Beyond Poona the ubiquitous steam engine took over and we puffed away into the dusk through well irrigated land bearing wheat, sugarcane, and alfa-alfa. I missed the Deccan as we arrived at Hyderabad early on the 26th morning. A day's stay was necessary as the connecting train for Orissa left in the afternoon. We utilised the time in going over the famous Salarjung Museum and bird watching in the attractively laid out public gardens stretching between the station and the Vidhan Sabha.

The section between Hyderabad and Rajamundry on the north bank of the Godavari was also covered under cloak of night and I was able to see little of the country, though I expect I missed little as much should be

arid and I expect scenically uninteresting. The Godavari Delta region was pleasing country, green, well cultivated and populous. Here there was an obvious demonstration of Man at harmony with Nature. People looked well fed, there were fine cattle and despite the human affluence, the trees and other vegetation around the stands of sugarcane and rice stubble were not mutilated. The fuzzy toddy palms lent a peculiar character to the scene. Around Bombay these palms look depressing, but here they have full crowns and were most attractive. Birdlife was plentiful and I expect there should be many roosts of wagtails in the sugarcane plots.

From Rajamundry upto Vizianagaram, where the night once again overtook us, the entire east coastal plain revealed a beautiful aspect. Sugarcane, golden rice stubble, thick stands of coconuts, rows of toddy palms, and closely ranked casuarinas all made a rich pastoral view, offsetting a distant panorama of high blue and tangled mountains of one of India's last great forests, the Dandakaranya. It was lovely country and birdlife was plentiful as could well be expected.

It was somewhere in the middle of the 27th night that the sleepy station of Balugaon saw us bundle out of the train. The entire platform was deserted except for the three of us and the Forest Range Officer deputed to receive us. I sleepily wondered why ever should the train stop at this place at all; Pilot Survey Parties could not be that frequent. A wet breeze blew through a large banyan tree outside the station and limpid stars were reflected in water alongside the road—dimmed imaginations conjured up a limitless expanse of water crowded with waterfowl and skeins darkening the skies overhead—a Pinkheaded Duck among them . . .

28th December. Mr. Rath, the afforestation D.F.O., stowed our luggage and us into two jeeps and we set off for our destination on the SE. edge of the lake. Till Rambha, we travelled along the Madras-Calcutta highway shaded by large trees many of them ancient banyans. The road skirted the sea-like Chilka. The country side had a picture postcard quality and a cool morning breeze blew from the blue mountains to our right. There were few birds apparent, and the lake itself was totally devoid of any waterfowl.

A little beyond Rambha we turned off the road on to a red dirt track and after winding through low scrub-covered hills we came out on to a vast flat expanse of wet grass and salt marshes at the southern end of the lake. There was much water in the roadside ditches, and long muddy inlets of the lake cut across them. The scene now abruptly changed; there were waders and ducks everywhere and, on one large bay of the lake, I was thrilled to see rafts of Pintail and Brahminies unconcernedly drifting close to lines of fish traps. This was fine unspoilt country indeed.

Soon we came onto the sandy flats which continue as a string of dunes to cut off the lake water from the sea. Here were thick stands of casuarinas and cashew trees. This narrow tongue of sand is broken by a single inlet of the sea through which the tide waters enter the lake and the many fish of the Chilka have access to the sea. Between the outer dunes and the body of the lake is a labyrinth of large low-lying islands and water channels. Our hope of coming across large congregations of birds centred on this complex and in this we were disappointed, as the further we proceeded along the dune, the number of birds became less and less and, except for one broad inlet where a great mass of shovellers rose on our arrival, we saw fewer birds in density than might be expected on any winter day on the lakes at Rajkot. Here a duck trapper had a pair of female shovellers and, as they were in good condition, I had them purchased for subsequent ringing and releasing, though other members of our convoy pressed to wring their necks instead. It was suggested we engage him and a few others of his tribe to catch birds for us, but he hardly appeared efficient and the number of birds did not justify making any optimistic arrangements. Despite the paucity of birds, I greatly enjoyed the drive as the freshness of the air and the lovely surroundings were in themselves worth experiencing. It was about 2.00 p.m. when we skirted the last bay and drew up beside two dug-outs with mat sails tied to stakes on the grassy verge. In these we crossed the furlong-wide channel to Barhampur Island which was selected as our headquarters for the survey. The water was crystal clear and nowhere deeper than four feet. The floor was covered by a thick mat of green water plants, but of birdlife there was a singular absence. Two Lesser Egrets and some Ringed Plovers waded along the water margin, and over the grass small flocks of Grey Plovers ran about looking for insects. Two Gadwall swam out in the water to our left. Nothing could have been less exciting. Shekar was disgusted, but I have given up getting disappointed as Dr. Longstaff's advice to Himalayan travellers has long been a part of my general outlook on life, and I make it a point to 'live in the present' and the present in such lovely country was infinitely charming.

The Forest Ranger's hut placed at our disposal was a structure of clean whitewashed adobe walls and thickly thatched roof standing on the northern shore of the island. It was separated from the water by a broad sward of grass, and surrounded by small rice fields, now in stubble, enclosed by earth bunds planted with screw-pine hedges and small wind-swept banyans and cashew trees. The bird population was composed of a scattered group of Ringed, and Grey plovers on the ground, a pair of Redvented Bulbuls, and a rabble of Whitethroated Munias in the hedges, while a Pied Bushchat cock and some Pied Mynas inhabited the small compound of the hut. These then were the surroundings and birdlife of

the Headquarters of the Survey Party for possibilities of ringing thousands of waterfowl!

29th December. After a late breakfast, Mr. Rath decided to take me in a larger dug-out to have a look at the birds reputed to be in large throngs on the mud surrounding the Barnikuda Island and this would also give us an idea of the congregation of birds, if any, on the main lake. Shekar elected to stay behind to string up a few nets along the water's edge in an attempt to get some of the Grey Plovers running about. The brawny boatmen poled us across the shallow waters nowhere deeper than seven feet and when we were well out in the channel and got the full force of the breeze, they unfurled their mat-sail and at a leisurely pace we headed for a narrow channel between Barnikuda and Noapara islands. The amount of birdlife increased and we passed rafts of Pochards and, closer in to land where they could upturn to reach the weeds, Pintail and Gadwall. On the flats, Brahminy Duck in droves grazed placidly. I have never seen so many of them and at such close quarters except in Tibet. There were many Stints of both species, Lesser Sand Plovers, Grey Plovers, and a large flock of Blacktailed Godwits. The variety of waders one sees on the Saurashtra coasts was lacking. A pair of Whitebellied Sea Eagles soared overhead and they had a huge stick nest in a large banyan on the water-edge of Noapara Island. I was brought a downy eaglet by one of the little boys, who apparently went up to the eyrie frequently and once retrieved a duck brought in by the great birds!

Circling the island to the north, I got a view of large concentrations of duck, and in the distance flocks of flamingos made a pink line above the shimmering water. All this concentration was to the west and I resolved to have a closer look at the islands as soon as possible. Our return to camp was uneventful and a brisk sea breeze carried us to a late lunch and a disappointed Shekar who was just in time to take down the nets as a couple of young water buffalos started taking interest in the quality of material used in the new 'fishing-net'.

It was quite apparent that if we wanted to achieve anything, we would have to abandon our idea of returning to Barhampur each evening and setting off the next morning in the boat, as our pace was too slow and we would not be able to cover much area of the islands. My resolve was finalized to spend nights either in the dug-out, or under the stars wherever we touched land at sundown.

The evening was one of intense beauty as a setting sun shed its golden rays on wide expanses of blue water and distant mountains across the lake. A skein of Pintail headed across the green sky towards the sea.

30th December. We accompanied Mr. Rath to the jeeps and saw them off. After the party left, we crossed the dunes through dense

casuarinas to the main sea. The water was clear, and the sand shelved steeply into the green depths. I was struck by the absence of sails along the horizon and it was apparent that coastal traffic was not as well developed as on the western coast.

On return to the rest house, we assembled all our gear and after a hurried lunch, we stowed things into the canoe and set off on our voyage of discovery. It was late afternoon and a stiff sea breeze drove us round the northern edge of Barhampur Island to the entrance of the Noapara channel. This circuit would give us a view into the channel between the islands and the main dune giving us an idea of conditions all the way to Titipo where on our way in we had seen large flocks of shovellers. The main channel and the narrow one into which we turned were devoid of much birdlife and it was again with a sense of nagging doubt that we moored at dusk and settled in for the night, the matting sail spread over the canoe to protect us from night dampness. The pink light of sunset faded to reveal lustrous stars reflected in placid waters and isolated pairs of Brahminy Ducks called to each other in resonant honks, while a few Brownheaded Gulls floated like phantoms on the glassy surface.

31st December. The channel further narrowed and at its narrowest, a cane pallisade cut it off with a couple of fish traps at one end. It was a lovely morning and gulls and Brahminy Ducks floating on the water made attractive pictures. Near the gate in the fish corral, we again grounded our boat and while the boatman went into the village to look for a reputed trapper and fetch some milk, we strolled along the waterside turf under curious but friendly gaze of muscular young fisherlads and watched a medley of common birds: Common Swallows were in numbers and, from the droppings around a large banyan, it was clear they had been roosting there. In a hedge below were a pair of Dhayal, a male Black Redstart, and flocks of Redvented Bulbul. The banyan was alive with Greyheaded Mynas, White-eyes, and high in its great crown was an immense platform of branches and twigs, the home of a majestic pair of Sea Eagles.

The trapper was away and so we pushed off, helped through the narrow passage by the bronzed youths and waved away by a young teacher from the village school who had joined us in our morning amble.

The muddy shores widened into broad flats and expanses of shallow water. Ahead stretched another corral beyond which lay the lake itself. The binoculars revealed an astonishing sight of throngs of waterfowl. Pintail, Gadwall, Wigeon, Common Pochards, and Brahminy Duck placidly floating on the water. To the south the concourse stretched into the hazy distance where a mass of pink proclaimed the presence of a multitude of flamingos. The entire afternoon was sailed parallel to the coast towards Krishnaprashad, and all along the shore were the

teeming multitudes. The flamingos were breath-takingly spectacular. It was indeed a memorable day worth all the distance of travel and the days of disappointment.

The reason why we had not come to know the great concentration of duck was clear. The birds rested and fed in the same area. In the shallows, an upending duck got all it needed from the lake bottom and further out the diving duck got easy fare. On all sides, the rice stubble was too dry and devoid of food for the duck to be attracted off the water, hence the total absence of feeding flights which are such spectacular and familiar sights at Bharatpur. All the ducks were out in the water, and I doubted the efficiency of the netters in harvesting the throngs for us.

That evening we moored beside two other boats off Krishna-prashad and turned in for the night, having accepted the ranking of Chilka among the waterfowl paradises in the country, and the boatmen promising greater sights on the morrow when we arrived at Nalbano Island in the middle of the lake.

1st January. The golden light of the New Year awoke us to a thrilling spectacle of flamingos (Lesser) flying in wavering skeins towards the fabled isle. I was reminded of the early dawn at Nir years ago when we had visited the Flamingo City in the Great Rann of Kutch. A flock of Little Cormorants followed the Flamingos and, among the Brahminy Duck, a group of twelve Shelducks swam past. After an early meal, which was to serve as breakfast and lunch combined, we set course in the direction the flamingos and cormorants had taken, and soon the trees of Krishnaprashad were dimmed in the haze. On the body of the lake itself there were no ducks and the interminable expanses of water and sky and a warm sun overhead induced an amnesia followed by a pleasant drowsiness.

At around noon, I bestirred myself and looked over the gunwale of our 'warship' and what I saw startled me into wakefulness. There ahead of us lay flocks of Pochards and, as we approached a low line of fish corrals which encircled the island, their multitudes became denser and denser. What astonished me more than the number of the birds was the vast pallisade of canes which encircled the entire island like a fortification.

The whole island is submerged under several feet of water in the rains, the fish come to feed and spawn in the shallow, weed-grown place. Before the level of the water falls, this great pallisade is put up by various villages; the island itself is divided into four compartments. As the water level further drops, the weeds are exposed. In fact at the time of our visit there was no dry land. The drying waters expose the fish which are easily captured. This provides, as can be imagined, an ideal feeding ground for duck, geese, flamingos, and Spotted Sandpipers. Great eagles arrive to take the pickings, and on one low em-

bankment I saw an assemblage of 2 Pallas's Fishing Eagles, 3 White-bellied Sea Eagles, 1 Tawny Eagle, a couple of Ospreys, and several Brahminy Kites, while overhead in constant flight were Blackeared Kites, Whiskered Terns, Blackheaded Gulls, and Common Swallows.

Immense flocks of Shoveller, Pintail, Wigeon, and Gadwall fed in the grass and a large flock of Lesser Flamingos rose in a pink haze to the sound of a shot-gun as some shikaris entered the defences of the island in a dug-out. A small flock of 15 Greylags took flight with much gagging. The afternoon was memorable as we waded through the squelching plants, mud, and black ooze. The site was indeed ideal for future ringing operations. That night we slept in the boat after moving out into the lake out of reach of an odious stench set free by the rotting material and bird droppings. We planned a further foray next morning into the marsh.

2nd January. During the night a strong easterly wind began to blow, and in the pale light of dawn I was horrified to see a pale film of cloud overhead, and thick clouds banked the horizon out to sea. 'We end our work on the lake, Shekar', I said and told the men to get us as fast as the gusty wind would take us across the lake to Balugaon. Quite obviously this was a cyclone and I did not fancy getting involved in high wind, waves, and heavy rain under inadequate shelter, rations in their last doles, and valuable cameras and books getting a soaking. So, we hoisted our picturesque but inefficient rattan sail and headed for a steep promontory near which was Balugaon landing. The gales grew intense and the high waves transformed the Chilka into a miniature sea. The dug-out raced forward and by 11:30 a.m. we reached Balugaon. That evening the storm struck with violent intensity. The grey clouds lowered and a deluge poured violently through the night. I was thankful I had abandoned the venture and talking things over with Shekar, I felt it would be correct to start operations in a planned way next season, and as he was to accompany Dr. Sàlim Ali to Bhutan in the summer, he should return to Bombay with me.

3rd January. Dawned weak and wet. The rain continued well into the afternoon and it was only at sundown that the storm clouds receded in a glory of gold and orange skies above the fine blue hills. On the way back, we saw ample testimony of the cyclone's velocity in flattened sugarcane and jute; the great winds, the papers told us, had struck the entire east coast from Orissa to the Krishna Delta.

In conclusion I would like to recommend a ringing project centred at Noapara, with tents to live in. Two boats, one large which could be used for spending nights at the island and a smaller one with an outboard motor for quick transport of personnel and equipment from one halting centre to another. The trappers could

operate from the large dug-out stationed at the island, the smaller craft bringing in the nightly catches each morning to the central camp. In this manner, a 15-day camp should yield fine bags. The ringing party should travel together from Bombay to Balugaon where prior arrangement of hiring boats etc. should be made through the Forest Department. Apart from the help in hiring craft and engaging men, the Society's party should be self-reliant.

There was a suggestion we engage local trappers, but I consider this unsound policy as our work should not encourage netting which subsequently might provide a lucrative occupation at the expense of the birds. There appears to be a good market for trapped duck around Chilka, now one of the sought-after tourist attractions, accessible overnight from Calcutta.

The Nalbano Island could well be declared a sanctuary for ducks. Its pallasades provide easy protection from marauding guns. Supervision would be easy. Shooting around the lake should not be restricted, however. Chilka properly managed is not only ideal for ringing operations, but could well be one of India's star tourist attractions.

Our deepest gratitude is due to Shri Rath, the D.F.O., the Forest Staff at Balugaon, and Shri Mahanty of Bird Heigler & Co., of Calcutta, for all the kind help and encouragement they extended us during our stay in the Chilka area.

Transport of the Fry and Fingerlings of the Milk Fish *Chanos chanos* (Forskål)¹

BY

T. A. MAMMEN²

Fisheries Extension Unit, Mandapam Camp

I. INTRODUCTION

Chanos culture is very popular in several SE. Asian countries, and extensive brackish water fish farms are exclusively devoted to its culture. The main points in favour of chanos culture are : (1) Ready availability of fish seed in creeks, lagoons, and salt pans connected to the sea ; (2) Capacity of the fry and fingerlings to rapidly acclimatize to freshwater conditions ; and (3) Good growth in fresh water, particularly hard water and highly alkaline water, in which the growth of major carp is poor.

From 1931 onwards the culture of chanos was attempted, particularly by the Department of Fisheries, Madras, but no appreciable progress was achieved. Ganapathi *et al.* (1950), Panikkar *et al.* (1952, 1958) and Viswanathan *et al.* (1952) worked out certain interesting aspects of the adaptability and acclimatization of chanos to low salinities. In the wake of this interest several chanos collection centres were located on the east and west coasts of India but, with the advent of improved technique and the shift of emphasis to major carp culture, chanos culture in India has been almost given up. The present production of major carp seed is only about 1% of the total requirements and the culture of chanos admirably fits into some of the places considered unfit for fish culture. The main difficulties in utilizing chanos seed resources are the inefficiency of the methods hitherto used for transporting chanos, the disappointing results of direct stocking of chanos fry, the equally disappointing growth of fry in nurseries, and the very great difficulty of transporting chanos fingerlings.

¹ Published with the kind permission of the Fisheries Development Adviser, Ministry of Food and Agriculture, (Department of Food), New Delhi.

² Present address : Ministry of Food and Agriculture, (Department of Food), New Delhi.

In view of the extensive resources of chanos fry and fingerlings in and around Mandapam, the present author undertook a study of the transport of chanos fry and fingerlings during 1959-62. Although, owing to the winding up of the Fisheries Extension Unit at Mandapam Camp and the transfer of the author to Hyderabad, it was not possible to complete the work, some observations were made, which would help towards the economic utilization of the chanos fry and fingerling resources.

2. TRANSPORT OF CHANOS FRY

2.1. *Chanos fry collection and transport*

The material for the present study was collected from Chinnapalem creek near Pamban. Fry were collected by dragging with a piece of cloth, usually early in the morning. Collection was easy, from a hundred to a thousand fry being collected with each haul. The fry were then taken by head-load in milk-can type containers to Pamban, where they were acclimatized to low salinities, by periodically replacing $\frac{1}{4}$ th water with Well water, this process being repeated till a salinity of 5‰ or so was obtained. The fry were then transported by rail in 40-gallon milk-can type containers, each filled with 25 gallons of water holding 250 to 400 numbers of fry. A mortality varying from 10 to 30% was usually reported after about 6 hours of train journey. As this mortality was considered excessive, alternate modes of transport were attempted.

2.2. Preliminary experiments were conducted, using small plastic bags filled with 175 c.c. of sea-water holding varying numbers of fry, to determine optimum concentrations. The bags were then filled with oxygen and kept for observation on the incidence of mortality. The results are given in Table 1.

It may be seen that, even at a very high concentration of 200 fry of 1.3 to 1.5 cm. size per 175 c.c. of sea-water, no significant mortality was noticed up to 36 hours. At a concentration of 100 fry, mortality was negligible even at 72 hours. With the latter concentration, trial consignments were sent to Madurai, a distance of 90 miles by road and rail. The procedure was as follows.

Chanos fry were obtained from Chinnapalem creek and transported to the Fisheries Extension Unit, Mandapam Camp, by milk-can type container each with 1000 fry, filled to capacity with water from the collection ground. The mouth of the container was plugged with a laboratory towel to avoid splashing during transport. The journey was performed partly by head-load (3 km.), partly by train (6 km.), and partly by Jeep (3 km.). No appreciable mortality was noticed. The fry were then transferred to enamelled trays and gradually acclimatized to low salinity conditions as described above. The entire process of trans-

TABLE I
MORTALITY OF CHANOS FRY (OF 1.3-1.5 CM. SIZE) AT DIFFERENT CONCENTRATIONS IN 175 C.C. OF SEA-WATER
PACKED IN SMALL PLASTIC BAGS WITH OXYGEN UNDER SLIGHT PRESSURE

Sl. no. of experiment	Quantity of water	No. of fry introduced	Mortality at the end of					Remarks	
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.		72 hrs.
	175 c.c.	25	nil	nil	nil	nil	nil	nil	
2	do.	25	1	1	1	1	1	1	
3	do.	50	nil	nil	nil	nil	nil	nil	
4	do.	50	nil	nil	nil	nil	nil	nil	
5	do.	75	1	1	1	2	2	2	
6	do.	75	2	2	2	2	2	2	
7	do.	100	nil	nil	nil	nil	nil	nil	
8	do.	100	nil	nil	nil	nil	nil	nil	
9	do.	150	1	1	2	14	55	95	
10	do.	150	1	2	4	20	78	100	
11	do.	200	1	1	15	47	200	..	
12	do.	200	nil	1	16	73	172	200	
13	do.	300	2	12	300	..	..	..
14	do.	300	6	27	300	..	..	..

NOTE.—The fry were packed in approximately 4 hours after reaching headquarters and 8 hours after collection.

port, and acclimatization, took 6-10 hours. The conditioned fry were counted and removed by petri-dish to finger-bowls, each receiving 100 in number. The water in each finger-bowl was renewed and made up to 175 c.c. and was transferred to plastic bags specially made for the purpose from 200 gauge lay-flat tubing; oxygen from an oxygen cylinder was passed into the plastic bag till it filled up and exerted a reasonable pressure. The free end of the plastic bag was twisted and double knotted. A deal-wood box, 54.5 cm. \times 31.5 cm. \times 33 cm. could hold 40 such bags in four rows in two tiers. The weight of the consignment was 10.2 kg., of which 7.4 accounted for the dead weight of the box. A few trial consignments were despatched to Madurai, where they were opened 20 to 48 hours after packing. In most of the cases the mortality was nil, in a few it ranged from 1 to 4%. One interesting feature was that the results from the transport tests did not appreciably vary from the standing tests. Hence the bulk of the remaining tests were standing tests. In some cases, for example where optimum surface area had to be determined, the jolting effect of the rail transport was simulated by stacking the bags on a weak table and running off and on an old table fan placed on this table.

2.3. *Causes of mortality of chanos fry*

2.3.1. *Handling mortality*

Chanos in all stages was extremely delicate and highly susceptible to injury. A good number were accidentally killed during collection, partly due to injury and partly to the clogging of the gills as a result of the stirring of the silty bottom during dragging. Rough handling invariably resulted in mortality. Thus, if after impounding the fry in the cloth used for collection, the water was drained with the object of measuring the collection, a high mortality would result. To avoid this mortality the fry were transferred with water using a petri-dish for the purpose.

2.3.2. *Medium of transport*

Despite their delicateness, chanos fry showed extreme powers of osmoregulation and could even stand direct transfer from sea-water to fresh water. The question for consideration was which of the salinity concentrations would be most conducive to maximum efficiency. To elucidate this point, fry of 1.7 to 1.9 cm. size were packed with oxygen in lots of 200 in bags, each containing 380 c.c. of water, some lots in collection-ground water, some in well water, some in a mixture of the two, and some in tap water. Where changes in salinity were involved, they were gradually acclimatized. The packed bags were left undisturbed and the occurrence of mortality noted at definite intervals. The physical properties of water were noted before and after the experiment. The results are presented in Table 2. It may be seen that the incidence of mortality was early in tap water, followed by well water, then in the mixture of well water and collection-ground water. Analysis of water

TABLE 2
EFFECT OF MEDIUM OF TRANSPORT ON THE SURVIVAL OF 200 FRY OF 1.3-1.5 CM. LENGTH IN 380 C.C. OF WATER WITH A SURFACE AREA OF 22.84 SQ. CM. IN SMALL PLASTIC BAGS

Sl. No. of expt.	Type of water used	Physical properties of water before expt.		Progressive Mortality at the end of										Physical properties of water after expt.	
		Salinity	pH	24 hrs.	40 hrs.	70 hrs.	90 hrs.	96 hrs.	112 hrs.	118 hrs.	135 hrs.	pH	Oxygen content		
15	Collection ground sea water	38‰	8.4	0	1	1	2	4	24	35	135	7.5	1.14 ml/L		
16	do.	do.	do.	0	0	0	0	31	35	40	140	do.	1.88 ml/L		
17	do.	do.	do.	0	0	1	2	3	15	25	145	do.	2.36 ml/L		
18	Well Water	1.5‰	8.0	2	2	2	10	15	105	discontinued	7.5	2.05 ml/L			
19	do.	do.	do.	0	0	1	6	30	160	discontinued	do.	2.34 ml/L			
20	do.	do.	do.	6	8	10	35	150	discontinued	do.	do.	2.68 ml/L			
21	Ordinary sea-water and well water	20‰	8.2	0	1	1	2	12	55	75	180	7.5	1.5 ml/L		
22	do.	do.	do.	1	2	3	5	7	40	60	175	do.	1.25 ml/L		
23	do.	do.	do.	0	0	0	6	6	31	32	165	do.	2.05 ml/L		
24	Tap Water	3.5‰	8.2	5	5	8	30	190				7.5	...		
25	do.	do.	do.	4	6	9	198					do.	1.71 ml/L		
26	do.	do.	do.	5	6	26	200					do.	...		

Mean Temperature 31°C.

at the end of the experiment showed a pH of 7.5 and sufficient dissolved oxygen in all cases.

The reason for mortality in the low salinities could be either (1) after-effect of acclimatization or (2) effect of accumulation of metabolic waste products. From published accounts (Panikkar *et al.* 1952) it appears unlikely that the former was the reason. This view is supported by the fact that, when larger quantities of water were provided, mortality was delayed. The limiting factor therefore appears to be the accumulation of waste products, whose ill effects are experienced early in the absence of buffer action of the saline medium. The actual physiological break-down responsible for the high degree of mortality between 118 hours and 136 hours, even under high salinity conditions, appears to have been starvation, as is revealed in a subsequent experiment. As the mortality up to 30-hour period is low in all cases and the duration of transport under field conditions was well within this period, all these media could be adopted, although the saline medium ensured a greater margin of safety. The final arrangement was as follows. After the collection of fry, about 6 hours were allowed for the emptying of the stomach—this period was conveniently used for gradually acclimatizing the fry to a salinity of say 20‰. The fry were then packed in saline medium and transported. At the salinity concentration of 20‰, the osmotic pressure was more or less similar to that of the body fluid of the fry, and this would facilitate the removal of the waste products and offer a certain amount of buffering action against the accumulation of carbon dioxide. The final acclimatization to fresh water was done after the completion of the transport.

2.3.3. *Transportation mortality*

This was due to one or more of the following reasons.

2.3.3.1. *Injury sustained.* As already mentioned any injury sustained by the fry ended in mortality. During transportation in milk-can type containers the fry were very liable to get injured by violent splashing. When these metal containers were used, say for short distance journey, splashing was avoided by filling the container to the very top and closing the mouth. The higher percentage of survival reported with the small plastic bag was essentially due to the resilience of the plastic bag cushioning out the splashing to a great extent; also the small surface area of water reduced the amplitude of the splashing.

2.3.3.2. *Lack of proper conditioning.* Conditioning of chanos fry prior to transport involved both acclimatization and physical conditioning. Since final culture was intended in fresh water, acclimatization to it at some stage was necessary. The physical conditioning was to prepare for a crowded journey so that the fry in transport would not suffer from crowding and pollute the medium by vomiting and defaecation. However, prolonged physical conditioning was unnecessary, for chanos fry

occur crowded in the natural environment. The alimentary canal at this stage is short and the contents are quickly voided. So conditioning for 6 hours was sufficient. However, the medium had to be periodically replaced, because the fry would otherwise reinject the faecal matter.

2.3.3.3. *Lack of sufficient oxygen.* The oxygen intake of chanos fry being of the order of 0.0002 c.c./fry/hour, the concentration of 100 fry per 175 c.c. arrived at was quite satisfactory for normal duration of transport. In actual transport, besides the oxygen contained in the medium, oxygen was replenished from the atmosphere and the exact quantity going into solution depended on (1) water surface area, (2) the pressure and the percentage of oxygen contained in the atmosphere.

2.3.3.3.1. *Water surface area.* Increased surface area favoured absorption of oxygen, but caused violent splashing and therefore more mortality. To determine optimum surface area, experiments were conducted with 4 distinct surface areas, keeping 200 fry of 1.7 to 1.9 cm. length in 350 c.c. sea-water as constant in all cases. These plastic bags were packed with oxygen and left in plastic (pickle) jars of appropriate surface area and the jolting effect was artificially simulated. Table 3 shows the optimum surface area for this particular volume and size of fry to be 25 sq. cm. The mortality with larger surface area was considerable, and was caused by injury sustained during splashing. With a limited surface area of 14 sq. cm. the splashing was negligible and the fry were not injured, but mortality set in at 48 to 60 hours and was quite evident at 72 hours. This appeared to be due to oxygen deficiency in the absence of adequate oxygen dissolution on account of the limited surface area.

2.3.3.3.2. *Pressure and percentage of oxygen contained in the atmosphere* determines the extent of oxygen dissolution (Dalton's law and Henry's law). In an open system the rate of dissolution was the least as there was only 20% oxygen and no extra pressure. This could be improved by providing an atmosphere of oxygen (i.e. 100% oxygen) and maintaining it under pressure, as in oxygen packing. Experiments were conducted to find out the relative merits of different packings. Some lots of bags were kept open. In the second lot the bags enclosed a certain amount of atmospheric air, and the free end of the bag was twisted once or twice and knotted so that the air was compressed and exerted a mild pressure on the water below. The third lot was packed with oxygen in the usual way, also maintaining a slight oxygen pressure.

The results presented in Table 4 show that, for short distance transport taking up to 24 hours, even open transport in plastic bags was possible, although not recommended because of the chance of accidental spilling. Merely keeping air under mild pressure prolonged the period of safe transport to 36 hours, and oxygen transport was necessary in cases requiring longer duration of transport.

TABLE 3
EFFECT OF SURFACE AREA ON THE SURVIVAL OF 200 CHANOS FRY OF 1.7-1.9 CM. SIZE IN 350 C.C. OF DILUTED SEA-WATER OF SALINITY 20‰, pH 8.2, AND MEAN TEMPERATURE 30.5°C.

Sl. No. of expt.	Surface area of water in plastic bag, in sq. cm.	Mortality at the end of					Remarks	
		12 hrs.	20 hrs.	36 hrs.	48 hrs.	60 hrs.		72 hrs.
27	14	nil	nil	nil	1	6	28	
28	14	nil	nil	nil	nil	1	22	
29	25	nil	nil	nil	nil	nil	2	
30	25	nil	nil	nil	nil	nil	nil	
31	38.5	16	18	28	48	60	80	
32	38.5	14	14	18	27	40	53	
33	75.5	24	68	154	200			Water was slightly turbid at the end of experiment.
34	75.5	48	124	190	200			do.

NOTE.—The jolting effect of transport was artificially simulated in this experiment.

TABLE 4
EFFECT OF MILD PRESSURE AND OXYGEN ON THE SURVIVAL IN TRANSPORT OF 100 FRY (OF 1.3 TO 1.5 CM.) IN 175 C.C.
OF WATER MADE UP OF EQUAL QUANTITIES OF SEA-WATER AND WELL WATER,
SURFACE AREA APPROXIMATELY 25 SQ. CM.

Sl. No. of expt.	Mode of packing	Mortality at the end of						Dissolved Oxygen concentration at the end of expt.
		12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.		96 hrs.
35	Bags kept open (air without pressure)	1	4	81	100			1.0%
36	do.	1	3	95	100			nil
37	Bags packed with Oxygen under slight pressure	nil	nil	nil	nil	nil	6	94.33%
38	do.	2*	2	2	2	2	3	83.48%
39	Bags packed with air under slight pressure	1	1	5	58	100		2.2%
40	do.	2*	2	2	42	95	100	1.8%

Mean Temperature—30.5°C.; pH=8.2; S=20‰.

* Presumably weak or injured fry.

2.3.4. Starvation mortality

From the Tables 1, 2, and 3 it was seen that even under the best conditions mortality of chanos fry occurred after the 5th day. This was suspected to be due to starvation, as provision of larger quantities of water did not improve the situation. In a large basin of 400 sq. cm. surface area, filled with 5 litres of sea-water 200 healthy fry were kept and the incidence of mortality noted at intervals. The dead fry when noticed were promptly removed to avoid fouling of the water. No mortality was observed until after the 5th day, 8% mortality occurred on the 6th day, 26% mortality (progressive) on the 7th day, 61% on the 8th day, and complete mortality on the 10th day. These deaths were evidently due to starvation. The natural endurance being thus limited, it was necessary that acclimatization, conditioning, and transport were completed and the fry were planted in nurseries within this short period. It is therefore necessary to restrict the combined period of acclimatization and conditioning prior to transport to a short period, say six hours.

2.3.5. Post-planting mortality

Growth of chanos fry in the natural environment is very rapid. They attain 5-8 cm. length (3 to 7.5 gm. weight) in one month and 8 to 16 cm. length (7.5-38 gm.) in the second month. As against this, growth in nurseries was negligible and was associated with a very high incidence of mortality. As direct stocking of fry was a failure, it was felt that naturally-occurring chanos fingerlings should be utilized for stocking.

3. TRANSPORT OF CHANOS FINGERLINGS

Chanos fingerlings occurred in the shallow lagoons in and around Mandapam, including those of the adjoining islands, in such large numbers that, during the late summer months, a fishery of chanos fingerlings existed in this area. Preliminary attempts to stock these large-sized fingerlings yielded good results in Ramanathapuram area. Similar good results were recorded from Vellore Moat farms (1953). The extreme difficulties in transport might have been the main reason for chanos fingerlings not being taken up for large scale stocking.

3.1. Collection of chanos fingerlings

At Pamban chanos fingerlings were caught mostly by scare line fishing. At Mandapam, *kondavalai* (an inshore drag net with wooden sticks at regular intervals keeping the head rope and foot rope at a fixed distance) was used. The *kondavalai* was dragged by 6 to 10 fishermen in the shallow regions of the lagoon. During low tide the fingerlings got stranded in the pools and collection was particularly easy, anything up to 2500 fingerlings being collected per hour per net.

The freshly collected fingerlings being over-active, hand picking led to loss of scales and consequent fungal attack and injury to the internal organs. The excited fingerlings knocked about in the container, bruising their body and polluting the water medium by the fallen scales and vomited and defaecated matter. The mortality was so great that in one instance the entire collection of about 2000 fingerlings died in the short period between collection and actual transport.

3.2. *Oxygen consumption of freshly caught chanos fingerlings*

Viswanathan & Tampi (1952) and Job (1957) worked out the oxygen consumption of chanos in relation to size. But the oxygen consumption reported appeared to be that of routine metabolism of conditioned fish as the figures did not amply reflect the oxygen requirements of freshly caught fingerlings. In actual practice it was necessary to know of the optimum quantity of water required per fingerling to keep them alive. With this object a series of trials were made using small cement cisterns having a surface area of approximately 0.8 square metres. Each cistern was filled with 35 gallons of water made up of equal quantities of fresh water and sea-water. Concentrations varying from 5-500 freshly caught fingerlings of size 7 to 9 cm. were kept in the cisterns. Mortality, except in the lower concentrations, was so rapid that it was not possible to keep a record. Having got an idea that the optimum number was between 10 and 20 fingerlings per cistern, the experiments were repeated to arrive at the optimum number. Fingerlings that died shortly after the experiment began were replaced, their mortality being considered due to injuries sustained during collection. The optimum number was found to be about 17. This indicated that about 2 gallons (9 litres) of water were required to sustain a single fingerling — a requirement inconsistent with economical transport. The solution was one of reducing the rate of oxygen uptake. Of the two methods available, (1) use of anaesthetics and (2) physical conditioning, the latter alone was tried.

3.3. *Conditioning of chanos fingerlings.*

The fingerlings, immediately after impoundment in *kondavalai*, were transferred with minimum handling to conditioning boxes with velon screen sides, kept immersed in water. The conditioning boxes were then transported, where possible, through water and, where overland transport was necessary, in water-proofed jeep trailers filled with salt water. Spilling of water from the trailer was minimised by firmly tying a thin tarpaulin over the trailer mouth. To begin with, the conditioning boxes with the fingerlings were kept immersed in the channel leading to the Marine Fish Farm at Mandapam. In due course the screen meshes got plugged with silt and not more than 150 fingerlings could be kept alive in a 105-gallon conditioning box. By periodical cleaning of the mesh, it was possible to keep alive 200 fingerlings. The conditioning

box was then moored to an anchor in the open sea, a little beyond the zone of turbulence. In these conditions a concentration of 250 fingerlings not only did not result in appreciable mortality but the fingerlings continued to be active, even after 4 days. Dissection revealed that they were getting sufficient food; starvation was evidently necessary to reduce the activity. For this purpose a 6000-gallon cemented tank at the Fisheries Campus was filled with water, partly salt and partly fresh, and the fingerlings in the conditioning box were left to starve in the tank. This procedure worked, the fingerlings became progressively less active, and several batches of 200 to 250 fingerlings were successfully conditioned.

Whereas freshly captured chanos fingerlings knocked about in frenzied excitement at the sound of an approaching foot-step the same fingerling of size 6-10 cm. did not respond to the sound of foot-steps after about a week's conditioning, though it could be excited by the beam of a flash light. After another week flashing a light merely induced a scattering of the shoal, and after 3 weeks of conditioning even this response was hard to detect. Conditioning time increased with the size of the fingerlings.

3.4. *Starvation mortality*

Unlike chanos fry, chanos fingerlings were hardy and, in a test case, survived 56 days of starvation. Though they appeared emaciated with somewhat disproportionately large heads, some of them grew very well when stocked in tanks near Chittarakottai—apparently the prolonged starvation did not impair their capacity for growth.

3.5. *Effect of starvation on the efficiency of chanos fingerling transport*

An experiment was conducted to determine the optimum number of 56 days conditioned chanos fingerlings. In standard plastic bags each containing 6 litres of water, 5, 10, 20, 30, 40, 50 and 60 fingerlings respectively were introduced and packed with oxygen. No mortality was seen in any lot in a standing test of 6 days' duration. The maximum efficiency in this case worked out to 10 fingerlings per litre as against 1 fingerling per 9 litres for unconditioned fingerlings. In actual practice such prolonged conditioning would be difficult, and the observation reported merely illustrates the possibility of economic transport by starving the fingerlings.

In order to arrive at the concentrations of fingerlings at various levels of starvation a few further experiments were conducted. The results obtained are presented in Table 6.

Since the season expired soon after and the author was transferred, by the next season these experiments could not be repeated on a statistical design.

TABLE 5
EFFECT OF CONDITIONING ON THE LIMITS OF CONCENTRATION OF CHANOS FINGERLINGS AS REVEALED IN STANDING TESTS IN STANDARD SIZE PLASTIC BAGS PACKED WITH OXYGEN UNDER SLIGHT PRESSURE, USING WATER OF LOW SALINITY (5‰)

Serial No. of expt.	Length of fingerling in cm.	No. of fingerlings.	Qty. of water in litres.	Qty. of water per fingerling in c.c.	Period of conditioning before packing.	Mortality recorded at the end of						Remarks on concentration for the conditioning given.		
						6 hrs.	12 hrs.	18 hrs.	24 hrs.	30 hrs.	36 hrs.		48 hrs.	
41	4-6	60	9	150	12 days	nil	nil	7	—	—	—	—	—	—
42	4-6	49	9	180	8 do.	nil	nil	nil	nil	nil	6	6	Safe.	
43	4-6	60	9	150	12 do.	nil	nil	nil	nil	nil	nil	nil	do.	
44	7 (av.)	25	6	240	1½ do.	nil	2	2	2	3	5	5	Slightly excessive.	
45	7 (av.)	60	9	150	7 do.	nil	nil	6	discontinued				Excessive.	
46	7 (av.)	70	9	129	7 do.	nil	6	11	discontinued				do.	
47	7 (av.)	40	9	225	12 do.	nil	nil	nil	nil	nil	nil	nil	Safe.	
48	7-5 (av.)	60	9	150	7 do.	nil	nil	3	7	discontinued			Excessive.	
49	7-5 (av.)	75	9	120	7 do.	nil	nil	6	11	discontinued.				
50	8 (av.)	25	9	360	3 hrs.	15	23	discontinued					Obviously in excess.	
51	8 (av.)	20	9	450	3 do.	20	20	discontinued					do.	
52	8 (av.)	25	9	360	1 day	2	4	discontinued					Obviously in excess.	
53	8 (av.)	50	9	180	7 days	nil	nil	nil	1	15	15	15	Slightly in excess.	
54	8 (av.)	50	9	180	7 do.	nil	nil	23					Excessive.	

TABLE 6
 RESULTS OF CHANOS FINGERLING TRANSPORT USING JEEP TRAILER WITH FINGERLINGS PACKED WITH
 OXYGEN IN STANDARD PLASTIC BAGS SUPPORTED IN CONVERTED KEROSENE TINS—DISTANCE 100 MILES;
 DURATION OF ACTUAL JOURNEY 5 HRS.

Serial No.	Length of fingerling in cm.	No. of fingerlings	Quantity of water in litres	Quantity of water per fingerling (in c.c.)	No. of days of conditioning before packing	Actual duration between time of packing and time of release	Mortality at the time of release
75	4-7	70	9	129	10	13 hrs.	1
76	4-8	54	9	167	14	13 "	nil
77	4-8	70	9	129	5	13 "	1
78	4-8	60	12	200	4	9 "	2
79	5-8	50	12	240	14	12 "	nil
80	5-9	55	12	218	5	10 "	2
81	5-9	45	12	267	5	10 "	3
82	5-9	50	12	240	5	11 "	2
83	5-9	50	12	240	5	9 "	2
84	6-10	46	12	267	5	11 "	nil
85	6-10	45	12	267	5	12 "	4

86	6-10	42	12	286	5	12 "	1
87	6-10	40	12	300	5	12 "	4
88	6-8	35	12	343	4	10 "	3
89	6-8	35	12	343	4	9 "	4
90	6-8	35	12	343	4	8½ "	3
91	7-9	40	12	300	4	9 "	4
92	8-10	40	12	300	4	9 "	3
93	8-12	28	12	429	10	13 "	nil
94	7-13	32	12	375	14	13 "	nil
95	9-12	20	12	600	4	9½ "	5
96	10-12	20	12	600	4	10 "	8
97	8-11	25	12	480	4	9 "	6
98	9-12	20	12	600	4	10 "	6
99	9-13	18	12	667	4	10 "	5

4. ACKNOWLEDGEMENTS

I am thankful to the Ministry of Food and Agriculture, Government of India, for facilities, and to the staff of the Fisheries Extension Unit, Mandapam Camp, particularly Shri P. Sulochanan, for assistance in this work.

This work was initiated in collaboration with Shri K. Virarajendra Rao, then the Fisheries Extension Officer, Fisheries Extension Unit, Mandapam Camp. After his transfer from this unit the work was carried out more or less independently by the author. The author is grateful to Shri Rao for his continued interest and several helpful discussions during the course of this work.

SYNOPSIS

Transport is the main difficulty in utilising the extensive seed resources.

It was found that chanos fry can be transported in small plastic bags very economically and with almost no mortality. Delicate handling and gradual acclimatization over 6 hours to about half salinity concentration prepare the fry for transport. The fry can be transported without any packing in small plastic bags upto 24 hours, with air under mild pressure upto 36 hours, and in oxygen under mild pressure upto 96 hours without appreciable mortality. Large water surface area reduces mortality by splashing. Optimum area was found to be about 100 sq. cm., for 350 c.c. of water.

The lack of sufficient knowledge on the technique of rearing chanos fry to fingerling size limits the applicability of the above method of transport.

Chanos fingerlings are available in large quantities in the natural environment. By a simple technique of starvation it was possible to overcome their extreme excitability and high oxygen demand and thus improve the transport efficiency by 90 times, a level at which it is economically feasible to undertake their long distance transport for stocking purposes.

REFERENCES

- ANONYMOUS (1954): Administrative Report of the Department of Fisheries, Madras, for the year ending 31st March 1953.
- GANAPATI, S. V., CHACKO, P. I., SRINIVASAN, R., AND KRISHNAMURTHY (1950): On the acclimatization, transport and culture of some salt water fishes in inland waters of Madras State. *Indian Geographical Journal* 25 (2): 1-15.
- JOB, S. V. (1957): The routine active oxygen consumption of the Milk fish. *Proc. Indian Acad. Sci.* 45 (B) (6): 302-313.
- PANIKKAR, N. K., TAMPI, P. R., VISWANATHAN, R. (1952): On the transport of Milk-Fish *Chanos chanos* (Forsk.) in plastic bags. *Curr. Sci.* 21: 18-19.
- (1958): Some observations on the adaptation of *Chanos chanos* (Forsk.) to different salinities. *Proc. Ind. Acad. Sci.* 37 (6) (B): 205-210.
- VISWANATHAN, R., & TAMPI, P. R. (1952): Oxygen consumption and its relation to size in *Chanos chanos* (Forsk.). *Proc. Ind. Acad. Sci.* 36 (4), Sec. B: 148-157.

Studies on the Insect Pollinators of *olitorius* and *capsularis* Jute

BY

S. K. GHOSE

Jute Agricultural Research Institute, Barrackpore, West Bengal

(With two figures)

INTRODUCTION

In the course of study on natural crossing in two cultivated species of jute, *Corchorus olitorius* Linn. and *C. capsularis* Linn. (Family: Tiliaceae), Ghose & Das Gupta (1945) found that, among flower-visiting insects, bees are the most numerous and frequent of the visitors effecting cross-pollination. But they did not mention the species of the bees. Ray (1960) assumed that insects, wind, gravitation, etc. were the possible agents of natural crossing in *olitorius* Jute. Dutt & Ghose (1962) ascertained that insects and not wind are the agents of cross-pollination in both the species. Ghose & Das Gupta (1945) hypothetically deduced that the higher frequency of natural crossing in *olitorius* was due to the bigger size of its flowers being preferred by the insects. None of the previous workers examined the population of pollinating insects. So the present investigations were carried out to study the insect pollinators of both these species of jute.

MATERIAL AND METHODS

Two field experiments, one with *olitorius* (JRO-632) and the other with *capsularis* (JRC-212), were conducted in 1962 season. Crops were raised in lines, 30.48 cm. (1 ft.) apart, in two separate but adjacent plots. Each plot was 21.34 m. \times 17.07 m. (70 ft. \times 56 ft.). The plant to plant distance along the lines was 7.62-10.16 cm. (3-4 in.).

The flower-visiting insects were caught simultaneously from both the *olitorius* and the *capsularis* trials for 11 days during the flowering stage and their records were maintained. Insects were caught at six fixed periods each day, namely 6.30-7.00, 8.00-8.30, 9.30-10.00, 11.00-11.30, 12.30-13.00, and 13.30-14.00 hours.

The number of flowers on three plants taken at random from every alternate row, i.e. 81 plants from each trial, were recorded on the days

of capturing the insects. In the case of both the species, correlation between the total numbers of hymenopterous insects and *Apis dorsata* Fabricius caught and the average number of flowers per plant on the respective dates have been calculated.

In order to assess the activities of *A. dorsata*, observations were made to find out the average number of flowers and plants visited per minute and also the time spent in a flower and in between two flowers by a single bee in both the species of jute.

OBSERVATIONS

Orders of insects visiting flowers :

(a) *olitorius* : Insects belonging to three orders, namely Hymenoptera, Diptera, and Lepidoptera were found to visit *olitorius* flowers in the proportions 80.00, 18.3, and 1.7% respectively. The average total catch of insects was 30 per day (Fig. 1).

(b) *capsularis* : *capsularis* flowers were also visited by these three orders of insects. The average capture of flower-visiting insects per day was 52 (Fig. 1). The percentages of hymenopterous, dipterous, and lepidopterous insects were 80.7, 18.3, and 1.0 respectively.

The ratio between the average daily catches of insects in *olitorius* and *capsularis* fields was 1 : 1.8. Therefore, the density of insect population in *capsularis* was nearly double that in *olitorius*.

Hymenopterous insects visiting flowers :

(i) *olitorius* : Three oriental species of honey bees, namely *Apis dorsata* Fabricius, *A. florea* Fabricius, and *A. indica* Fabricius, were found to visit *olitorius* flowers. Their respective daily average number of captures were 18.0, 1.0, and 0.5 (Fig. 1), representing 75.3, 5.3, and 2.3 % respectively of the hymenopterous insects. The remaining 17.1 % hymenopterous insects consisted of bees other than honey bees, wasps, etc., none of them in considerable number.

(ii) *capsularis* : In *capsularis*, the corresponding average number of daily captures of *A. dorsata*, *A. florea*, and *A. indica* were 28.0, 6.0, and 0.5 respectively (Fig. 1), constituting 66.4, 14.8, and 1.3 % respectively of the hymenopterous insects. Like *olitorius*, among the remaining 17.5 % hymenopterous insects, none of the species of other bees, wasps, etc., was worth mentioning.

The average daily captures of *A. dorsata*, *A. florea*, and the remaining hymenopterous insects in *capsularis* were 1.55, 6.0, and 1.75 times respectively more than in *olitorius*. The populations of *A. indica* were negligible and equal in both the fields.

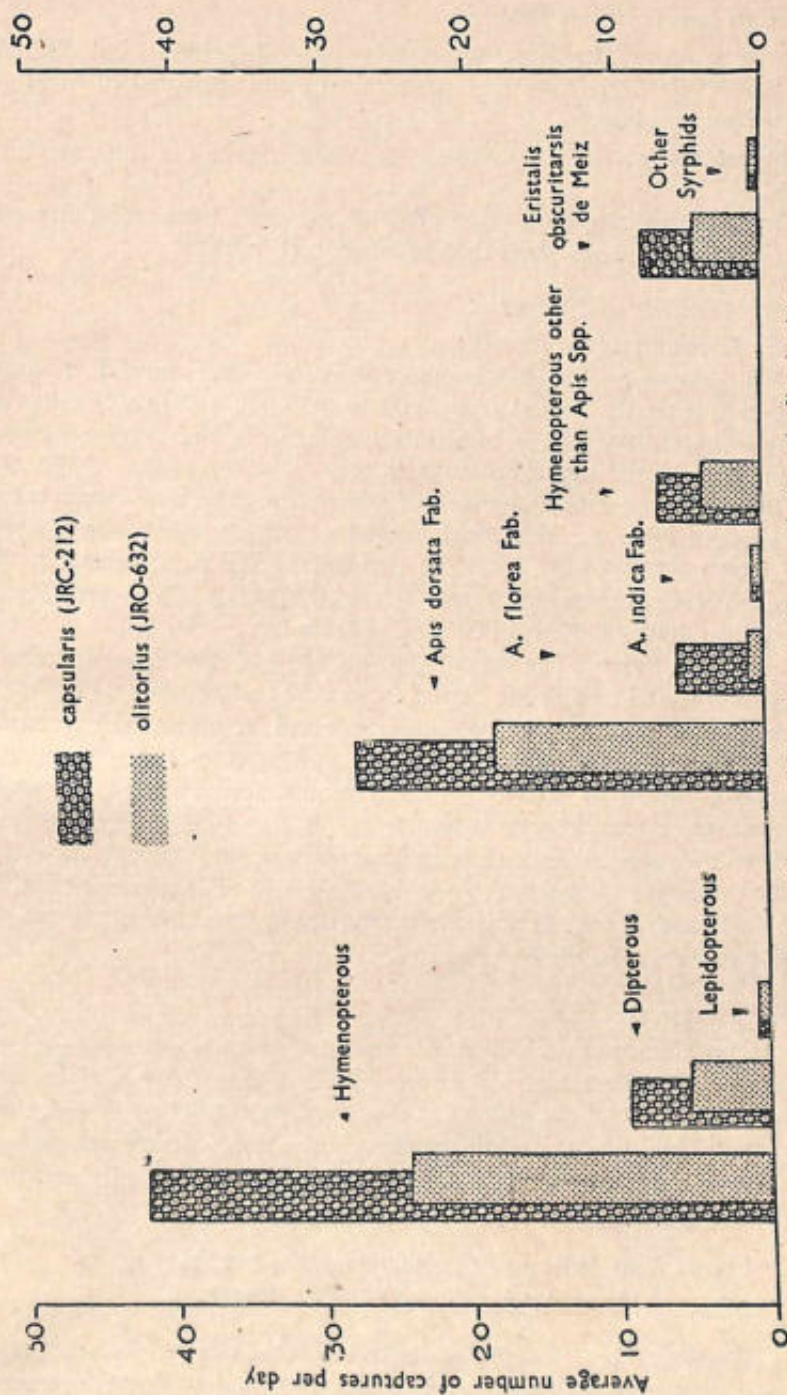


Fig. 1. Activities of flower-visiting insects in *capsularis* and *olitorius* jute.

Dipterous insects visiting flowers :

(a) *olitorius* : The dipterous insects were all syrphids, but *Eristalis obscuritarsis* de Meiz. was very predominant and consisted of 81.97 % of the dipterous insects.

(b) *capsularis* : *E. obscuritarsis* was 86.91 % of the total syrphids caught.

The captures of syrphids and of *E. obscuritarsis* were 1.75 times and 1.84 times more in *capsularis* than in *olitorius* (Fig. 1).

Periods of activity of insects :

A. Hymenopterous insects :

(i) *olitorius* : The hymenopterous insects were found in large numbers during the period from 8.00 to 8.30 hours (Table 1). But as *A. dorsata* was 60 % of the total insect pollinators and none of the remaining species of hymenopterous insects was more than 3.3 %, the activities of *A. dorsata* alone and of the others collectively were taken into account (Fig. 2). The peak period of activity of *A. dorsata* was from 8.00 to 8.30 hours, but there was no marked peak period in the activities of the remaining hymenopterous insects. They were found to be active during 8.00 to 14.00 hours (Table 2a).

(ii) *capsularis* : The maximum activity of the hymenopterous insects was found during the period from 9.30 to 10.00 hours (Table 1). It is evident from Table 2b that *A. dorsata* and *A. florea*, which constituted 53.8 and 11.5 % respectively of the total capture of insects had the same peak period of activity. But hymenopterous insects other than *Apis* spp. were found to be active from 8.00 to 14.00 hours, without showing any appreciable peak in their activities (Table 2b).

The difference in the peak periods of activity of *A. dorsata* (Fig. 2) in *olitorius* and *capsularis* was obviously due to the different times of opening of flowers in the two species.

B. Dipterous insects :

In both *olitorius* and *capsularis* jute, dipterous insects were present in maximum numbers during the period from 6.30 to 7.00 hours, though *capsularis* flowers had not opened at that time. During that period, they were found to sit on the closed *capsularis* and *olitorius* flowers which had bloomed on the previous day and also to visit fresh *olitorius* flowers.

Correlations between the population densities of flowers and hymenopterous insects and A. dorsata

(a) *olitorius* : No significant correlations between the average numbers of flowers per plant and of daily capture of hymenopterous insects and *A. dorsata* (Table 3) have been found.

TABLE I
ACTIVITIES OF HYMENOPTEROUS AND DIPTEROUS INSECTS DURING DIFFERENT PERIODS

Insect Orders	Species of jute	Average no. of captures in half-hours beginning :							Total
		6-30 hrs.	8 hrs.	9-30 hrs.	11 hrs.	12-30 hrs.	13-30 hrs.		
Hymenoptera	<i>olitorius</i>	1.18	11.82	5.18	3.18	1.45	1.09	23.90	
	<i>capsularis</i>	0.27	5.18	20.45	8.00	5.09	3.27	42.26	
Diptera	<i>olitorius</i>	2.09	0.36	0.36	1.09	1.09	0.54	5.53	
	<i>capsularis</i>	4.64	1.54	0.64	0.73	1.36	0.82	9.73	

TABLE 2a
ACTIVITIES OF HYMENOPTEROUS INSECTS IN *olitarius* DURING DIFFERENT PERIODS

Insects	Average no. of captures in half-hours beginning: ●						Total
	6-30 hrs.	8 hrs.	9-30 hrs.	11 hrs.	12-30 hrs.	13-30 hrs.	
<i>Apis dorsata</i>	1-00	10-73	3-91	1-54	0-73	0-09	18-00
<i>A. florea</i>	0-09	0-18	0-45	0-18	0-18	0-18	1-26
<i>A. indica</i>	0-00	0-00	0-18	0-18	0-09	0-09	0-54
Insects other than <i>Apis</i> spp.	0-09	0-91	0-64	1-28	0-46	0-73	4-11

TABLE 2b
ACTIVITIES OF HYMENOPTEROUS INSECTS DURING DIFFERENT PERIODS IN *capsularis*

Insects	Average no. of captures in half-hours beginning:						Total
	6-30 hrs.	8 hrs.	9-30 hrs.	11 hrs.	12-30 hrs.	13-30 hrs.	
<i>Apis dorsata</i>	0-00	3-27	15-73	5-09	3-17	0-82	28-08
<i>A. florea</i>	0-00	0-45	3-91	1-09	0-26	0-54	6-25
<i>A. indica</i>	0-00	0-00	0-18	0-09	0-18	0-09	0-54
Insects other than <i>Apis</i> spp.	0-27	1-55	0-64	1-71	1-47	1-82	7-46

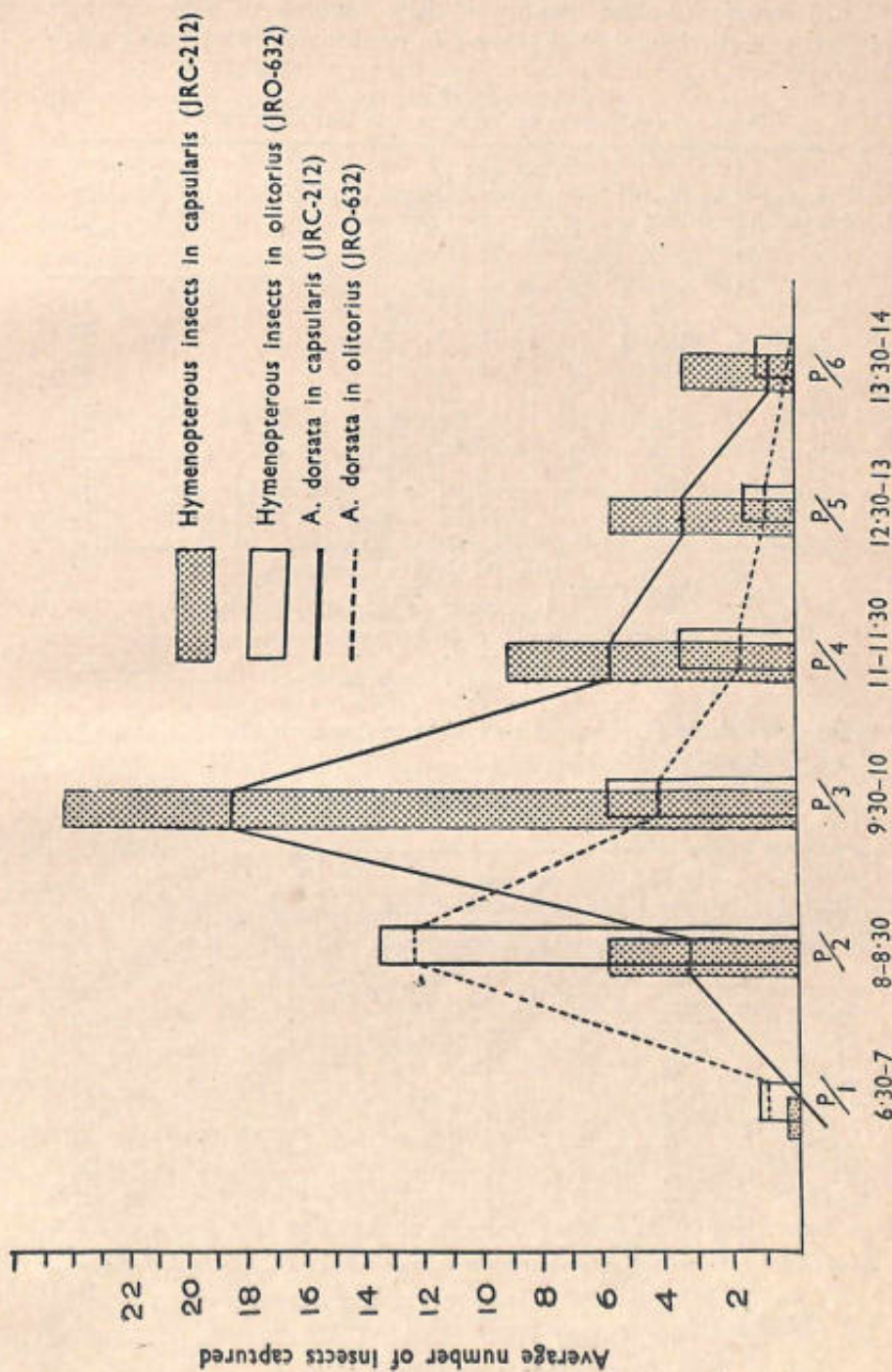


Fig. 2. Activities of Hymenopterous insects and *Apis dorsata* Fabricius during different periods in the day.

(b) *capsularis*: The number of daily captures of hymenopterous insects collectively and of *A. dorsata* in particular showed highly signi-

TABLE 3
POPULATION DENSITIES OF FLOWERS AND INSECTS IN *olitorius*

Date of observation	Av. no. of flowers	Number of hymenopterous insects			No. of lepidopterous insects	No. of dipterous insects	Total
		<i>A. dorsata</i>	Others	Total			
25-9-62	3.54	20	9	29	—	5	34
27-9-62	2.67	5	5	10	3	8	21
29-9-62	3.22	11	7	18	2	13	33
3-10-62	1.84	23	8	31	1	14	46
4-10-62	1.96	22	7	29	0	4	33
5-10-62	2.64	43	1	44	0	5	49
9-10-62	2.68	44	3	47	0	4	51
11-10-62	2.13	15	9	24	0	3	27
12-10-62	2.28	5	9	14	0	2	16
16-10-62	1.54	9	4	13	0	3	16
18-10-62	0.84	1	3	4	0	0	4

Correlations : $\left\{ \begin{array}{l} r_{12} \ 0.345 \\ r_{13} \ 0.418 \end{array} \right\}$ The correlations are not significant.

1=average number of flowers per plant

2=number of *A. dorsata*

3=total number of hymenopterous insects

ficant correlations (at 1% level) with the average number of flowers per plant per day (Table 4).

TABLE 4
POPULATION DENSITIES OF FLOWERS AND INSECTS IN *capsularis*

Date of observation	Av. no. of flowers	Number of hymenopterous insects			No. of lepidopterous insects	No. of dipterous insects	Total
		<i>A. dorsata</i>	Others	Total			
25-9-62	6.85	25	6	31	4	7	42
27-9-62	6.53	25	20	45	1	10	56
29-9-62	10.64	54	25	79	—	12	91
3-10-62	3.34	34	23	57	—	12	69
4-10-62	4.49	32	11	43	—	29	72
5-10-62	7.30	56	4	60	—	9	69
9-10-62	5.36	56	10	66	—	14	80
11-10-62	3.42	17	13	30	—	4	34
12-10-62	2.13	7	22	29	1	5	35
16-10-62	1.22	3	19	22	—	4	26
18-10-62	0.39	0	3	3	3	1	7

Correlations : $\left\{ \begin{array}{l} r_{12} \ 0.800 \\ r_{13} \ 0.796 \end{array} \right\}$ 1=average number of flowers per plant
2=number of *A. dorsata*
3=total number of hymenopterous insects
The correlations are highly significant.

Effects of climatic conditions on the activities of pollinating insects :

Dutt & Ghose (1962) assumed that the activities of pollinating insects are affected by rainfall ; in the present experiments, their activities were observed to be greatly reduced in cloudy weather.

Behaviour of A. dorsata in olitorius and capsularis fields :

(a) *olitorius* : *A. dorsata* was found to visit on an average 9.93 flowers and 8.85 plants per minute. Rarely, was it found to visit two flowers of the same plant consecutively. It spent on an average 4.37 and 3.63 seconds in a flower and in between two flowers respectively (Table 5).

TABLE 5

BEHAVIOUR* OF *A. dorsata* IN *olitorius* AND *capsularis* FIELDS

Species of jute	Av. no. of flower per plant	No. of plants visited per minute	No. of flowers visited per minute	Time (in secs.) spent in a flower	Time (in secs.) spent between two flowers
<i>olitorius</i>	2.65	6.06-11.35 av. 8.85	4.61-19.45 av. 9.93	2.23-10.38 av. 4.37	1.92-7.16 av. 3.63
<i>capsularis</i>	6.91	6.95-12.63 av. 8.38	6.40-17.14 av. 11.18	1.50-3.75 av. 2.40	1.35-3.62 av. 2.36

*Observations on different aspects were made separately.

(b) *capsularis* : It visited on an average 11.18 flowers and 8.38 plants per minute (Table 5). Frequently, the flowers of the same plant were visited consecutively by a single bee. It spent less time in a flower (average 2.40 seconds) and in between two flowers (average 2.36 seconds) than in *olitorius*. The difference in behaviour was probably due to the smaller size and greater number of *capsularis* flowers.

DISCUSSION

In order to justify their view on the cause of higher percentage of natural crossing in *olitorius* jute, Ghose & Das Gupta (1945) stated that *olitorius* flowers, owing to their larger size, were preferred by the flower-visiting insects. Dutt & Ghose (1962) were of the opinion that the lower percentage of natural crossing in *capsularis* was due to the larger number of flowers per plant, i.e. all the flowers were not visited by the insects. Neither explanation seems satisfactory to the present author, since the proportion of flowers to insects in the *olitorius* field was virtually the same as that in *capsularis*. For example, while the number of flowers in

capsularis was double that of *olitorius*, the number of insect visitors to the former was also nearly double, i.e. 1.8 times. Moreover *Apis dorsata*, the most important species, was found to visit *capsularis* flowers more frequently and as such there is little chance of any *capsularis* flower remaining unvisited as assumed by the above workers. In the opinion of the present author, the higher percentage of natural crossing in *olitorius* is due to a much larger number of ovules in its flowers than in *capsularis* and less chance of close-pollination than in the latter as ascertained from the behaviour of *A. dorsata*. According to Ghose & Das Gupta (1945), the average number of ovules per ovary of *olitorius* is 200 against 50 in *capsularis*. It is, therefore, likely that the number of unfertilised ovules after anthesis will be higher in *olitorius*, thereby enhancing chances of natural crossing by the insects.

The variations in the extent of natural crossing in *olitorius* jute in the observations of Ghose & Das Gupta (1945) and of Ray (1960) were slight, although they followed quite different techniques. The former authors thought that, if the number of dominant plants be increased, the chances of a flower of a recessive plant being out-pollinated by the pollen of another recessive plant would be less. Accordingly, they raised four recessive plants in a field of dominant plants and recorded on the average 12.8% natural crossing per plant, with a maximum of 17.0%. Ray (1960), on the other hand, raised both the strains of *olitorius* in alternate rows and registered on an average 10.5% natural crossing per plant, the highest being 17.7%, the figures differing little with those of Ghose & Das Gupta (1945). Considering the proportion of dominant and recessive plants, the percentages of natural crossing should have been higher in the former experiment. The present author considers that the lack of any significant variation is most probably due to differences in the population and activities of pollinating insects. The findings of Dutt & Ghose (1962) tend to support this view, since they recorded much less natural crossing in *olitorius*, though following the same technique as Ray (1960). They attributed this phenomenon to the reduced activity of the pollinating insects due to frequent rainfall. Likewise, the same factor seems to be responsible for the variations in the percentages of natural crossing in *capsularis*, as observed by Ghose & Das Gupta (1945), in different years or in the same year and in the same or different localities.

The part played by insects in the pollination of *olitorius* and *capsularis* jute is further realised from the work of Dutt & Ghose (1962), who observed that the setting of seeds per pod was about 46% and 12% more in non-caged *olitorius* and *capsularis* plants respectively in comparison with caged plants and expressed the opinion that 16-mesh wire-net cages were satisfactory from the point of view of aeration, light, and humidity. It was, therefore, quite likely that visits of the insects

increased the intensity of self-pollination, leaving aside the question of close- and cross-pollination, and thereby increased the production of seeds in non-caged plants.

It is evident from the above observations that *A. dorsata* is the most important insect pollinator of both the cultivated species of jute. Unfortunately, this species cannot be maintained in hives, which is however possible for *A. indica*. It may be worth while to place colonies of this species in jute fields during the flowering season for the increase in the production of seeds.

SUMMARY

Hymenopterous and dipterous insects represented about 80 and 18% respectively of the pollinating insects both in *olitorius* and in *capsularis* jute; lepidopterous insects were negligible. The total capture of insect pollinators in *capsularis* was 1.8 times more than in *olitorius*.

The percentages of *Apis dorsata* among the hymenopterous insects were about 75 and 66 in *olitorius* and *capsularis* respectively. The corresponding percentages of *A. florea* were about 5 and 15. No other species of hymenopterous insect was important.

Eristalis obscuritarsis was about 82 and 87% of the total syrphids captured in *olitorius* and *capsularis* respectively.

The peak period of activity of *A. dorsata* was from 8.00 to 8.30 hours in *olitorius*; in *capsularis*, this species and *A. florea* showed highest activity from 9.30 to 10.00 hours. This was due to the different times of opening of flowers in the two species of jute.

The number of daily captures in *capsularis* of total hymenopterous insects and of *A. dorsata* showed highly significant correlations with the average number of flowers per plant. But no such correlation has been found in *olitorius*.

Cloudy weather affected greatly the activity of the insects.

Owing to the smaller size and greater number of the flower in *capsularis*, *A. dorsata* visited more plants and flowers per minute and spent less time in a flower and in between two flowers of this species than in *olitorius*.

The higher percentage of natural crossing in *olitorius* was probably due to its larger number of ovules which increase the chances of natural crossing as compared with *capsularis*.

For production of seed, colonies of *A. indica* might usefully be placed in jute fields during flowering.

ACKNOWLEDGEMENT

Thanks are due to Sri P. Dutta, Statistician, Central Inland Fisheries Research Institute, Barrackpore, for helping in the analysis of the data.

REFERENCES

- DUTT, N. & GHOSE, S. K. (1962): Measurement of natural crossing as effected by insects in *olitorius* and *capsularis* jute. *Indian J. of agric. Sci.* **32**: 242-250.
- GHOSE, R. L. M. & DAS GUPTA, B. (1945): Floral biology, antheses and natural crossing in jute. *Indian J. Genet.* **4**: 80-84.
- RAY, B. (1960): Natural crossing in *Corchorus olitorius* L. *Indian Agrist.* **4**: 1-4.

Nomenclatural Notes on some Flowering Plants

BY

N. P. BALAKRISHNAN*

Botanical Survey of India, Shillong

The following notes involving nomenclatural changes were compiled by the author during the course of his work in the large Central National Herbarium at Calcutta. The names are arranged family-wise. In addition to the citation of original publication, indication of type specimens wherever located, and important floras, a brief explanation to the required name change is included.

AQUIFOLIACEAE

Ilex tavoyensis Balak. nom. nov. *I. wallichii* Hook. f. Fl. Brit. Ind. 1 : 605, 1875 (non Steudel 1840) ; Kurz, Fl. Brit. Burma 1 : 246, 1877. Type : Tavoy, Gomez s.n. Herb. Maingay 1774 (CAL).

ANACARDIACEAE

Holigarna wightii Balak. nom. nov. *H. grahamii* Hook. f. Fl. Brit. Ind. 2 : 37, 1876 (non Kurz 1872) ; Woodr. in J. Bombay nat. Hist. Soc. 5 : 273, 1897 ; Talbot, Trees Bombay 63, 1902 ; Gamble, Fl. Pres. Madras, Reprint ed. 191, 1957 ; Cooke, Fl. Pres. Bombay, Reprint ed. 1 : 298, 1958. *Semecarpus grahamii* Wight, Ic. Pl. Ind. Or. 1 : t. 235, 1839 ; Dalz. & Gibs. Bombay Fl. 52, 1861.

Wight's Icon 235 is based on specimens from peninsular India which he named *Semecarpus grahamii*. Later Kurz (1872) wrongly referred certain specimens from Pegu to this species and described them under the name *Holigarna grahamii*, indicating *Semecarpus grahamii* Wight in parentheses as synonym. J. D. Hooker (1876) found the specimens on which Wight's name is based are different from those described by Kurz, and he gave a new name, *Holigarna albicans*, to the specimens of Kurz and applied *H. grahamii* to Wight's specimens, thus creating a later homonym. This is clearly against the provisions of Art. 64 of the Code. The combination *H. grahamii* Hook. f. (1876) is based on a type different from that on which the combination *H. grahamii* Kurz (1872) is based,

and is therefore a later homonym. A new name *H. wightii* is proposed here for the peninsular Indian species.

Holigarna grahamii Kurz in J. As. Soc. Beng. 41 : 395, 1872, pro parte, *Holigarna albicans* Hook. f. Fl. Brit. Ind. 2 : 38, 1876.

Holigarna grahamii Kurz, excluding the synonym *Semecarpus grahamii* Wight, is validly published; Kurz has given a detailed description which is entirely based on his Burmese specimens. The inappropriate indication of a synonym does not invalidate a name otherwise validly published. *H. albicans* Hook. f. is a superfluous name and should be rejected in favour of *H. grahamii* Kurz.

PAPILIONACEAE

Astragalus ladakensis Balak. nom. nov. *A. strictus* Grah. ex Benth. in Royle, Illustr. Bot. Himal. 198, 1835 (non Siev. ex Fisch. 1825); Hook. f. Fl. Brit. Ind. 2 : 124, 1876.

Desmodium benthamii Balak. nom. nov. *D. brachystachyum* Grah. ex Benth. in Miq. Pl. Jungh. 223, 1852 (non Schlecht. 1838); Baker in Hook. f. Fl. Brit. Ind. 2 : 171, 1876; Gamble, Fl. Pres. Madras, Reprint ed. 245, 1957; Haines, Bot. Bih. Or. 265, 1922.

Desmodium bakeri Balak. nom. nov. *D. rottleri* Baker in Hook. f. Fl. Brit. Ind. 2 : 174, 1876 pro parte (non G. Don, 1832); Gamble, Fl. Pres. Madras, Reprint ed. 245, 1957. *Eleiotis rottleri* Wight & Arn. Prodr. 231, 1834.

D. rottleri Baker is a later homonym of *D. rottleri* G. Don (Gen. Syst. 2 : 297, 1832). A new name, *D. bakeri*, is chosen for this species. The Burmese specimens cited by Baker *loc. cit.* belong to *Neocollettia wallichii* (Kurz) Schindl. in Fedde Rep. 21 : 16, 1925.

UMBELLIFERAE

Bupleurum hamiltonii Balak. nom. nov. *B. tenue* Buch.-Ham. ex D. Don, Prodr. Fl. Nep. 182, 1825 (non Salisbury, 1796); DC. Prodr. 4 : 128, 1830; Clarke in Hook. f. Fl. Brit. Ind. 2 : 677, 1882; Duthie, Fl. U. Gang. Pl. 392, 1903; Wolff in Engler, Pflanzenr. 43 : 145, 1910.

Bupleurum hamiltonii Balak. var. *khasianum* (Clarke) Balak. comb. nov. *B. tenue* D. Don var. *khasianum* Clarke in Hook. f. Fl. Brit. Ind. 2 : 677, 1882; Wolff, l.c. 145.

APIACEAE (RUBIACEAE)

Ixora arborea Roxb. ex Seem. var. *zeylanica* (Hook. f.) Balak. comb. nov. *I. parviflora* Vahl var. *zeylanica* Hook. f. Fl. Brit. Ind. 3 : 143, 1880. Type : *Thwaites* C.P. 2, 'Ixora jucunda Thw. var. r.' (CAL).

Bremekamp (in *J. Bot.* 75 : 324, 1937) changed the name *Ixora parviflora* Vahl to *I. arborea* Roxb. ex Seem., the former being a later homonym. J. D. Hooker *loc. cit.* described a variety *zeylanica* under *I. parviflora* Vahl, which differs from the typical form in having broadly elliptic, obovate, acute, acuminate leaves, which are cuneate at base, more membranous, less reticulate; the petioles are longer and the stipules longer cuspidate.

ASTERACEAE (COMPOSITAE)

Artemisia edgeworthii Balak. nom. nov. *A. stricta* Edgew. in Trans. Linn. Soc. 20 : 73, 1846 (non Heyne ex DC. 1838); Hook. f. *Fl. Brit. Ind.* 3 : 323, 1881.

ACANTHACEAE

Rhinacanthus nasuta (L.) Kurz var. *montana* (Clarke) Balak. comb. nov. *R. communis* Nees var. *montana* Clarke in Hook. f. *Fl. Brit. Ind.* 4 : 451, 1885; Gamble, *Fl. Pres. Madras*, Reprint ed. 759, 1957.

LAURACEAE

Actinodaphne malabarica Balak. nom. nov. - *A. hirsuta* Hook. f. *Fl. Brit. Ind.* 5 : 152, 1886 (non Blume 1851); Gamble, *Fl. Pres. Madras*, Reprint ed. 862, 1957. *Actinomorpha hirsuta* (Hook. f.) O. Kuntze, *Rev. Gen.* 570, 1891.

Litsea cuipala (D. Don) Balak. comb. nov. *Tetranthera cuipala* D. Don, *Prodr. Fl. Nep.* 65, 1825. *T. lanuginosa* Wall. ex Nees in Wall. *Pl. As. Rar.* 2 : 64, 1831. *Litsea lanuginosa* Nees in *Syst. Laurin.* 634, 1831; Meissn. in DC. *Prodr.* 15(1) : 221, 1864; Brandis, *For. Fl.* 382, 1874; Gamble, *Man. Ind. Timb.* 312, 1881; Hook. f. *Fl. Brit. Ind.* 5 : 178, 1886.

Litsea saligna (Nees) Balak. comb. nov. *Tetranthera saligna* Nees in Wall. *Pl. As. Rar.* 2 : 67, 1831. *T. angustifolia* Wall. ex Meissn. in DC. *Prodr.* 15(1) : 183, 1864, pro parte. *Litsea angustifolia* (Wall. ex Meissn.) Hook. f. *Fl. Brit. Ind.* 5 : 169, 1886 (non Blume 1826, nec Kurz 1875); Prain, *Beng. Pl.* 903, 1903; Kanjilal et al. *Fl. Assam* 4 : 87, 1940.

The oldest name for this species is *Tetranthera angustifolia* Wall. (1830), but this is a *nomen nudum* and cannot be taken into consideration for purposes of priority. This name was validated only in 1864 by Meissner, when he furnished a description. There was already an earlier validly published name for this species, *Tetranthera saligna* Nees (1831); J. D. Hooker on transferring this species to *Litsea*, chose the

epithet of Wallich, *angustifolia*, and this is against the rule of priority of the Code. Further, *L. angustifolia* Hook. f. (1886) is a later homonym of *L. angustifolia* Blume (1826) and *L. angustifolia* Kurz (1875).

Litsea thwaitesii Balak. nom. nov. *L. undulata* Hook. f. Fl. Brit. Ind. 5 : 158, 1886 (non Zipp. ex Blume 1851). *Tetranthera lingustrina* Thw. Enum. Pl. Zeyl. 254, 1861 (non Nees 1831).

ORCHIDACEAE

Anoectochilus Blume : The genus *Anoectochilus* was founded by Blume in 1825. In 1858 he described the genus *Odontochilus*, differentiating it from the former by the shorter sac of its lip, which is concealed by the bases of the sepals and also because of the more developed columnar processes. These distinctions seem to be insufficient to justify generic rank, an opinion first expressed by J. D. Hooker in *Icones Plantarum* 2 : t. 2168, 1893, and later supported by King & Pantling in *Ann. R. Bot. Gard. Calc.* 8 : 293, 1898, and recently by Holttum in *Rev. Fl. Mal.* 1 : 124, 1953. To quote Holttum : 'As construed here, this includes two genera *Anoectochilus* and *Odontochilus*. The former has coloured leaves and distinct spur, the latter genus green leaves and a saccate base to the lip. The species *A. calcaratus*, however, is intermediate between the two ; and the essential flower structure of both is very similar ; so that the union of the two genera is not unnatural.'

The following new combination is proposed.

Anoectochilus rotundifolius (Blatt.) Balak. comb. nov. *Odontochilus rotundifolius* Blatter in *J. Bombay nat. Hist. Soc.* 32 : 521, 1928 ; Fischer in Gamble, *Fl. Pres. Madras*, Reprint ed. 1016, 1957.

AMARYLLIDACEAE

Molineria trichocarpa (Wight) Balak. comb. nov. *Curculigo finlaysoniana* Wall. ex Hook. f. Fl. Brit. Ind. 6 : 279, 1892. *Hypoxis trichocarpa* Wight, *Ic. Pl.* 6 : t. 2045, 1853 (sinistra fig. tant.) ; Thwaites, *Enum. Pl. Zeyl.* 323, 1864 ; Kurz in Miquel, *Ann. Mus. Lugd.-Bat.* 4 : 178, 1869. *H. latifolia* Wight, *I.c.* t. 2044, 1853. *H. leptostachya* Wight, *I.c.* t. 2045 (dextra fig. tant.). *H. pauciflora* Wight, *I.c.* t. 2046 (sinistra fig. tant.). *H. brachystachya* Wight, *I.c.* t. 2046 (dextra fig. tant.). *Molineria finlaysoniana* Baker in *J. Linn. Soc.* 17 : 121, 1878 ; Fischer in Gamble, *Fl. Pres. Madras*, Reprint ed. 1049, 1957.

Curculigo finlaysoniana is the oldest name given to this species by Wallich in 1832 as a *nomen nudum*, which was validated only in 1892 by J. D. Hooker. Next in order of priority follow five names described by Wight in 1853 under *Hypoxis*. All these are synonymous with the

present species and have equal status, having been published on the same date, March 1853. Of these, *H. trichocarpa* has been later adopted by Thwaites & Kurz, who treat the other binomials of Wight as synonyms and hence chosen here as the basionym.

The genus *Molineria* has been segregated from *Curculigo* by all recent authors and can be distinguished as follows :

Perianth tube produced above the ovary ; stamens perigynous	<i>Curculigo</i>
Perianth tube not produced above the ovary ; stamens epigynous	<i>Molineria</i>

Studies on Indian Copepods—8. Observations on the diurnal vertical movements of Planktonic Copepods in the Gulf of Mannar¹

BY

A. N. P. UMMERKUTTY²

Central Marine Fisheries Research Institute, Mandapam Camp

(With a map and seven text-figures)

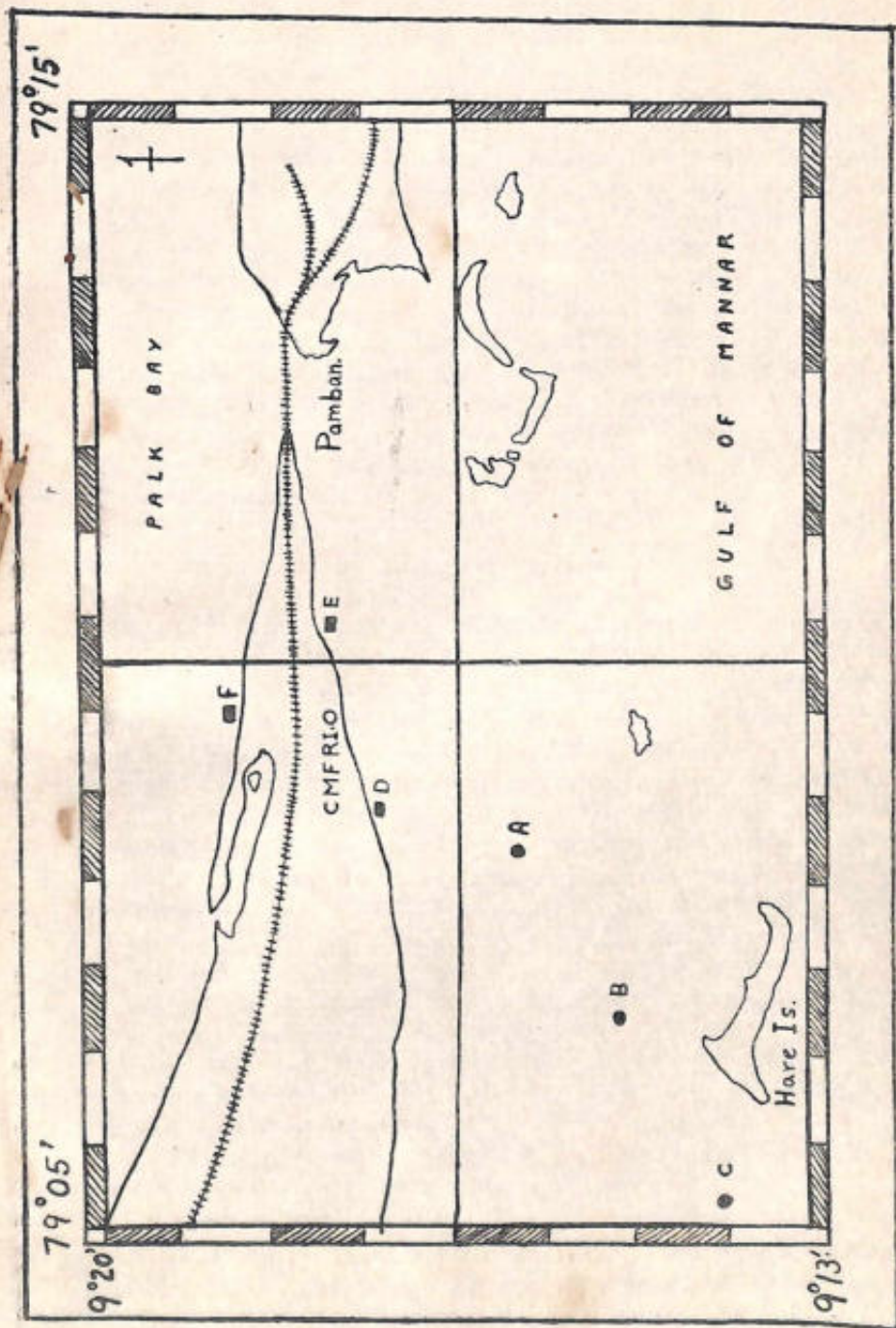
INTRODUCTION

Both Russell (1927) and Cushing (1951) have reviewed this problem and have shown that the majority of zooplankton species make extensive vertical movements in the waters they inhabit. Their massive movement, up and down every 24 hours is an impressive phenomenon which must be fully studied for a closer understanding of the biological and ecological conditions characteristic of a given species. The patterns of vertical movements may differ not only between different species, but also between different developmental stages and sexes of the same species. It may also vary in different latitudes, under different physico-chemical environments of the same latitude, and also in various seasons. It results from a combination of several physical and physiological factors which, acting together, produce a unique rhythm more or less steady in a species under a particular set of conditions.

The vertical movements of copepods have been the subject of extensive investigations in Polar and Temperate waters (Bogorov 1946; Ussing 1938; Wiborg 1954; Russell 1925, 1926, 1928 a & b; Nicholls 1933; Clarke 1933; 1934a, b, & c; Farran 1947; Bainbridge 1952). The information on this subject in tropical and subtropical waters is, however, very meagre, particularly of the Indian region where little work has been done in this field. The studies reported here aim at establishing the nature of the vertical migration of planktonic copepods in our waters. As the investigations have been carried out at a depth of about six

¹ Published with the permission of the Director, Central Marine Fisheries Research Institute, Mandapam Camp.

² Present address: Zoological Survey of India, 27, Jawaharlal Nehru Road, Calcutta 13.



Map of Mandapam area showing the various centres of collection. Samples for studies on the vertical movements were taken at Station C.

fathoms, the data on which the present conclusions are based refer to shallow waters only.

The results obtained indicate that diurnal vertical migration occurs in tropical waters also, at least in some species of copepods. This statement is based on two types of evidence. Firstly, the number of individuals of a species, especially adults and late copepodite stages, vary considerably in surface hauls made at 4-hourly intervals. During the dark hours there is a great increase in their number, and a considerable reduction during the bright daylight hours. This indicates that the general population withdraws from the brightly lit zones, although stray individuals remain in all the layers irrespective of changing light intensities. Secondly, simultaneous collections made with Clarke-Bumpus apparatus at surface and at depth indicate that during daytime adults and late copepodites concentrate in the deeper areas, and extend their distribution to the upper waters only when darkness sets in. This alteration in distribution of populations in the two layers, coinciding with changes in light intensity, is consistent with the idea of diurnal vertical movements.

MATERIAL AND METHODS

The material for the present study was collected at Station C in the Gulf of Mannar (Map), situated about six miles from the Central Marine Fisheries Research Institute and about one mile from Hare Island. Three series of collections were made. (1) Using organdie nets, 4-hourly surface hauls were made on 12 and 13 January 1960 commencing at 6 a.m. on the first day and ending at 6 a.m. on the second day. Temperature of the water both at surface and at depth was noted along with each collection and water samples were taken for determining the salinity from both hauls. (2) Attempts to make similar collections throughout day and night did not succeed on 20 February 1960. After 6 p.m. the sea became rough, with a strong wind blowing towards the mainland, and it was found difficult to continue the work. In this second series of collections therefore, data are available only for the day. (3) Four-hourly collections were made for 24 hours on 8 and 9 March 1960. The Clarke-Bumpus apparatus was employed for making collections both at the surface and down below. Organdie half-metre nets were used for surface hauls.

All the collections were preserved in 5% formalin immediately after the haul. Subsampling for laboratory analysis was done as follows. All samples were raised to 250 cc. by adding properly diluted formalin and a subsample of 10 cc. pipetted out. In the case of collections obtained by Clarke-Bumpus apparatus the entire subsample was examined. However, as the half-metre net collections invariably contained a much

higher amount of organisms, it was difficult to make a detailed study of the entire subsample. Subsequently, further subsampling had to be done of collections made by organdie nets and only a sample of 2 cc. of the original 250 cc. was examined in detail.

VOLUMETRIC COMPOSITION

The volumetric composition of copepod and non-copepod items was determined in wet condition using the principle of displacement and is presented in Table 1. Copepod and non-copepod items of each subsample were sorted out separately and were introduced into graduated capillary tubes which contained known quantities of sea-water. The volumetric value of the introduced item was then directly found from the difference between the initial and final water-level readings.

TABLE I

ACTUAL VOLUMES OF COPEPOD (C) AND NON-COPEPOD (NC) ITEMS AND THEIR PERCENTAGES IN SURFACE HAULS IN JANUARY 1960

Date & Time	Total volume in cc.	Relative volumes in cc.		Percentage	
		C	NC	C	NC
12.1.1960					
5.45 a.m.	2.2	1.2	1.0	54.5	45.5
9.45 a.m.	1.2	0.6	0.6	50.0	50.0
1.45 p.m.	1.15	0.6	0.55	53.0	47.0
5.45 p.m.	1.3	0.7	0.6	53.8	46.2
9.45 p.m.	2.0	1.15	0.85	57.5	42.5
13.1.1960					
1.45 a.m.	2.2	1.18	1.02	53.6	46.4
5.45 a.m.	2.8	1.5	1.3	53.4	46.6

The maximum concentration of copepods at the surface was found at 9.45 p.m. The distribution of a certain percentage of copepods in the surface waters persists because early larval forms are relatively less rapid in changing the site than adults and late copepodites. Some non-copepod items of plankton show as much migratory behaviour as copepods. *Sagitta* spp. and *Lucifer* spp., both well known to display pronounced vertical movements, have been found making day and night journeys in response to light.

GRAVIMETRIC ESTIMATION

To give a clearer picture of the whole series of changes in diurnal migration a gravimetric estimation is more important. A subsample of copepods in 2 cc. of the surface hauls by organdie net was dried in a watch glass and weighed. Similarly, a subsample of 10 cc. of each of

the collections taken by Clarke-Bumpus apparatus at surface and at 5-metre depth was dried and weighed. The data obtained are presented

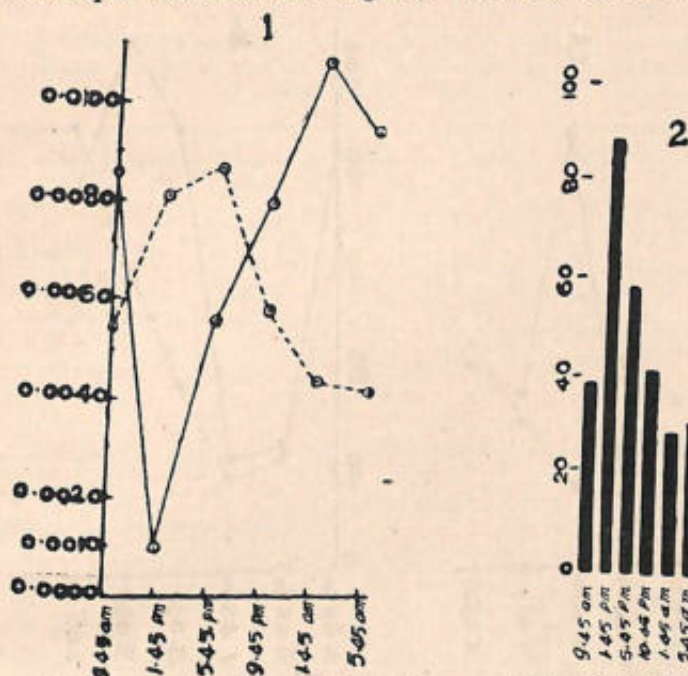


Fig. 1. Actual dry weights of copepods in 10 cc.-subsamples at surface (—) at 5-metre depth (.....), collected with Clarke-Bumpus apparatus during March 1960.

Fig. 2. The same collections expressed as percentages of the total catch from the two layers of the water column.



in Text-figs. 1 and 2, in which copepod populations are expressed as a whole and include adults and copepodites of both sexes. The figures show that, though the population as a whole goes up and down, a certain percentage of plankton retain their respective levels. These include not only early copepodites of several species but also adults of such species as *Acrocalanus monachus*, *Paracalanus parvus*, and *Oithona* spp. which are composed of small-sized individuals. However, there is clearly a conspicuous reduction in the abundance of copepods at the surface about midday, followed by a high concentration in surface waters about midnight.

NUMERICAL COMPOSITION OF SPECIES

Pseudodiaptomus aurivilli Cleve

Text-figs. 3 and 4 show the distributional pattern of this species at 5 metre level and at surface as sampled by Clarke-Bumpus apparatus in March 1960; the actual numbers of copepodites and adults caught in

surface hauls by organdie net during the 24-hour period are presented in Table 2. The two figures and the table show that the adult population

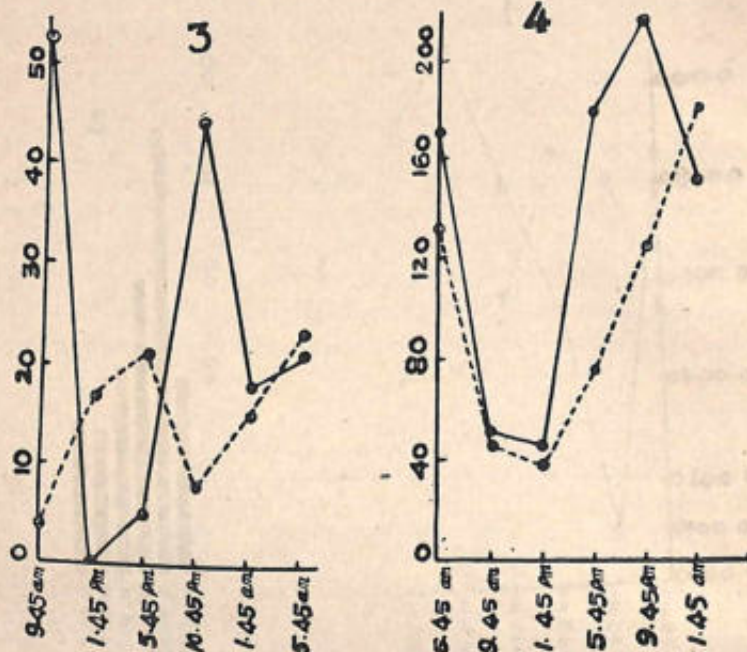


Fig. 3. *Pseudodiaptomus aurivilli*: Distribution of adults at surface (—) and at 5-metre depth (.....) on 12-13 January 1960, collected by Clarke-Bumpus apparatus.

Fig. 4. *Pseudodiaptomus aurivilli*: Distribution of adults at surface on 8-9 March 1960 (—) and 12-13 January 1960 (.....).

of this species displays great variation in its numbers in surface waters. After sunset five times more adults are caught in surface waters than at noon. There seems to be little change in the distributional pattern of copepodites except, to some extent, in the case of the fifth stage, which shows a higher concentration at surface during late hours of the evening.

A sex-wise analysis of adults does not show any difference in the pattern of response to light. The males dominate most of the time except during the dusk and early morning. This dominance of the male may be due to the greater percentage distribution of that sex in the population during breeding months (December-March). The apparent dominance of females during dusk and early morning is probably attributable to the transient condition of the population, the animals being in an active state of migration thus disturbing the normal stability.

TABLE 2

Pseudodiaptomus aurivilli: ACTUAL NUMBERS OF ADULTS AND COPEPODITES (Cop.) CAUGHT IN SURFACE HAULS WITH ORGANDIE NETS DURING 24-HOUR PERIOD ON 12-13 JANUARY 1960

Date & Time	Cop. I	Cop. II	Cop. III	Cop. IV		Cop. V		Adults	
				♂	♀	♂	♀	♂	♀
12.1.1960									
5.45 a.m.	0	1	4	26	22	73	38	121	50
9.45 a.m.	0	2	5	22	16	32	32	34	17
1.45 p.m.	0	0	8	13	12	20	15	33	14
5.45 p.m.	0	3	11	12	20	24	49	71	106
9.45 p.m.	0	0	6	12	19	44	42	115	100
13.1.1960									
1.45 a.m.	0	0	2	10	11	24	27	68	82

Centropages furcatus (Dana)

This species is composed of fairly large-sized individuals, but it occurs only in small numbers. The members of this species appear to react strongly to day and night changes. During noon not a single adult was observed at surface in any of the three subsamples analysed, but in samples taken at 10 p.m. and at 2 a.m. twelve and sixteen individuals respectively were caught. During the intervening hours the increase or decrease showed graduations (Text-fig. 5). The species being scarce in plankton could not be sampled properly by the Clarke-Bumpus apparatus and a thorough observation could not be made on its distribution in different vertical levels.

Calanopia elliptica Dana

In this species also substantial evidence of migratory movements was obtained. At dawn the species is represented by a few adults in the plankton; as the day advances it gradually disappears from surface waters and is not seen throughout the brightly-lit hours. At night at about 10 p.m. large numbers become available at surface. However, a decline in abundance is seen in the early hours that follow (by 2 a.m.). This may be due to what Cushing (1951) termed a departure from the surface at midnight. According to this view, copepods migrate upwards as darkness intensifies and reach their maximum surface distribution by about 10 p.m. In complete darkness they stop swimming and sink passively. Thus, being unable to maintain their topmost level, they get distributed in layers down below. This phenomenon which could be termed positive geotaxis gets combined with photokinesis. It is parti-

cularly notable in the present species probably because of its larger size (Text-fig. 6).

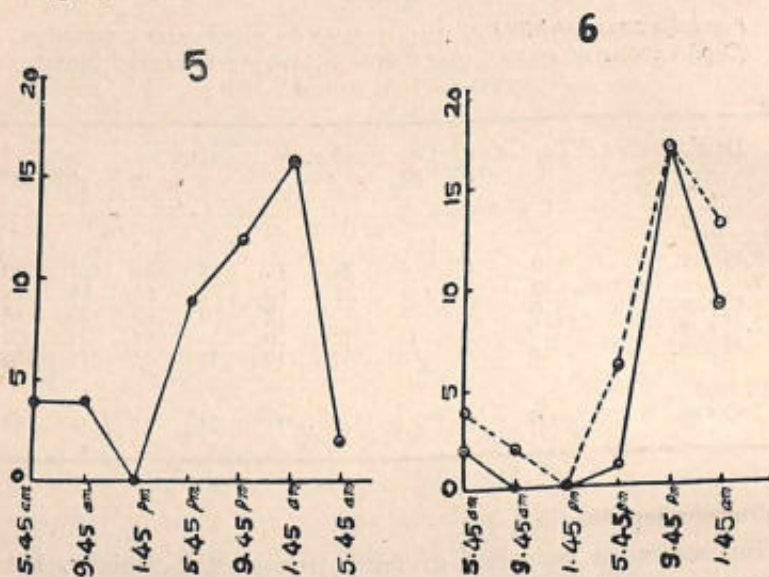


Fig. 5. *Centropages furcatus*: Distribution of adults at surface on 12-13 January 1960, collected by organdie net.

Fig. 6. *Calanopia elliptica*: Distribution of adults at surface on 12-13 January (.....) and 8-9 March 1960 (—), collected by organdie net.

Acartia erythraea Giesbrecht

This is one of the commonest species of this area and seems to prefer upper water layers during the dark hours. Minimum numbers are found at surface during noon while maximum concentration occurs eight hours later and persists till the early hours. The data obtained for the months of January and March by organdie net are plotted in Text-fig. 7. In March only the adults and the fifth copepodites were found. This suggests that at this time of year the species reaches the end of its breeding season. As in *C. furcatus*, in this species maximum concentration in surface waters occurs at about 10 p.m. and is followed by a slight declination.

Probably in this species, as in several others, diurnal migration is not obligatory. They tend to avoid the brightly-lit surface layer during the day and in doing so get distributed at lower layers. The chief notable features are the low number of adults captured at surface during the noon and the gradually higher concentrations appearing at deeper levels. After sunset there is no appreciable decrease in their numbers in areas near the bottom. This signifies that the population remains fairly well-distributed at all levels above the bottom. In the

surface layer, however, there occurs a progressive increase as the darkness prevails.

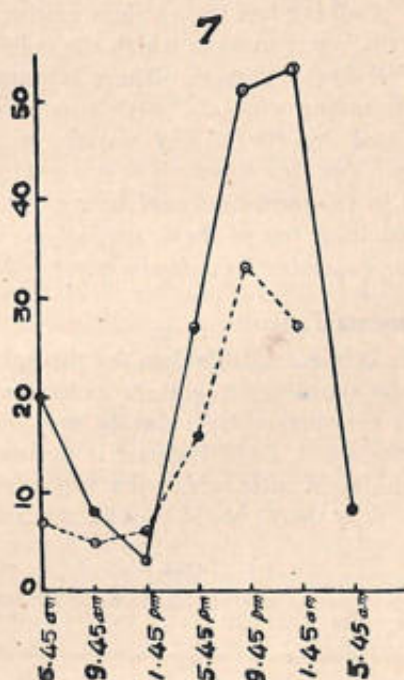


Fig. 7. *Acartia erythroaea*: Distribution of adults at surface on 12-13 January (.....) and on 8-9 March 1960 (—), collected by organdie net.

Centropages dorsispinatus Thompson & Scott ♀

This species showed a very irregular distribution. Though there was an apparent withdrawal of the population from the surface during the sunlit hours, the population did not return to its original density in the surface waters even during the darkest hours (Table 3). Cushing

TABLE 3

Centropages dorsispinatus: DISTRIBUTION OF ADULTS AND COPEPODITES (COP.) IN SURFACE LAYER ON 12 AND 13 JANUARY 1960

Date & Time	Cop. I	Cop. II	Cop. III	Cop. IV		Cop. V		Adult	
				♂	♀	♂	♀	♂	♀
12.1.1960									
5.45 a.m.	0	7	19	36	33	50	27	36	31
9.45 a.m.	1	2	5	5	9	3	1	5	2
1.45 p.m.	0	5	7	36	39	18	16	8	5
5.45 p.m.	0	4	6	7	12	4	2	2	2
9.45 p.m.	2	3	7	5	5	5	6	2	3
13.1.1960									
1.45 a.m.	1	2	7	9	7	6	5	2	1
5.45 a.m.	0	2	5	10	12	13	18	16	11

(1951) and other earlier workers have rightly pointed out the inadequacies of the studies of selected horizontal stations in the investigations on vertical migration. Cushing has shown that neither the vessel making the collections nor the water mass in which the collections are made remain static even for short intervals. There is always an exchange of fauna with the surrounding waters. This changing pattern becomes all the more complicated by the patchy nature of the distribution of copepods in the sea. An area where there is a swarming of a particular species of copepod in the morning could be replaced in the evening by a mass of water containing few of them, specially so if the patch noticed is a small one. The example of *C. dorsispinatus* may be such a case.

Schmackeria serricaudata T. Scott

Within the limits of the available data for this species, it appears that there is an inherent, positive, migratory behaviour. The maximum number is found in the surface layer during the dawn, and then there is a decline in numbers. A slight increase is noticed at dusk which is maintained up to midnight after which the species records appreciable increase (Table 4). Why there should be a concentration on the surface

TABLE 4
Schmackeria serricaudata: DISTRIBUTION OF ADULTS AND COPEPODITES (COP.) IN SURFACE WATERS ON 12 AND 13 JANUARY 1960

Date & Time	Cop. I	Cop. II	Cop. III	Cop. IV		Cop. V		Adult	
				♂	♀	♂	♀	♂	♀
12.1.1960									
5.45 a.m.	0	0	0	0	0	6	4	28	25
9.45 a.m.	0	0	0	0	1	5	0	5	4
1.45 p.m.	0	0	1	3	2	4	7	5	7
5.45 p.m.	0	0	0	0	0	8	8	7	8
9.45 p.m.	0	0	0	1	2	4	7	8	7
13.1.1960									
1.45 a.m.	0	0	0	2	2	4	7	14	12
5.45 a.m.	0	0	0	0	0	3	1	3	1

in early morning hours, rather than during darkness, immediately after dusk is hard to explain. It is likely that there is an error in the data because of their patchy distribution in plankton, a feature common in copepods as has been already noted earlier.

GENERAL REMARKS

Russell (1927) and Cushing (1951) have discussed the various factors which influence the behaviour pattern of the migrating species. These factors include sunlight, weather, water temperature, presence and

abundance of phytoplankton, age of the animal concerned, etc. In addition to these, physiological factors have also been held responsible for the hazardous vertical sojourns that these tiny creatures undertake during the course of a day.

The effect of weather is rather indirect. During a cloudy day, the penetration of light into the water is poor. It thus creates artificially a situation which is comparable to dawn or dusk. Windy weather will make the surface turbulent thus making this layer physically uninhabitable. Both these factors seem to be insignificant in the present studies. Both in January and in March when the studies were carried out the weather was fair.

The effect of temperature appears to act chiefly in the regions of thermoclines: 'It is a possibility that a homogeneous group of animals (stage, sex or brood of a species) has a temperature range beyond the extremes of which the animal does not appear; a thermocline near the limits of this range will be obviously more effective in modifying migration than one in the centre of the range. As a mediator of migration temperature was shown by Esterley (1912) to be without effect as the diurnal differences in temperature at any depth was only a small fraction of the temperature range through which the animals moved' (Cushing 1951, p. 165). This view is substantiated by the present series of observations. The change in temperature between the surface and 5-metre depth during the 24 hours was negligible (Table 5).

TABLE 5

TEMPERATURE OF WATER MASS AT STATION C IN THE GULF OF MANNAR
DURING JANUARY AND MARCH 1960

Date	Time	Temperature in °C.	
		Surface	Five-metre depth
12.1.1960	5.45 a.m.	26.1	26.0
	8.45 a.m.	26.2	26.0
	1.45 p.m.	26.6	26.3
	5.45 p.m.	26.8	26.4
	9.45 p.m.	26.4	26.3
13.1.1960	1.45 a.m.	26.2	26.1
	5.45 a.m.	26.0	26.0
8.3.1960	5.45 a.m.	26.5	26.4
	9.45 a.m.	27.0	26.8
	1.45 p.m.	27.3	27.2
	5.45 p.m.	27.5	27.3
	9.45 p.m.	27.1	27.0
9.3.1960	1.45 a.m.	26.6	26.5
	5.45 a.m.	26.6	26.5

The importance of phytoplankton in the migratory activities of planktonic copepods has recently been discounted as these animals are filter feeders and are incapable of discriminating between food-abundant areas and others. Age and inner physiological rhythm certainly play important roles in deciding the migratory pattern of individual species. But the most important factor appears to be light. The large amount of work that has been done in boreal and austral waters on this subject demonstrates beyond doubt that changes in the intensity of light that penetrates into the water during different hours of the day have direct bearing on the diurnal vertical movements of copepods. 'It is now generally agreed that the immediate stimulus to diurnal migration is light, perhaps modified in extreme cases by temperature. The conception of an optimum light intensity inside which the copepods keep, each stage and each population having perhaps its own optimum, has proved the most fruitful explanation of their movements' (Marshall & Orr 1955). Why and how the changes in light intensity come to exert such strong influence on the movements of these organisms is not clear.

The fact that in the present studies all species avoided the bright light of the sun to a great extent is in full agreement with the conclusions arrived at by earlier workers. But why the adult population does not withdraw completely from the surface during the day and why some species are quite indifferent to changing light intensities are not clearly understood. Fuller and comprehensive studies on these links are needed in our waters.

ACKNOWLEDGEMENTS

The studies presented above were carried out at the Central Marine Fisheries Research Institute, Mandapam Camp, during the tenure of a scholarship given by the Ministry of Scientific Research & Cultural Affairs, Government of India, under the guidance of Dr. S. Jones, Director. I am very thankful to him for his kind encouragement and directions during the course of the investigations. I am also thankful to Dr. R. Raghu Prasad, Deputy Director, and Dr. S. Z. Qasim, Professor of Fishery Biology at the Central Institute of Fisheries Education, Bombay, (formerly of the Department of Zoology, Aligarh University), for going through the manuscript and offering valuable constructive criticism.

SUMMARY

The diurnal vertical movements of the following species of planktonic copepods are studied : *Pseudodiaptomus aurivilli*, *Centropages furcatus*,

Calanopia elliptica, *Acartia erythraea*, *Centropages dorsispinatus*, and *Schmackeria serricaudata*.

It is found that all these species are fairly well distributed in the surface waters from dusk to dawn, but they avoid the top layer during the brightly lit hours of the day. The salient features of these migratory movements and the probable causes that influence them are briefly discussed.

REFERENCES

- BAINBRIDGE, R. (1952): Underwater observations on the swimming of marine zooplankton. *J. Mar. biol. Ass. U.K.* **31**: 107-112.
- BOGOROV, B. G. (1946): Peculiarities of diurnal vertical migrations of zooplankton in polar seas. *J. Mar. Res.* **6**: 25-32.
- CLARKE, G. L. (1933): Diurnal migration of plankton in the Gulf of Maine and its correlation with changes in submarine illumination. *Biol. Bull. Wood's Hole* **65**: 402-436.
- (1934a): Further observations on the diurnal migration of copepods in the Gulf of Maine. *op. cit.*, **67**: 432-455.
- (1934b): The diurnal migration of copepods in St. George's harbour, Bermuda. *op. cit.*, **67**: 456-460.
- (1934c): Factors affecting the vertical distribution of copepods. *Ecol. Monogr.* **4**: 530-540.
- CUSHING, D. H. (1951): The vertical migration of planktonic crustacea. *Biol., Rev.* **26**: 158-192.
- FARRAN, G. P. (1947): Vertical distribution of plankton (*Sagitta*, *Calanus* and *Metridia*) off the south coast of Ireland. *Proc. R. Irish Acad.* **51**, B: 121-136.
- MARSHALL, S. M. & ORR, A. P. (1955): The biology of a marine copepod. Oliver & Boyd, Edinburgh and London.
- NICHOLLS, A. G. (1933): On the biology of *Calanus finmarchicus*. Vertical distribution and diurnal migration in the Clyde sea area. *J. Mar. biol. Ass. U.K.* **19**: 139-164.
- RUSSELL, F. S. (1925): The vertical distribution of marine macroplankton. An observation on diurnal changes. *op. cit.* **13**: 769-809.
- (1926): The vertical distribution of marine macroplankton. The apparent importance of light intensity as a controlling factor in the behaviour of certain species in the Plymouth area. *op. cit.* **14**: 415-440.
- (1927): The vertical distribution of plankton in the sea. *Biol. Rev.* **2**: 213-262.
- (1928a): The vertical distribution of marine macroplankton. VI. Further observations on diurnal changes. *J. Mar. biol. Ass. U.K.* **15**: 81-99.
- (1928b): The vertical distribution of marine macroplankton. VII. Observations on the behaviour of *Calanus finmarchicus*. *op. cit.*, **15**: 429-454.
- USSING, H. H. (1938): The biology of some important plankton animals in the fjords of East Greenland. *Medd. Greenland* **100**: 1-108.
- WIBORG, K. P. (1954): Investigations on zooplankton in coastal and offshore waters of western and north-western Norway with special reference to the copepods. *Fiskeridir. Skr. Havundersok.* **2**: 1-246.

An Account of the Weeds of Central Research Farm, Jodhpur, Rajasthan

BY

Y. SATYANARAYAN AND S. K. SAXENA

Central Arid Zone Research Institute, Jodhpur

Weeds constitute a serious problem to agricultural production in western Rajasthan. Most of these weeds can be controlled by simple agronomic practices like clean cultivation. Apart from perennial weeds such as *Zizyphus nummularia*, *Saccharum spontaneum*, *Pluchea lanceolata*, *Cyperus rotundus*, and *Cynodon dactylon*, some of which provide either useful top-feed or fodder, it is the annual weeds which severely compete with the growing crop for moisture and nutrients.

A preliminary study of the weeds of Central Research Farm, Jodhpur, was conducted during 1963. Weeds were collected from all over the 700-acre farm during June to December. Some of the weeds had both a normal life form and a habitat form and could be considered as ecotypes. The soil of the Farm is sandy loam in texture, with a hard kankar pan occurring at a depth of 2 metres from the surface. The topography is flat with less than one per cent slope. The soil reaction is alkaline but the total soluble salts are low. The majority of weeds come up during the monsoon season (July to September) and disappear at the end of the season. Biennial and perennial weeds, however, continue to thrive for a longer duration. Winter weeds are few.

Analysis of the weed flora showed that there are 25 families with 58 genera and 79 species among the dicots and 2 families, 16 genera and 29 species, among the monocots. Families with the largest number of species are :

1. DICOTS : Compositae—9 genera and 9 species ;
Papilionaceae—5 genera and 10 species ;
Amaranthaceae—5 genera and 7 species.
2. MONOCOTS : Gramineae—15 genera and 26 species.

Eight families are represented by a single genus and species, viz. Papaveraceae, Polygalaceae, Caryophyllaceae, Malvaceae, Cucurbitaceae, Pedaliaceae, Chenopodiaceae, and Portulacaceae. There are altogether 73 annuals, 2 biennials, and 33 perennials, of which the dicots consist of 60 annuals, 2 biennials, and 17 perennials. The monocots contain 13 annual and 16 perennial species.

SYSTEMATIC ENUMERATION

Dicotyledons

PAPAVERACEAE

Argemone mexicana Linn. Vern.¹ *Satyanasi*. Tall annual herb. Common throughout the Farm.

CAPPARACEAE

Cleome papillosa Steud. Small, branched, semi-erect annual. Occasionally found near fencing of Farm boundary.

Cleome viscosa Linn. Vern. *Pilli-hulhul*; Hindi *Gandhia* and *Kalo*. Common on roadsides, botanical garden, fallow, ploughed, and *bajra* fields.

Gynandropsis gynandra Brig. Vern. *Bagra*. Erect, unbranched annual. Common on roadsides, and in botanical garden and fallow fields.

POLYGALACEAE

Polygala erioptera Lamk. Vern. *Chota bhekaria*. Small erect annual. Occasional in fallow, *bajra*, and castor fields.

CARYOPHYLLACEAE

Polycarpha corymbosa Lamk. Vern. *Zutaniakad*. Small erect annual herb. Abundant in fallow, *bajra*, and legume fields, and nursery.

PORTULACACEAE

Portulaca oleracea Linn. Vern. *Bara-noonia*, *Lunki*. Succulent annual herb. Occasional in fallow fields, botanical garden, and nursery.

MALVACEAE

Abutilon indicum Sw. Vern. *Dabi*, *Jhili*, *Tarakanchi*. Perennial undershrub. Occasional in botanical garden.

¹ The vernacular names are local Marwari names except where otherwise specified.

TILIACEAE

- Corchorus antichorus** Raensch. Vern. *Hadeka Khot*. Prostrate, perennial herb. Very common in fallow fields, along roadsides, and in nursery.
- Corchorus tridens** Linn. Vern. *Chuchki* (Gujarati). Semi-procumbent annual herb. Occasional in legume fields and nursery.
- Corchorus trilocularis** Linn. Vern. *Hardikekat, Kagle-ki-tamaku*. Erect annual. Occasional in ploughed and fallow fields and along roadsides.

ZYGOPHYLLACEAE

- Fagonia cretica** Linn. Vern. *Damasha*. Small spiny annual herb. Occasional in fallow and harvested fields.
- Tribulus terrestris** Linn. Vern. *Gokro, Konti*. Prostrate annual. Very common and abundant in fields and on unmetalled roads.

PAPILIONACEAE

- Crotalaria burhia** Ham. Vern. *Sannai*. Perennial undershrub. Very common in fallow and *bajra* fields.
- Crotalaria medicaginea** Lamk. Vern. *Ghagri*. Annual herb. Occasional in fallow fields.
- Heylandia latebrosa** DC. Vern. *Gorakbutti, Sonda*. Prostrate annual. Rarely found, in botanical garden.
- Indigofera anabaptista** Steud. Vern. *Bekrioneel*. Annual herb. Rarely found in fallow and ploughed fields ; and in legume crop.
- Indigofera cordifolia** Heyne. Vern. *Bechka, Godadi, Panbekrio*. Prostrate annual. Very common and abundant in fields of *bajra*, legumes, and castor ; also in nursery and on roadsides.
- Indigofera enneaphylla** Linn. Prostrate annual. Common in fallow fields, near nursery, and on roadsides.
- Indigofera linifolia** Retz. Vern. *Bekar, Bakri*. Prostrate annual. Common in fallow and *bajra* fields ; nursery.
- Indigofera trigonelloides** Jaub. & Spach. Trailing annual. Common in fallow fields and legume crops, near nursery.
- Phaseolus trilobus** Ait. Vern. *Jungli Moth*. Trailing annual. Occasional in fallow and ploughed fields.

Tephrosia purpurea Pers. Vern. *Sarphunka, Dhamasa*. Erect biennial. Very common and abundant in all fields, fallow lands, and along roadsides.

CUCURBITACEAE

Citrullus colocynthis Schrad. Vern. *Tastumba, Tumba*. Prostrate annual. Common on roadsides and in fallow fields.

FICOIDEAE

Gisekia pharnaceoides Linn. Vern. *Morang, Sareli*. Succulent annual herb. Very common and abundant throughout the Farm.

Lineum indicum Stocks. Vern. *Shapari*. Prostrate annual herb. Found rarely in fallow lands, ploughed fields, and in botanical garden.

Mollugo cerviana Seringe. Vern. *Pada, Pata, Ragatia, Khar, Chiruro-khel*. Small erect annual. Very common in botanical garden, *bajra*, castor, and cotton fields.

Mollugo nudicaulis Lamk. Vern. *Ragatia khar*. Small annual herb. Common in botanical garden and in nursery.

Trianthema pentandra Linn. Vern. *Santa, Sarta*. Succulent annual. Occasional in botanical garden ; fallow and ploughed fields.

Trianthema portulacastrum Linn. Vern. *Safed santar, Sarta*. Annual, slightly succulent. Occasional near nursery and agronomy block.

RUBIACEAE

Borreria stricta Schum. Small annual herb. Rarely found in fallow and ploughed fields ; in nursery.

Oldenlandia aspera DC. Vern. *Danakar*. Erect annual. Occasionally found in botanical garden, irrigated fields, and agronomy block.

COMPOSITAE

Blainvillea rhomboidea Cass. Annual herb. Rarely found in agronomy block ; near nursery and building area.

- Blumea amplexans** DC. Vern. *Kukronda*. Woolly annual herb. Occasional in agronomy block.
- Dicoma tomentosa** Cass. Vern. *Vajradanti*. Erect annual. Common on roadsides, botanical garden, fallow and *bajra* fields.
- Eclipta erecta** Linn. Vern. *Jalbangra*. Prostrate annual. Rarely found, in irrigated fields and in botanical garden.
- Launaea chondrilloides** Hook. Vern. *Dhudphad*. Perennial herb. Occasionally found in botanical garden, nursery, and on boundaries of irrigated fields.
- Pulicaria wightiana** C. B. Clark. Vern. *Sonela*. Erect annual. Very common and abundant throughout the Farm; more on roadsides.
- Tridax procumbens** Linn. Vern. *Tunki* (Hindi). Perennial herb. Occasional in botanical garden, and near new buildings.
- Vernonia cinerea** Less. Vern. *Sahadavi*, *Phulni*. Erect annual. Rarely found near agronomy block, nullah, and nursery.
- Volutarella divaricata** Benth. & Hook. Vern. *Lin-Katmanda*. Small erect annual. Common in fallow, ploughed fields, in *bajra* and pasture fields; near building site.

ASCLEPIADACEAE

- Calotropis procera** R. Br. Vern. *Ak*, *Akra*, *Akda*. Erect shrub. Common along Farm boundary and in fallow and pasture fields.
- Pergularia daemia** Wight. Vern. *Gadaria kavel*. A large, twining shrub. Rarely found along Farm fencing.

BORAGINACEAE

- Arnebia hispidissima** DC. Vern. *Rambas*. Annual or biennial herb. Very common in fallow fields, on roadsides, in *bajra* and pasture fields.
- Heliotropium strigosum** Willd. Vern. *Chotisantri*. Prostrate annual. Very common throughout the Farm.
- Heliotropium zeylanicum** Lamk. Vern. *Khalibui*. Erect annual. Very common throughout the Farm.
- Sericostoma pauciflorum** Stocks. Vern. *Kharsan*, *Kharhani*. Small perennial undershrub. Occasional in fallow fields, roadsides, and *bajra* fields.

Trichodesma indicum R. Br. Vern. *Salkonta, Phuldar*. Erect annual. Rarely found in botanical garden, fallow and *bajra* fields.

CONVOLVULACEAE

Convolvulus glomeratus Choisy. Vern. *Rhota Bhel*. Perennial. Occasional in botanical garden ; *bajra* and fallow fields.

Convolvulus microphyllus Sieb. Vern. *Santari, Sanowri, Phulwati*. Procumbent perennial. Very common throughout the Farm.

Cressa cretica Linn. Vern. *Lona, Oyindo*. Prostrate annual. Rarely found, in a temporary pond.

Evolvulus alsinoides Linn. Vern. *Sanka-Huli*. Small perennial herb. Common in botanical garden and in *bajra* fields.

Ipomoea pes-tigridis Linn. Twining annual. Common in botanical garden, *bajra* fields, and nursery.

SOLANACEAE

Solanum indicum Linn. Vern. *Mothi-ring*. Tall undershrub. Rarely found in botanical garden, roadsides, fallow and ploughed fields.

Solanum xanthocarpum Schrad. & Wendl. Vern. *Baringni, Adkuntali*. Perennial herb. Common on roadsides, irrigated plots, botanical garden.

SCROPHULARIACEAE

Anticharis linearis Hochst. Erect annual. Common in botanical garden, roadsides, and fallow fields.

Lindenbergia urticaefolia Link & Otto. Vern. *Pindra*. Annual herb. Rarely found near Farm boundary.

PEDALIACEAE

Pedaliium murex Linn. Vern. *Mothegekhru*. Erect annual. Rarely found, in botanical garden.

ACANTHACEAE

Justicia procumbens Linn. Vern. *Gungi bunti, Kagner, Mokra ghas*. Erect annual herb. Common in botanical garden, legume, *bajra*, and castor fields.

Justicia simplex D. Don. Small annual herb. Occasional in fallow fields, *bajra* fields, and nursery.

Peristrophe bicalyculata Nees. Vern. *Kagner*. Prostrate or procumbent perennial. Common on roadsides, below *Prosopis* trees in botanical garden.

LABIATEAE

Leucas aspera Spreng. Vern. *Goama*, *Mund* (Hindi). Erect annual. Common in botanical garden, roadsides, castor, cotton, and fallow fields.

Salvia aegyptiaca var. **pumila** Hook. Vern. *Tukam*. Small undershrub. Rare, along Farm fencing.

NYCTAGINACEAE

Boerhavia diffusa Linn. Vern. *Chelavri*, *Sata*. Perennial trailing herb. Very common throughout the Farm.

Boerhavia repanda Willd. Annual herb. Common on roadsides, pasture fields, below trees in botanical garden.

AMARANTHACEAE

Achyranthes aspera Linn. Vern. *Unda kanta*, *Khutia bharutia*. Erect annual. Rarely found, in Silvatum, nursery, botanical garden.

Aerua persica Merrill. Vern. *Bari bui*. Tall undershrub. Common on roadsides, ploughed and cultivated fields.

Aerua pseudo-tomentosa Blatt. & Hall. Vern. *Chotti bui*. Small perennial herb. Common on roadsides, ploughed and cultivated fields.

Amaranthus blitum var. **oleracea** Hook. Vern. *Jangli Cholai*, *Tanduladge* (Hindi). Erect, succulent herb. Occasional on irrigation bunds of the agronomy block.

Amaranthus viridis Linn. Vern. *Chonlai* (Hindi). Erect annual. Rarely found, in botanical garden and agronomy block.

Celosia argentea Linn. Vern. *Mokhmal*, *Pramarti*. Annual herb. Occasional, along roadsides and in *bajra* fields.

Digera muricata Forsk. Vern. *Lahsua*, *Lulero*. Annual which occurs in erect, procumbent, and prostrate forms. Very common in fallow, ploughed, *bajra*, and legume fields.

CHENOPODIACEAE

Chenopodium album Linn. Vern. *Goela*, *Chill* and *Bathua* (Hindi). Succulent annual. Rare in fallow, cotton, and castor fields.

EUPHORBIACEAE

Euphorbia granulata Forsk. Vern. *Dudeli*. Prostrate annual. Occasional, in fallow *bajra* fields, and botanical garden.

Euphorbia hirta Linn. Vern. *Dudhdi* (Hindi). Decumbent or prostrate annual. Very common in nursery, near building site, botanical garden, and irrigated plots.

Euphorbia microphylla Heyne. Vern. *Chotti-Dudhi*. Prostrate annual. Common in botanical garden, nursery, building site and in castor fields.

Euphorbia thymifolia Linn. Vern. *Duddi*. Small annual herb. Very common in botanical garden, roadsides, and in legume fields.

Phyllanthus niruri Linn. Vern. *Hasardana* (Hindi), *Bawal* (Gujarati). Erect annual. Very common throughout the Farm.

Monocotyledons

CYPERACEAE

Cyperus arenarius Retz. Vern. *Motha*. Erect perennial. Occasional in botanical garden and on roadsides.

Cyperus conglomeratus Rottb. Vern. *Motha*. Erect perennial. Occasional on roadsides, fallow or ploughed fields.

Cyperus rotundus Linn. Vern. *Motha* (Hindi). Erect perennial with stolons. Very common throughout the Farm.

GRAMINEAE

Aristida adscensionis Linn. Vern. *Lomp*, *Lompri*. Slender perennial. Very common in fallow fields and silvatum plots.

Aristida funiculata Trin. & Rupr. Vern. *Lambda*. Small annual. Common in botanical garden, and in fallow fields.

- Aristida hirtigluma** Steud. Vern. *Lomp*, *Lompri*, *Lompla*. Semi-erect perennial. Occasional in fallow fields, along Farm boundary.
- Aristida mutabilis** Trin. & Rupr. Vern. *Loump*. Erect annual. Occasional on roadsides, silvatum plots.
- Aristida setacea** Retz. Erect perennial. Common in botanical garden, fallow fields, and silvatum plots.
- Cenchrus biflorus** Roxb. Vern. *Bhurut*. Erect annual. Very common throughout the Farm ; more on fallow fields.
- Cenchrus ciliaris** Linn. Vern. *Anjan*, *Dhaman*. Annual and perennial forms. Common throughout the Farm.
- Cenchrus pennisetiformis** Hochst. & Steud. Vern. *Dhaman*, *Kala-Dhaman*. Decumbent perennial. Occasional in fallow fields and Farm boundary.
- Cenchrus setigerus** Vahl. Vern. *Kala Dhaman*. Perennial. Common in fallow fields, botanical garden, and silvatum plots.
- Chloris barbata** Sw. Vern. *Gharania-ghas*. Tufted perennial. Occasional near nursery and botanical garden.
- Cynodon dactylon** (Linn.) Pers. Vern. *Dubhi*, *Dobh*. Slender perennial. Very common in cultivated fields, roadsides, nullah of agronomy block, and botanical garden.
- Dactyloctenium aegyptium** (Linn.) Beauv. Vern. *Makra*. Prostrate annual. Frequent on roadsides, cultivated fields, and silvatum plots.
- Dactyloctenium indicum** Boiss. Vern. *Ganthil*, *Ganthia*. Perennial. Common in botanical garden.
- Dichanthium annulatum** Stapf. Vern. *Karad*, *Jharnia-ghas*. Perennial. Common in fields, botanical garden, nursery, and building site.
- Digitaria adscendens** Henr. Vern. *Tara*, *Kuri*. Annual. Occasional in fallow and uncultivated fields, botanical garden, and silvatum plots.
- Echinochloa crus-galli** Beauv. Vern. *Soma*. Annual. Occasional in silvatum plots ; botanical garden.
- Eleusine compressa** Aschers. & Schweinf. Vern. *Tantia*, *Gandil*. Perennial. Common in fields outside botanical garden.

- Eragrostis ciliaris** R. Br. Vern. *Chirioroghas*. Small annual. Common on roadsides and in fallow fields.
- Eragrostis pilosa** Beauv. Erect annual. Common on roadsides and in fallow fields.
- Eragrostis tenella** (Linn.) P. Beauv ex R. & S. var. **plumosa** (Retz.) Stapf. Slender annual. Common along roadsides, near observatory, and Farm boundary.
- Eragrostis tremula** Hochst. Vern. *Kiriya*. Small annual. Occasional in fallow fields, on roadsides near agrostology block.
- Lasiurus ecaudatus** Satya. & Shank. Vern. *Sehwan*. Woody perennial. Occasional near nursery, building site, and botanical garden.
- Panicum antidotale** Retz. Vern. *Girona*, *Gramma*. Perennial. Occasional, in legume plots and botanical garden.
- Perotis indica** (Linn.) Ktze. Vern. *Undra-Poonch*. Small annual. Occasional in botanical garden, on roadsides, and near nursery.
- Tragus biflorus** Schult. Vern. *Sita ghas*. Tufted grass. Occasional near building site and silvatum plots.
- Urochloa panicoides** Beauv. Vern. *Kuri*. Decumbent annual. Common in nursery, building site, and Farm fencing under shade.

ACKNOWLEDGEMENTS

The authors are deeply obliged to Dr. P. C. Raheja, Director, Central Arid Zone Research Institute, Jodhpur, for his encouragement. They also desire to express their thanks to Dr. K. A. Shankaranarayan, Systematic Botanist, for his help in the identification of specimens.

REFERENCES

- BLATTER, E. & HALLBERG, F. E. (1918-1921): The Flora of the Indian Desert (Jodhpur and Jaisalmer). *J. Bombay nat. Hist. Soc.* 26 and 27 (different pages).
- BOR, N. L. (1960): The Grasses of Burma, Ceylon, India and Pakistan. Pergamon Press, London.
- COOKE, T. (1901-1908): Flora of the Presidency of Bombay. London.
- KING, G. (1879): Sketch of the Flora of Rajputana. *Indian For.* 4: 226-36.
- RAMACHANDRA RAO, Y. (1941): A list of some of the more common plants of the Desert Areas. *I.C.A.R. Bull.* No. 43.
- SARUP, S. (1951-1954): A list of the common plants of Jodhpur and its neighbourhood. *Univ. Rajputana Studies. Biol. Sect.* 29-35.
- SATYANARAYAN, Y. & SHANKARANARAYAN, K. A. (In press): Flora of the Central Luni Basin. *J. Bom. nat. Hist. Soc.*
- SESHAGIRI RAO, ROLLA & KANODIA, K. C. (1962-1963): Studies on the Vegetation and Flora of Jodhpur Division, Rajasthan State. *Ann. Arid Zone*, 1 & 11: 16-46 and 35-60.

Indian wood-destroying termites

BY

M. L. ROONWAL, sc.D. (Cantab.), F.N.I.

AND

O. B. CHHOTANI, M.Sc. (Hons.)
Zoological Survey of India, Calcutta

(With two plates and an Appendix)

I. INTRODUCTION

While all species of termites feed on cellulosic materials including wood, some have a more direct and intimate association with wood. Out of approximately 180 species occurring in the Indian Region (India, Pakistan, Ceylon, and Burma), nearly 58 may be termed wood-destroying. These species may be conveniently divided into two categories, viz. (i) those which are wood-inhabiting and spend either the whole or a part of their life in wood, where they breed (42 species); and (ii) those which do not habitually inhabit wood, but are nevertheless its important destroyers whenever opportunity occurs (16 species).

These species (vide Appendix for a list) belong to four families, namely the Kalotermitidae (27 species), Hodotermitidae (1 species), Rhinotermitidae (14 species), all wood-inhabiting; and the Termitidae (16 species, mostly soil-inhabiting but also wood-destroying).

Brief particulars of the more important wood-destroying species are given here. Several of the wood-inhabiting species prefer relatively moist wood (*Archotermopsis wroughtoni* and some species of the genera *Kalotermes*, *Neotermes*, *Glyptotermes*, and *Stylotermes*), while others prefer dry and seasoned wood (all members of the genera *Cryptotermes*, *Coptotermes*, and *Heterotermes*, and some species of the genera *Kalotermes* and *Neotermes*). Of the latter category, *Coptotermes* and *Heterotermes* have also close connections with the ground, where they live in subterranean colonies. It is fortunate and rather curious that *Neotermes tectonae* (Dammermann), a serious pest of teak trees in Java, is not found in India and Burma, where also teak is grown in abundance.

All the non-wood-inhabiting species concerning us here belong to the family Termitidae and are largely subterranean, although a few of them build earthen mounds above ground such as some species of the genus *Odontotermes*.

Some species destroy woodwork in buildings. Such species may conveniently be divided into two groups, namely: (i) dry-wood species (species which live entirely in dry wood, e.g. beams, pillars, doors, windows, furniture, etc.); and (ii) subterranean species (which, while attacking woodwork in buildings, railway carriages, etc., are also subterranean, often breeding underground in the soil). The more important species damaging buildings in the Indian Region are:

Dry-wood species:

1. *Cryptotermes domesticus* (Haviland)—South India and Ceylon.
2. *Cryptotermes dudleyi* Banks—India, Ceylon, and E. Pakistan.

Note.—Ahmad (*Spol. Zylan.* 27(1), p. 35, 1953) has recorded *Cryptotermes cyanocephalus* Light as having been introduced into Ceylon. We have examined these specimens, kindly sent by the Colombo Museum, and find that they are *C. perforans* Kemner.

Subterranean species:

3. *Heterotermes ceylonicus* (Holmgren)—Ceylon.
4. *Heterotermes indicola* (Wasmann)—India and Pakistan.
5. *Heterotermes malabaricus* Snyder—India.
6. *Coptotermes ceylonicus* Holmgren—Ceylon, India.
7. *Coptotermes formosanus* Shiraki—Ceylon.
8. *Coptotermes gaurii* Roonwal & Krishna (*exiguus*¹ auct.)—Ceylon.
9. *Coptotermes heimi* (Wasmann) (syn. *C. parvulus* Holmgren)—India and W. Pakistan.
10. *Odontotermes ceylonicus* (Wasmann)—Ceylon.
11. *Odontotermes feae* (Wasmann)—India, E. Pakistan, and Burma.
12. *Odontotermes redemanni* (Wasmann)—Ceylon.
13. *Hypotermes obscuriceps* (Wasmann)—Ceylon.
14. *Nasutitermes ceylonicus* (Holmgren)—Ceylon.

No precise estimates, in financial terms, of the damage caused by termites to buildings in India are available, but there is no doubt that the damage is very heavy. The principal species in India which damage buildings are: *Heterotermes indicola*, *Coptotermes heimi*, and *Odontotermes feae*. Instances where almost an entire township was thus destroyed by *Heterotermes indicola* have been reported (Roonwal 1955).

II. PARTICULARS OF SOME WOOD-DESTROYING SPECIES

Brief particulars of the more important wood-destroying species, especially with reference to recent work, are given below.

¹ '*Coptotermes exiguus* (Holmgren)', as given by Harris (1961, pp. 156 and 159) is most probably *C. gaurii* R. & K. No valid name '*exiguus* Holmgren' seems to exist (vide also discussion in Roonwal & Krishna 1955, p. 143; and Roonwal & Chhotani, 1962, p. 30).

(a) *The wood-inhabiting species*1. *Kalotermes beelsoni* Gardner (Plate II)

Occurs in northern India (Uttar Pradesh) and W. Pakistan (Punjab). Some aspects of its biology have been studied by Chhotani (1962*a, b*). Emergence of winged imagines occurred in June-August. The proportion of the castes, viz. imagines, soldiers and pseudoworkers, was 1 : 5 : 94. Alates collected in the field, as well as those obtained in laboratory emergences, consisted only of females, the males being entirely wanting, thus suggesting that the colony was breeding by means of parthenogenesis. For a detailed taxonomic description and illustrations of the species vide Roonwal & Sen-Sarma 1960.

2. *Neoterme bosei* Snyder (syn. *N. gardneri* Snyder, vide Roonwal & Sen-Sarma 1960, p. 153).

Occurs in northern and eastern India (Uttar Pradesh and Bengal). Generally attacks dead wood of several species of trees, but infestation may pass on to the living portions of trunks and branches. Some aspects of its biology have been studied by Roonwal & Sen-Sarma (1955). Alates emerge from February to July but mostly in May. Faecal pellets are small (length c. 0.9-1.14 mm.; diameter c. 0.5-0.7 mm.), reddish brown and longish, with a hexagonal cross-section. In the galleries, these pellets are often lumped together in masses which are covered with wood-dust. These masses are sometimes as large as 3 × 4.5 cm. and, being hygroscopic, may serve to condition the humidity inside the galleries. For a detailed taxonomic description and illustrations of the various castes vide Roonwal & Sen-Sarma 1960.

3. *Neoterme greeni* (Desneux)

Widely distributed in Ceylon where it is a serious pest of tea and rubber plants, but less so than *N. militaris*. It also infests a number of other trees. For its taxonomic description and illustrations vide Roonwal & Sen-Sarma 1960.

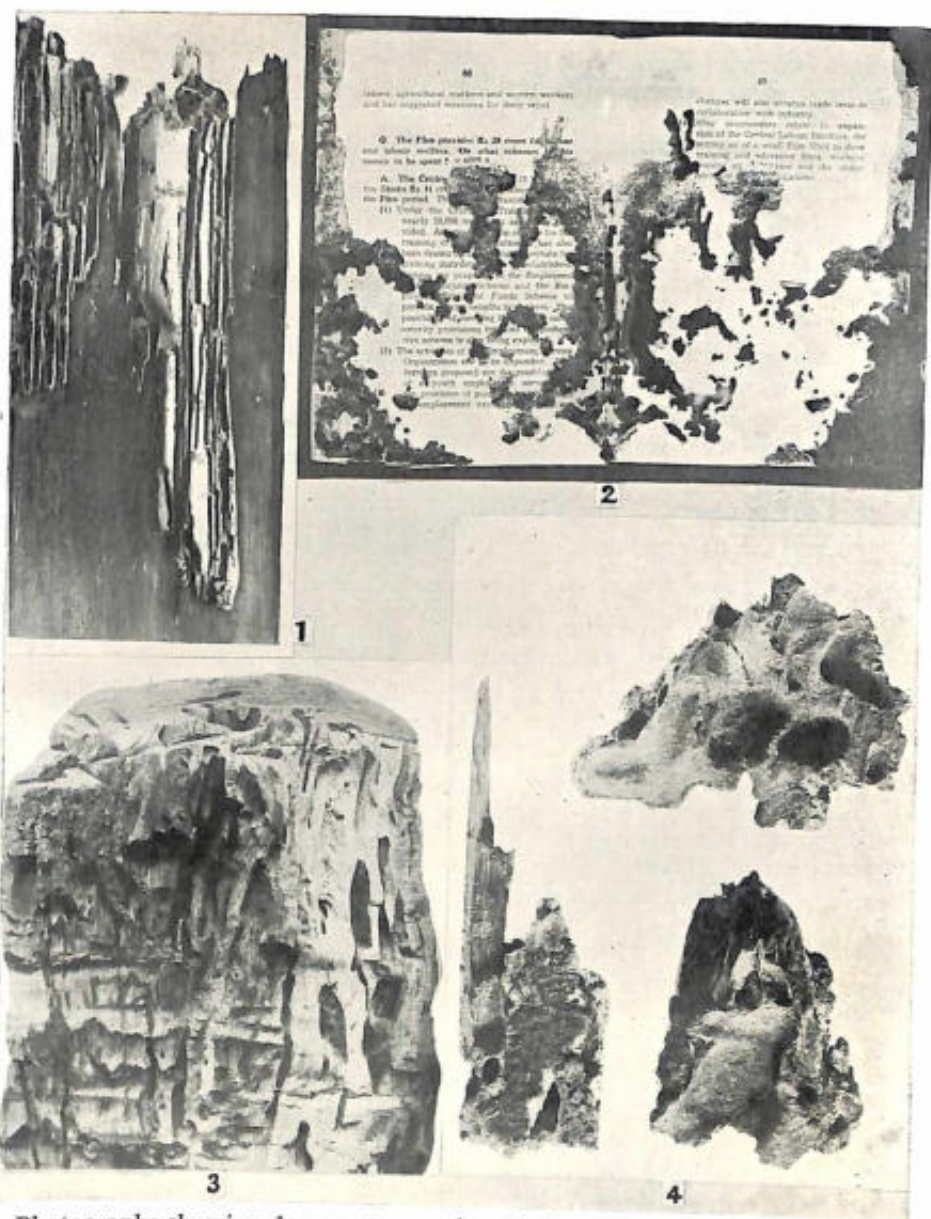
4. *Neoterme militaris* (Desneux)

Widely distributed in Ceylon. Is a serious pest of tea plants whose heartwood it generally hollows out. A single tea bush may harbour a colony of as many as 3000-4000 individuals. Also infests other trees. For its taxonomic description and illustrations vide Roonwal & Sen-Sarma 1960.

5. *Cryptoterme cyanocephalus* Light

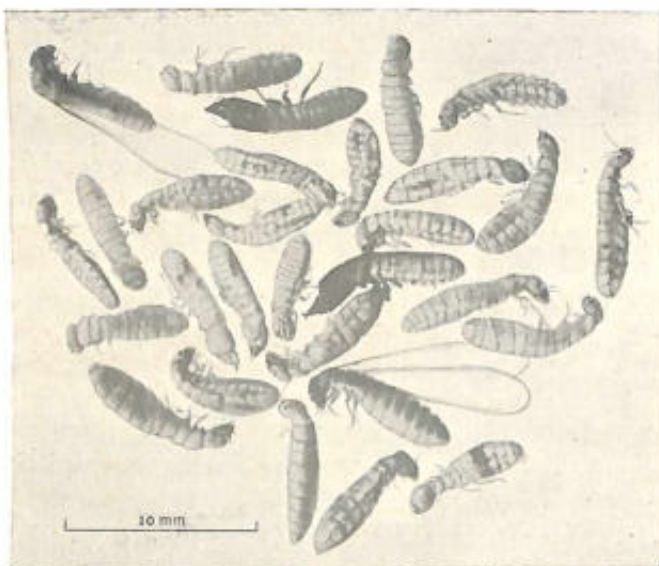
A dry-wood species widely distributed in SE Asia (Java and the Philippines). Recorded as a major destroyer of woodwork in buildings in Ceylon (Harris 1961, p. 158), but see Note under 'Dry-wood species' at page 355 above.

Roonwal & Chhotani: Termites



Photographs showing damage to wood and other cellulosic materials by termites.

Fig. 1. Part of a soft-wood (pine) door-piece, showing damage by *Heterotermes indicola* (Wasmann); Fig. 2. A book damaged by termites; Fig. 3. A piece of wood of bar (*Ficus bengalensis* Linn.), showing galleries made by *Cryptotermes havilandi* (Sjöstedt); Fig. 4. Pieces of wood from a log of unknown covered by it with earth coverings and fillings.



Upper figure : *Kalotermes beesoni* Gardner. Imagos (alates) soldiers and pseudoworkers.

Lower figure : *Coptotermes heimi* (Wasmann). Imagos (alates), soldiers and workers.

6. **Cryptotermes domesticus** (Haviland)

A dry-wood termite, widely distributed in south east Asia (India and Ceylon to Indonesia and Formosa, etc.). Is a serious pest of woodwork in houses in Ceylon and Malaya.

7. **Cryptotermes dudleyi** Banks

A most widely distributed dry-wood species—India to New Guinea ; and Central and South America. Is a serious pest of woodwork in houses, etc.

8. **Cryptotermes havilandi** (Sjöstedt) [syn. *C. bengalensis* (Snyder)]
(Plate I)

A dry-wood termite widely distributed from India to Africa and the West Indies. Species of *Cryptotermes* are generally distributed in coastal areas, many being introductions. But Chhotani (1963) has recently recorded *C. havilandi* from the interior of India (Madhya Pradesh).

9. **Glyptotermes dilatatus** (Bugnion & Popoff)

Occurs widely in Ceylon. Is a serious pest of two economic plants, tea and rubber.

10. **Archotermopsis wroughtoni** (Desneux)

Western Himalayas (Hazara and Kashmir to Kumaon) at altitudes of 2800-9000 ft. above sea-level. Attacks and lives in dead logs and stumps of conifers (pines and deodar). Its morphology and biology was studied long ago by Imms (1919).

11. **Heterotermes** spp. (Plate I)

Members of this genus are subterranean, but attack dry wood above ground in houses and elsewhere, being able to reach such wood by means of long surface-galleries which they construct. Four species of *Heterotermes* are known in the Indian Region, all of them pests of woodwork in houses. The most important species are *H. ceylonicus* (Holmgren) in Ceylon, and *H. indicola* (Wasmann) and *H. malabaricus* Snyder in India. Roonwal (1955) records an instance in which the township of Sri Hargobindpur in the Punjab was partially abandoned a few years ago due to the serious infestation of beams and other woodwork in houses by *H. indicola*.

12. **Coptotermes** spp. (Plate II)

Like *Heterotermes*, the genus *Coptotermes* is a subterranean termite which reaches dry wood above ground, as in houses, railway carriages, etc., and does serious damage. Eight species are known from the Indian Region (vide the recent revision by Roonwal & Chhotani 1962a, where

taxonomic descriptions and illustrations are given). The more important species are discussed below briefly.

(i) *Coptotermes ceylonicus* (Holmgren): Southern India and Ceylon. A pest of tea and rubber and also attacks dry wood.

(ii) *Coptotermes gaurii* Roonwal & Krishna (*exiguus* auct.): Ceylon. A serious pest of tea plants.

(iii) *Coptotermes formosanus* Shiraki: A species which is widespread (Ceylon, Formosa, S. China, Japan, Hawaiian Is., U.S.A., and S. Africa). A pest of tea and rubber, and also attacks dry wood.

(iv) *Coptotermes heimi* (Wasmann) (syn. *C. parvulus* Holmgren) (Plate II): All over India and West Pakistan where it is very common. Is a serious pest of woodwork, furniture, etc. in houses and elsewhere. Also known to destroy electric-wire casing, railway coaches, etc. Our knowledge of its biology has been summarised by Roonwal (1959). It is known to attack the dead wood of a large number of trees. Swarming of winged imagines generally occurs at dusk and early night (c. 6-10 p.m.). The season of swarming is spring and early summer (March-May) in the more humid areas (W. Bengal, Orissa, and Bombay) and during the monsoon (June-August) in the drier parts (Uttar Pradesh). The nest is made of semi-porous material in dead wood, sometimes even in railway carriages.

(b) *The non-wood-inhabiting species*

1. ***Globitermes audax*** Silvestri (syn. *G. birmanicus* Snyder)
Burma. Attacks forest trees. Little is known about its biology.

2. ***Microcerotermes heimi*** Wasmann
Species of *Microcerotermes* are characterized by the inner margin of the mandibles being serrated like a saw instead of toothed. Nearly 20 species are known from the Indian Region. The most common one is *M. heimi*, occurring in Assam, south India, and Ceylon; it lives chiefly in logs etc. in forests and makes large globular carton-nests.

3. ***Odontotermes*** spp.
Species of this genus are among the most common termites in the Indian Region, a few species building earthen mounds. The more important species are discussed below.

(i) *Odontotermes ceylonicus* (Wasmann): Ceylon. A major pest of woodwork in buildings in Ceylon (Harris 1961, p. 159).

(ii) *Odontotermes feae* (Wasmann) (Plate I): India, E. Pakistan, and Burma. One of the most destructive termites for woodwork in buildings. Also attacks and kills *Eucalyptus* seedlings in nurseries. No mound is formed as a rule but this happens occasionally (vide Roonwal &

Chhotani 1962b). Winged adults swarm out at the beginning of the monsoon.

(iii) *Odontotermes obesus* (Rambur): The most common mound-building termite in the greater part of India except the south. Attacks moist woodwork and other cellulosic materials (books, textiles, etc.) in houses particularly during the rainy season. But as a pest of dry wood in buildings does not seem to be important. Builds earthen mounds which may rise as high as 2.6 m. (c. 8.7 ft.) high. For its mound-structure, vide Roonwal (1958a, 1962b). For destruction of mound-colonies, vide Roonwal (1951) and Roonwal & Chatterjee (1962).

(iv) *Odontotermes parvidens* Holmgren & Holmgren: All over India. A large species commonly attacking the bark of trees. Was responsible for the killing of plantation teak in Uttar Pradesh (Roonwal 1954) by eating the bark and producing a sort of girdling effect. No mound is built; nesting occurs underground. Swarming of winged alates occurs in March from small holes in the ground.

(v) *Odontotermes redemanni* (Wasmann): Peninsular India, Bengal, and Ceylon. Builds earthen mounds as high as those of *Odontotermes obesus*. Is destructive to woodwork in houses, especially in the wet season.

4. *Microtermes obesi* Holmgren (syn. *M. anandi* Holmgren)

A small, widely spread species in India and Ceylon. Often occurs in association with *Odontotermes obesus* in the mound of the latter and in nest-areas of *O. feae*. Does not occur in buildings but attacks logs and dead wood in forests, as well as growing crops such as sugarcane, wheat, millets, etc. (vide Roonwal 1958).

5. *Nasutitermes ceylonicus* (Holmgren)

Ceylon. Is a major pest of woodwork in buildings in Ceylon (Harris 1961, p. 159).

6. *Hospitalitermes birmanicus* (Snyder)

Burma. Attacks saplings. Like other members of the subfamily Nasutitermitinae, the soldiers are characterized by a nasute process in the front part of the subglobular head-capsule and by minute, non-functional mandibles.

III. CONTROL

The destruction and control of wood-destroying termites is a difficult task, mainly because of the difficulty of reaching the population inside the affected timber. The best course is to build houses according to anti-termite designs and to use chemically treated wood (coal-tar creosote is very effective). The use of naturally resistant timbers, e.g. heartwood

of teak, is also helpful. Some of the effective control methods devised in recent years in India against subterranean termites may be mentioned briefly.

Control in mounds. Pouring suitable quantities of water-emulsions of some of the chlorinated hydrocarbons (benzene hexachloride, aldrin, and dieldrin) completely destroys mound-colonies in less than a week (Roonwal 1951; Roonwal & Chatterjee 1962).

Control by soil treatments (mud-wall poisoning). Laboratory experiments indicate that, if the mud used to plaster huts in villages is mixed with small quantities of benzene hexachloride, effective protection to the super-structure (roof etc.) of bamboo and wood is obtained up to about two years (Roonwal, Chatterjee & Thapa 1962).

IV. SUMMARY

Out of nearly 180 termite species occurring in the Indian Region about 58 destroy wood. Of these, 42 commonly inhabit wood; the remainder, while not commonly inhabiting wood, nevertheless are important destroyers of wood. They belong to the families Kalotermitidae (27 species), Hodotermitidae (1 species), Rhinotermitidae (14 species), all wood-inhabiting; and Termitidae (16 species), soil-inhabiting.

REFERENCES

- ASSMUTH, J. (1913): Wood-destroying white ants of the Bombay Presidency. *J. Bombay nat. Hist. Soc.* 22 (2): 372-384, 4 pls.
- BEESON, C. F. C. (1941): A guide to the control of termites for forest officers. *Indian For. Rec. (Ent.) (N.S.)* 4 (2): 44-90.
- CHHOTANI, O. B. (1962a): Biological observations on the termite *Kalotermes beesoni* Gardner. *Proc. 1st All-India Congr. Zool. (Jabalpur, 1959)*, Calcutta, Pt. 2 (*Sci. Pap.*): 476-478, 1 pl.
- (1962b): Further observations on biology and parthenogenesis in the termite *Kalotermes beesoni* (Kalotermitidae). pp. 73-75. In: *Termites in the Humid Tropics (Proc. New Delhi Sympos., 1960)*—Paris (UNESCO).
- (1963): The termite *Cryptotermes havilandi* [Sjöstedt] from the interior of India. *J. Bombay nat. Hist. Soc.* 60 (1): 287-288, 1 pl.
- HARRIS, W. V. (1961): Termites: Their Recognition and Control. xii+187 pp., 57 figs., 8 col. pls.; 1 figd. chart.—London. Longmans, Green & Co.
- IMMS, A. D. (1919): On the structure and biology of *Archotermopsis*, together with description of new species of intestinal Protozoa and general observations on the Isoptera. *Philos. Trans. roy. Soc. Lond. (B)* 209: 75-180, 8 pls.
- ROONWAL, M. L. (1951): Practical directions for the prophylactic treatment of timber, bamboos and plywood for protection against insect damage. *Indian Forester* 77 (10): 648-650. Also as *Indian For. Leaflet (Ent.)*, Delhi, No. 125: 1-3, 1951.
- (1954): Biology and ecology of oriental termites (Isoptera). No. 1. *Odontotermes parvidens* Holmg. and Holmg. severely damaging the bark and contributing to the death of standing teak trees in Uttar Pradesh, India. *J. Bombay nat. Hist. Soc.* 52 (2 & 3): 459-462, 1 pl.
- (1955): Termites ruining a township. *Z. angew. Ent. Berlin* 38 (1): 103-104.
- (1958): Recent work on termite research in India (1947-57). *Trans. Bose. Res. Inst. Calcutta* 22: 77-100, 4 pls.
- (1959): Biology and ecology of oriental termites (Isoptera). No. 4. The drywood termite, *Coptotermes heimi* (Wasm.), in India. *J. Bombay nat. Hist. Soc.* 56 (3): 511-523, 3 pls.

- ROONWAL, M. L. (1962a): Recent developments in termite systematics (1949-60). pp. 31-50, 1 pl. (Pl. 1). (In: *Termites in the Humid Tropics: Proc. New Delhi symposium, 1960*)—Paris (UNESCO).
- (1962b): Biology and ecology of oriental termites. No. 5. Mound-structure, nest and moisture-content of fungus combs in *Odontotermes obesus*, with a discussion on the association of fungi with termites. *Rec. Indian Mus.* 58 (3 & 4) [1960]: 131-150, 4 pls.
- , & CHATTERJEE, P. N. (1962): Destruction of colonies of mound-building termites in India. pp. 211-212. (In: *Termites in the Humid Tropics: Proc. New Delhi Symposium, 1960*)—Paris (UNESCO).
- , & THAPA, R. S. (1962): Recent results of work on the protection of timber against subterranean termites in India. Pp. 183-184, 2 pls. (Pls. 33 & 34, on p. 1). (In: *Termites in the Humid Tropics: Proc. New Delhi Symposium, 1960*)—Paris (UNESCO).
- ROONWAL, M. L. & CHHOTANI, O. B. (1962a): Indian species of Termite Genus *Coptotermes*. ix+115 pp. (18 pls.). Delhi Indian Council, Agric. Res., Entom. Monogr. No. 2). Manager of Publ., Govt. of India.
- &———, (1962b): The mound of the termite *Odontotermes feae* in India. *Abstracts Papers 2nd All-India Congr. Zool.* (Varanasi, Oct. 1962), Cuttack: 85.
- , & KRISHNA, K. (1955): Systematics of oriental termites. II. A new species, *Coptotermes gaurii*, from Ceylon. *Indian J. agric. Sci.* 25 (2): 143-152.
- , & SEN-SARMA, P. K. (1955): Biology and ecology of oriental termites (Isoptera). No. 3. Some observations on *Neotermes gardneri* (Snyder) [Family Kalotermitidae]. *J. Bombay nat. Hist. Soc.* 53 (2): 234-239, 2 pls.
- &———, (1960): (Contributions to the Systematics of Oriental Termites.) 2+xi+406 pp., 65 pls. New Delhi (Ent. Mongr. No. 1, Indian Council, Agric. Res.).

APPENDIX

LIST OF INDIAN WOOD-DESTROYING TERMITES

(a) Species which commonly inhabit wood

Family I. KALOTERMITIDAE

Subfamily Kalotermitinae

1. *Kalotermes beesoni* Gardner
2. *Kalotermes jepsoni* Kemner
3. *Kalotermes pintoii* Kemner
4. *Neotermes andamanensis* Snyder
5. *Neotermes artocarpi* (Haviland)
6. *Neotermes assmuthi* Holmgren
7. *Neotermes bosei* Snyder (syn. *N. gardneri* Snyder)
8. *Neotermes buxensis* Roonwal & Sen-Sarma
9. *Neotermes fletcheri* Holmgren & Holmgren
10. *Neotermes greeni* (Desneux)
11. *Neotermes kemneri* Roonwal & Sen-Sarma
12. *Neotermes magniferae* Roonwal & Sen-Sarma
13. *Neotermes megaoculatus megaoculatus* Roonwal & Sen-Sarma
14. *Neotermes megaoculatus lakhimpuri* Roonwal & Sen-Sarma
15. *Neotermes microculatus* Roonwal & Sen-Sarma
16. *Neotermes militaris* (Desneux)
17. *Neotermes pishinensis* Ahmad
18. *Cryptotermes cyanocephalus* Light
19. *Cryptotermes domesticus* (Haviland)
20. *Cryptotermes dudleyi* Banks
21. *Cryptotermes havilandi* (Sjöstedt) (syn. *C. bengalensis* Snyder)
22. *Cryptotermes perforans* Kemner
23. *Glyptotermes almoresis* Gardner
24. *Glyptotermes ceylonicus* (Holmgren)
25. *Glyptotermes coorgensis* Holmgren & Holmgren
26. *Glyptotermes dilatatus* (Bugnion & Popoff)
27. *Glyptotermes minutus* Kemner

Family II. HODOTERMITIDAE

Subfamily Termopsinae

28. *Archotermopsis wroughtoni* (Desneux)

Family III. RHINOTERMITIDAE

Subfamily (i) Heterotermitinae

29. *Heterotermes ceylonicus* (Holmgren)
30. *Heterotermes gertrudae* Roonwal
31. *Heterotermes indicola* (Wasmann)
32. *Heterotermes malabaricus* Snyder
33. *Reticulitermes chinensis* Snyder

Subfamily (ii) Stylotermitinae

34. *Stylotermes fletcheri* Holmgren & Holmgren

Subfamily (iii) Coptotermitinae

35. *Coptotermes ceylonicus* Holmgren
36. *Coptotermes emersoni* Ahmad
37. *Coptotermes formosanus* Shiraki (*nec* Holmgren)
38. *Coptotermes gaurii* Roonwal & Krishna (*exiguus* auct.)
39. *Coptotermes gestroi* Wasmann
40. *Coptotermes heimi* (Wasmann) (syn. *C. parvulus* Holmgren)
41. *Coptotermes kishori* Roonwal & Chhotani
42. *Coptotermes travians* Haviland

(b) Species which do not commonly inhabit wood but attack and destroy it

Family IV. TERMITIDAE

Subfamily (i) Amitermitinae

43. *Globitermes audax* Silvestri (syn. *G. birmanicus* Snyder)
44. *Microcerotermes annandalei* Silvestri
45. *Microcerotermes heimi* Wasmann

Subfamily (ii) Macrotermitinae

46. *Odontotermes bangalorensis* Holmgren
47. *Odontotermes brunneus* Holmgren
48. *Odontotermes ceylonicus* (Wasmann)
49. *Odontotermes feae* (Wasmann)
50. *Odontotermes horni* (Wasmann)
51. *Odontotermes obesus* (Rambur)
52. *Odontotermes parvidens* Holmgren & Holmgren

53. *Odontotermes redemanni* (Wasmann)
54. *Hypotermes obscuriceps* (Wasmann)
55. *Microtermes mycophagus* (Desneux)
56. *Microtermes obesi* Holmgren (syn. *M. anandi* Holmgren)

Subfamily (iii) Nasutitermitinae

57. *Nasutitermes ceylonicus* (Holmgren)
58. *Hospitalitermes birmanicus* (Snyder)

The Birds of Nepal

PART 12

BY

BISWAMOY BISWAS

Zoological Survey of India, Indian Museum, Calcutta

(With four plates and five figures)

[Continued from Vol. 60 (3) : 654]

PHYSIOGRAPHY, VEGETATION, etc. OF NEPAL

Nepal exhibits two general surface features, the lowland in the south, and the Himalaya mountains in the north (Figs. 4 and 5).

LOWLAND

The lowland consists of the plain, tarai and bhabar. The former is, in fact, a part of the highly cultivated and densely populated Gangetic plain as seen in Uttar Pradesh and Bihar of India, and is indistinguishable from it.

The tarai (altitude *c.* 140-150 m.) is the slightly sunken tract of land lying immediately to the north of the plain. It has come into being by 'filling up by long-continued alluviation of a tectonic basin formed when the strata of the Tethys Sea were folded and raised into the Himalaya Mountains' (Karan 1960, p. 22). Typically, the tarai is a tract where the meandering rivers which are open to annual flooding, flow through alluvium, and give rise to a number of swamps and supports a thick tropical moist deciduous forest consisting chiefly of Sisoo (*Dalbergia sisoo*), Silk-cotton (*Salmaalial malabarica*), Khair (*Acacia catechu*), Siris (*Albizia lebbek*), Figs (*Ficus religiosa*, *F. bengalensis*), Palas or the Flame-of-the-Forest (*Butea frondosa*), Tund (*Cedrela toona*), Haldu (*Adina cordifolia*), Jarul (*Lagerstroemia*), a few Palm (*Phoenix*), and large stretches of various grasses, such as Kharaul (*Saccharum narenga*) *Cymbopogon*, *Andropogon*, *Setaria*, etc. Large portions of the tarai have, however, been cleared off for the purpose of cultivation. Such areas are indistinguishable in appearance from the Gangetic plain on the south.

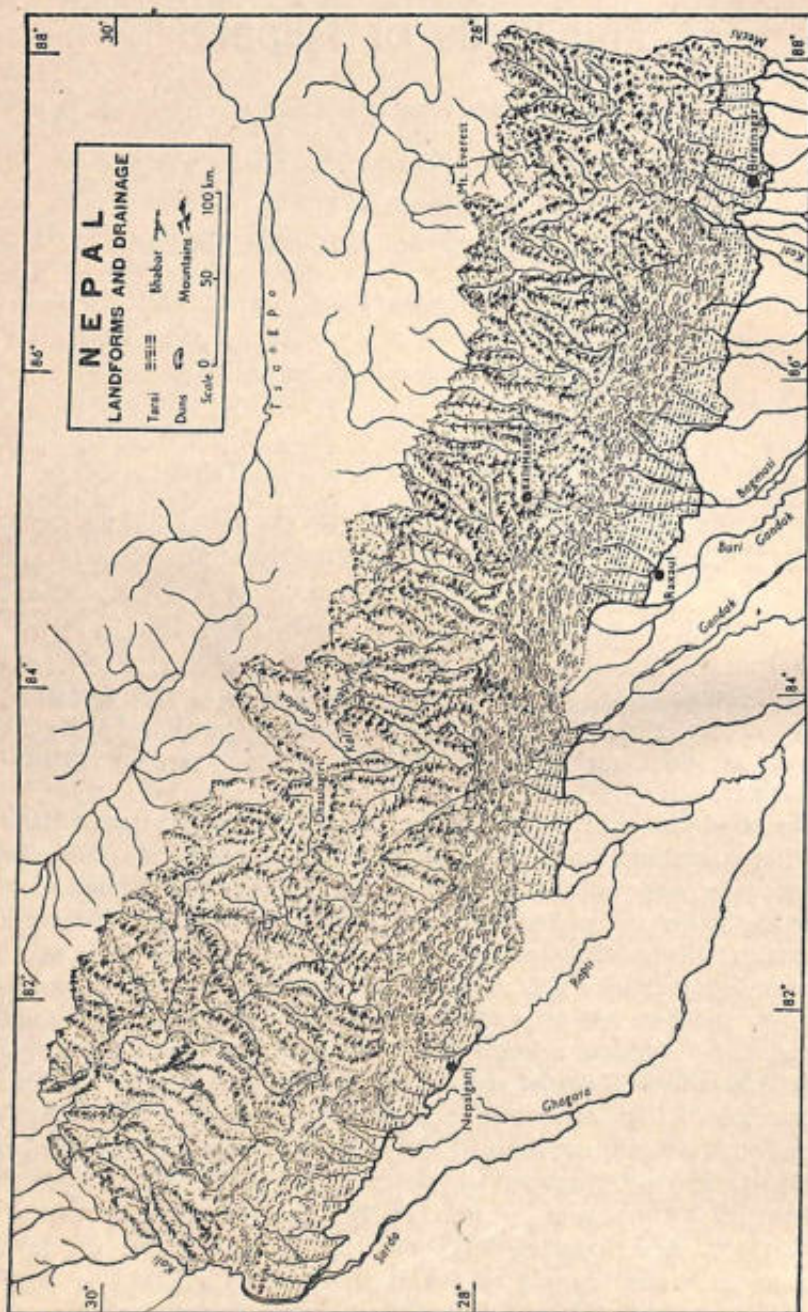


Fig. 4. Land-forms and drainage in Nepal (Adapted from Karan's 'Nepal', 1960)
(By the courtesy of the University of Kentucky Press, Lexington, U.S.A.)

The **bhabar** (altitude *c.* 150-300 m.) comprises a belt of 'hill wash and of alluvial fans composed of highly porous gravels' (Karan 1960, p. 22), immediately on the north of the tarai. It has a low gradient from north to south. All the streams originating from the southern face of the Siwalik Hills on the north, traverse the bhabar. However, because of the nature of its soil and the gradient, water does not accumulate in this zone, although the silt brought about by the streams is deposited. This makes it possible to sustain a luxuriant moist deciduous forest consisting mainly of Sál (*Shorea robusta*), with some Sisoo (*Dalbergia sisoo*), Silk-cotton (*Salmaalía malabarica*), *Bauhinia malabarica*, Sinduré (*Mallotus philippensis*), Haldu (*Adina cordifolia*), Tund (*Cedrela toona*), Asan (*Terminalia tomentosa*), *Phyllanthus*, creepers (*Spatholobus*, *Dioscorea*, *Zehneria*), a thick undercover of grasses (*Oplismenus*, *Setaria*, *Pollinia*, *Andropogon*, etc.) and occasional scrub of *Elephantopus*, *Mimosa*, *Crotalaria*, *Sida*, etc.

HIMALAYA MOUNTAINS

The Himalaya mountains in Nepal may be conveniently divided into four zones from south to north, viz. the Subhimalaya, the Lesser Himalaya, the Great Himalaya and the Tibetan zone.

The **Subhimalaya** or the **Siwalik Range** (altitude *c.* 300-1220 m.): The low range of hills running east-west throughout the length of Nepal immediately on the north of the bhabar, and consisting mainly of sandstone, sandy limestones and gravel beds, is the Siwalik range. It is known as the Churia hills in Nepal, and is in fact, a continuation of the Siwalik system of the Punjab and Uttar Pradesh of India. Its maximum elevation is about 1220 m., and its ridges and spurs are narrow and sharply edged. It supports thick tropical moist deciduous vegetation composed chiefly of Sál (*Shorea robusta*), with some Sisoo (*Dalbergia sisoo*), Asan (*Terminalia tomentosa*), *Reinwardtia trigyna*, *Lindenbergia*, *Inula*, *Leucas*, and in the upper reaches, *Pinus roxburghii*, *Swertia angustifolia* var. *wallichii*, *Aechmanthera*, *Indigofera*, *Blumea*, *Strobilanthes*, *Scutellaria*, etc., and climbers like *Dioscorea*, and *Sabia*. The undergrowth consists of Sabai grass (*Eulaliopsis binata*) and a few other grasses and scrub.

A large number of streams originate from the Siwalik range. Those taking off from its southern slopes flow into India or form tributaries of other rivers, while those from the northern slopes join several rivers coming down from the Lesser or the Great Himalayan ranges. Those rivers flow south through a number of deep gorges across the Siwaliks into India.

Between the Siwalik range and the Lesser Himalaya on the north are a series of canoe-shaped longitudinal valleys running northwest-southeast

and separated by narrow ridges. These valleys which are more or less wide, are called 'duns' (altitude c. 300-1370 m.). They are thickly clothed with deciduous forest of mainly Sâl (*Shorea robusta*) in the lower elevations and Pine (*Pinus roxburghii*) at the upper reaches, with Sindurê (*Mallotus philippensis*), *Millettia auriculata*, Chilone (*Schima wallichii*), Champa (*Michelia champaca*), Haldu (*Adina cordifolia*), *Callicarpa macrophylla*, Bankar (*Clerodendrum colebrookianum*), wild Raspberry (*Rubus rosaefolia*), *Vallis solanacea*, *Inula indica*, *Indigofera dosua*, patches of *Phragmitis karka*, *Anthistiria gigantea*, and other grasses and scrub like *Mimosa*, *Phyllanthus*, *Drymaria*, etc. —

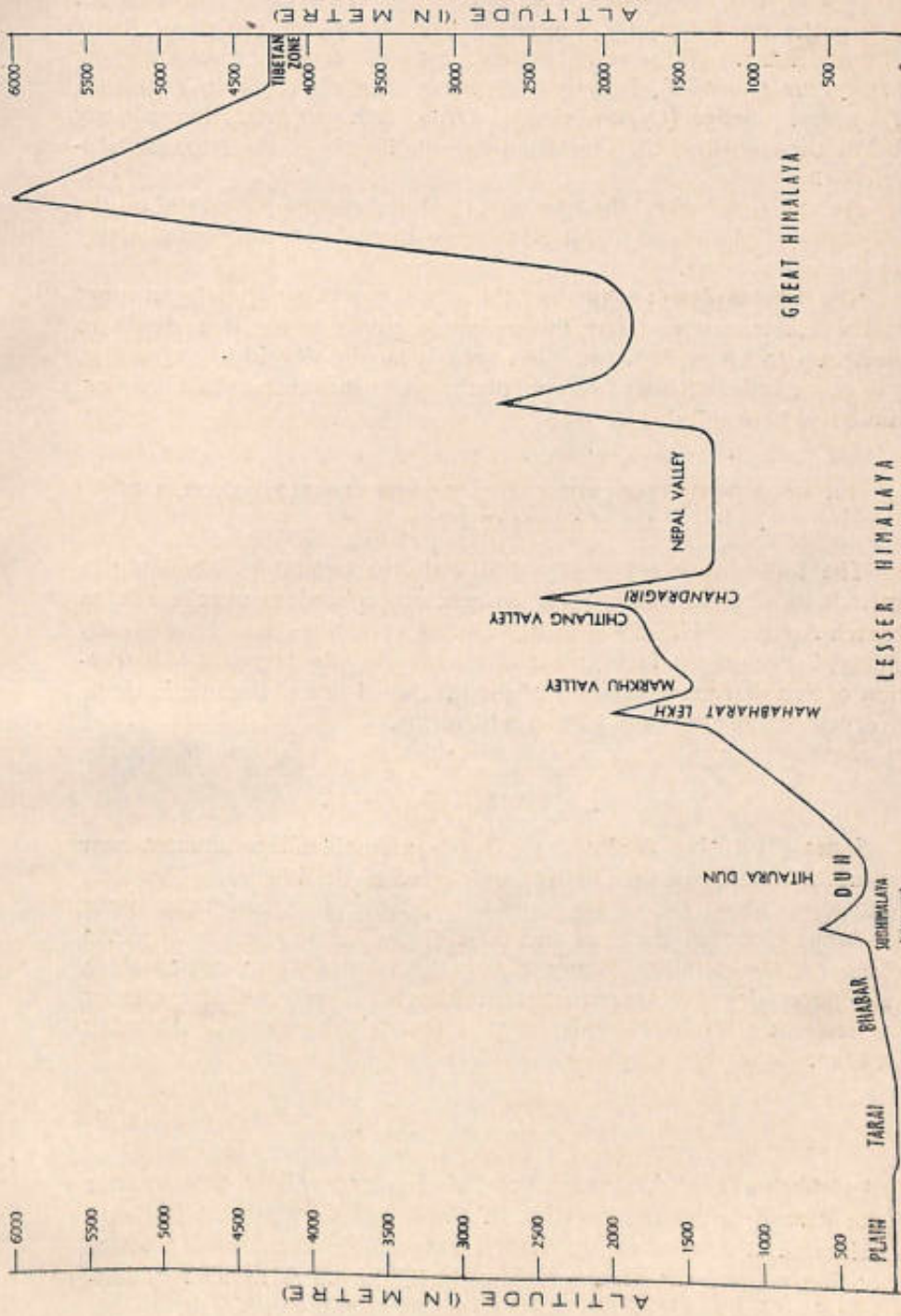
The Lesser or Middle Himalaya lying on the north of the duns, is an intricate array of high ranges (altitude c. 1370-4570 m.) sprawling east-west throughout the length of the country. These are cut into deep ravines and precipitous defiles which fan out into irregularly directed ridges with repeated ramifications. The southern slopes of its ridges, except in protected valleys, are generally too steep to maintain a soil-cap for the growth of forests, but the northern slopes are gentler and clad with dense vegetation.

Depending on the location and altitude, the forests of the Lesser Himalaya consist mainly of Katus (*Castanopsis*), Ash (*Engelhardtia*), Pines (*Pinus* spp.), Oaks (*Quercus* spp.), Rhododendrons (*Rhododendron* spp.), Poplar (*Populus*), Walnut (*Juglans*), Alder (*Ainus*), *Magnolia*, Deodar (*Cedrus*), Larch (*Larix*), Fir (*Abies*), Birch (*Betula*), Maple (*Acer*), thin Bamboo (*Pleioblastus*), etc.

The well-defined mountain-range called the 'Mahabharat Lekh', extending throughout the length of Nepal from west to east, lies in the Lesser Himalaya.

The Great Himalaya : North of the Lesser Himalaya lies the single range of the Great Himalaya with its lofty mountainous wall rising above the limits of perpetual snow. It completely shields the north. A number of the greatest peaks of the world stand in clusters and rows in this range. Numerous rivers of Nepal, which originate in the north of the axis of the Great Himalaya, cut deep gorges across it to flow southward. The average altitude of the crest of the Great Himalaya in Nepal is more than 6000 metres.

In the lower regions of the Great Himalaya, from about 2450 m. up to the tree limits (c. 3960-4264 m.), there are good temperate coniferous forests of Blue Pine (*Pinus excelsa*), Spruce (*Picea*), Oak (*Quercus*), Fir (*Abies*), Cypress (*Cupressus*), Tree Juniper (*Juniperus*), Birch (*Betula*), with Hemlock-Spruce (*Tsuga*), Yew (*Taxus*), some deciduous Maples (*Acer*) and Cherries (*Prunus*), thin Bamboo (*Pleioblastus*), *Lyonia*, Jasmin (*Jasminum*), *Syringa*, *Rosa*, *Berberis*, *Rhododendron*, Larch (*Larix*), Asarê (*Viburnum*), *Spiraea*, *Sorbus*, and some alpine plants, like the Primrose (*Primula*), *Pedicularis*, *Potentilla*, *Androsace*, *Saxifraga*, *Gentian*



(*Gentiana*), *Iris*, *Meconopsis*, etc., depending on elevation and location. Above the tree limits, the vegetation consists of low bushes of dwarf Rhododendrons (*R. setosum*, *R. anthopogon*), creeping or scaly Juniper (*Juniperus squamata*), Primrose (*Primula*), *Iris*, *Meconopsis*, *Potentilla*, *Pedicularis*, Sedge (*Cyperus*), grass (*Helichotrichon*), etc. Immediately below the snowline, the vegetation consists largely of the grass *Helichotrichon*.

As one goes higher, the number of plants becomes scarce, till on the moraines of glaciers at about 5000 m. or thereabouts, they stand singly or in small clusters.

The **Tibetan Zone**: North of the axis of the Great Himalayan range is the Tibetan zone. Here the mountain slopes gently from south to north up to about 3660 m. The area is largely devoid of vegetation, except for little patches of xerophytic thorny bushes such as of *Caragana*, and grass here and there.

PHYSIOGRAPHY, VEGETATION, &C., OF THE COLLECTING AREAS IN CENTRAL NEPAL

The following notes briefly deal with the conditions obtaining in various localities in central Nepal where our collections were made in March-August 1947. Since then, however, conditions there have greatly changed through the interference of man, mainly by large-scale destruction of forests for reclamation of land for agriculture, communications, hydroelectric projects and human settlements.

TARAI

Simra (27°10' N., 84°58' E.): This is a small village situated near the northern edge of the central tarai, close to the bhabar. There are cultivations about the village, especially in the south, and thick moist deciduous forest in the west, north and east. Two rivers have joined together in the vicinity of Simra to form the Sariswa River, one of which was almost dry during our visit in March. There are also one or two streams with fairly wide beds in the neighbourhood. Altitude: c. 140 m.

BHABAR

Amlekhganj (27°17' N., 85°E.): This is a large village, the terminus of the Raxaul-Amlekhganj section of the Nepal Government Railway, and situated at the foot of the Siwalik range. There are small plots of cultivation around the village amidst thick forest. A number of hill-streams flow in the vicinity of this village. Altitude: c. 300 m.

DUN

Hिताura (27°26' N., 85°02' E.) area (with Suparitar, 27°28' N., 85°2' E., Kusumtar, 27°27' N., 85°5' E., Paharé Ghat, 27°26' N., 85° E., Karra,

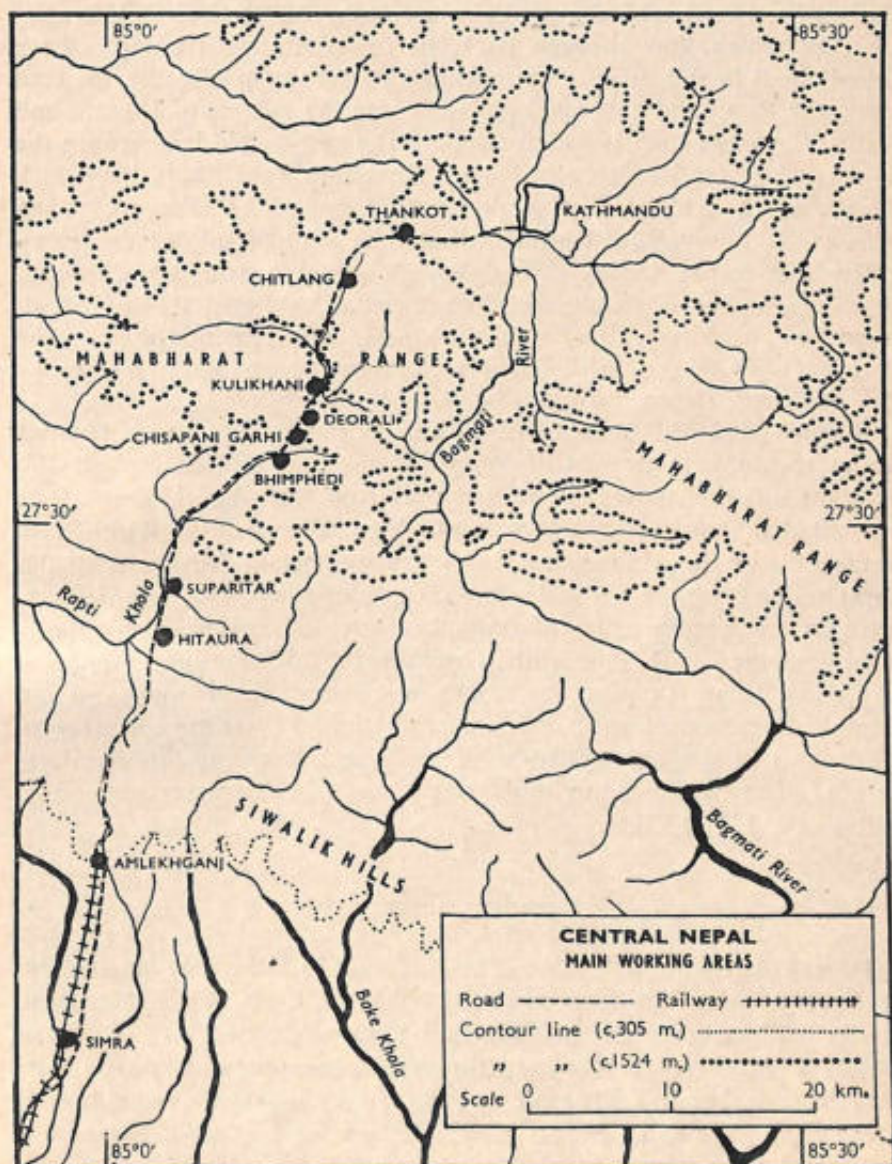


Fig. 6. Map of central Nepal showing main working areas of Koelz-Biswas team.

27°25' N., 85°2' E. as collecting localities): This area (Figs. 6, 7) lies in the valleys of the Rapti, Samri, and Karra Kholas. The principal

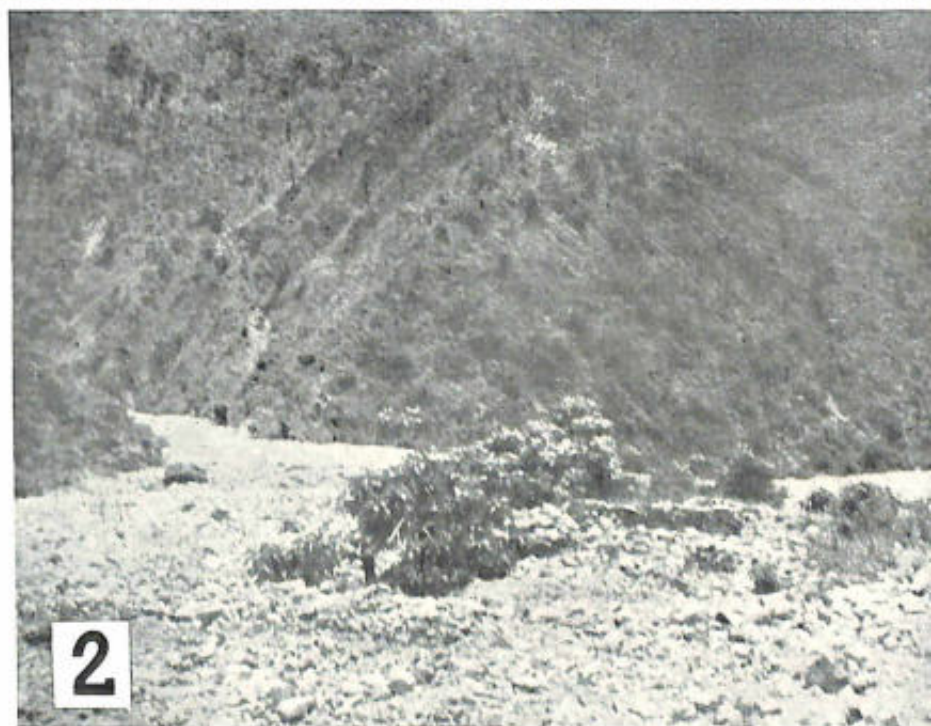
river of the area, namely the Rapti, flows north to south. North of the Hitaura village, it receives the Samri Khola flowing east to west, and south of the village it receives the Karra Khola coming from east, and a small tributary from the south. The Rapti River then turns sharply westward. Moreover, there are many hill-streams in this area, some of which flow through dark, narrow ravines. The rivers have shingle beds in this area. Apart from a narrow strip of cultivated land along the Rapti and cultivated plots between the villages of Hitaura and Karra, the entire area is well forested. The east-west ridge between the Samri and Karra Kholas, and Paharé Ghat across the Rapti, have thick forests of Sal (*Shorea robusta*), some Lampati (*Duabanga*), Asan (*Terminalia tomentosa*), *Bauhinia*, Kadamba (*Anthocephalus cadamba*), a few Silk-cotton (*Salmalia malabarica*), Amaltas (*Cassia*), *Clematis*, *Drymaria*, and shrubs and weeds like *Mimosa*, *Sida*, etc. Patches of tall grass, like *Saccharum*, *Phragmitis*, *Anthistiria*, occur here and there. The river beds are fringed with thickets of thorny plants and creepers like *Rhaphidophora glauca*. Altitude : c. 420-610 m.

Bhimphedi (27°33' N., 85°09' E.) : Further to the north-east of Hitaura (about 16 km. in a straight line) lies the small town of Bhimphedi, the terminus of the motor route from Raxaul and Amlekhganj. It is situated at the upper limit of the dun on the left bank of the Rapti River at the foot of the Mahabharat Lekh. A number of tributaries of the Rapti, rising from the Mahabharat, flow around the town. The western, northern and eastern sides of Bhimphedi are surrounded by mountains densely clothed with Pine with a mixture of deciduous and evergreen vegetation (Plate I). On the south-west, south, and south-east of Bhimphedi there are some patches of cultivation. There are a number of hill-streams in the vicinity, some of which at places run through deep ravines. The banks of the larger rivers sustain tall grasses and scrub. Altitude : c. 1220-1370 m.

MARKHU VALLEY

Deorali (27°34' N., 85°09' E.) : This is a place in name only situated on the northern side of the pass on the Mahabharat Lekh above Chisapani Garhi (= Sissagarhi) on the Bhimphedi-Kathmandu trail. In this area, there is a thin forest of Rhododendron (*R. arboreum*), with some Cheer Pine (*Pinus roxburghii*), Kharsu Oak (*Quercus semecarpifolia*), and bushes of *Luculia*, *Viburnum*, *Rhus*, *Rubus*, *Prunus*, etc. The undergrowth consists of *Clematis*, *Galium*, *Hypericum*, *Valeriana*, *Dipsacus*, *Strobilanthes*, etc., and *Anaphalis*. There are also some orchids, like *Otochilus*, and epiphytes (*Peperomia*). Abundant mosses festoon the trees. A few small hill-streams are present in the area. Altitude : c. 1980 m.

Biswas : Birds of Nepal



1, 2. Forests on the Mahabharat Lekh, east of Bhimphedi, Central Nepal
19 June 1947.

(Photos : B. Biswas)

Biswas : Birds of Nepal



3. Looking north from Chandragiri Pass, above Thankot. 18 March 1947.
4. Vegetation on northern edge of Thankot Village, Nepal Valley. 18 March 1947.

(Photos : B. Biswas)

Kulikhani ($27^{\circ}35'N.$, $85^{\circ}9'E.$): This is a small village situated on the right bank of the Markhu River below Deorali, and on the trail to

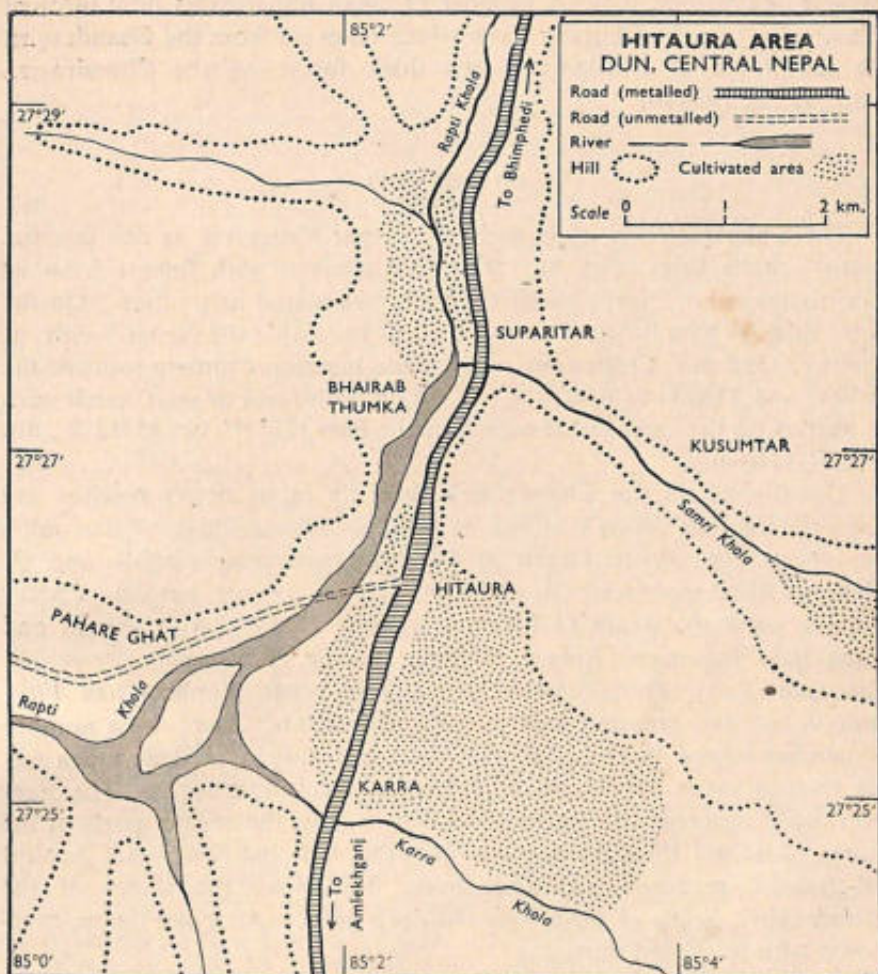


Fig. 7. Map of the Hitaura area, central Dun, Nepal.

Kathmandu. There is extensive cultivation along the river, but to the south and west on the mountain slopes, there are mixed deciduous and evergreen forests. Altitude : *c.* 1400 m.

CHITLANG VALLEY

Chitlang ($27^{\circ}39'N.$, $85^{\circ}11'E.$): This is a village lying at the southern foot of the Chandragiri below the pass on the Kathmandu trail, and near the head of the Chitlang Valley. There is extensive cultivation on the south of the village, with patches of scrub and grass here and there.

Such vegetation consists of *Potentilla*, *Teucrium*, *Artemisia*, *Swertia*, *Micromeria*, *Lotus*, *Viola*, *Gentiana*, *Arenaria*, *Oldenlandia*, *Stellaria*, *Pollinia*, *Anthistiria*, etc. A number of small hill-streams flow through this area to join the Chitlang River which takes off from the Chandragiri. On the north of Chitlang, is the thick forest on the Chandragiri. Altitude : c. 1830 m.

CHANDRAGIRI

The Chandragiri range bounds the Nepal Valley on its western and south-western sides (Fig. 8). It is well covered with forests from its base to the crest, except about the villages situated at its foot. On the outer side, its base lies at about c. 1830 m., but inside the Nepal Valley, at about c. 1525 m. Collections were made between Chitlang (outside the Valley) and Thankot (inside the Valley) on both faces of the Chandragiri, as well as on the crest in the region of the Pass (27°41' N., 85°12' E., alt. c. 2285-2440 m.).

The forests on the Chandragiri, specially in its upper reaches, are largely of the type which Champion (1936, p. 231) classified as 'Ban oak'. The vegetation consists largely of Oaks (*Quercus semecarpifolia* and *Q. glauca*), Rhododendron (*R. arboreum*), Aru (*Pyrus pashia*), Cherry (*Prunus puddum*), Asaré (*Viburnum*), Angeri (*Pieris*), with shrubs and herbs like *Jasminum*, *Rubus*, *Berberis*, *Randia*, *Ranunculus*, *Artemisia*, *Valeriana*, Fern (*Pteris*), *Lindenbergia*, *Thalictrum*, climbers like *Vitis*, *Smilax*, etc. and grasses (*Andropogon* and others). There are a number of patches where the undergrowth is very scanty, as well as much cut-out treeless areas having thick secondary shrubby growths. The trees are thickly covered with mosses and lichens. In the steeper parts of the slopes, there are thick herbaceous growths with but few trees. Several hill-streams, medium-sized and small, flow down the slopes of the Chandragiri. Some of them have cut deep gorges, dark and damp, overgrown with ferns and mosses.

NEPAL VALLEY

Almost completely enclosed by a series of ridges, the irregularly oval-shaped Nepal Valley (Fig. 8) is situated in the Lesser Himalayan mountain system. The more important of these ridges are the Sheopuri Lekh on the north, Phulchauki Danda on the south-east and south, Chandragiri on the south and south-west, and the Nagar Jong on the north-west. The floor of the valley is more or less level and about c. 1220 m. in elevation, but the surrounding ridges range from c. 1830 m. to almost c. 3000 m. in height (Plate II, fig. 3, and Plate III, fig. 5). The floor of the valley is densely populated and extensively cultivated, even

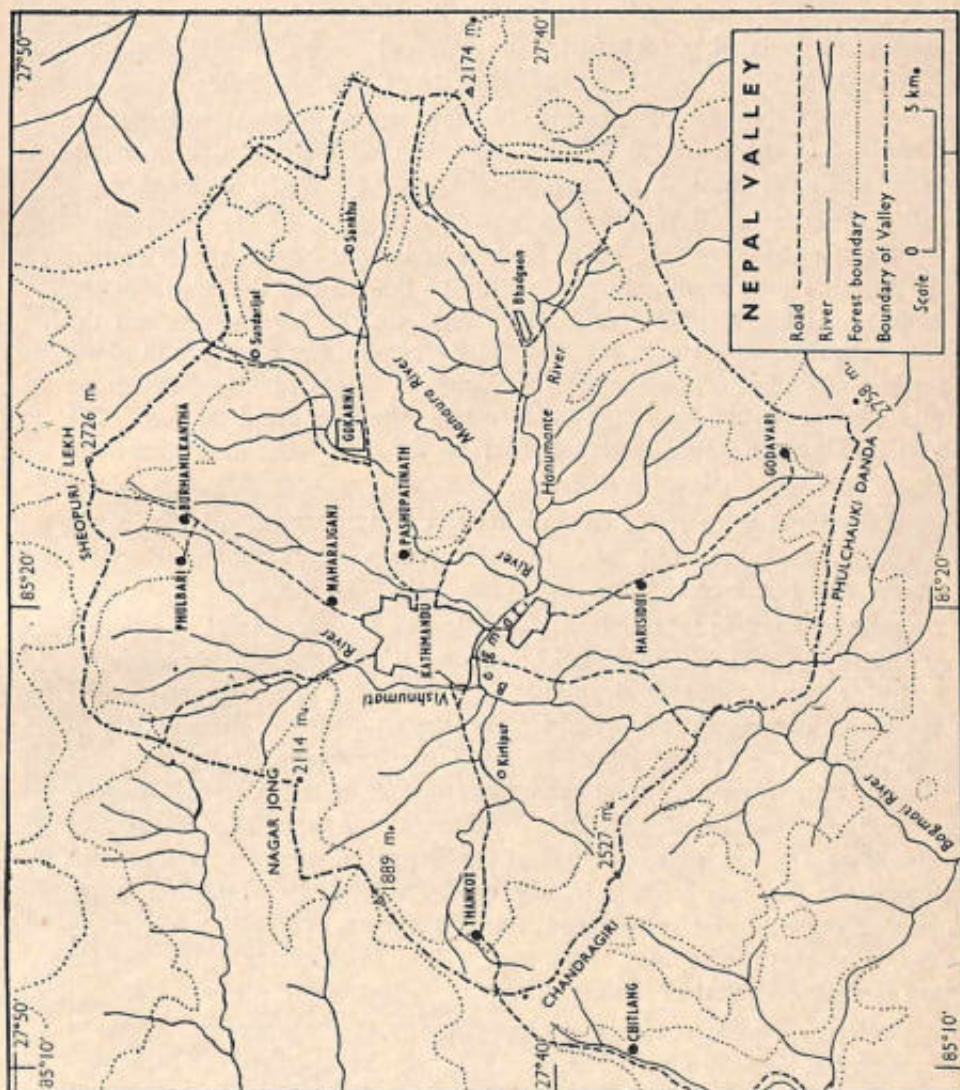


Fig. 8. Map of the Nepal Valley, Nepal.

up to the foothills in many areas. Barring some small patches of woods here and there, there is no forest in the floor of the valley. The surrounding ridges are, however, well forested in most parts. They are chiefly mixed forests of Oaks, Rhododendrons, Pines, Walnuts, Poplars, Alders, and different shrubs, herbs and grasses, depending on the elevation and location. The patches of woods on the floor of the valley are generally located on isolated 'tilas' (little hillocks), and consist of pine and other trees. They represent the 'central woods' of Scully (1879).

A large number of streams, big and small, originate from the surrounding ridges and flow into the valley. All of them form tributaries of the Bagmati—the only river that leaves the Nepal Valley through a narrow gorge on the south-west.

Kathmandu (27°42'N., 85°19'E.): The capital city of the Kingdom of Nepal, Kathmandu is located a little to the west of the centre of the Valley. The principal rivers of the Valley, viz. the Vishnumati and the Bagmati, flow adjacent to the city, the former flowing north-south along its western edge, while the latter which has first a north-south course along its eastern edge, flows east-west along its southern border. The two join at the south-western corner of the city. The area all around Kathmandu is well cultivated.

Collections were made in and around a number of villages in the outskirts of Kathmandu, as well as on the Vishnumati and Bagmati rivers. Altitude : c. 1300 m.

Burhanilkantha (27°48' N., 85°22' E.): This is a small village situated at the foot of the Sheopuri Lekh, about 13 km. north of Kathmandu. A hill-stream named Rudramati (a tributary of the Bagmati), flows north-south through the village. Another hill-stream flowing north-south along the eastern edge of the village, joins the Rudramati after turning west to pass through the southern part of the village. There is a small reservoir on the Rudramati above the village. To the east of the village, there is a narrow spur of the Sheopuri, which is covered with thick secondary scrub (Plate III, fig. 6). A little to the west, on a larger spur, lie the villages Phulbari and Jhar. There are cultivations about the villages and on the south, but the mountainside is forested. The vegetation is similar to that of the Chandragiri.

Collections were made in Burhanilkantha-Phulbari and surrounding areas and some way up the Sheopuri. Altitude : c. 1830-2155 m.

Godavari (27°36' N., 85°23' E.) is a small village situated at the south-eastern corner of the Nepal Valley between two spurs of the Phulchauki Danda coming out of it. The extensive forest around is a preserve of the ruling Prime Minister. There is a spring and a number of hill-streams in this area, and barring small patches of cultivation the whole area and the mountain are thickly clad with evergreen forest (Plate IV).

Biswas : Birds of Nepal



5. Looking towards Kathmandu from Thankot, Nepal Valley. 18 March 1947.
6. Vegetation on a spur of the Sheopuri Lekh, east of Burhanilkantha, Nepal Valley. 4 May 1947.

(Photos : B. Biswas)

Biswas : Birds of Nepal



7. Forest on a spur of the Phulchauki Danda, east of Godavari, Nepal Valley. 13 May 1947. 8. Looking north-west from Godavari, Nepal Valley. 16 May 1947.

(Photos : B. Biswas)

The vegetation is similar to that of the Chandragiri. There are also some grassy patches in this area. Altitude : *c.* 1675-2135 m.

Thankot (27°41'N., 85° 13'E.) : Located at the foot of the Chandragiri on the main trail from Bhimphedi to Kathmandu, this little village has some cultivation and a few grassy meadows. The area around Thankot is well forested, specially on the spurs of the Chandragiri about the village, except on the eastern side where the extensive cultivated area of the Valley begins (Plate II, fig. 4, and Plate III, fig. 5). In the immediate vicinity of the village, however, the forest is much cut down (for firewood, etc.), and as a result, large treeless patches overgrown with shrubs and grasses are not uncommon. A few hill-streams flow through the forest bed. The nature of the vegetation has already been mentioned under 'Chandragiri' (p. 374). Altitude : *c.* 1525-2135 m.

In addition to the above mentioned places in the Nepal Valley, collections were made at various spots along Kathmandu-Thankot, Kathmandu-Sundarijal, Kathmandu-Sankhu and Kathmandu-Godavari roads. All these localities were in the cultivated areas with no forests in the vicinity, and in altitudes of *c.* 1285-1525 m. Opportunity was availed of for making collections in a few of the 'central woods' on tilas.

(to be continued)

Re-use of Cells and Brother-Sister Mating in the Indian species *Stenodynerus miniatus* (Sauss.) (Vespidae: Eumeninae)

BY

S. D. JAYAKAR AND H. SPURWAY

*Genetics and Biometry Laboratory, Government of Orissa,
Bhubaneswar*

(With a plate)

INTRODUCTION

During the first period of colony formation, before any workers have emerged, the behaviour of queens of the social non-swarving haplometrotic species of Vespidae is comparable with the behaviour of females of solitary species (Yoshikawa 1962). At the foundation of her nest a queen builds cells and lays in them. When her first eggs hatch, food gathering begins and this alternates with continued building and oviposition. A cell is not finished once and for all, but loads are added after it contains a larva, both to accommodate this as it grows and to elaborate the architecture of the nest under various internal and external stimuli (Deleurance 1957, Olberg 1959). A queen wasp can also clean out a previously used cell and re-use it. She does this after she has removed an egg, larva, or pupa, which she has part eaten herself, and part fed to her other offspring. This destruction of some part of the brood is characteristic of this early stage in the formation of the nest (Deleurance 1955). The queen re-uses a cell after a normal imago has emerged only during the few days before the first daughter returns from her first foraging flight, after which the queen abruptly ceases all building and provisioning activities. The cleaning and structural reconditioning of previously used cells is however repeatedly performed by workers and forms an essential part of the economy of such colonies. All social wasps build their cells of paper, or other plant fragments.

The solitary vespoids (eumenines) that build for their offspring not only use mud (not paper) for this purpose, but lack the versatility of the social species. They are usually divided into two behavioural groups: (1) the potters who build individual cells for each egg, usually in

clusters; and (2) the renters (Iwata 1942) or squatters (Jayakar & Spurway 1965a) who lay their eggs in various holes and cavities including the deserted mud cells of the potter species. Squatters not only seal these cavities with mud, but also show considerable architectural skill in filling chinks, partitioning cavities, and rebuilding walls.

This paper describes a species which combines both the capacity to build individual cells and therefore qualifying as a potter wasp, and the capacity to service and re-use these cells repeatedly after her first offspring have emerged from them, and hence functioning as a squatter in her own cells. Thus, though a mud builder and solitary, this species shares a cell economy with the social species, and may mirror a condition which some ancestor of theirs exhibited. As would be expected on the previously hypothesized phylogeny of the social habit (Roubaud 1916, Wheeler 1923, Iwata 1942, Richards & Richards 1951) this species also performs progressive, though not simultaneous, provisioning.

THE MATERIAL

The species concerned is *Stenodynerus miniatus* (Sauss.), the cells of which have been described and figured by Horne and Smith (quoted by Bingham 1897) under the name *Pterochilus pulchellus* Smith. This mainly black species is variable, individuals within the same sibship differing both in the number and extent of the yellow spots on the head and thorax and their appendages, and in the extent of red on the petiole and anterior region of the gaster. The main body of this paper describes the fourth nest and mother in our files and they are both numbered *Stenodynerus miniatus* 4 or *St. m.* 4 (Fig. 1). The histories of *St. m.* 1, 2, and 3 begun on 18/v/63, 12/xi/64, and 20/vii/65 respectively all confirm in some way that here reported, and will be further referred to below. These four nests are all that we have observed in our house (Unit 5, Type VIII, No. 2) in New Bhubaneswar (20° 15' N.; 85° 50' E.; altitude 45 m.), which is built on laterite originally covered with wet semi-evergreen forest which was cleared in 1947.

Nests 5-18 and A-T were dissected soon after discovery, only a few observations of the mothers' behaviour being sometimes made. Their contents were either preserved in alcohol or kept alive. Nests 5 and 6 were collected on 14/iv/66 from a house from the village of Balakati which, though only 8 km. from the Bhubaneswar house, is on the delta of the Mahanadi and surrounded by rice fields. The mother of nest 5 was also collected. Many other nests were present in this house. The remaining nests were collected on 2/v/66 from a single

house in Barabil ($22^{\circ} 05' N.$; $85^{\circ} 25' E.$; altitude 520 m.). This is a mining town associated with iron and manganese mines in the midst of wet deciduous forest in which the dominant species is *Shorea robusta*.

At Barabil, all nests found on the house and judged to have been made this season were collected. Of these nine (nos. 7, 9-11, 14-18) were collected with the mothers working in them, three (nos. 8, 12, and 13) were identified by the young developing in their cells and seventeen (A to F and J to T) are associated with this species of *Stenodynerus* on the nest architecture alone.

NEST STRUCTURE AND SITING

These nests consisted of one or more granular mud vaults about 4 mm. in diameter and 18-20 mm. long. These were usually attached to a single surface, there being only three exceptions (9, 15, and E) (Figs. 2 and 3). These apparent tubes are numbered with Roman figures, in the order of building when this was watched (in nests 1-4) or could be discovered from the architecture. They were usually built parallel and touching throughout their length, and when on a vertical surface might be at any angle between 0° and 90° to the horizontal. *St. m.* 1 built tube II and tube III so that tube I was between them; the other three individuals watched built their later tubes in a series above tube I. The open vault was usually but not always completed with a chimney, i.e. a complete tube about 3 mm. in diameter and 5 mm. long curved slightly away from the substrate and with its opening bent slightly downwards. The outer walls of these chimneys were smoother than those of the vaults. Usually the tubes of a nest opened in the same direction but in four (8, 14, Q, and S) one of the tubes had been built opening in a different direction to the rest. In 8 and S (Plate, fig. 4) the opening of this exceptional cell was at the opposite end of the construct, the vaults of the tubes being parallel. In 14, the only nest with 4 completed tubes, though the openings of the chimneys were opposite but parallel, the vault of one (called I) was curved round and under the mouths of the other three (Plate, fig. 5). In Q two cells were found in the usual parallel relationship, then an unused but sealed half vault at right angles to them at their open ends, and finally, on the other side of this, another normal tube parallel to the other two (Plate, fig. 6). This partial tandem arrangement of tubes was also present in nest 15 (Plate, fig. 3). The most curious structure, which we have only seen in derelict nests, was for a tube to be curved more or less into a ring built round the shaft of a stout nail and in a plane perpendicular to it (Plate, fig. 7).

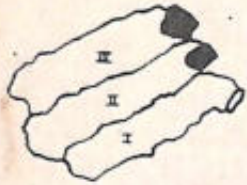


Fig. 1
 0 1 2
 cmL.

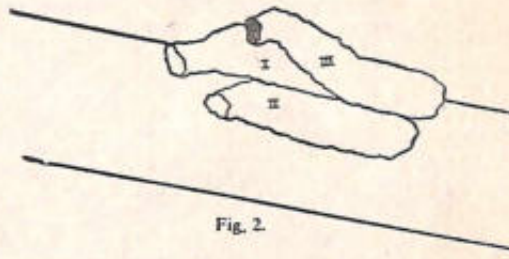


Fig. 2.

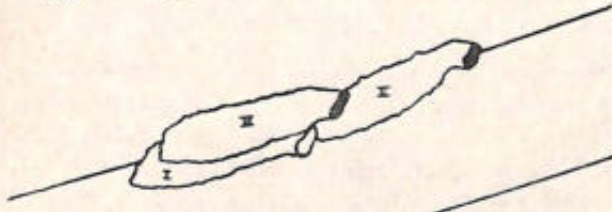


Fig. 3.

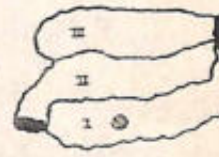


Fig. 4.

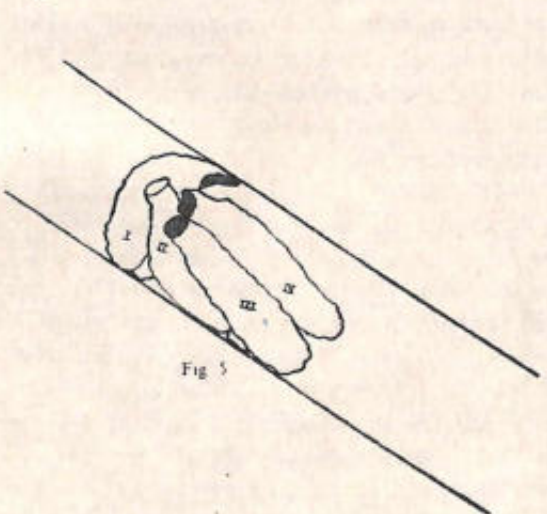


Fig. 5.

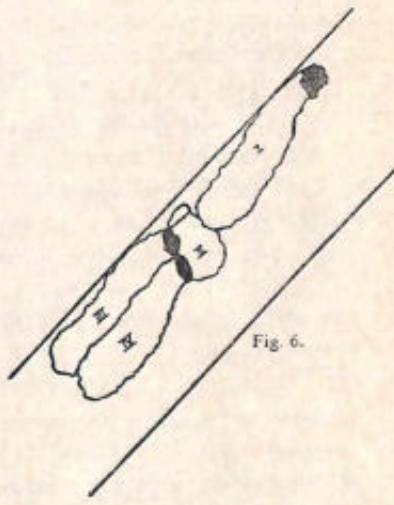


Fig. 6.

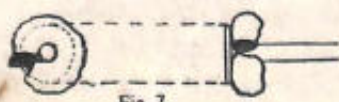


Fig. 7.

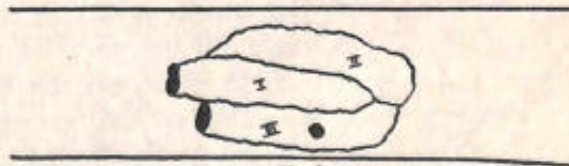


Fig. 8.

Nests of *Stenodynerus miniatus* (Sauss.)
 Note : All figures drawn to same scale

Considering the 35 nests studied :

1 nest (14)	contained	4 tubes
1 ,, (Q)	,,	3½ ,,
17 nests (1, 3-5, 7-10, 15-17, C, F, O, P, R, S)	,,	3 ,,
3 ,, (13, 18, B)	,,	2 ,,
2 ,, (2, K)	,,	1½ ,,
8 ,, (6, 12, A, D, E, L, M, T)	,,	1 tube
3 ,, (11, N, J)	,,	½ ,,

Thus three was the commonest number of tubes and the behaviour of *St. m.* 4 suggests that a nest of three may be regarded as the typical 'completed' nest.

All nests were built on the outer surface of ground floor rooms or on verandah pillars, and all except T were sheltered by a roof or eaves. Their height above the nearest soil ranged from 1.0 to 3.64 metres. Nest 2 was built on a vertical pane of glass and nests 1, 3, 4, 5 and 6, i.e. all the others observed in the plains, were built on vertical white-washed brick walls, as was nest 18. Nest R was built on the lower surface of a masonry lintel on a surface at an angle of 45°. Nest P was built on a vertical wooden component of a wall, and T was built on the wooden vertical surface above a window lintel. The remaining nests at Barabil were all on the ceiling of a large verandah of a complicated shape. This was edged by stout beams. Nest 13 was on the outer or garden side of one of these. The remaining twenty-four nests were on and under the verandah ceiling. Nests C, F, and S were on the lower horizontal surface of these edging beams and, while remains of derelict nests were found on their inner vertical surfaces, no nest included in the sample was so situated. Similar beams attached the verandah roof to the house and nest L was on a vertical surface and nests 8 and 17 on their horizontal surfaces.

The ceiling itself is higher nearer the house than at its garden edge, the surface sloping upwards at an angle of about 15°. This ceiling is made of many rectangular and triangular sheets of asbestos painted white and held together with thin strips of wood, which like all the other wooden structures is painted blackish brown to resemble European oak. The ½ tube of nest 11 was built entirely on this asbestos and, even if construction had not been interrupted, could not have extended on to any wood. The remaining twenty-one nests were built mainly or entirely on these strips of wood. Five nests (10, 12, A, B, D) were built on the lower surfaces 3-4 cm. in width and either completely horizontal or sloping at a small angle. The long axis of the cells might

be parallel or at right angles to the long axis of the strip. The greater number (7, 9, 14, 15, 16, E, J, K, M, N, O, Q) were on the more or less vertical surface of these strips and as these were usually less than 2 cm. in width the long axes of the nests were parallel to the strips. In nests 9 and 15 (Figs. 2 and 3) most of the wall of one tube touched the asbestos, and the single tube of E was built more or less vertically on the wood and then bent over so as to be continued at right angles away from the strip on the nearly horizontal asbestos. An angle between two surfaces seemed rarely to be sought as a foundation for the first tube, as it usually is by the sphecoid tube builder *Sceliphron madraspatanum* (Fabr.).

The openings of the tubes were never directed towards the nearest point in the garden. Usually they pointed towards the house walls but sometimes towards a large area of roofed verandah.

THE EVIDENCE FOR PROGRESSIVE NON-SIMULTANEOUS PROVISIONING

The dissections of nests 5-18 were made much later than the diary of nest 4, but they were made to answer questions raised by that diary. Therefore it is convenient to consider some of the results obtained from these dissections before considering the behaviour of *St. m.* 4, as this will permit certainty in the interpretation of some of her actions.

Table 1 shows the contents of all nests seen worked on by or containing individuals of *Stenodynerus miniatus* or other wasps, including those concerning which diaries had previously been kept. If known, the sex of the cell contents has been given, and also the dates of pupation (*p*) and eclosion (*i*) if these occurred. The presence or absence of a cumenine cocoon was not systematically recorded. Only during the collection was it realized that these are not removed by the mother before a cell is re-used, as they are by the social vespoids.

In all tubes that contained two early stages of the wasp these were separated by a mud partition, i.e. the tube was divided into two cells the lower of which is called 1 and the upper 2, and in any given tube the contents of cell 1 were at a more advanced stage of development than those in cell 2 (e.g. pupa 4·I·1 having black eyes while those of 4·I·2 were brown, and 5·III·1 eclosing 1 day before 5·III·2).

Cells 7·II·1, 10·I·1, and 14·I·1 were not sealed but contained larvae that were fully grown or nearly so. The prey in 10·I·1 was seen inserted by the mother who immediately came out, re-entered the cell abdomen first, and was collected. This observation together with the contents of the cells makes it certain that members of this species practise progressive provisioning, i.e. continue to bring food for their larvae throughout the larval life, only sealing them in at, or towards, the end of this.



TABLE I
 CONTENTS OF NESTS BEING WORKED ON BY OR CONTAINING *Stenodynerus minutus* OR OTHER WASPS

nest and date of dissection		Tubes in decreasing order of development of contents			
Cell					
14 2/v/66	2	IIss pupa <i>a</i>	IV♀	III	I
	1	pupa <i>b</i>	prey remains + large larva		
3 2/x/65	2	II	Is	IIIss	lepidopteran remnants
	1	<i>T.p.</i> 16 diapausing larva	♂		
4 29/x/65	2	Is	II	III	
	1	pupa <i>b</i> i 9/xii pupa <i>b</i>	♂ ♀	minute larva	
5 14/iv/66	2	IIIss	Is	III♀	
	1	pupa <i>d</i> i 18/iv pupa <i>d</i> i 17/iv	♂ ♀	large larva <i>p</i> 17/iv i 24/iv pupa <i>a</i> i 23/iv	
7 2/v/66	2	Is	III♀	III	
	1	pupa <i>d</i> i 4/v <i>c. t.</i> pupa <i>d</i> i 4/v	♂ ♀	1 prey + large larva	
8 2/v/66	2	IIss	I	III	
	1	pupa <i>d</i> i 4/v debris	♂		
9 2/v/66	2	IIss	Is	III♀	
	1	pupa <i>d</i> i 3/v imago	♂ ♀	prepupa <i>p</i> 4/v	

TABLE I
 CONTENTS OF NESTS BEING WORKED ON BY OR CONTAINING *Stenodynerus minutus* OR OTHER WASPS

nest and date	IIss		I♀	IIIss	
2/v/66	2	1	♂ ♀ imago imago	1 prey + large larva	IIIss
15 2/v/66	2	1	♂ ♀ pupa b i 5/v pupa c	3 prey + small larva full grown larva p 4/v i 13/v ♀	III
16 2/v/66	2	1	♂ S. sp. dead imago	I♀	III
17 2/v/66	2	1	♂ ♀ pupa a i 9/v pupa b i 7/v	large glassy larva	II
18 2/v/66	2	1	♂ pupa a i 9/v	6 prey + half grown larva	II♀
13 2/v/66	2	1	♂ dead imago imaginal fragments	IIss	
2 8/xii/64	2	1	♂ ♀ pupa c i 12/xii pupa d i 9/xii	II	not built

KEY TO TABLE I

Roman numerals tubes
 s sealed
 ss sealed (double lid)
 a butter-coloured pupa
 b ditto with coloured eyes
 c pupa with black on body
 d fully coloured pupa
 p pupated
 i enclosed
 partition - tube 18 I was not divided

However the contents of cell 18·II·2 showed that the prey is not brought 1 or 2 at a time. The six prey in this cell were collected at 11.42 and were foolishly kept with the wasp larva; four were consumed before alcohol could be added at 17.34. Therefore these may reasonably be regarded as half a day's provisions.

Cell 17·I·1 is particularly important. It was sealed and contained a larva which was full grown, though it had not yet defaecated and become butter-coloured and opaque, as aculeate larvae do before pupation. As cell 17·I·2 did not yet contain an egg this demonstrates that the provisioning of one cell is completed before that of another begins, i.e. simultaneous provisioning does not occur.

The 15 prey recorded in Table 1 were, with one exception, lepidopteran larvae, those in 18·II·1 having only one pair of pro-legs in addition to the anal claspers. The exception is grossly unexpected for a vespoid (Iwata, 1942) and may not have been inserted by the mother wasp. The cell 9·III·1 contained 1 lepidopteran larva but the newly hatched wasp larva was attached near the waist of the empty cuticle of a spider. Alcohol was added at 17.34, and the spider remains were sufficient to confirm under a stereoscopic microscope that the facts were as stated. As the mother had been captured from tube 9·III only 17 minutes before dissection of the nest, it is difficult to dismiss the spider as an intruder. Though Bingham (1897) quoted Horne and Smith as interpreting spiders to be the prey of *Pterochilus pulchellus* Smith [= *Stenodynerus minutus* (Saussure)], it would seem more likely that their cells were being squatted, like our nest 3, by some spider provisioning squatter. The larva in 9·III·1 could not belong to *Trypoxylon pileatum* Smith because we have seen this species lay its egg only after all prey have been inserted into the cavity. Nest 16 reveals that *St. minutus* may return to a construct after it has been used by a squatter species. If so cell 9·III·1 may have been in the process of being provisioned by two species at the time we dissected the nest! We have never seen a sphecoid and a vespoid performing this, but we have a record of a *Rhynchium brunneum* (Fabr.) and a *Pareumenes brevirostratus* (Sauss.) working alternately on the same tunnel in our nest boxes. Though each removed many prey brought by the other, an egg with adequate provisions was finally sealed, both females contributing mud to the lid.

The slightly crescentic egg in cell 11·I was about 3 mm. long, and lying at the bottom of the vault, at right angles to its long axis, touching and fitting the curvature of the wall. This confirms Roubaud's (1916) discovery that the typical eumenine egg suspension may be lost in species that practise progressive provisioning.

THE BEHAVIOUR OF THE MOTHER *St. m.* 4

At 09.09 on 13/viii/65, tube I of nest 3 was found newly opened and a pair of wasps, the male mounted on the female, was standing on the nest and, at least qualitatively, performing the rhythmic alternation of courtship + display previously described (Jayakar *in press*). This was not timed but the female was captured, etherised, painted red on the thorax, and released. As she was the only female present on the construct at the time it was hoped that her further behaviour would reveal whether she was the mother wasp, i.e. *St. m.* 3 herself, or a daughter. As there is no evidence that any wasp ever returned to nest *St. m.* 3 the results are equivocal, for it would be a coincidence if the mother should have chosen that moment to desert since, being absent at the time, she could not have been disturbed by the capture of an offspring. *St. m.* 2, the only mother similarly painted, did not complete the tube she was building before capture, and is not known to have returned to her construct.

On 15/viii/65 the red-marked individual was observed having just begun tube I of nest *St. m.* 4 on another outside wall of the same house. While building, like other wasps of this species, she was at right angles to the edge to which she was adding mud. Each load was rolled out by side to side movements of increasing range first of the head only and then of the whole body. Thus her building movements resembled those made by members of the related genus *Eumenes* who however build round pots, and did not resemble those of the sphecoid genus *Sceliphron* who also build tubular vaults; however, like a *Sceliphron* and unlike a *Eumenes*, a *Stenodynerus* of this species can and does enter her cells both head first and abdomen first.

In the tube 4·I the egg 4·I·1 was laid when the vault was just over half-made. This had been noted also in the tube 3·I. In both, the vault was immediately extended and the chimney completed within twenty-four hours, and as long as the contents of the tube were visible no prey was brought during this post-ovipositional construction, i.e. this species has, at this phase of its life cycle, the relatively rare sequence 11 of Iwata (1942), 'Preparation—Oviposition—Preparation—Hunting—Closing'. The dissections have revealed that sequence 12, i.e. an egg being laid in the second cell before the provisioning, or hunting, for both begins (i.e. simultaneous provisioning) does not occur in this species.

The dates of building activity for *St. m.* 4 are given in Table 2. She was last seen on the morning of 27/xi after spending the night (*pernoctating*) in tube II and the red mark on her thorax was last checked on 20/xi while she was sealing tube I for the third time. Therefore this individual, if, as we must assume, the daughter of *St. m.* 3, lived as an imago for 106 days, during which period 14 of her offspring completed

their metamorphoses. The dates (Table 2) between the commencement of a tube, or between the return to an empty tube, and its subsequent sealing, delimit periods of between 8-20 days. Periods of such lengths are to be expected if provisioning is progressive (Roubaud 1916).

TABLE 2

DATES OF BUILDING ACTIVITY AND EMERGENCE FOR NEST *Stenodynerus miniatus* 4

Date	Tube	Cell	sealed	emerged	Sex	Ref. no. of wasp
POTTER PHASE						
begun						
15/viii	I	1		10/ix	?	
17/viii		2	27/viii	11/ix	♂	4·I·2·(1)
27/viii	II	1		20/ix	♀	4·II·1·(1)
28/viii		2	6/ix	20/ix	♂	4·II·2·(1)
6/ix	III	1		29/ix	♀	4·III·1·(1)
7/ix		2	14/ix	29/ix	♂	4·III·2·(1)
SQUATTER PHASE						
1st						
re-pernoctation						
	I	1		7/x	♀ ♂	4·I·1 & 2·(2)
14/ix		2	25/ix	7/x		
	II	1		16/x	♀	4·II·1·(2)
25/ix		2	3/x	16/x	♂	4·II·2·(2)
	III	1		6/xi	♀	4·III·1·(2)
3/x		2	23/x	6/xi	♂	4·III·2·(2)
	II	1		18/xi	♀	4·II·1·(3)
23/x		2	1/xi	18/xi	♂	4·II·2·(3)
	I	1	pupa	29/xi	♀	4·I·1·(3)
1/xi		2	20/xi pupa	29/xi	♂	4·I·2·(3)
20/xi	II	1	small larva	29/xi		4·II·1·(4)
		2				

The mother wasp *St. m.* 4 was almost continuously present in the nest inside the second or outer cell of the tube in which she was working

at the time, facing outwards. Whether or not she was pernoctating was systematically checked on and after 31/viii. She was absent on only one night (21/xi) from the nest. During the hours of daylight, she seemed to leave the nest at least daily, sometimes apparently only once, sometimes once in the morning and once in the afternoon. As she was not watched continuously, we can only guess at the duration of the periods she was away but these seemed at first to be of the duration of about 1 hour but later in the season this lengthened to over four. There is some suggestion in the notes, strengthened by the examination of nest contents (Table 1), that these periods of apparent absence were a series of absences of short duration during which she brought several prey only remaining long enough on the nest to insert each into the current cell. Such behaviour is what would be expected were she provisioning progressively. At night she was completely withdrawn within the cell but during the day her antennae were protruding.

Her loads being small, these were not seen as frequently as could be wished. Mud was seen being brought on 15/xi, five days before the final closure of I for the third time on 20/xi. This load can be interpreted as for the partition in the tube closing the lower cell, i.e. I·1(3). If so the mother took 14 days to provision 4·I·1(3) and only 5 days to provision 4·I·2(3). Considering the completed tubes in the dissected nests, omitting 4 known to have been deserted, only 1 outer tube contained a larva but was not yet sealed, whereas 6 inner tubes were in a comparable condition (Table 1). The difference is not yet significant (probability $\frac{1}{16}$), but again suggests that more time is occupied provisioning the inner cell than the outer cell of a pair. The periods of intense work deep within a cell alternating with many short absences, which were recorded on several occasions during the twenty-four hours before final closure, must be concerned with this rapid provisioning. After these periods of work the mother could not enter so deeply into the tube. The dissections have demonstrated that this internal working cannot be interpreted as the closure of the inner cell which had previously been open and provisioned simultaneously with the outer.

Mud was brought to seal the tube, but material from the chimney was always incorporated, so that this was also drastically shortened. The architecture was variable; usually the tube was closed with a more or less flat lid at right angles to the longitudinal axis of the chimney. Sometimes this lid was within the remnants of the chimney which formed a little crenellation round it, and sometimes the mud was worked so that the tube was sealed with a convex knob. There was no daubing such as is seen in the more typical potter wasps, and immediately after sealing a tube the wasp either built another or worked deep inside one previously used. This resembled the cleaning activity performed both by the soli-

tary squatter wasps and by the comb-building social wasps but, confirming the dissections, no mention of removal of cocoon tissue can be found in the notes. If the cell wall contained an emergence hole (see below), it was repaired at this time, and perhaps part of the chimney was rebuilt, but this latter building was usually done gradually during the subsequent provisioning period. Table 2 shows that the three cells were not always re-used in the order in which they were originally built. Only once (see below) did the wasp attend to both the empty cells then available alternately before finally confining her attention to one of them.

The nest dissections have supplied architectural details not obtainable from watching the females. Firstly the partitions between the two cells in a tube which divide the vault into two more or less equal parts are thin, less than 1 mm. in thickness, and fragile. Secondly several chimneys appeared not to have been shortened during sealing. Seven of these chimneys (10-II, 10-III, 14-II, 15-I, 17-III, 18-I, B-I) contained two lids, one at the mouth and the second 2-3 mm. within it. The remaining fourteen sealed tubes contained only single lids. We have not yet found single and double closures in the same nest. Such variation in the number of layers with which a cavity is sealed is characteristic of squatters, e.g. *Subancistrocerus sichelii* (Sauss.) and *Antodynerus flavescens* (Fabr.).

THE EMERGENCES FROM NEST 4 AND THEIR MATINGS

Table 2 shows the dates on which the offspring of *St. m.* 4 emerged from the cells. With one exception, the two offspring from a single tube emerged on the same day. The wasp I-1(1) was not seen—only the hole through which it had emerged was found in the cell wall in the lower part of the tube. There had been a longer delay after the laying of egg I-1(1) before the laying of egg I-2(1) than for the other pairs of eggs for which the dates of laying were known. Such an emergence hole through the belly of the pot (not the mouth) is typical of the pot-building vespoids, e.g. *Eumenes* spp.

All other offspring emerged by walking out through a hole which they had bitten in the lid with which their mother had sealed the original mouth of the tube. Such an egression or emergence is performed by the sphecoid potters of the genus *Sceliphron*, and by vespoid squatters when the walls of the cavities in which they have built are harder than their mud lids. All other offspring of *St. m.* 4 were seen, and except for I-1(2) and I-2(2) the process of emergence was first noticed when the lid had been opened and the head of the occupant of the upper cell (called 2) was visible inside it. From then, watching was continuous until the two offspring were captured. These observations are summarized in Table 3.

TABLE 3
OBSERVATIONS ON NEST *Stenodynerus minutus* 4 FROM THE COMMENCEMENT OF EMERGENCE

Pair	Date	Last time lid unopened	Lid open facing out	Behaviour of <i>St. m.</i> 4 (m) to face of ♂	♂ walks out of tube	Behaviour after ♂ walks out	♀ visible	♀ begins to come out	Behaviour of ♂ and ♀, m ignored in all	♀ out cop.	captured
I (1)	11/ix	07.10	08.53	in III	09.14	♂ feels m, taps chimney III, flies 09.53, m in III		09.53			09.53
II (1)	20/ix p.m.	19/ix	07.21	in I, comes out, re-enters I 12 times including once leaving nest, feels and bites ♂ repeatedly	08.58	♂ quiet	08.58	09.01	♀ bites ♂ from below repeatedly	09.02	09.27
III (1)	29/ix	07.45	09.06	walking, feels ♂, enters II	09.08	feeling m in II; stands over mouths II and III, quiet	09.08	09.12	♀ pushing	09.13	09.18
II (2)	16/x	09.25	09.40	in III, out and in 5 times, ignores ♂	12.07	quiet m in III	12.18	12.20	♂ grabs ♀, ♀ retires	12.20	12.22
III (2)	6/xi	09.20	10.10	in I, out and in 4 times including once leaving nest, ignores ♂	11.01	quiet m in I	11.01	11.06	♀ pushes ♂	11.06	11.06
II (3)	18/xi p.m.	17/xi	08.22	in I, out and in 4 times leaves twice	09.23	♂ quiet m returns (prey), out, feeling ♂, once in out, leaves	09.27	09.32	♂ grabs ♀, ♀ retires	09.37	09.37

From this table it is seen that these emergences occurred relatively early in the morning. The complete period between the opening of the cell and the emergence of the male has not yet been accurately timed, but that part of it that has been attended has usually been of the order of an hour. The male has always been visible in the open cell but has been characteristically farther within it than the usual position of the mother wasp when she is resting during the day within the chimney of the tube which she is provisioning. The mother has always been present for some period at least while the emergence was in this stage, and on five occasions she spent some time walking on, and therefore feeling, the construct. The mother's behaviour to her sons' faces has been variable. Sometimes she ignored the male so that there was no evidence that she was aware of his presence, sometimes she made feeling movements with her antennae, and on 20/ix she behaved in an aggressive manner to II·2(1).

With one exception, the mother was resting in the currently worked-in tube while the male finally walked out, and she showed no further reaction to him. On the exceptional occasion (on 18/xi) when she was away, she returned carrying prey. She ignored the male and inserted this prey, came out, felt him once and returned into the worked-on cell abdomen first, and remained facing out in her usual position. During the short period before the emergence of the second inner wasp the male only once (on 29/ix) felt his mother. He usually remained quietly over the open tube from which he had just emerged and reacted immediately to the behaviour of the second wasp within the tube, which became visible almost immediately. However, on 11/ix, when there was no second wasp to emerge, the male I·2(1) spent 39 minutes assiduously feeling his mother and tapping the chimney of the tube in which she was resting. It is difficult not to conclude that he was attempting to stimulate her to come out. He was not disturbed, and was captured only after he had flown from the nest of his own accord.

In the other tubes considered in Table 3, another wasp appeared within the tube very soon after the emergence of the first. In all examples, this second wasp was a female. She stimulated the male either with her mandibles or by pushing him from below. As soon as her thorax had emerged, the male seized it, before her abdomen was out of the tube. Twice a female slipped from the male's grip and retired into the tube, but immediately re-emerged to be seized again.

All these pairs (the male standing upon the female's thorax and facing in the same direction) entered into a rhythmic series of copulations qualitatively indistinguishable from those previously observed, probably in this species, and certainly in *Subancistrocerus sichelii*, and

described elsewhere (Jayakar *in press*). To summarise, and in part add to, this previous description, after the mounting immediately upon the emergence of the females, both fluttered occasionally for about a minute before the first copulation, which lasted less than 10 seconds. Immediately after this, the male began tapping the female's head with his antennae, fluttering his wings and swinging his abdomen in an arc of about 60° over hers so that he was repeatedly stroking the tip of hers with it, with a rhythm of about 3 strokes a second. After about 1 minute, the wing movements alone stopped, after another 4-5 the antennal movements stopped, and after another 2-5 the abdominal movements stopped. Then the female might walk on the nest carrying the male and both might flutter occasionally, and in usually less than 10 minutes, another copulation occurred, to be immediately followed by the recommencement of the rhythmic abdominal movements accompanied by the antennal and wing movements.

The mating behaviour of offspring of *St. m. 4* was not timed in any detail, but they were captured and, with one exception, preserved. The exception, III·1·(1), was painted and released. She was not seen again.

The pair I·1·(2) and I·2·(2) were discovered on 7/x mounted on the cell. Therefore we know that this tube also produced a male and a female simultaneously, but we do not know whether the male emerged from the upper cell and the female from the lower.

The pupae removed from tube I after the desertion of the nest lived long enough to be sexed. I·1·(3) (which died as a pupa) was a female and I·2·(3) a male. (These are entered in both Tables 1 and 2.)

Therefore *St. m. 4* laid 17 eggs in this nest, and 14 of her offspring emerged as imagines while she was still feeding their younger sibs. Of the offspring, 7 of the possible 8 from the upper cell, built later than the other and continuous with the chimney, are known to have been males, and 6 of the possible 9 from the lower cell built first and forming the belly of the tube are known to have been females. Of the unscored individuals one tube produced a male and a female but the order of emergence is unknown, one wasp emerged abnormally and was not observed, and one was only obtained as a larva without provisions. Thus, in this nest no exception was observed to the generalization that the eggs are laid in pairs of unlike sex, and so arranged by the mother that the male leaves the tube before the female.

OTHER DATA ON EMERGENCES, SEX DETERMINATION, DEVELOPMENT, AND BEHAVIOUR

In the Bhubaneswar sample, previous to 4·I·(1) on 10/ix/65, emergences through the wall of the tube had twice been observed in I·II·1·(1)

on 14/vi/63 and in 1·I·1(?) on 19/viii/63. In the dissected sample, holes made by ten such flank emergences were found. Seven of these were from cells that contained remains of chrysidid cocoons; of these six (16·III·1, B·I·1, B·II·1, K·I·1, O·III·1, and S·I·1) were in the inner cell of a tube, but one (K·I·2) was in the outer cell, the typical chimney opening of which remained sealed. Empty chrysidid cocoons were also found in 16·III·2, A·I·1, B·II·2, O·III·2, Q·III·1, and S·I·2. In these cells the mouth of the chimney was open and in Q·III the partition between the two cells was broken down.

However lateral emergence holes were observed in three cells in which no chrysidid vestiges were found. All these three were otherwise exceptional. Considering the hole in 13·II·1, the upper cell of the tube, 13·II·2, though sealed, contained no vestiges of a eumenid cocoon and therefore is presumed to have been sealed empty. It is interesting to speculate as to what stimuli prevented its occupant from waiting indefinitely for its absent tube-mate to make way for it. Two of its sibs, 13·I·1 and 13·I·2 were found dead in their cells.

Both the other wall emergence holes occurred in the same tube. Tube 10·III carried a large hole at about the centre of its length. Excavation revealed that this opened into both cells III·1 and III·2 and that the partition between these had been destroyed. If, as this suggests, both occupants of the tube came out of this single large hole, the wasp in 10·III·2 must have pupated facing in the wrong direction. Spurway *et al.* (1964) have recorded an example of this in the vault building sphecoid *Sceliphron madraspatanum*. As in both these species the egg is laid very early in the filling of the vault, it is difficult to suggest causes for such inversions.

Therefore though an individual of *Stenodynerus miniatus* can emerge through a hole in the wall, more commonly these holes are made by chrysidid parasites. Nest 7 reveals that the *Stenodynerus miniatus* mother need not react to parasitism by ceasing oviposition, as a mother of a *Eumenes* species usually does (Jayakar and Spurway 1965b, and in press, and unpublished observations). A *Chrysis* (*Trichrysis*) *mendicalis* Cam. was seen on nest 4, unfortunately while the female was absent, and this was captured before any oviposition was performed. However as this occurred on 15/x/65, this chrysidid was probably not the mother of the unknown wasp that left I·1 on 10/ix/65.

Considering nests other than 4, eleven outer cells (cell·2) contained males and none contained females, and ten inner cells (cell·1) contained females. The offspring of the only tube found which was not divided into two cells (18·1) was male. This latter tube was not architecturally abnormal, but it contained only one cocoon occupying its inner two-thirds, which contained the male pupa.

However, the laying of eggs in pairs, the female being older than the male, is confirmed as the rule in this species. The dissections have revealed that these females have completed most of their larval lives before the corresponding male egg of a pair is laid. The female of a pair was visibly more advanced in development at every stage until the pupae become fully coloured just before eclosion.

Four pairs have eclosed under observation. There was 3 days' difference between 2·I·1 and 2·I·2 in December, 1 day's difference in April for both the pairs from nest 5, and two days' difference for the pair from 17·III, which was surprising as May was hotter than April. Thus the synchronisation of the emergence from the mouth of the tube opened by the male is not due to synchronisation of eclosion due to different developmental rates, though there is evidence that the males develop more rapidly than the females, as is common among eumenines. In this species, the female, after eclosion, waits until the male leaves his cell and thus makes way for her. It is interesting to speculate what stimuli cause her to become active, and the circumstances in which wasps are found dead in tubes may provide evidence. Such waiting by the imagines developed from the inner, and therefore older, eggs for their younger siblings to eclose and emerge is again common among tunnel filling aculeates. In *Stenodynerus miniatus* it is exploited to almost ensure brother-sister mating.

Two other examples of pairing on the nest other than those described on nests 3 and 4 have been seen. Both were on nest 1 and both support the generalization that these synchronised emergences and pairings occur in the morning. One was observed on 23/viii/63 and timed from 09.24, when the pair was discovered mounted, until 11.15 when the male dismounted and flew away. The female also flew during the next minute. This has been referred to previously, and is described elsewhere (Jayakar *in press*). The second was on the same nest at 08.58 on 16/ix/63.

The ♂ of a species of *Subancistrocerus*, which may be an atypical member of *S. sichelii*, found dead in cell 16·II·1, provides evidence that *Stenodynerus miniatus* may re-use a nest after a period of desertion. This male was found in a lower cell and the upper was closed by curving round so that the mouth of this vault was occluded by the wall of the centre tube called I (because as in nest 1, it was apparently built first) (Plate, fig. 8). This abnormal closure may be the work of the *Subancistrocerus* mother and the space which table 1 schematizes as cell 16·II·2 may represent the space which, as we have mentioned, *S. sichelii* often leaves between the closure of the last cell and the plug in the mouth of the tube. This *Subancistrocerus* mother may have removed any *St. miniatus* or chrysidid silk which may once have been present. Both 16·III·2 and 16·III·1 contained chrysidid cocoons.

Cell 16·I·1 contained a eumenid cocoon but cell 16·I·2 did not. There was no partition between them. No egg was present in 16·I·1. Therefore the female *St. miniatus* captured facing out of cell 16·I·2 seems only to have entered the nest recently after a period in which it was squatted by a *Subancistrocerus* sp. It is not impossible that this female originally built these tubes and returned to them after they had been squatted by the other species, and after at least one generation of inhabitants had been parasitized. However, it is perhaps more likely that the female *St. miniatus* numbered 16 did not build the tubes with which she was found associated. If individuals of *St. miniatus* can utilize cells which they did not build themselves, this species resembles the African *Rhynchium anceps* Gribodo, which uses tunnels excavated by the same species, including the same individual, not removing the previous occupant's cocoon. In this digger vespoïd the ovipositional rhythm observed suggests that such re-use is the rule (Roubaud 1916). Finally it is possible that *St. miniatus* may be found behaving as a typical squatter nesting in deserted cells of other species or even hollow stems and man-made cavities, i.e., having an ecology similar to that of the mass provisioning species *S. sichelii* but differing in that it practises progressive provisioning.

DESERTION AND DISSECTION OF NEST 4

On 20/xi, after 11.50, when she sealed I, *St. m.* 4 was seen working in III repeatedly during the afternoon. However, she pernoctated in II and did so also during the nights beginning on 21, 24, 25 and 26/xi. She was apparently absent from the construct on the night beginning on 22/xi, and spent the night beginning on 23/xi in III. She was not otherwise seen in III. She had not been seen previously to work on two tubes simultaneously, nor had she been previously recorded as spending a night away from the construct. Both these behaviour patterns suggest that she did not lay in II until 24/xi, and this is confirmed by the stage of development of the larva observed on 29/xi. These changes in behaviour pattern can also be described by saying that she was becoming disorganized, and we were not surprised when we did not see her again after 07.34 on the morning of 27/xi. On 29/xi at 12.05, the construct was dissected (Table 1).

DISCUSSION

The only references to similar species we have been able to find are to the larger *Ancistrocerus fukaianus* Schulthess referred to several times under the genus *Odynerus* by Iwata (1942) and a smaller Thai species reported as "*Odynerus* sp. No. 1 (van der Vecht)" in Iwata (1964,

p. 339) and in Yoshikawa's companion paper (1964, p. 398, Plate 12). This latter species, which Dr. van der Vecht informs us is closely related but not identical to *St. miniatus*, also builds on the wood work of outdoor roofs. The slightly larger vaults of these tubes seem more gourd-shaped and less cylindrical than in the Orissa species. In all the nests found, they were vertical. The contents of the tubes of the Thai species compared with the condition of the ovaries of the only working female dissected revealed that it performed progressive provisioning. Iwata uses the adjective 'subsocial'. He only watched provisioning of these tubes on one day, so he inferred from the maximum number of tubes in an aggregate that the species must produce on an average only 6 offspring, an apparent infecundity on which he commented. If the Thai species, like the Orissa species, re-uses her own tubes, she could also raise considerably more offspring than 6. Iwata (1964, p. 340) also reared specimens of the squatter species *Subancistrocerus sichelii* from tubes made by this species. The *Subancistrocerus* that uses tubes of *Stenodynerus miniatus*, though not certainly *S. sichelii*, is very similar and we consider that the parallelism in courtship, the brother-sister mating, the ecological interaction and superficial morphological resemblances between these at most three species which still makes us confuse them macroscopically (Jayakar *in press*), may be examples of convergence, and at least require explanation. The sphecoid *Trypoxylon pileatum* that competes with *S. sichelii* for the same size range of tunnels in our nest boxes was also found squatting in the deserted nest of *St. m.* 3 (Table 1).

Stenodynerus miniatus shows two unexpected features. The first, the re-use of cells built by herself, is harmonious with contemporary phylogenetic hypotheses. It is a mirroring of a behaviour that it is reasonable to hypothesise could have occurred in some ancestors of the social vespoids and, as would be expected, is associated with the intermediate condition of progressive provisioning.

In parenthesis, we would like to emphasise with Roubaud (1916) that the evolution of the capacity for *progressive* provisioning should be considered a separate step which necessarily preceded the evolution of the capacity for *simultaneous* progressive provisioning, and which, in the species discussed in this paper and many others, can occur alone. We are convinced by Roubaud's inductions that progressive provisioning, at first facultative, could evolve as an adaptation to inclement conditions which caused provisioning to be delayed. On its first appearance, any further eggs laid before the open cell was closed would presumably not receive the environmental requirements to develop, as observed and emphasised by Roubaud, and which we have described (*in press*) in *Eumenes campaniformis esuriens* (Fabr.) delayed by rain. Any

wastage of gametes seems itself to create a selection pressure to minimise such wastage, i.e. either the ovarian cycle would be brought under the control of external factors so that egg maturation would be delayed until a cell was prepared for it, or some behavioural capacity would be evolved to care for each egg as it was produced, the re-use of cells being one such adaptation. Such selection pressures would become more powerful once a population with compulsory progressive provisioning returned to a favourable environment. There must also be very general selection pressures favouring the supervision of any process at every stage, so that in the event of a catastrophe, correction may be made, or no further work need be wasted on it (Roubaud 1916). If progressive provisioning, and consequent wastage of gametes, initiated the evolution of simultaneous provisioning, this removes the difficulty expressed by Richards & Richards (1951) in explaining the evolution of simultaneous provisioning which they see merely as a *redeployment* of effort, and not providing any *economy* of effort. They suggest that some unexplained alternation of the ovarian cycle may have made it necessary.

The important consequence of the evolution of progressive provisioning for the evolution of societies is that the mother was still present on the construct when her offspring emerged, as we have described for *Stenodynerus miniatus*.

The second peculiar feature of *Stenodynerus miniatus* is, on the contrary, unharmonious with contemporary evolutionary theory. This species seems to have evolved the combination of three behaviour patterns to virtually ensure brother-sister mating, and, failing this, perhaps son-mother mating. The first is shown by the mother, who lays a female and then a male egg so that the male will walk out first. (This behaviour pattern is the rule among tunnel nesting eumenines.) The second is that this male offspring does not fly as soon as he has emerged as, for example, is the practice of members of the species of *Eumenes* (Jayakar & Spurway *in press*), but remains on the nest as do the social vespoids. However, unlike these, he stays for a fraction of an hour if necessary but, while present, actively stimulates any other wasp (his mother or his sister) who may be in any open cell and copulates immediately this becomes mechanically possible. Courtship performed by a male social wasp on the comb from which he developed is both rare and unsuccessful (Yoshikawa 1963). The third pattern is shown by the female offspring who, like many other eumenines, waits within her cell for 1 to 3 days after eclosion for her brother to make way for her, instead of emerging through the cell wall, which we know to be physically and behaviourally possible for this species. It will be important, but arduous, to discover the sex of the exceptional individuals who make these flank emergences.

We wish to emphasise that this compulsory brother-sister mating or adelphogamy seems effected entirely by these specializations, which are all exploitations or modifications of widely distributed capacities and which seem to have no other biological role for this species.

In several species of parasitic hymenoptera, not closely related, e.g. *Telenomus fariae* (Lima), Scelionidae (Dreyfus & Breuer 1944), and *Melittobia* spp., Eulophidae (Schmiedler & Whiting 1947, Whiting 1947), son-mother and/or brother-sister matings are the rule. These take place in the confined space in which the imagines eclose, and in which another generation may be produced. Therefore the close inbreeding in these forms seems a secondary consequence of the parasitic habit. *Stenodynerus miniatus* and the morphologically similar, perhaps ecologically associated, *Subancistrocerus sichelii* are both common around human habitations, at least in some areas, so there is no reason to suggest that the behaviour patterns here described are adaptations to a difficulty in encountering a conspecific partner once the maternal nest has been deserted. Their evolution remains at present inexplicable.

In addition to the general disadvantages of close inbreeding which hold widely in the organic world, there are special reasons which make it unexpected in the hymenoptera. Whiting (1943) demonstrated in the braconid *Habrobracon juglandis* (Ashmead) that a diploid was female only if it was heterozygous at a precise locus, at which at least nine different alleles existed. If, by inbreeding, a diploid was produced homozygous for any one of these alleles, this diploid was a male, though non-functional and subviable. The haploid is apparently male because it cannot be heterozygous. The discovery of various mosaics confirmed the hypothesis. If this system were universal in the hymenoptera, some vestiges of the homozygous diploid zygotes would be found in broods of the species with intense inbreeding, probably as sterile eggs. These have been sought and are absent in the species of *Melittobia* studied. However Machensen's (1951) demonstration, that in *Apis mellifera* L. such sterile eggs in expected proportion are produced by inbreeding, once more makes it likely (Whiting 1947) that sex-determination based on complementary allelic systems, though not universal in the hymenoptera, may be generally distributed. It may perhaps be primitive, or a later specialization now characteristic of at least a large section of the group. If this is so, the discovery of any specialization which so far has no discernible biological role but to produce inbreeding in common free-living species with equality of the sexes (Jayakar & Spurway, 1966 and unpublished, for data on *S. sichelii*) becomes even more disquieting.

SUMMARY

Data obtained from thirty-five nests of *Stenodynerus miniatus* are described and discussed.

A female (*St. m.* 4) was disturbed while mounted by a male on a nest of that species, captured, marked, and released on 13/viii/65. She was observed for 106 days and during this period built a nest containing three tubes of mud, each of which was divided into two cells. By the time she had sealed the third tube, the offspring of her first tube had emerged. She then re-used the first tube, and for the rest of the period during which she was observed, she re-used these six cells, laying 17 eggs, 14 of which emerged as imagines while she was attending to the nest. At each use of a tube, whenever we were able to observe the emergences, she laid a female egg in the lower cell and a male egg in the upper, i.e. the cell nearer the mouth of the tube, and the two offspring of these cells typically emerged from the tube together. The male walked out of the tube first and, as the female walked out, he immediately mounted her and copulation occurred, before they had left the construct.

The species is typically eumenine in its building movements and practises progressive provisioning with lepidopteran larvae and perhaps spiders. The laying of the eggs in pairs is the rule, but one exception has been found. *St. miniatus* may re-use a nest after this has been squatted in by another species.

Solitary species which possessed a similar habit of re-using cells while performing progressive provisioning may have formed a stage in the evolution of the social groups. The occurrence of virtually compulsory brother-sister mating is puzzling.

ACKNOWLEDGEMENTS

We thank Dr. K. Iwata of the Entomological Laboratory, Hyogo University of Agriculture, Japan for reading the first draft of this paper, and for suggesting dissections to determine the method of provisioning. These disproved our previously expressed hypothesis. We thank Dr. J. van der Vecht of the Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands for identifying our vespoids and sphecoids and Dr. S. Zimmermann of the Naturhistorisches Museum, Vienna, Austria for identifying our chrysidids. Our colleagues Mr. R. Mangipudi and Mr. H. Pulugurtha were extremely helpful at Balakati and Barabil.

We also wish to thank Mr. S. K. Ghose, Mr. N. S. Clair, and Mr. S. Lal, who arranged for our accommodation in Barabil, and Mr. M. Mahapatra for making possible the Balakati dissections.

REFERENCES

- BINGHAM, C. T. (1897): Hymenoptera vol. 1, Fauna of British India, Taylor and Francis, London.
- DELEURANCE, É.-P. (1955): Contribution à l'étude biologique des *Polistes* (Hyménoptères Vésipides) II—Le cycle évolutif du couvain. *Insectes Sociaux* 2: 285-302.
- (1957): Contribution à l'étude biologique des *Polistes* (Hyménoptères—Vésipides). I. L'activité de construction. *Behaviour* 11: 67-84.
- DREYFUS, A. & BREUER, M. E. (1944): Chromosomes and determination in the parasitic hymenopteron *Telenomus fariae* (Lima). *Genetics* 29: 75-82.
- IWATA, K. (1942): Comparative studies on the habits of solitary wasps. *Tenthredo* 4: 1-146, 5 plates.
- (1964): Bionomics of non-social wasps in Thailand. *Nature and Life in Southeast Asia* 3: 323-383.
- JAYAKAR, S.D. (*in press*): Sexual behaviour in solitary eumenid wasps. *J. Bombay nat. Hist. Soc.*
- & SPURWAY, H. (1965a): Winter diapause in the squatter wasps *Antodynerus flavescens* (Fabr.) and *Chalybion bengalense* (Dahlb.) (Vespoidea and Sphecoidea). *op. cit.* 61: 662-667.
- & ——— (1965b): Normal and abnormal nests of *Eumenes emarginatus conoideus* (Gmelin) including notes on crépissage in this and other members of the genus. *op. cit.* 62: 193-200.
- & ——— (1966): The sex ratios of some mason wasps. *Nature* 212: 306-307.
- & ——— (*in press*): The nesting activities of the Vespid potter wasp *Eumenes campaniformis esuriens* (Fabr.) compared with the ecologically similar Sphecoid *Sceliphron madraspatanum* (Fabr.) (Hymenoptera). *op. cit.*
- MACHENSEN, O. (1951): Viability and sex determination in the honey bee (*Apis mellifica* L.) *Genetics* 51: 500-509.
- OLBERG, G. (1959): Das Verhalten der Solitären Wespen Mitteleuropas. Deutscher Verlag der Wissenschaften, Berlin.
- RICHARDS, O. W. & RICHARDS M. J. (1951): Observations on the social wasps of South America (Hymenoptera Vespidae). *Trans. Roy. Ent. Soc.* 102: 1-169.
- ROUBAUD, É. (1916): Recherches Biologiques sur les Guêpes Solitaires d'Afrique. La Genèse de la vie Sociale et l'Évolution de l'Instinct Maternel chez les Vésipides. *Annales des Sciences Naturelles (Zoologie) Sér. X*, 1: 1-160.
- SCHMIEDER, R. G. & WHITING, P. W. (1947): Reproductive economy in the chalcidoid wasp *Melittobia*. *Genetics* 32: 29-37.
- SPURWAY, H., DRONAMRAJU, K. R. & JAYAKAR, S. D. (1964): One nest of *Sceliphron madraspatanum* (Fabr.) (Sphecidae; Hymenoptera). *J. Bombay nat. Hist. Soc.* 61: 1-26.
- WHEELER, W. M. (1923): Social Life Among the Insects. Constable, London.
- WHITING, P. W. (1943): Multiple alleles in complementary sex determination of *Habrobracon*. *Genetics* 28: 365-382.
- (1947): Some experiments with *Melittobia* and other wasps. *J. Hered.* 38: 11-20.
- YOSHIKAWA, K. (1962): Introductory Studies on the Life Economy of Polistine Wasps. I. Scope of problems and consideration on the solitary stage. *Bull. Osaka. Mus. Nat. Hist.* 15: 3-27.
- (1963): Introductory Studies on the Life Economy of Polistine Wasps. III. Social state. *J. Biol., Osaka City University* 14: 63-66.
- (1964): Predatory hunting wasps as natural enemies of insect pests in Thailand. *Nature and Life in Southeast Asia*. 3: 393-398 23 + plates.

Life History of the Indian Cuckoo, *Cuculus micropterus micropterus* Gould, in the Soviet Union¹

BY

I. NEUFELDT

Zoological Institute of the Academy of Sciences of the
U.S.S.R., Leningrad

(With four plates)

The Indian Cuckoo was described in 1837 by J. Gould from a specimen from the Himalaya. Twenty years later it was for the first time collected in Russia near Blagoveshchensk on the Amur by G. Radde. It was wrongly identified and recorded as *C. optatus* (Radde 1863), and was kept under this name in the collection of the Zoological Museum of the Academy of Sciences in Leningrad for many years. In 1928 Stegmann collected an adult male of the Indian Cuckoo in Amurland as the first record of the species. Later, working with the Museum collection, he 'discovered' Radde's specimen, and included this species in the bird-list of the U.S.S.R. (Stegmann 1930). It is to Stegmann and Radde that we are indebted for our first information on the habits, voice, and habitats of the Indian Cuckoo. Though rather scanty, these data were till now nearly the only source of information for authors of Russian ornithological handbooks and species keys. Very little was known of the breeding biology of the bird, and up to 1957 the eggs and nestlings of the Indian Cuckoo from the USSR were not described, its fosterers remained unknown, and even museum skins were rare in collections.

In the summer of 1957, 1958, 1959, 1961, and 1962 the authoress collected in Amurland new and interesting data which form the basis for the present paper on the life history of this bird.

DISTRIBUTION

Ignoring the incorrect views of Caldwell & Caldwell (1931), Buturlin & Dementiev (1936), and Belopolsky (1950) on the distribution of the Indian Cuckoo, its breeding range in the Soviet Union may be confined

¹ Following the majority of modern authors I accept the existence of only two geographical forms of the Indian Cuckoo: *C. m. micropterus* and *C. m. concretus*. Comparison of 30 adult birds from the USSR and China with Indian ones has shown that *C. m. ognevi* (Vorobiev 1951) is a synonym of the nominate form.

to Amurland from the valley of Burinda River in the west (Radde 1863) to at least the city of Komsomolsk in the east (Kistjakovsky 1959; Kistjakovsky *et al.* 1962). Within the limits of Amurland, where this cuckoo is recorded as a common and even numerous bird, its distribution at the breeding period coincides nearly exactly with areas having two zonal botanical-geographical complexes: broadleaved-coniferous taiga and broadleaved forest (Sochava 1957). The most northerly points of distribution of this bird in Amurland [the basins of Burinda, Olga, Ushumun, and Tu Rivers, the mouth of Selemdzha River, and Bureja River (Radde 1863); Stegmann 1930; Vorobiev 1951; Kistjakovsky & Smogorzhevsky 1964] nearly reach the northern limit of the most typical oak-larch, and oak-pine forests. In Ussuriland, the Indian Cuckoo is distributed sporadically and in small numbers, predominating in the west of the region. Some records come from the regions of the middle reach of Ussuri River and the lower reach of Bikin River (Vorobiev 1951; Leonovich, *in litt.*) and is also recorded from the lower reaches of Iman River eastward to Kartun village (Spangenberg 1965).

The main breeding area of this species is outside the limits of the U.S.S.R and embraces NE. China (Manchuria), the forest regions of the provinces Hopeh, Shansi, etc. extending southward up to Kwantung and Kwangsi (Vaughan & Jones 1913; Stresemann 1923, 1930; La Touche 1931; Meise 1934; Shaw 1936; Hoffmann 1950). The Indian Cuckoo is also known from Korea but its status there is not clear. Austin (1948) considers it to be an uncommon spring transient, but a few known records of this species (Kuroda 1918; Yamashina 1932) are consistent with its breeding irregularly in Korea. The Indian Cuckoo inhabits India (except the north-western arid regions), eastward to Assam, West and East Pakistan, and Nepal. It is widely distributed in Burma, Ceylon, and apparently in northern Thailand, and is found further south up to the Malay peninsula (Robinson & Chasen 1939; Deignan 1945; Phillips 1948, 1952; Smythies 1953; Ripley 1961).

Nearly everywhere within its breeding range the Indian Cuckoo is a typical migratory species, though in Ceylon and in some parts of India a part of the population is resident. In winter, apart from Ceylon, it is common in small islands in the Strait of Malacca, in the Philippines, Banka, and the Thousand Islands; it winters also in Sumatra, Java, and Borneo where *C. m. micropterus* occurs together with the smaller resident form, *C. m. concretus* (Peters 1940).

ARRIVAL IN BREEDING AREA

The Indian Cuckoo leaves its winter quarters very early. In Burma one may hear its characteristic call from the end of January or middle of February (Bingham 1880; Smythies 1953). In Thailand Deignan

(1945) recorded their song on 12 March. In Ceylon the Indian Cuckoo becomes active in March to early April; later, when all winter migrants have left the island for their breeding ranges further north, the summer resident Indian Cuckoos become inconspicuous. According to Hewetson (1956), in India in southern Madhya Pradesh the birds were recorded in March and in northern Madhya Pradesh in May. At the end of March their arrival was noticed in the north-East of the country, in Bhutan (O'Donel 1936); from the beginning of April, in northern Bengal (Storrs 1944; Lister 1954) and southern Bihar (Lowther 1949). In Punjab the earliest arrivals were recorded on 23 April (Whistler 1926). In Nepal the birds are common in April-May (Rand & Fleming 1957; Ripley 1950; Biswas 1960). In China in the second half of April these birds were noticed during their migration in Yunnan (specimens preserved in the collection of the Institute of Zoology, Academia Sinica). In Kwangtung these cuckoos were recorded in the first week of May (Vaughan & Jones 1913); in Fukien, in April; northwards in the provinces Hupeh, Kiangsu, Hopeh, Liaoning, and in north-eastern China, in May (Caldwell & Caldwell 1931; Shaw 1936). According to observations made by A. Hoffmann (1950) the first Indian Cuckoos in Nanking were noticed 28-29 April and in Peking nearly two weeks later, 11-12 May. In the vicinities of these cities these cuckoos were recorded somewhat earlier. Their arrival in 1944-1947 coincided with the appearance of the Blacknaped Orioles in the parks and gardens of Nanking and Peking and preceded by some days the arrival of Common Cuckoos. According to Piechocki (1958) in the suburbs of Peking at the beginning of May the voice of the Indian Cuckoo was not heard. Meise (1934) mentions a male shot in Manchuria near Dshalantun on 29 May. In Korea, in the west of Pyongan Pukto province, these birds were collected during 24-31 May (Kuroda 1918; Yamashina 1932). In Ussuriland (U.S.S.R) along the lower reaches of Iman River, Spangenberg (1965) recorded the earliest song during 27-29 May.

Males commence singing in winter and continue calling on their way to their breeding places. Among palaeartic birds no other species possesses a similar voice; that is why the arrival of the Indian Cuckoo cannot remain unnoticed and the date of the arrival of this bird can be recorded accurately to a day.

According to my records the species arrived on the Amur-Zeya plateau at the same time during five years. Thus, the first male call was recorded near Klimautzy village (NW. of Blagoveshchensk) in 1957, 1958, and 1962 on May 23 and in 1959-1961 on May 24, i.e. 4 days later than the date of arrival of the Common Cuckoo and 2-3 days later than that of the Himalayan Cuckoo. In 1957-1959 in May the weather was rather warm but cloudy, and drizzled occasionally. On the contrary in

1961-1962 the end of May was dry and sunny, and the night temperature fell to -5° C. The forest started to turn green : larch was covered with young needles, small green leaves began to come out on *Betula platyphylla* growing on the plateau along the sunny hill slopes ; oaks and rhododendrons broke into leaf ; Dahurian Birch (*Betula dahurica*) burst into blossom and its buds swelled. On the first few days of their arrival the Indian Cuckoo males sing little. A strong wind and incessant rain, or a sharp fall of temperature or heat, exerted a negative influence upon their activity. Owing to the lack of food (caterpillars are few and small in size) in spring the Cuckoos had to spend much time in search of food. Single individuals were repeatedly observed awkwardly hopping on the ground in the most sparse and warmed parts of the forest, picking up insects on the leaves of the previous year, in grass, or on the surface of the ground. Apparently, on May 23-24 only the first males arrived ; females were absent till 25-26 May. From May 27 to 28 the number of males and females increased and the rise in their activity became noticeable.

VOICE AND HABITS

In Chinese one of the names of this bird means 'four-syllabled cuckoo'. In fact, the very peculiar ringing song of the Indian Cuckoo consists of four sibilant, flute notes repeated one after another, a kind of *fju-fju-fju-fu*. The song is rather melodious and easily memorized. In the far east of the U.S.S.R, in China, India, Burma, and in other countries of south-eastern Asia where the Indian Cuckoo is met with during its breeding or non-breeding time, the local people know this song very well and readily recognise it. Without going into particulars since it was done in detail by A. Hoffmann (1950), I would like to repeat that in the majority of the Asiatic languages the name of this bird has an onomatopoeic etymology (Whistler 1926; Baker 1927; La Touche 1931; Burton 1935; Shaw 1936; Ali 1953; Smythies 1953; etc.). Abdulali (Ali & Abdulali 1938) likens the song of *C. micropterus* to the voice of *Pomatorhinus horsfieldi*.

As in the Common Cuckoo, males of the Indian Cuckoo have individual differences in the key and timbre of the call. Being always four-syllabic, the song may be dull and rough, or clear and ringing. In Amurland the voices of individual males in the majority of cases differed so much that it was rather easy to recognise them and to trace the movements of individual birds all over the territory.

In the south of the Amur-Zeya plateau Indian Cuckoos could be heard all day in the breeding season. In June and the beginning of July the birds did not cease singing even at night. According to my observations, at the end of May and the middle of June males began to

sing before dawn, at 2-2:30 a.m. They sang at intervals which apparently coincided with the feeding times. At 18-18:35 p.m. the birds were active again. Many individuals did not cease singing after sunset. Within the breeding season even prolonged rain accompanied by strong wind did not affect the time and intensity of the singing. It seemed to me that on warm rainy days they called more readily. On the contrary, the long summer drought of 1962, so unusual in Amurland, rather oppressed the birds: some males nearly stopped singing in June, others were heard only early in the morning, at dawn when the air was more humid. However, the recession and rise of activity of Indian Cuckoos depends to a greater extent on their breeding cycle than on the weather. On days preceding copulation and on the days when it takes place males and females are very excited and call often. With the beginning of egg-laying Indian Cuckoos are nearly always silent in their breeding territory.

A male usually sings perched at the very top or on a lateral branch of a high larch or pine tree; sometimes it settles in the crown not far from the main trunk of the tree. Each individual has a favourite place for singing, usually a tall tree. Some other birds living in the neighbourhood (Common Cuckoo, Indian Jungle Nightjar, Eastern Turtle Dove, Whitethroated Rock Thrush, Chinese Greenfinch, migratory Chinese Grosbeak, etc.) show a preference for the same trees. Thus, on 7 June a male of the Indian Cuckoo sang at the top of an old pine three times, from 4 a.m. to 7 a.m. (once with a female), and a male of the Common Cuckoo was heard on the same tree twice. Loud calls of the Indian Cuckoo are audible more than one kilometre away. As distinct from the Common and Himalayan Cuckoos, which before and after cuckooing utter some additional sound, the Indian Cuckoo has no other sound but the main song. While singing the male slightly hangs its wings. When displaying before a female, at the moment of highest excitement, the male spreads his tail in an erect position, slightly moves it from side to side, and begins to call louder and rapidly. Often a male calls even on the wing when chasing the female.

The nuptial call of females is composed of an interrupted warble greatly resembling that of the Common Cuckoo female, but some tones higher. Unlike the male the female is very seldom seen. Usually she hides in a tree crown or perches rather often on a bough like a nightjar and is very difficult to notice. Whereas the male prefers to keep to the very tops of tall trees, usually coniferous ones, a female shows a definite preference for the middle and the thickest part of a tree crown and does not avoid leaf-bearing trees. A cuckoo-hen calls in full measure only when flying; when perching it utters a short and muffled warble.

When frightened or disturbed, Indian Cuckoos instantly fly a long

way off, never to the nearest tree as many other forest birds do. On the wing, the Indian Cuckoo can be easily distinguished from the Common and Himalayan Cuckoos by its fuscous-brown purple-glossed mantle plumage, broad widely-spaced transverse bars on the breast, and short rounded wings (hence its name *micropterus*). Its flight resembles much that of *C. canorus*, but is more swift, with frequent flapping of wings.

Nearly all ornithologists who have had an opportunity to watch the Indian Cuckoo in the Far East have noted its extreme shyness. In my first expedition to Amurland I had the same experience (Neufeldt 1959), in the summer of 1957 I was lucky to shoot one female, and in 1958 with equally great effort two males. In the years that followed, when collection was not so keen and attention was directed to the study of the biology of the bird, we found that it is no more shy than the well-known Common Cuckoo but considerably more mobile. The fact is that the female Indian Cuckoo is constantly moving over its territory, and so accompanying males continually change their singing places. Besides, the male-cuckoo regularly visits every part of its territory singing by turns at set perches. The intervals between such flights are short, usually less than the time the observer must spend for concealment and subsequent watch for the bird. In the meantime the male (the main partner is meant), after flying round the territory, returns again to its original place. Thus, if you know the routes and favourite trees of an individual bird you can judge beforehand where it can be met. It is of interest that males of this species choose the same trees not only within one season but during several years. Keeping this in mind, in the summer of 1962, without any reconnoitring I installed the microphone on the top of an old high pine which was often used by Indian Cuckoos in 1957 and 1958 for singing, and in 40-50 minutes I made a rare tape-recording at short distance of this wonderful bird's voice. We found ourselves misled at times because a male that is not very excited has the habit of interrupting his song without leaving the tree. During such a pause another bird may start singing not far away and when he stops the first starts afresh. Thus, males do not sing in chorus but call to one another. Only when a female appears do the males call all together.

As mentioned earlier Indian Cuckoos begin to sing as early as January in their winter quarters and stop when the breeding season is over. In the south of the Amur-Zeya plateau at the beginning of July their singing was not so intensive and was confined in general to early morning and late evening. In the limits of the territory under study solitary males could be heard up to 8 July in 1957, 10 July in 1958, 6 July in 1959, 11 July in 1961, and 12 July in 1962. In those years Common Cuckoos sang somewhat later, up to 23-25 July. According to Hoffmann's observations in Peking and its environs also, the Indian Cuckoo sings

seldom and one at a time, in mid-July. In India, according to Baker (1927) their calls were recorded before July. Storrs (1944) registered their last song in Bengal on 31 June. In Thailand, these birds whistle up to 7 June (Deignan 1945); in Burma up to June (Smythies 1953); in Ceylon, where the breeding takes place during the winter-spring months, the Indian Cuckoos sing before May (Phillips 1948). The cessation of singing does not mean that the birds have left the breeding area.

BREEDING HABITATS AND NUMBERS

The distribution of the Indian Cuckoo during the breeding season depends, as in other parasitic birds, on the distribution of its main fosterers. All Passeres, supposed or known to be foster-parents of the young cuckoos, inhabit sparse portions of forests or old parks. The Indian Cuckoo is also a typical forest inhabitant. In Thailand, for instance, the birds keep to both evergreen and pine forests (Deignan 1945). In India at the breeding period this cuckoo is common in forests at elevations about 1500 m. above m. s. l.; in the Himalayas it occurs sometimes up to 2700 m. (Baker 1927; Brooks 1875; Whistler 1926; Hewetson 1956). In China in Hopeh province the Indian Cuckoo lives in forest regions (Shaw 1936). According to Hoffman's (1950) information, in Peking and Nanking it is very abundant in gardens and parks as well as in neighbouring hill forests. In Manchuria it prefers leaf-bearing and mixed forests. Favourite habitats of the Indian Cuckoo are mentioned by Spangenberg (1965) to be sparse plantings of old birches, oaks, and maples, and other leaved trees covering hills. Vorobiev found this bird in Ussuriland in oak-groves on small hills; Kistjakovsky (1959, 1962) met them not far from Komsomolsk on the Amur in larch taiga. In the western part of Amurland the main biotope of these birds is old pineries with an undergrowth of dwarf oak, growing on hills and along the Amur River bank (Stegmann 1930). At a distance of 40 km. from the Amur River Stegmann met this cuckoo in oak-groves together with the migratory Chinese Grosbeak and the Grey Minivet. Radde (1863) writes that he observed the bird on high pines in the plains between Burinda and Olga Rivers.¹

According to my observations near the town of Svobodny where larch trees are very abundant in neighbouring forests, Indian Cuckoos at breeding time are confined to stunted oak-larch forests, influenced by fire and cutting. Such forests usually occupy the plateau and its slopes of various steepness and exposure. The Dahurian Larch (*Larix dahuricus*) forming the upper canopy is represented here by very high solitary trees

¹ All Radde's observations on this species are described under his review of *C. optatus*.

usually with dead tops. Occasionally, generally on southern slopes, there are old pine trees. In the second canopy Mongolian Oaks and Birches (*Betula platyphylla* and *B. dahurica*) dominate. The undergrowth is well developed and comprises in general the Hazel, Lespedeza, and Dahurian Rhododendron. In more humid places the admixture of alders and willows is rather significant. Brush and grass cover is rich and variable. On the ground there is plenty of wind-fallen wood and dead twigs. Such parts of the forests represent in general, clearings at different stages of secondary growth and are favoured breeding places of the Amur Brown Shrike, the density of whose population here is 0.5-1.0 and even 2.0 pairs per hectare. In the Shimanovsky district (environs of Simonovo village) the larch is nearly absent. Here the Indian Cuckoos inhabit oak-pine forests with Rhododendron and Lespedeza. Such forests cover terraces of narrow forested valleys and flat elevations. The upper canopy is composed of solitary old pines, in the second canopy oaks and birches prevail. The undergrowth is dense and composed of undersized oak trees, Rhododendron, and Lespedeza. Oak-groves without admixture of high coniferous trees, and very dense deciduous and pine forests without clearings are avoided by this bird. The abundance of Amur Brown Shrikes (*Lanius cristatus confusus* Stegm.), the regular fosterers of the Indian Cuckoo in the Amur-Zeya plateau (Neufeldt 1963), and the presence in both the above mentioned biotopes of the high pine and larch trees, on which male cuckoos perch for singing, make the conditions favourable for the breeding of the cuckoos.

The arrival of Indian Cuckoos at their breeding places in Amurland coincided with the time of pair-formation and occupation of nest sites among the Shrikes. On returning from winter quarters male cuckoos kept to biotopes situated immediately near the nesting ones. By the end of May territories of the cuckoo-hens were distinctly demarcated. One female controlled an area inhabited by 25-30 pairs of shrikes; thus the range of the individual cuckoo's area depended on the population density of the host species. In years when numerous areas of secondary growth provided a high concentration of shrikes, an area of 100-125 hectares in the environs of Klimautzy village (Amurland) was constantly inhabited by Indian Cuckoos: 1957—2 ♀♀, 4 ♂♂; 1958—2 ♀♀, 3 ♂♂; 1961—1 ♀, 2 ♂♂; and 1962—2 ♀♀, 3 ♂♂. (Cases in which territories occupied by the females overlapped have not been taken into account). Very often, due to rugged terrain with complicated network of forest valleys and diversity of plant associations, the territory occupied by one cuckoo-female was considerable and separated into isolated parts situated as much as 100-300 metres from each other.

The associates of Indian Cuckoos and Amur Brown Shrikes inhabiting the same biotopes were Gray's Grasshopper-Warbler, Thickbilled Warbler, Rubythroat, all rather common and numerous in the under-

growth, and the scarcer but still typical forest dwellers, such as Radde's Bush-Warbler, Indian Tree Pipit, and Masked Bunting. Occasionally nesting migratory Chinese Grosbeaks could be seen. The abundance of open-nesting songbirds attracted Common Cuckoos to these biotopes. All the forest valleys were occupied by the Great Spotted Woodpecker, Whitebacked Woodpecker, and Tits.

Long-term observations on Indian Cuckoos undertaken at one territory have shown that these birds are confined to definite parts of the forest and even to individual trees. Unfortunately, I was not able to ring Cuckoos and so to establish individual identity. The return of Common Cuckoos to the same area over a number of years has been proved beyond doubt (Makatsch 1955).

BREEDING

As stated above, in the territory under observation a preponderance of males over females was noticed every year. The literature shows that this phenomenon, characteristic also of the Common Cuckoo, has contributed to the widespread opinion that the parasitic cuckoo is polyandrous and female mates with several males visiting her territory. On the contrary, some authors (e.g. Harbø & Moebert, cit. Makatsch 1955), on their own long-term observations, have concluded that in the breeding period Common Cuckoos live in pairs. Now we have data indicating that the excess of males over females is not invariable. Thus, Malchevsky (1954) records an equal correlation between sexes or even an excess of females over males. So polyandry seems unlikely. This problem can be solved only by ringing or otherwise marking the birds and making a special study on the composition of their population.

I give below some results of my stationary visual observations on the Indian Cuckoo and state my opinion on its breeding habits. I would premise that, as regards males with distinctive voices, I was dealing with 'marked' individuals.

At the height of the breeding season one female is followed by 1 or 2, sometimes 3, males who frequently visit her territory. But only one male is believed to impregnate her. This male is most often seen near her. On the day of copulation the female's 'chuckle' is heard very often and she repeatedly changes her place flying from one end of the territory to another. It is very significant that in this period the hen's call is a reciprocal reaction to the song of the 'favoured' male, who judging by his activity is considerably more excited than other males in the vicinity. I saw repeatedly the 'favoured' male try to drive out the other males, who apparently took no part in breeding. When laying eggs the cuckoo-hen is especially cautious and silent. But the male is sometimes heard or seen nearby. He flies openly and diverts to some

extent the attention of host-species, thus making the female's task easier. It thus appears that during the breeding season Indian Cuckoos live in pairs. Brood parasitism involves an escape from the chief duties of raising a family: building the nest, incubating the eggs, and rearing the young. Thus the duties of mates become minimal, being limited to the selection of the breeding biotope and its protection, to a timely search for fosterers' nests, and egg-laying. The relation between mates is not so stable as in non-parasitic species of cuckoos, but the female always shows a preference for a definite male and he becomes her partner for the breeding season.

The 'superfluous' males who occur in the territory are, seemingly, one-year old birds come from their winter quarters to the area where they hatched and grew up. Nearly half of the singing Indian Cuckoo males collected in Amurland had, in varying number, unmoulted juvenile secondaries and greater coverts, a fact that indicates a considerable proportion of young males in the population. Owing to the generally unequal correlation of the sexes that is observed in nature, not only in cuckoos but also in many other birds, a number of males (particularly young and less experienced birds) remain unmated in their first year. In regions with great density of population, where several females' territories are contiguous, unmated males in moments of great excitement pursue more than one female. Such a pursuit is common even in birds living in constant pairs. In many perching birds, woodpeckers, and birds of prey, not only unmated but also paired males are lured from their territories by the voice or the display of a female from another pair. Several times I observed the nuptial call of the Indian Cuckoo female attract Common Cuckoo males, but this fact does not prove that Indian Cuckoo females mate with males of another cuckoo species. The idea of polyandry in these birds is, I think, groundless. Finally, I would like to note that the impression of a numerical excess of males over females among cuckoos is probably due to the impossibility of observing all the female cuckoos in an area during a short trip.

The Indian Cuckoo is a typical nest parasite, like the other eleven species of the genus *Cuculus*. Though about two hundred host species of the Common Cuckoo are known, for the Indian Cuckoo only isolated trustworthy records are available. For example, the Azure-winged Magpie, *Cyanopica cyana*, is one of the commonest hosts of the Indian Cuckoo in Peking and its environs (Shaw 1938, 1940; Hoffmann 1950). In northern Bengal this cuckoo's eggs were found in the nests of the Drongo, *Dicrurus macrocercus* (O'Donel 1936; Storrs 1944), and in Sikkim in those of the Spider hunter *Arachnothera magna* (Gammie 1877). In Ceylon the Ceylon Blackheaded Oriole, *Oriolus xanthornus ceylonensis*, is probably a foster-parent of this cuckoo (Phillips 1952). The majority of the data, however, is based on gues-

work and supposition and needs confirmation by observed fact. Sometimes having found an egg ready for laying in the oviduct of a dead bird, ornithologists have tried to determine the host species by matching the colour of the egg's shell. Sometimes an abnormal egg in the nest of a songbird, which differed from the others in shape, size, or colour has been referred to some species of cuckoo. Lastly, some authors have listed as host species of the Indian Cuckoo birds among whom the appearance of the cuckoo near their nest caused anxiety (Rattray 1905; Vaughan & Jones 1913; Nehrkorn 1910 *cit.* Makatsch 1955; Hoogerwerf 1949, *cit.* Makatsch 1955, Spangenberg 1965). In the above mentioned works Drongos (*Dicrurus* and *Buchanga*) are mentioned most often as the host-parents of the Indian Cuckoo.

In the U.S.S.R., in Amurland, the egg of the Indian Cuckoo was first found by me in the nest of the Amur Brown Shrike in 1957. The astonishing similarity in the coloration of the eggs of the two species, as well as an obvious adaptation of Indian Cuckoos to the nesting-biotopes of the shrikes in the investigated territory, had long since suggested that the connection between these two species is not accidental. The additional material collected by me in the same region of Amurland now enables me to state quite definitely that this species of shrike is the main, and apparently the single, host of the Indian Cuckoo in this part of its range. Further avifaunistic investigations in our Far East will possibly add to the list of birds fostering Indian Cuckoos. It is not impossible that in the Amur flood-land, as in China, these birds parasitize the Azurewinged Magpies, and that, south of this river, there are nests of the Amur Brown Shrike with eggs of Indian Cuckoos in them. Hoffmann (1950) has mentioned this shrike as a possible foster-parent of the Indian Cuckoo in the parks of Peking.

The breeding period of this cuckoo is correlated with that of its main fosterers. At the end of December, near the southern borders of the breeding range, in Ceylon, Phillips (1948, 1952) found in the nest of the Blackheaded Oriole an egg which is supposed to have been laid by an Indian Cuckoo, and at the beginning of May he obtained a fledgling of this cuckoo. In different regions of India the egg-laying takes place from March-April till May-June (Baker 1927; Jones 1941; Storrs 1944; Ali 1953). Northward, in Peking and its environs, the breeding takes place in general in June. Shaw (1938) reports, for instance, the finding of a week-old cuckoo in the nest on 25 June. Hoffmann (1950) observed young Indian Cuckoos able to fly well in 1946 from 31 July to 16 August, in 1947 from 19 July to end of the month.

In the south of the Amur-Zeya plateau fresh eggs were found in 50 nests of Amur Brown Shrikes from 6 June to 30 June. Some individuals were building their nests till the middle of July. In all the cases known to me Indian Cuckoo eggs were laid also in June at the time of

the intensive breeding of the shrikes. Thus, on 8 June 1957 a cuckoo-female was obtained just after she had laid the second egg of that season (apparently the first egg was laid on 5 or 6 June); on 12 June 1962 a shrike's nest was found containing a fresh cuckoo egg, the nestling hatched on June 22 (the clutch was apparently laid on June 11); on 12 June 1961 I watched for a long time a female Indian Cuckoo try, though unsuccessfully, to enter the nest of a shrike; on 4 August 1959 I obtained a 40-day old Indian Cuckoo, and on 26 July a fledgling whose age was estimated as about 30 days (both could have hatched from eggs laid in the middle of June); on 28 June 1962 a nest was found with a fresh cuckoo egg, the nestling hatched on June 9. The gonads of all male Indian Cuckoos shot at the height of the breeding period (7-27 June) were of equal size, measuring in mm.: 4.0×4.0 - 6.0×4.0 , and 4.0×3.7 - 5.0×4.0 .

Nearly 75% of the Amur Brown Shrikes nests observed in Amurland were built on the ground, the rest at a height of 0.5-1.9 m. above the ground in bushes and trees. The Indian Cuckoo parasitized nests of both types. Its eggs were twice discovered in nests situated on the ground in dense grass and once in a nest built in the crutch of a willow bush. When looking for the nests of shrikes, females of the Indian Cuckoo as well as those of other parasitic species are guided in the first instance by the behaviour of the fosterers. The singing of male shrikes, which is usually accompanied by typical displays, as well as the loud call notes of these birds attracted the Indian Cuckoos to their nest. Later, cuckoo-hens watch the birds in the process of nest-building or discover their nests by the alarm-calls or behaviour of the host. To begin with, cuckoos apparently discover the less disguised nests and the nests of those individuals who by their high excitability and carelessness attract the cuckoo's attention.

On 12 June 1961 I watched a female Indian Cuckoo, perched in the low branches of an old larch on the outskirts of the forest, looking very attentively at a thicket near which a male shrike frightened by me was flying. For a long time she remained unnoticed, but the moment she made a careless movement the shrike noticed her. With a loud call he attacked her and pressed the attack till she left the territory. So the nest built in a heap of dead branches and containing a fresh clutch was not discovered by the cuckoo.

When laying in a nest found beforehand the cuckoo-hen acts with confidence and most persistently. Thus on 8 June 1957 during a trip my attention was attracted by a male shrike flying in agitation near his nest containing fresh eggs. Through binoculars I could make out that he was trying to drive away a rather large bird, an Indian Cuckoo female, perched on the branch of a dry willow bush. In 15-20 minutes the cuckoo flew on to a fragment of a larch branch lying on the ground at

Neufeldt : Indian Cuckoo



Above : Nest with complete clutch of Amur Brown Shrike eggs and one Indian Cuckoo egg ; Below : Two-day old nestling of Indian Cuckoo in the nest.

(Photos : I. Neufeldt)

Neufeldt : Indian Cuckoo



Above : Amur Brown Shrike female brooding 7-day old Indian Cuckoo ; *Below* : Same bird with food for young cuckoo.

(Photos : I. Neufeldt)

1.5 m. distance from the nest. The frightened female shrike immediately left the nest and joined her mate. Looking round but paying no attention to her attacking hosts the cuckoo reached the nest. In 20-30 seconds she flew away from the nest leaving her egg there.

Complete clutches of the Amur Brown Shrike consist usually of 6-7 and sometimes 4-5 eggs, in some nests we found only 3 eggs—the last apparently a case of second laying. In one nest containing 6 eggs, an Indian Cuckoo laid her egg, leaving host's clutch untouched. In two other nests used by these cuckoos we found only 3-5 eggs. It is difficult to say whether cuckoos were to blame or they had laid their eggs in nests with incomplete clutches. It is of interest that, analyzing the stomach contents of Indian Cuckoos collected in China, Shaw & Liu (1940) found the shells and inner shell membranes of a bird's egg. Apparently, this cuckoo as well as the Common Cuckoo sometimes carry off and swallow eggs from their fosterers' nests. In all cases known to me Indian Cuckoos laid their eggs in nest which contained full fresh clutches. Judging by the behaviour of the cuckoos in their territory and by the changes in the activity of males and females during the breeding season the eggs are normally laid at intervals of 1.5-2 days. I do not know the number of eggs laid by one female in one summer, but I think this species lacks the high fertility usually attributed to Common Cuckoo females. If one Indian Cuckoo female could lay 25-20 or even 15 eggs in a summer, at least every second shrike nest examined by me should have contained a cuckoo egg, but actually it was otherwise.

The Indian Cuckoo eggs found in the nests of Amur Brown Shrikes are mimetic. In two cases they practically did not differ in pattern, coloration, and shape from fosterers' eggs. They had a dirty-white, slightly greenish ground colour with beige surface and deeper grey spots and speckles concentrated near the blunt end of the egg thus forming a nimbus-like thickening (Plate I, *above*). The third egg found in the shrike's nest had a pink background mottled with darker greyish brown spots and somewhat different in coloration from the two preceding eggs. Thus, in Amurland according to the coloration of the eggs Indian Cuckoos may be arranged in two groups corresponding to the two types of pigmentation of their fosterers' eggs. In general, the eggs of these cuckoo parasites of the shrikes resemble by coloration the eggs of Azurewinged Magpies, Drongos, and even Streaked Spiderhunters, birds known as Indian Cuckoo host-species in other parts of the area. The eggs of the Indian Cuckoo are larger than those of the Amur Brown Shrike, the measurements (in mm.) being:

Nest No. 1—*Shrike*: 20.0 × 17.0 (2), 21.5 × 16.7, 21.6 × 17.0, 22.0 × 17.2, 23.0 × 17.0, average 21.4 × 16.98; *Cuckoo*: 25.0 × 19.0.

Nest No. 2—*Shrike*: 23.0×17.0 , 23.5×17.0 , 23.5×17.5 , average 23.3×17.1 ; *Cuckoo*: 26.0×20.0 .

Nest No. 3—*Shrike*: 20.5×16.5 (3), 21.0×16.5 (2), average 20.7×16.5 ; *Cuckoo*: 25.0×19.5 .

The shell surface of fresh Indian Cuckoo eggs is matt but on hatching it acquires a faint lustre.

In all cases known to me shrikes did not notice the increase of the number of eggs in the nest and readily accepted the larger and roundish cuckoo eggs.

Indian Cuckoo eggs hatch in about 12 days, whereas the shrike eggs require 14 days. The cuckoo nestlings always hatch before the fosterers'. The hatching sometimes lasts long. Thus, in one nest cracks on the cuckoo-egg were recorded on 8 July at 18 hrs. and the chick emerged only between 9 and 10 hrs. on 9 July. Whenever cuckoo-females laid their eggs before midday, usually in the morning, the hatching also took place in the morning.

The newly-hatched Indian Cuckoo chick is blind and naked, with closed acoustic ducts; skin on the body, bill, nostrils, and legs yellowish pink; tongue (except the very tip) and inside mouth orange-red; commissures of the jaw and tip of the tongue yellow—even at this age the chicks differ from Common and Himalayan Cuckoos' chicks in having a lighter tip to the tongue. Immediately on hatching, the chick weighs 4.7-4.9 gm.

In the one-day old chick the acoustic ducts are open and the skin on the dorsal part of the body and on the legs is darker. The two-day old is very limp and lies cheeping quietly at the bottom of the nest (Plate I, below). Only on strong tactile irritation of the rump skin does the blind nestling strike a rather typical ejection attitude: stands up with legs wide apart, throws its wings well back, and bends its neck down setting the top of the head against the nest bottom. Contact with eggs or newly-hatched fosterers' chicks does not cause this reaction. The actual ejection takes place on the third and partly on the fourth day; after this period the 'overboard' instinct gradually disappears.

On the third day in the region of the future remiges and rectrices there appear hardly visible 'hairs', which may be regarded as rudiments of ancestral nestling 'down'. It is known that only non-parasitic cuckoo-chicks (*Centropus*, *Geococcyx*, *Coccyzus*, etc.) have 'down'. Shelford's (1900) investigations have shown that these thread-like structures (trichoptiles) are not down, but abnormally elongated apexes of horny sheaths enveloping growing feathers. With the growth of a feather papilla trichoptilia lengthen as well. When feathers begin to unfold the trichoptilia break off. I think that the degeneration of the thread-like structures in parasitic cuckoo nestlings is of an adaptive nature, tactile receptors in a naked skin being more sensitive and easily provok-

ing a reflex act of ejection. On the fourth or fifth day appear the first feathers on the nape and shoulders, and then on the forehead, ulnar, carpal, and femur regions; the eyes half open; the skin of the dorsal surface of the head, body, and wings as well as the bill and tip of the tongue grow darker and become dark-grey with a violet shade. Now the Indian Cuckoo chick differs very well from those of the Common and Himalayan Cuckoos, not only in tongue colour but also in the colour of the feather sheaths, the tapering apexes of the undeveloped feathers being beige or pale-yellow in colour in the Indian Cuckoo while in the two other species they have white or slightly greyish distal poles.

In the 7-day old Indian Cuckoo the eyes are entirely open, feather papillae grow over all the pterygiae except the dorsal one, the caudal portion of the ventral one, and some parts of the head (Plate II, *above*). The week-old juvenile weighs eight times the newly hatched one. It is still poikilothermal and is constantly brooded by the host-hen. While sitting in the nest the cuckoo cheeps quietly and even when hungry does not utter loud calls. Sometimes it tries, though rather clumsily, to preen.

On 8th day the feathers on the nape, shoulders, thighs, and greater wing-coverts begin to unfold; the eyes are entirely open, though in the nest the chick prefers to keep them closed; the bill flanges, nostrils, and the tip of the tongue become black. The nestling weighs 40-45 gm., i.e. more than an adult Amur Brown Shrike. The length of the second primary is 13-15 mm. and the second rectrix 5-6 mm.

By 9-10 days of age nearly all the feathers emerge from their sheaths; there remain in papillae only the feathers on the crown, the forehead, and the rump, corresponding to the parts of the body with high sensitivity in the 2- to 3-day old nestling. The wing-coverts as well as the first feathers on the nape and thigh have rather large vanes. The skin on the dorsal, the most exposed side of the body is dark, whereas abdominally it is a pale pinkish yellow.

At the approach of a man the 10- to 11-day old cuckoo produces some threat gestures: ruffles its feathers on the head, opens its wings, raises the tail, and tries to peck. The foster parents still continue to brood the nestling.

12-day old chick weighs 73-75 gm., the second primary is 41 mm. the second rectrix 24 mm. All feathers unfold; only the lores and feathers near the orbital ring remain in sheaths. From the age of 12 days regular brooding of the nestling ceases. When its shrike-hosts are absent the young cuckoo sits very quietly in the nest, sometimes preening, raising, and stretching itself. It constantly cheeps without opening its bill. When hungry it screams out its shrill *tu-fju*. On hearing or seeing its foster-parents approaching with food the nestling calls louder, opens its bill, and shakes its wings (Plate III, *above*). At the moment of

taking the food the cuckoo-chick cheeps and trembles all over. In general, all vocal reactions of the young Indian Cuckoo are very similar to those of the young Common Cuckoo but somewhat muffled and low. The female shrike for some unknown reason fed the chick of the Indian Cuckoo less willingly than the males did. Sometimes they did not feed them at all. In such cases young cuckoos readily recognized the male bird and responded only to its calls. Usually, in the nestlings of the Indian Cuckoo and of many passerine birds, each discharge of excrement is enclosed in a gelatinous capsule (faecal sac) so that it can be removed by the parents. It is of interest that the droppings of nestlings of the non-parasitic cuckoos are not encapsuled. However, you have only to touch the Indian Cuckoo chick or take it in the hand for it instantly splashes you over with a large excretion of brown stinking liquid. Thus, at this age the young cuckoo is capable of actively protecting itself from enemies.

When 14 days old the Indian Cuckoo is rather well feathered (Plate III, *below*) though the bases of all the feathers are more or less concealed in feather sheaths. When in the nest the young cuckoo closely watches its foster parents bringing food and actively gets the food from them. It was quite indifferent to calls of the male and female Indian Cuckoos. When the shrikes are out of the nest it raises, stretches, and cleans itself.

On the 18th day the young cuckoo tried to perch on the edge of the nest. When three weeks old it left the nest and perched on a high stump (Plate IV); the remiges, rectrices, and the majority of the small feathers had not reached normal length and the cuckoo was not capable of active flight. Its weight after leaving the nest was 90 gm.

In captivity the Indian Cuckoo chick grows to adult size and acquires the complete juvenile plumage at the age of 45 days (Shaw 1940). According to my data the 30-to 40-day old cuckoo is airborne and does not differ from adults in size, but still continues to beg for food from the foster parents. From shrubs growing on the edge of the forest or from the glade where it hatched and grew up, the chick now moves into the heart of the forest. The shrikes follow it rather unwillingly in this change from their habitual biotope and try to lure it out in every possible way. When hungry the cuckoo flies to the forest edge and perches on a low branch or stump, where it receives food. When perching or flying the juvenile Indian Cuckoo utters in succession low and rather tuneful calls, a kind of *tu-fju, tu-fju*. At the moment of feeding it utters sounds resembling the hunger cry of the foster parents' chicks. Flying from place to place a frightened young cuckoo produced a loud ringing warble resembling that of the juvenile Common Cuckoo. Fledglings of the Indian Cuckoo at the age of one month weighed 119.5 and 127.0 gm., the same weight as adults. The weight of adult birds collected in

Neufeldt : Indian Cuckoo



Above : 13-day old Indian Cuckoo begs for food ; *Below* : 14-day old Indian Cuckoo in Amur Brown Shrike nest.

(Photos : I. Neufeldt)

Neufeldt : Indian Cuckoo



Young Indian Cuckoo newly out of nest being fed by foster-parent, an Amur Brown Shrike.

(Photo : I. Neufeldt)



Amurland was as follows: ♂♂ 112.0, 114.0, 115.0, 120.0, 124.0, 129.0 gm.; ♀ 119.0 gm.

The coloration of the Indian Cuckoo's juvenile plumage is so peculiar that young birds of this species cannot be confused with the chicks of any other cuckoo. The difference from the adult plumage is the absence of pure white colour and of various grey tints, and in the predominance of dirty cream, isabelline, dark-brown, and ferruginous shades. The plumage of the upper part of the head (besides the crown), hindneck, and throat is basally black with broad isabelline apical bands. On the forehead, along the mouth, and around the eyes and ear-coverts the feathers are entirely black with a light base and black apex. The lower throat of the juvenile is also black with considerably longer covering feathers and has an additional black stripe against an isabelline background. By such coloration of some feathers in the lower part of the lower throat sparse transverse bars are outlined and the lower throat itself looks considerably darker. The plumage of the belly has a pure isabelline coloration and only the under tail-coverts sometimes have black markings. On the flanks and the breast grow feathers bearing two rather broad dark transverse bars on isabelline vanes. Those which are situated nearest to base are usually concealed by the apex of overlapping neighbouring feathers. Apical bars are distinctly seen; they impart typical cross-banded coloration to the underpart of young cuckoos (Plate IV). On the dorsal side isabelline or a paler colour stretches, except for the head and hindneck, to the apexes of some scapulars and to the ends of all the tail feathers. The crown and rump juvenile feathers grow later than the rest of the plumage and are dark-brown with ferruginous apical bars and transverse stripes and speckles on the inner and outer webs, with a hardly noticeable purple shade. The primaries are of the same colour, their inner webs barred with ferruginous. The ends of all the wing feathers are ochre-fulvous. The wing-coverts are dark brown with ochre apexes and spots or stripes of the same colour on the vanes. All the rectrices are greyish brown, and the preapical part black with transverse ferruginous bars. The central part of each feather bears against each stripe hardly noticeable depigmented spots. The orbital ring is yellow, the legs flesh-pink, the iris dark-brown, the tongue and the inside of the mouth salmon-orange, the tip of the tongue black, the upper mandible, margins of the eyelids, and the nostrils black, the under mandible of horny colour darkening to the apex.

The food given to the young Indian Cuckoo is identical with that used by the foster parents themselves. Grasshoppers and locusts of various size, caterpillars and imagines of moths (Noctuidae, Geometridae) and sphinxes (Sphingidae) predominated in the diet (Plate IV). Gaily-coloured butterflies such as *Vanessa urticae* and *Papilio xurus* were recorded as food at that time. The shrikes pick up small beetles

(Carabidae and Cerambycidae) but rarely. Horseflies and cicadas (*Lyristes* sp.?) formed a large part of the diet of the Indian Cuckoo chicks. Sometimes the hosts brought small spiders (Plate II, below). The older juveniles were fed even with the meat of lizards (*Lacerta*) and shrews (*Sorex*). It is of interest that the cuckoo young digested large pieces of meat together with skin and bone and did not eject pellets. Adult Indian Cuckoos are typical insectivorous birds and, in this respect, do not differ from the Common and Himalayan Cuckoos living in the neighbourhood. The stomachs of all specimens collected in Amurland contained large caterpillars, mainly hairy ones which are serious forest pests. They feed very willingly on caterpillars of the Siberian Moth (*Dendrolimus sibiricus*), the pest of larches—we found up to 9 specimens in one stomach. Sometimes they pick up caterpillars of the Tussock Moth (*Dasychira albodentata*), click beetles (Elateridae), and black carpenter ants (*Campanotus*).

THE NON-BREEDING LIFE, MOULT

After the breeding period Indian Cuckoos become silent and very shy and are very difficult to observe. In Amurland in the second half of July and the beginning of August I saw only juvenile individuals. But this did not mean that the adults had left their breeding area; they had merely become less noticeable. The majority of these birds leave the territory of the Soviet Far East apparently in the second half of August. In August-September they start to move to their winter quarters in most parts of China and India, though some individuals, generally immature ones, sometimes stay up to October (Whistler 1926; Caldwell & Caldwell 1931; O'Donel 1936; Shaw 1936; Hewetson 1956; etc.).

It is possible that before the autumn migration young Indian Cuckoos start a partial post-juvenile moult which lasts during their migration and in winter quarters. This process involves nearly all the contour feathers but does not include the remiges and their coverts, rectrices, and upper tail-coverts. Yearlings are easily distinguished among wintering or newly-arrived birds by the remains of this nest-plumage. By mid-summer the light bands on wings and tail feathers of the juvenile cuckoos become so shabby and faded that by this feature they can be easily distinguished from adult birds. During the summer the young birds change the most exposed and consequently the shabbiest and loosest feathers. Thus on 7 June 1961 in Amurland in a yearling-male among very shabby and faded wing feathers were seen fresh last secondaries and greater wing-coverts; the upper tail-coverts, some wing-coverts, and other small feathers were moulting as well. The year-old Indian Cuckoo from 9 June 1959 changed many lesser wing-coverts, the

10th primaries and the 2nd, 3rd, 4th rectrices of the left side of the tail, which reached $\frac{2}{3}$ of the normal length. A male yearling shot on 27 June 1959 had lost its last secondary on the right wing whereas on the left wing the same feather and its coverts reached the normal length.

In the Zoological Institute of the Academy of Sciences of the U.S.S.R we have not got a collection of moulting adult Indian Cuckoos made during the breeding season. In one male collected by me on June 21 both the central rectrices are half grown. In a male dated 5 June 1934 obtained in China (Institute of Zoology, Academia Sinica) the tail feathers were moulting. Apparently adults (with a small exception) have a complete moult in their winter quarters, in late autumn and winter.

ACKNOWLEDGEMENTS

I express my thanks to Dr. Sálím Ali, of the Bombay Natural History Society, for editing the manuscript. I am also grateful to Professor A. I. Ivanov, Curator of Birds of the Zoological Institute of the Academy of Sciences of the U.S.S.R, Leningrad, for his helpful suggestions.

REFERENCES

- ALI, SÁLIM (1953): The Birds of Travancore and Cochin : 217. Oxford University Press, Bombay.
- & ABDULALI, H. (1938): The Birds of Bombay and Salsette. Pt. IV. *J. Bombay nat. Hist. Soc.* 40 (2) : 164.
- AUSTIN, O. L. (1948): The Birds of Korea. *Bull. Mus. Comparat. Zool.* 101 (1) : 142-143.
- BAKER, E. C. STUART (1927): The Fauna of British India including Ceylon and Burma. Birds 4 : 144-145. Taylor and Francis, London.
- (1934): The Nidification of Birds of the Indian Empire 3 : 347. Taylor and Francis, London.
- (1942): Cuckoo Problems : 59. Taylor and Francis, London.
- BELOPOLSKY, L. O. (1950): The birds of Sudzukhe nature Reserve. In memory of acad. P. P. Sushkin. Moskow, Acad. of Sci. : 400. Acad. of Sci., Moskow, Leningrad. (In Russian).
- BINGHAM, C. T. (1880): Additional notes on the birds of Tenasserim and specially those of the Thoungyeen Valley. *Stray Feathers* 9 (1-3) : 167.
- BISWAS, B. (1960): The Birds of Nepal. Part 2. *J. Bombay nat. Hist. Soc.* 57(3) : 540.
- BROOKS, W. E. (1875): Notes upon a collection of Birds made between Mussoori and Gangaotri in May 1874. *Stray Feathers* 3 (1-3) : 232.
- BURTON, R. W. (1935): Cuckoo-Lore. *J. Bombay nat. Hist. Soc.* 38 : 266-281.
- BUTURLIN, S. A. & DEMENTIEV, G. P. (1936): A complete key of Birds of the USSR 3 : 164. Koiz, Moskow-Leningrad. Moskow. (In Russian).
- CALDWELL, H. R. & CALDWELL, I. C. (1931): South China Birds : 238. Hester May Vandenburg, Shanghai.
- DEIGNAN, H. G. (1945): The Birds of Northern Thailand. *U. S. Nat. Mus. Bull.* 186 : 160-161.
- GAMMIE, J. A. (1877): Occasional notes from Sikkim, No. 1. *Stray Feathers* 5 (5-6) : 386.
- GOULD, J. (1837): Description of New Species of Himalayan Birds. *Proc. zool. Soc. London* 5 : 137.
- HEWETSON, C. E. (1956): Observations on the bird life of Madhya Pradesh. *J. Bombay nat. Hist. Soc.* 53 : 627.
- HOFFMANN, A. (1950): Der Indische Kuckuck (*Cuculus micropterus* Gould). Studien aus Peking und Nanking, *Bonner Zool. Beitr.* 1 : 21-30.
- JONES, A. E. (1941): Presumptive evidence of the nidification of the Indian Cuckoo (*Cuculus micropterus* Gould). *J. Bombay nat. Hist. Soc.* 42 : 931-933.

- KISTJAKOVSKY, A. B. (1959): New data on northern limits of Manchurian ornithofaunistic complex on the Amur river. Summaries of the reports 2 All-Union ornithological conference in Moscow 3: 80-81. Moscow Univ., Moscow (In Russian).
- , LOSKOT, V. I., & SMOGORZHEVSKY, L. A. (1962): New data on northern limits of Manchurian fauna. Summaries of the reports 3 All-Union ornithological conference in Lvov. 2: 25-26. Lvov Univ., Lvov. (In Russian).
- & SMOGORZHEVSKY, L. A. (1964): On the limits of the Chinese ornithofaunistic complex on the Bureja river. *Nauchnye Doklady Vysshei Shkoly, Biol.*, 3: 26-29. (In Russian).
- KURODA, N. (1918): Notes on Corean and Manchurian birds. *Annotat. Zool. Jap.* 9 (4): 521.
- LA TOUCHE, J. D. D. (1931): A Handbook of the birds of Eastern China 2 (1): 45-46. Taylor and Francis, London.
- LISTER, M. D. (1954): A contribution to the ornithology of the Darjeeling area. *J. Bombay nat. Hist. Soc.* 52: 63.
- LOWTHER, E. H. N. (1949): A Bird Photographer in India: 32. Oxford Univ. Press, London.
- MAKATSCH, W. (1955): Der Brutparasitismus in der Vogelwelt: 1-236. Naumann Verlag, Radebeul und Berlin.
- MALCHEVSKY, A. S. (1954): On the relationships between the Common Cuckoo and Redstart in the breeding period. *Vestnik Leninger. Univ.* 7: 3-18. (In Russian)
- MEISE, W. (1934): Die Vogelwelt der Mandchurei. *Abh. u. Ber. Mus. Tierk. u. Völkerkunde Dresden* 18 (2): 55.
- NEUFELDT, I. A. (1959): On breeding biology of the Indian Cuckoo in Amurland. *Ornithologia* 2: 192-195. (In Russian)
- (1963): The Indian Cuckoo (*Cuculus m. micropterus* Gould) a nest parasite of the Amur Brown Shrike (*Lanius cristatus confusus* Stegm.). *Doklady Akad. Nauk SSSR* 151 (6): 1446-1449. (In Russian)
- O'DONEL, H. V. (1936): The Indian Cuckoo (*Cuculus m. micropterus* Gould). *J. Bombay nat. Hist. Soc.* 39: 175.
- PETERS, J. L. (1940): Check-list of Birds of the World 4: 17. Harvard Univ. Press, Cambridge.
- PHILLIPS, W. W. A. (1948): Cuckoo problems in Ceylon. *Spolia Zeylanica* 25 (2): 47-49.
- (1952): The Indian Cuckoo—*Cuculus micropterus micropterus*—in Ceylon. *J. Bombay nat. Hist. Soc.* 51: 274-275.
- PIECHOCKI, R. (1958): Beiträge zur Avifauna Nord-und Nordest-Chinas (Mandschurei). *Abh. u. Ber. Mus. Tierk. u. Völkerkunde Dresden* 24: 165.
- RADDE, G. (1863): Reisen in Süden von Ost-Sibirien in der Jahren 1855-1859. Bd. 2, *Vogel St. Pet.*: 135-136.
- RAND, A. L. & FLEMING, R. L. (1957): Birds from Nepal. *Fieldiana, Zool.*, 41 (1): 75.
- RATTRAY, R. H. (1905): Birds nesting in the Murree Hills and Gullies. *J. Bombay nat. Hist. Soc.* 16: 661.
- RIPLEY, S. D. (1950): Birds from Nepal, 1947-1949. op. cit. 49: 371.
- (1961): A Synopsis of the Birds of India and Pakistan together with those of Nepal, Sikkim, Bhutan and Ceylon: 176. Bombay Natural History Society.
- ROBINSON, H. C. & CHASEN, F. N. (1939): The Birds of Malay Peninsula. The Birds of the Low-country, Jungle and Scrub. 4: 142. H. F. & G. Witherby Ltd., London.
- SHAW, TSEN-HWANG (1936): The Birds of Hopei Province. *Zoologica Sinica, Ser. B*, 15 (1): 502-504.
- (1938): Nordchinesische Blauelstern als Pflegeeltern von *Cuculus micropterus*. *Orn. Mber.* 46: 154-155.
- (1940): Some observations on the growth of the Indian Cuckoo (*Cuculus micropterus micropterus*) held in captivity. *Bull. Fan. Mem. Inst. Biol. Zool. Ser.* 10: 119-130.
- & LIU, CHINTING (1940): The food of some wild birds. op. cit. 10: 140.
- SHELFORD, R. (1900): On the Pterylosis of the embryos and nestlings of *Centropus sinensis*. *Ibis* 6: (24): 654-667.
- SMYTHIES, B. E. (1953): The Birds of Burma: 321. Oliver & Boyd, Edinburgh, London.
- SOCHAVA, W. B. (1957): Zonal features of vegetation throughout the territory from Tukuringra ridge to the Amur river. *Botanical Journ.* 42 (2): 195-210. (In Russian)
- SPANGENBERG, E. P. (1965): Birds of Iman river basin. *Proc. Zool. Mus. Moscow Univ.* 9: 151-152. (In Russian)
- STEGMANN, B. (1930): Die Vögel des dauro-mandschurischen Uebergangsbietes. *Journ. f. Ornith.* 78 (4): 456-458.
- STORRS, H. T. (1944): Indian Cuckoo (*Cuculus m. micropterus*) laying in the nest of the Himalayan Black Drongo. *J. Bengal nat. Hist. Soc.* 18: 116-120.
- STRESEMANN, E. (1923): Zoologische Ergebnisse der Walter Stötznerschen Expeditionen nach Szetschwan, Osttibet und Tschili, *Abh. Ber. Mus. Tierk. u. Völkerkunde Dresden* 16 (2): 35.

STRESEMANN, E. (1930): Eine dritte Vögelsammlung aus Kwangsi. *Journ. f. Ornith.* 3: 305.

VAUGHAN, R. E. & JONES, K. H. (1913): The Birds of Hong Kong, Macao, and the West River or Si Kiang in South-East China, with special reference to their nidification and seasonal movements. *Ibis* 2: 186-187.

VOROBIEV, K. A. (1951): The new form of the Indian Cuckoo—*Cuculus micropterus ognevi* subsp. nova. *Doklady Akad. Nauk SSSR* 77 (3): 511-512. (In Russian)

WHISTLER, H. (1926): The Birds of Kangra District, Punjab. *Ibis* 3: 749.

YAMASHINA, Y. (1932): On the specimens of Korean Birds collected by Mr. Hyojiro Orii. *Tori* 7 (33-34): 241.

More new races of birds from the Andaman and Nicobar Islands

BY

HUMAYUN ABDULALI

After the publication of my report on my collection of birds mainly from the Andamans (1964, 1965), I have visited the area again spending more time in the Nicobars and obtaining 280 specimens from Car Nicobar, Central Nicobars, and Great Nicobar.

I have also had the opportunity of examining at the British Museum (Natural History) the specimens collected by Hume, Davison, and others about a hundred years ago, enabling me to take some decisions which were not possible with the material available earlier. An account of the trip together with a general report on the birds of the Nicobars is ready but, as I understand that there is not much chance of its early publication, I am publishing the descriptions of new races earlier. The description of a new race of *Aplonis panayensis* from the Central and Great Nicobars is being published in the *Bulletin of the British Ornithologists' Club*.

1. *Rallus striatus* : Bluebreasted Banded Rail.

The race *obscurior* described by Hume from the Andamans has been accepted as the form found in the Nicobars.

A single male, obtained at Nancowri, Central Nicobars, has a 128 mm. wing and is much darker (almost black) on the upper parts and much deeper grey below than any of the specimens from India (9) and the Andamans (1) available in Bombay. At the British Museum there were no specimens from the Nicobars, but specimens from the Andamans were all smaller and much paler than the others of this species available for examination. Javan birds are also very similar to those from India, and it would therefore appear that the birds from Central Nicobars are different and I name them :

Rallus striatus nicobarensis subsp. nov.

Holotype : ♂ collected by B. R. Grubh at Nancowri, Central Nicobars, on 23 March 1966, Collection No. 193 and Bombay Natural History Society Register No. 22562.

2. *Macropygia rufipennis* : Cuckoo Dove.

The two males I obtained in the Middle Andamans can be separated from the two males and one female from the Central Nicobars by the outer webs of the primaries having a fine fringe of rufous against the basal two-thirds being entirely rufous in the Nicobar birds. This rufous shows as a strikingly different patch of colour in the folded wing which in Andaman birds is more or less concolorous with the other feathers of the back. This character is consistent in the large series (32 Andamans, 10 Nicobars) at the British Museum and Mr. Derek Goodwin who had a look at the specimens agreed that the Andaman birds were different, and I name them :

Macropygia rufipennis andamanica subsp. nov.

Holotype: ♂ collected by me at Betapur, Middle Andamans, on 24 February 1964, and bearing Bombay Natural History Society Register No. 22135

Paratype: ♂ collected by me at Bakultala, Middle Andamans, on 21 February 1964, and bearing Bombay Natural History Society Register No. 22134.

None of my specimens show the ' lilac-purple gloss on the crown of the male ' mentioned in most earlier descriptions. Though unfortunately not specially looked for, this was not noticed in the specimens handled at the British Museum.

Curiously, though the original type locality is Southern 'Nicobars' this species has always been called the Andaman Cuckoo Dove. These names will now have to be reversed.

3. *Oriolus xanthornus* : Blackheaded Oriole

This oriole has been accepted as a migrant to the Andamans, and I have already drawn attention (1965 : 549) to the single specimen I obtained being too small for the nominate race *xanthornus* (Type locality Chandernagor, Bengal) and its similarity to Ceylon birds, *ceylonensis* Bonaparte.

I have now had the opportunity of examining the material at the British Museum and there appears to be no difference in size.

<i>Andamans</i>		<i>Ceylon</i>	
<i>Wings</i>			
6 ♂♂	122-134 av. 128·6	4 ♂♂	125-134 av. 128·75
5 ♀♀	125-130 av. 127·4	3 ♀♀	122-130 av. 125·3
<i>Tails</i>			
6 ♂♂	72-84 av. 78·8	4 ♂♂	79-82 av. 80·2
5 ♀♀	76-82 av. 79·2	3 ♀♀	72-78 av. 76·3

The Andaman birds are however a deeper mango yellow, and have the edges to the outer webs of the inner secondaries yellow against pale yellow, almost whitish, in the Ceylon birds. On these differences I separate the Andaman birds as

***Oriolus xanthornus andamanensis* subsp. nov.**

Holotype: a ♂ collected by me at Wrightmyo, South Andamans, on 16 February 1964 and bearing Bombay Natural History Society Register No. 22021.

From the material examined it also appeared that the females and immature males (with streaked throats) of Indian birds have pale underparts, while Andaman birds appear to be as dark as the adults, a fact to which Blyth (1846) had drawn attention many years ago.

REFERENCES

- ABDULALI, HUMAYUN (1964): Four new races of birds from the Andaman and Nicobar Islands. *J. Bombay nat. Hist. Soc.* 61(2): 410-17.
- of the Andaman and Nicobar Islands. op. cit. 61(3): 483-571.
- BLYTH, E. (1846): Notes on the Fauna of the Nicobar Islands. *J. Asiat. Soc. Bengal* 15: 367-379.
- (1965): The Birds

Reviews

1. THE BEHAVIOUR OF ARTHROPODS. By J. D. Carthy. pp. 148 ($5\frac{1}{2} \times 8\frac{1}{2}$ inches). 41 black-and-white figures (drawings and graphs). Edinburgh/London, 1965. Oliver & Boyd. University Reviews in Biology 1. Price 12s. 6d. net.

The arthropod nervous system comprises a few cells, with small cell bodies and a smaller receptive area than corresponding mammalian cells. Such a nervous organization produces rigid behaviour patterns under set circumstances, resulting in adaptive behaviour in changed circumstances which appears to be purposeful, though in fact it is not. An excellent account of the nervous system and its working was given by Roeder in 1963, in a book entitled NERVE CELLS AND INSECT BEHAVIOUR which was reviewed in this journal a few years ago. Dr. Carthy's book is concerned with the behaviour patterns produced by simple nervous systems of this type among the arthropods.

Hairs are the commonest sense organs on the surface of the arthropod body. They serve as chemoreceptors, or hygrometers, or are sensitive to bending or to touching. Many insects have hair plates on the articulation between the head and the thorax. An example of how these function is in the dance of the honey bees. When the insect is horizontal the head presses equally on the two neck plates, but when it is dancing vertically with its head directed upwards, the lower or heavier part of the head sinks and the pressure on the lower part of the head is greater. If a piece of lead is attached to the top of the bee's head, so that the top of the head presses down on the hair plate, the bee will confuse 'up' and 'down'. There are other hair plates at the articulation of the thorax and the abdomen, and at the leg joints, which are also involved in gravity perception.

Central summation takes place in the nervous system of arthropods. The stimulation of chemosensitive hairs on the tarsi of a fly by contact with sugar causes it to extend its proboscis. If a tarsus on one side is touched with a sub-threshold concentration at the same time as tarsus on the other side, the proboscis will be extended if the sum of the concentrations is greater than threshold. Heterogeneous summation can also take place when a group of stimuli act together to release an instinctive act. Mosquitoes are more attracted to dark than to fair skins, and to warm rather than to cool skins. A fair warm skin can be as attractive as a cooler dark one. Similarly, the spider *Salticus scenicus* can be induced to attack models, and shows a distinct preference for

three-dimensional models and for models moving fast. A flat fast-moving model can be as effective as a rounded one moving slowly.

One of the most interesting chapters deals with learning in arthropods. Many arthropods are capable of learning simple T-mazes to get at a food source, and wood-lice can in addition learn to take the upper or the lower of two alternative pathways. Ants can learn much more complicated mazes. These are examples of 'positive conditioning'. The spider *Salticus scenicus* can be trained to associate attacking a particular shape with an electric shock, and learn not to jump at it. This is 'negative conditioning'.

Arthropods also show 'latent learning', where the experience is not of immediate importance but memory influences behaviour after an interval of time. Such learning of landmarks by social insects does not bring any immediate reward. A particularly interesting example is the ichneumon fly, which lays eggs on the flour moth *Ephestia kuhniella* caterpillars and will choose these by smell if offered a choice between them and other lepidopteran larvae. But, if the parasites after emergence are exposed to an air-stream bearing the scent of the moth *Meliphora grisella*, they choose this scent as often as that of *Ephestia* in the olfactometer.

Most work on arthropod behaviour has been concerned with insects. The author has integrated this with information about other groups wherever possible.

R. R.

2. THE COMPANY OF ANIMALS. By Ronald McKie. pp. 225 (22.5×14.5 cm.). With 31 photographs on 16 plates. Sydney, 1965. Angus & Robertson Ltd. Price \$3.75, 37s. 6d.

Since the War there has been a spate of books on animals, particularly on those that are usually termed as large game. The bombs effectively prevent universal participation in the so-called peoples wars which occur like brush fires in odd spots of the world and the searcher for vicarious thrills has to rely on the exploits, often questionable, of the hunter. The trend now shows a welcome inclination towards conservation of Wild Life rather than its decimation. This book is, however, slightly different being the biography of James Hislop, the last 'white' Game Warden of the King George V National Park in Malaya.

Many of the incidents are related at considerable length and being told by a person who was not present, leave an air of scepticism about the whole story. There are also unfortunate repetitions of some of the old saws like the King Cobra's speed equalling that of a galloping horse.

and other stories which one is inclined to view with surprise e.g. a small bird crossing the river seated on the tail of a Great Hornbill (p. 20) and lightning visible at several miles created by elephants shaking their bodies. It is added that the cows and the bulls make different kinds of lightning, while Seladang also produce a flickering lightning. A wild elephant cow was seen nursing six calves, and Mouse Deer are said to tap with their feet when courting. The baby Mouse Deer is 3 inches long and 2 inches high, a miniature of the adult.

On page 16, reference is made to the many volumes of the Bombay Natural History Society's *Journal* which formed an important part of Hislop's library. Some of the items mentioned in the book would certainly have made excellent subjects for Miscellaneous Notes and it is unfortunate that we do not get them directly from the observer, for there is little doubt that some of them have been misquoted.

In Malaya as in India, Wild Life is on the decline. The Javan Rhinoceros is extinct and the Sumatran Rhinoceros well on the way to extinction. The passage, from the book, quoted below precisely expresses what protection of Wild Life asks of the human population of a country.

'Preservation is a state of mind, a climate of opinion, a realizable aim. It doesn't emerge from apathy and indifference. It doesn't prosper on the assumption, rooted in ignorance, that animals, and the land that is their home, are limitless and will last for ever. It is a product of maturity. It rises out of intelligent concern not only for animals but for the nation's most precious asset, its land.'

J. C. D.

3. THE PHYSICAL GEOGRAPHY OF THE OCEANS. By Charles H. Cotter. pp. 317 (16×24 cm.). Numerous figures. London, 1965. Hollis & Carter. Price 35s. net.

This book is a welcome addition to the large number of books that are now being published on Oceanography. The study of the oceans has made rapid advance during the last score of years. With the dwindling of natural resources on land, man is now turning his attention to the vast unexplored and less exploited regions of the oceans and many nations of the world are planning large-scale studies of the oceans.

In this context, bringing together all the related knowledge of the oceans and presenting it in a concise form is very essential and Cotter's book is an admirable job in this respect. The author's long career as a navigation officer in the Merchant Navy from 1939 and later as lecturer in Navigation at the South Shields Marine and Technical College

since 1962, has helped him to present different aspects of Oceanography in simple and precise language. On account of this, the book is eminently suitable as a text book for colleges, and more particularly for marine science and marine engineering students, who require a basic knowledge of the science of Oceanography.

The book covers almost the entire gamut of Oceanography and includes chapters on origin and distribution of the Continents and Oceans, coastlines and shores, the ocean bed, properties of sea water, life in the sea, corals and coral reefs, sediments and deposits on the sea floor, weather and climate over the oceans, tides and related phenomenon, ocean currents, and instruments used in ocean research. The book ends appropriately with a chapter on the history and progress of the science of the sea.

T. S. S. R.

4. **BUDONGO.** By Vernon Reynolds. pp. 228 (14×24 cm.). 16 black-and-white plates. 5 figures. London, 1965. Methuen & Co. Ltd. Price 36s. net.

The exuberant Chimpanzee, man's nearest relative in the Animal Kingdom has been studied in captivity more than any other species of ape. Their life and social behaviour in the wild was little known. In this book Vernon Reynolds tells of his field observations on the Chimpanzee, during the eight months, he and Mrs. Reynolds spent in the Budongo forests of Uganda studying the daily life and social behaviour of the Chimpanzee. The results of their hours of patient observation make absorbing reading.

The Chimpanzee's social organisation is not family based like that of the Gorilla but is a loosely knit community of sixty to seventy animals using a home range of six to eight square miles where their life revolves round the different fruiting seasons of their main food plants. Its extreme noisiness and the habit of drumming on the buttress roots of forest trees, advertises the movement of Chimpanzee groups through the forest when food is abundant, and enables groups to concentrate at the source of food. The hooting and drumming by a group in movement is so fantastically loud that it is very intimidating to other species including Man.

The book is a fund of information on the Chimpanzees, other animals, the forest and the people that the Reynolds saw and lived with, during their eight months stay in Uganda.

J. C. D.

5. HANDBOOK OF WATERFOWL BEHAVIOUR. by Paul A. Johnsgard. pp. 378 (24 × 16 cm.). With 11 plates and 96 figures. London, 1965. Constable & Co. Ltd. Price 75s.

Based on earlier publications in scientific journals and extensive original research, mostly at the Wildfowl Trust in England, Dr. Johnsgard provides a detailed survey of the fixed action behaviour patterns of ducks and geese. The method is comparative and each species is described individually and then related to those it most resembles. The result is an important contribution to the taxonomy of the group. More than 100 pages of photographs and drawings make this work one of the most effective exercises in descriptive ethology yet completed and the waterfowl the best known group of birds in this respect.

This book is, however, by no means the last word on waterfowl behaviour. Most of the study is based on observation under captive conditions and much further information regarding species ecology, population dynamics and population dispersion in different seasons is needed before a comprehensive evolutionary analysis can be attempted. Johnsgard's book remains an important step forward and will be essential reading to those whose research interests include comparative avian ethology or any aspect of wildfowl life.

J. H. C.

Miscellaneous Notes

1. CALCIUM DEPRIVATION AND OSTEOMALACIA IN A SLENDER LORIS, *LORIS TARDIGRADUS* (LINNAEUS)

(With a plate)

In November 1964, a tame male loris, *Loris tardigradus* (Linnaeus), was purchased in Bangalore. This animal handled easily and climbed freely on anyone. He was taken to Vellore and permitted to live free in the bedroom of E.E.C. His diet consisted of half a banana and three ounces of whole unboiled milk daily. In February 1965, a wilder and larger female loris was obtained and she too was placed in the same room as the male. The food ration was doubled.

The two animals spent their days huddled together sleeping in a corner but became active at night, eating and exploring. A small residuum of milk and banana in the morning proved the adequacy of the diet offered. They appeared to get on well. Following the addition of the female, however, the male was less easily picked up.

In mid-April 1965, we left Vellore for three months, leaving the lorises in the care of a couple who occupied our home. On our return in July 1965, the male was found huddled in a corner, scarcely walking and objecting noisily to any handling. He seemed in pain whenever he moved. He did not climb at all. His arms were noted to be markedly bowed. The female appeared normal.

X-rays (Plate) of the arms of both animals were read by Dr. A. S. Tucker, Department of Radiology, Christian Medical College Hospital, Vellore, as follows :

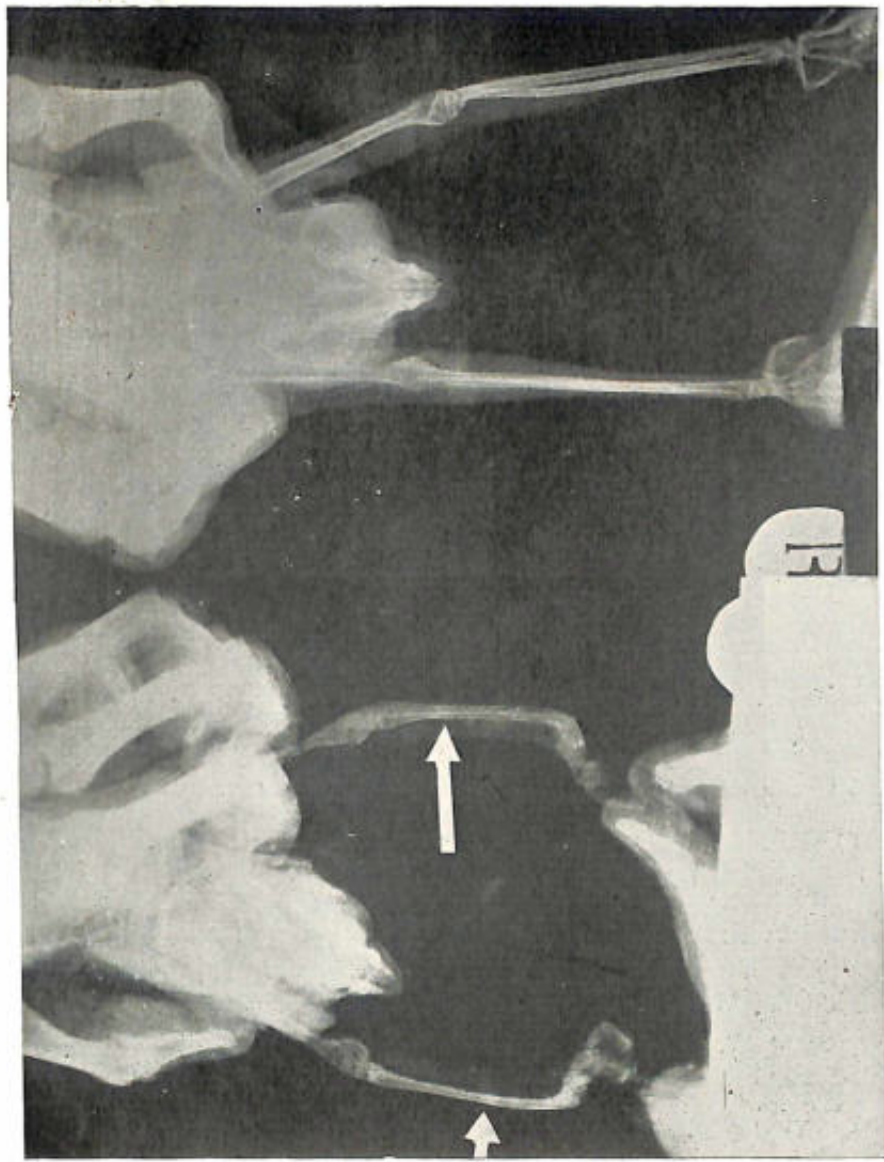
"View shows under mineralization of the bones of the forearms, and several irregular bands of sclerosis across the bones which seem to represent healing fractures.

"There is bowing of the forearms, most marked just above the wrists.

"The cortex is rather thin in both upper and lower arms, which fact is rather readily apparent on comparison of the film with those of the control adult female."

Questioning then revealed that, instead of their regular two cups of milk daily, the lorises had in our absence been offered only one cup.

Apparently, the stronger, more aggressive female had consumed this leaving the male without milk and practically without calcium and vitamin D. As a result, he had, it seems, over the three-month period lost sufficient calcium from his bones to render them incapable of supporting his weight when he climbed, thus leading to the fractures.



X-ray of arms of calcium-deficient loris (*left*) and normal comparison (*right*)

According to Duncan (1953) an adult human requires 7-8.5 mgm. of calcium per kg. per day. The original diet offered supplied approximately 89 mgm. of calcium per day to each of the 200-300 gram lorises.

A full milk and banana diet was restored, and the loris was given in addition 400 units of vitamin D daily for a month. Within two weeks there was marked improvement in his activity but it was approximately six weeks before he was again climbing. The deformities, as would be expected, persisted. Although activity returned to normal, there was little change to be seen in a X-ray taken ten weeks following the first.

Shortly thereafter he was accidentally electrocuted while climbing on a lamp.

This report is offered simply as an interesting case and also as yet another example of the pervasiveness of what James Thurber has termed the 'War Between Men and Women'.

CHRISTIAN MEDICAL COLLEGE,
VELLORE,
May 5, 1966

DONALD E. CAREY
EDWARD E. CAREY

REFERENCE

- DUNCAN, G. O. (1953): Diseases of Metabolism, 3rd ed. W.B. Saunders Co., Philadelphia.

2. AUTHORSHIP OF THE NAME *PRESBYTIS GEEI*
[MAMMALIA: PRIMATES]

The existence of the Golden Langur in Assam was first brought to the notice of the writer of this note and his colleagues by Mr. E. P. Gee in the winter of 1954-55. On that information, the Zoological Survey of India sent a party headed by Mr. H. Khajuria in March-April 1955 to Jamduar, Goalpara district, Assam, to obtain some specimens of that langur for the department. Mr. Khajuria brought back six specimens which on careful study were found to represent a hitherto unknown species of langur of the genus *Presbytis*. Mr. Khajuria prepared the description and in appreciation of Mr. Gee's contribution to the discovery of the species, named it after him as *Presbytis geei*. While this paper was still under publication in the *Annals and Magazine of Natural History* (Sr. 12, Vol. 9, pp. 86-88, published February 1956), an article on the habits and a brief description of the Golden Langur by Mr. Gee appeared in the *Journal of the Bombay Natural History Society* (Vol. 53, pp. 252-254, published January 1956), in which he wisely and carefully refrained from

using a scientific name for this species. Unfortunately, the editors of the *Journal* added a note to Mr. Gee's paper (*op. cit.*, p. 254): 'We understand from Mr. Khajuria of the Zoological Survey of India that his description of this new species of langur, which he has named *Presbytis geei*, will shortly be published in *Annals and Magazine of Natural History*.' Mr. Khajuria's paper also bore an editorial note (*op. cit.*, p. 86): 'Following a strict interpretation of the International Rules of Zoological Nomenclature this species has already been named (although unintentionally) *Presbytis geei* by E. P. Gee (*J. Bombay Nat. Hist. Soc.* 1956, 53: 252-254, 1 fig., published 20th January 1956). The present work is however the first scientific description of the new species.'

Since Mr. Gee was not responsible for the new name, the present writer has been ignoring his paper for the purpose of nomenclature. However, in the recently published revised edition of Prater's *THE BOOK OF INDIAN ANIMALS* (Bombay, 1965), there is a footnote on p. 42, which says that the author of the name *Presbytis geei* is Gee and not Khajuria, and this has prompted the writer to examine the question in detail.

All this confusion has arisen from the editors of the *Journal of the Bombay Natural History Society*, publishing the manuscript name *Presbytis geei* of Khajuria simultaneously with Mr. Gee's descriptive paper. Now, according to the Article 50 of the International Code of Zoological Nomenclature (1961) the author of a name is the person who 'is alone responsible both for the name and the conditions that make it available.' It is very obvious that Mr. Gee is not responsible for the name *Presbytis geei* even though the descriptive matter in the text are not only diagnostic but also made by him. The editorial note to the paper (Gee, *op. cit.*, p. 254), however, constitutes, for the purpose of nomenclature, a separate article by separate authors. In this separate article no description is given and the authorship of the new name is clearly credited to Mr. Khajuria. At this place and in this separate paper by the editors the name *Presbytis geei* is a *nomen nudum*. Furthermore, the authorship of this footnote article is anonymous and the name *Presbytis geei* would be unavailable according to Article 14 of the Code, even if it were otherwise considered available. In Mr. Gee's paper the name *Presbytis geei* does not occur anywhere except in the caption of the distribution map, but there is no indication anywhere if this name refers to the Golden Langur. As such, Mr. Gee cannot be held responsible for introducing the new name.

It follows, therefore, that the first publication of the name *Presbytis geei* in a manner to satisfy the provisions of the Code for availability is that in the *Annals and Magazine of Natural History*, Series 12, Volume 9, pages 86-88, and that the authorship of the name is to be credited to Mr. Khajuria as of February 1956.

The writer is greatly indebted to Professor Ernst Mayr and Dr. Krishna Kant Tiwari for their wise counsel in his attempt to solve this problem.

ZOOLOGICAL SURVEY OF INDIA,
INDIAN MUSEUM,
CALCUTTA 13,
August 1, 1966

BISWAMOY BISWAS

3. SOME OBSERVATIONS ON THE HAIRYFOOTED GERBILLE, *GERBILLUS GLEADOWI* MURRAY, IN THE RAJASTHAN DESERT

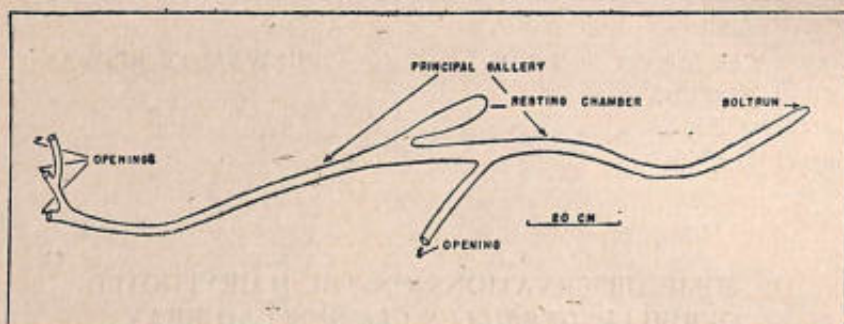
(With a text-figure and a photograph)

There is little information available on the ecology of the Hairyfooted Gerbille, *Gerbillus gleadowi* Murray (Blanford 1888-91). These observations were, therefore, recorded on the rodent in the westernmost part of the Rajasthan desert.

Habitat. *G. gleadowi* is distributed in the arid belt of Jaisalmer-Gadra Road-Jodhpur and is more common in the Gadra Road region where its burrows are found on sand dunes, usually in association with the bushes *Calotropis procera*, *Zizyphus nummularia*, *Capparis decidua* and *Aerva tomentosa*—they seem to prefer the first plant to burrow under. Their burrows are not found on sandy plains in this area; there they are replaced by the Desert Gerbille, *Meriones hurrianae*. In the Jaisalmer tract, the desert is predominantly characterized by gravelly sand formations and the *Gerbillus* inhabit mainly the sides of the roads where their burrows are to be found under *Calotropis* and *Zizyphus* bushes. Their habitat is characterized by *Calotropis* bushes and long streaks of sand dunes in the sandy plains, away from the road where they are found in patches and their number is usually very low. In this region they prefer habitat having hummocks of sand. Discussing the habitat preference of the gerbilles of Israel, Zahavi & Wahrman (1957) grouped *G. gerbillus*, the Middle Eastern species nearest to *G. gleadowi* as psammophile, i.e. 'confined to either shifting sand dunes or to more or less stable sand formation'. In the Rajasthan desert, *G. gleadowi* is also psammophile in its habitat preference.

Burrows. The burrows follow a simple pattern and have a principal gallery with two to three smaller tunnels leading to openings outside a bolt run, and a resting chamber (see Figure). The burrow resembles that of *G. gerbillus*, which comprises of a main tunnel bifurcating at both extremities into four galleries (Petter 1961), a bolt run, and an ampul

accommodating the nest and corresponding to the resting chamber of *G. gleadowi*.



Text-fig. View (from above) of the burrow of *Gerbillus gleadowi* Murray

Habits. The Hairyfooted Gerbilles (photograph) are nocturnal, venturing out soon after dusk and retiring after midnight. They are not crepuscular like the Desert Hare, *Lepus nigricollis dayanus*.

We did not find any gerbille in the Jaisalmer region during winter, which suggests that they either hibernate or are torpid during the cold spell.

Although their hind feet are quite long they do not move about only on them as the true jerboas do. When chased they leap to keep the collector at a distance. Collection of gerbilles was done with spot light and butterfly net. While collecting them we observed that they stand erect on their hindfeet and jerk their body forward and backward in quick succession. At times, while escaping, they entered the burrows of the merion gerbille but quickly came out to enter their own burrows, which they closed from the inside by shovelling sand on to the opening, an action done so quickly and neatly that it was very difficult to locate the burrow opening afterwards. This might be an effective adaptation to evade the snakes which feed on the rodents.

Stems of *Cenchrus biflorus*, the leaves and flowers of *Crotalaria burhia*, stems of *Eleusine compressa*, and seeds of *Lasiurus indicus* were found in the burrows. In captivity, *Gerbillus* thrived on grains and preferred millet, *Pennisetum typhoideum*, and the pulse *Phaseolus acontifolius*, the total daily consumption being 16.20 and 15.07 gm. per 100 gm. body weight respectively. Their food requirement appears to be more than that of the Desert Gerbille, which consumes 8.08 gm. of millet and 5.29 gm. of the pulse per day per 100 gm. body weight. *G. gleadowi* being of a smaller size than *Meriones hurrianae*, a higher rate of food consumption per unit body weight is to be expected as the former will have a higher metabolic rate than the latter.

Sex Ratio. In collections from the Rajasthan desert females were slightly in excess, 29 against 25 males, but the difference was not statis-

tically significant. Contrariwise, a sample of this gerbille from Sind (Ellerman 1961) comprised 14 males and 10 females.



The Hairyfooted Gerbille, *Gerbillus gleadowi* Murray

Note white pelage around eyes and on bases of ears

Breeding. Out of the summer collection, two females were pregnant, carrying three and four young respectively. Two more females delivered litters of two young each. Out of 19 rodents collected in July 1964, 8 were sub-adults, indicating that littering had taken place in June. In the Gardens of the Zoological Society of London, *G. gerbillus* delivered from April to June and litters consisted of three to five young (Zuckerman 1953). Our observations also indicate that littering in *G. gleadowi* occurs during summer.

The New-born. Pink in colour; skin translucent and abdominal

contents almost visible; no hair coat; eyes closed; pinnae folded and enclosed in a membrane; very short vibrissae.

The young ones in the two litters were almost equal in size; head and body length 39.0-40.0 mm. (mean 39.5 mm.); tail 15.0 mm., hind-foot 8.0-9.0 mm. (mean 8.2 mm.); weight 1.8-2.0 gm. (mean 1.9 gm.).

Zoogeography. Most species of the genus *Gerbillus* are distributed in the Palaearctic deserts (Ellerman 1961), only three species having entered the Oriental Region: *G. nanus* distributed from Algeria and south Egypt to Baluchistan; *G. dasyurus* from Algeria to Thar Desert; and *G. gleadowi* found only in the Sind-Rajasthan desert and regarded as an endemic desert species (Prakash 1963). Presumably *G. gleadowi* evolved after xeric conditions started establishing in this subcontinent.

Acknowledgements. Thanks are due to Dr. Pulak K. Ghosh, Animal Physiologist, Shri L. R. Kametkar, Senior Scientific Assistant, and Shri H. P. Sharma, Junior Scientific Assistant, for assistance during the field work.

DIVISION OF SPECIAL ANIMAL STUDIES,
CENTRAL ARID ZONE RESEARCH INSTITUTE
JODHPUR,
February 2, 1966.

ISHWAR PRAKASH
K. G. PUROHIT

REFERENCES

- BLANFORD, W.T. (1888-91): *The Fauna of British India, Mammalia*, Taylor and Francis. London.
- ELLERMAN, J. R. (1961): *The Fauna of India including Pakistan, Burma and Ceylon*. 3 (1): 391. Manager of Publication, Delhi.
- PETIER, F. (1961): *Repartition géographique et ecologie des rongeurs desertiques (du sahara occidental a Iran)*. *Mammalia* 25 (No. special): 1-222.
- PRAKASH, ISHWAR (1963): *Zoogeography and evolution of the mammalian fauna of Rajasthan desert, India*. *op. cit.* 27: 342-351.
- ZAHAVI, A. & WAHRMAN, J. (1957): *The cytotaxonomy, ecology and evolution of the gerbilles and jirds of Israel (Rodentia: Gerbillinae)*. *op. cit.* 21: 341-380.
- ZUCKERMAN, S. (1953): *The breeding seasons of mammals in captivity*. *Proc. Zool. Soc. London*, 122: 859.

4. AN OUT-SIZE ELEPHANT (WITH A NOTE ON MEASURING ELEPHANTS)

On 21 May 1965 at about 6 p.m. in Koilamari Tea Estate grant, bordering on Reserve Forest and North East Frontier Agency, I came upon the out-size tracks of this very large Bull Elephant, after a day of heavy rain. The tracks led out of the Reserve Forest and along a boundary path which separated the Koilamari T. E. grant from the

Reserve Forest. The spoor was very fresh and, as I hurried along the gloomy path following the spoor, my ears were attuned to hear the crash of breaking jungle which normally heralds the close proximity of elephant.

Tree trunks along the path I now followed showed rub marks which to me passing beneath and beside them indicated a gigantic animal. The tracks crossed a small water course and, as evening was now closing in fast, I knew that if I did not contact the animal within half an hour, I would have to look for him another day.

About sixty yards after crossing the stream, he had rubbed himself against a large dead tree stump, so recently that water and mud were still dripping off the trunk. I stopped and listened, and about forty yards to my right front I heard the cracking and breaking of branches. The tracks led off the boundary path towards the noise I heard. Quietly and quickly, as there was not much time, I hurried along the path he had made—fortunately the jungle was thin and the undergrowth sparse. He was very close now, and not being able to check wind direction, I paused a few seconds in order to calm down and make final checks on my rifle.

Fifteen yards ahead was a giant tree, and from just behind this had come the last sound of elephant noise. Creeping forward, I peered around the tree and saw the huge rear of the elephant, who was still unaware of my presence. So I stepped around the tree, raised my .404 rifle, and prepared to shoot as soon as I could see a vital spot—the distance was twenty paces. He slowly swung three-quarters round and I saw the dull gleam of ivory. Using the $\frac{3}{4}$ -angled brain shot for the head for the first time, I pressed the trigger as soon as line and angle were right.

With the roar of explosion, the huge beast slumped to his knees and I am quite sure he did not hear the shot which killed him. However, I ran up at once and administered my normal safety shots.

As my eyes ran over his magnificent proportions, I realized that here indeed was a very large elephant, possibly one of the largest I would ever shoot. His measurements, taken next day, more than proved this.

I note below the measurements which have been verified by the Forest Range Officer, North Lakhimpur :

Circumference Measurement :	Left Forefoot	65½ in.
	do	Right Forefoot 65½ in.
	do	Left Rearfoot 56½ in.
	do	Right Rearfoot 56½ in.

Height at shoulder taken down the length of the leg, right side (measured with steel tape) : 10 ft. 11½ in.

Estimated height (2 × circumference of forefoot) : left 10 ft. 11 in.
right 10 ft. 10½ in.

The right forefoot had one toe nail damaged which would account for the $\frac{1}{4}$ in. difference between the forefeet measurements.

KOILAMARI TEA ESTATE,
LAKHIMPUR NORTH P.O.,
NORTH LAKHIMPUR,
ASSAM,
August 6, 1965.

DUNCAN HAY

[Mr. E. P. Gee, whose comments were invited, writes :

'I have read with interest the account by Mr. Duncan Hay of the killing by him of a very large wild elephant, and find that his report appears to be authentic. I would point out, however, that it is extremely difficult to avoid errors in measuring elephants—whether dead or alive. I have myself done quite a lot of measuring of live tame ones, and I seldom find it easy to do—even with a very docile captive elephant, because of uneven ground, continual changes of posture of the animal, and the measuring tape (for the forefoot measurement) being either too stiff (of steel) or too soft (of cloth).

'I have found that the only accurate method of measuring the forefoot is to use a piece of thin, flat cane and to have another man lift up the other forefoot so that the one that I am measuring is pressed down. For measuring the shoulder height two stiff and straight bamboo sticks are required, with another man standing some distance away to see that I have got the upper piece of bamboo flat across the shoulder and absolutely level with the ground. Even with all these ideal conditions, I find a lot of differences and discrepancies in the measurements, and usually have to take the average of a number of times. And the shoulder height is seldom exactly, usually only approximately, double the circumference of the forefoot.

'Obviously measuring a dead elephant, especially one lying in an awkward position or on uneven ground, must be very much more difficult.

'The measurements of the largest dead wild elephants are nearly always greater than those of the largest live captive ones; and this fact has always led people to believe either one or both of the following: (1) that elephants grow to a bigger size in the wild state, and/or (2) that elephants measure more when lying down (whether dead or alive) than when standing up.

'The only case, I think, of anyone putting to the test whether live elephants measure more when lying down than when standing up is the late E. O. Shebbeare. He once measured the shoulder heights of 23 female elephants both standing up and lying down, and also the circumferences of their forefeet. The average of these measurements

shows an increase in height of no less than six inches when the elephants were lying down: 8 ft. $7\frac{1}{2}$ in. compared with 8 ft $1\frac{1}{2}$ in. Incidentally the twice-round-the-forefoot measurement came to 8 ft. 2 in., almost coinciding exactly with the standing height. Now a difference of six inches in 8 ft. 6 in. means a difference of $7\frac{3}{4}$ in. in 11 ft., so this amount of allowance would have to be made in all measurements of record dead elephants unless these were based on the forefeet circumference.

'Shebbeare's own conclusions after the above experiment were that "a live elephant measures approximately 6.3% more lying down than standing up and that the twice-round-a-forefoot measurement is a good approximation on the average though there may be glaring exceptions in individuals."

'So it follows that the large elephant shot by Mr. Duncan Hay, and also the record 11 ft. elephants recorded by Mr. P. D. Stracey in the *Journal*, Vol. 46 at pp. 717-718, must also have 6.3% deducted from their dead measurements to show what they must actually have measured when alive.

'The following two museum pieces are, I think, the record Indian elephants of all time (within the last hundred years or so): (1) the one which I think is in the Madras Museum measuring over 11 ft., and (2) the skeleton in the Indian Museum of Calcutta, which measures 11 ft. 3 in. at the anterior dorsal vertebra just above the scapula, and bears the laconic description: "Santal Parganas, W. M. Smith 1879." When alive this latter elephant must have stood about 12 ft. high—a truly formidable creature.']

5. THE SHORT-TAILED OR RED-BILLED TROPIC-BIRD (*PHAETHON AETHEREUS INDICUS* HUME) AT KIHIM ON THE MAHARASHTRA COAST

On the 8th of May 1966, a Short-tailed Tropic-bird was found dead in some bushes at around 11.00 a.m. on the coast of Kihim, about 12 miles south of Bombay, location c. $18^{\circ} 45'N.$, $72^{\circ} 53'E.$, by Idrees Ali and Nisar Sikander. It was skinned by me there, and sent to the Bombay Natural History Society through Mr. Humayun Abdulali.

33, PALI HILL,
BANDRA, BOMBAY-50,
May 24, 1966

RAUF ALI

[The author is a twelve year old boy. The skin, now in the Society's collection, is identified as that of *Phaethon aethereus indicus* Hume.

According to Hume (1876, *Stray Feathers* 4: 481) the bird is found in a zone between 7 and 30 miles offshore. Sinclair (1886, *J. Bombay nat. Hist. Soc.* 1: 168) included it among pre-monsoon strays and swept-ins but recorded no specimen actually taken on the coast. The first such record, from Marine Drive in Bombay, was reported by Novarro (1962, *J. Bombay nat. Hist. Soc.* 59: 649). The present specimen, found in good condition in vegetation 8 to 10 yards above high-water mark, is probably a bird that was washed ashore in an exhausted state. A sight record in February (Novarro, *ibid.*) is interesting as it suggests the possibility that the bird is commoner ashore than is generally realised.

—Eds.]

6. NOTES ON INDIAN BIRDS 10—OCCURRENCE OF THE CHINESE GREY DUCK/SPOTBILL (*ANAS POECILORHYNCHA ZONORHYNCHA* SWINHOE) IN INDIA

In *Cheetal*, the journal of the Wild Life Preservation Society of India, for October 1964, Mr. M. J. S. Mackenzie of Balijan North Tea Estate, Chabua P.O., Assam, referred to Chinese Spotbill (*Anas poecilorhyncha zonorhyncha* Swinhoe) as regularly found in Assam during the cold weather. Since the earlier records of this form were discarded in the FAUNA and the SYNOPSIS and the only evidence of its occurrence in India was believed to be the bird obtained by Inglis in Bihar (*J. Bombay nat. Hist. Soc.* 34: 810), I suggested a mistake in its identification.

Mr. Mackenzie promptly countered by shooting and sending to me two ducks which, from the specimens and literature available to me in Bombay, appeared to be *zonorhyncha* and this has been confirmed by Dr. Dillon Ripley. I also found these specimens to be identical with another shot by Parsons at Pasighat, Sadiya Frontier, Assam, and noted by Stuart Baker (*op. cit.*, 39: 638) as intermediate between *zonorhyncha* and *haringtoni* [from Burma with a green speculum—H. A.]. His note however went on to say that the latter had a purple-blue, speculum¹. This prompted me to make a more careful examination of the earlier records with the following results:

In 1904 (*J. Bombay nat. Hist. Soc.* 15: 718) Stuart Baker said that he and, earlier, Moore and Mandy had shot several *zonorhyncha* out of a flock of about 40 birds on Sirsi Bheel in Dibrugarh in the extreme east of Assam, and repeated the statement in the first (1908) edition of INDIAN DUCKS AND THEIR ALLIES. In the latter, he discredited Oates's recently described *haringtoni* from Burma, holding that they were only

¹This statement appears to be due to some oversight. The error was corrected in the *errata* list at page xviii of Vol. 39, Nos. 3-4 of the *Journal*.—Eds.

immature birds in which the red spots at the base of the bill had not yet developed.

In 1913 (*J. Bombay nat. Hist. Soc.* 22: 806) he agreed that *haringtoni* was separable and classed the east Assam birds as of this race. This was repeated in the second (1921) edition of INDIAN DUCKS, and in the FAUNA, where Inglis's specimen from Bihar, referred to earlier, was said to be the only record of *zonorhyncha* from India.

In 1931 J. C. Higgins (*J. Bombay nat. Hist. Soc.* 35: 460), seeing Inglis's note and having access only to the first edition of INDIAN DUCKS, drew attention to the earlier records of *zonorhyncha* and said he had seen and shot them himself in Assam. Inglis (*op. cit.* 35: 687) replied that the earlier records were of *haringtoni* 'a quite different bird with a blue and not green speculum'. Higgins (*op. cit.* 36: 266) drew attention to this error in colour, but Inglis neither offered an explanation nor admitted an error. Later Higgins repeated his earlier records (*op. cit.* 36: 421) and referred (*op. cit.* 37: 224) to two more *zonorhyncha* shot on the north bank of the Brahmaputra.

In all this confusion one can only guess that, when accepting *haringtoni* as a valid race from Burma, Stuart Baker made the mistake of assuming, without examination, that the earlier records of *zonorhyncha* from Assam were all in error for this form. That these Assam birds were not *haringtoni* is endorsed by the fact that Oates, when describing this race specifically referred to two specimens from Assam 'recently acquired for my collection and recorded in the Society's Journal as *zonorhyncha*'.

From the material and literature available in Bombay, *zonorhyncha* is distinguished from the typical race by:

(a) the absence of red spots at the base of the bill (a character shared with *haringtoni*, at least at certain seasons or stages),

(b) the lower portion of the underparts being more or less uniformly brown, and not spotted,

(c) the absence of the white bar on the secondaries above the speculum,

(d) the speculum being purple-blue and not green. Regarding the colour of the speculum it must be noted that, though the speculum of typical *poecilorhyncha* from peninsular and western India is green and at the same angle outstandingly different from the purple-blue in *zonorhyncha*, these colours change and replace each other at different angles and it is possible to get a purple-blue effect in the greenest speculum, and *vice versa*. From the limited number available for examination, it also appears that this tendency to turn from one to the other increases as one approaches an intermediate area and is most prominent in specimens of *poecilorhyncha* from Assam and in *haringtoni* from Burma, though both can be accepted as green.

(e) a dark line formed by speckles extending from the base of the bill towards the ear-coverts. This character is shared with at least three races of *Anas superciliosa* (vide Delacour's THE WATERFOWL OF THE WORLD 2: 62) but does not occur in *poecilorhyncha*.

The westernmost record of *zonorhyncha* is still Inglis's from Bihar, which is now at the Yale University, and whose identity is confirmed by Dr. Ripley. But there is also no doubt that the earlier records from Assam were correct and there was no need to discard them.

The number of mistakes that have dogged the descriptions and accounts of this species is indeed remarkable—even the colleague whose birds Stuart Baker first identified as *zonorhyncha* has had his name written as Mandy, Mondy, and Mundy in the notes referred to above!

However there can now be no doubt that *A. p. zonorhyncha*, The Chinese Grey Duck, is a fairly regular winter visitor to eastern Assam, and once strayed as far west as Darbhanga in Bihar.

75, ABDUL REHMAN STREET,
BOMBAY-3,
June 7, 1966

HUMAYUN ABDULALI

7. THE PINKHEADED DUCK [*RHODONESSA* *CARYOPHYLLACEA* (LATHAM)] AGAIN

(With a plate)

This is to inform the Bombay Natural History Society that, in the year 1947 on the 27th January in the afternoon, I shot a Pinkheaded Duck [*Rhodonessa caryophyllacea* (Latham)] at Manroopa Lake in Khagaria subdivision, Dist. Monghyr, in my Estate area known as Bahadurpur Estate. The said duck, six in number, took off from Manroopa jheel and came over me and I shot only one. Sir Hugh Dow, Governor of Bihar, and Mr. E. O. Lee, I.C.S., Member of the Board of Revenue, Bihar, were in the shoot. The latter gave me a letter of testimony which read that the Pinkheaded Duck is rarely found in India and he congratulated me, but this letter is misplaced at present.

Again in 1948-49 I saw some Pinkheaded Duck on the Lake Manroopa, about 5 to 8 of them, but they did not come over me so I could not shoot.

SHAKARPURA RAJ,
P.O. SHAKARPURA RAJ,
DISTRICT MONGHYR, BIHAR,
January 18, 1965.

LALITESHWAR PRASAD SINGH

Singh : Pinkheaded Duck



Pinkheaded Duck *Rhodonessa caryophyllacea* (Latham) in the Patna Museum.

(Photo : T. P. Singh)

[The last authentic record of the Pinkheaded Duck dates back to 1935. It is feared that the species is extinct, and for some time now the Society has been making enquiries about it. A report of an unsuccessful investigation in north Bihar is published at pp. 415 ff. of Vol. 57 of the *Journal*. Immediately after the report follows a claim by Mr. K. L. Mehta, Deputy Game Warden, Himachal Pradesh, to have seen Pinkheaded Duck in February 1960 about 40 miles south of Simla. This, however, was in circumstances which made identification difficult, by torchlight between early dawn and sunrise (see H.A.'s review at page 626 of Vol. 59 of the *Journal*). The present claim comes from near Bakhtiarpur (generally known as Simri Bakhtiarpur to distinguish it from Bakhtiarpur in Patna District), formerly in Monghyr District and from 1965 in Bhagalpur District, where a pair of Pinkheaded Duck were shot in 1924 (see Plate opposite and our Editorial Note at the top of page 417 of Vol. 57 of the *Journal*).

The letter of testimony referred to by our correspondent has not been traced. Mr. E. O. Lee is dead. Sir Hugh Dow, now in London, remembers the shoot but not the shooting of a Pinkheaded Duck. He adds, however, that he sees no reason to doubt our correspondent's statement. It is not impossible that the species still survives in some remote corner of its former haunts. We are therefore placing the present claim on record, in the hope that those of our readers who live in or visit this area or any other area where the species is known or believed to have been seen will keep a look-out for it. We may add that since 1956 it is a punishable offence to kill or capture the bird. Sportsmen would therefore be wise to learn to recognise the bird. If the bird is found, intimation should be sent at once to the Society.

We are grateful to Mr. T. P. Singh, Chief Secretary, Government of Bihar, for sending us the photograph of the Pinkheaded Duck exhibit in the Patna Museum.—EDS.]

8. AGGRESSIVE BEHAVIOUR OF A SPOTTED OWLET [*ATHENE BRAHMA* (TEMMINCK)]

A pair of Spotted Owlets, *Athene brahma* (Temminck), have their roost under the roof of the Range Forest Office here. One of the pair has an annoying habit; when they come out of the roost in the evening, it attacks anybody walking or sitting outside in the Range Office compound.

On 20 March 1966, at about 17.15 hrs., while I was walking about the compound, it swooped down on my head from behind giving me a nasty shock! At that time, I thought it overshot one of the common yellow bats (*Scotophilus heathi*?), which were flying around, and landed on my head and I was thankful that I am not bald! On 27 March

evening, I was talking with a gentleman sitting outside in the Range Office compound; I saw both the birds come out of the roost and perch on a branch of a *Zizyphus* tree. Suddenly without any reason or provocation, one of the owlets came sweeping down on my companion's head from behind. It made three more unsuccessful and determined attacks on us within the next fifteen minutes, and we beat a hasty retreat! Only one of the pair made the attacks—the other just took a ringside seat.

The Depot Officer, who lives next to the Range office, reported that almost everybody in his family had been attacked by the owl. The old forest guard sadly said that the *saitan* (devil) has a special liking for him, once or twice inflicting bleeding wounds. Only today the Depot chowkidar had the benefit of unwelcome attention from the owl.

I do not know what makes it attack. It is not nesting and does not attack anybody in the Office—otherwise I would have run away by this time because they have their roost just six feet above my head, where I am sitting now.

RANGE FOREST OFFICE,
BASUGAON,
GOALPARA, ASSAM,
April 7, 1966

K. K. GUPTA

[The author informs us that the owls occupied the roost till the first week of July, when they were driven away by some children who had been attacked by the aggressive owl.—EDS.]

9. OCCURRENCE OF THE WIRE-TAILED SWALLOW (*HIRUNDO SMITHII* LEACH) IN NORTHERN CEYLON: A FIRST RECORD

While out looking at birds with Mrs. Nugawella, Miss A. Perera, and Dr. Somasunderam, on the afternoon of 26 February this year, we were motoring slowly along the coast road from Pooneryn to Mannar on the north-western coast of Ceylon; near Illupaikkadavai, some 15 miles from Mannar, we noticed a party of about 10 swallows sitting on the telegraph wires that skirted the roadside.

As we approached we saw that all but one of the birds were the Swallow (*Hirundo rustica* Linnaeus), and our attention immediately focussed upon the single bird, sitting with the others, which was obviously of a different species. This bird, which was not more than 10 ft. away, had two long wiry tail feathers and pure white underparts including throat, steely blue wings and back, and chestnut cap. We were all able to observe it closely and were unanimous in our identification of it as a Wire-tailed Swallow (*Hirundo smithii* Leach).

This swallow, although not recorded from Ceylon, is reported to

occur in Southern India in winter, so the bird we saw had probably overshot its usual winter habitat.

STORTH, MANOR WAY,
ALDWICK BAY,
BOGNOR REGIS,
March 20, 1966.

(MRS.) E. M. WYNELL-MAYOW

[Mrs. Wynell-Mayow's father Major W.W.A. Phillips first recorded the occurrence of the Indian Cliff Swallow (*Hirundo fluvicola* Blyth) in Ceylon (1948, *J. Bombay nat. Hist. Soc.* 47: 740). That stranger, like the stranger in the present case, was in a party of *H. rustica* and Major Phillips suggested that it might have straggled into Ceylon with them at the time of their annual migration. *H. smithii* is not common in S. India. Sálím Ali has seen it several times in Mysore, but there is no record from Travancore and Cochin. We know of no evidence to indicate that it is a winter migrant to S. India; this species is accepted as a resident form, except perhaps for small local migrations.—EDS.]

10. BEHAVIOUR MIMICRY BY THE LARGE
RACKET-TAILED DRONGO [*DICRURUS PARADISEUS*
(LINNAEUS)]

The tongue of land on which the Tourist Lodges are situated at the Periyar Lake Wild Life Sanctuary is an ideal place for birdwatching. Among the many species of birds that can be seen in this area, one of the most vocal is the Large Racket-tailed Drongo [*Dicrurus paradiseus* (Linnaeus)] whose exasperating habit of mimicking the calls of other birds limits one's bird list to sight records only.

While on a visit to the Sanctuary in May this year, I was intrigued by the large repertoire of calls of this drongo and, after being twice 'taken in' by its mimicry of the Giant Squirrel (*Ratufa indica*), made a habit of investigating each call from unseen sources. On one such occasion, while following a mixed hunting party of birds, I heard the agitated squeaking calls of a Jungle Babbler (*Turdoides striatus*) and was surprised to see that the calls were being made by a drongo perched on a low branch. While calling the drongo had the feathers of its body fluffed out, its wings drooping, and its tail depressed, and was pivoting from side to side on its perch—an exact mimicry of the behaviour of the Jungle Babbler while thus calling!

There were no babblers in the vicinity.

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE,
BOMBAY 1-BR,
August 17, 1966.

J. C. DANIEL
Curator

11. RECOVERY OF RINGED BIRDS

Ring No. and species	Date and place of ringing	Date and place of recovery	Remarks
A-10400 <i>Passer hispaniolensis</i> ♀	25.3.1962. Bharatpur (c. 27° 13' N., 77° 32' E.), India	+, 9.5.1965. Ernazar, near Djambul, Djambul Region, Kazakh SSR (42° 54' N., 71° 24' E.)	Reported by Bird-Ringing Bureau, USSR
A-10616 <i>Passer domesticus parkini</i> ♂	26.3.1962. do.	+, 15.5.1965. Dekhkan-Abad near Parkhar, Parkhar District, Tajik SSR (c. 37° 30' N., 69° 20' E.)	do.
AB-8264 <i>Philomachus pugnax</i> ♀	20.10.1965. do.	(V), 16.2.1966. Naral Subdiv. Jessore District (c. 23° 10' N., 89° 30' E.), E. Pakistan	Reported by Mr. S. M. Ilias
AB-10217 <i>Tringa glareola</i>	26.3.1965. Beliaghata, N. Salt Lake, Calcutta (c. 22° 35' N., 88° 21' E.)	+, 25.5.1965. Srednyaya, Olekma, Tun-giro-Olekminsk District, Chita Region, USSR (c. 55° 15' N., 120° E.)	Reported by Bird-Ringing Bureau, USSR
B-1609 <i>Philomachus pugnax</i> ♂	3.10.1965. Bharatpur (c. 27° 13' N., 77° 32' E.), India	V. (13.2.1966), Ramkola, Uttar Pradesh (c. 26° 30' N., 83° 30' E.)	Reported by Mr. Sant Prasad of Ramkola
B-1657 <i>Tringa totanus</i> o?	6.10.1965. do.	+, Spring 1966, Altai Region, Near Blagoveshchenka, USSR (52° 50' N., 79° 53' E.)	Reported by Bird-Ringing Bureau, USSR
B-1721 <i>Philomachus pugnax</i> ♂	10.10.1965. do.	+, 28.2.1966. Uzbek SSR near Syrdariya (40° 50' N., 68° 42' E.)	do.
B-1931 <i>Philomachus pugnax</i> ♂	13.10.1965. do.	+, 23.3.1966. Sheikpura District (31° 30' N., 74° 30' E.) near Lahore, W. Pakistan	Reported by Pakistan Zoological Survey Department
B-1938 <i>Philomachus pugnax</i> ♂	13.10.1965. do.	+, 18.4.1966. Turkmenian SSR near Kunya-Urgen (42° 20' N., 58° 55' E.)	Reported by Bird-Ringing Bureau, USSR
B-3476 <i>Tringa glareola</i>	1.1.1965. Bakhri, Monghyr Dist., Bihar (c. 25° 23' N., 86° 30' E.), India	+, 8.5.1966. Irkutsk Region, near Cheremkhovo (53° 10' N., 103° 05' E.)	do.

RECOVERY OF RINGED BIRDS (contd.)

Ring No. and species	Date and place of ringing	Date and place of recovery	Remarks
C-147 <i>Anas crecca</i> ♂?	18.2.1964. Manjhaul (c. 25° 23' N., 86° 30' E.), Monghyr District, Bihar, India	+, 8.5.1966. Near Nizhnii Ingash (56° 10' N., 96° 28' E.), Krasnoyarsk Region	Reported by Bird-Ringing Bureau, USSR
C-1008 <i>Anas querquedula</i> ♂	27.9.1965. Bharatpur (c. 27° 13' N., 77° 32' E.), India	+, 10.5.1966 Novosibirsk Region, Chylum District, near Uzhanikha (54° 40' N., 81° 03' E.)	do.
C-1193 <i>Anas crecca</i> ♂	7.10.1965. Bharatpur (c. 27° 13' N., 77° 32' E.), India	+, 2.1.1966, Kasimpur village, Agra (c. 27° 10' N., 78° 03' E.)	Reported by Mr. R. S. Sharma, Sr. Supdt. of Police, Agra
C-1230 <i>Anas crecca</i> ♂	8.10.1965. do.	+, 2.3.1966. Uzbek SSR, Bukhara District near Karakul (39° 34' N., 63° 50' E.)	Reported by Bird-Ringing Bureau, USSR
C-1288 <i>Anas querquedula</i> ♂	17.10.1965. do.	+, 21.1.1966. Devakottai, near Madurai (c. 9° 57' N., 78° 51' E.)	Reported by Mr. Kailasam, Chairman of Devakottai Panchayat
C-1710 <i>Anas crecca</i> o?	3.12.1964. Manjhaul (c. 25° 23' N., 86° 30' E.), Monghyr District, Bihar, India	+, 19.5.1966. Yakutian ASSR, near Churapcha (62° 02' N., 132° 36' E.)	Reported by Bird-Ringing Bureau, USSR
C-1711 <i>Anas crecca</i> ♂	3.12.1964. do.	+, 7.10.1965. Novosibirsk Region, near Kraznozerskoe (54° N., 79° 16' E.)	do.
C-1715 <i>Anas crecca</i> ♂	3.12.1964. do.	+, 11.5.1966. Near Khorinsk (52° 10' N., 109° 44' E.), Buryatian ASSR	do.
C-1958 <i>Anas crecca</i> ♀	6.1.1965. Bakhri, Monghyr District., Bihar (c. 25° 23' N., 86° 30' E.), India	+, 12.5.1966. Krasnoyarsk Region, near Ilanskii (56° 14' N., 96° 05' E.)	do.
C-1968 <i>Anas crecca</i> ♀	8.1.1965. do.	+, 7.9.1965. Chita Region, Nerchinsk district, near Olinsk (52° 14' N., 116° 12' E.)	do.

RECOVERY OF RINGED BIRDS (contd.)

Ring No. and species	Date and place of ringing	Date and place of recovery	Remarks
C-2090 <i>Anas crecca</i> ♀	3.2.1964. Bakhri, Monghyr Dist., Bihar (c. 25° 23' N., 86° 30' E.), India	+, 3.5.1966. Irkutsk Region, near Zima (c. 53° 56' N., 102° 02' E.)	Reported by Bird-Ringing Bureau, USSR
F-1017 <i>Anas acuta</i> ♂	27.9.1965. Bharatpur (c. 27° 13' N., 77° 32' E.), India	+, 1.5.1966. Omsk Region, near Tara (56° 54' N., 74° 20' E.)	do.
F-1058 <i>Anas clypeata</i> ♂	15.10.1965. do.	+, 1.5.1966. Severo-Kazakhstan Region, near Bulaevo (54° 54' N., 74° 30' E.)	do.
F-1090 <i>Anas clypeata</i> ♂	17.10.1965. do.	+, 30.4.1966. Altai Region, near Blagoveschenka (52° 50' N., 79° 53' E.)	do.
F-1130 <i>Anas acuta</i> ♂	18.10.1965. do.	+, 7.12.1965. Karimnagar, Andhra Pradesh (c. 18° 26' N., 79° 08' E.)	Reported by Mr. Rahim Khan of Karimnagar Police Headquarters
F-3044 <i>Anas acuta</i> ♂	7.2.1966. Dibrugarh (c. 27° 41' N., 94° 57' E.), Assam	+, 6.5.1966. Buryatian ASSR, Selenga River (52° 20' N., 106° 23' E.)	Reported by Bird-Ringing Bureau, USSR

Note. + = shot or killed by man.

(V) = trapped and died in captivity.

V = caught alive and released with ring removed.

All these birds were ringed in the course of BNHS/WHO Bird Migration Field Study Project, except AB-10217 (B. Biswas, Calcutta), and F-3044 (M. J. S. Mackenzie, Assam).

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE,
BOMBAY 1-BR,
August 27, 1966.

EDITORS

12. OCCURRENCE OF THE TOAD *BUFO FERGUSONII*
BOULENGER IN HYDERABAD, ANDHRA PRADESH,
INDIA (ANURA : BUFONIDAE)

On 8 August 1961, JPD, accompanied by Schuyler Giles, collected several frogs and toads from grassy monsoon puddles in the Banjara Hills neighbourhood of Hyderabad, Andhra Pradesh. Among the specimens were two calling males of *Bufo fergusonii* Boulenger (JPD 136, 137), with snout-vent lengths of 30 mm. and 33 mm., respectively.

This species has apparently not been previously reported from Andhra Pradesh, although it has been recorded from the states of Mysore, Kerala, and Madras (J. C. Daniel, 1963 : Field guide to the amphibians of western India, part 1. *J. Bombay nat. Hist. Soc.* 60 : 415-438).

Other anurans collected the same night from similar puddles were *Rana cyanophlyctis* Schneider, and *R. limnocharis* Boie.

All specimens mentioned in this note are deposited in The Museum, Michigan State University.

DEPARTMENT OF ENTOMOLOGY,
MICHIGAN STATE UNIVERSITY,
EAST LANSING, MICHIGAN, U.S.A.

JULIAN P. DONAHUE

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE,
BOMBAY 1-BR,
August 17, 1966.

J. C. DANIEL

13. AN INSECT'S PERSISTENT VITALITY

Entomologists, and even a few laymen like myself, are familiar with the 'decentralization' of an insect's nervous system. Nevertheless, the following instance of persistent vitality may prove of some slight interest.

About 9 o'clock of an April morning, I discovered a large specimen of the Hooded Grasshopper known as *Teratodes monticollis* on a plant in my garden. I picked it up by the wing-cases and found it somewhat sluggish. To kill it, I forcibly pinched its head, and while doing so unintentionally pulled the head clean off; it came away with the front pair of legs and practically all the entrails attached to it. I dropped this on the ground, and close by I dropped the remaining portion consisting of the hind-legs, median legs, wing-cases and the now hollow thorax and abdomen (all attached together).

A few minutes later, I happened to observe that this 'rear end' was standing normally erect, exactly as though it had not lost its head and

forelegs and 'innards'. When I picked it up, the powerful hind-legs attempted to push my fingers away in the usual manner. Being curious to see how long this half-insect's life would persist, I carried it indoors and placed it under an inverted glass in my room.

About noon, three hours after separation from the head, this rear portion was still standing normally, and showed the usual reaction when I picked it up. Six hours after decapitation, at 3 p.m., I lifted the glass and lightly touched the wing-cases, whereupon the creature executed a typical leap, which landed it some two feet away and reached a roughly estimated height of 15 inches. At 6 p.m. there was some sign of sagging from the upright stance; but it was only at 9 p.m., twelve hours after decapitation, that the body definitely collapsed and spontaneous movement ceased.

DEV KUNJ,
PRABHAT ROAD,
POONA-4,
April 26, 1966.

THOMAS GAY

[A. D. Imms (1957, A GENERAL TEXTBOOK OF ENTOMOLOGY) writes '... each segment of the (insect) body, with its ganglion, is capable of a considerable degree of autonomous reflex behaviour... Centralization of function is, therefore, less well developed than in the vertebrates. ... Local reflexes are also involved in reproductive movements—the isolated abdomen of a female silkworm moth can be fertilized and lay eggs, while in mantids the copulatory movements of the male and movements of the ovipositor can be made after decapitation.'—EDS.]

14. RECORD OF *PARACLEPSIS PRAEDATRIX* HARDING, 1924
(ANNELIDA: HIRUDINEA), FROM A NEW HOST, *NATRIX*
PISCATOR (SCHNEIDER), THE CHECKERED KEELBACK
(REPTILIA: SERPENTES)

The leech *Paraclepsis praedatrix* Harding, 1924, is distributed throughout India, mostly in a free-living state in ponds, tanks, etc. (but not in running water). The only record of parasitization by the leech is on the freshwater tortoise, *Lissemys punctata granosa* (Schoepff) (Harding & Moore 1927). The present note deals with another record of parasitization on a reptile, the new host being the Checkered Keelback *Natrix piscator* (Schneider), a very common snake of India. The leech was seen coming out of the buccal cavity of the snake, collected alive by Dr. B. Biswas from Salt Lake, off Calcutta, when the snake was freshly killed by chloroform in the laboratory two days after collection.

The translucent leech (in live state) had a pinkish white ground colour, profusely ornamented with dull green pigment cells on the dorsal surface. It had three pairs of eyes disposed in two subparallel rows. The first and second pairs were situated on third and fourth rings respectively, while the third pair was on the seventh ring, separated from the others by two annuli.

We are thankful to Dr. B. Biswas of the Zoological Survey of India for letting us identify the specimen and make this interesting record.

ZOOLOGICAL SURVEY OF INDIA,
CALCUTTA,
August 8, 1966.

MAHESH CHANDRA
S. S. SAHA

[Two earlier instances of leeches feeding on snakes have been recorded in the *Journal*. Wall collected two unidentified freshwater leeches from the mouth of a Copperheaded Ratsnake (*Elaphe radiata*) which he caught in water (Vol. 23 : 208 ; 1914), and Kinloch records a land leech on a species of *Dryophis* which he caught on the ground in a coffee estate in the Nelliampathy Hills (Vol. 28 : 557 ; 1922).—EDS.]

REFERENCE

HARDING, W. A. & MOORE, J. P. (1927): Fauna of British India, Ceylon and Burma. Hirudinea : 88-90. London. Taylor and Francis.

15. INTERTIDAL ENTOPROCTA AND ECTOPROCTA (BRYOZOA) OF BOMBAY

(With one plate)

In this second paper in the series on the marine fauna of Bombay are listed the Entoprocta and Ectoprocta. These two phyla were earlier included as two groups under the phylum Bryozoa, also known as Polyzoa but were assigned phylum rank by Hatschek (1888) and are now accepted as such by most workers.

Most of the taxonomic work on these phyla done in India is on forms living in fresh water. Thus Annandale has published a series of papers between 1907 and 1916. Seshaiya (1946) described a new species of *Urnatella* from Annamalainagar (South India). Marine forms from India have been studied by Thornely (1907) and Hincks (1884). Thornely has also dealt with Polyzoa from Ceylon (1905) and from the Indian Ocean (1912—material from the Percy Sladen Trust Expedition).

Other papers on Indo-Pacific Polyzoa have been by O'Donoghue & de Wattedville (1935-1944) from South Africa, Waters (1913) from British East Africa and Zanzibar, Kirkpatrick (1888) from Mauritius, Waters (1909-10) from the Red Sea, Hastings (1932) from Australia, Canu & Bassler (1929) from the Philippines, and Okada & Mawatari (1935-1956) from Japan.

In addition to the general works on Indian Polyzoa, those of Bengal have been dealt with by Robertson (1921). The polyzoan fauna of the west coast of India has, however, not received much attention in the past, except for the work by Thornely (1916) at Okha. The vast area south of this has remained unexplored, except for stray records by the same author from Mangalore, and by Patil (1953) from Karwar. It was, therefore, decided to make a representative collection from Bombay. Collections were confined to the inter-tidal zone.

A total of 11 species, belonging to seven different families, comprises the present collection. None of these has been previously recorded from Bombay.

Phylum ENTOPROCTA

Family PEDICELLINIDAE

Genus *PEDICELLINA* Sars

1. *Pedicellina cernua* (Pallas)

Genus *BARENTSIA* Hincks

2. *Barentsia gracilis* (Sars)

Phylum ECTOPROCTA

Class GYMNOLAEMATA

Order CTENOSTOMATA

Suborder STOLONIFERA

Family VESICULARIIDAE

Genus *AMATHIA* Lamouroux

3. *Amathia convoluta* (Waters)

Genus *BOWERBANKIA* Farre

4. *Bowerbankia imbricata* Adams

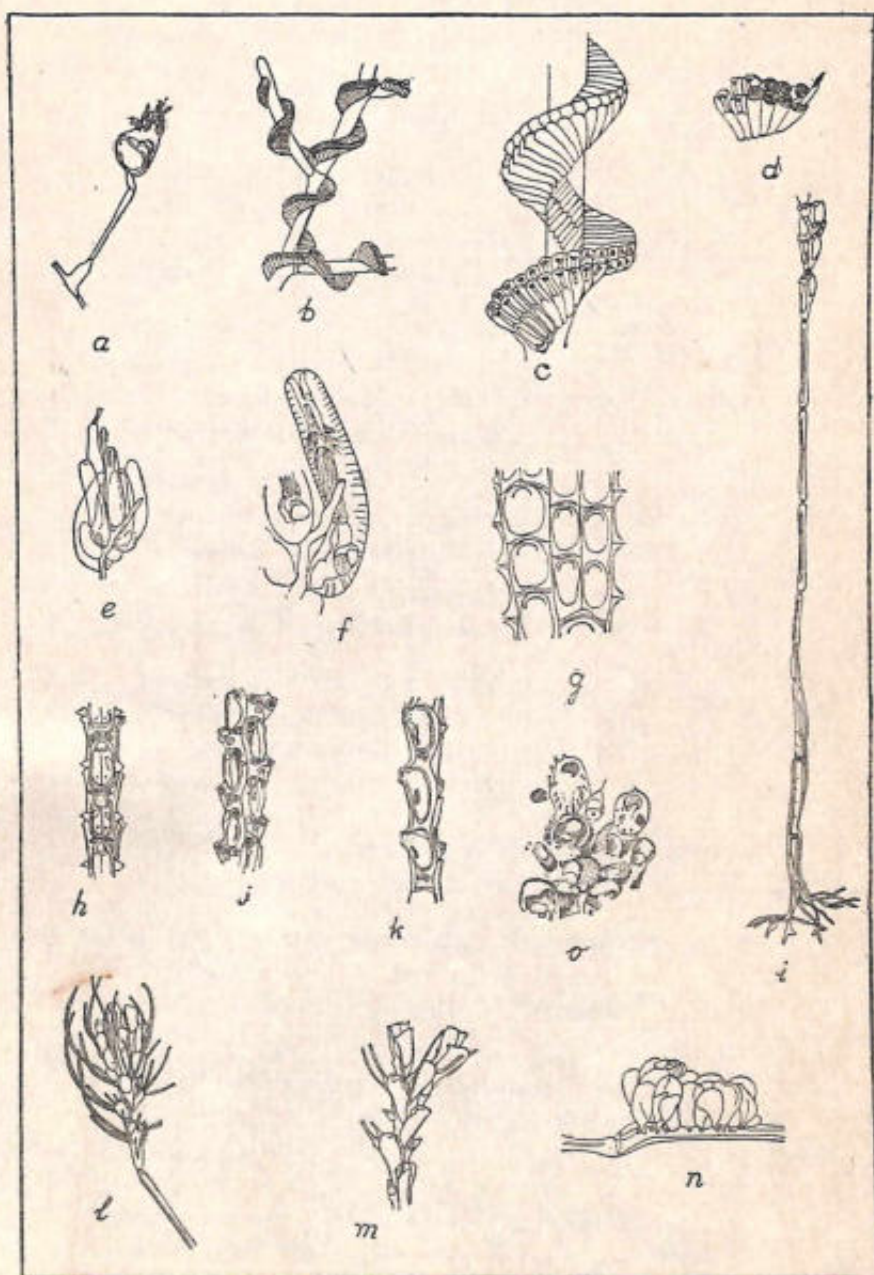
Order CHEILOSTOMATA

Suborder ANASCA

Division MALACOSTEGA

Family MEMBRANIPORIDAE

Genus *ELECTRA* Lamouroux



Barentsia gracilis: a. side view of individual. *Amathia convoluta*: b. part of zoarium; c. group of zoecia; d. zoecia. *Bowerbankia imbricata*: e. group of zoecia; f. portion of stem with one complete zoecium and parts of several others. *Acanthodesia savartii*: g. zoecia. *Nellia oculata* var. *quadrilatera*: h. ovicells. *Poricellaria ratoniensis*: i. proximal part of young colony; j. front view; k. side view. *Caulibugula zanzibariensis*: l. zoecial fan, showing modified proximal zoecium, and end of last kenozoecium of stalk; m. part of branch, showing avicularia; n. parts of two kenozoecia, one with a group of stem-vesicles near distal end. *Celleporaria pilaefera*: o. zoecia, avicularia and ovicells. (All illustrations after Harmer).

5. *Electra pilosa* (Linnaeus)
Genus *ACANTHODESIA* Canu & Bassler
6. *Acanthodesia savartii* (Audouin)¹

Genus *NELLIA* Busk

7. *Nellia oculata* var. *quadrilatera* D'Orbigny

Division COELOSTEGA

Family PORICELLARIDAE

Genus *PORICELLARIA* D'Orbigny

8. *Poricellaria ratoniensis* (Waters)

Division CELLULARINA

Family BICELLARIELLIDAE

Genus *CAULIBUGULA* Verrill

9. *Caulibugula zanzibariensis* (Waters)²

Suborder ASCOPHORA

Division ASCOPHORA IMPERFECTA

Family CELLEPORARIIDAE

Genus *CELLEPORARIA* Lamouroux

10. *Celleporaria prox. pilaefera* (Canu & Bassler)

Division ASCOPHORA VERA

Family VITTATICELLIDAE

Genus *VITTATICELLA* Maplestone

11. *Vittaticella* sp.

KEY TO THE IDENTIFICATION OF ENTOPROCTA AND
ECTOPROCTA OF BOMBAY

- | | |
|---|-------------------------------|
| 1. Anus lying inside the circlet of tentacles
(Entoprocta) | 2 |
| Anus lying outside the circlet of tentacles
(Ectoprocta) | 3 |
| 2. Stalk approximately of the same diameter and
muscularity throughout, lacking special mus-
cular enlargements | <i>Pedicellina
cernua</i> |
| Stalk has muscular thickenings along it, also a
basal muscular socket | <i>Barentsia gracilis</i> |



¹ The specimens in the present collection do not show the internal proximal cryptocystal denticle characteristic of this species.

² The stolons of the specimens in the present collection do not bear the large vesicles which are characteristic of this species.

- | | |
|--|---|
| 3. Zoecia not calcified, membranous; orifice terminal or subterminal, closed by a pleated collar, ovicells and avicularia absent (Ctenostomata) | 4 |
| Zoecia box-like, with small subterminal orifice closed by a hinged operculum; brood chambers frequently in the form of ovicells; often with avicularia (Cheilostomata) | 5 |
| 4. Zooids in spirally curved double rows | <i>Amathia convoluta</i> |
| Zooids in clusters | <i>Bowerbankia imbricata</i> |
| 5. Zooids without compensation sac (Anasca) | 6 |
| Zooids with compensation sac (Ascophora) | 9 |
| 6. Zooids more or less contiguous, generally calcified except for the frontal membrane; with or without ovicells and avicularia (Malacostega) | 7 |
| Cryptocyst extending to orifice, leaving opesicles; ovicells hyperstomial or endozoecial | <i>Poricellaria ratoniensis</i> |
| Zoecia uncalcified or only moderately so, in branching colonies; with hyperstomial ovicells and typical avicularia | <i>Caulibugula zanzibariensis</i> |
| 7. Frontal membrane occupying entire ventral surface (Membraniporidae) | 8 |
| Frontal membrane reduced to an oval area bordered with spines | <i>Electra pilosa</i> |
| 8. Gymnocyst and ovicells wanting | <i>Acanthodesia savartii</i> |
| Short gymnocyst and small, entozoecial ovicells present | <i>Nellia oculata</i>
var. <i>quadrilatera</i> |
| 9. Colony with irregularly piled up, erect zooids. | <i>Celleporaria prox. pilaefera</i> |
| Colony with delicate, jointed branches with one to three successive zooids, all facing in one direction, making up each internode between joints | <i>Vittaticella</i> sp. |

ACKNOWLEDGEMENTS

The authors are grateful to Miss Patricia Cook, of the British Museum (Natural History), London, for identification of some specimens and confirmation of the identification of others, and to Dr. C. V. Kulkarni, Director of Fisheries, Maharashtra State, and Dr. H. G. Kewalramani, Senior Scientific Officer, for facilities for work at the Taraporevala Marine Biological Station, Bombay.

TARAPOREVALA MARINE BIOLOGICAL
STATION,
BOMBAY 2-BR,

B. F. CHHAPGAR

c/o SACHETAN,
L/4-5 SITARAM BUILDING,
PALTON ROAD,
BOMBAY 1-BR,
August 27, 1966.

S. R. SANE

REFERENCES

- ANNANDALE, N. (1907a): Further note on a Polyzoan from the Himalayas. *Rec. Ind. Mus.* 1: 145-148, 3 text-figs.
- (1907b): The fauna of brackish ponds at Port Canning, Lower Bengal. Part VI. Observations on the Polyzoa, with further notes on the ponds. *op. cit.* 1: 197-205, 4 text-figs.
- (1908): Ditto. Part VII. Further observations on the Polyzoa, with the description of a new genus of Entoprocta. *op. cit.* 2: 11-24, 7 text-figs.
- (1909a): Preliminary note on a new genus of Phylactolaematus Polyzoa. *op. cit.* 3: 279-280.
- (1909b): A new species of *Fredericella* from Indian lakes. *op. cit.* 3: 373, 374, 1 text-fig.
- (1911a): Systematic notes on the Ctenostomatous Polyzoa of fresh water. *op. cit.* 6: 193-201, pl. 13.
- (1911b): Freshwater sponges, hydroids and polyzoa. Fauna of British India: 163-247, pls. 3-5, 20 text-figs.
- (1912a): Fauna Symbiotica Indica. No. 1. Polyzoa attached to Indo-Pacific Stomatopods. *Rec. Ind. Mus.* 7: 123-126, 1 text-fig.
- (1912b): Ditto. No. 3. Polyzoa associated with certain Gangetic tortoises. *op. cit.* 7: 147-150, pl. 13.
- (1912c): The occurrence of Entoprocta in Indian waters. *op. cit.* 7: 205.
- (1915): The genus *Austrorella* and some allied species of Phylactolaematus Polyzoa. *op. cit.* 11: 163-169, pls. 2, 3, 2 text-figs.
- (1916): Zoological results of a tour of the Far East. Polyzoa Entoprocta and Ctenostomata. *Mem. Asiat. Soc. Bengal* 6: 15-37.
- & KEMP, S. (1912): Observations on the invertebrate fauna of the Kumaon lakes, with special references to the sponges and Polyzoa. *op. cit.* 7: 129-145, 2 text-figs.
- CANU, F. & BASLER, R. (1929): The Bryozoa of the Philippine region. *Bull. U.S. Nat. Mus.* 100, pt. 9: 1-685.
- GRAVELY, F. H. (1927): The littoral fauna of Krusadai Island in the Gulf of Manaar. *Bull. Madras Govt. Mus., n. ser., nat. hist.* 1(1): 89-94, pl. 11.
- HARMER, S. F. (1915): The Polyzoa of the Siboga Expedition. Part I. Entoprocta, Ctenostomata and Cyclostomata. *Siboga Exped. Rep.* 28a: 1-180, pls. 1-12.
- (1926): Ditto. Part II. Cheilostomata Anasca. *op. cit.* 28b: 181-501, pls. 13-34, 23 text-figs.
- (1934): Ditto. Part III. Cheilostomata Ascophora. I. Family Reteporidae. *op. cit.* 28c: 503-640, pls. 35-41, 25 text-figs.
- (1957): Ditto. Part IV. Cheilostomata Ascophora II. (Ascophora, except Reteporidae, with additions to Part II, Anasca). *op. cit.* 28d: 641-1147, pls. 42-74, 70 text-figs.

- HASTINGS, A. (1932): The Polyzoa, with a note on an associated Hydroid. *Sci. Rep. Great Barrier Reef Exped.* 4 (12): 399-458.
- HINCKS, T. (1884): Contributions towards a general history of the marine Polyzoa. XII. Polyzoa from India (coast of Burmah). *Ann. Mag. nat. Hist.* (5) 13: 356-369.
- (1887): Polyzoa and Hydrozoa of the Mergui Archipelago. *J. Linn. Soc. (Zool.)* 21: 121-135.
- KIRKPATRICK, R. (1888): Polyzoa of Mauritius. *Ann. Mag. nat. Hist.* (6) 1: 72-85, pls. 7-10.
- (1890a): Reports upon the Hydrozoa and Polyzoa China Sea. op. cit. (6) 5: 11
- (1890b): Report upon the zoological collections made in Torres Straits by Prof. A. C. Haddon 1888-1889, Hydrozoa and Polyzoa. *Sci. Proc. R. Dublin Soc. (n.s.)* 6: 603.
- MAWATARI, S. (1952): Bryozoa of Kii Peninsula. *Publ. Seto Marine Lab.* 2: 261
- (1953): Studies on Japanese Ctenostomatous Bryozoa. op. cit. 3: 213.
- (1956): Cheilostomatous Bryozoa from the Kurile Islands. *Pacific Sci.* 10: 113-135.
- O'DONOGHUE, C. H. & WATTEVILLE, D. DE (1935): A collection of Bryozoa from South Africa. *J. Linn. Soc. (Zool.)* 39: 203-218.
- (1937): Notes on South African Bryozoa. *Zool. Anz.* 117: 12-22.
- (1944): Additional notes on Bryozoa of South Africa. *Ann. Natal Mus.* 10: 407-432.
- OKADA, Y. & MAWATARI, S. (1935): Bryozoa around Izu Peninsula. I. *Sci. Rep. Tokyo Bun. Daig., sec. B.* 2.
- (1936): Ditto. II. op. cit. 3: 53-73.
- (1937): On the collection of Bryozoa of Honshu, Japan. op. cit. ser. 4, *blol.* 5: 433-445.
- (1938): Bryozoa along the middle part of Honshu, Japan. *Annot. zool. Japonenses* 17: 445-462.
- PATIL, A. M. (1953): A study of the marine fauna of the Karwar coast and the neighbouring islands. *J. Bombay nat. Hist. Soc.* 51(4): 429-434.
- ROBERTSON, A. (1921): Report on a collection of Bryozoa from the Bay of Bengal and other Eastern Seas. *Rec. Ind. Mus.* 22 (pt. 1) no. 8: 33-65, 11 text-figs.
- SANE, S. R. & CHHAPGAR, B. F. (1962): Intertidal Echinodermata of Bombay. *J. Bombay nat. Hist. Soc.* 59(2): 672-676, 2 pls.
- SESHAIVA, R. V. (1946): *Urnatella indica*, sp. nov. *Proc. 33rd Ind. Sci. Congr. pt. III, abstracts*: 121.
- STOLICZKA, F. (1869): On the anatomy of *Sagartia schilleriana* and *Membranipora bengalensis*, a new coral and a bryozoan. *Journ. Asiat. Soc. Bengal* 38(2): 55.
- THORNELLY, L. R. (1905): Polyzoa, in W. A. Herdman's report to the Government of Ceylon on the pearl oyster fisheries of the Gulf of Manaar (published by the Royal Society), pt. 4, *Suppl. Rep.* 26: 107-130, 1 pl.
- (1906): Corrections and additions, Ditto, pt. 5. 449, 450.
- (1907): Report on the marine Polyzoa in the collection of the Indian Museum. *Rec. Ind. Mus.* 1: 179-196, 8 text-figs.
- (1912): The marine Polyzoa of the Indian Ocean, from H.M.S. 'Sealark'. *Trans. Linn. Soc. 2 ser. zool.* 15: 137-157, pl. 8.
- (1916): Report on the Polyzoa collected at Okhamandal in Kattiawar, in J. Hornell's *Rep. Govt. Baroda Mar. Zool. Okhamandal*, pt. 2: 157-165.
- THURSTON, E. (1895): Rameswaram Island and fauna of the Gulf of Manaar. *Madras Govt. Mus. Bull. no. 3 (2nd Ed.)*: 131, 132.
- WATERS, A. W. (1908): A sub-fossil Polyzoan from Calcutta. *Rec. Ind. Mus.* 2: 109, 110.
- (1909): Reports on the marine biology of the Sudanese Red Sea. XII. The Bryozoa. Part I. Cheilostomata. *J. Linn. Soc. (Zool.)* 31: 123-181, pls. 10-18, 24, 25.
- (1910): Ditto. Part II. Cyclostomata, Ctenostomata, and Endoprocta. op. cit. 31: 231-256.
- (1913): 'The marine fauna of British East Africa and Zanzibar, from collections made by Cyril Crossland, M.A., B.Sc., F.Z.S., in the years 1901-1902. Bryozoa — Cheilostomata. *Proc. Zool. Soc. London*: 458-537.
- (1914): Ditto. Bryozoa — Cyclostomata, Ctenostomata, and Endoprocta. op. cit. 831-858, pls. 1-4.

16. CORRECT NAME FOR *VENTILAGO CALYCVLATA*
TULASNE

The present note gives the correct name, *Ventilago denticulata* Willd., for *Ventilago calyculata* Tulasne. To explain the change, I have put the list of necessary synonyms after the correct name.

Ventilago denticulata Willd. in Ges. Naturf. Fr. Neue Schr. 3: 417, 1801. *V. maderaspatana* Roxb. Pl. Corom. 1: 55, t. 76, 1796-98; Wt. & Arn. Prodr. 164 (non Gaertn. 1788). *V. maderaspatana* var. β Roxb. loc. cit. *V. calyculata* Tulasne in Ann. Sc. Nat. (Ser. 4) 8: 124, 1857. *V. macrantha* Tulasne in Ann. Sc. Nat. (Ser. 4) 8: 123, 1857. *V. silhetiana*, *smithiana* et *sulphurea* Tulasne in Ann. Sc. Nat. (Ser. 4) 8: 125, 1857. *V. maderaspatana* Gaertn. var. *calyculata* King in Journ. As. Soc. Bengal 65(2): 378-79, 1896.

DEPARTMENT OF GENERAL EDUCATION,
M. S. UNIVERSITY OF BARODA,
BARODA,
February 18, 1966.

G. M. OZA, Ph.D., F.L.S.

17. A NEW SYNONYMY IN UMBELLIFERAE

Pternopetalum vulgare (Dunn) Hand.-Mazz. Symbol. Sinic. 7: 719, 1933. *Cryptotaeniopsis vulgaris* Dunn in Hook. f. Ic. 8: t. 2737. 1902 et in J. Linn. Soc. Bot. 35: 494. 1903; Wolff in Engl. Pflanzenr. IV. 228: 176. 1927. *Pternopetalum davidii* Boissieu in Bull. Herb. Boiss. II. 2: 806. 1902, non Franch., 1885. *Deringa vulgaris* (Dunn) Koso-Poljansky in Monit. Jard. Bot. Tiflis 11 (3-4): 6. 1915 et in Bull. Soc. Nat. Mosc. 29: 136. 1915. *Pimpinella clarkeana* Watt ex Banerji in J. Bombay nat. Hist. Soc. 50 (1): 88. 1953.

Pimpinella clarkeana Watt ex Banerji being based on Watt 6556, a syntype (here chosen as Lectotype) of *Cryptotaeniopsis vulgaris* Dunn in Hook. f. Ic. 8: t. 2737. 1902, is a synonym of the latter.

CENTRAL NATIONAL HERBARIUM,
INDIAN BOTANIC GARDEN,
HOWRAH,
May 26, 1966.

D. B. DEB

18. FLORAL VARIATIONS IN THREE SPECIES OF
CESTRUM LINN., VIZ. *C. DIURNUM* LINN., *C. ELEGANS*
 SCHLECHT., AND *C. NOCTURNUM* LINN.

INTRODUCTION

Though a considerable literature is available on the teratology of vegetative organs, the data on floral variations are comparatively rare. It may be because such a study involves a critical examination of a number of flowers. Whenever a variation is observed, it is often bypassed as an abnormality. If floral variations have to play an important role in taxonomy, a detailed study of several flowers is necessary to find out the nature and frequency of such variations.

Cestrum diurnum L., *C. elegans* Schlecht., and *C. nocturnum* L. belong to the family Solanaceae. Reports on teratological variations in this family seem to be scanty. Singh (1935) reported the flattening of the vegetative and reproductive axes in *Lycopersicon esculentum* Mill. Floral variations occur in *Solanum melongena* L. (Sayeeduddin & Salam 1936) and *Capsicum annum* (Sunderaj & Balasubramanyam 1956).

According to Linnaeus (1753), Dunal (1852), and Bentham & Hooker f. (1876), the genus *Cestrum* is characterized by 5 sepals, 5 petals, and 5 stamens. In fact Dunal (1852) and Bor & Raizada (1954) have described pentamerous flowers for *C. diurnum* L. and *C. nocturnum* L., though the last-named authors casually mention that the corolla is 5 or more lobed in the genus *Cestrum* and in *C. elegans* in particular. This seems to be the only report on floral variation in the genus. In a cursory study of these plants a few hexamerous and tetramerous flowers were observed. A critical study of as many fresh flowers and buds as possible was, therefore, undertaken to find out the range of variation. Since the variations were many even in the same plant and even in the same inflorescence, it was thought necessary to record them. They will be taxonomically useful while comparing the descriptions of these plants with those in published books.

The material of *C. diurnum* L. and *C. elegans* Schlecht. was collected from different plants growing at Vallabh Vidyanagar and Mahableshwar respectively, while that of *C. nocturnum* L. was obtained from both localities.

OBSERVATIONS

220 flowers of *C. diurnum* L., 300 flowers of *C. nocturnum* L., and 113 flowers of *C. elegans* Schlecht. were examined, of which 93 flowers (42.3%), 94 flowers (31.3%), and 40 flowers (35.4%) respectively showed variations. They were in the number of sepals, petals, and stamens,

but the gynoecium remained unaffected. About 14 types of variations were seen in *C. diurnum* L., 9 types in *C. nocturnum* L., and 12 types in *C. elegans* Schlecht. They can be grouped as follows: (a) Variations in three whorls, i.e. sepals, petals, and stamens of the same flower; (b) Variations in two whorls, i.e. (i) sepals and petals, (ii) sepals and stamens, and (iii) petals and stamens of the same flower; (c) Variations only in one whorl, i.e. sepals, petals, or stamens of a flower. Instead of describing them separately they are tabulated (Tables 1-3) so as to enable one to see the range of variations at a glance.

TABLE 1. *C. diurnum* L.

Serial number.	Number of flowers showing variations.	Number of sepals.	Number of petals.	Number of stamens.
1	10	4	4	4
2	36	6	6	6
3	1	6	6	6
4	2	6	5	6
5	1	6	5	4
6	2	5	7	7
7	20	5	6	6
8	1	5	4	4
9	1	6	6	5
10	2	4	4	5
11	1	4	5	5
12	5	6	5	5
13	3	5	5	4
14	8	5	5	6
Total ..	93			

Fasciation. In addition to the floral variations described above, fasciation was observed in three cases of *C. elegans* Schlecht. In two cases, the sepals of the two adjacent flowers were so fused that they had a common whorl of ten sepals. In a third case, a flower consisted of eight sepals, nine petals, eight stamens, and two fused gynoecia.

TABLE 2. *C. nocturnum* L.

Serial number.	Number of flowers showing variations.	Number of sepals.	Number of petals.	Number of stamens.
1	5	3	3	3
2	71	4	4	4
3	1	3	4	4
4	1	4	6	6
5	1	5	6	6
6	1	7	5	5
7	1	5	4	5
8	11	5	5	4
9	2	4	5	5
Total	.. 94			

TABLE 3. *C. elegans* Schlecht.

Serial number.	Number of flowers showing variations.	Number of sepals.	Number of petals.	Number of stamens.
1	13	6	6	6
2	3	7	6	6
3	1	10	6	6
4	1	6	6	4
5	1	6	5	4
6	1	4	5	4
7	1	10	6	5
8	1	6	6	5
9	5	5	5	3
10	3	5	5	4
11	8	6	5	5
12	2	7	5	5
Total	.. 40			

This was due to a complete fusion between different whorls of the two adjacent flowers.

SUMMARY

Observations on floral variations in *C. diurnum* L., *C. elegans* Schlecht., and *C. nocturnum* L. are recorded. Among the flowers with variations, the hexamerous flowers are by far the largest in number in the first two plants and the tetramerous ones in the last one. There are fourteen types of variations in *C. diurnum* L., twelve types in *C. elegans* Schlecht., and nine types in *C. nocturnum* L. The variations are in the number of sepals, petals, and stamens, but the gynoecium remained unaffected.

ACKNOWLEDGEMENT

The authors are deeply grateful to Dr. H. Santapau for valuable suggestions and help.

DEPARTMENT OF BOTANY,
SARDAR PATEL UNIVERSITY,
VALLABH VIDYANAGAR,
GUJARAT STATE,
May, 17, 1965

G. L. SHAH
B. SURYANARAYANA

REFERENCES

- BENTHAM, G., & HOOKER, J. D. (1876): *Genera Plantarum* 2 : 904.
BOR, N. L., & RAIZADA, M. B. (1954): Some beautiful Indian climbers and shrubs : 118-120. Bombay Natural History Society, Bombay.
DUNAL, M. F. (1852): Solanaceae in DC. *Prod.* 13 (1) : 598, 603 and 631.
LINNAEUS, C. (1753): *Genera Plantarum*, No. 234.
SAYEEDUDDIN, M. & SALAM, M. A. (1936): Teratological notes. *Curr. Sci.* 5 : 203, 204.
SINGH, T. C. N. (1935): Notes on teratology of certain Indian plants—VIII. *J. Indian bot. Soc.* 14 : 320.
SUNDERAJ, D. & BALASUBRAMANYAM, G. (1956): Abnormal carpellary conditions in a few plants. *Sci. and Cult.* 21 : 468-470.

19. *UTRICULARIA MINUTISSIMA* VAHL : A NEW RECORD FOR NORTH INDIA

A species of *Utricularia*, collected near Nuanai bridge in October 1965 during a botanical exploration in Balukhand Reserve Forest, Puri District, Orissa State, has been subsequently identified as *U. minutissima* Vahl, a new record for northern India. The plant grows in abundance in sandy marshes in association with *U. baouleënsis* A. Chev., *U. bifida* L., *U. caerulea* L., *U. hirta* Klein, and *U. stricticaulis* Stapf.

C. B. Clarke (1885) in Hooker's FLORA OF BRITISH INDIA includes *U. minutissima* in the group of imperfectly known species. Subramanyam & Balakrishnan (1960) reported the occurrence of *U. lilliput* Pell. in India, based on a collection from Courtallam, Madras State; this name has been subsequently proved to be synonymous with *U. minutissima* Vahl. Recently Vasudevan Nair (1965) has reported this species from Palghat, Kerala State. So far there is no other report of this plant from anywhere else in India and its presence in Orissa State adds information about its distribution in India. The specimens are deposited in Blatter Herbarium (BLAT), Bombay.

In essential characters, the present collection of *U. minutissima* matches with the details of its earlier reports; certain variations noticed are pointed out below: (i) Leaves bear 8-14 minute bladders arranged alternatively; (ii) flowers bluish white, unlike the previous reports, where they are described as pinkish or pinkish red. The bladder has a lateral mouth. As in other semi-marshy species, this also has bladders but lacks the sensitive hairs on the door. The mouth is guarded by the door, velum, and threshold and bears the usual type of sessile glands as in other semi-marshy species. Within the bladder, there are a few digestive glands, usually quadripartite, sometimes bipartite. Exomorphic characters of the seeds of *Utricularia* are highly variable from species to species and they could be used for their identification. In this species the shape and structure of the seed are unique; they are globose and reticulate and look almost similar to seeds of *U. squamosa* Wt.

Specimens examined:

Abraham 264, 354 (BLAT), Balukhand Reserve Forest, Orissa, October 1965.

My thanks are due to Dr. K. Subramanyam, Joint Director, Botanical Survey of India, Calcutta, for encouragement and for the facilities provided for this study.

BOTANICAL SURVEY OF INDIA,
76, LOWER CIRCULAR ROAD,
CALCUTTA 14,
April 6, 1966.

V. ABRAHAM¹

REFERENCES

- SUBRAMANYAM, K. & BALAKRISHNAN, N. P. (1960): *Utricularia lilliput* Pellegrin—A new record for India. *Bull. bot. Surv. India* 2: 247-348.
- VASUDEVAN NAIR, R. (1965): New record of *Utricularia minutissima* Vahl in South India. *J. Bombay nat. Hist. Soc.* 62: 180-182.

¹ Present Address: Biology Division, Atomic Energy Establishment, Trombay, Bombay 8.

20. TWO INTERESTING ORCHIDS FROM N. W. HIMALAYAS

The author who was a botanist member of the mountaineering expedition to the Tirsuli Peaks, Pithoragarh District, Kumaon, undertaken by the Himalayan Association, Calcutta, during April-May 1965, collected two plants of the genus *Pleione* D. Don, viz. *P. grandiflora* Rolfe. and *P. humilis* D. Don var. *albata* Reichb. f., from Kalamuni Pass at an altitude of 2600-2700 m. The former is a central Asiatic (Yunan, Mengtze) species and has not been previously reported from India. The other taxon is known only from temperate Nepal and the Sikkim Himalayas. Both the species have been collected from mossy rocks in *Quercus-Rhododendron* forest. The specimens are deposited in the Central National Herbarium, Sibpur, Calcutta (CAL) and Herbarium of the Botanical Survey of India, Northern Circle, Dehra Dun (BSD).

P. grandiflora Rolfe in Orch. Rev. 11 : 291, 1903 ; Pfitz. et Kraenzlin Pflanz. 32 : 124, 1907. *Coelogyne grandiflora* Rolfe in J. Linn. Soc. 36 : 22, 1903.

Rhizome repent ; root fibrous. Pseudobulb ovate to flask-like, surrounded by leaf fibres, 3 to 4 cm. long, about 1.5 cm. in diameter ; apical annulus, cylindrical, dentate, 1-leaved. Leaf lanceolate, acute, projecting much above the annulus, 4 to 5 cm. long when the flower opens. Scape appearing with the leaves, erect, 4 to 5 cm. long, single-flowered ; basal sheath tubular, obliquely truncate, thin and membranous, almost transparent, shining, equalling the pseudobulb in length. Bracts narrowly elliptic, tip rounded. Flowers white. Sepals and petals similar, lanceolate-oblong, obtuse, 4 to 5 cm. long, 0.75 cm. broad, 5- to 7-nerved. Labellum white, streaked and spotted brown inside, trilobed with rounded lateral lobes and trapeziform median lobe, emarginate, margin fimbriate ; carina with 5 longitudinal fringed lamellae. Gynostegium slender with triangular wing which towards the apex become two-lobed.

N. C. Nair 35536.

Pfitzer & Kraenzlin (loc. cit.) report that the size of the scape is 10 to 12 cm. long and sheath 12 cm. long. In the present material the scape and sheath were short.

P. humilis D. Don var. *albata* Reichb. in Gard. Chron. 1 : 392, 1888 ; Pfitz. et Kraenz. 32 : 122, 1907. *Coelogyne humilis* (D. Don) Lindl. var. *albata* (Reichb.) Hook. f. in Fl. Brit. Ind. 5 : 841, 1890.

Pseudobulb flask-shaped, 3 to 3.5 cm. long, 1 to 1.5 cm. diameter, single-leaved ; annulus membranous. Leaves oblong-obovate, acuminate, 5-nerved, 20 cm. long appearing later than the single-flowered scape. Bracts longer than the ovary. Flowers white. Sepals lanceolate, sub-acute. Petals similar, obovate from a cuneate base. Labellum

streaked and spotted purple inside ; margin lacerate towards the tip ; lamellae 5, fimbriate.

N. C. Nair 35519.

I am thankful to Dr. M. A. Rau for encouragement.

BOTANICAL SURVEY OF INDIA,
63, RAJPUR ROAD,
DEHRA DUN,
April 27, 1966

N. C. NAIR

21. *ELEOCHARIS FISTULOSA* SCHULT. : A NEW RECORD FOR THE UPPER GANGETIC PLAIN

Duthie (1929) recorded three species of *Eleocharis* (Cyperaceae), namely, *E. atropurpurea* Kunth, *E. palustris* R. Br. and *E. plantaginea* R. Br. from the Upper Gangetic Plain. Recently one more species of *Eleocharis* was collected by the authors from Meerut, which was later identified as *E. fistulosa* Schult. Since this species has not been reported from the Upper Gangetic Plain, the publication of this record may be of some interest.

Eleocharis fistulosa Schult. : Hook. f. Fl. Brit. Ind. 6 : 626, 1893 ; Cooke, Fl. Bomb. Pres. 2 : 863, 1908 ; Haines, Bot. Bih. & Or. 912, 1924 ; Fischer, Fl. Pres. Mad. 1948, 1931.

A rush-like caespitose herb, 30-90 cm. high ; rhizome stoloniferous. Stems tough, terete, glabrous, triquetrous at the top, basally embraced by loose, membranous, obliquely truncate, sheaths. Spikelets terminating the stems, embraced at the base by a short rounded bract, cylindric, acute, dusky, green, 2-4 cm. high, as broad as stem. Glumes laxly imbricate, much striated, suberect, obovate, subacute. Bristles 6, slightly longer than the nut, brown. Nuts obovoid, faintly striate, pale or dark brown, tipped with persistent style bases.

Flowers and Fruits : October-December.

Amhera, Meerut, November 5, 1965, *Murty & Singh* 2495.

This species was growing gregariously in marshy places near village Amhera, associated with *Eleocharis plantaginea* R. Br. and *Isoetes coromandelina* Linn. It can be readily distinguished in the field from other species of the genus occurring in the Upper Gangetic Plain by its sharply triquetrous stem at the top.

Hooker (1893) gives the distribution of this species from Nepal and Assam to Burma and Ceylon. Probability of its being overlooked by earlier collectors is strong.

The authors record their thanks to Professor V. Puri for his interest

in this study and to Dr. S. Kedarnath for facilities to work in Forest Research Institute Herbarium, Dehra Dun.

SCHOOL OF PLANT MORPHOLOGY,
MEERUT COLLEGE,
MEERUT,
June 10, 1966

V. SINGH
Y. S. MURTY

22. DISTRIBUTION OF *SPINIFEX LITTOREUS* (BURM. F.) MERR. ALONG INDIAN COASTS

Although most plants in Indian coasts are more or less well known, information on their habitats and distribution is meagre. Recently a population of *Spinifex littoreus*, a suffruticose dioecious perennial grass, near Digha of Midnapur coast in West Bengal was observed. This is the first report for West Bengal State, thus indicating an extension of the known range of distribution from the shores of Puri, Cuttack and Balasore.

This hardy grass is found along the western and eastern coasts of India. It is ecologically restricted to the maritime strand ecosystem and is prominent there. It occurs along the tropical coasts of China, Formosa, Siam, the Malay archipelago, Burma, the Laccadive and Maldivic islands, and Ceylon where it forms a major component of the strand vegetation. Along Indian coastal areas it occurs along the west coast; Domas near Surat in Gujarat State is the north-western limit of its extension; along the east coast its occurrence has been reported from the sandy shores of Puri by Prain (1903) and Cuttack and Balasore by Haines (1924). Recently, male clumps were found near Digha in Midnapur District. These observations thus indicate that *Spinifex* perhaps has invaded this area only recently.

The plant is sometimes associated with the sand-binding *Ipomoea pes-caprae* (L.) Sweet. However, it does not have any consistent association with any plant species, but exhibits special adaptations for competing successfully with other species of the strand ecosystem.

BOTANICAL SURVEY OF INDIA,
76 ACHARYA JAGADISH BOSE ROAD,
CALCUTTA 14,
May 3, 1966

T. ANANDA RAO
P. G. SHANWARE

REFERENCES

- HAINES, H. H. (1921-5): The Botany of Bihar and Orissa. London.
PRAIN, D. (1903): Bengal Plants. Calcutta.

23. A NEW SPECIES OF *HYDROGONIUM* FROM THE WESTERN HIMALAYAS

(With a plate)

***Hydrogonium mussoorianum* Vohra, sp. nov.**

Affine *H. amplexifolio* (Mitt.) Chen, ab eo tamen differt foliis minoribus, fortiter carinatis, obtusis, nervo lato et complanato desinente ad apicem vel in dentem brevem; cellulis basalibus versus marginem subquadratis.

Typus, *Vohra 453A*, et isotypus, *Vohra 453B*, lecti ad Mussoorie in Himalaya Septentrionali occidentali, ad altit. 2000 m. die 22.3.1963. Holotypus positus in CAL, isotypus in BM.

***Hydrogonium mussoorianum* Vohra, sp. nov.**

Allied to *Hydrogonium amplexifolium* (Mitt.) Chen, but differs in leaves being smaller, strongly carinate, obtuse, nerve wide and flattened, ceasing with the apex or projecting in a short tooth; and basal cells towards margin somewhat quadrate.

Plants laxly tufted, brownish green or dark green. Stems slender, weak, 2-3 cm. tall, simple or branched with 2-4 subapical innovations. Leaves when dry coiled round the stem with apices incurved or circinate, when moist spreading from an erect sheathing base, amplexicaul, strongly carinate, apices more or less curved upwards, 0.75-1 mm. \times 0.5-0.6 mm., ovate lanceolate, obtuse; margin erect, entire, somewhat crenulate due to papillae; nerve yellowish brown, wide, 70-90 μ at base, flattened, uniform or slightly narrow at apex, ceasing with the apex or projecting into a short tooth, papillose at back; cells rounded-quadrate, 5-7 μ , densely papillose with 4-5 minute semilunar papillae in each cell, obscure, at base pellucid, oblong, thick-walled, 8-11 \times 14-34 μ , 5-10 rows toward margin short and quadrate.

The holotype of this species (*Vohra 453A*) and isotype (*Vohra 453B*) were collected from Mussoorie, NW. Himalayas at an altitude of 2000 m., on 22-3-1963. The holotype has been deposited in the Central National Herbarium, Howrah, CAL, and isotype in the British Museum (Nat. Hist.), London, BM.

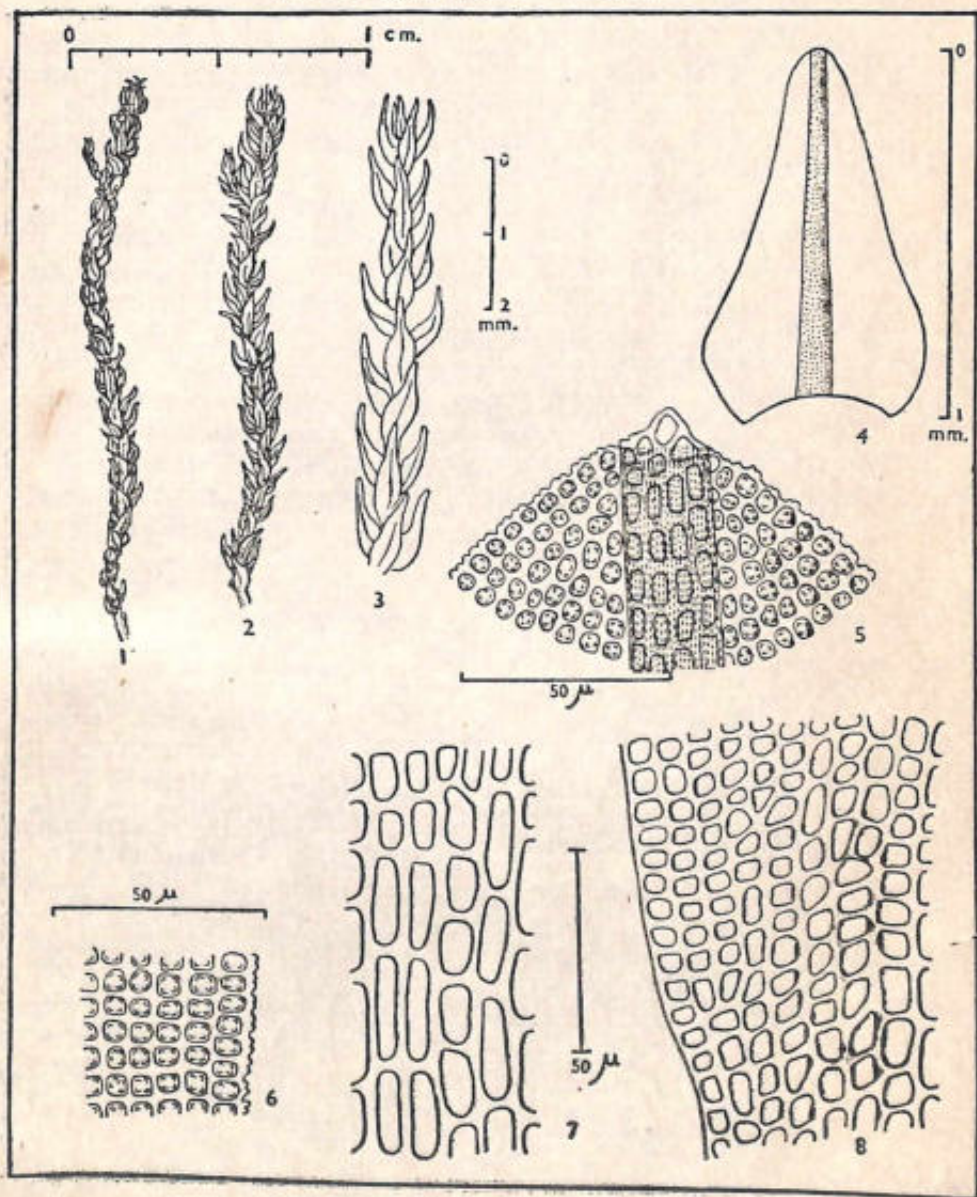
ACKNOWLEDGEMENTS

I wish to thank Dr. Santapau, S.J., F.N.I., Director, Botanical Survey of India, for going through the manuscript and for the Latin diagnosis, and Mr. A. H. Norkett of the British Museum (Nat. Hist.) for his valuable opinion on this species.

BOTANICAL SURVEY OF INDIA,
76 ACHARYA JAGADISH BOSE ROAD,
CALCUTTA 14,
May 18, 1966.

J. N. VOHRA

Vohra : *Hydrogonium mussoorianum*



Hydrogonium mussoorianum Sp. nov.

1. Dry Plant 2. Moist Plant 3. Shoot Apex 4. Leaf 5. Leaf Apex
6. Laminar cells 7. Basal cells towards nerve 8. Basal cells towards margin

24. OCCURRENCE OF *STREPTONEMA TRILOBATUM*
WALL. AT RAIPUR, MADHYA PRADESH

Wallich in 1855 reported *Trigonema trilobatum* from lower Bengal and later in 1860 synonymised it with *Streptonema* and described it. Subsequently it was reported and described by Turner (1892) from East India and since then there are no reports of this alga from any other parts of the country. During the author's collection of algae from here in October 1964 it was found submerged in Mahant Tal near Science College. When the water is disturbed the filaments come very near to the surface but do not float. There are no reports about the habit of the alga by previous authors. The filaments do not form clusters and were found only at the margin of the pond. It was observed for nearly two months in 1964; in 1965, perhaps due to lack of rains, the alga was not seen.

The author could not get any reproductive stages. The alga shows a little difference in size from the previously reported forms. The filaments are 2 to 3 cm. long or even longer. Semi-cells 20 to 24 μ long, 40-45 μ broad and processes 4 to 7 μ long.

I am thankful to Dr. R. Ross, Keeper, British Museum (Natural History), London, for identification, and to Dr. G. S. Venkataraman for giving me the literature.

DEPARTMENT OF BOTANY,
GOVERNMENT COLLEGE OF SCIENCE,
RAIPUR, M. P.

K. SANKARAN UNNI

December 30, 1965.

REFERENCES

- TURNER, W. B. (1892): The Freshwater Algae of East India. *Kongl. Sve. Vet. Akad. Handl.* 25 (5): 144-45.
WALLICH, G. C. (1855): Descriptions of Desmidiaceae from Lower Bengal. *Ann. Mag. Nat. Hist.* 5: 196-197.
WALLICH, G. C. (1860): *ibid.* 39-46.



ANNUAL REPORT OF THE BOMBAY NATURAL HISTORY
SOCIETY FOR THE YEAR 1965-66

EXECUTIVE COMMITTEE

President

Dr. P. V. Cherian, *Governor of Maharashtra*

Vice-Presidents

Major-General Sir Sahib Singh Sokhey, I.M.S. (Retd.)

Dr. Sálím Ali, D.sc., F.N.I.

Rev. Fr. H. Santapau, S.J.

Hon. Secretary

Mr. Zafar Futehally

ex officio

Hon. Treasurer

Mr. J. D. Kapadia, I.C.S. (Retd.)

Member

Secretary, Ministry of Education, Govt. of India

Elected Members

Mr. Humayun Abdulali

Mr. G. V. Bedekar, I.C.S. (Retd.)

Prof. P. V. Bole

Mr. R. E. Hawkins

Dr. C. V. Kulkarni, M.Sc., Ph.D.

Mr. S. Majeedullah, I.P.S.

Dr. A. N. D. Nanavati, M.D.

Mr. D. J. Panday

Dr. T. Ramachandra Rao, D.Sc., F.N.I.

Mr. D. E. Reuben, I.C.S. (Retd.)

ADVISORY COMMITTEE

Mr. H. G. Acharya	..	..	..	<i>Ahmedabad</i>
Mrs. Jamal Ara	..	..	..	<i>Ranchi</i>
Mr. F. C. Badhwar, O.B.E.	..	..	..	<i>New Delhi</i>
Sir Chintaman Deshmukh, kt., C.I.E., I.C.S. (Retd.)	..	..	..	<i>New Delhi</i>
Mr. E. P. Gee, M.A., C.M.Z.S.	..	..	..	<i>Shillong</i>
Mr. M. Krishnan	..	..	..	<i>Madras</i>
Dr. N. K. Panikkar, M.A., D.Sc., F.N.I.	..	..	..	<i>New Delhi</i>
Dr. Bains Prasad, D.Sc., F.N.I.	..	..	..	<i>Dehra Dun</i>
Mr. P. D. Stracey, I.F.S.	..	..	..	<i>New Delhi</i>
Lt.-Gen. Sir H. Williams, C.B., C.B.E., M.I.C.E., M.I.E.	..	..	..	<i>New Delhi</i>

HONORARY SECRETARY'S REPORT FOR THE YEAR 1965

At the last Annual General Meeting of the Society held on 30th July 1965, we presented a report on the activities of the Society up to April 1965. The present report covers the 8 months thereafter up to 31st December 1965.

MEMBERSHIP

The total number of members on our register on 31st December 1965 was 1415. Out of this 71 were nominees of the Forest Department (who received the *Journal* at the concessional rate of Rs. 20), 249 were life members, and 2 honorary members. The position of the six previous years is tabulated below :—

Year	Life	Honorary	Ordinary		Total
			<i>Paid</i>	<i>Pending</i>	
1960	235	3	680	180	1098
1961	237	2	749	174	1162
1962	240	2	763	208	1213
1963	242	2	741	297	1282
1964	241	2	764	306	1313
1965	249	2	836	328	1415

During the year under report 100 ordinary and 6 life members were enrolled as against 23 ordinary and 7 life members who resigned or died. Even after allowing for the fact that Natural History is not a very popular subject in this country there is still scope for enlarging our membership very considerably. It may be pointed out that corporate members pay

the same fees as individuals and business firms, many of which are getting increasingly public spirited, could be induced to become members and support the Society in its various schemes.

THE SOCIETY'S JOURNAL

Three numbers of the *Journal*, Vol. 61, No. 3, and Vol. 62, Nos. 1 and 2, were published during the period under report. The 620 pages include 9 papers on Botany, 7 on insects, 3 on birds, and 2 each on mammals, fishes, crustacea, and molluscs. The 64 Miscellaneous Notes covered many subjects and, together with the papers, included descriptions of several new species and races of plants and animals.

With financial assistance received from authors of two articles we were able to include colour plates in two of the issues published during the year. The Society records its appreciation for this assistance.

It is unfortunate that we have not been able to publish the *Journal* on its scheduled date. This delay is, among other things, due to the fact that the Society is very understaffed for its editorial and clerical work.

GENERAL

BNHS/WHO Bird Migration Study Project. During the period under report one bird banding camp was held at Bharatpur, Rajasthan, between 22nd September and 25th October 1965. This year the main effort was on ringing ducks and waders. 2085 ducks and waders were ringed; the trapping was done with the help of professionals recruited from Bihar. Blood samples collected from the birds were sent to the Kievskae Shosse Institute of Poliomyelitis and Virus Encephalitis, Moscow, U.S.S.R., for virological investigation. We have had several recovery reports of these ringed birds, five of which are from Russia and one from East Pakistan. These recoveries are very important from the point of view of studying the migratory routes of birds.

A pilot survey party was also sent to the Chilka Lake area in Orissa and information collected by them will be useful for future camps.

This work, as you know, is carried out with the financial assistance of WHO with Dr. Sálim Ali as the Chief Investigator. During the year a sum of \$ 1000 has been received for continuing with this project.

Additions to the Collections. During the year 639 additions were made to our collections as under :

Mammals	..	9	
Birds	..	136	(20 specimens were received in exchange from Berlin and Denmark Museums)
Reptiles and Amphibians	..	406	
Insects and other invertebrates	..	88	

Interesting additions among these are :

Birds

Astur gentilis
Anser fabalis
Anser fabalis brachyrhynchus
Catharacta maccormicki

Reptiles

Cabrita leschenaulti
Oligodon travancoricus

Amphibians

Rana brevipalmata
Rana dobsonii
Microhyla zeylanica

Wild Life Preservation. We mentioned in our last report that a seminar was held in Delhi in April 1965 between representatives of the Planning Commission, the Ministry of Food & Agriculture, and the Indian Board for Wild Life. At this meeting a memorandum was submitted on behalf of the Society dealing with the administrative set-up necessary for wild life preservation in this country. This was followed up by a seminar in New Delhi on 24th of November 1965 in which several distinguished members of the International Union for Conservation of Nature and Natural Resources participated. The report of the seminar has not yet been published in our *Journal* because the minutes of the meeting have not yet come in from the Ministry of Food & Agriculture. The seminar, however, proved a useful forum for drawing attention to matters of importance in connection with nature conservation in this country.

The Society had been concerned about the proposal to establish an air rifle factory in the Punjab, and representations had been made to the Home Ministry advising that it was necessary to have suitable legislation enacted to prevent damage to our bird life by youngsters handling these air rifles. We have now been advised that this project has been dropped.

The Society has been exerting itself to preserve the small area of forest around Karnala Fort in Kolaba District, and to have it designated as a bird sanctuary. Members will recall that in this area a new bird record for the Indian limits, namely *Pericrocotus divaricatus*, the Ashy Minivet, has been found. This was reported in Vol. 62, No. 2, of the *Journal*, at page 303. The Maharashtra State Wild Life Board on which the Society is represented is recommending to the Government that this

area be designated as a bird sanctuary, and it is hoped that this representation will be successful.

At our instance Mr. M. Krishnan of Madras, a member of our Advisory Committee, wrote to the Secretary, Forest Department, Government of Kerala, about the destruction of the forest in the Periyar Wild Life Sanctuary, and stressing the importance of preserving this area in its natural condition. We hope that the Government of Kerala will consider this representation carefully.

PUBLICATIONS

A SYNOPSIS OF THE BIRDS OF INDIA AND PAKISTAN. Our stock of this book was exhausted during the year and Dr. Ripley was kind enough to donate 100 copies from the lot of 750 sent to the U.S.A.

The sale of our popular publications THE BOOK OF INDIAN BIRDS and THE BOOK OF INDIAN ANIMALS is satisfactory. The stock of SOME BEAUTIFUL INDIAN CLIMBERS AND SHRUBS and SOME BEAUTIFUL INDIAN TREES is now nearly exhausted and the Committee is considering the possibility of reprinting these publications as well as the book CIRCUMVENTING THE MAHSEER AND OTHER SPORTING FISH IN INDIA AND BURMA by Macdonald. The main difficulty is the lack of funds, though the profits from the sale of our publications are the mainstay of the Society's finances.

HANDBOOK OF INDIAN BIRDS, by Sálim Ali and S. Dillon Ripley. Work on the Handbook is continuing and the first volume is now in the press and is expected to be published in 1967. The paintings for the Handbook have been received and blocks will be prepared before the end of 1966.

FAUNA OF MAHARASHTRA. The Society has undertaken to prepare a volume on the Fauna of Maharashtra in the Maharashtra Gazetteer series. The work is now in progress and is expected to be completed before the end of the year 1966.

DONATIONS

Members are aware of the generous manner in which the late Dato Loke Wan Tho assisted the Society. The executors of Loke Wan Tho's will have donated to the Society a bird-call tape recording set and accessories, a photo enlarger, and all the negatives of photographs taken by Dato Loke Wan Tho, and Col. R. S. P. Bates. Col. Bates's negatives were earlier purchased by Loke Wan Tho. The Society is deeply indebted to the executors for this most valuable and useful gift.

Sálim Ali/Loke Ornithological Research Fund. We are glad to report that Dr. Sálim Ali has donated a sum of Rs. 10,000 for starting a research fund for the study of field ornithology and generally to promote the cause of bird preservation in this country. The interest from the fund will be available to both amateur and professional biologists and we appeal to our members for further contributions so that a substantial fund can be built up for use in future years.

A donation of Rs. 100 has already come in from Dr. (Miss) R. Reuben.

Dr. Sálim Ali has also donated his entire library of about 500 volumes and 1000 separates of scientific papers to the Society. We are deeply grateful for this very generous gift.

Col. R. W. Burton Fund. The late Col. R. W. Burton who was one of the most active members of our Society during the 70 years of his stay in this country left the Society a sum of Rs. 3000. The Society proposes to invest this fund and use its proceeds for furthering the cause of Nature Conservation.

Furniture. The National Institute of Oceanography who have been given temporary accommodation in our building and who have been using our library and auditorium for their training programme in Oceanography have thoughtfully donated to the Society furniture and fittings for the auditorium.

RESEARCH STUDIES

The Sir Dorabji Tata Trust Fund. One of the research fellows of the Society was given financial assistance for investigating the status of the Largebilled Reed Warbler, *Acrocephalus orinus*. The study was carried out in Rampur in Uttar Pradesh. Another member was given monetary assistance for doing a survey of the Hazaribagh National Park. The report of the survey will be published in a future issue of the *Journal*.

Field Ornithology. A student from Cambridge University under the guidance of Dr. Sálim Ali is at the moment working on the social behaviour and breeding biology of the Indian Hill Myna (*Gracula religiosa*).

Herpetology. With the financial assistance from the California Academy of Sciences herpetological collections were made in two selected areas in Madras and Mysore States and some very interesting material has been obtained. Further work under the same programme will be continued during 1966.

Sea Anemone Fauna. Facilities were offered to a CSIR Research Fellow for the study of Sea Anemones of Maharashtra.

NATURE EDUCATION SCHEME

The Nature Education Scheme financed by the Government of Maharashtra is now in its 18th year. Tours of the Natural History Section of the Prince of Wales Museum and special talks on natural history subjects with the aid of exhibits and specimens, films, and living animals were continued. The activities under the scheme have now been extended to Poona and Bassein and Virar in the Bombay environs. Efforts are being made to reprint booklets in the "Glimpses of Nature" series which are out of print and also to publish new booklets in the series.

LIBRARY

During the year 125 books and bound journals were added to the library, of which 7 books were purchased, 9 received for review, and 11 presented. Our thanks are due to the donors.

EXHIBITION

An exhibition of wild life paintings by Shri Basu Roy Choudhury was held at the Society's auditorium from 30-7-1965 to 7-8-1965.

REVENUE ACCOUNT

The audited accounts for the year are attached. It will be seen that the revenue account is somewhat better than in previous years mainly because of the sale of our two popular books THE BOOK OF INDIAN ANIMALS by S. H. Prater, and THE BOOK OF INDIAN BIRDS by Sálím Ali.

STAFF

The Committee wishes to record its appreciation of willing co-operation of the entire staff in the activities of the Society.

ACKNOWLEDGEMENTS

The Committee's thanks are due to Mr. J. L. Bernard who continues to look after the Society's interests in the United Kingdom.

BALANCE SHEET AS AT 31 DECEMBER 1965—(continued)

FUNDS AND LIABILITIES	Rs. P.	Rs. P.	ASSETS	Rs. P.	Rs. P.
Brought forward ..	3,175.88	1,18,960.50	Brought forward ..		41,892.64
<i>Other Earmarked Funds (Contd.)</i>					
<i>Building Fund:</i>			<i>Investments: (At cost) (Contd.)</i>		
Balance as per last Balance Sheet ..	30,000.00		Rs. 85,000	80,341.37	
<i>Publication Fund:</i>			Rs. 470 4½% Defence Bonds	6,266.67	
Balance as per last Balance Sheet ..	30,725.00		(2nd issue) at cost	86,608.04	
			<i>Less: Provision for Depreciation</i>		
<i>Staff Welfare Fund:</i>				6,750.00	79,858.04
Balance as per last Balance Sheet ..	500.00		<i>Loans: (Unsecured) Good Doubtful</i>		
<i>Saibm Ali/Loke Wan Tho</i>			Loan, Scholarship	nil	
<i>Ornithological Research</i>			Other Loans (to staff)	345.00	345.00
<i>Fund:</i>			<i>Advances:</i>		
Amount received during the year ..	10,000.00		To Trustees	Good Doubtful	
Add: Interest earned during the year ..	80.55		" Employees (WHO Orissa Trip)	nil	
			" Lawyers	1,000.00	
<i>Col. Burton's Nature Conservation Fund:</i>			" Nature Education scheme	nil	
Amount received during the year ..	3,000.00	10,080.55	" C.S.I.R. for the Scheme on the role of Birds in our National economy	1,907.25	
Add: Interest earned during the year ..	24.16		" Others	500.00	
				53.12	
			<i>Stocks: (At cost or under)</i>		
			Books and Publications	40,736.35	
			Ammunition (Cartridges)	755.59	
			<i>Income Outstanding:</i>		
			Rent	..	
			Interest (Accrued)	..	1,340.79
			Other Income:		
			Supplies and Services	..	45,521.15
Brought forward ..	77,505.59	1,18,960.50	Carried forward ..		46,861.94
					1,67,047.99

BALANCE SHEET AS AT 31 DECEMBER 1965—(continued)

FUNDS AND LIABILITIES		Rs. P.	Rs. P.	ASSETS	Rs. P.	Rs. P.
16	Brought forward ..	77,505.59	1,18,960.50	Other Income: (Contd.)	46,861.94	1,67,047.99
	Other Earmarked Funds—(Contd.)			Government of Maharashtra		
	Grant from California Academy of Sciences for Herpetological Survey: Amount received during the year ..	1,423.00		Educational Activity Grant 1965-66.	4,000.00	
	Less: Utilised during the year ..	525.00		Government of Maharashtra Maintenance Grant 1965-66 ..	23,356.00	
				Government of India	10,000.00	
	Grant from Govt. of Madhya Pradesh for the Survey of Wild Buffaloes in Bastar: Amount received during the year ..	898.00	2,000.00	Grant for the Secretarial Assistance for the publication of Hand Book of Indian Birds in five volumes 1965-66 ..	2,250.00	
	Less: Utilised during the year ..		2,000.00	Grant for Nicobar Survey of Birds Expenses 1965-66 ..	9,000.00	
				Grant for the purchase of steel cabinets 1965-66 ..	31,500.00	
				Government of Madhya Pradesh: Grant for the Survey of Wild Buffaloes in Bastar 1965-66 ..	2,000.00	1,28,967.94
				<i>Cash and Bank Balances:</i>		
				(a) In Current Account with: National & Grindlays Bank Ltd., Bombay.	12,088.79	
				National & Grindlays Bank Ltd., London (£258-3-2) ..	3,442.11	
				Chartered Bank, Bombay ..	316.47	
				<i>In fixed Deposit with:</i>		
				National & Grindlays Bank Ltd., Bombay ..	25,000.00	
				Bank of India Ltd., Bombay ..	13,000.00	
				(The above Accounts are in the name of the Bombay Natural History Society)		
				(b) With the Trustees ..		
				(c) With the Cashier ..	397.77	54,245.14
	Carried forward ..	88,365.79	1,18,960.50	Carried forward ..		3,50,261.07

BALANCE SHEET AS AT 31 DECEMBER 1965—(continued)

FUNDS AND LIABILITIES	Rs. P.	Rs. P.	ASSETS	Rs. P.	Rs. P.
Brought forward ..	88,365.79	1,18,960.50	Brought forward ..		3,50,261.07
<i>Other Earmarked Funds—(Contd.)</i>					
<i>Unspent Grant-Government of Maharashtra</i>					
1964-65 Unspent Balance					
Brought forward ..	14,859.94				
Less: Spent during the year (as per Income & Expenditure Account) ..	10,584.27				
	4,275.67				
<i>Grant from Government of Maharashtra</i>					
1965-66 Grant for the year	23,356.00				
Less: Spent during the year (as per Income & Expenditure Account) ..	15,569.64				
	7,786.36				
<i>Unspent Grant World Health Organization</i>					
Balance as per last Balance Sheet ..	16,914.77				
Add: Amount received during the year ..	4,762.00				
	21,676.77				
Less: Utilized during the year ..	13,390.89				
	8,285.88				
Brought forward ..	1,08,713.70	1,18,960.50	Carried forward ..		3,50,261.07

BALANCE SHEET AS AT 31 DECEMBER 1965—(continued)

FUNDS AND LIABILITIES	Rs. P.	Rs. P.	ASSETS	Rs. P.	Rs. P.
Brought forward ..	1,08,713.70	1,18,960.50	Brought forward ..		3,50,261.07
<i>Other Earmarked Funds—(Contd.)</i>					
<i>Grant Government of India (Unspent)</i> (for the publication of Handbook of Indian Birds in five volumes) Balance as per last Balance Sheet ..	25,750.00		<i>Income and Expenditure Account</i> Balance as per last Balance Sheet Add : Deficit as per Income and Expenditure Account ..	22,684.44 2,872.96	25,557.40
<i>Add : Amount received</i> during the year ..	2,250.00				
	<u>28,000.00</u>				
<i>Less : Spent during the</i> year ..	3,000.00				
	25,000.00				
<i>Grant Government of India</i> For the purchase of steel cabinets 1965-66 ..	31,500.00				
For the survey of birds at Nicobar Islands 1965-66 ..	9,000.00				
		1,74,213.70			
Carried forward ..		2,93,174.20	Carried forward ..		3,75,818.47

BALANCE SHEET AS AT 31 DECEMBER 1965—(continued)

FUNDS AND LIABILITIES	Rs. P.	Rs. P.	ASSETS	Rs. P.	Rs. P.
Brought forward ..		2,93,174.20	Brought forward ..		3,75,818.47
<i>Liabilities</i>					
For Expenses ..	71,947.60				
" Advance Subscriptions ..	662.84				
" Sundry Credit Balances ..	10,033.83	82,644.27			
Total ..		3,75,818.47	Total ..		3,75,818.47

The above Balance Sheet to the best of my belief contains a true account of the Funds and Liabilities and of the Property and/Assets of the Trust.

As per our report of even date
(Sd.) A. F. FERGUSON & Co.,
Chartered Accountants

(Sd.) J. D. KAPADIA,
Trustee

BOMBAY, 26th May, 1966

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1965—(continued)

EXPENDITURE	Rs. P.	Rs. P.	INCOME	Rs. P.	Rs. P.
To Establishment Expenses: ..		26,153.91	Brought forward ..		44,370.16
Salaries including Dearness Allowance ..					
Society's contribution to Staff Provident Fund ..	38,907.25		Income from Other Sources:		
Postages ..	2,177.97		Membership Subscriptions ..	22,167.77	
Printing and Stationery ..	1,503.46		Entrance Fees ..	500.00	
Advertisement ..	1,704.42		Publications:		
Telephone charges ..	85.50		Journal Sales ..	5,114.72	22,667.77
Electricity charges ..	609.91				
Bank charges ..	722.44		Profit on Sale of Books:		
Meeting expenses ..	250.05		Book of Indian Birds ..	15,006.66	
Motor Car Charges ..	780.80		Some Beautiful Indian Climbers and Shrubs ..	526.30	
Conveyance and Travelling ..	788.48		Some Beautiful Indian Trees ..	745.72	
	184.55	47,714.83	Butterflies of the Indian Region ..	1,302.82	
To Building Maintenance Account:			Synopsis of Birds of India and Pakistan ..	106.48	
Salaries ..	1,981.16		Book of Indian Animals ..	10,590.36	
Miscellaneous Expenses ..	515.00	2,496.16	Indian Molluscs ..	179.32	
			Identification of Indian Butterflies, by Evans ..	11.00	
Remuneration to Trustees ..	nil		Other Publications ..	231.70	
Legal Expenses (In the case of Math) ..	nil		Nature Calendars ..	4,437.50	
Audit Fees ..	203.00				
Contribution and Fees ..	750.00	953.00			
	nil				
Amounts Written off:					
(a) Bad Debts ..	nil				
(b) Loan Scholarships ..	nil				
(c) Irrecoverable Rent ..	nil				
(d) Other Items ..	nil				
Carried forward ..		77,317.90	Carried forward ..	38,252.58	67,037.93

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1965—(continued)

EXPENDITURE	Rs. P.	Rs. P.	INCOME	Rs. P.	Rs. P.
To <i>Miscellaneous Expenses</i> :		77,317.90	Brought forward ..	38,252.58	67,037.93
General Charges ..	741.84		<i>Less : Books Written-off :</i>		
Opening ceremony of New Building ..	1,504.70		Identification of Poisonous Snakes Charts ..	2,503.10	
Office Shifting Expenses ..	1,385.98		Game Birds of India Vol. III ..	22.44	
Fire and Accidental Insurance ..	229.30				
Donation to Zoological Society of London ..	66.67				
Repairs to Furniture ..	200.00	4,128.49		2,525.54	
<i>Depreciation :</i>					
On Investment ..	3,000.00		<i>Less : Packing and forwarding charges ..</i>	35,727.04	
On Furniture ..		3,000.00		881.37	
<i>Expenditure on Objects of the Trust :</i>					
(a) Religious ..			<i>Miscellaneous receipts ..</i>		34,845.67
(b) Educational—Journal Expenses ..	22,423.71		<i>Deficit carried over to Balance Sheet.</i>		5,610.73
<i>Library Account :</i>					2,872.96
Subscription to other Societies ..	997.05				
Purchase of Books ..	638.37				
Periodical and Binding charges ..	724.50				
<i>Maintenance of Reference Collections ..</i>	2,359.92	25,920.90			
	1,137.27				
		1,10,367.29	Total ..		1,10,367.29

As per our report of even date

(Sd.) A. F. FERGUSON & Co.,

Chartered Accountants

(Sd.) J. D. KAPADIA,
Trustee

BOMBAY, 26th May, 1966

BOMBAY NATURAL HISTORY SOCIETY
COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH GRANT-IN-AID

Receipts and Payments Account for the year ended 31 December 1965

RECEIPTS	Rs.	P.	PAYMENTS	Rs.	P.	Rs.	P.
Balance as at 1st January 1965			<i>Grant No. I :</i>				
Brought forward :			Salaries		6,673.41		
With National and Grindlays Bank Ltd., Bombay on Savings Account		2,306.62	Miscellaneous		744.36		7,417.77
Grant No. I for the year 1965-66		3,847.65	<i>Grant No. II :</i>				
Grant No. II for the year 1965-66		1,860.00	Salaries		600.00		
Interest on Bank Account		37.00	Miscellaneous		..		
Refund of Travelling Expenses for the previous year		1.00	<i>Balance as at 31st December, 1965 :</i>				600.00
Balance carried forward being advance from Bombay Natural History Society		500.00	On Savings Bank Account with National and Grindlays Bank Ltd., Bombay		..		534.50
Total		8,552.27	Total				8,552.27

BOMBAY, 26th May, 1966

(Sd.) A. F. FERGUSON & Co.,
Chartered Accountants

(Sd.) J. D. KAPADIA,
Trustee

MINUTES OF THE ANNUAL GENERAL MEETING OF THE
BOMBAY NATURAL HISTORY SOCIETY HELD AT
HORNBILL HOUSE, APOLLO STREET, BOMBAY 1, ON
FRIDAY, 26TH AUGUST 1966, AT 6.30 P.M., WITH
DR. SÁLIM ALI, D.Sc., F.N.I., IN THE CHAIR

(1) The Honorary Secretary's report for the year ending 31st December 1965 having been previously circulated to members was taken as read and was adopted.

(2) The Balance Sheet and Statement of Accounts presented by the Honorary Treasurer were approved.

(3) The following were elected as members of the Executive and Advisory Committees for the year 1966-67.

EXECUTIVE COMMITTEE

President

Dr. P. V. Cherian, *Governor of Maharashtra*

Vice-Presidents

Major-General Sir Sahib Singh Sokhey, I.M.S. (Retd.)

Dr. Sálím Ali, D.Sc., F.N.I.

Rev. Fr. H. Santapau, S.J.

Hon. Secretary

Mr. Zafar Futehally

ex officio

Hon. Treasurer

Mr. J. D. Kapadia, I.C.S. (Retd.)

Member

Secretary, Ministry of Education, Govt. of India

Elected Members

Mr. Humayun Abdulali
 Mr. G. V. Bedekar, I.C.S. (Retd.)
 Prof. P. V. Bole
 Mr. R. E. Hawkins
 Dr. C. V. Kulkarni, M.Sc., Ph.D.
 Mr. S. Majeedullah, I.P.S.
 Dr. A. N. D. Nanavati, M.D.
 Mr. D. J. Panday
 Dr. T. Ramachandra Rao, D.Sc., F.N.I.
 Mr. D. E. Reuben, I.C.S. (Retd.)

ADVISORY COMMITTEE

Mr. H. G. Acharya	.. ..	..	<i>Ahmedabad</i>
Mrs. Jamal Ara	.. ..	..	<i>Ranchi</i>
Mr. F. C. Badhwar, O.B.E.	.. ..	..	<i>New Delhi</i>
Sir Chintaman Deshmukh, Kt., C.I.E., I.C.S. (Retd.)	.. ..	..	<i>New Delhi</i>
Mr. E. P. Gee, M.A., C.M.Z.S.	.. ..	..	<i>Shillong</i>
Mr. M. Krishnan	.. ..	..	<i>Madras</i>
Dr. N. K. Panikkar, M.A., D.Sc., F.N.I.	.. ..	..	<i>New Delhi</i>
Dr. Bains Prashad, D.Sc. F.N.I.	.. ..	..	<i>Dehra Dun</i>
Mr. P. D. Stracey, I.F.S.	.. ..	..	<i>New Delhi</i>
Lt-Gen. Sir H. Williams, C.B., C.B.E., M.I.C.E., M.I.E.	.. ..	..	<i>New Delhi</i>

(4) A Talk was delivered by Mr. Zafar Futehally on the International Union for Conservation of Nature and Natural Resources. The Talk was followed by a film show.

(5) The meeting terminated with a vote of thanks to the British Information Service for the films, and to the Chairman of the meeting.

Gleanings

Sound production by an Indian catfish

A common Indian catfish, *Heteropneustes fossilis*, has been found to possess three types of sound-producing organs. A high-pitched sound, particularly audible during the breeding period especially at the time of spawning, is produced by the movements of the pectoral spine. It is caused by the rubbing of striations on the pectoral spine against striations on the groove of the cleithrum of the pectoral girdle into which the pectoral spine fits. A sound of lower pitch is produced by the rubbing together of numerous small fine teeth situated in four tooth-patches, two in the roof and a corresponding pair on the floor of the buccal cavity. The third sound, of infrequent occurrence, is caused by the expulsion of gas from the suprabranchial diverticulae. The authors do not suggest any useful purpose served by these several sounds.

1965, V. P. Agarwal & R. S. Sharma, *The Annals & Magazine of Natural History*, ser. 13, Vol. viii : pp. 339-344.

The ethology of the Marabou Stork

The African Marabou Stork (*Leptoptilos crumeniferus*) is well known as a carrion eater, but it also consumes numerous small living vertebrates e.g. frogs, mice, and fish, especially when rearing young. It eats great quantities of termites at the time when they are swarming. In turbid water it is capable of finding food by tactolocation. One means of heat dissipation employed in hot weather is the excretion of dilute urine on the legs, which by evaporation cools the blood supply to the legs; this causes the white deposits so commonly seen on the legs. In a group of Marabou Storks dominant individuals can be easily picked out by the inflated throat sac; apparently, in adults the throat sac functions as a warning signal. Contrary to some published statements, the Marabou is not voiceless. It is very vocal, particularly near the nest, and some of its noises can be heard several hundred metres away. The young in the nest are fed by regurgitation by both the parents, the regurgitated food being dropped for the purpose on the floor of the nest—a procedure which gives the advantage to the older, stronger chicks. These and many other observations are recorded at length by M. P. Kahl in a paper, the first of a series planned for the study of the storks (Ciconiidae) from the point of view of comparative behaviour.

1966, M. P. Kahl, *Comparative Ethology of the Ciconiidae*.

Part 1. The Marabou Stork, *Leptoptilos crumeniferus* (Lesson)
Behaviour, Vol. 27, Parts 1-2, pp. 76-106.

A selective control for the Red Cotton Bug

An interesting possibility of the discovery of a selective control for the pest, the Red Cotton Bug (*Dysdercus koenegii* F.) is opened up by observations reported by K. N. Saxena and C. M. Williams in a recent issue of *Nature*. Previous observations by K. Sláma and C. M. Williams have shown that certain species of American wood used for paper pulp contain a powerful analogue of the juvenile hormone of the European bug, *Pyrrhocoris apterus* L., and that the metamorphosis of the 5th instar larva of this bug is inhibited by rearing the larva in contact with 'active paper' or by a topical application of an extract of the 'paper factor'. Contact with 'active paper' has been found to inhibit the hatching of newly laid eggs and, when an extract of the 'paper factor' was topically applied to freshly moulted adult females, the eggs subsequently laid by them were similarly affected. The present observations show that the 5th instar larvae of *D. koenegii* are sensitive to the 'paper factor', though not as sensitive as those of *P. apterus*. It is noted that the experiments in the present instance were performed with a crude extract prepared from 250 paper napkins, containing at most only trace amounts of the 'paper factor'.

1966, K. N. Saxena & C. M. Williams: 'Paper Factor' as an Inhibitor of the Metamorphosis of the Red Cotton Bug, *Dysdercus koenegii* F., *Nature*, Vol. 210, pp. 441.

Thermoregulation in Brooding Python

It is generally believed that there is no internal regulation of body temperature in reptiles. As long ago as 1832 Lamarre-Piquot read a communication to the French Academy in which he claimed that the python, after laying eggs, coils 'itself about them and produces heat to help in incubation. His statements were not accepted. Recent observations on Indian Pythons (*Python molurus bivittatus*) at the New York Zoological Park have indicated that brooding pythons are able to maintain their body temperature up to 7.3° C. above the ambient air and substrate temperatures for long periods. They do this by a process analogous to shivering in birds and mammals. One of the brooding pythons was kept in a respiration chamber in a temperature-controlled room. At temperatures below 33° C. there were spasmodic contractions of its muscles, which resulted in an increase in metabolism and in body temperature. Between 33° and 25.5°C. the metabolic rate and the number of contractions per minute increased as the air temperature was lowered, but below 25.5°C. the snake could not maintain its metabolism

and the metabolism fell. The same snake was tested when it had finished brooding ; this time there was no thermoregulation and the metabolic rate fell as the temperature was lowered below 33°C.

1966, Victor H. Hutchinson, Herndon G. Dowling, & Allen Vinegar, *Science* 151, pp. 694-696.

On ecotypes in the Indian Shad

On a study of the literature S. Dutt, Department of Zoology, Andhra University, suggests the possible existence of three ecotypes of the Indian Shad, *Hilsa ilisha* (Hamilton): (1) Anadromous stock, feeding and growing in coastal water and spawning in middle or lower reaches of rivers ; (2) Potamodromous stock inhabiting the middle reaches of river, and ; (3) Stock that lives and spawns in the sea.

1966, S. Dutt, *Current Science*, Vol. 35, No. 13, pp. 329.

A war-use of biological luminiscence

'*Cypridina* is a small crustacean with two hinged valves covering its body. It is found in both fresh and salt water, but only the marine forms are luminous. During World War II, Japanese soldiers used dried *Cypridina* as a source of low-intensity light when they did not want to run the risk of using a flashlight. A small quantity of *Cypridina* powder placed in the palm of the hand and moistened provided enough light for reading a map or a message.'

1962, William D. McElroy & Howard H. Seliger, *Scientific American*, December 1962, pp. 79.

CONTENTS

AN ANNOTATED LIST OF THE BUTTERFLIES OF DELHI, INDIA. By Julian P. Donahue	235
AESTIVATION OF PERIANTHS OF <i>Areca catechu</i> LINN. FRUITS. By T. A. Davis and Abantika Kundu	270
A REPORT ON TICKS COLLECTED FROM BIRDS AND SMALL MAMMALS IN NORTH ARCOT AND CHITTOOR DISTRICTS, SOUTH INDIA. By M. J. Rebello and Rachel Reuben	283
CHILKA LAKE : A PILOT SURVEY FOR BANDING POSSIBILITIES. By K. S. Lavkumar	290
TRANSPORT OF THE FRY AND FINGERLINGS OF THE MILK FISH <i>Chanos chanos</i> (FORSKÅL). By T. A. Mammen	298
STUDIES ON THE INSECT POLLINATORS OF <i>olitorius</i> AND <i>capsularis</i> JUTE. By S. K. Ghose	315
NOMENCLATRURAL NOTES ON SOME FLOWERING PLANTS. By N. P. Balakrishnan	327
STUDIES ON INDIAN COPEPODS—8. OBSERVATIONS ON THE DIURNAL VERTICAL MOVEMENTS OF PLANKTONIC COPEPODS IN THE GULF OF MANNAR. By A. N. P. Ummerkutty	332
AN ACCOUNT OF THE WEEDS OF CENTRAL RESEARCH FARM, JODHPUR, RAJASTHAN. By Y. Satyanarayan and S. K. Saxena	344
INDIAN WOOD-DESTROYING TERMITES. By M. L. Roodwal, sc. d. (Cantab.) F.N.I. and O. B. Chhotani, m.sc. (Hons.)	354
THE BIRDS OF NEPAL. Part 12. By Biswamoy Biswas	365
RE-USE OF CELLS AND BROTHER-SISTER MATING IN THE INDIAN SPECIES <i>Stenodynerus miniatus</i> (SAUSS.) (VESPIDAE : EUMENINAE). By S. D. Jayakar and H. Spurway	378
LIFE HISTORY OF THE INDIAN CUCKOO, <i>Cuculus micropterus micropterus</i> GOULD. IN THE SOVIET UNION. By I. Neufeldt.	399
MORE NEW RACES OF BIRDS FROM THE ANDAMAN AND NICOBAR ISLANDS. By Humayun Abdulali	420
REVIEWS	423
MISCELLANEOUS NOTES	428
ANNUAL REPORT OF THE BOMBAY NATURAL HISTORY SOCIETY FOR THE YEAR 1965-66	466
STATEMENT OF ACCOUNTS OF THE BOMBAY NATURAL HISTORY SOCIETY	473
MINUTES OF THE ANNUAL GENERAL MEETING	484
GLEANINGS	486