SUNDARBANS MANGROVE

(Ecology & Wild Life)

A.B. Chaudhuri
&
Kalyan Chakrabarti

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PREFACE

Mangrove forests until recently did not receive adequate attention despite their potentialities and being nature's richest laboratory and most complex ecosystem. Foresters were pioneer in bringing mangrove forests under scientific management and have collected adequate data on tree resources. Though most of the mangrove forests in general are rich in faunal resources, they do not compare Sunderbans in richness of fauna, their diversity and complexities which are result of special deltaic formation, geographic position and of interactions of mechanical, chemical, biological and physical environments. These complex environments have caused physiological and sometimes psychological changes in the entire animal population. No indepth study on behavioural patter, breeding biology, growth pattern etc. on such animals has so long been made.

The authors have worked for long years on Sunderbans of West Bengal and have made indepth extensive studies on behavioural pattern, breeding biology, growth, population etc., of tiger, honey bee, birds, crocodiles, crabs, fishes etc. Several such observation were earlier published in various journals as news letters and in symposia,workshops and conference literature. Vast,statistical,data and research finding which has been presented in this work are not generally available in the existing literature on wildlife. Plant animal relationship has also been closely studied and presented.

The authors used the shape and size of pug marks of tigers in determining tiger population as early as 1970 and had ascertained the number of tiger between 112 and 120. Many such data and information have been incorporated in the work which are findings of indepth studies. Besides, various aspects of flora have been presented. Mangrove forest resources of Andamans and the extent of forests have been recorded. These informations have made the work interesting and absorbing.

Much work has been done, but vast field of research still awaits to be unveiled. It is hoped that more revealing facts on the behaviour pattern of fauna of the tract will be unearthed by future generations of researchers.

A.B.Chaudhuri.

Kalyan Chakrabarti

FOREWORD

Though the mangrove biotopes have been considered a highly productive ecosystem and that they provide a wide range of valuable forest products, maintain estuarine water quality and play crucial role in the life cycle of many commercially important species of fin fish and sheel fish etc., the Indian foresters and scientists have not paid due attention to such areas until recently. In spite of the fact that Ganga-Brahmaputra delta forms the largest single patch of mangrove forests on earth (about 10,100 sq. km.) abounding with sinister man eating tiger, venomous snakes, world's largest crocodiles and countless numbers of vertebrates and invertebrates, the necessity of any biological and socio economical investigations had not been felt till recent past.

Population growth and economic development have brought immense pressure on mangrove wealth and its system for firewood, timber, fish, shellfish, honey, etc. While other mangrove countries have given much stress to develop aquaculture, Indian counterpart has primarily worked for supply of fuel wood and timber to the poor neighbouring villagers. It was never thought that the study of behavioural pattern of the maneaters and precarious socio economic conditions of the mangrove dependent people was imperative to change existing situation.

The authors have been pioneer to take up the risky work to determine the tiger population by use of pug mark supplement by various other parameters. They have been able to identify several important patterns of behaviour of the maneaters; besides they have also extensively studied and presented facts about the breeding biology and bio ecology of rock bee, avi-fauna, fish, crab and on several other animals. Their work also include survey of the flora of Sunderbans mangrove. Some information on the mangrove of Andamans and land use pattern of those islands have also been presented. It is believed that the authors have presented enough

data and facts which could inspire new researchers to work in these virgin areas.

The authors deserve congratuations as they have braved risks in a hostile territory and rigorous environment to collect data and carry out extensive research. It is very much encouraging that though the findings have been about a decade old, not a single such findings and observations have been found wrong over all these years. It is satisfying that various organisations have now initiated research programmes on mangroves.

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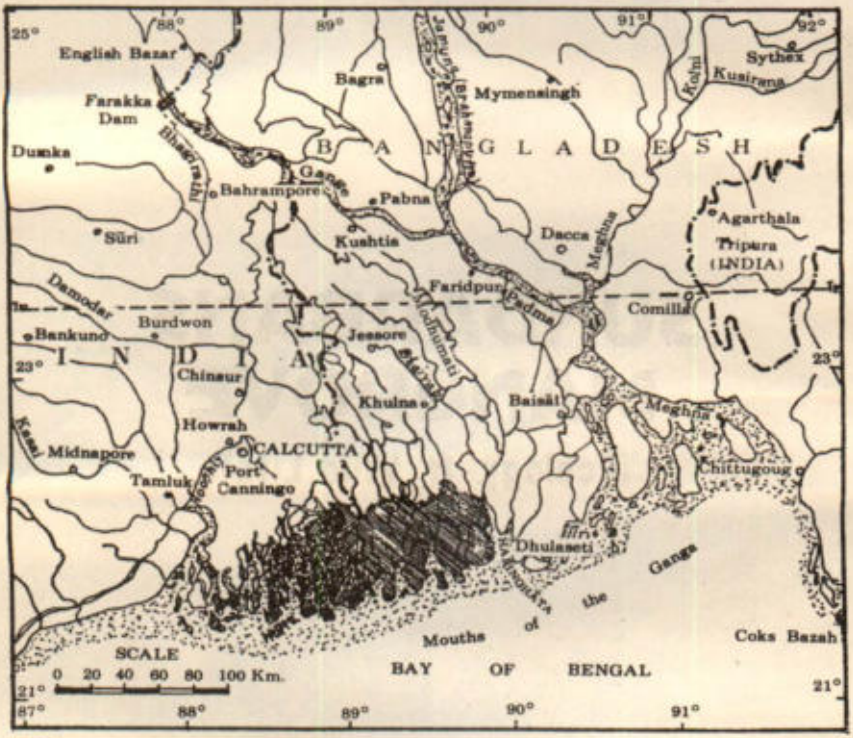
DELTA OF GANGA AND BRAHMAPUTRA.



INDIAN SUNDERBANS

BENGLA DESH SUNDARBANS

1

Sundarbans Estuary
A Unique Natural Habitat –

Whatever may be the derivations of the three appellations –

(i) Forests of Sundri *(Heritiera minor)*

(ii) Beautiful *(Sundar)* Forests and Animals,

(iii) Forests of ocean (Samudraban),

the Sundarbans stand supreme in habitat maps of the world. Few areas exist in the world with such diversities in animal species that live in a complex physical, chemical, mechanical and animate environment. The plants and animals are in perfect balance in a rich biomass by their stresses and strains, thrusts and counter thrusts. Sundarbans offer a perfect example where different societies of living organisms live in a hostile and complex biosphere-(biogeocoenosis) developing various adaptations (Osmo-regulatory mechanism, Endogenous Self Sustaining Oscillation, Pneumatophores etc.).

This is a peculiar terrain where man-eating tigers live in the midst of man-eating ferocious crocodiles and with sharks, lizards, birds, porpoises, fish, turtles, snakes, honey bee, crabs, snails and innumerable vertebrate and invertebrate species. Even people operating in the hostile estuarine tract develop peculiar habits, and the influence of myths, legends and the fisher-folk of the Sundarbans make the habitat as one of the most difficult but interesting for any biological study.

Some special characteristics of the habitat have been enumerated in the paragraphs below:

(i) Water :

Water in the estuary is saline and turbid. No animal in this terrain has opportunity to drink sweet water. As such, body fluids have to be controlled by special osmoregulatory adaptations. Fluids of marine bony fishes are hypotonic; marine fishes drink water and excrete a

concentrated urine and excessive salt. The role of saline water in higher terrestrial mammals in the Sundarbans is a virgin field of study. The ferocity in the habit of tiger may be attributed to the damaging liver and kidney developed owing to drinking of saline water for generations.

The characteristic zone of land in between high and low tide (intertidal zone) and its extent and depth determines the distribution and nature of animal life in the sub-stratum.

(ii) Periodicities :

Many animals of the region (especially the marine) have lunar periodicities in their breeding activities. Marine community does show a variety of rhythmic response to tides. Lunar rhythm does influence salinity, water temperature, currents and sediments. Fiddler Crab (*Uca* species) have internal biological clock that help them to time their feeding activities. Colour changes on the fiddler crabs are synchronised to diel or tidal cycles.

Preponderence of planktonic flora and fauna has correlation with the salinity, tidal fluctuations, lunar position and the available sunlight. Planktonic fauna, however, has negative correlation with intensity of sunlight and such fauna sink to the bottom (vertical movement).

Study of animals on seashore during daytime only will provide evidence of half the life and behaviour of the communities. All the animals are exposed to three different types of periodism viz., Seasonal, Lunar and Dial (or daily phenomenon).

The activities of tiger relating to human casualities shows a definite pattern and further study of facts aided by research will likely reveal some correlation.

Nocturnal collections record significantly more planktons than that of diurnal ones in any water area of the estuary.

(iii) Wind and its effect on flora and fauna.

Strong wind current to which the forests of Sundarbans are exposed during the months from March to September cause immense disturbance to the estuarine plants and animals. Owing to a very low forests most of the animals are exposed to strong wind and rains, water currents and high tides. Small animals are blown over miles; they have to stick fast to the ground or hold tight to tree trunks or in case of smaller animals aggregate to form colonies. A gale of 160 k.m. per hour (not uncommon in Sundarbans) exerts 16 times the force of a wind that is belowing 40 k.m. per hour. Obviously the formation of muscle and bones have to be tougher than any other habitat to withstand such

physical pressure.

The tidal waves sweep over the area twice a day, the tidal current changing its direction after every six hours. The tides penetrate far inland and the maximum rise or fall occurs in March and April. The tidal wave makes its way across the Sundarbans from west to east and consequently the tide changes earlier in the west than it does in the east. In large rivers the velocity of the current usually varies from 3 Km an hour near the sea surface to 6 Km an hour higher up in the forests. The speed increases further inland on account of gradual construction of the rivers. The average rise and fall is high in the western rivers than in the east. The average rise and fall near the sea face is about 2.2 m; further up it is 3 m; where the tide has little or no stream to contend against, an average rise and fall of 5-6 m is common.

(iv) Estuary and tidal currents.

Estuary is the buffer zone between fresh water of streams and salt water of the sea. Several factors and processes operate in the area. Opposite, undirectional and oscillating tidal currents meet and exert considerable and complicated force for entire biota. This also affects sedimentation. The tidal flow, however, is not constant. It accelerates upto half the height of tide and retards from there downwards.

(v) Salinity.

The mixing of salt and fresh water produce a peculiar chemical environment. Diurnal changes of salinity in water creates condition to make physiological adjustments of the animal and plant communities. Salinity also varies widely in vertical and horizontal planes.

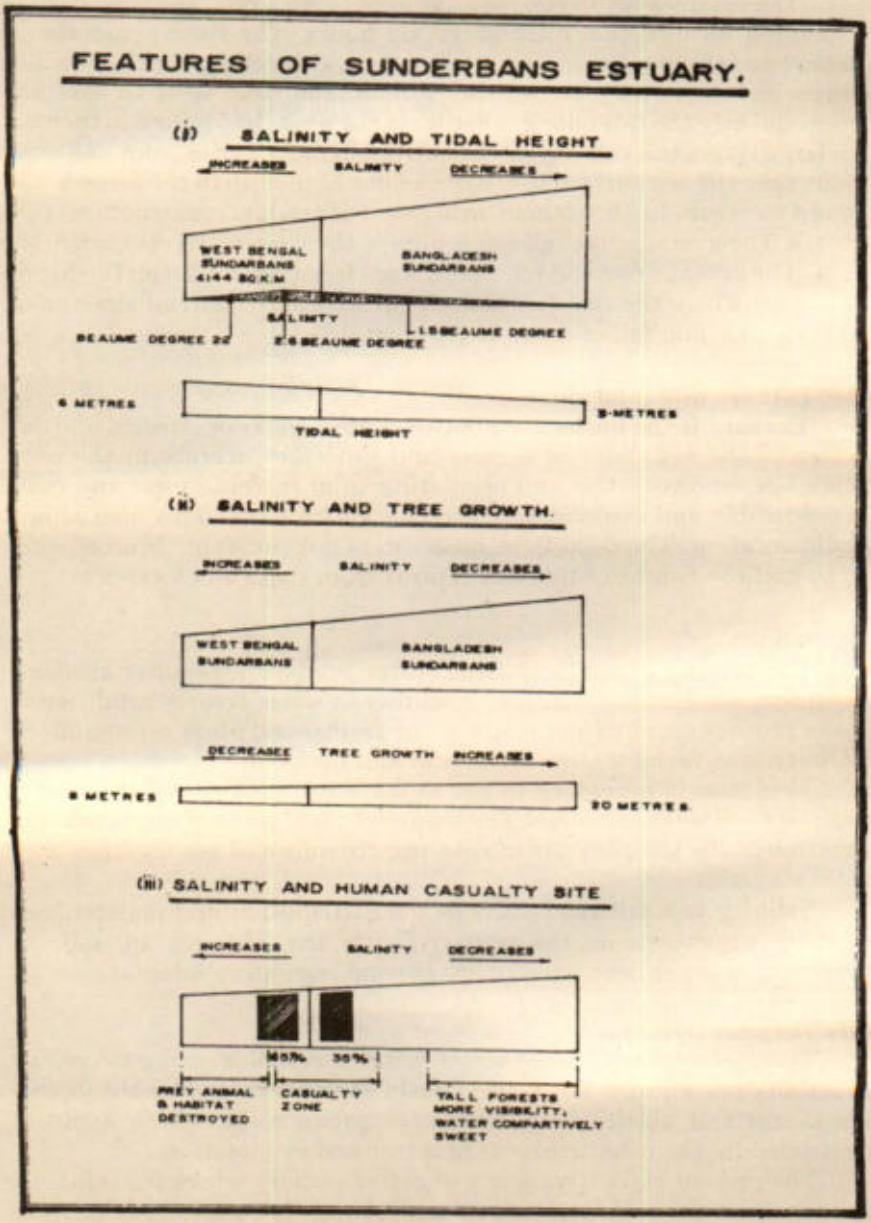
Less heat is necessary to get saline water heated and the heat is derived from solar radiation. The temperature of estuary is, therefore, a function of the temperature of entering streams and sea together with tidal stages.

Salinity is a critical factors in the distribution and maintenance of many organisms in the estuary. With the changes of salinity percentages organisms have to adapt osmoregulatory adaptations.

(vi) Thermal Dynamics :

Thermal dynamics in estuarine water is complex owing to change in salinity percentage. The form of basin and channel guides the flow of horizontal and vertical distribution of saline water which again is controlled by the tides, currents of water and evaporation.

The present tiger terrain is a negative estuary where the influx of fresh water is not sufficient to maintain mixing. In such estuary oxygen


FEATURES OF SUNDERBANS ESTUARY.
(i) SALINITY AND TIDAL HEIGHT
INCREASES SALINITY DECREASES
WEST BENGAL SUNDARBANS 4144 SQ.K.M
BANGLADESH SUNDARBANS
SALINITY
BEAUME DEGREE 2½
2·6 BEAUME DEGREE
1·5 BEAUME DEGREE
6 METRES
3 METRES
TIDAL HEIGHT
(ii) SALINITY AND TREE GROWTH.
INCREASES SALINITY DECREASES
WEST BENGAL SUNDARBANS
BANGLADESH SUNDARBANS
DECREASES TREE GROWTH INCREASES
8 METRES
20 METRES
(iii) SALINITY AND HUMAN CASUALTY SITE
INCREASES SALINITY DECREASES
65% 35%
PREY ANIMAL & HABITAT DESTROYED
CASUALTY ZONE
TALL FORESTS MORE VISIBILITY, WATER COMPARTIVELY SWEET

content is low in deep water and the bottom sediments contain considerable organic material.

(vii) Terrain :

The Sundarbans is a land of diverse eco-system. This is more than a mere transition zone with varied ecological characteristics and lies between the sea and the inland. The swamps lie close to the sea and have thick forests that are biologically most diverse. Estuarine and marine organism in the area exhibit incredible array of adaptations. Along the shore line thrive thousands of adapted species. The terrain is one of the most naturally fertile in the world. It is also a curiously anomalous tract.

(viii) Bio-luminescence

During the winter months quite often the river water near sea face is found to glow at night. This is due to the pressure of millions and millions of micro-organism *(Dinoflagillates, Ceratium* species, *Noctiluca* species and *Peridium* species). These microorganisms contain chlorophyll, carotene and xanthophyll. Entire atmosphere turns into a "Fairy land". Even the forests flanking the streams are frequently illuminated at night by swarms of fireflies.

Do the man-eaters derive extra energy or impetus to prowl at night and search for human prey to pick them up due to this incredible bio-luminescence?

(ix) Accessibility

Entire area is practically inaccesible owing to (i) high tide when forests are inundated; (ii) low tide when the shallow rivers do not allow watercrafts to get access; (iii) sharp pointed pneumatophores prevent easy trekking; (iv) soft mud does not allow easy trekking; (v) thick strong stems of regeneration which are impenetrable; (vi) impenetrable masses of stilt root of *Rhizophora* flanking stream banks and (vii) the rivers being infested by shark, crocodiles etc. and land by snake and man-eaters.

All these make the entire terrain either on land or water impenetrable, difficult to traverse both for animals and human beings.

It becomes immensely difficult for the predators and prey both to easily move in the forests. Similarly the terrain is difficult for human being to make any type of scientific investigation.

The vast expanse of swamps, studded closely with a network of tiny island of mud flats supports a low wooded forest of high density of virgin beauty. The rivers around tiny mud flats, form fantastic

labyrinths, bifurcations and interlaces where pneumatophores give a trying time to the mysterious flamboyant tigers who have to survive venomous snakes, sharp toothed shark and lusty crocodiles.

Photo 1 A panoramic view of Sundarban forest at the initiation of high tide.

2

Sundarbans Estuary – a brief history

To trace back the history it may be recalled that the lands of 24-Parganas ceded to the East India Company by a treaty of 1737 which subsequently became the Jaigir of Lord Clive. The earlier and recent history of the Sundarbans is a continuous history of reclamation of mangrove forests for agriculture. The first effort to reclaim the Sundarbans was made in 1770 by Mr. Claude Russel, Collector General 24-Parganas. Nothing much is known about the Sundarbans during the period intervening between the regime of Nawab and acquisition of Dewani by the East India Company. The whole of the District is a pure delta formed by the action of the river, Ganga which brings down fine silt and sand from the Himalayas through the two great channels the Bhagirathi and the Padma. While the Bhagirathi is the original southward course of the Ganga, the Padma is a later east flowing branch of it. Some time during the 16th century the main volume of the Ganges passed from the Bhagirathi to the Padma. As a result land building process took place at a much faster rate in the delta region of the Bhagirathi on the west than in the delta region of the Padma in the east. This formation of new alluvial hand naturally attracted the early settlers. This has practically started a progressive and continuous wave of reclamation of the forest areas. Records about the Sundarbans (including the portion in Bangladesh) show that the total area of the sundarbans forests was taken as about 20,000 square kilometres by Clarke in 1895, 17,500 square kilometres by Prain in 1903 and only 10,000 square kilometres by recent estimate of which hardly 4,000 square kilometres are included in West Bengal. Although by about 1879 a total area of about 4690 square kilometres of forests was declared as protected forests in 24-Parganas District, leasing of new areas which included

some of the notified protected forests continued. This was followed by deforestation and thence reclamation. As a result in 24-Parganas District alone during the last 90 years or so an area of about 750 square kilometres of forest land had been released for agricultural purpose. The whole area in 24-Parganas District was declared first as protected forests under a notification dated 7th December, 1878 and the boundaries of the remaining protected forests were fixed by the notification dated 19th April, 1926. The protected forests in the Basirhat Sub-Division of District (Basirhat Range present Tiger Reserve area) were constituted in the Reserve Forests as per Govt. notification dated 9th August 1928.

3

Mangrove Vegetation of Sundarbans and Andaman Islands

The estuarine forests are 'Halophytes' that grow on swampy clay, muddy and saline substratum. Such forests in the Sundarbans have, generated a fascination on the human mind. Some of the high flats were once regarded as hiding places of Bengal Kings viz. Raja Basant Roy and his nephew Pratapadity a during the reign of Mughal emperor, Akbar. After the fall of Bengal Kings anarchial conditions followed and the oppressions of Portuguese pirates put an end to the prosperity of the tract. Ruins of old buildings and camping sites are still to be found in Netidhopani, Gosaba, Khatuajhuri and some other blocks. The dense jungles, man-eating tigers, sinister crocodiles, dampness of the swamps and nature's virulence offered protection to the Sundarbans forest. But human ingenuity outwitted the defence of nature. Vast areas were reclaimed for settlement. Illicit felling of trees by a large but poor population denuded the forests.

Botanical exploration dates back to 1796 by Roxburg who detailed the account of plants collected through Dr. Buchanan Hamilton and Dr. William Carey in his publication 'Hortus Bengalensis' published in 1814. C.B. Clarke in 1895 gave an account of the Sundarbans. Mr. Heining, a Forest Officer, made an effort to collect plants and also prepared a Working Plan. On his and Clarke's collection and on further work, David Prain published a flora of Bengal plants in 1903.

Ecological succession in the eastern Sundarbans is different from that in the Western Sundarbans. Sundarbans soils are alluvial while the soils of the deltaic region of South India are derived from trap and siliceous rocks. Rehabilitating the saline blanks existing in the estuarine forest at the moment has posed a major problem.

No mud flats like Ganga-Brahmaputra occur in the Andamans. There is no river in Andaman where delta can be formed. Since the islands are tips of submerged hills, the sores are steep. Coastal flat

land does not occur. Evergreen, semi-evergreen and litteral forests extend right upto sea face, leaving long strips of estuarine vegetation with hardly any appreciable width. Where the sea enters inland and forms creeks, extensive long stretches (with comparatively longer width) of Mangrove Swamps are found.

Forests in Sundarbans grow in various associations (associes) in different seral stages. As many as ten to twelve such distinct associations (associes) can be identified. In such a terrain lives euryphagous and eurythermal amphibious tigers which are man-eaters. They are even now considered by the local people to possess supernatural power. About 40 precious human lives are lost every year. The close associations of tiger, crocodiles, turtles, lizards, fishes, crabs, snails, snakes, barnacles, oysters, shrimps, honey bees and myriads of others animals with the plant life make a thorough study of the plants extremely hazardous and risky, but excitingly complex and interesting. As such, thorough study is yet to be undertaken on various aspects of estuarine plants, especially on their physiology, anatomy and ecology.

The present attempt is to :

(i) Classify the plants into various formations.

(ii) Prepare a list of plants which are purely estuarine and littoral

(iii) Prepare field keys of common species for use by the foresters.

(iv) Give broad descriptions of typical estuarine species.

(v) Indicate a broad outline of plant succession.

The list is not exhaustive, although most of the important estuarine species and some on recently reclaimed land have been recorded. It must be borne in mid that the Indian part of Sundarbans have almost all typical estuarine species found in Bangladesh but fewer of littoral and sandy beach species.

TRACT DEALT WITH

Sundarbans Forests in the Ganga-Brahmaputra delta, falling in India and Bangladesh are contiguous and comprise single patch of estuarine forest: it is the largest single patch of estuarine forest in the world, though cut up by countless rivers, creeks and waterways.

Area of various estuarine tracts in India and abroad are as follows :

India	Area (ha)	Abroad	Area (ha)
West Bengal			
Sundarbans	4,18,888	*Malaya*	1,55,500
Andhra Pradesh		*Puerto Rico*	
Godavari delta	13,304	*Fiji*	2,000
Krishna delta	5,120	*Kenya*	32,500
Tamil Nadu			
Cauvery delta	2,640	*Tanzania*	10,500
Orissa			
Mahanadi delta	12,000	Zaire	20,000
Maharashtra			
West Coast	62,208	Indonesia	1,00,000
Saurashtra & Kutch	52,616	Mekong delta	2,50,000
Andaman & Nicobar		*Sundarbans in*	
Islands	*1.15.200*	*Bangladesh*	*12.97.500*
	6.81.976		

As such, Sundarbans and Andaman Forests taken together form a substantial percentage of estuarine forests.

The Indian Ocean and Western Pacific regions have 65 out of total of 90 typical mangrove species. Pacific America and Atlantic America both have 16 species each, while West America has 11 species. In India, the Gujarat coast has fewer species than the West coast and the both have combined fewer than the east coast species. Sundarbans, however, has the maximum number of species represented. Salinity in water and soil in Bangladesh is far less than in the West Bengal sector and these factors contribute to the emergence of a large number of species.

ECOLOGICAL STATUS OF FORESTS

There are various views. Some place it as 'Climatic Climax' some as 'Edaphic Climax' and some as 'Seral'.

The authors (1972) classified the formation of vegetation in the West Bengal Sundarbans as detailed in the statement, No. 1. Another classification has been made on tide level, also keeping the formation unchanged which may be seen in another statement No. 2. The statement also gives the density of crop. A series of profile diagrams have been given to show the two vertical strata of forests in each formation.

Suaeda maritima and *S. nudiflora, Sesuvium portulacastrum. Acanthus illicifolius* and *Acrostichum aureum* form saline vegetation in partly

reclaimed areas where sweet water species invade. Invasion of species has been recorded in detail and enumerated in the family, genera and species list *(Chapter - II)*.

While *Heritiera* spp. and *Excoecaria* spp. dominate in Bangladesh, *Excoecaria* (dwarf form) and *Ceriops* spp. dominate in Indian Sundarbans. *Avicennia* is rather poorly represented. It is probably a 'Seral' species.

There is no humus on Sundarbans forests floor. The flat lands that grow higher and higher by silt deposition sometimes create large flattish and shallow depressions known as maidan or blanks (Saline blanks) where owing to absence of inundation solar and aerial evaporation leads to concentration of salt. The status of such land is yet to be determined.

Stamp (1925) while studying Burma mangroves identified the forests as 'Climatic climax community'. Tansley and Chipp (1926) considered mangrove forests as an 'Edaphic community'. Champion (1936) placed such forests under 'Primary Seral type' of moist Tropical Seral formation. But Davy (1938) placed mangrove under Woodland formation of tropics which is climatic climax.

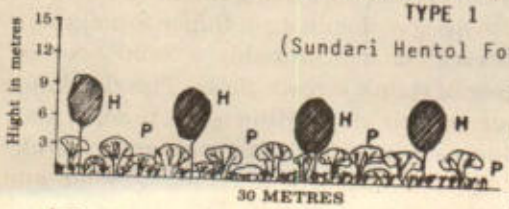
It is necessary to study such forests from aerial photographs followed by ground survey. From aerial photographs the following has been ascertained on the distribution of Mangrove forests in Andaman and Nicobar Islands.

North Andaman	29254 ha.
Middle Andaman	23116 "
South Andaman	21389 "
Other areas of Andaman & Nicobar Islands	41441 "
	Total 1,15,200 ha.

PROFILE DIAGRAM OF SOME FOREST TYPES OF SUNDERBANS FORESTS SHOWING TIGER HABITAT

TYPE 1

(Sundari Hentol Forests)

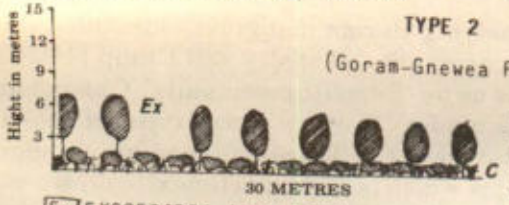


[H] HERTIERA FOMES [P] PHOENIX

Tiger Habitat 5000 Stems/ Acre Forms abouts 2% of the Sunderbans Forest
PH : 7.8
Salinity % :0.60

TYPE 2

(Goram-Gnewea Forests)

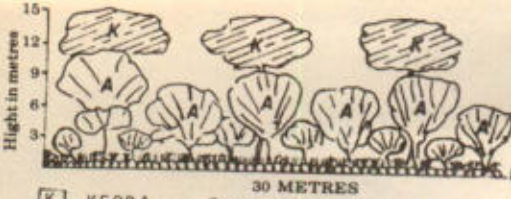


[Ex] EXCOECARIA AGALLOCHA
[C] CEREOPS ROXBURGHII ASSOCIATION

1000-4000 Stems
Forms about 70% of Sunderbans Forests Rastricted Tiger Habitat
PH: 7.8 Salinity % : 0.84

TYPE 3

(Bain - Keore Forests)

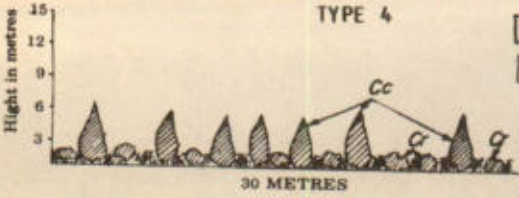


[K] KEORA, Sonneratta A
[B] BAIN Avicennia Sp.
[D] DHANIGRASS, Oryza Coarciata

AVICENNIA SONNERATIA ASSOCIATION
(Bajn Keora)

2000-3000 Stems/Acre
Forms about 2% of Sunderbans Forests
PH : 8.0 Salinity % : 0.60

TYPE 4

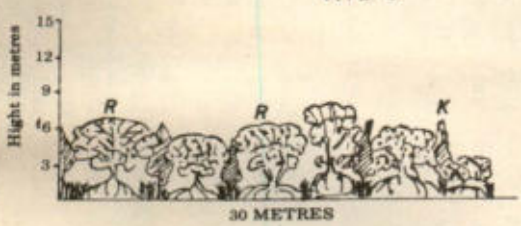


[Cr] PURE CEREOPS ROXBURGHII
[Cc] PURE CEREOPS CANDOLEII

(Pure Goran Association Forest)
PH: 7.9 Salt %:1.2

PROFILE DIAGRAM OF SOME FOREST TYPES OF SUNDERBANS FORESTS SHOWING TIGER HABITAT

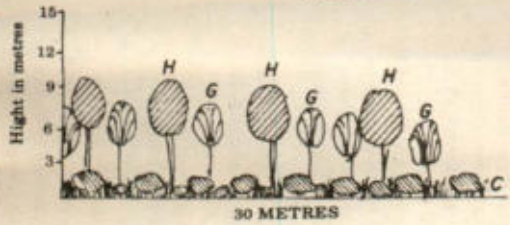
TYPE 5



RHIZOPHORA BRUGUIERA ASSOCIATION
(Garjan Kankure Association)

[R] RHIZOPHORA
[K] BRUGUIERA
PH: 5.7 Salt %: 0.40

TYPE 6

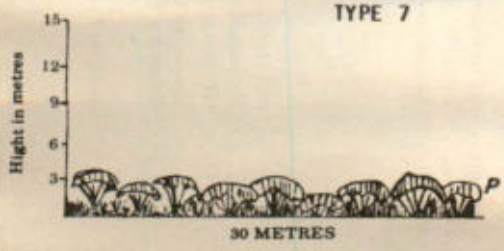


HERITIERA EXCOECARIA ASSOCIATION

[H] ERITIERA FOMES
[G] EXCOECARIA AGALLOCHA
[C] CEREOPS ROXBURGHIANA

3000-5000 Stemps acre
Forms about 2% of Sunderbans Forests
PH :8.0 Salt %: 0.49

TYPE 7



[P] PHOENIX PALUDOSA

PURE PHOENIX FORMATION
(Hental Formation)
Best Tiger Habitat
3000 Stemps acre
(Forms about 4% of Sunderbans Forests)
PH: 8.0 Salt %: 0.72

STATEMENT NO. I
HABITAT TYPES & FORMATIONS

Forest types	Types of formations	Principal association	Percentage forest under each type.	Density of crop per acre (0.4 ha)	Abode of Tiger	Actual type (col. 1)	Geneal remarks (Habitat of man eaters)
1	2	3	4	5	6	7	8
(a) Salt-water *Heritiera* type (Champion (IS 2 (c)	(i) *Heritiera-phoenix (H. fomes-P. paludosa)*	Thick clumps of *phoenix* with *Heritiera* trees scatt ered all over in the upper storey. *Nypa fruticans* occurs on river banks.	2	5,000 stems	Yes	(a)	Analysis of records that (i) low density and poor type of forest casualty is very low.
(b) Low mangrove forest types (Champion (IS/2 (a)	(ii) *Heritiera Excoecaria (H. fomes. E. agallocha)*	*Heritiera* is more common than (i) and forms an intimate mixture, *Nypa* occurs along river banks. *Ceriops* forms good proportion in the mixture, scattered *Xylocarpus* sp. also grows.	2	3,000-5,000 stems	Yes, but restricted,	(a)	(ii) *Phoenix* areas are most vulnerable and where percentage of casualty is maximum in such area.
	(iii) *Heritiera-Excoecaria-Ceriops (H. fomes E. agallocha* Ceriops decandra. *C. tegal.*	*Heritiera* & *Excoecaria* in the upper storey and dense crop of *Ceriops* in the lower Also scattered *(Xylocarpus* and other species.	4 4	3,000-5,000 stems	—do—	(a)	and (iii) *Nipa* areas adjoint to *Phoenix* are very dangerous.
	(iv) Pue *Phoenix*	Thick *Phoenix* clumps forming dark shade, and formed shelter to tigers and allow free movement.	4	3,000	Yes, ideal habit	(a) and (b) partly	(iv) Pure *Ceriops tegal* in saline blanks in the interior of each Islands indicate a danger zone.

(v) Pure *Ceriops*	A forest of bushes hardly 1 - 2 metres tall. Tigers move about with difficulty but the crops give ideal cover.	5	500 (2-30 stems in each plant)	Yes	(a) and (v) (b)type	*Calymperes* and *Callogrossa* from green cushion on penumatophores and on ground over large area. They form food materials for many species of fish and other animals.
(vi) *Avicennia Porteresia (A. alba, A. officinalis; Porteresia coarctata)* coarctata)	These species invade now char areas and form forests on mud-flat	2	Countless	No.	(b) (vi) types mostly some (a)	Besides the stems (in col. 5) the spreading superficial roots, phenumatophores, branchy *Ceriops* the forests are almost impenetrable.
(vii) *Avicennia-Sonneratia (Avicennia* sp. *S. apetala)*	Next to type (xi) comes this type on mud-flat	2	2,000-3,000	No.	(a) and (b)type	Not ideal habit
(viii) *Rhizophora-Bruguiera, R. mucronata-B.gymnorr hiza)*	This is rather an uncommon association in general, but 3 blocks of Matla, some areas of Haldi and Mayadwip blocks have these forests.	4	Various	In recent years tiger concentration has increased.	(a) and (b)type	Not ideal habit
(ix) Pure *Excoecaria*	Most common	5	*Excoecaria* 100-4000 stems and *(Cerops* 500 stems	Yes Yes	(a) and (b)	Most unproduction from wildlife point

STATEMENT NO. 2

Habitat Formations Based on Tide Level

(i) Tide Level (High Special)	Principal formation Special type of Beach Forest (on sand). This area/ perhaps rarely under water or nor at all. On sandy sea-coast typical mangrove species are replaced by sweet water or some littoral species.
(ii) Above general tide level (these areas go under water once twice during May to October at full and new moon or in exceptionally high tide level)	(a) *(Heritiera-Phoenix.* Thick clumps of *Phoenix* with *Heritiera* trees scattered all over in the upper *Nipa fruticans* occurs on river banks. (b) *Heritiera-Excoecaria* Heritiera is more common than (i) and forms an intimate mixture. *Nipa* occurs along river banks. *Ceriops* forms good proportion in the mixture. Scattered *Xylocarpus* spp. also occurs. (c) *Heritiera-Excoecaria* *Heritiera* and *Excoecaria* in the upper storey and dense crop of Ceriops in the lower. Also scattered *Xylocarpus* and other species occurs. (d) *Excoecaria-Phoenix.* Thick clumps of *Phoenix* with *Excoecaria* in the top-Interspace between the clumps provide tunnel for tiger movement. (e) *Pure phoenix.* Thick *Phoenix* clumps forming dark shade, but tunnels formed in the interspace provide shelter to tiger and allows free movement.
(iii) Frequently inundated by salt water.	(f) *Excoecaria* There are 'Dhal' or low areas at the head of Jhoras. Trees are scattered and forests open. (g) Pure *Ceriops* A forest of bushes hardly 2-3 metres tall. Tigers move about with difficulty but the crop gives ideal cover.

(h) *Excoecaria-Ceriops.*

Most common and principal association in the forests; has scattered *Xylocarpus, Rhizophora Bruguiera* Species.

(iv) Below tide level.

This is rather an uncommon association in general, but 3 blocks of Malta, some areas of Chulkati, Haldi and Mayadwip blocks have these forests.

(j) *Porteretia coarctata* (Pure)

(k) *Avicennia-Porteresia.*

These species invade new char areas and form forests on mud-flat.

(1) *Avicennia-Sonneretia.*

Next to type (ii), comes this type on mud-flat.

Principal Forest Association in Andaman and Nicobar Islands, is that of *Bruguiera-Rhizophora* which occupies 80% of the total mangrove forests. *Bruguiera* trees are about 20 m tall and grow to a girth of about 120 cm. *Rhizophora* comes next, *Avicennia, Nipa, Lumintzera, Ceriops, Excoecaria* do not form tall and extensive forests. *Nipa fruticans* grows to magnificant sizes (about 15 m)and exquisitely beautiful and grows in association with other species.

THE FLORA-ITS CHARACTERISTICS

The mangrove forests are evergreen; peculiar terrain (saline, mud and frequent inundation) does not allow many species to flourish. The tree flora is primarily confined to Rhizophoraceae, Verbenaceae and Sonneratiaceae.

Vivipary is one of the adptations for germination in *Rhizophora, Bruguiera, Ceriops, Kandelia.* In *Aegiceras, Avicennia, Excoecaria, Xylocarpus* and *Sonneratia* vivipary does not occur.

Leaves, are thick, coriaceous, have hydathodes, sunken stomata, aquous tissue, mucilage-cells, long stone cells.

Pneumatophores (breathing roots) are of various types and shapes. *Kandelia* does not have any; Ceriops have rounded, scaly, reddish; *Sonneratia apetala* has small; *Xylocarpus* has surface roots vertically flattened or have finger like projections; *Heritiera* has inconspicous; *Lumnitzera* has inconspicuous projection; *Excoecaria* has snakelike curvature of ordinary root; *Avicennia* has *Asparagus* like and *Sonneratia apetala* has most well developed strong shrply pointed vertical woody dangerous breathing roots.

Length of viviparous germinated fruits in order of length are as under :

Rhizophora mucronata, R. apiculata, Ceriops tegal, Kandelia candel, Bruguiera parviflora, B. gymnorrhiza, B. sexangula, B. cylindrica; Bruguiera radicles are stoutest.

FORESTS AND FOREST TYPES

The Bangladesh Sundarbans have received more attention of the foresters and administrators as large extent of valuable forests are situated in that country (Khulna district). The salinity of water being low and the variation of tidal level being appreciably less, the growth of trees have attained maximum where bushy formation of species like *Ceriops, Avicennia* and others are unknown. Contrary to that the crop in Indian Sundarbans is stunted and bushy.

Classification of vegetation in Sundarbans has been done as under :

Curtis in 1933 has classified the forests into 4 types viz;

1. Salt water Forests.
2. Mangrove Forest.
3. Moderate Salt Water Forests.
4. Fresh Water Forests.

Champion & Seth 1968 has classified the forests into 5 types viz;

1. Mangrove Scrub.
2. Mangrove Forest.
3. Salt Water Mixed Forest *(Heritiera)* .
4. Brackish Water Mixed Forest *(Heritiera).*
5. Palm Swamp.

Champion has distinguished four types of tidal forests in the Indo-Burma region. These are Low Mangrove Forests; Tree Mangrove Forests; Salt Water *Heritiera* Forest and Fresh Water *Heritiera* Forest.

Principal species in

(i) Low Mangrove are - *Ceriops* spp. *Avicennia* spp., *Excoecaria agallocha, Kandelia candel, Bruguiera cylindrica, Aegialitis* spp., *Rhizophora* spp., *Sonneretia* spp. and *Tamarix* spp.,(ii) Tree Mangrove Forests are - *Rhizophora* spp., *Sonneratia* spp. *Bruguiera* spp. *Xylocarpus* spp. and *Kandelia candel.* (iii) Salt Water *Heritiera* Forests are - *Heritiera fomes, Excoecaria agollocha* and *Ceriops* spp. (iv) Fresh Water *Heritiera* Forests are - *Heritiera* spp. and *Xylocarpus* spp.

Prain (1903) divided Sunderbans (undivided) into (i) Southern coastal strip and South-Western part containing mainly mangrove species (ii) the Central Zone of *Heritiera* and (iii) North-Eastern part of Savannah type vegetation. All these areas fall in Bangladesh.

Troup (1921) and Griffith (1936) also described Mangrove forests of Bangladesh. The forests of Indian Sundarbans present a complicated and diverse types.

In Andamans the *Dipterocarpus* forests growing along the sea shore and creeks are sometimes inundated by high tide. As a result mangrove species regenerate such areas. In a preservation plot near Betapur a typical such invasion of mangrove species (*Bruguiera* and *Rhizophora* primarily) may be identified under *Dipterocarpus* and other evergreen species.

Pure *Bruguiera* and pure *Rhizophora* forests are common sight everywhere. Extensive forests of Nipa *fruticans* grow under shadow of evergreen forests; *Nipa* in such forests grow in low lying areas flanked by evergreen forests. In a mixed crop- *Myristica*, *Sterculia* and *Dipterocarpus* grow with Mangrove species. It is unknown in Sundarbans orelsewhere.

QUANTITATIVE ESTIMATE OF TIMBER AND FIREWOOD

Heavy exploitation of timber and firewood was made in Sundarbans in the past. Average out-turn from a clear felled area was about 50 quintals (Produce sold by weight) which was equal to 200 cft. per acre or say about 15 m^3 per ha. This volume is very insignificant. But considering small diameter and poor height of the trees, the density of crop seems to be very high.

Excoecaria agallocha and *Ceriops* spp. (Goran) together form about 96% of total quantity of firewood and timber. This figure also testifies to heavy density of crop. The statement on Forest type and formation may be referred to on page. 5.

High salinity, lack of fresh water flush, extremely high velocity wind, bank erosion and siltation are principal adverse factors for development of forest trees.

North Andaman (Result of enumeration)

(i) In a mixed crop, average density of mangrove species is about 655 trees/ha.

(ii) In a pure Mangrove plot number of trees per hectare is about 1431 trees.

(iii) *Rhizophora apiculata* has about 300 trees/ha

(iv) *Bruguiera gymnorrhiza* has about 427 tree/ha.

(v) *B. parviflora* has about 2 trees/ha

(vi) ***Avicennia officinalis*** has about 150 trees/ha.
(vii) *Heritiera littoralis* has about 4 trees/ha.
(viii) Other species has about 48 trees/ha.
(ix) *Rhizophora* and *Bruguiera* have about 500 trees/ha.

MANGROVE FORESTS OF NORTH MIDDLE & SOUTH ANDAMANS

(Champion type 4 B/TS 2)

These forests are situated along the edge of waterways and sheltered muddy coast. There is no sandy bank.

Outer edge	*Rhizophora mucronata* & *R. apiculata* also with *Sonneratia* spp.
Next line	*Bruguiera gymnorrhiza* & *B. parviflora*, *Avicennia officinalis*, *Ceriops tegal*, *Kandelia candel*, *Xylocarpus* spp., *Sonneratia caseolaris*, *Excoecaria agallocha*.
Next	*Heritiera littoralis*

The littoral forests (Champions types 4A/4) of Andamans have many species which are found in the Sundarbans Mangrove. *Pongamia*, *Erythrina*, *Calophyllum*, *Terminalia*, *Cordia*, *Thespesia*, *Hibiscus*, *Ipomoea*, *Crinum*, *Caesalpinia* etc. occur in the sandy sea face.

The composion of Mangrove forests in Andamans are unlike Sundarbans. Two Species dominate *(Rhizophora* and ***Bruguiera)*** and except in the creeks the mangrove does not occur on extensive areas; rather the forests occur in their linear strip on the fringe of evergreen forests facing the sea, intensive studies are yet to be made in various Islands.

Creeks in three Andaman Divisions which are principal Mangrove Zones (Main creeks are given below in italics) are:

North Andamans Division

Buchanan bay creek, Elezabeth bay creek, Reef Inlet creek, Casuavine bay creek. *Mepherson creek* Balmi creek, Moare bay creek, Beele bay creek, *Gribb creek*, *Candel bay creek* Teropa Bulyo creek, Throughfan creek, Blair bay or Kalpong creek, Laxmipur creek, Deglipur creek, Kalara creek, Jagannath area creek, Austin strait creek, Yeratila Jig creek.

IDENTIFICATIONS OF SPECIES

Palms

Erect, stemless, leaves like ***Cocos nucifera*** (Coconut). — *Nipa fruticans* (Golpata)

no spines.	
Erect, stem like *Areca* palm	*Phoenix paludosa*
Leaves like date palm; spinescent; stem annular; leaflets bifarious	(Hental)
Ferns	
shrubs, leaves coarse	*Acrostichum aureum*
gregarious; sorus under surface of fertile leaves. Climbers	
Leaflets 3-5, alternate, flower rose	*Derris trifoliata*
coloured, pods flat.	(Panlata)
Leaves opposite, ovate;	*Finlaysonia obovata* (Dudhilata)
exudes milk,	*horrida* (Dennst) Mabberly
Leaflets 5-6, pods reniform flowers	*Dalbergia* var. *glabrescens*
white, tips of branches spiny.	(Prain)Thoth Nair (Noalata)
Leaflets 5, ovate rounded,	*Dalbergia candentensis*
Flowers white, pods flat.	
Leaflet 3-6 pairs.	*Derris scandens*
Raceame 15-25 cm; leaflets 6-8 pairs, prickly, flower yellow.	*Caesalpinia crista.*
Shrubs	
Undersurface of leaves	*Clerodendrum inerme*
Scaly, with strong rutaceous odour; flowers white with bright red filaments	(Banjai).
fruit 4- grooved.	
Herbaceous	
Leaves prickly, flowers blueish white;	
fruit 3 cm.	*Acanthus illicifolius*
Trees	
Still root; black dots	
on undersurface;	
Tip of leaf mucronate.	*R. mucronata* (Gurjan).
Buttressed Lenticellate, fluted; bark	*Ceriops tegal* (Math goran)
fawn coloured, pneumatophores kneed	
Reddish bark, papery. flakes,	*Xylocarpus granatum* (Dhundul)
compound leaves 16 cm, leaflets 4.	
Buttress normal, leaves 12	*Bruguiera parviflora* (Kankra)
cm, yellowish.	
Bark with conspicuous	*Bruguiera sexangula* (Kankra).
lenticel; flower 2 m. yellowish green.	
Dark brown bark, flakes imbricate,	*Xylocarpus moluccensis*
compound leaves, 4 - leaflets	(Passur).
Reddish lenticels.	*Heritiera fomes* (Sundri).

Bark brown or black, red; flower over 2.5 cm.	*Bruguiera gymnorrhiza* (Kankra).

KEY TO GENERA
(Based on vegetative organ)

Leaves opposite:	
Shrub with margin of leaves spinescent; flower blue; gregarious	*Acanthcus illicifolius.* (Hargoza)
Tree; leaves mucronate, not spiny.	*Rhizophora mucronata* (Gurjan)
Tree; leaves without projection of the midrib.	*R. apiculata* (Gurjan).
Petiole 2 - 3 mm; no. viviparous germination	*Sonneratia* sp.
Petiole over 6 mm, undersurface of leaf green,	*Bruguiera* sp.
Undersurface of leaf white; fruite capsule with one seed;	*Avicennia* sp.
Leaves notched at the apex, petiole more than 1 cm in length.	*Ceriops* sp.
Leaves alternate:	
Margin entire, tips pointed, petiole over 2 cm; exudes milk, leaves less than 12 cm, flower in spikes.	*Excoecaria* sp.
Petiole less than 2 cm in length, plants without milky juice:	
Leaves rounded at base	*Heritiera* sp.
Leaves pointed at base	*Browalowia* sp.
Leaves peripinnate;	
Fruit globose	*Xylocarpus* sp.
Leaves oblique; fruit globose, 3 - valved.	*Amoora* sp.
Fruite wrinkled pod.	*Cynometra* sp.

TREE FORM

Trees with stilt root:	
Rhizophora mucronata	Bark lenticellate; horizontally fissured.
R. apiculata	Bark smooth, furrowed.
Trees with buttresses:	
Ceriops tegal	Bark **lenticellate, buttressed fluited.**

Bruguier agymnorrhiza	Bark grey, reddish lenticeled.
Xylocarpus granatum	Reddish bark, papery flakes roots serpentine.
X-moluccensis	Chocolate brown bark; leaves large.
Buttress inconspicuous or absent:	
Avicennia sp.	Grey smooth bark.
Excoecaria agallocha	Grey, red brown lenticelled.
Stems conically thickened at base:	
Aegiceras corniculata	Leaves alternate simple. Bark smooth, reddish, lenticellate.
Excoecaria agallocha	Grey, red brown lenticelled white sap.
Bark furrowed	
Sonneratia apetala	Fissured bark, blackish, twigs pendulous.
Lumnitzera racemosa	Pale pink lenticelled, flowers white.
Acanthus illicifolius	Shrubs. Leaves prickly, flower blue.

IDENTIFICATION OF PLANTS FROM LEAVES

Leaves prickly, 12 cm, simple, opposite, flower blue.	*Acanthus illicifolius.*
Leaves 10 cm, alternate, margin as long as leaf, flower yellow.	*Hibiscus tiliaceus*
Leaves 8 cm, alternate, shrubs flower white, fruit crescent sharped.	*Aegiceras corniculata*
Leaves alternate, flower white in lax raceme.	*Lumnitzera racemosa*
Leaves compound, leaflet 3-5 alternate, climber, single seeded pod.	*Derris trifoliata*
Leaves alternate, 10 cm, white milky.	*Excoecaria agallocha,*
Leaves alternate, brownish scale on under surface, shrub.	*Brownlowia lanceolata*
Leaves compound, alternate, 2 pairs, trees.	*Xylocarpus moluccensis*
Leaves opposite, simple, petiole 4 cm long	*Ceriops tegal.*
Leaves compound, alternate, 2 pairs.	*Xylocarpus granatum.*
Leaves 10 cm, margin reflexed, under surface grey, tree.	*Avicennia officinalis*

Leaves 10 cm, margin relexed, bud twisted, small tree.	***Kandelia candel.***
Leaves mucronate, undersurface black dotted.	*Rhizophora mucronata*
Leaves 13 cm, yellowish	*Bruguiera parviflora*
Leaves 15 cm, midrib red without black dot beneath, flower scarlet.	*Bruguiera gymnorrhiza*
Leaves 10 cm, sessile, opposite midrib crimson.	*Sonneratia caseolaris*
Leaves 8 to 12 cm long, Lanceolate, petiole 1 - 2 cm.	*S. apetala*
Leaves thick coriaceous, orbicular, black, 5 - 8 cm; petiole sheathing.	*Aegialitis rotundifolia*
Leaves acicular, margin spinulose serrate, grass.	*Porteretia coarctata*

ECONOMIC IMPORTANCE OF THE SUNDARBAN MANGROVE

The estuarine tract of water and land form an inexhaustible source of raw materials to meet the demand of local people and develop industries. Estuaries must be considered as a "multiple use" environment. Estuaries are examples of perfect balance between physical and biotic components. Owing to inaccessible terrain, transporation only through slow moving countrymade water crafts, high current, fluctuation of tide level, scarcity of drinking water and the presence of man-eating tigers and crocodiles, the terrain is inhospitable and difficult to work.

Besides vast areas of forests that are source of supply of timber, firewood, bark for tannin material, golpata for thatching material, this tract is a potential breeding ground for innumerable speceis of fish including those of Hilsa *(Hilsa ilisa),* Chingri and Bhetki *(Lates* sp.) *Excoecaria* timber is being used as raw material for pulp in a paper mill in Bangladesh; this species is also useful as matchwood timber. *Xylocarpus* and *Heritiera* species are useful house post and timber.

Man-eating tigers of the tract are myth and they are being preserved in a sanctuary under a Project called 'Project Tiger'.

The vast block of forests of Sundarbans act as a buffer to severe cyclonic storm and reduce the severity of gales. The preservation of this estuarine forests in this region is absolutely necessary as they will afford protection to people and paddy land behind such forest and intercept even 10 metres high waves. Lakhs of people have died in Sagar Island areas in the past from devastating cyclones. Mention may be made of devastating cyclone of 1978-1979 in Andhra Pradesh where thousands of

A small tree. *Leaves* orbicular, whitish pubescent beneath, 8 × 20 cm, deeply cordate, crenulate. *Flower* bell shaped, yellow with crimson and purplish centre. *Capsule* 2 cm in diameter formation, Staminal tube long. Occurs on sandy sea coast in Sundarbans and Andamans.

Thespesia

T. populnea (Linn.) Soland. ex. Corr. Local name - *Pores pipal.*

A medium sized tree, bark furrowed. *Leaves* cordate, triangular, acuminate, petiole 3 cm to 10 cm, flower large, axillary bracteoles 5 - 8 *calyx* 5 - tooth, petals - 5 yellow with purple centre, stamens numerous, in a tube. *Ovary* 4 - 5 locular; unripe capsules covered with rusty scales about 3.5 cm in diameter. On sandy Sea coast formation.

STERCULIACEAE

Heritiera Dryand.

Leaves simple, coriaceous, silver scaly beneath. *Flower* small unisexual in axillary panicle; petals 0; staminal column bears a ring 4 - 5 2 celled anther at the top.

H. fomes Buch. - Ham. syn. *H. minor* Roxb. Local name *Sundri.* Small tree. *Leaves* lanceolate leathery lepidote beneath. *Flowers* unisexual in axillary panicle, pinkish yellow; *calyx* 5; *petals* 0; stamens in a column with a ring of stigma ovules solitary in each carpel. *Fruit* a cluster of woody winged fruit; seeds solitary. A gregarious tall tree in Eastern Sundarbans. In West Bengal Sundarbans trees of 10 cm or so.

H. littoralis Dryand ex Ait. Local name - Sundri

A gregarious tree, very hard, heart wood red. *Leaves* elliptic-oblong, petiole 8 cm, silvery white lower surface. *Flower* creamy pink. *Fruit* 4 cm to 7 cm. long. A gregarious mangrove plant of Andaman.

TILIACEAE

Brownlowia Roxb.

This is the only species of the family represented in the tract. Not common.

B. lanceolata Benth. Local name - Bola Sundri

A littoral shrub, scaly. Leaves 16 - 60 cm × 5 cm, lanceolate, acuminate, base rounded, lower surface silvery, entire; petiole 5 cm. Flower white small, *petals* 5, *Stamens* many *Fruit* 2 cm in diameter brownish scaly. In creeks or slopes of streams forming dense thickets.

MELIACEAE

Xylocarpus Koen.

Compound leaves (also in Afzelia and Amoora cucullata), globose big

people died and cost the country seven hundred crores of rupees for rehabilitation of the people.

Honey bees and honey production are special features of the Sundarbans forests. More than 1000 quintals honey is collected annually, besides wax. *Aegiceras corniculatum* gives the best honey but bulk of honey comes from *Ceriops* and *Excoecaria* and a limited quantity from *Avicennia*, *Sonneratia*, *Phoenix* and other plants.

Avicennia and *Sonneratia* have delicious fruits which are edible by birds, fish, animal and human being. Other fruits are also eaten to a limited extent.

Estuarine tracts are biologically important because of innumerable vertebrate and invertebrate inhabiting the various ecological niches from sandy shore to clayey intertidal zones. Scores of species of Crustacea and Mullusca some which are of economic importance add to the intrinsic value of estuarine forests.

DESCRIPTION OF FAMILIES, GENERA AND SPECIES

TAMARICACEAE

Shrubs or small trees. *Leaves* alternate minute, scale like, imbricate. Two species viz. *T. indica* willd. and *T. dioica* Roxb. are wide spread almost all over India.

Tamarix Linn. T. indica Willd.

Local name - Ban Jhau.

A gregarious shrub, wood reddish. *Leaves* not sheathing, apex acute. *Flower* bisexual, pentamerous, white or pink (mostly pinkish); spikes in slender panicles. Occurs in Sundarbans and not in Andamans. On sandy Sea shore.

MALVACEAE

The littoral members are confined to sandy sea shore on sea face. These are small trees and recognized by large, alternate broadly heart-shaped, acuminate, leaves. *Flower* large yellow; style as many as carpels. Ovary 5-celled.

KEY TO GENRA

Leaves lobed, crenate. Flower with epicalyx, styles 5. Capsule open by valve	*Hibiscus*
Leaves entire, Flower without epicalyx. Styles entire, Capsule hardly opening.	*Thespesia*

Hibiscus Linn. Tiliaceous Linn. Local name — *Bola*

fruits. Small tree, very hard timber. Two species of *Xylocarpus* and one of *Amoora* are the representative of this tract. *Amoora* is rare while *Xylocarpus* species are well represented all over the forests.

X. granatum Koenig syn. *X. obovata*-Juss. *Leaves* 7.5-15 cm, long, leaflets 1-2 pair, coriaceous, ovate, apex broad, base narrowed; panicles 4-8 cm, stout, few flowered, *Fruit* 17-25 cm in diameter.

X. moluccensis Roem.

Leaves 10 - 25 cm long; leaflets 2 to 3 pair, thinly coriaceous, ovate from a broad base; panicles 7 - 15 cm, slender, few flowered, pinkish yellow. *Fruit* 8 - 13 cm in diameter, 4 - grooved, brown valvety.

Amoora cucullata Roxb.

Small tree. *Leaflet* 2 - 4 pair, falcate, very oblique at the base, 8 - 12 cm long. Flower-pedicellate: male in panicles, female in short few flowered supra-axillary racame. *Fruit* globose, 8 cm in diameter, 3-valved, orange coloured; 3-seeded. Sporadic in Sundarbans, not recorded from Andamans.

LEGUMINOSAE

Dalbergia, Derris, Cynometra and *Pongamia* are four genera of typical estuarine forests. The species of Dalbergia and *Derris* are climbers while *Cynometra* is a small tree of clayey soil; Pongamia a small tree of sandy Sea shore.

Pongamia Vent.

Pongamia pinnata (Linn.) Pierre syn. *P. glabra* Vent.

Local name - Karanja.

A moderate sized tree, bark with horizontal black or reddish marking. *Leaves* imparipinnate, leaflets 8-22 cm by 7 - 15 cm ovate, acuminate; *Flower* 1.5 cm, pink or violet; *Stamens* 10 Pod 5 to 7 cm long woody, oblique, *Derris* Lour.

Climbers, imparipinnate leaves, leaflets opposite. *Flower* white or pink. *Pod* thin flat.

D. trifoliata Lour. syn. D. uiglinosa Benth. Local name - Panlota

A large climbing shrub, *Leaflets* 3 - 5 each 3 to 6 cm long. Flower white; *Pod* orbicular. Occur in Sundarbans and Andamans.

D. scandens (Roxb) Benth.

A large climbing shrub. Leaflets 5 - 9, or more, each 3 to 7 cm long. *Pods* winged along both edges, silky. Very common in creeks in Sundarbans and Andamans.

Dalbergia Linn.

D. spinosa Roxb.

A large woody climber, branches spinescent. Leaflet 5 - 9 about 2 cm. *Stamens* in two lateral phalangs of 4 to 5 each. Flowers yellowish-white. Pods 3 cm long reniform, 1 seeded.

D. candenatensis Prain.
A climbing shrub, branchlets spirally coiled. *Leaflet* 5, 3 - 5 cm long. *Flower* white *Stamens* 10 in one hundle.
Pod flat.
Cynometra Linn.
C. ramiflora Linn. Local name - Shingar
A small evergreen tree. Leaflets 1 or 2 pair. 3 - 7 cm long, *Flower* white on pendulous pedicels, in sessile umbelliform corymbs. *Ovary* hairy. *Pod* fleshy, wrinkled, 2 cm long.

RHIZOPHORACEAE

Leaves simple, opposite, coriaceous, entire; stipules caducous. Petals not entire. Does not have treue specialised pneumatophores. Large radicle germinating while the fruit still on the tree.

Key to Genera

Sepals 4, petals 4, entire, stamens 8, ovary 2-celled.	*Rhizophora*
Sepals and petals 5 or 6, emerginate, stamens 10 - 12, ovary 3 - celled	*Ceriops*
Sepals and petals 5 or 6, bifid, lobes laciniate, ovary 1 - celled. Sepals and petals 8 - 14, bifid or emerginate, stamens 16 - 28, ovary 2 - 4 celled.	*Kandelia* *Bruguiera*

Rhizphora Linn.

Flying buttress: Stems with prominent stipular scar. Leaves mucronate, sometimes black dotted below; stipules, reddish, interpetiolar. Calyx 4-lobed. Petals white. Ovary 2-celled.
R. mucronata Lamk.
Leaves elliptic; cymes longer than petiole, 3-flowered, Flower-pedicelled. *Petals* fleshy.
R. apiculata Bl.
Leaves oblong; cymes shorter than petiole, 2-flowered. Flower sessile. *Petals* fleshy.
Petals glabrous.
Ceriops Arn.
Flowers in compact many fid cyme; Calyx deeply divided into 5-segments. Petals 5. *Stamen* 10. Ovary 3-celled, 2-ovules in each cell. Viviparous germination.
C decandra (Griff.) Ding Hou syn. *C. roxburghiana* Arn. Local name - Jhamti Goran.

A tall shrubs with many upright stems and branches. *Leaves* coriaceous, ovate, 7 - 10 cm, sessile. Flowers each with a bract and 2 bracteoles. Sepals 4 - 6 Petals 4 - 6; Stamens 8 - 10. *Fruit* commonest all over the estuarine tract of Sundarbans but not in Andamans.

C. tegal (Perr.) Rob. syn. *C. candoleana* Arn. Local name - Math goran. Tree pyramid shaped, Stem conical, strong. *Leaves* ovate, obtuse, twice as long as wide. *Cymes* branching, pedicel short. *Petals* with 3 appendages. *Filament* much longer than another. *Fruit* 2.5 cm pear shaped. Occurs at selected places in pure formation or in association with C. decandra, in Sundarbans and Andamans.

Kandelia W. & A.

Often a single fruit bears several radicels. Flower sheathed at base by connate bracts.

K. Kandel W. & A.

A small tree. *Leaves* opposite, coriaceous, oblong, obtuse; stipules interpetiolar, caducous. Flowers few, axillary, dichotomous cyme. Sepals 5 - 6 in a tube. *Petals* 5 - 6 bifids, white. *Stamens* many carpels 3 connate in a unilocular ovary. Fruit 1-celled, one seeded. Occurs sporadically on stream banks.

Bruguiera Lamk.

Trees, trunk buttressed, knee roots prominent. Calyx tube long, 8-14 lobed. Petals 2-fid. Stamens 16-28. Ovary 2-4 celled, 2 ovules in each cell. Fruit fleshy, seed one. Viviparous germination.

Key to Species

Flowers solitary; petal lobes acute; mature calyx red to pinkish red.	*B. gymnorrhiza*
Flowers solitary; petal lobes obtuse; mature calyx yellow.	*B. sexangula*
Flowers (2–) 3(– 5); calyx tube smooth; lobes nearly equal to tube.	*B. cylindrica*
Flowers (2–) 3(– 5) Calyx tube bilobed; lobes 1/4-1/5 the length to tube.	*B. parviflora*

B. gymnorrhiza Lam. syn. B. conjugata Merr. Local name Kankra *Leaves* coriaceous, shining, elliptic, lanceolate; blade 10-20 cm, petiole 3-5 cm, *Flower* solitary, axillary, Calyx 10-14. *Ovary* 3-celled.

B. cylindrica (Linn.) Bl. Syn. B. caryophlloides Bl. Local name - Kankra *Leaves* thinly coriaceous, *Cyme* axillary, peduncle 2 - 3 fid. *B. sexangula* (Lour.) Poir. syn. eriopetala W. & A. *Calyx* lobes 10, 2.5 cm long, *Petals* deeply hirsute along the edges. *Flowers* small, peduncle 3 or more fid. This species has been recorded from Sundarbans.

B. parviflora (Roxb.) W. & A. ex Griff.

Cymes axillary, 2-fid, erect. *Ovary* 3-celled. Fruit cylindric, ribbed, radicle 10 to 13 cm long. Occurs in Sundarbans and Andamans.

SONNERETIACEAE

Sonneratia Linn.
Leaves opposite, entire. Calyx thick 4 or 6. Petals 0 or 4 to 6. Stamens many at the month of calyx tube. Ovary - many called. Fruit many celled.

KEY TO SPECIES

Leaves broadly ovate or lanceolate; Calyx lobes 4, petals 0 ... *apetala*
Leaves almost orbicular; calyx-lobes 6; petals 6 *caseolaris*

S. apetala Buch. Ham. Local name - Keora.
A gregarious tree 15 m, bark fissured in square. Tallest tree in estuarine tract. Branches pendulous. *Leaves* lanceolate; petiole 1-2 cm *Calyx* 4 equal. *Capsule* depressed, globose 2 cm, edible. Grows on stable river bank still under successional stage. Does not occur in Andamans.
S. *caseolaris* (Linn.) Engl. Syn.S.acida Linn. f. Local name - Ora
A small tree 6 to 10 m *Leaves* ovate; petiole 5 to 10 cm; *Flowers* 5 cm across, solitary. Calyx tube small not ribbed, segments usually 6. *Petals* dark purple, acuminate 5 cm. *Fruit* globular, 5-7 cm in diam., edible. Occurs in Sundarbans and Andamans.

FICOIDEAE

Sesuvium Linn.
S. portulacastrum Linn. Local name - Gima Sak.
Succulent, branching, prostrate. *Leaves* opposite, fleshy. Flowers purplish. *Sepals* 5; lobes triangular; *Petals* O. *Stamens* 5 or many Carpele 3-5 celled. *Fruit* 3 - 5 celled. Occurs in Sundarbans.

RUBIACEAE

Scyphiphora Gaertn.f.
S. hydrophyllacea Gaertn.f.
A small tree or a big shrub 2 m high. *Leaves* crowded at the end of branchlets, 4 to 7 cm long and about half as broad. *Flower* white in axillary *Symes, Corolla* 4 - 5. *Drupe* furrowed, 2 cm long. Occurs in Andamans.

COMBRETACEAE

Lumnitzera Willd.
A shrub or a small tree. *Leaves* alternate, clustered at apex of branch, spathulate, fleshy, small, sessile, Flower bisexual, pentamerous. Fruit crowned by persistent calyx limb, 1.5 to 2.5 cm long.

L. racemosa Willd. Local name - Kripa.
A straight stemmed small tree. *Leaves* 5 to 7 cm. long, ovate, crenate. *Flower* white in axillary racemes. *Fruit* Feb. - April. Occurs in Sundarbans and Andamans (West Coast).

PLUMBAGINACEAE

Mostly herb, few shrubs. Flower regular bisexual, bracts scarious. Calyx 5-ribbed. *Petals* 5, free or connate at base. *Stamens* - 5 epipetalous. *Ovary* 1-celled. *Aegialitis R. Br.*
A. rotundifolia Roxb. Local name - Tora
Stem with thick conical trunk, branchlets marked by the scars of the amplexicaule petiole. *Leaves* alternate, thickly coriaceous, orbicular, blade 5 - 1 cm; petiole sheathing longer than blade. *Flower* panicle cyme. *Calyx* 5 - ribbed. *Petals* white. *Capsule* 10 cm long. Common in Sundarbans in early successional stages. Recorded from Andaman also.

MYRSINEAE

Aegiceras Gaertn.
A. corniculatum (L.) Bl. Syb. A. majus Gaertn. Local name - Khalse.
A large shrub or small tree, gregarious. *Leaves* scattered, coriaceous; ovate, blade 5 - 7 cm; petiole 5 cm. *Umbel* many fid at the end are branchlet. *Flower* white, highly fragrant. *Sepal* or *petal* lobes highly twisted in bud; petal 1 cm long. another cells transversely separate. Ovules numerous. *Fruit* cylindric, curved, acuminate, 5 cm long. Gregarious on slopes of small rivers and creeeks in Sundarbans; less common in Andamans.

VERBENACEAE

Clerodendrum Gaertn.
C. inerme (L.f.) Gaertn. Local name - Banjai.
A straggling shrub, branches at right angle to main stem. *Leaves* 3 to 7 cm, ovate, entire, strong smelling when crushed, fleshy, elliptic-ovate, rounded tip; petiole short. *Flower* white, stems purple. *Drupe* pear shaped, 4-grooved. Very common in stream hands, gregarious. Occurs in Sundarbans.
Avicennia Linn.
Leaves opposite; coriaceous, petiole short. Inflorescence capitulate. Calyx 5 lobed. Corolla 4-lobed. Stamens 4. Ovary 4 celled, 4-ovuled.

KEY TO SPECIES

Shrubs or small tree. Leaves acuminate, Lanceolate; Flower yellow; capsule less than 2.5 cm. *A. alba.*

A large tree. Leaves ovate, obtuse; fruit yellow, more than 2.5 cm.
A. officinalis
A. alba B. Local name - Kala Baen
A large shrub or a small tree. *Leaves* lanceolate, whitish beneath. *Flower* yellow; cymose panicle 6 cm. *Fruit* 2 cm, tomentose.
A. officinalis Linn. Local name - Sada Baen
A large tree. *Leaves* oblong, elliptic, tip rounded, midrib dark yellow, 3-chotomous. Panicle 8 cm long. *Fruit* opaque, green, wrinkled, ovoid, 3 cm long.

ACANTHACEAE

Acanthus Linn.
A. illicifolius Linn. Local name - Hargoja.
A shrub, forming clump in maritime swamp. *Leaves* toothed or pannatifid, spinous, holly-lime. *Corolla* blue *Flower* support 2 pairs of bracteoles. *Capsules* 5 cm long.

CHENOPODIACEAE

Suaeda Forsk.
Herb or undershrub, styles 2 - 3 seeds horizontal.
S. nudiflora Moq. Local name - Novagiri.
A woody branched under shrub, 24-40 cm; branches spreading close to the ground. *Leaves* fleshy. *Flower* numerous in cluster. Occurs in Sundarbans only.
S. maritima (Linn.) Dumort.
An erect herb, branching from ground level. *Leaves* fleshy, ternate. *Flowers* minute, axillary, bisexual; perianth 5- lobed. *Stamens* 3. Carpel 1 - celled ovary. *Seeds* horizontal. Occurs in Sundarbans only.

LORANTHACEAE

Viscum Linn.
V. monoicum Roxb.
A large parasitic shrub. *Leaves* opposite, flat, thick, obliquely foliate, acute. *Flowers* unisexual, fascicled; parianth 3 - 4 lobed. *Stamens* 3 - 4. Ovary 1 - celled. *Fruit* a succulent berry. Occurs in Sundarbans.

EUPHORBIACEAE

Excoecaria Linn.
Only one species occurs in estuarine tract. It is a gregarious species, occurs all over the track and in association with several other species. It grows to a height of about 8 to 10 m with a girth (at breast height) of about 70 cm. Leaves turn yellow to red before being shed. Stem gives

acrid white juice which is poisonous.
E. agallocha Linn. Local name - Grewa
Leaves entire or sub-serrate. *Flowers* dioecious or monoecious. In male flowers. Sepals - 3 fid. Petals - 0 Stamens - 3 In famle *flowers* pistillode 0, disc. 0; Sarpel 3 - celled. *Fruit* capsule of 3 coccis. Seeds globose. Occurs in Sundarbans and Andamans.

PALMAE

Key to the genera

Erect palms, leaves pinnate, numerous, sword shaped; leaflets folded inwards lengthwise. *Phoenix*. Littoral with underground stem; leaves about 900 cm, leaflets 120 - 150 cm. *Nipa*
Phoenix.
P. paludosa Roxb. Local name - Hental
A slender palm with annular stem. *Leaves* 1 to 2 m long, arranged in pais, sword shaped, spines 3 cm long. *Flowers* yellow in compact spikes. *Fruit* 2 cm in a diam., orange red. black when ripe. Very common in Sundarbans on raised firm and land, growing pure or in association with other species. Also occurs in Andamans.
Nipa Wurmb
N. fruticans Wurmb, Local name - Golpata.
Stem under ground. *Leaves* like coconut palm. Flowers. elegant, pink coloured, spadix, densely crowded; female in globose head; *Fruit* 10 - 15 cm long, turbinate angular, fibrous and edible. Andaman plants are much bigger sized.

GRAMINEAE

Porteresia Tateoka
A genus very close to *Leersia* and *Hygroryza*. *Porteretia coarctata* (Roxb.) Tateoka Syn. *Oryza coarctata* Roxb. Local name - Dhani grass.
The margin of leaves spinulose-serrate. *Lemma* dorsally winged. *Ligule* short. root creeping, erect and stout. It is one of the pioneer colonizer in recently formed charland. Not recorded from Andamans.

PLANT RESOURCES OF ESTUARINE SUNDARBANS

No thorough Botanical exploration has been made in the West Bengal portion of Sundarbans. David Prain's work (1903) in Chakaria Sundarbans (Eastern limit of Sundarbans) enumerated 75 Natural orders, 245 genera and 334 species, of these about 78% of the genera are monotypic.

30 species are purely estuarine in the project area most of which are gregarious, other species are sporadic. The sandy coastal belt and the

areas above high inundation level are gradually being invaded by sweet water species.

The following plants have been recorded by the authors from the project area; (asterisks ** show pure estuarine species; other species are either those of reclaimed areas or of sandy sea coast).

CAPPARIDACEAE	*Capparis sepiaria* (Linn.
BIXACEAE	*Flacourtia indica* (Burm.f.) Merr.
TAMARICACEAE	*Tamarix indica* Willd.
CUTTIFERAE	*Calophyllum* sp.
MALVACEAE	*Hibiscus tilliaceus* Linn. H. *tiliaceus* spp. similis (bl.) *Bross.* *Thespesia populnea* (Linn.) Soland. Corr.
STERCULIACEAE	** *Heritiera fomes* Buch. Ham.
TILIACEAE	** *Brownlowia lanceolata* Benth
OXALIDACEAE	*Oxalis corniculata* Linn.
MELIACEAE	** *Amoora cucullata* Roxb. *Azadirachta indica* A. Juss., ** *Xylocarpus moluccensis* Roem., ** *X. granatum* Koeng.
RHAMNACEAE	*Zizyphus muritiana* Lamk., *Zizyphus* sp.
VITACEAE	*Cissus quadrangula* (Linn.) *Cayratia trifolia* (L.) Damin, *C. pedata* (Lamk.) Jus. ex. Gagnep.
RUTACEAE	*Aegle marmelos* (Linn.) Corr, ** *Paramignya citrifolia* Hook.f.
SAPINDACEAE	*Allophylus cobbe* Linn. var. *glabra* *Cardiospermum halicacabum* Linn.
ANACARDIACEAE	*Mangifera indica* Linn., *Spondias pinnata* (Linn.) Kurz
MORINGACEAE	*Moringa oleifera* Lamk.
LEGUMINOSAE	*Crotalaria retusa* Linn., *vigna luteola* (Jacq.) *Benth.*, *Cyamopsis tetragonoloba* (Linn.) Taub., *Sesbania grandiflora* Pers., *Tamarindus indica* Linn., *Teramnus flexilis* Benth., *Canavalia obtusifolia* DC., *C. maritima*, C. gladiate (Jacq.) DC., ** *D. scandens* Benth., ** *Dalbergia spinosa* Roxb., *D. candenatensis* Prain, *Desmodium velutinum* (Willd.) DC. *Phaseolus adenanthus* Mey, *Parkinsonia aculeata* Linn., *Erythrina* sp., *Cassia sophera*

Linn, ** *Derris trifoliata* Lour, *Pongamia pinnata* pierre, *trifoliata* Lour, *Pongamia pinnata* pierre, *Entada pursaetha* DC., *Caesalpinia crista* Linn., ** *Cynometra ramiflora* Linn., *Afzelia retusa* Kurz.

RHIZOPHORACEAE

** *Kandelia candel* W. & A., *Rhizophora apiculata* Bl., ** *Rhizophora mucronata* Lamk, ** *Ceriops tegal* (Perr.) Robins., ** *C. decandra* (Griff.) Ding Hou, ** *Bruguiera gymnorrhiza* Lamk, ** *B. parviflora* W. & A.

COMBRETACEAE *Terminalia catappa* Linn.
** *Lumnitzera racemosa* Willd.

SONNERATIACEAE ** *Sonneratia apetala* Ham.
** *S. caseolaris* (L.) Engl.

CUCURBITACEAE

Coccinia grandis (.) Voigt, *Trichosanthes* cucumerina Linn.

CACTACEAE *Opuntia dillenii* (Ker. Grawl). Haw.

FICOIDEAE ** *Sesuvium porlulacastrum* Linn., *Trianthama portulacastrum* Linn.

MOLLUGINACEAE *Glinus oppositifolius* (Linn.) DC.

RUBIACEAE *Oldenlandia corymbosa* Linn., *Ixora coccinea* Linn.

COMPOSITAE

Ageratum conyzoides Linn., *Blumea lacera* (Burm.f.) DC., *Xanthium strumarium* Linn., *Eclipta prostrata* (L.) Linn. *Tridex procumbens* Linn., *Wedelia biflora* (L.) DC., *Launeass., Mikania micrantha* H.B.K.

PLUMBAGINACEAE ** *Aegialitis rotundifolia* Roxb.

MYRSINACEAE *Manilkara achras* (Mill.) Fosb.

APOCYNACEAE

Thevetia peruviana (Pers.) Schum., *Plumeria rubra* Linn., *Nerium indicum* Mill., *Parsonsia spiralis* Wall., *Cerbera odollam* Gaertn.

ASCLEPIADACEAE

** *Finlaysonia obovata* Wall., *Calotropis gigantea* (Linn.) Ait. *Pentatropis capensis* (L.f.) Bullock., *Sarcolobus carinatus* Wall., *Tylophora tenuis* Bl., *Dischidia nummularia* R. br., *Hoya parasitica* Wall.,

GENTIANACEAE *Nymphoides cristata* (Roxb.) O. Kuntze, *Canscora decussata* (Roxb.) J.A. & J.H.

BORAGINACEAE *Heliotropium indicum* Linn.

CONVOLVULACEAE

Volvulopsis nummularius (Linn.) Roberty ** *Ipomoea pescaprae* (L.) R. Br. *Merremia hederacea* (Burm.f.) Hallier f. *Cuscuta reflexa* Roxb.

SOLANACEAE *Solanum trilobatum* Linn., *Datura metel* Linn. *Solanum surattense* Burm.f., *Physalis peruviana* Linn.

SCROPHULARIACEAE

Lindernia ciliata (Colsm.) Merr.

ACANTHACEAE *Hemigraphis hirta* T. And., ** *Acanthus ilicifolius* Linn.

VERBENACEAE

** *Avicennia officinalis* Linn., ** *A. alba* Bl., ** *A. marina* (Forsk.) Vierh, *Premna integrifolia* Linn., ** *Clerodendrum inerme* (L.f.) *Gaertn, Vitex trifolia* Lin., *Phyla nodiflora* (Linn.) Creen, *Clerodendrum indicum* (L.) O.ktz., *Duranta repens* Linn.

LABIATAE *Ocimum sanctum* Linn.

NYCTAGINACEAE *Boerhavia diffusa* Linn.

AMARANTHACEAE

Psilotrichum ferrugineum Moq. *Alternanthera sessilis* (Linn.) DC., *Amaranthus polygamus* Linn.

CHENOPODIACEAE ** *Suaeda maritima* (Linn.) Dum.

LORANTHACEAE *Bendrophthoe flacata* (L.f.) Ettingh.. *Viscum monoicum* Roxb.

EUPHORBIACEAE

Croton bonplandianum Baill, *Euphorbia nivulia* ham., *E. bombaiensis* Santapau, *E. antiquorum* Linn., ** *Excoecaria agallocha* Linn., *Chrozophora rottleri* (Geis.) A. Juss *Breynia rhamnoides* (Retz.) Muell-Arg., *Drypetens assamica* (Hook.) Pax & Hoffm.

CASUARINACEAE *Casuarina equisetifolia* Forst.

HYDROCHARITACEAE *Vallisneria spiralis* Linn.

COMMELINACEAE *Commelina benghalensis* Linn.

PALMAE *Borassus flabellifer* Linn., ** *Phoenix paludosa* Roxb. *Nypa fruticans* Wurmb

PANDANACEAE *Pandanus odoratissinus* L.f.

TYPHACEAE *Typha elephantina* Roxb.

ARACEAE *Colocasia esculenta* (Linn.) Schott., *Alocasia indica* Schott, *Pistia stratiotes*, Linn.

LAMNACEAE	*Lemna perpusilla* Torr.
CYPERACEAE	*Cyperus rotundus* Linn., *C. tuberosus* Rottb., *Carex indica* Linn., *Cyperus polystachyos* Rottb., *Fimbristylis ferruginea* Vahl., *F. polytrichoides* (Retz.) *Scirpus articulatus* Linn.
GRAMINEAE	*Cynodon dactylon* (Linn.) Pers., *Dactyloctenium* aegyptium (Linn.,) P. beauv., *Desmostachya bipinnata* Stapf, *Vetiveria zizanioides* (Linn.) Nash, *Setaria barbata* (Lamk.) Kunth, *Leptochloa chinensis* (Linn.) Nees, *Paspalum scrobiculatum* Linn., ** *Porteretia coactata* (Roxb.) Tateoka, *Phragmites karka* (Retz.) Trin., Imperata cylindrica (L.) P. Beauv., *Saccharum spontaneum* Linn., *Myriostachya wightiana* (Nees) Hook.f., *Sporobolus tremulus* (Willd.) Kunth, Eragrostis sp., *Zoysia matrella* (Linn.) Merr.
ORCHIDACEAE	*DENDROBIUM* SP., *OBERONIA* SP.
DIOSCORIACEAE	*Dioscorea* sp.
AMARYLLIDACEAE	*Crinum asiatcium* Linn.

Ferns

Adiantum sp., *Asplenium adiantoides* (L) C. Chr., *Drynaria quercifolia* (L.) Smith, *Pyrrosia adnascens* SW.) Ching, *Drymoglossum* sp., ** *Acrostichum scandens, Ceratopteris thalictroides* (L.) Brong.

Fungi

Guepinia spathularia (Schw.) Fr. * *Schizophyllum commune* Fr., *Daldinia concentrica* (Bolt.) Ces de Not., *Ganoderma* sp., *Polystictus sanguineus* L. ex. Fr., *Polyporus thawaitessaii* Berk. H. Br., P. *ochroleucus* Berk., *Hexagonia discopoda* Pat. & Har.

Lichens

Principal genera are *Arthopyrenia, Trypethalium, Arthothelium, Schismatommae, Leoanora, Ramalina.*

Moss

Calymperes tenerum Muell., *C. calcuttense* Bart. et Gang., *Fissidens* (several species on clayey soil), *Hyophila* involuta (Hook.) Jaeg, (on walls), *Brachymenium indicum, Semibarbula* sp., *Ptychomitrium* sp.

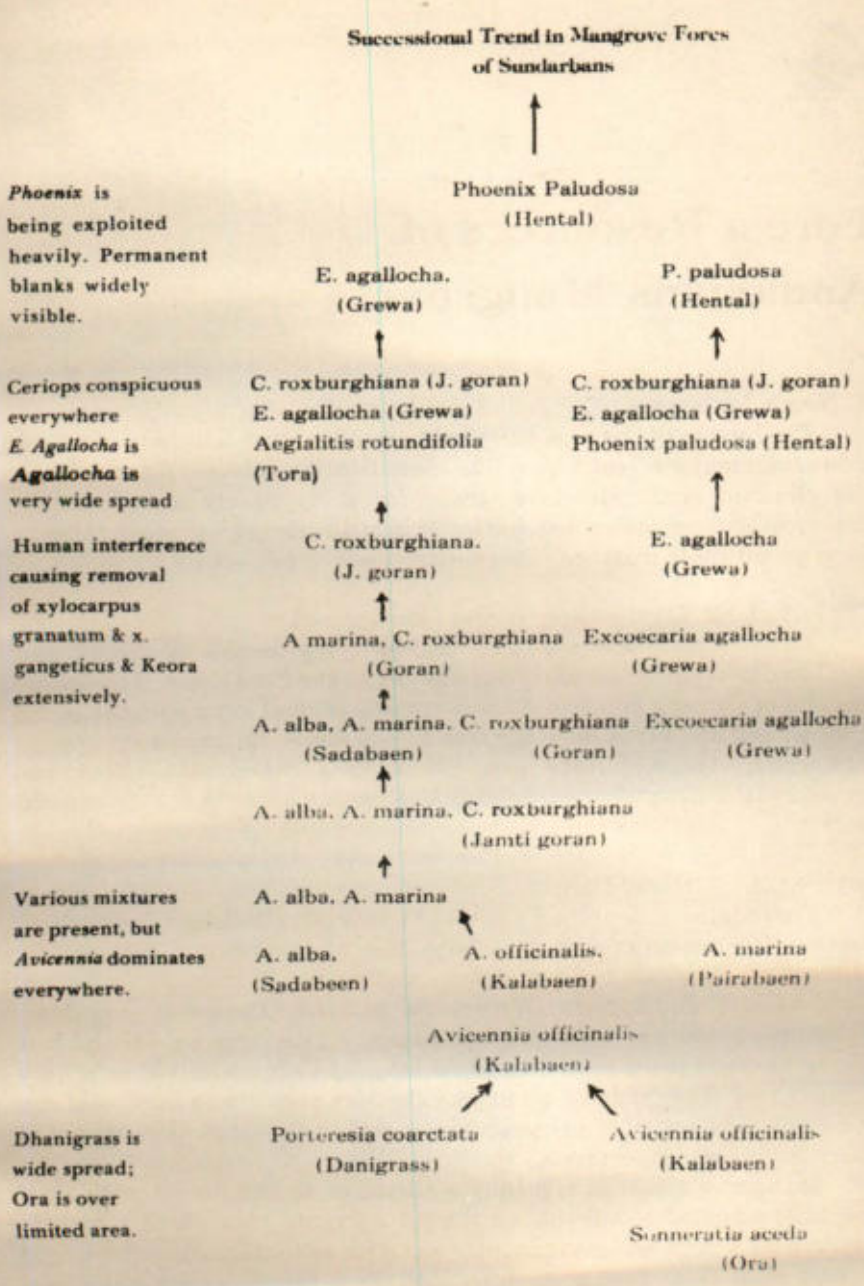
Algae

Perennial plankton association of various blue green and few green algae are common in reclaimed and stagnant water in sea face. *Microcystis aeruginosa,* Kutz., *Oscillatoria princeps* Vancherox Gemont, *O. laetevirens* (Grouan) Gom., *O. salina* Biswas, *O. amphibia,* Ag. & Gom., *O. tenuis* Ag., *Phormidium tenue* (Menegh) Gom., *Spirulina major*

Kutz., *Anabaena spiroides* Klebahn, *A. flosaquae* (Iyngby.) Breb ex. Born., *Microcoleus chithonoplastes* Thur. et. Gomont. On muddy flats Diatoms are common - *Synedra* and other important genera are *Melssira, Nitzschia, Coscinodiscus, Navicula* etc. Rarely found, *Enteromorpha intestinalis* (L.) Link, *E. prolifera*, other genera are *Melosira, Chaetoceros, Biddulphia.* Most important and common of the estuarine algae in Sundarbans in ** *Caloglossa leprieurii* (Mont.) Ag. which is found on the roots and pneumatophores upto the level of inundation. *Germium sp.* and *Catenella* occur sporadically. These algae have vital importance as fish food.

Principal Andaman Mangrove Species are as follows:–

Rhizophora mucronata, R. apiculata, Ceriops tagel, Kandelia candel, Bruguiera gymnorrhiza, B. parviflora, Xylocarpus granatum, X. moluccensis, Cynometra ramiflora, Lumintzera racemosa, L. coccinea, Sonneratia caseolaris, S. apetala, S. alba, Aegiceros corniculatus, Acanthus illicifolus, Avicennia officinalis, Excoecaria agallocha, Phoenix paludosa and *Nipa fruticans.*


Successional Trend in Mangrove Forcs of Sundarbans
Phoenix Paludosa (Hental)
Phoenix is being exploited heavily. Permanent blanks widely visible.
E. agallocha. (Grewa)
P. paludosa (Hental)
Ceriops conspicuous everywhere
E. Agallocha is Agallocha is very wide spread
C. roxburghiana (J. goran) E. agallocha (Grewa) Aegialitis rotundifolia (Tora)
C. roxburghiana (J. goran) E. agallocha (Grewa) Phoenix paludosa (Hental)
Human interference causing removal of xylocarpus granatum & x. gangeticus & Keora extensively.
C. roxburghiana. (J. goran)
E. agallocha (Grewa)
A marina, C. roxburghiana (Goran)
Excoecaria agallocha (Grewa)
A. alba, A. marina. (Sadabaen)
C. roxburghiana (Goran)
Excoecaria agallocha (Grewa)
A. alba, A. marina, C. roxburghiana (Jamti goran)
Various mixtures are present, but Avicennia dominates everywhere.
A. alba, A. marina
A. alba. (Sadabeen)
A. officinalis. (Kalabaen)
A. marina (Pairabaen)
Avicennia officinalis (Kalabaen)
Dhanigrass is wide spread; Ora is over limited area.
Porteresia coarctata (Danigrass)
Avicennia officinalis (Kalabaen)
Sonneratia aceda (Ora)

4

Forest Resources of Andamans Mangroves

A. North Andamans.

The forests of the area have been classified by Champion and Seth into seven major forest types. The classification is based on edaphic or the climatic facts. However, these forest types are not distinctly demarcated from each other and imperceptibly merge with each other to form an intimate mixture. Two conspicuous types are :

(1) 4B/1 S2 Tidal swamp forest (Mangrove).

These forests are confined to low lying banks of creeks and sheltered portion of the coast line subject to the tidal effect. They occur in belts of varying depth of a few metres to several metres on the saline alluvial soil and serve as protection to soil loss. The important species comprising these forests are, *Rhizophora mucronata, Bruguiera gymnorrhiza, Bruguiera parviflora, Xylocarpus obovata* and *Sonneratia acida.*

(ii) 4A/L1 Littoral Forest

These forests, found on alluvial high level soil along the sea coast beyond the reach of the sea, form the most striking species like *Mimusops littoralis, Tetrameles nudiflora, Terminalia catappa, Calophyllum inophyllum, Hernandia peltata, Thespesia populnea, Pongamia pinnata* and *Barrintonia* species. These forests are found just above the mangrove forest on plain land and are restricted to a very limited area. They neither occur on extensive area nor do they yield any substantial quantity of any valuable timber and as such, they are not of much economic importance.

Mangrove forest is typically a closed evergreen forest with trees specially adapted to survive on the tidal swamp area which is mostly covered with mud and permanently wet with salt water and sub-merged during high tide. Tree growth in mangrove forest is very thick and

height is moderate. These forests are rarely developed on the open sea face and never on the sandy banks.

Some resources figures (quantitative) are produced below :

DENSITY OF MANGROVE SPECIES IN NORTH ANDAMAN
(PER HA & TOTAL STEMS)

Name of the species	Stems/ha	Total estimated stems ('ooo' , units)
1. *Rhizophora candolaris*	800.690	23423.396
2. *Bruguiera conjugata*	427.089	12494.079
3. *Bruguiera parviflora*	1.915	56.021
4. *Avicennia officinalis*	148.975	4358.120
5. *Heritiera littoralis*	4.377	128.062
6. Other Mangrove species	48.016	1404.683

Forested area from Aerial photograph.

Mangrove forests are easily distinguished from rest of the forest crop in the aerial photographs (A1, A2, A3 described below) because of their gregarious nature. They comprise a few species primarily of Rhizophoraceae family.

A1-This type consists mainly of *Rhizophora* species more or less in pure form. The crop appears to be a woollen carpet in dark tone on the aerial photographs. This is homogeneous, uniform with comparatively lower average height and mostly found in sub-merged water-logging areas and also on the sea coasts or river mouths.

A2-This crop consists mainly of *Bruguiera* species and appear on the aerial photographs to be more or less similar to type A1 except the tone, which is generally whitish grey or lighter grey. Crop height is more than that of A1 and it comes on little higher elevations.

A3-At places *Rhizophora* and *Bruguiera* become intermixed and it becomes difficult to separate them out.

Facts and Figures

The Mangrove forests or the Tidal swamp forests form a natural protection belt to the land mass from the hazards of soil erosion. It occupies a major portion of the edges of the tidal creeks namely Balmi creek, Parangara creek and Kalara creek. The aerial photographs of the mangrove forests exhibit the appearance of a smooth carpet with a medium grey to dark grey colour. Texture is smooth even for *Rhizophora* while it drastically changes in case of *Bruguiera* since it

depicts a rough and uneven texture.

It is observed that *Rhizophora* species are abundant at the edge of the tidal creeks and remain hanging on the creek at the low tide. The belt extends from 1m to several metres on the land side. Above the *Rhizophora* species is the *Bruguiera* species characterised with an admixture with *Rhizophora* species. Breathing roots and stilt roots are typical for *Rhizophora* while stilt roots do not develop in case of Bruguiera.

It is observed from a study of the data that the average height in *Rhizophora* ranges between 7 m to 8 m while for *Bruguiera* it goes upto 10 m.

The distribution of stems/ha for various mangrove species is as under:—

Mangrove species	Stems/ha
Rhizophora candelaris	800.6
Bruguiera conjugata	427.1
Bruguiera parviflora	1.9
Avicennia officinalis	148.9
Heritiera littoralis	4.4
Miscellaneous	48.0

Thus it is evident that the abundance of *Rhizophora* species surpass *Bruguiera* in the areas.

Volume distribution for various mangrove species is as follows:—

Species	Volume (m3/ha)
Rhizophora candelaris	38.4
Bruguiera conjugata	68.3
Bruguiera parviflora	0.5
Avicennia officinalis	3.2
Heritiera littoralis	0.5
Miscellaneous	4.6

A perusal of the above table clearly indicates that the volume/ha for *Bruguiera* species is more than that the *Rhizophora* (nearly 1.8 times). Further it is observed that nearly 60% of volume lies in the diameter range of (4-9 cm.) and thereafter falls gradually. Volume distribution after diameter class 50 cm onwards is extremely poor.

Mangrove species is mainly used by the local population as fire

wood for high caloric value. However, the crop is characterised by higher tanin content.

B. Middle & South Andaman.

Forest Type

The vegetation of Andaman Islands has been classified by Champion and Seth into different groups as per edaphic or climatic facts. These groups are not very distinct on the ground. Only few classes can be distinguished from each other.

The main forest types are as under:–

1) 4B/152 Tidal swamp forest (Mangrove): This type of forest is a typical type occupying the coastal banks of the tidal creeks as well as sea faces. It comprises of important species like *Rhizophora mucronata, Bruguiera gymnorhiza, Bruguiera parviflora, Xycocarpus obovata* etc. The sea coasts or the creek banks are sometimes covered by thick growth of these species. Their extent varies from a metre to several metres. This type of forest can be very well distinguished from any other type in Andaman.

2) 4A/1.1, Littoral Forest This type of forest is found just above the mangrove forest from the sea coast and is mainly found on the alluvial high level soil along the sea coastal region, beyond the reach of the sea water. Most common species found in this type are *Manilkara littoralis, Pongamia pinnata, Morinda citrifolia, Erythrina variegata, Calophyllum inophyllum, Terminalia catappa, Barringtonia asiatica, Cordia subcordata* etc.

Forest Resources

The baks of the tidal creeks are mainly covered with various types

Sl. No.	Name of the species	Stems per ha		Total estimated stems '000 units	
		Middle Andamans	South Andamans	Middle Andamans	South Andamans
1.	*Rhizophora candelaria*	317.694	756.000	5388.479	12251.734
2.	*Bruguiera conjugata*	309.553	128.000	5233.415	2074.367
3.	*Heritiera littolaris*	45.710	156.000	775.320	2528.133
4.	Other Mangrove species	62.850	100.000	1066.065	1620.598

of mangrove species. Among these, *Rhizophora candelaris* and *Bruguiera conjugata* are main species occurring on the creek banks and coastal areas. Contribution of mangrove forests to the forest resources of the project area are not negligible. They play a vital role to meet up the demand of fire wood in the area. Mangrove woods have more caloric value as fire wood. Except for fire wood, mangrove wood can be used for construction purposes in rural areas. The mode of better utilization of mangrove is not can be yet known. Tannin extracted on a large scale from mangrove bark.

The forest and land-use classification

The vegetation types and land-use classes used in photo-interpretation are as below :

Forested areas :

Mangrove forests are distinguished from rest of the forest crop because of their gregarious nature. These are composed of a few species of a particular family namely *Rhizophoraceae.*

A^1 This type consists mainly of *Rhizophera* spp. more or less in pure form. The crop appears like a woollen carpet in dark grey tone on aerial photos. This is homogenous, uniform and having comparatively lesser average height and mostly found in totally merged on sub-merged water logging areas along the sea coasts.

B^2 This crop consisting mainly of *Bruguiera* spp. appearing on photo more or less similar to type A^1 except the tone, which is generally whitish grey or varying to lighter grey. Crop height is more than that of A^1 and it comes on little higher elevation.

A^3 At places the species of *Bruguiera* and *Rhizophora* come inter-mixed and are unseparable. Such areas where *Bruguiera* and *Rhizophora* come inter-mixed approximately in fifty fifty ratio categorised under A^3

Distribution of mangrove species

Mangrove forest is found on the mud banks of the deltaic streams, the tails of islands, and other more extensive areas near the sea face wherever accretion is in progress. It does not develop on the sandy banks at the sea face, for though some young growth may be found, it passes on the other types without full development in the present one. The ground is flooded daily by salt water and never has time to dry out.

It is observed that *Rhizophora* species are abundant in the area. Average height in *Rhizophora* ranges between 7 m to 8 m while for *Bruguiera* it goes upto 10 m.

The distribution of stems/ha. for various mangrove species is as under:—

Species	Middle Andaman Stem/ha	South Andaman
Rhizophora candelaris	317.698	756.000
Bruguiera conjugata	308.556	128.000
Heritiera littoralis	45.712	156.000
Miscellaneous	62.854	100.000
	734.820	1140.000

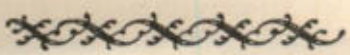
In South Andaman 54.04% of the species are between 1 to 9 cm diameter class. Only 3.16% are above 20 cm. diameter. For diameter class distribution table 1.2.2. may be referred to. In Middle Andaman only 30.33% of trees are below 10 cm diameter and 15.56% of the trees are above 20 cm. diameter. Trees above 60 cms, are rather, rare.

Volume distribution for various mangrove species is as follows:—

Species	Middle Andaman Volume/ha (in m3)	South Andaman
Rhizophora candelaris	28.118	36.021
Bruguiera conjugata	55.342	6.189
Heritiera littoralis	1.421	11.646
Miscellaneous	20.670	5.027
	105.552	58.883

From the above table it is evident that the volume/ha. for *Bruguiera* species is more than all other species in the area. *Rhizophora candelaris* accounts for 26.44% of the total volume. Only 1.90% of tree are below 9 cm. diameter in Middle Andaman. Distribution of volume by species and diameter class is given in table.

In south Andaman *Rhizophora candelaris* is more than *Bruguiera conjugata* and accounts for 61.17% of the total volume whereas Bruguiera is only 10.51%. Volume is maximum in the diameter class 10.19 cm and thereafter falls gradually.



5

Aerial Photointerpretation of Sundarbans and Andaman forests.

A. Sundarbans

Definite changes were recorded in the boundary of several blocks which have been shown in the map. Changes in the rivers and creeks have also been included which were hitherto, not shown.

The following discussion will illustrate the changes observed in the blocks during field reconnaissance.

1. Saptamukhi Block :

An area about 0.65 square km. in the extreme South portion and about 2.58 sq.km. at the east of Lothian Island has been eaten away by river. A land formation about 5.16 square km. has been found on the North east side of this Island. A sandy new formation about 9.03 sq.km. from South to North of the western part of the Prentice Island has been observed.

2. Thakuran Block :

Some land area of about 5.16 sq.km. in the South and South west portion of Thakuran Block has been eaten away by river. Similarly an area of about 1.29 sq.km. in the South of Binmary Khali has also been eaten away by the sea. Further, the width of the Binmary river is noticed to have increased and has been connected with another Nala close to the eastern coast.

3. Chulkati Block :

The width of the mouth of Bijarekha Khali has recorded an increase and about 2.58 sq.km. of land area has been eaten away by the sea (South west side). A sandy formation of about 5.16 sq.km. in the West coast of compartment no. 6 and 7 has been formed. In South

and South west side of compartment No.5, the sandy island of about 5.16 sq.km. has been eaten away by the sea and about 1.29 square km. of new land formation has taken place in the eastern side.

4. **Dulibhasani Block :**

A sandy portion at about 2.58 square km. in the extreme South of compartment no. 8 has been eaten away by the sea. Similarly, land mass of about 2.58 sq. km. area to the South east of compartment No. 7 has gone into the sea. Besides, about 1.29 sq.km. area in the North and West of compartment No.2 is under water. In compartment No.1 a land mass of about 5.16 sq. km. area has been newly formed.

5. **Ajmalmari Block :**

About 0.65 sq. km. area of land mass has been formed in the South compartment No. 10 and a sandy belt of about 1.29 sq. km. area has been formed in the eastern side of compartment No. 6 and 8. Land formation of about 1.29 square km.is observed in the West side of compartment No. 6 and 7. A sandy island of about 5 sq. km. in the west of compartment No. 6 has been eaten away by the sea. Besides, in the east of compartment No. 12, a land mass of about 1.29 sq.km. area has been newly formed.

6. **Herobhanga Block :**

An area of about 0.65 sq. km. area in the mouth of Chhota Matla river, Chhota Herobhanga and Bara Herobhanga has been eaten away by the sea. About 0.65 sq.km. land mass has developed in the Western side of compartment No. 8.

7. **Pirkhali Block :**

A small island in the South West of the compartment No. 5 has been eaten away by the sea (Area of about 0.65 sq. km.)

8. **Panchmukhani Block :**

About 0.65 sq. km. in South side of compartment No. 5 has been eaten away by Goashaba river. Similarly, about 0.65 sq. km. land of compartment No. 3 (in the North West) has been eaten away by Gazikhali.

9. **Netidupenni Block :**

Mouth of the Netidupenni Khali has widened and some land portion has been lost (about 0.65 square km.)

10. **Chamta :**

No remarkable change is recorded.

11. **Matla Block :**

A small island in the mouth of Habhatidoni Khali (area 0.65 sq.km.) has been eaten away by Matla river. Three isolated islands in the western side of compartment No. 1 & 2 have been eaten up by Matla river. A small portion of land has developed in the South of compartment No. 4 and a small portion of land has vanished in Haldikhali.

12. **Goashaba Block :**

A small portion in the North east side of compartment No.3 has been formed as land. And a sandy portion in the South-West of the compartment No. 8 has also been formed.

13. **Chhota Hardi Block :**

Land mass of an area of about 1.29 sq.km. in West side of compartment No.1 and in the South of compartment No.3 has been eaten away by the Matla and Mayadip river respectively. Similarly, small portion in the South West and South east of Goashaba Block has also gone under the Goashaba river. New land formation of about 1.29 sq.km is observed in the South east of compartment No.4. Further the mouth of Chota Banka Khal has widened.

14. **Mayadwip Block :**

A land portion around the South and Western side of Bhangaduni island (area about 18.06 sq. km.) and the South and West sides of the Dalhousie island of about 20.64 sq.km. land portion has been eaten away by the rivers Bhangaduni and Matla respectively. Also a sandy portion about 1.29 sq. km. has been lost in the East of compartment No. 1 .A small portion of compartment No.1 (North side) has come up as new land formation.

15. **Gona Block :**

Sandy part of about 2.58 square km. area has come up as new land mass. Also a small portion in the east of compartment No. 8 has developed as land. Some land area of about 0.65 sq. km. has been eaten away by the Gona river (In the West side of compartment No. 8). Similarly, some land portion in the West and South west of compartment No. 8 has been eaten away by the Goashaba

river (area about 3sq. km.).

16. **Baghmara Block :**
Aerial photograph not available.

17. **Chandkhali Block :**
No change.

18. **Harinbhanga Block :**
A small land portion of about 0.65 sq. km. in the North of compartment No. 1 and a sandy portion of compartment No. 2 and 3 has been eaten away by river. Similarly, a small land mass of about 1.29 sq. km. in the North of compartment No. 1 has gone under Jhilla river. Sandy portion of about 0.65 sq. km. has come up as land mass.

19. **Khatuajhuri Block :**
Aerial photograph not available.

20. **Jhilla Block :**
A portion of about 0.65 sq. km. in North side of compartment No. 6 has developed as land and nearly 0.65 sq. km. in the South of compartment No. 5 has been eaten away by water. Similarly, a portion about 0.65 sq. km. in the West side of compartment No. 3 has gone into the river and a small portion in the North of compartment No. 3 of about 0.65 sq. km. has been formed as land.

21. **Arbesi Block :**
Sandy portion in the North side of compartment No. 2 is under the Raimangal river and a small sandy portion of about 0.65 sq. km. has developed as land in the North side of compartment No. 2.

B Land use pattern of Andaman and Nicobar Islands.

From the analysis of aerial photographs the following data of the forests and non-forests areas have been calculated (in Sq. km.)

Forest Division.	Evergreen, Semievergreen and Deciduous Forests.	Percentage.	Mangrove Forests.	Percentage.
Little Andaman	653.98	96.2	37.59	5.5

Middle & South Andaman	2448.71	87.7	371.12	12.3
North Andaman	1191.50	72.8	272.20	16.6
Nicobar Islands	592.62	91.5	12.89	2.0
Total :	4886.81	87.6%	693.80	12.4%

According to State Working Plans Mangrove Forest area has been identified as 115200 ha. which also involves ecotone areas. There might be quite a lot of shrinkage owing to felling of trees for firewood.

The statements that follow in Tables I to IV give the summary of findings.

TABLE – I

Andaman and Nicobar Islands

Land use pattern in North Andaman from Aerial photo interpretation.

GENERAL

Particulars	Area	Percentage
(a) Total area interpreted	1636.91	100
(b) Forest area	1517.58	92.7
Plantations	20.17	1.2
Scrub	25.90	1.6
Scrub and bamboo	7.79	0.5
(c) Non-Forested area	119.55	7.3

FOREST TYPES

(a) Evergreen, Semievergreen and deciduous forests	1191.50	72.8
(b) Mangrove Forests ... Rhizophora species	118.64	
Bruguiera sp.	83.83	
Nlixed Crop	69.73	16.6

TABLE – II

Land use pattern in Nicobar Islands from aerial photo interpretation.

GENERAL

Particulars	Area	Percentage
(a) Total area interpreted	647.15	100

(b) Forest area	611.92	94.6
Plantations	19.30	3.0
Scrubs	0.60	0.1
(c) Non-Forests	25.23	5.4

FOREST TYPES

(a) Evergreen, deciduous and Semi evergreen forests	592.62	91.5
(b) Mangrove Forests		
..Rhizophora	3.50	0.6
Bruguiera	3.96	0.6
Mixed	5.43	0.8

TABLE – III

Land use pattern in Middle and South Andaman

GENERAL

Particulars	Area	Percentage
(a) Total area interpreted	3026.68	100
(b) Forest area	2819.83	93.5
Plantation	93.97	3.1
Scrub	16.61	0.6
Scrub and Bamboo	8.40	0.3
(c) Non-Forested area	206.85	6.8

FOREST TYPES

(a) Evergreen, Semievergreen and deciduous forests	2448.71	87.7
(b) Mangrove forests		
..Rhizophora	201.31	6.6
Bruguiera	31.91	1.1
Mixed	137.90	4.6

TABLE – IV

Land use pattern in Little Andamans as interpreted from aerial photo interpretation.

GENERAL

Particulars	Area	Percentage
(a) Total area interpreted	679.82	100
(b) Forest area	656.47	96.6
(c) Plantations	0.05	—
(d) Scrub	2.44	0.4

FOREST TYPES

(a) Evergreen, Semievergreen and deciduous forests	653.98	96.2
(b) Mangrove Forests		
..Rhizophora	7.27	1.1
Bruguiera	7.63	1.1
Mixed	22.69	3.3

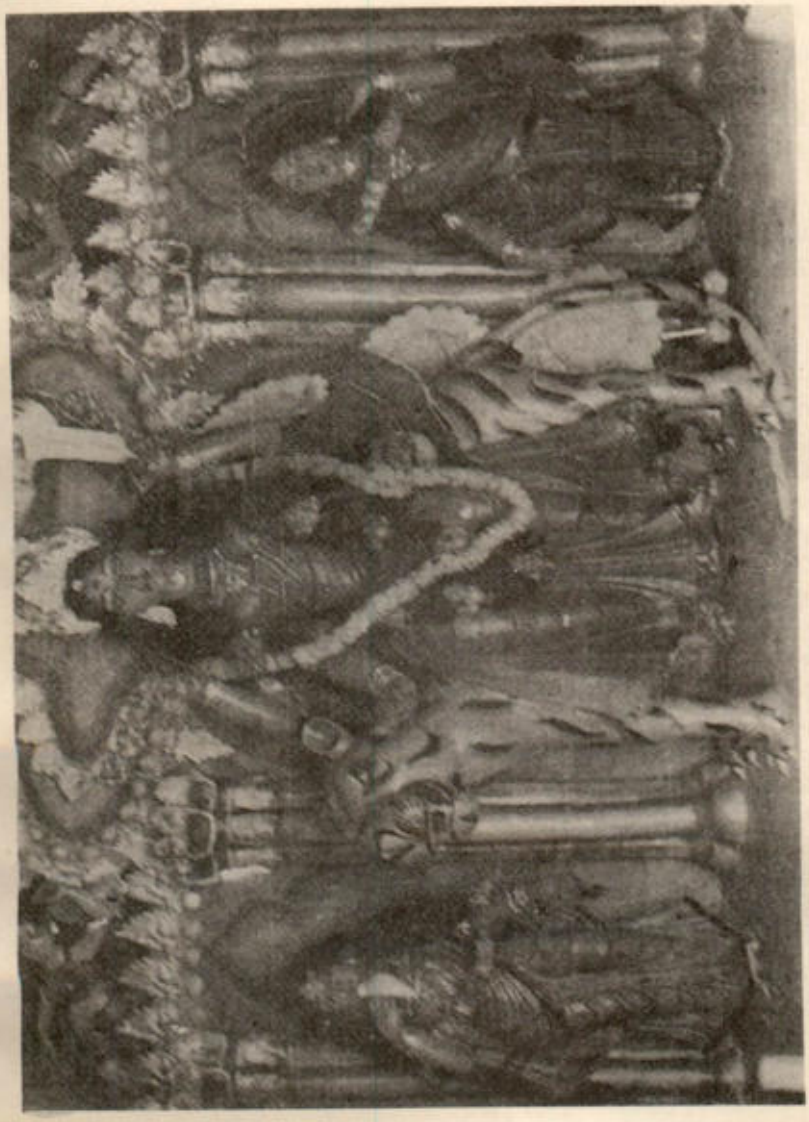


Photo 2 Banbibi mounted on a Tiger is adored by all those enter Sundarbans. They offer Puja and Sacrifice.

6

Wildlife Biology of Sundarbans

TIGER AND MAN

The Sundarbans tiger as viewed by Fishermen and others who eke out their livelihood from the area.

Nature's masterpiece of creation are the Tigers of Sundarbans. The resourcefulness, intelligence, agility as personified in such tigers have turned this magical species into a legendary myth. Superstition, and supernatural qualities attributed to the man-eaters, however fictitious they may appear, have their basis in facts. Locating its human prey, silently stalking him in ever closing circles for hours, high degree of intelligence to baffle trap gunner and trappers, diabolical understanding of the human mind, high precision in attacking human beings and crossing rivers, great power in controlling reflexes in mounting a boat, with least rocking, have made it a mythical animal. Blessings are invoked from Dakshin Ray (Tiger God), Narayani Ma, Banbibi, Kalu Khan, Sa Jungli, Gazi Sahib prior to entering the forests as it is thought that the animal has supernatural qualities of destruction of human beings who are helpless against its machinations.

Tigers in the Sundarbans have taken a toll of about six hundred human lives in the last sixteen years. These are all reported cases; it is difficult to estimate the number of unreported cases. The victims are almost invariably poor villagers from the adjacent areas which are among the most backward in the country. Sheer economic necessity compels them to brave the hazards of the terrain over and over again. Fishermen, honey-collectors, wood-cutters and others engaged in work of an allied nature constitute the bulk of "permit-holders". These are the people for whom the Sunderbans tiger is a living entity-almost a part of their lives.

When such people talk of their experience-no matter how tragic these are-the references to the tiger are rarely, if at all, in inimical terms. The tiger is "accepted". It is almost as if there is an elaborate

ritual of ground rules to ensure co-existence. A priest accompanies them to the forest and invokes the blessings of Dakshin Ray- the principal folk deity and lord of the forest, in the robe of a warrior, armed with sword, gun, bow and arrows, and seated on a tiger-and also of Narayani Ma, Banbibi, Kalukhan, Sa Jungli and Gazi Saheb to obtain immunity from any attack by man-eaters, Crocodiles, Manasa (snake) and other creatures.

The authors have presented a series of true stories collected from a vast number of interrogatory data and have depicted the pattern of behaviour and other biological features of the tigers of Sundarbans. The stories narrate exicting encounters with the tigers in the sinister beauty of the wild, swift flowing water, armoured deadlines of the crocodiles gliding noiselessly through water in quest of prey, mating call of the tigress and answering roar of the mate prowling silently along deserted jungle paths. Pathetic stories of honey collectors, fishermen and wood cutters give a grim picture of their struggle for survival against a powerful and cunning beast which is still considered mysterious. Yet these men have observed meticulous silence about their ruthless extermination; rather they wanted to coexist. Whatever be the Scientist's view on the overlay of superestition, the stories reveal certain interesting insights into the preying habits of the Sundarbans Tigers.

1. They are superb, long-distance swimmers; they cross rivers at right angles to the current; once the crossing is decided, it is undertaken with a firm determination; and boat coming in the way is attacked; in the water they are just as strong as on land; an extremely crafty fighter with indefatigable energy.

Mayadwip River - April - Afternoon 1969.

A Motor launch was gliding smoothly into the calm; glass-smooth and crystal clear waters of the mighty Mayadwip river. It was the season for honey collection and the entire atmosphere was surcharged with the sweet fragrance of Khalsi (Aegicerus majus) flowers with numerous swarms of rock bees busy collecting honey. But the Keen eyes in the launch were rivetted on a black, moving object in the middle of the river.

The launch was powerful with a steel hull and manned by a crew of ten. The serang (the pilot) steered the Launch towards the moving object which resolved itself as a full-grown tiger, crossing the river. Shikar stories about the Sundarban tigers infuse these animals with immunity in water from fatal shots as only their

nostrils peep above the surface even in rough weather. A strong wind had picked up in the meantime and the Launch started violently rocking on the crests of the waves. Attempts were made to shoot the animal. Five shots were fired in quick succession from the unsteady launch. But the rocking diverted the bullets well away from the animal which was closely watching the proceedings.

The crew set in, aiming lumps of coal at the swimmer which casually blocked the few accurate missiles by its broad left paw. Long bamboo poles, the normal equipment of a launch, were thrust at the tiger but the ends were gripped and it caught hold of the pointed end with both paws and chewed it up until reduced to shreds. The exhausted crew were getting more and more nervous at its ingenuity.

The serang repeatedly rammed and over-ran the animal to suffocate and drown it, criss crossing the launch over its head. The cook splashed hot water on the animal. But neither any injury nor exhaustion was noticed. This charmed existence of the tiger caused a section of the superstitious crew to bolt themselves in a cabin below.

The serang was perplexed but the animal temporarily solved the problem, by getting air borne, raising its body in mid-air and effecting a smooth landing on the small dinghy attached to the launch. Having climbed the dinghy, it lay its head below the wooden planks to register its tiredness and fear. Fear, in turn struck the crew like an electric shock with the thought that the dinghy would now be used as a platform to climb on to the launch. To stave off such an eventuality, the tow rope was extended considerably with the help of another rope.

The battle of nerves was reaching its climax. The panic-striken crew were petrified. At long last it was decided to drag the dinghy with the tiger to the timber coupe of Herobhanga where the animal could be brought under control with the help of the coupe staff in possession of rifles. It was a long way and Matla, a mightier river, had to be crossed. As the launch entered Matla, its rushing waves overturned the dinghy and the tiger was tossed back into the water. It swam ashore-completely fagged out-looked at the helpless and curious crew of the launch and leisurely walked away turning its head at the launch several times before vanishing into the mangrove forests.

It had fought a grave battle single handed for three hours against man and machine and had won.

Lunch was over. About 3-30 p.m. Gazi noticed the absence of one of the watchers and approaching the spot where the man was posted, discovered the man-eater's pugmarks on the receptive soil. A man of determination, Gazi followed the track with the other watcher till he sighted the man's deadbody. Keeping his distance, he began scanning the area. The next moment the man-eater seemed to float silently through the air from behind and had the right side of the neck of Ashraf, the 40-year old second watcher, in his jaws. Though Gazi was able to scare away the animal, his only reward was to be able to carry, along with others, both the deadbodies back to the waiting boat.

Seven sad days had passed and Gazi was forced to shed his sorrow and to start his work once again as money was running low. He landed in Gosaba-3 with four companions and was horrified to be confronted with fresh pugmarks of the dreaded tiger. To add to their miseries, a discussion on the plans for work and watch was interrupted rudely by the tiger's roar close at hand and all four of Gazi's companions were frightened into unconsciousness. This time luck was with him as he finally succeeded in scaring away the animal before it could launch an attack. Fortune was kind to him for a change.

(d) Panchamukhani Block - 5 - Time 9 A.M. 29th November, 1971.

Harihar Samaddar with his friends, Nibaran Mandal and two others, got off their boat to collect dry twigs for firewood and to check the spoors of different animals. Harihar busied himself with noting down the pugmarks and their sizes. Having found some dry twigs Nibaran collected some and carried them to the boat enchored hardly 500 metres away. On his way back from the boat, Nibaran was half-way when he detected fresh pugmarks of a tiger. Frightened movement of monkeys on the trees confirmed his fear and nervousness made him shout out to his companions. Before any help arrived, the cunning and stealthy man-eater caught him and was about to carry him away when Harihar's crackers started bursting and the two other men came to Nibaran's rescue. His lifeless body was abandoned by the tiger which disappeared into the jungle.

On examination it was found that the jugular vein and cerebellum had been pierced and the spinal cord at neck was broken and Nibaran had died instantaneously.

Harihar has not yet reconciled himself to the incident which continues to baffle him with its lightening speed and unexpectedness.

(c) Panchamukhani - 5. Time - 10 P.M. - August, 1970.

Satis Mandal at 50 had been in the timber trade for 30 years and had lost many of his friends and relations in the Sundarbans.

He was camping in Panchamukhani. It was 10 P.M. and as he was about to turn in for the night, he jerked upright as he felt slight jolt of the boat. It struck, him as somewhat unusual. He gripped a stick, grabbed a torch, and came out on the deck of the boat. The pencil of rays from the torch revealed a full-grown tiger struggling to climb on to the stern of the boat. The boat was a big one and the stern was quite high above the water and there was no dingy to use as platform. These factors were frustrating the tiger's attempts to jump on board. Mandal summed up the situation immediately and woke up his men. They lustily shouted in unison and struck the tiger with strong Goran (Ceriops spp.) sticks. The tiger swam back to the shore, leaving the entire party unharmed.

3. The tiger climbs on to a boat anchored in midstream without a sound; not even a splash is heard, the boat does not rock and the silence is unbroken; the tiger then selects its prey; the boat rocks this time as the tiger jumps off the boat into the water with the man securely clamped in its jaw for a quick exit; it is then too late to intercept it and save its prey.

(a) Sajnikhali Patrol Party Staff, Time-11 P.M. August, 1966.

As with smugglers in the Sundarbans, tigers too avoid Government boats and patrolling forest staff.

A Forester happened to step outside the cabin of a boat around 11.P.M. one night. As he settled down on his bed after re-entering the cabin a soft thud was barely heard from the stern that jolted the boat slightly. All the inmates of the boat were cautioned. To ascertain the cause, a guard moved out with a torch. He scanned the front end of the boat and then turned the light towards the stern where he faced a tiger in a corner, ready to jump on him. The guard although scared had enough presence of mind to jump back into the cabin and wake up the inmates. The disappointed tiger had to jump back into water and swim ashore as his manoevure failed.

(b) Bagmara-8. Time-11 P.M. May, 1969.

Sanyasi Mandal was saying: "I opened my eyes from deep slumber. It was about 11 P.M. A pair of eyes glowing in the

2. They appear all of a sudden in the most unexpected places; They attack in broad daylight, aiming mostly at the most vulnerable point - the right side of the prey's neck so as to pierce the jugular vein and cerebellum.

Chotohardi Block, Time 4.30 P.M. 28th December, 1971

It was at the junction of Nekrikhali and Chotohardi rivers that Kirpa Mandal, a permit holder, was busy catching crabs with his associates. They had had a good catch. But the high tide was just beginning and they decided to continue for another hour before dropping anchor for the night, blissfully unware that they were being watched and stalked for the past several hours by a notorious full-grown man-eater of Chotohardi.

Oblivious of the dangerous surroundings, Mandal was concentrating on his work, sub-consciously reassured by the thought that his boat was in the mid-stream on the wide expanse of water. In their pre-occupation, however, the fishermen had overlooked the fact that the channel of Nekrikhali, further ahead, narrowed down to a bare ten metres rendering the boat vulnerable to a tiger's leap from the bank; and they would be passing the narrow neck in another forty minutes. The intelligent tiger, however, had anticipated the course of Mandal's boat and had silently marched off in advance to take up his position behind a Keora tree (**Sonneratia apetata**)along the bank of **the river at its narrowest. One of the fishermen at this point instinctively scanned the bank, and with hawk-eyed accuracy of vision,** spotted the tiger. With characteristic courage, the fishermen stopped the boat and attempted to scare away the animal by shouting with their powerful lungs. The undaunted tiger came out into the open and pondered his next move. But the shouting brought a Forest Patrol boat to the scene and the disappointed animal turned back into the thick mangrove with a snort of disgust.

(b) Khatuajhuri Block 5 Time 5.P.M. December, 1949.

Mohan Ganguly lowered his hookah and gave a lop-sided smile. A timber contractor by profession, he was narrating how a reign of terror had engulfed Khatuajhuri. One after another the timber workers fell to the wily man-eaters, although this block had never been considered dangerous. All precautionary measures proved ineffective.

Forest Department Staff were stationed with rifles. But the

animal took its ninth victim. Ganguly was shocked. Of the nine killed, only three bodies could be recovered. As the body of the last victim was being carried back by a party of camp-mates, the feared cry 'tiger, tiger' echoed. A giant of a tiger appeared ahead of the party, the slanting rays of the setting sun making its dark tan shine against its black stripes. The time was about 5 p.m. The deadbody was hastily dropped as the entire party ran for life and dived into the river not realising that the water was still more dangerous owing to unseen whirlpools and multi-directional currents, not to speak of sharks and crocodiles. It was all over in a matter of seconds.

Ganguly's vivid description, with a far-away look in his eyes, almost re-enacted the horrifying and pathetic scene with the frightened swimmers helplessly floating downstream and the man-eater leisurely following them along the bank of the river within easy sight. Death was the closest follower with the twin weapons of drowning by exhaustion or being caught alive by crocodiles, sharks or the tiger. Every second seemed to be taking these lost souls closer to doom. But it had been decreed otherwise. The crew of a "Sundarbans Despatch Service" vessel bound for erstwhile East Pakistan sighted the tragic scene. With the help of a speed boat, they rescued the unfortunate persons and took them to the camp. From a distance the tiger watched the entire proceedings closely accepting his defeat but only temporarily.

Forest Department authorities ordered a temporary suspension of all work. But necessity knew no law. At the request of the permit holders the work was allowed to be resumed. Although security arrangements were tightened considerably, two more helpless workers were carried away by tigers in quick succession. Finally, with the sacrifice of eleven persons at the altar of Dakshin Ray, the Forest Department officially closed the camp that had claimed so many lives. Mohan Ganguly fell silent, his hookah forgotten.

(c) Chamta-6 Time-3.30 P.M. August, 1965
Gosaba-3 Time-8.30 A.M. August, 1965.

Nurul Gazi had passed his 65th year in a happy home. His source of income was collecting Golpatta (**Nipa fruiticans**) for roofing and he was one of the oldest permit holders with a vast knowledge of the terrain and its denizens. Caution was his second nature and on this particular day he had posted two men to watch and warn, while he himself concentrated on his work in Chamta-6.

poor, flickering light of the kerosene lamp in the boat and a warm putrid breath was fanning my face. The animal stood among the four of us while choosing its prey. I tried to shout but my voice failed. I have seen many tigers but nothing like the one I saw this time."

Sanyasi was in the fish trade for a long time and knew the terrain very well. A bright young man of 25, with thick tufts of curly hair and a complexion like varnished ebony, he often went in parties of five or six for fishing in the creeks and streams meandering through over-hanging Goran and Garjan bushes. Each fisherman could hardly earn anything more than a meagre sum of Rs. 2/ to 3/ a day while the middle man raked the lion's share of the profit. A lovable young man, Sanyasi kept close contact with the patrolling staff of the Forest Department. He was aware of the multidirectional currents of the channel running east-west and other hazards of the terrain.

It was customary for the fishing-folk to get under the bamboo canopy of the boat after the day's work. On this day too, they had sat there and chatted for hours before turning in. Sanyasi cannot recall why he suddenly woke up to find the man-eater towering above him and his team mates right under the canopy. The animal selected Ananta Mandal, a man of 40, lifted him up his jaws and jumping out of the boat, vanished in the darkness. Nothing could be done as it all seemed to be over in a second.

Sanyasi recollected his promise to Ananta's wife that they were going together and would return together. He was disturbed over the thought of having to face the deceased's wife. He continued to say that tigers, crocodiles, sharks and venomous snakes had to be encountered daily by them in a hostile terrain. Boats sink in storms, dacoits rob them of their belongings, drinking water and edibles; yet they continue their professional work ignoring the sorrowful tears of wives, mothers and children.

He attributed supernatural powers to the tiger; otherwise how could they get inside the boat so silently without any indication of their presence.

4. When challenged these animals pause and stand still; when they scent any danger, they bolt. Are they cowards? Why do they attack from the rear and to the right or mount a boat like a thief?

(a) Gosaba Block. Time-9 P.M. July, 1968.
Rashik Mandal narrated his thrilling encounters with tigers; he

had escaped unscathed, while his team-mates fell one after another. He said, man-eaters were everywhere and they migrated from block to block. He considered the tigers of Chamta as the most cunning and notorious.

He had once had the experience of a tiger boarding his boat. Fortunately that night all the inmates were relaxing but had not gone to sleep. The boat tilted just a little and unless one was experienced it was impossible to associate the tilt with the presence of a tiger on board.

However, that night the tiger was scared away and everybody was saved.

(b) Chotahardi Block. Time-10 A.M. April, 1970.

Bishnu Mandal, aged 60 was a honey collecter. He and his guru (preceptor), both priests, were in a group. The guru had a premonition of grave danger and decided that the men should stay together for sometime. His hunch paid off and they sighted a huge tiger as they were detailing their duties. It was a Friday and they spent the rest of the day in intensive prayer.

Early on Saturday morning they stepped out on the dry bank of a creek. Blessings were invoked from the Tiger-God. Mantras (incantations) were chanted to keep the man-eaters away and also to immobilise them. In the process, Mandal lagged behind the rest of the party. A huge tiger appeared as if from nowhere. But Mandal's courage prevailed and he faced the animal and shouted at it :

"You rascal where do you come from?" Mandal had a sharp cutting implement with him. But the tiger was hungry, snarling, twitching its tail with its facial muscles expanded, spitting frequently and the saliva oozing out, hind legs grazing the ground; it visibly grew to double its size. Though death was imminent, Mandal did not give into panic but held the sharp instrument high, ready to strike. This caused the animal to pause. Mandal's eyes locked with those of the tiger while he was backing slowly. He touched the ground with both hands and chanted a mantra. The animal scented danger and suddenly retreated. Mandal was rescued and found to be running high temperature. His eyes were "blood red" and it has remained so till today. A few minutes' strain had changed his facial expression altogether.

(c) Chamta Block. Time-9 A.M. April, 1967.

Golam Muhammed of Gosaba, had been collecting honey for 20 years. As an eye-witness, he described now, under pathetic circumstances, he had lost seven of his close colleagues on different occasions.

But the present incident which he was going to relate was different. It was a bright and clear morning. A mild breeze broke the gentle swell of the river into dancing little waves. Reclining at ease on the prow of the boat Gulam Muhammed was watching the golden brown colour of golpatta and the emerald green of the Dhani grass **(Oryza coarctata)**.The tide was running and the boat stood close to the bank. Golam, along with some others, was relaxing as he expected some of his men to join him. His son, cooking inside the boat, suddenly shouted 'Tiger, Tiger' and the animal was over Golam. With the impact of the jump the boat moved and instead of bringing Golam's neck between the canines the animal could only put the front paws on his knee. Golam, out of sheer fright and nervousness, caught hold of the man-eater's broad head and shouted in a frenzy: " You rascal, get away; don't you know wherefrom you have come?" Almost simultaneously his other colleagues arrived; repeated shouting and beating with the sticks made the tiger retreat into the forest. Golam showed his scar which was still giving him trouble. He, however, proudly asserted that the man-eater had to depart as he had chanted mantras.

5. Men die; they lose their near and dear ones to the tigers, every time they go back home, they decide not to come out again; yet they come; in this saline tract, soft feelings and fear vanish; it makes a man ruthless, tough and teaches him to fight for survival.

(a) Block Gosaba-2. Time - 4 P.M. April, 1970.

Gajan Howley, a honey collector of Amtoli, had been on the job for 28 years. He had heard and seen many people die. He, like others, had accepted it all as inevitable.

This particular afternoon Gajan selected a creek for his collection as a swarm of honey bees was detected in the sky. Four of them got off the boat and proceeded deep into the forest in a row each hardly 20 meters from the next. Gajan was talking as he proceeded. After sometime he looked for his companions but none could be seen. He looked carefully again and found that a man-eater which had so long

concealed itself and seized Pratap Howley by the throat and was holding on till all signs of life vanished; while two others lay unconscious on the ground at the sight of the man-eater as it attacked Pratap. Intense love for his friend prevailed over fear and nervousness. Howley held a Goran stick in hand and chased the tiger as he shouted. At one stage Pratap's leg - he was dead by then - got entangled in a Goran bush and the tiger could not extricate it. Gajan caught hold of a leg. A tug of war began - the tiger pulling the body from the front and Gajan pulling one leg from behind. In the meantime two of his men regained consciousness and joined Gajan in beating the tiger with Goran sticks. In desperation the tiger finally left the dead body and vanished into the forest.

(b) Gosaba block-3 Time-4 P.M. April, 1963.

A party of honey-collectors had just returned to the boat with the lengthening of shadows when a swarm of low flying bees attracted Ananta Mandal's attention. He thought a few honey-combs must be located close and set out for the combs with two other collectors.

To ascertain the exact location Ananta climbed a tree. A comb was located and two of them proceeded towards it.

The area was bushy and almost impenetrable. As he climbed down Ananta saw a tiger crouching stealthily towards a companion of his from a very close distance. Fright paralysed him and he could neither shout nor move. He saw the animal twitching its tail and just about to leap on its prey. The unfortunate man hardly knew that his death warrant had been signed.

As the animal swiftly leaped high in the air, the victim had some premonition of danger and turned twice so that the tiger missed the target by inches - a bush having intercepted. The scene that followed for the next few seconds was unique for the Sundarbans. The tiger was trying to get a grip with his jaws while the three honey collectors were loudly beating the ground with branches and shouting lustily. This was perhaps a danger signal for the tiger and it vanished hurriedly.

On being interrogated, Mandal stated that they all were aware of the danger and the risk involved but these were inevitable. In his opinion this tiger was perhaps a young and inexperienced one.

To eke out a living, they have to trek such risky and difficult, mud deep terrain where venomous snakes, deadly crocodiles and

man-eaters are encountered frequently.

6. They are invisible, they appear to be supernatural, they approach with supreme stealth even in broad day light; they attack on the right side of the neck, piercing the jugular vein and the cerebellum

(a) Chamta Block. Time-9 A.M. November, 1970.

Maherali Mallick, 60, worked in a Golpatta coupe. He had terrifying experience of a life and death struggle of the permit holders for survival. In early '70 he had seen two of his men being taking away by man-eaters.

While seven of his men were engaged in working the coupe, two were specially employed as watchers to guard the two vulnerable flanks. It was about 9 A.M., work having started at 8 A.M., when some of the men noticed that one of the watchers was missing. A search revealed the fresh pugmarks of a tiger and a few fresh drops of blood.

A search-party was arranged with a 'Priest' leading it. They had trekked about 5 kilometers tracking the blood drops and the body was found in a Hental (Phoenix) bush. On the 'Priest' lay the responsibility of recovering the dead body. On careful search it was found that the tiger was not in the vicinity.

As the priest went close to the dead body, the man-eater roared savagely and pounded on him from the right and, in full view of the other men, carried him away as if to mock at the efficacy of mantras.

It was a pitiable story of the death of two hapless men.

(b) Chamta Block. Time-7.P.M. May, 1969.

Another honey collector, Nagar Ali of Katakhali, considers the tiger a coward. He said they act like thieves, coming stealthily and attacking from behind.

He cites the incident when he and his team mates were on a boat anchored in Chamta river. It was dark; food was being cooked and everyone was relaxing, some were singing and some were engaged in conversation. Malek Molla was seated in a corner and was not participating in any discussion.

They all became alert as a sound came of something heavy splashing in the water. Where was Molla ? It certainly seemed that

he had vanished. Torches were flashed all round and the faint figure of the man-eater with 'Molla' clamped between its canines, was spotted on the far bank.

Molla's half-eaten body could be recovered only the following day. The Sundarban man-eater eats the soft stomach first when breaking its fast.

Nagar Ali also recalls that another worker was killed in the same compartment the previous year under similar circumstances.

(c) Chamta Block - 5 Time - 8 A.M. February 16, 1970.

Provash Baul, Forest Ranger, was in-charge of a timber coupe near which hundreds of boats, big and small were anchored.

It was a bright, sunny morning in winter, and Baul requested Sunil Mandal (40), a permit holder, to accompany him in his boat. Mandal begged to be excused on grounds of sickness.

Sunil had in his mind a different plan to fish in Khal (channel) as it was ebbtide and the water had receded. Immediately after Baul had left, Sunil took a fishing net and started casting it not far from the anchored boats.

A sudden thud was heard and a tiger vanished with Sunil just like a cat holding a fish.

There was no indication of a tiger so close to the anchored boats where hundreds of workers were camping. Places to hide are very scarce in a working timber coupe. Yet it was there that a life was lost when Sunil vanished for ever as if an invisible force had dragged him away.

(d) Chota Chamta Khola-Time-4 P.M. September, 1966.

Basanta Reften (40), of Hinglegunj was a worker in a golpatta coupe and had come face to face with two charging tigers. He survived both the charges but went down for several months thereafter with a high fever.

On the second occasion, six of his colleagues were engaged in cutting leaves. One was posted to guard against any probable attack from crocodiles or tigers. Yet stealing through the shadows a tiger came slinking in and took away Bimal Raften (40) from one corner and the others never knew about it for a full ten minutes. The fact was verified from the pugmarks and blood drops.

All the workers were determined to recover the dead body and were following the blood trail and the spoors. After trekking for

about half a kilometre inside the forests, they disturbed the tiger as it was eating the dead. The animal displayed unmistakable signs of dissatisfaction and anger as it snarled and growled. Sibu Mandal, one of the men, dropped down unconscious in sheet fright. Once he regained consciousness, he started shouting "Tiger", "Tiger", "Tiger". Sibu could only be carried to the boat after the tiger had moved away from the kill. He ran high temperature for months with regular fits of nervousness and he kept shouting 'Tiger', 'Tiger; in his delirium.

7. Baulies, or priests, must accompany each party of permit holders; blessings are invoked from 'Tiger God,' Banbibi or Narayani Ma; the permit holders have immense faith in such priests as they volunteer to enter the forest first in the belief that they are capable either of immobilising the tigers or of mesmerizing them into obeying their orders. Many priests are killed in the process.

(a) Jhilla Block-3. Time-7 A.M. February, 1957.

It was a Golpatta coupe and Anil Mridha and others had a priest in their party.

Soon after setting foot on the land, the priest put both of his hands on the root of a Goran bush and chanted mantras for several minutes. Then he moved in a circle with a cutting implement for sometime muttering all the while.

Thereafter the party started cutting the golpatta leaves within an area demarcated by the priest who specifically kept the adjoining ground out of bounds for the workers.

But curiosity led Anil Mridha to approach close to the boundary. As soon as he removed a few leaves, he found a tiger lying mesmerized. Mridha was mortally afraid and ran for his life shouting 'Tiger, Tiger'. The priest came forward and expressed his disapproval at the discovery. Fortunately no accident occured in the coupe as the tiger quietly moved away.

(b) Lahiripur Village - (Jote land)

Dhirendra Mandal described how some tigers cross over to the villages in search of cattle and dogs; and was emphatic that man-eaters do not enter any village. In this respect the man-eaters of Sundarban differ from the man-eaters elsewhere in India. It is through causing annoyance or irritation that people sometimes get mauled or

killed by tigers.

Mandal relates an incident. A big crowd had assembled as news reached Lahiripur village that a gunin (priest) had mesmerized a tiger in a plantation of tall grass. A few shikaris also came with their firearms but could not do anything as they could not take up any convenient position for shooting. An artificial camouflage was erected and the shikaris positioned themselves inside. The priest permitted them to shoot the tiger on condition that substantial offering would be made to the Tiger-God of the Sundarbans.

The Shikaris shot at the tiger, but the tiger reacted by jumping at them although it missed its target. The wounded tiger finally hid inside a small bush across a channel. Once again the shikaris chased it and the tiger returned to the plantation.

The priest wanted to mesmerize it once again but locals disapproved of his doing so as the tiger was wounded.

The priest, however, said that he would make it easy for the shikaris to shoot by removing the tall grass. His efforts only made the tiger jump on him. He was caught by the neck and died on the spot. Subsequently, the wounded tiger was shot and killed.

8. They select their prey; age may be a factor; the middle-age group suffers greater casualities than the young and old.

(a) Malta Block-2. Time-8.30 A.M. May, 1968.

Nibaran Mandal (45), of Chotomollakhali was a professional honey-collector and had seen his friends being taken away by man-eaters in various situations. One such fantastic incident he has narrated.

It occurred near the banks of Havila-Duania river on a bright, sunny morning. Ten honey-collectors clambered down to the bank, stood in a line facing the morning sun and the **bauli** commenced chanting mantras. The surface of the meandering river was crystal clear and calm and smooth as a sheet of glass. The mantras were chanted and the Tiger-God was being invoked.

Suddenly a mild thud broke the silence and Deben Mandal standing in the middle, was seen in the jaws of a man-eater; the sight was akin to a fish in a cat's mouth and he was being taken towards the jungle. Nibaran was next to Deben but due to shock he did not realise what had happened. Four of the collectors however fell down unconscious at the sight. Nibaran quickly arranged a search-party

and followed the pugmarks and the trail of fresh blood. They recovered the half-eaten body of Deben after taking grave risks. The stomach was found to be completely consumed.

None could solve the mystery of the man-eater's sudden appearance eluding so many watchful eyes.

A strange fact, confirmed by many witnesses, is that the human body, with less of life, contracts to about half its size enabling the man-eater to carry it away with ease.

9. Analysis and conclusion

The problems involving socio-economic, scientific and administrative aspects of man in relation to tiger of the Sundarbans are specific and unique and attempts to solve them will require considerable time and intensive attention.

The stories describe the miseries, worries and anxieties of the permit-holders who have to encounter man-eaters frequently without any protection, except the blessings of the 'Tiger God' and mantras chanted by the priests accompanying them. They die under helpless and pathetic circumstances.

The eye-witness accounts, on analysis, reveal the following features of the tigers of Sundarbans which merit further scientific studies :

(i) Exceptional strength (ii) high capacity for manoeuvring itself (iii) great power and prowess in swimming (iv) diabolical understanding of human psychology (v) favourite hours of attacking human prey (vi) migratory behaviour (vii) aggression during full moon and new moon (viii) adaptation to drinking saline water (ix) consumption of wide variety of food (subject of research) (x) preference for middle aged men for prey (xi) apparent cowardice (xii) influence of saline water on its physiological and psychological processes (a subject of research) (xiii) influence of saline water on liver and kidney (a subject of research)

Curiously, the permitholders' firm conviction is that the tigers recognize the boats of forest personnel as the latter carry firearms. This is why the tigers elude them, while the permit-holders come across so many. They seem to be convinced that many tigers were shot, and trap guns laid during British rule. Since the fifties few tigers have been killed. Now pugmarks are visible almost everywhere and incidence of death and injury has risen sharply and is actually quite in excess of official reports.

The tigers are no less powerful in water; they have developed their own techniques to keep the entire body submerged except for the nostrils and are able to board dinghis and boats with ease.

The locals have a firm conviction that death is an inevitable phenomenon and occurs as decreed by the Tiger-God and there is nothing one can do about it; they have reconciled themselves to a co-existence with maneaters; as such a supernatural creature cannot be exterminated. This leads to the worship of "**Kalukhan**" for protection against the crocodile and the worship of "**Manasa**" for protection against the reptile. Permit-holders of all religions, irrespective of their social position, caste and creed, sit together and pray. This is the philosophy of man's relationship with the Sundarbans tigers.

TIGERS (PANTHERA TIGRIS TIGRIS)

Observation made in 1970-72

The Sundarbans tiger stands supreme in the tiger map of the World. It is believed that they are hereditary man-eaters, fiercest, most cunning and intelligent of all tigers. The present observations include their habitat types, vulnerable operational zones, comparative casualty pattern among different professional men, casualty in various age groups of men, monthly and yearly pattern of casualty, breeding potential, food habits and other aspects of their behaviour. Such studies have never been made in the estuarine tract in the present manner and it is expected that this study will enable to throw light, on many facts so far unknown about the tigers of the tract.

The Javan rhinoceros (**Rhinoceros sondaicus Desmarest**), swamp deer and wild buffaloes which were once a feature of the Sundarbans no longer exist in the area. However, reptiles, sharks, peculier fish, wild boar, spotted deer, monkeys and Chough and mysterious tigers abound in the area. It is a curious anomalous tract where fish (**Periopthalmus and Boleopthalmus**) creep up the tree, tides in the same creek run in the opposite directions, molluscs and crustacea are in abundance and the high tides occur twice a day. The tigers operate in such a peculiar saline terrain and their behaviour and adaptations being unique and unparallel as elsewhere have made them a subject of study and research.

OBJECTS AND METHODS OF STUDY

Observations have been made on the tigers (i) habitat and their principal formations, (ii) behaviour pattern, (iii) casualty pattern, (iv) breeding potential and sex ratio and (v) population etc.

The methods followed have been on (i) the measurement of innumerable pugmarks and their analysis, (ii) collected records on human casualties, time of kill, methods of kill, seasons of kill, age and profession of the persons killed and their analysis, (iii) reply of interrogation made to thousands of forest workers and their analysis and (iv) the analysis of kill observed at various places of human beings and other animals.

HABITAT TYPES

(a) Plant community

The vegetation is of a poor quality, and almost impenetrable. Water-logging, humidity, salinity and regular inundations are the salient features of the habitat. **Heritiera** and **Phoenix** formations are high level forests which are either not regularly inundated or inundated for a short period and, therefore, form an ideal tiger habitat. The forersts on the sandy and sandy loam soil in the sea shore form a special type of habitat over a very small area.

The principal forest formations have been based on the tide-level and have been shown in a tabular form in which the density of stock, principal forest formations and the tiger habitat have been enumerated in detail in chapter III

Further features on the tiger habitat are as follows :

There is complete absence of ground flora to afford cover and shelter to the tigers. Humus is completely absent, the leaves and branches that fall to the ground are washed away in high tide leaving no chance to form soft cushion; there is no thick crowned bush or branchy trees to afford shade and shelter. **Ceriops** and **Aeigialitis** plants afford side shade, and the tunnels in **Phoenix** bushes afford them best shade and shelter. In extreme high tide when the **Phoenix** areas go under water, the tigers have to lead an amphibious life. They have to be constantly on the move and cover wide areas even swimming across wide rivers. High and low tide constantly change the physical environment and the force of the current affects the muscle formation; the saline water form the chemical environment and tiger has to adapt to drinking saline water (although they do prefer sweet water as evident from the pugmarks found near water

holes dug artificially in the beach forests) and the area is swept over by severe storm along with high current and wild animals have to cling to forest floor hard for survival.

(b) Animal Community

The animal community makes the environment exceedingly complex. Some are directly associated with the tigers and some indirectly. The spotted deer which are found in abundance in large herds form the principal food and the pigs come next. Non-scheduled foodstuff is formed by crabs, monitor lizards, fish, monkeys and even birds. The association of the tiger with the land and water animals cannot be overlooked. In extreme high tides almost entire land areas go under water and the aquatic animals especially the sharks, crocodiles, water lizards and porpoises etc. come very near the tiger which is compelled to lead an amphibious life. There are several species of crabs, snails, marine borers, a species of bee (**Apis dorsata**) and birds that form the animate environment of the tigers and they are directly or indirectly associated with these animal.

STATEMENT NO 1
CASUALTY PATTERN AMONGST THE DIFFERENT PROFESSIONS OF FOREST WORKERS

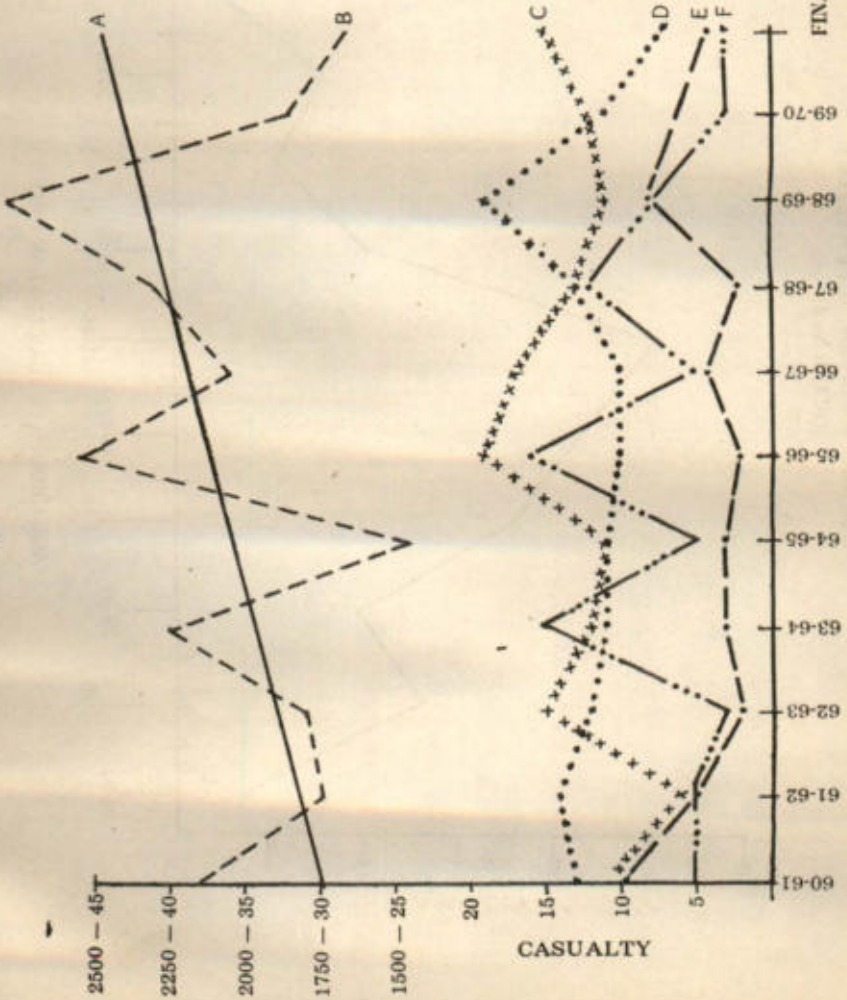
The statement placed below will testify to the pattern of human casualty among various professional man.

Profession	No. of workers per year	Persons killed in a year	% of total kill	No of persons killed for every 4,500 workers per year	% casualty due to tiger	Expected	% Age class of people
1	2	3.	4.	5.	6.	7.	8.
1. Coupe Workers	4,580	6	16.6	6	12.50	25.00	Old age class is maximum
2. Fishermen	24,900	12	33.3	3	6.25	25.00	among the Fishermen
3. Honey Collectors	1,350	7	19.4	28	58.30	25.00	Young age classis maximum honey
4. Golpatta Hental Collectors	4,500	11	30.7	11	22.95	25.00	among collectors.
Total a year	35,330	36	100%	48	100.00		

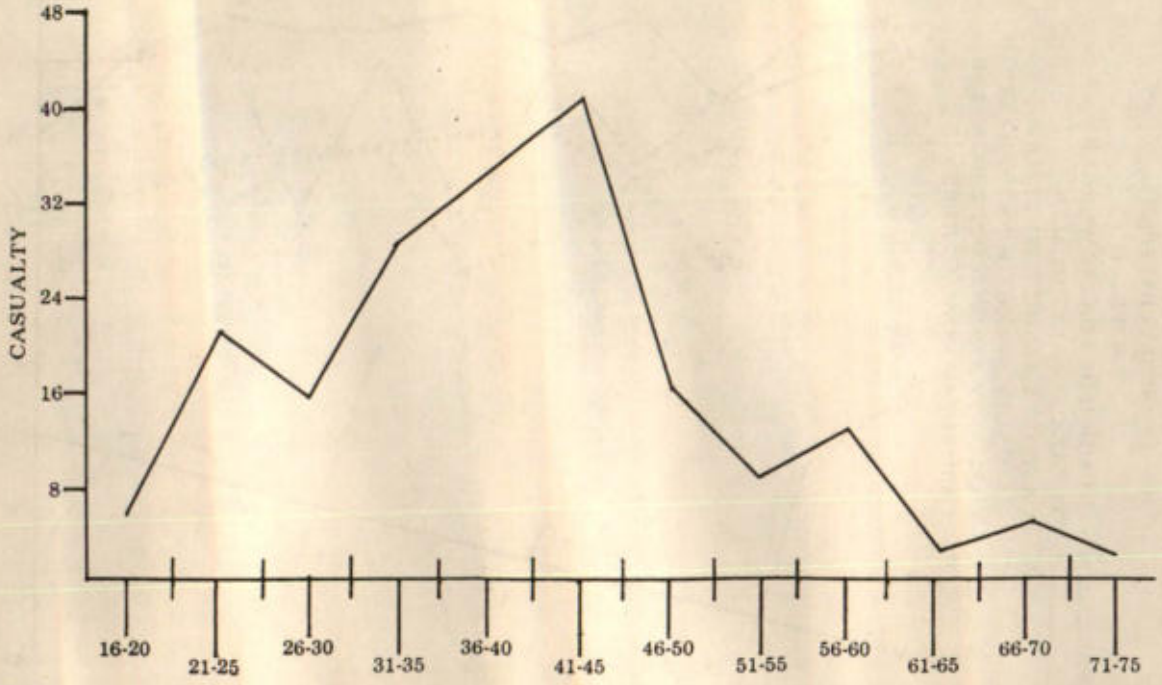
To test whether there was any significant difference in casualty amongst the various Professional persons. Test (chi-square) was applied. 2 was highly significant. A very high degree of significant difference was indicated. The casualty of honey collectors was significantly more than other.

PERMIT HOLDERS OF DIFFERENT PROFESSION AND CASUALTY PATTERN
(GRAPH – 1)

SYMBOL ____ A — NUMBER OF FOREST WORKERS
" _____B — TOTAL CASUALTY OF MEN
" xxxxxC — CASUALTY AMONG FISHERMAN
" ..... D — CASUALTY AMONG HONEY COLLECTOR
" _._._ E — CASUALTY AMONG COUPE WORKERS
" _.._.. F — CASUALTY AMONG OTHERS



AGE GROUP AND CASUALTY PATTERN
(GRAPH No 2)



Casualty Pattern.

(i) Graph - I. Casualty pattern among permit holders. This is a composite graph showing.

(a) The gradual (10 years' figure) increase in the number of workers in the forests.
(b) The casualty pattern among total workers going to the forests.
(c) The casualty pattern among the fishermen.
(d) The casualty pattern among the honey collectors.
(e) The casualty pattern among the timber coupe workers.
(f) The casualty pattern among the other professional men.

Comments :

There is gradual increase in the number of workers in the forest (see line A). The trend of casualty, however, shows fluctuation, though overall trend is upwards (see line B). Casualty figures among all other professional men individually very often fluctuate; the trend of increase in number of men among different professions, however, remained almost similar. The Statement No. 1 gives a detailed analysis of the pattern.

(ii) Graph 2-Age group and casualty pattern.

The total numbers of persons killed during the period of ten years were grouped into 4-year age classes and tabulated against the persons killed. Table 2 shows the detail of the casualty.

Table showing the number of workers of individual age groups and the number of casualty due to man-eaters in corresponding age groups.

TABLE No. 2

Age groups	No. of casualty due to tiger	No. of workers in forests of Sundarbans	% of the casualty of of workers	% of workers in the forests of Sundarbans.
1.	2.	3.	4.	5.
16-20	3	1050	4.2%	1.4%
21-25	10	2560	10.8%	3.1%
26-30	7	5799	8.2%	7.2%
31-35	14	7843	13.8%	9.8%
36-40	17	6778	18.2%	8.5%

41-45	18	9000	18.8%	11.1%
46-60	8	13462	8.7%	16.6%
51-55	4	13000	5.3%	16.2%
56-60	6	14000	6.8%	17.3%
61-65	1	5100	1.2%	6.3%
66-70	2	1160	2.7%	1.4%
71-75	1	908	1.3%	1.1%
	91	80660	100%	100%

Comments :

The table shows that maximum casualty is among the age group 36 to 45 which means that the middle aged healthy people are mostly the victims of the man-eaters. This also justifies the age old belief and observation that the man-eaters select the strongest among men. To support this, an analysis of the people of different profession and their age class (average of 10 years) and the casualty pattern amongst the different age groups of forest workers are given in Table 1 and 2 respectively.

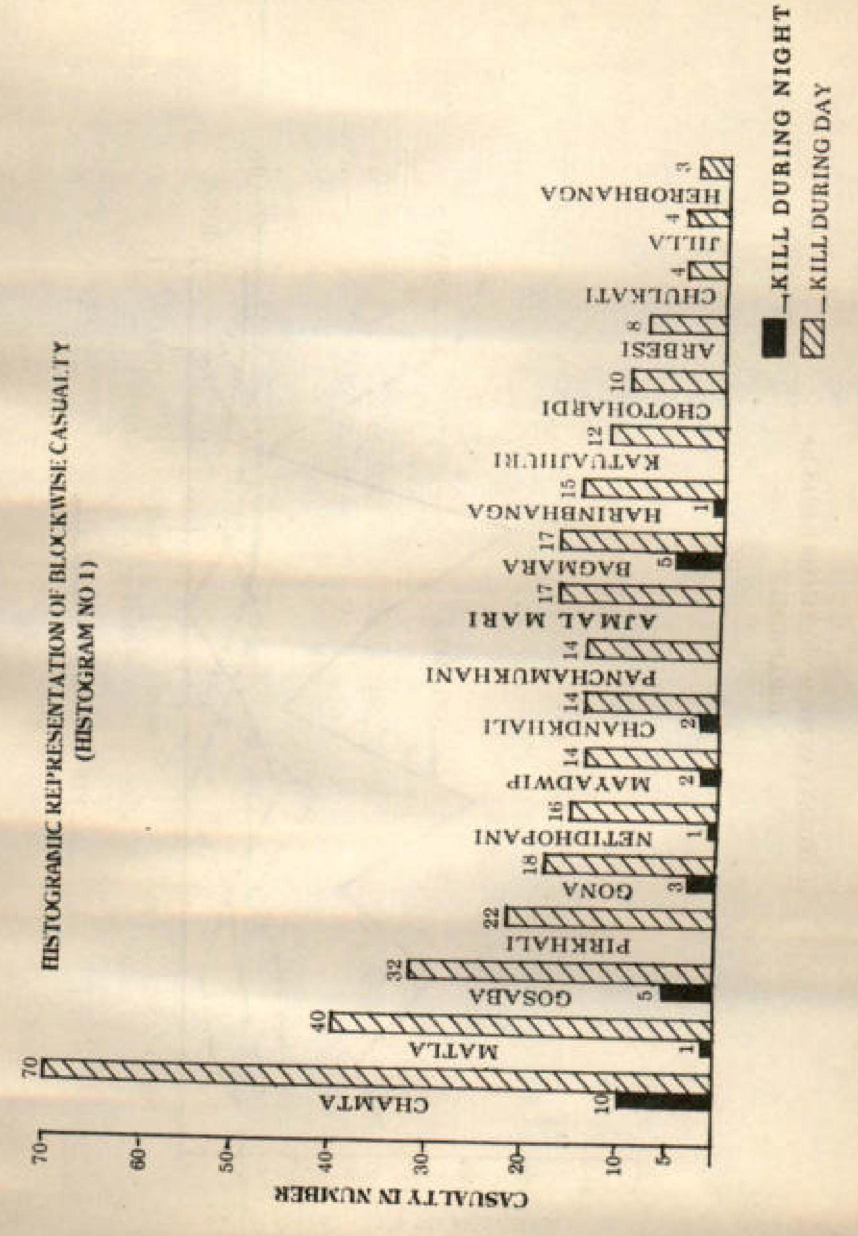
Of 35,330 persons, the age of about 25,000 or two-third fisherman varies from 40 to 69; Balance 1/3 belong either to the younger or old age group or both. It is, therefore, seen that most of the workers belong to older age group, but the maximum casualty is among the middle age group.

(iii)Graph 3. Blockwise Casualty Pattern in four most Vulnerable Blocks.

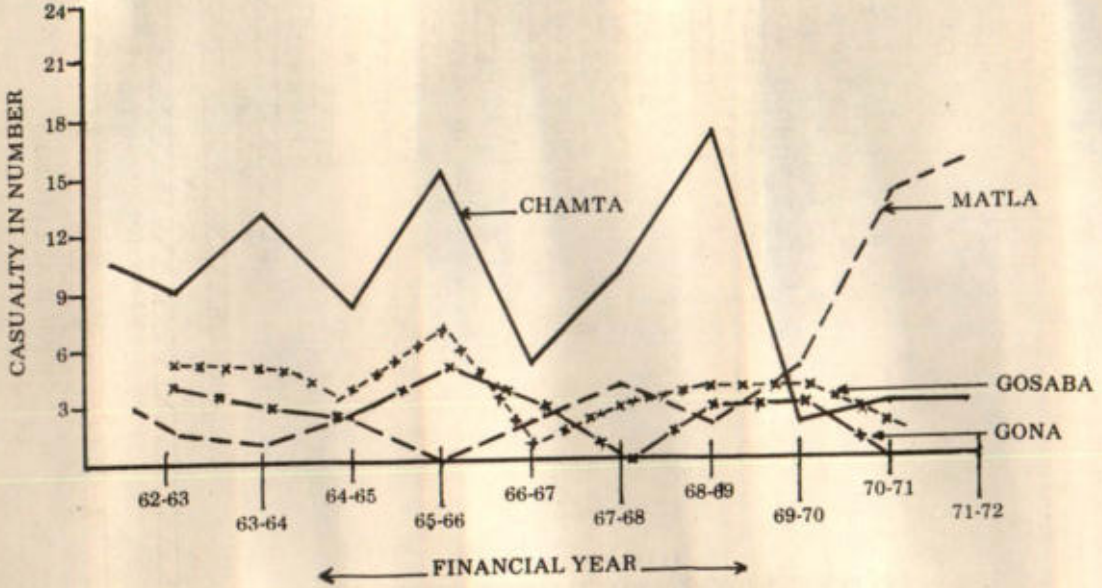
The graphs show the pattern of casualty in Chamta, Matla, Gosaba and Gona which are four vulnerable blocks. Chamta shows regular fluctuations of human death but abounds with maximum number of tiger; the area flanked by Chota & Bara Chamta was considered as the worst area in the past. The areas near Surjamukhi & Gobdikhals near Matla 1 & 3 respectively have been the worst depredation zones during 1970 and 71. This shows a decreasing trend in Chamta and increasing trend in Matla and indicates a migratory tendency of the tigers from block to block.

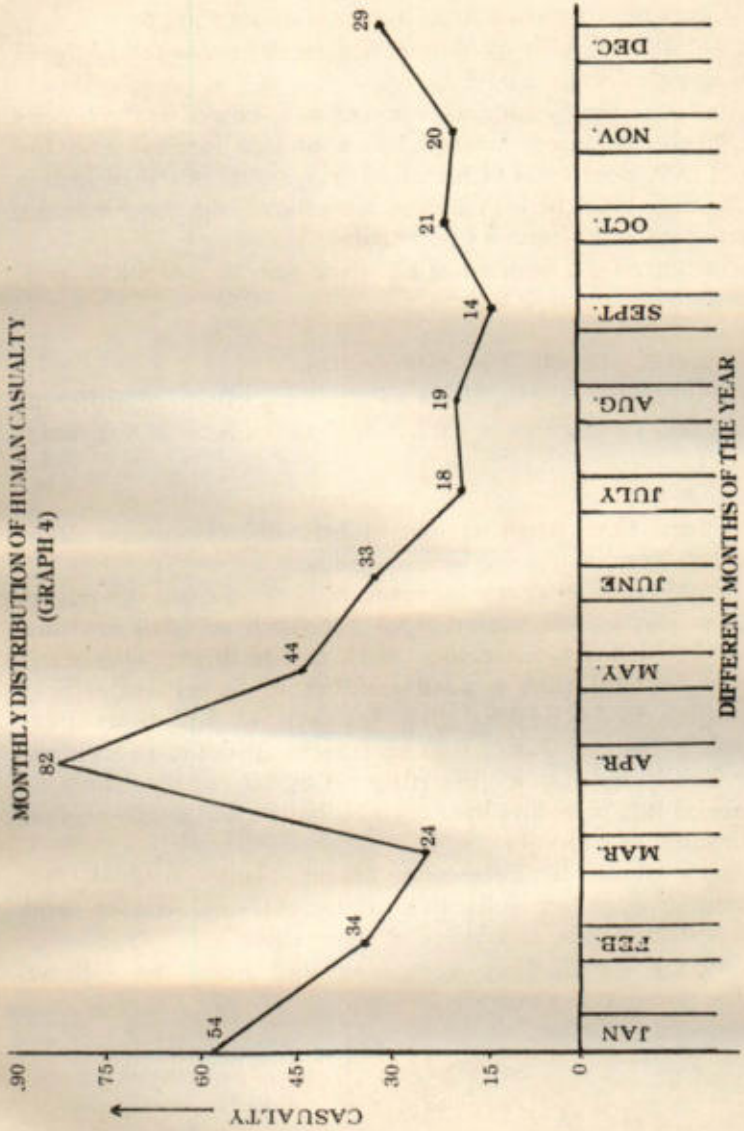
Comments on Histogram No. 1

(a) The ferocity, cunningness, intelligence and understanding of the human nature.


HISTOGRAPHIC REPRESENTATION OF BLOCKWISE CASUALTY
(HISTOGRAM NO 1)
CASUALTY IN NUMBER
70
60
50
40
30
20
10
5
CHAMTA
10
70
MATLA
1
40
GOSABA
5
32
PIRKHALI
22
GONA
3
18
NETIDHOPANI
1
16
MAYADWIP
2
14
CHANDKHALI
2
14
PANCHAMUKHANI
14
AJMAL MARI
17
BAGMARA
5
17
HARINBHANGA
1
15
KATUAJHURI
12
CHOTOHARDI
10
ARBESI
8
CHULKATI
4
JHILLA
4
HEROBHANGA
3
KILL DURING NIGHT
KILL DURING DAY

CASUALTY IN FOUR VULNERABLE BLOCKS
(GRAPH 3)




MONTHLY DISTRIBUTION OF HUMAN CASUALTY
(GRAPH 4)
CASUALTY
90
75
60
45
30
15
0
54
34
24
82
44
33
18
19
14
21
20
29
JAN.
FEB.
MAR.
APR.
MAY.
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
DIFFERENT MONTHS OF THE YEAR

(b) That man-eaters of these eight blocks are hereditary, and their number could be 20-25.

(c) The tigers have receded from the Namkhana Range.

(d) The number of kills in Arbesi indicates movement of tigers from Bangla Desh.

There has been heavy concentration of man-eaters in the blocks of Bangla Desh adjoining eastern block of our forests, and the indication is that poor type of forest as in eastern block of Indian union and Western block of Bangladesh have maximum concentration of man-eaters (casualty figures justify this).

(e) Fluctuation in the number of kill each year in a block record constant movement of tigers.

(iv)Graph 4. - Month wise distribution.

The graph shows the number of persons killed in different months of a year. The figures in each month is the total of ten years.

Comments :

(a) It is seen that April is the month of maximum tiger casualty. Next comes the month January.

(b) The number of workers increase slightly during the winter months. During the period from 1st April to 15th of June, about 1400 honey collectors work in the forest. Obviously it may be said that a good number of honey collectors get killed in April; Why then January should come next instead of May or June? It is extremely difficult to explain this. Can it be due to infertility of either of the male or female leading to some physiological change and augmentation of ferocity in January.

(c) Declining trend in February, March, July, August and September, perhaps, indicates that extreme winter and rains inhibits the activities of the tiger.

(d) Kill during April, May and June had been as follows (during honey collection):

Year	No. of persons killed	No. of persons that worked for honey.
1965-66	16	1,120
1966-67	17	1,225

1967-68	17	1,310
1968-69	17	1,400
1969-70	11	1,320
1970-71	16	1,530
1971-72	16	1,400

Striking uniformity in the number of persons killed for seven consecutive years indicates that the number of man-eaters is small and static. Considering the kills which are scattered over wide area. The number of man-eaters may be 10-17 as evident from the distribution of kill.

Statistical analysis shows that it is very much improvable that in any particular year the number of casualty during April, May and June will go beyond 30 or come down below 5. The distribution of casualty with 97.50% confidence interval is 30 as upper limit and 5 as the lower limit.

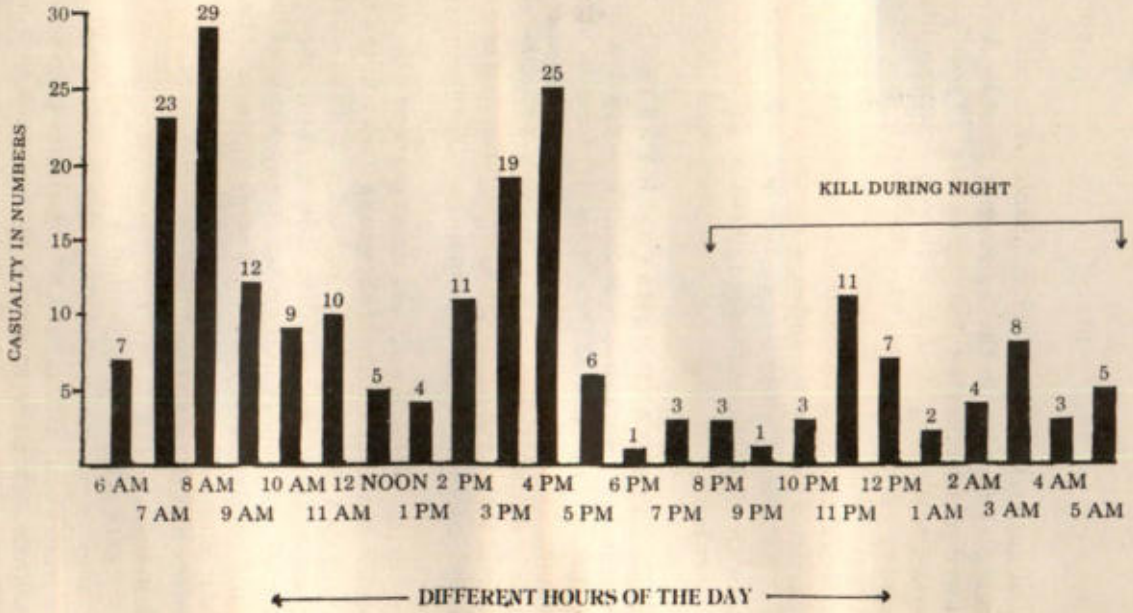
FOOD AND BEHAVIOUR PATTERN

Inhospitable habitat has reduced the tigers to a short and stout legged animal. The coastal (beach forest) form is bigger but with fader colour. 12% of the human casualty during the night makes them mainly diurnal animal. Those tigers are ferocious agile, strong and cunning, they have a diabolical understanding of human nature. They avoid encroachment to human habitation, though sometime they do.

They drink saline water, eat deer, pig and also crabs and fish etc. Opinion however differs if they take honey in the honey season (April-June) but they have been sighted to pounce upon combs and bolting away from the vicinity. Entire skull bone is eaten up including all portions of human bones and horns of deer have also been found partly eaten. Feather of some birds have been recovered from their stomach. The tigers visit the sanctuary frequently for eating birds and the water and land monitors in the breeding season of birds in the Sajnakhali Sanctuary.

The tigers attack from behind with a deep bite on the right jugular vein of the neck and drag the human bodies to various distance from about 200 metres or sometimes even to 1 to 2/3 kilometres. While dying the human body contracts to a much smaller size facilitating the drag. The bulk food, however, is obtained from spotted deer and pigs. Instances are there when one tiger killed 2/3 persons on the same spot. Stomach is eaten first and then the rest of

TIME AND CASUALTY PATTERN
(GRAPH NO 5)



the body. Out of the total kill, only in 28.5% of the cases the dead body could be recovered. The shows the ferocity of the man-eaters and their determination to devour the human body.

Other special features of the tigers (based on innumerable permit holder encounter with the tiger) are as follows :

(i) Tigers are rarely sighted though the (ii) pugs marks are found every where in the forests. Maximum incidence of pug marks are found in **Mechua** and **Chaimari areas** of beach forests (iii) they prefer sweet water as evident from the pugmarks near the water holes which the permit holders dig on the sand. (iv) they devour the entire body within few hours of attack.

Other notable information and behaviour of the tiger are as follows:

(i) Maximum incidence of pugmarks are found in Mechua and Chaimari (in the beach forests) and more in the vicinity of sweet water holes dug in the same area (ii) they devour the entire human body in couple of hours after kill (iii) irrespective of the force of current they swim straight across a river at right angles to the current (iv) they can manoeuvre their body on water surface in such a way that when a tiger mounts a boat neither slight jerk is felt nor water is disturbed. (v) the helthiest person is a victim invariably (vi) attacking tigers secrete immense quantity of saliva from its mouth (vii) they could never be captured in a cage (viii) dead bodies buried on the forest floor have been found to be unearthed and eaten away. (ix) human casualty is neither related to the density of persons working in the forests nor on the density of deer population (x) maximum number of human casualty is in Chamta, Matla and Gosaba blocks suggests that the tigers in this central zone of the forests of western Sundarbans are most dangerous; salinity increase gradually from east to west, and it is likely that salinity induces some physiological changes in the body; but concentrated zone of operation cannot be explained adequately.

Based on all these facts the behaviour of the Sundarbans tiger has been classified in a pattern as detailed in the Chart I.

(iv) Graph 5, Time and Casualty pattern

The graph represents hourly pattern of casualty in a day (10 years average)

Comments :

It is seen that maximum activity of the tigers is in the afternoon (3 p.m) and in the morning (8 a.m.). This may be owing to the fact that the tigers have a diabolical understanding of human nature. The workers that set out for work in the morning get killed immediately after they enter the forest; the man-eaters, perhaps, anticipate the prey and strike at an unguarded moment. Similarly, in the afternoon when the workers return to their boats, the man-eaters sieze the opportunity of the unguarded or careless moment of the workers which invariably happens during the return journey.

Casualty at night :

A number of people are killed at night in their boats. It is seen that maximum incidence of kill centres round 11 p.m. The man-eaters pick up their prey from their boats. The workers go to sleep in early hours of the night and are in deep sleep around 11 p.m. and the tigers seize the opportunity of this helpless state of men. It is only when the man-eaters jump out of the boat with the kill that the other inmates know what has happened. The boats do not tilt when the mighty 300 pounder jumps into the boat (reason described later). Such kills cannot be recovered.

ASSESSMENT OF POPULATION

Record of kills during the past ten years from 1961 to 1970 show the blockwise distribution as follows :

Chamta	—	80	Netidhopani	—	17
Matla	—	41	Ajmalmari	—	17
Gosaba	—	37	Mayadwip	—	16
Pirkhali	—	22	Chandkhali	—	16
Bagmara	—	22	Panchamukhani	—	14
Gona	—	21	Arbesi	—	8
Chulkati	—	4	Harinbhanga	—	16
Jhilla	—	4	Katuajhuri	—	12
Herobhanga	—	3	Chotahardi	—	10

Total :- 360

This shows that the annual number of kills 36. Non official circles, however, put the figure at three times the official figure. This is owing to many unauthorised intruders getting killed which are either not recorded or reported to the police. This cannot be accepted

as there is no evidence of such intruders. Pugmarks have been sighted all over the blocks by the honey collectors and others. More than 500 pugmarks have been measured all over the forests and the sizes reveal that (i) most of the tigers are middle to old aged, the diameter of pugmarks varies from 11 cm. to 16 cm. (ii) the proportion male to female is 1:3 and (iii) the young age class is conspicuously absent.

The above 36 kills are distributed over about 10-15 blocks in a year showing the presence of at least one man-eater in each block. All the tigers in block are not man-eaters (this has been verified from reports and observation) but the pugmarks of different sizes show the presence of 3/4 tigers in a block as verified only from the examination of pugmarks in the fringes of the forests. This brings the population to 60 which can be taken confidently as the minimum number. Further, it so happens in a few blocks that several persons are killed in such block within a short time, sometimes simultaneously or on successive days; this reveals the presence of several man-eaters in a block one or two very notorious man-eaters. Tigers have been sighted crossing over to the adjoining villages, also several harmless tigers have been sighted in the blocks of working coupes. These reveal that (i) the presence of atleast 6 to 7 tigers in a block (ii) all the tigers are not man-eaters (iii) old age and physical disability do not lead the tigers to become man-eaters. Had all the tigers been man-eaters there would have been many more casualties. There are some tigers which chase human being, sometime injures them put do not kill them; this type of tiger together with the aggressive man-eaters described earlier in this paragraph constitute about 20-25 numbers or one fifth of the total tigers. The number of the tigers, therefore, can be assessed at 112 (18 block × 6 tigers in each block or 108 or 23 man-eaters × 5 or 115).

Another fact is clear that the concentration of kill is more on the block, lying in central position viz. the blocks Chamta, Gosaba and Matla. There is plenty of deer in this region and irrespective of the number of human beings working in the area the casualty is maximum.

FOOD AND ASSESSMENT OF TIGER AND DEER POPULATION

Accepting the tiger population at 112, the annual requirement of meat should be 112 × 365 × 10 kg. (daily requirement per head

is 10 kg.) or 4,08,800 kg. Most of this meat is from the dominant mammal species i.e., the spotted deer, the wild boar being the next dominant species. Taking the average weight of a deer killed at 60 kg. the number of deer required annually is 4,08,800/60 kg. or 6,813 numbers; more correct figure for deer should be 5,000 Nos. the balance 1,813 Nos. being the meat of wildboar. But the Sundarbans tiger take to other types of food like monkeys, monitor lizards, crabs, fish, crocodile and birds. It is also very well within the observers limit of count to justify that annually atleast 6,000 calves survive out of many more born of the deer population to keep the population at steady level; observation and hoof mark count also justifies the presence of about 6,000 hind and half the number of stag. The spotted deer population in the 22 blocks, where the tigers operated in the past 20 years may therefore be assessed at about 10,000 or 4 to 5 deer per sq.Km. Hoof marks of deer are sighted all over the forests throughout 700 square miles of forests. This number therefore justifies the tiger population as 112.

COMPARATIVE SITUATION IN WEST BENGAL AND BANGLADESH

From the available information it is gathered that 16 persons are killed annually by the tigers in Bangladesh where the total number of tigers has been assessed at 100. In West Bengal according to the same proportion there should be 225 tigers. This has to be established as there is no physical evidence or any proof from casualties or tigers sighted. One point supports this number when it is accepted that all tigers are not man-eaters.

Mr. Guy Montfort in his book "The Vanishing Jungle" assesses the tiger population of Bangladesh Sundarbans to about 50 to 100 and refutes the forest officers' figure of 300. He records 82 deaths in Bangladesh Sundarbans during 1963 to 1967; The figure in West Bengal Sundarbans during this corresponding period is 188. Another point is worth noting. While 20 tigers have been shot in the foreign territory of the Sundarbans during this period, 2 have been shot in West Bengal Sundarbans (12 shot in 10 years).

Old records show the following casualties in the undivided Sundarbans.

Year	Man killed by man-eater	Man-eater shot dead	Remarks.
1881-82	161	3	Column 3 shows

Photo 3 A Sunderban tiger with its prey a pig (in Hardi block)

1883-84	168	8	tiger killed
1907-08	120	9	mostly in the
1911-12	112	61	portion now in
1914-15	79	86	Bangladesh.

This shows that the casualty figure has not come down very much since 1914-15 in the undivided Sundarbans, but much less tigers have been shot, especially in the western portion.

It is reported that 16 persons are killed in a year in Bangladesh when the total number of tiger has been assessed 100 as the minimum; in the same proportion the tiger population should be 226 (36 kill a year) in West Bengal. This is not so, as otherwise there would have been more kills and more tigers would have been sighted. If the number be as large as 226, then the obvious conclusion would be as follows :

(a) There are few hereditary man-eaters.
(b) Many tigers avoid men,
(c) Many tigers attack men when their operation areas are encroached upon,

and

(d) Tigers are habitually wanderers as the casualty in a parti cular area is fluctuating.

BREEDING POTENTIAL AND SEX RATIO

The peculiar nature of the terrain makes it impossible to follow any standard method of population count. It is, therefore, extremely difficult to measure the sex ratio and breeding potential in the Sundarbans.

Interrogation of about 3500 persons many of whom have spent more than 20 years in the forests have registered to have sighted only a few cubs so far. Out of 450 pugmarks only in 2% of the cases, pugmarks of tiger cubs have been sighted which lead to the conclusion about

(i) declining trend in fertility or
(ii) wide interval of fertility cycle, or
(iii) death or destruction of young cubs, or
(iv) low female population ratio of male to female as evident from the pugmarks is 3:1

The above situation depicts a gloomy picture about the future of the tigers in Sundarbans; only few tigers are shot every year but even then number is not increasing fast. The identification of the sex from

BEHAVIOUR PATTERN OF THE SUNDARBANS TIGER
ALL HAVE INHERENT TENDENCY AND POTENTIALITY OF MAN-EATERS)

Inherent and designed man-eater (Kills man at sight or hunt men out) 25% of tiger population		Undersigned man-eater (Kills men when they encroach upon their den) 15% of tiger population. Mostly the honey collector or dry firewood collector. Dead body rarely recoverable	Circumstancial maneater (Chance given, it avoids unless hungry, injury or old age is not considered circumstantial) 60% of tiger population.
Aggressive man-eater (80%)	Lusty and adventurous man-eater. 20%		
Most daring and cunning (10%)(Noctural & swimmer to boat. Casualty a certainty). Deadbody not recoverable. All categories of permit holders.	Ferocious (90%) (Charges directly at sight). Casualty a certainty. Hental and honey collectors are victims mainly. Deadbody partially recoverable.	(Stalks men, follows Deadbody along creeks and rivers) Fishermen are mostly victims. Deadbody rarely recoverable.	Encroaches habitation for cattle, do not kill (10%) In forest habitat; not aggressive. (Generally kills men when extremely hungry and other natural animal food is not readily at hand). (90%) Timber Coupe workers, Honey collector etc. Deadbody partially recoverable. recoverable.
Responsible for 70% of human casualty.		Responsible for 20% of human casualty.	Responsible for 10% of human casualty.

N.B. Only 28.5% of the dead is recoverable.

the pugmark does not follow the same pattern as elsewhere. Impressions of the pugmarks taken on paper show that in the female the paws are closely set, while in the male they are some distance apart (the permit holders identify the sex in the same method).

Analysis of pugmarks and population study

A random sample in strips along the periphery of nine blocks were made and pugmarks measured and recorded in a statement made for this specific purpose.

The sizes so obtained were grouped in five size classes as follows :

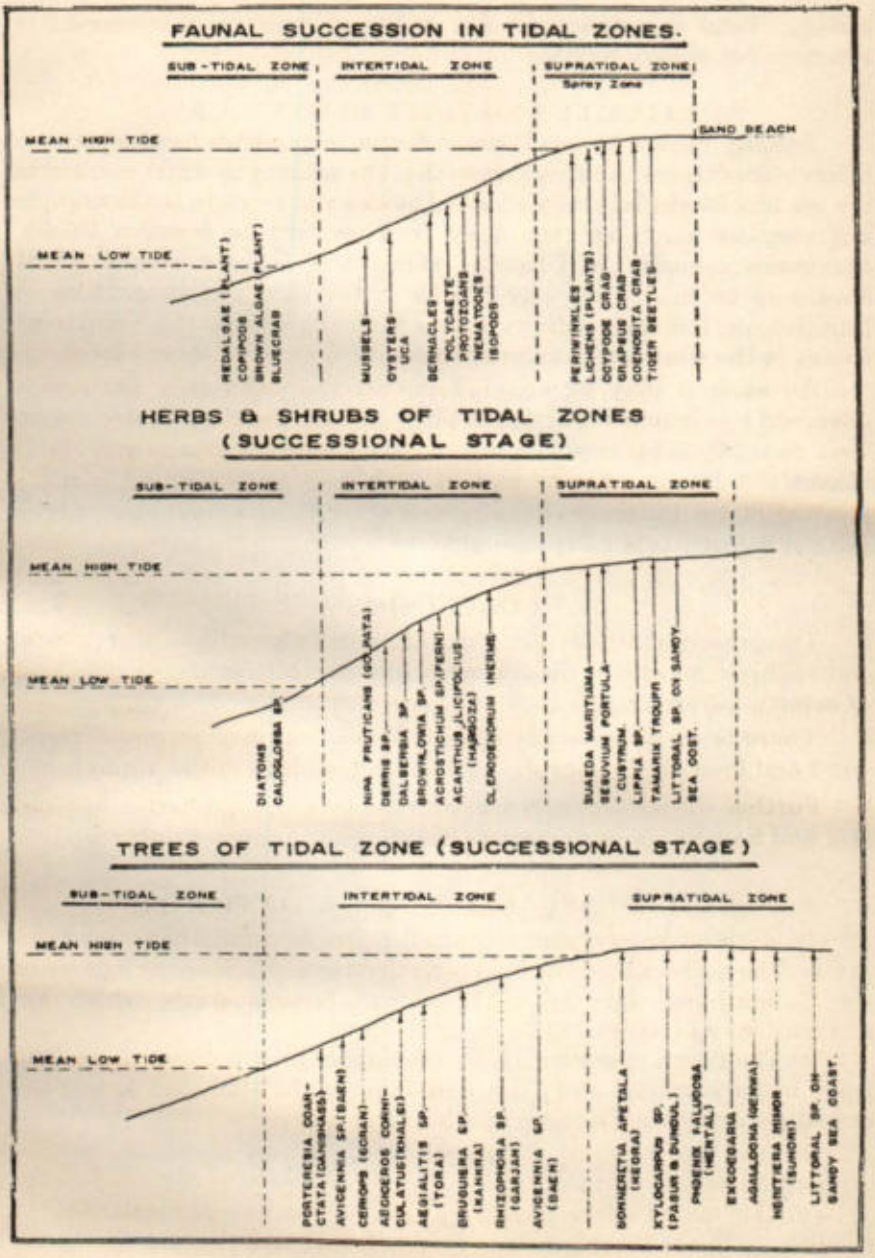
	Length × Width	in centimetres
	less than	
Class I	7 × 6	"
Class II	7—10 × 6—10	"
Class III	10—15 × 10—15	"
Class IV	15—20 × 10—15	"
Class V	15—20 × 15—20	"

In each of the above class, the proportion of tigers was found to be 1, 1, 9, 7 & 1 respectively. The pugmarks in the study area also revealed the presence of 13 tigers in Arbesi, 3 in Panchamukhani, 2 in Jilla, 2 in Harinbhanga, 2 in Chandkhali, 4 in Chamta, 6 in Matla, 5 in Bagmara and 1 in Gosaba tigers or 38 in the 9 sample blocks, or say 4/5 tigers in each block in average.

Pugmarks of same size were counted as a single tiger though several tigers of same size are likely to be there in each block. This exactly agrees with the authors' finding detailed on page 13 as the study did not account for designed and aggressive tigers that reside in dense forests and the present finding could include 1/2 more tigers in each block bringing total to 6/7 in a block which is barest minimum in a block.

The study also showed that Bagmara block in the beach forest has tigers of 9 × 8 cm. size; Chandkhali, Matla and Arbesi blocks recorded 18 × 16, 17 × 14, 18 × 13 cm. sizes; Chandkhali, Bagmara and Gosaba recorded 6-10 × 7-10 cm. sizes; Arbesi, Panchamukhani, Jilla, Harinbhanga, Chamta and Chandkhali recorded 10-15 × 10-15 cm. sizes; Chandkhali recorded 15-20 × 15-20 cm. sizes; and Chandkhali, Chamta, Matla, Arbesi and Panchamukhani recorded 15-20 × 10-15 cm. sizes.

Obviously, danger is indicated as small sized tigers are rare in the


FAUNAL SUCCESSION IN TIDAL ZONES.
SUB-TIDAL ZONE
INTERTIDAL ZONE
SUPRATIDAL ZONE
Spray Zone
MEAN HIGH TIDE
MEAN LOW TIDE
SAND BEACH
REDALGAE (PLANT)
COPIPODS
BROWN ALGAE (PLANT)
BLUECRAB
MUSSELS
OYSTERS
UCA
BERNACLES
POLYCAETE
PROTOZOANS
NEMATODES
ISOPODS
PERIWINKLES
LICHENS (PLANTS)
OGYPODE CRAB
GRAPSUS CRAB
COENOBITA CRAB
TIGER BEETLES
HERBS & SHRUBS OF TIDAL ZONES
(SUCCESSIONAL STAGE)
SUB-TIDAL ZONE
INTERTIDAL ZONE
SUPRATIDAL ZONE
MEAN HIGH TIDE
MEAN LOW TIDE
DIATOMS
CALOGLOSSA SP.
NIPA FRUTICANS (GOLPATA)
DERRIS SP.
DALBERGIA SP.
BROWLOWIA SP.
ACROSTICHUM SP.(FERN)
ACANTHUS JLICIFOLIUS (HARBOZA)
CLERODENDRUM INERME
SUAEDA MARITIANA
SESUVIUM PORTULA
- CUSYRUM
LIPPIA SP.
TAMARIX TROUPII
LITTORAL SP. ON SANDY
SEA COAST.
TREES OF TIDAL ZONE (SUCCESSIONAL STAGE)
SUB-TIDAL ZONE
INTERTIDAL ZONE
SUPRATIDAL ZONE
MEAN HIGH TIDE
MEAN LOW TIDE
PORTERESIA COARCTATA (DANDNAES)
AVICENNIA SP.(BAEN)
CERIOPS (GORAN)
AEGICEROS CORNICULATUS(KHALGI)
AEGIALITIS SP. (TORA)
BRUGUIERA SP. (KANORA)
RHIZOPHORA SP. (GARJAN)
AVICENNIA SP. (BAEN)
SONNERETIA APETALA (KEORA)
XYLOCARPUS SP. (PASUR & DUNDUL)
PHOENIX PALUDOSA (HENTAL)
EXCOECARIA
AGALLOCHA (GENWA)
HEINTIERA MINOR (SUNDRI)
LITTORAL SP. ON SANDY SEA COAST.

forests. Total population of 112 assessed may be a conservative estimate but is very reliable.

SALINITY AND TIGER BEHAVIOUR

Salinity cannot be one isolated factor responsible for the peculiar behaviour of tigers. Analysis show that the salinity of water and soil in the sea face blocks centrally situated blocks and block in the interior do not vary as much as they vary from eastern to western blocks. Maximum casualty in Chamta, Matla and Gosaba blocks would obviously be more than any blocks in the east including those in Bangladesh; but their salinity is less than any area in the Namkhana Range in the west; yet maximum casualty is in these three blocks.

As such it may be concluded that the behaviour pattern is governed by cumulative action of physical and chemical environment. Deer population (animate environment) is high in Gosaba and Matla blocks but less in Chamta and as such deer concentration is not a guiding factor for more casualty and scarcity or abundance of food are not directly related to casualty.

CONCLUSION

1 The present state of tiger population calls for adoption of drastic and realistic measures for enumeration, protection and destruction of some notorious tigers.

2 There is scope for study of the effect of salinity, strong current, wind and food on the morphology and physiology of the animals.

3 Further research is necessary on the breeding potential, age and size and how to adopt protective measures to reduce death rate.

HUMAN CASUALTIES – HOW TO STOP IT

It is a well known axiom that all tigers of Sundarbans are man-eaters. The authors made useful revelations on the behaviour pattern of the Sundarbans tiger with the aid of factual study which are summarized as follows:

(i) The tigers operate actively for human prey between 7 am. and 9 am. in the morning, and 3 pm. and 5 pm. in the afternoon 90% of the casualties occur within these four hours of a day.

(ii) The age class of the majority of victims invariably ranges between 35 and 45 years.

(iii) The death figure fluctuates year to year in a particular block; this may be due to (a) migration of tigers from block to block, or (b) the urge for human flesh changes from year to year indicating somewhat

rhythmic action in the tigers' behaviour pattern.

In this connection it is worth mentioning that "Endogenous periodism" is perhaps manifested, as in other animals, in the tigers of the Sundarbans. Just as colour changes in the fiddler crab are synchronized to dial or tidal cycle, the behaviour pattern so far as human kill is concerned seems to be similarly synchronized; there is some rhythm in their behaviour pattern.

(iv) The tigers that operate at night and pick up men from boats are most dangerous and most cunning.

In order to explain the behaviour pattern of tiger, human casualty ranging over 11 years is furnished below:

Casualty among professional men

Year	Honey	Fishing	Timber-trader	others	Total
1963—64	10	13	3	15	41
1964—65	7	9	3	5	24
1965—66	9	20	2	15	46
1966—67	9	18	4	5	36
1967—68	13	13	2	13	41
1968—69	19	11	13	8	51
1969—70	11	12	6	3	32
1970—71	7	16	1	4	28
1971—72	13	9	—	—	22
1972—73	2	9	1	4	16
1973—74 (upto June)	8	2	1	—	11
	108	132	36	72	348

The figures show that death among honey collectors is very common as the toll is taken in only two months time i.e., in April and May when bulk of honey is collected; moreover the honey collectors penetrate into interior of forest all alone giving the tiger opportunity to prey. Complete enumeration of human beings killed in each block and pug mark analysis showed that the tigers are distributed all over the Sundarbans and this enumeration indicated their concentration in different blocks.

According to the authors all tigers of the Sundarbans are not man-eaters; they think only 25% of the tigers are inherent or designed man-

eater.

The authors assessed the tiger population from a thorough study of pug marks collected from different parts of Sundarbans. The classification, according to size, showed that younger age class tigers are few and most of the tigers are middle aged to mature.

Having thoroughly studied the behaviour pattern of tigers in the Sundarbans forest and in view of heavy casualties suffered among professional men efforts were made to reduce death from the man eaters.

The authors are of the opinion that nothing fruitful can be achieved as the permit holders are extremely poor and cannot make their boats secure enough to give them protection at night; secondly, they surrender to "Vana-mata", the forest Goddess who, they think, is their sole protector, thirdly they have to collect honey, fish etc. within a short span of time and therefore, have to take the risk and no other way is left out.

However, difficult and strenuous it was, the authors made it a point to caution all the permit holders about vulnerable time of kill and age of victims. This had some effect as can be seen from the statement where death recorded during 1970-71, 1971-72 and 1972-73 has been less than in any of the three previous years. 16-17 honey collectors had been killed per year since 1965-66 to 1971-72 and earlier. This came down to 2 in 1972-73 though it slightly increased to 7 in 1973-74.

Casualty figures furnished below will show that since 1969-70 Matla has been the most vulnerable block, Arbesi has turned out to be the next vulnerable block in 1972-73 as the figures will show. Chamta which was earlier the most dreadful block in the whole of Sundarbans did not record much kills since 1968-69 in which particular year 17 persons were killed. Katuajhuri block recorded 11 casualties in a year (1949-50).

Casualty in Matla & Arbesi (April to December)

Year	Total No. of Kill	In how many blocks the kill occurred	Maximum casualty in a single block.
1969—70	17	11	Matla — 3 Nos.
1970—71	13	4	Matla — 7 Nos.
1971—72	20	5	Matla — 10 Nos.
1972—73	16	5	Arbesi — 8 Nos.
1973—74 (part)	10	5	Chamta — 3 Nos. Arbesi — 3 Nos.

Latest casualty figures also justify the authors' preliminary report as follows :

(i) Age class of persons killed by maneaters from 1969-70 to 1972-73 (part) are as follows :

16-25 ..... 13 Nos
26-35 ..... 12 Nos
36-45 ..... 26 Nos
46-55 ..... 15 Nos
56-65 ..... 9 Nos

(ii) Time of kill for 1969-70 to 1972-73 (part) are as follows :

7 am. to 9 am. ..... 24 Casualties
10 am. to 2 am. ..... 12 Casualties
3 pm. to 5 pm. ..... 23 Casualties
8 pm. to 10 pm. ..... 7 Casualties

As such it is evident that casualty from tiger can be **appreciably reduced if the permit holders stay away from forests** between **7 am. and 9 am. and 3 pm. and 5 pm. Low casualty during 1971-72 and 1972-73** supports the authenticity of the findings. As tigers in a particular block become dangerous and they act rhythmically, it may be possible-should the rhythmic periodicity is known-to predict which area would be most dangerous or likely to be dangerous in a particular year.

However, study is being continued and it is expected that thrilling information about the behaviour pattern of the Sundarbans tiger will be collected.

WILD LIFE BIOLOGY OF SUNDARBANS FORESTS THE SIZES OF TIGERS CAN BE FORECAST

There is no thumb rule to ascertain the size of a Sundarban tiger as in the case of measurement of height of an Indian elephant from the circumferance or diameter impression of foot print of fore toe.

So far no methods exist for measuring length of tigers from their pugmarks. But such a method is absolutely necessary in the forests where tigers can hardly be sighted or killed or found dead.

Problem in Sundarbans The forests are low and one of the densest anywhere in the world. In this dense low forests inundated twice daily by high tide and cut up by innumerable small and big channels and creeks, the cunningness of the tigers has reached a very high order. Their presence is felt, pugmarks seen; they kill human being in the forests, pick up victims from boat, yet they are hardly sighted. They cannot be easily killed over a bait as in the case of other tigers, cannot be trapped and therefore hardly can be measured to arrive at a definite conclusion about their size.

Measurement of pugmarks. Innumerable pugmarks were measured and according to size, these were divided into 5 (five) classes. Care was taken to eliminate any fallacy arising out of too much soft soil and on sand.

Many cases were, however, found in the forests where the pugmarks of fore and hind toes were available and measured subsequently. A few animals either killed or naturally dead were actually measured and a relationship could be mathematically established between length/ pugmarks as follows :

Tiger pugmark analysis method of study: In order of find out the relationship between the size (length × width) of pugmark and the length of tiger representative areas in each of the forest compartments of Sundarbans were inspected and pugmarks of fore and hind legs and their distances were measured in centimetre using tiger tracer and by actual measurement. It was observed that with increase in the size of pugmarks the inter-distance of fore and hind legs also increased.

Some figures on full length of tiger and the distance between the fore and hind legs were available from actual measurement. The entire data was analysed statistically and a suitable mathematical relationship between pugmark and the tiger length could be established from a suitable formula thus arrived at.

The figures shown in the two tables are the averages of about 400 pugmarks taken by means of tiger tracer and actual measurements. All these pugmarks have been statistically analysed and condensed into the two tables set cut. Scanty pugmark data on cubs reveal the paucity of cubs in the Sundarbans.

Let the relationship between the size of pugmark (product of length and breadth) (X^1) and the distance between fore and hind legs (Y^1) be assumed to be of the following form :

$Y = a + bx$ where a, b are constants to be determined in such a manner that the linear form gives the line of best fit.

By the use of normal equations, the constants, a b are calculated

$\Sigma Y = na + b\Sigma X$

$\Sigma X'Y' = a\Sigma x' + b\Sigma x$ where $n = 9$

$\Sigma x = 1415$, $\Sigma y' = 1099$, $\Sigma x'Y' = 18299$,

$\Sigma X'^2 = 259171$, $a = 78, 10$, $b = 0.28$

The regression equation comes to $Y' = 78.10 + 0.28\,X'$... ... ...(1)

Let $Y = A + BX$ where

Y = length of tiger in centimetres

X = Interdistance between fore and hind legs.

In the same way, the constants A B are calculated by means of normal equations :

TABLE – 1

SHOWING THE DATA OF INTER DISTANCE BETWEEN LEGS (FORE & HIND) AND THE SIZE OF PUGMARK

Sl. No.	Fore leg in cms.	Hind leg in cms.	Average of 2 & 3	Average of product of (2 × 3) X' in square cms.	Distance between fore and hind leg in cms. Y'	X' × Y'	X'²	Y'²
1	2	3	4	5	6	7	8	9
1.	7.5 × 8.5	6.5 × 7.5	7 × 8	56	75	4200	3136	562
2.	11 × 9	9 × 8	10 × 8.5	85	112	9520	7225	1254
3.	9.5 × 12.5	10.5 × 11	10 × 11.5	115	115	12225	13225	1322
4.	13 × 11	13 × 11	13 × 11	143	122	17446	20449	14884
5.	13.5 × 12.5	12.5 × 11.5	13 × 12	156	125	19599	24336	15625
6.	11.5 × 14	12.5 × 14	12 × 14	168	130	21840	28224	16900
7.	14 × 14.5	13 × 14.5	13.5 × 14.5	196	135	26460	38416	18225
8.	14 × 16	14 × 16	14 × 16	224	140	31360	50176	19600
9.	17 × 16	17 × 16	17 × 16	272	145	39440	73984	21025
			Total	1415	1099	182090	259171	137653

TABLE 2

Showing the length of tiger and the interdistance between fore and hind leg.

Serial No.	Interdistance between fore & hind leg in cms. (X)	Length of the tiger (Y)	XY	X²	Y²
1.	60	190	11400	3600	36100
2.	80	205	16400	6400	42025
3.	110	240	26400	12100	57600
4.	132	275	36300	17424	75625
	382	910	90500	39524	211350

$\Sigma Y = 4A + B\Sigma X$

$\Sigma XY = A\Sigma X + B\Sigma X^2$

The equations are :

$910 = 4A + 382B$

$90500 = 382A + 39524B$ ... ...(2)

Solving (2) we get $A = 114.81$

$B = 1.18$, equation is $Y = 114.81 + 1.18X$ ... ...(3)

But $X = 78.10 + 0.28\ X'$ from (1)

Therefore, Regression equation correlating the length of tiger to size of pugmark is given as follows :

$Y = 206.97 + 0.33X'$ .. .. (4)

Where Y = length of tiger in centimeters, X' Size of pugmark (product of length and breadth) in square cms. Thus if X' is known, Y can be determined with the help of the above equation.

The above equations (3), (4) have got some obvious drawbacks and should not be applicable for cubs which are equal to or less than 114.81 cms. in length. But nevertheless, this equation is a rough guide to determine the length of tiger in Sundarbans. Since the length data for new born tiger cubs are difficult to record and in Sundarbans the percentage of tiger cubs is significantly less, the formulae can be safely used as a rough guide.

The co-efficient of correlation between size of pugmark and distance between for and hind legs is computed and then r " test of significance is applied.

The co-efficient of correlation (r) was calculated to be 0.91.

Tests of significance :

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$ Follows t—distribution with $(n\text{-}2)$ degrees of freedom.

$$\text{Therefore } t = \frac{0.91X\ 7}{0.414} = 5.80$$

consulting t = table we find,

$t.05$ with 7 $d.f.$ = 1.895

$t.01$ with 7 $d.f.$ = 2.998.

The observed t value is highly significant and thus there is reason to believe that a high degree of correlation exists between the size of pugmark and the distance between hind and fore legs.

In order to find out the co-efficient of correlation between the inter-distance between fore and hind legs and the length of tiger, the coefficient of correlation is computed and then t' test is applied.

The said co-efficient of correlation between inter-distance between fore and hind legs and the length of tiger was calculated as :

$$r = 0.99$$

To test, we apply

$$t = \frac{0.99 \times \sqrt{2}}{0.14} = 10.0 \text{ with 2 d.f.}$$

Table values:

$t.05$ with 2 d.f. = 2.920

$t.01$ with 2 d.f. = 6,965

Thus a high degree of correlation exists amongst the size of pugmark, inter-distance between more and hind legs and the length of the tiger. In other word the linear regression equation found would serve as excellent formulae for predicting the length of he tiger from the observed data on the size of pugmark.

SALINITY AND BEHAVIOUR PATTERN OF TIGER

(i) Salinity in various forest formations.

The Sundarbans is a swampy land of diverse eco-system, where tidal action promotes a rapid circulation of nutrients, waste products of metabolism are removed easily, benthic microflora are rich and salinity various widely in both vertical and horizontal planes. Marine and estuarine organisms exhibit incredible array of adaptations.

The following table shows the different values of desiderata like Mhos/centimetre, PH, total soluble salts, salt percentage at three different soil depths of 15 centimetres, 30 centimetres and 60 centimetres for twelve different habitat formations identified for Sundarbans tiger reserve area :

Habitat formation types	Depth in cm.	Mhos *(A) cm.	PH	TS*(B)	Salt %
a) *Heritiera-Phoenix*	15	10.01	7.90	100.0	0.54
	30	11.19	7.95	111.9	0.60
	60	10.01	7.70	101.1	0.54
b) *Heritiera-Excaecaria*	15	10.01	8.1	100.1	0.54
	30	9.43	8.05	94.3	0.49
	60	8.78	7.95	87.8	0.48
c) *Heritiera-Excaecaria-Cereops.*	15	15.32	7.85	153.2	0.84
	30	14.73	7.8	147.3	0.84
	60	18.27	7.8	182.7	1.05
d) *Excaecaria-Phoenix*	15	9.05	8.5	90.5	0.49
	30	9.05	8.2	90.5	0.49
	60	14.35	8.05	143.5	0.78

f) Pure *Excaecaria*	15	11.05	8.20	110.5	0.60
	30	12.15	8.15	121.5	0.66
	60	13.25	8.10	132.5	0.72
g) Pure *Cereops*	15	17.32	8.00	173.2	0.96
	30	20.22	7.95	202.2	1.2
	60	28.32	7.70	283.2	1.7
h) *Excoecaria-Cereops*	15	13.27	7.25	130.7	0.72
	30	15.60	6.25	156.0	0.90
	60	15.02	7.30	150.2	0.84
i) *Rhizophora-Brugiera*	15	10.02	6.0	100.2	0.54
	30	9.17	6.2	91.7	0.49
	60	13.45	5.0	134.5	0.72
j) Pure *Porteretia*	15	6.70	8.10	67.0	0.38
	30	8.27	8.20	82.7	0.44
	60	10.80	8.25	180.0	0.60
k) *Avicennia-Porteretia*	15	10.97	8.35	109.7	0.60
	30	11.55	8.45	115.5	0.60
	60	15.02	8.35	150.2	0.84
l) *Avicennia-Sonneratia*	15	10.02	8.0	100.2	0.54
	30	11.37	8.0	113.7	0.60
	60	19.57	8.0	195.7	1.10

(A) indicates milli Mhos of salt per centimetre.
(B) indicates total soluble salts.

The Javan Rhinoceres *(Rhinoceros sondaicus desmarest)*, Swamp deer *(Cervus dauvaceli dauvaceli)*, wild buffaloes *(Bubalus bubalis)*, which were once the pride of Sundarbans no longer exist in the area now. Sundarbans is a curiously anomalous tract where fish *(Periopthalmus* and *Boleopthalmus)* creep up the tree, tides in the same creek sometimes run in opposite directions, molluscs and crustacea are in abundance. The tigers operate in such a peculiar saline terrain and their behavioural pattern and adaptations are simply bewitching. Will the Salinity elimin ate the mammals?

(ii) Salinity index and human casualties.

It is a point of controversy if the habitat formations and salinity indices both of soil and water maintain any correlation with the man-eating propensity of Sundarbans tigers. A statistical analysis of the data collected from typical habitat formations, salinity indices and man-eating tends to throw some light into this age-old controversy. The following two tables (Table Nos.1 and 2) exhibit the data and analysis :

Table – 1

Habitat formation type / Average value of Desiderata	*Heritiera-Phoenix.*	*Heriteira-Excoecaria*	*Heritiera-Excoecaria Cereops*	*Excoecaria-Phoenix*	*Pure Phoenix*	*Pure Excoecaria*	*Pure Cereops.*	*'Excoecaria Cereops.*	*Rhizophora-Brugi-*	*'Pure Qryza Oryza*	*Avicennia Oryza*	*Avicennia Sonneratia*
Mhos/cm	10.4	9.4	16.1	9.0	13.4	12.1	22.0	14.6	10.9	8.6	12.5	13.7
pH	7.8	8.0	7.8	8.2	8.0	8.1	7.9	6.9	9.7	8.2	8.4	8.0
TSS	104.3	94.0	161.1	90.5	134.5	121.5	219.5	145.6	108.8	85.9	125.1	136.5
Salt %	0.69	0.49	0.84	0.49	0.72	0.66	1.2	0.96	0.49	0.46	0.60	0.60
Ranking	6	7	3	7	4	5	1	2	7	7	6	6
Percentage frequency of pugmarks recorded	12	2	3	18	20	3	5	15	2.5	1.5	20	2
Percentage human casualties	10	8	10	3	8	8	20	18	0.5	.5	2	5
Ranking	3	4	3	4	4	4	1	2	7	7	6	5

TABLE – 2

TABLE SHOWING THE CALCULATION OF RANK CORRELATION CO-EFFICIENT BETWEEN SALT PERCENTAGE AND PERCENTAGE HUMAN CASUALTIES.

Rank of salt % = U_i	Corrected U_i	Rank of human casualties (V_i) percentage.	Corrected V_i	D_i: ($U_i - V_i$)	d_i^2
1	2	3	4	5	6
6	6	3	3½	2½	25/4
7	9	4	5	4	16
3	3	3	3½	−½	¼
7	9	4	5	4	16
4	4	4	5	−1	1
5	5	4	5	0	0
1	1	1	0	0	
2	2	2	2	0	0
7	9	7	11½	−2½	25/4
7	9	7	11½	−2½	25/4
6	6	6	10	−4	16
6	6	5	9	−3	9

Spearman's rank correlation $\Sigma di^2 = 19 + 58 = 77$

is given by : $r = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$

In the case of ties the Spearman's rank correlation co-efficient formula is given by $r_s = 1 - \frac{6\left[\Sigma d^2 + \frac{t^3 - t}{12}\right]}{n(n^2 - 1)}$

Where d = difference in two ranking

t = number of items involved in tie

n = total number of items on which this ranking is made.

$r = 1 - .17 = .83 > .5$

This indicates that there is a remarkbale closeness between the two sets of ranks.

(iii) Salinity and behaviour pattern of tiger:

Salinity can never be an isolated factor responsible for the man-eating tendency of Sundarbans. The following table shows the average

water indexes for different blocks in Sundarbans Tiger Reserves area:

	Name of block	Average water salinity % for twelve months.
Northern Zone	Pirkhali	1.44
	Panchamukhani	1.24
	Jhilla	1.11
	Arbesi	1.29
	Netidhopani	1.79
	Chamta	1.78
	Khatuajhuri	1.41
	Harinbhanga	1.34
Central zone	Chandkhali	1.81
	Goashaba	1.82
	Matla	1.69
Southern Zone	Chhotahardi	1.46
	Mayadwip	2.37
	Gona	2.31
	Bagmara	2.34
Total average		1.45%

(iv) Average soil salinity of different zone	15 cm	30 cm	60 cm
a) Northern zone (Pirkhali, Panchamukhani, Jhilla, Arbesi, Netidhopani, Khatuajhuri, Harinbhanga)	0.80	0.96	1.04
b) Central zone (Chamta, Chandkhali, Goashaba, and Matla)	0.97	0.97	0.03
c) Southern zone. (Chhotohardi, Mayadwip, Gona and Bagmara)	1.29	1.33	1.37

Analysis of the data in Table 3 & 4 exhibit that water salinity tends to increase as one proceeds from Northern zone to Central zone and then to Southern zone of the Reserve and the similar pattern is also noticed so far as soil salinity index is concerned. But the frequency of human casualties does not vary according to such zonations. Facts indicate that the man-eaters of Sundarbans are concentrated to some habitat formations only which also incidentally record significantly more salinity but the operational zones vary. It requires further detailed probe to come to any definite conclusion

TABLE – 3
Soil Salinity % at different depths.

Name of the Block	Soil depth	Average salt percentage
Pirkhali	15 cm.	0.63
	30 cm.	0.64
	60 cm.	0.58
Panchamukhani	15 cm.	0.79
	30 cm.	1.04
	60 cm.	1.18
Jhilla	15 cm.	0.75
	30 cm.	0.82
	60 cm.	0.96
Arbesi	15 cm.	0.95
	30 cm.	0.94
	60 cm.	0.03
Netidhopani	15 cm.	1.02
	30 cm.	1.02
	60 cm.	1.03
Chamta	15 cm.	0.96
	30 cm.	0.93
	60 cm.	1.11
Khatuajhuri	15 cm.	1.08
	30 cm.	1.03
	60 cm.	1.12
Harinbhanga	15 cm.	1.35
	30 cm.	1.20
	60 cm.	1.39
Chandkhali	15 cm.	1.10
	30 cm.	1.25
	60 cm.	1.12
Goashaba	15 cm.	1.30
	30 cm.	1.07
	60 cm.	1.14
Matla	15 cm.	0.52
	30 cm.	0.64
	60 cm.	0.74
Chhotohardi	15 cm.	1.02
	30 cm.	1.10
	60 cm.	1.23
Mayadwip	15 cm.	1.40
	30 cm.	1.43
	60 cm.	1.43
Gona	15 cm.	1.40
	30 cm.	1.33
	60 cm.	1.30
Bagmara	15 cm.	1.35
	30 cm.	1.46
	60 cm.	1.51

Photo 4 A muddy slope in lowtide showing countless sharp and strong breathing roots of Keora (Sonneretia apetala) which are hazards for movement of wildlife & men.

TABLE – 4
Human casualty due to tiger from different blocks.

Block	Year					Total
Chamta	9	8	1	4	3	25
Goashaba	—	—	—	—	—	—
Matla	1	1	—	—	—	2
Arbesi	2	6	2	4	2	16
Jhilla	—	1	2	4	2	9
Khatuajhuri	2	2	4	2	7	17
Harinbhanga	1	3	2	1	4	11
Pirkhali	2	14	7	6	8	37
Netidhopani	4	8	3	4	8	27
Panchamukhani	7	10	6	3	6	32
Chandkhali	8	10	14	14	6	52
Gona	—	1	—	—	—	1
	36	64	41	42	46	229

and ascribe reasons for the man-eating urge of Sundarbans tigers in heavy salinity areas. It may be concluded that the man-eating urge, a peculiar trait marked in a small percentage of Sundarbans tiger is governed by cumulative action of physical,mechanical,animate and chemical environment of Sundarbans. It has been further noted that the abundance or scarcity of prey animals are not directly related to the human casualties from tiger.

Sundarbans is a natural laboratory. It provides astonishing examples how a physical and chemical environment can exert influence to the different forms of life. The extent of endogenous and exogenous periodism, osmo-regulatory adaptations amongst different organisms were perhaps no where so much pronounced and diversified as they are in Sundarbans. All these complex factors guide the behaviour pattern of animals and it is still a subject of further study

FURTHER STUDY ON THE HABITAT AND BEHAVIOUR PATTERN OF SUNDARBAN TIGER

(Observation made in 1978–79)

From time immemorial the cattle lifting tigers have enjoyed the dubious distinction of a public enemy. Anthropomorphic anecdotes of cattle lifters are abundant, those on man-eaters are many, but very scanty on the estuarine man-eaters. The view that the predatory aberration has been a persistent deviation from normal is held by a

group of experts. It has to be established in respect of the estuarine tiger. In the estuarine tract, physical, chemical, mechanical and animate environments create a series of specialised niches where aggression, tenacity, battle for survival are retentless and supreme.

The authors' initial investigational reports on the tiger of the Sundarbans estuary were detailed in a series of articles published in 'Cheetal', 'Science & Culture' and in 'The Bulletin of the Botanical Society of Bengal' during 1972 and 1973.

Besides these and other observations on vegetation and habitat, studies on the breeding habit and bio-ecological aspects on various fish species, honey bee **(Apis dorsata)** and several species of birds in relation to tigers, have been made in a separate series of publications. (Science & Culture, Volume 40, March 1974, Science & Culture, Volume 38, June 1972, Science & Culture, Volume 39, January 1973, Cheetal, Volume 15, July 1972 and Cheetal, Volume 15, March 1973). Extensive data have been collected on soil, water, pugmarks, human casualties etc. and those have been analysed. Some of these findings are enumerated in this paper.

A. *Earlier findings between 1970-72*

(a) Tigers are present in all the fifteen (15) blocks in the Sundarban Tiger Reserve (2,585 sq.km.) and casualties are recorded in all the compartments (65 nos.) of these 15 blocks; in fact 21 blocks of the entire Sundarban forests record the incidence of man-eaters.

(b) Tigers migrate from block to block as was evident from pug-marks on muddy, sandy and loamy soil and on actual sightings.

(c) About 40 persons are killed every year on an average (unofficial reports record about 100).

(d) Maximum casualty is in April and May during the honey collection season. Minimum casualty is during the rains. Fishermen are the highest victims.

(e) Permit holders of all professions die; in the timber coupes where the maximum number of workers stay and work together (contrary to fishermen who are isolated all over the areas) have comparatively minimum casualty.

(f) Casualty in a particular block do not maintain a uniform level, it fluctuates in a regular *rhythmic* pattern (Table No. 2 also refer to graphs produced in earlier papers referred to in para 3 under introduction).

(g) (i) Maximum casualty (80%) is between 7.00 hours and 9.00 hours, 15.00 hours and 17.00 hours and at 23.00 hours.
(ii) The age of persons killed varies between 35 to 45 years in 80% of the cases.
(iii) Those killed at night are attacked at their boat after the tiger swam to the boat and mounted on it, selected the victim and jumped with it back into water.

(h) Salinity is suspected to have positive correlation with the ferocity of the animal. Damage of liver and kidney has been suspected.

(i) The tigers understand the human mind meticulously and all their plans of attack are designed on human movement.

(j) All the forests were classified into types or formation on the basis of tidal level and on their tree associations; the density of such forests were determined and the human casualty pattern in such types and formations enumerated.

(k) Pugmarks were measured and classified into various size classes and assessment of the younger class was made. It was observed that the younger class was poorly represented.

(l) Recovery of the human body could be done only in 28.5% of the cases, whereas in 71.5% cases dead body could not be recovered from the tiger. This indicated the tenacity and ferocity of the man-eaters as the persons engaged in retrieving the dead body were attacked.

(m) The initial attack was always on the right hind part of the neck and the injury inflicted on the jugular vein and the cerebellum by the right and left paws respectively.

(n) Pigs and deer were the primary prey animals, but circumstances compel the tigers to take monkey, fish, bird, lizard and even crab. They have been observed to eat honey but this may not be a regular feature.

(o) Striking uniformity in the number of persons killed in honey collection over the years showed that the number of man-eaters was quite small and static (in average 17 honey collectors were killed out of about 1300 men engaged in this job each year).

(p) Maximum casualty zones were the areas of high salinity.

(q) The man-eater did not cross into human habitation for predation, which is striking feature of the Sundarbans tiger.

(r) The sex ratio of the female to male was 1:3.

(s) The man-eater dug up recently burried human body to eat it.

(t) Man-eaters were mostly male. No human female has been killed by a man-eater as per record.

(u) There was no source of sweet water in the entire tract and although the animals drunk only saline water, yet sweet water was an attraction and was preferred to saline water.

B. *Findings after complete closure of high density tiger populated areas to permit-holders in mid-1974.*

All the aforesaid observations made under paragraph. A were found correct on later observations. About census, the Project authorities found an increase in tiger population excess of 112 (in 1979 census the number was 206) which was assessed earlier in 1972. Further, the Tables 1 and 2 show the corresponding casualty figures during (i) 1960-69, (ii) 1969 to 1973 and (iii) 1974 (September) to 1978.

The following are the analyses of data and findings:

1. The wave of human casualty maintained the same rate of about 40 persons a year. It is significant that eight blocks out of a total of 15 in the project area were closed to the permit-holders from 1974 (September); yet the rate of death was the same. This positively indicated :

(a) Migration of tigers from the blocks which were made out of bound for the permit-holders to the areas where the permit-holders were now working. It is evident that the concentrated zone of the heaviest kill in the Chamta and Matla blocks got diluted owing to migration of tigers to the adjoining Chandkhali, Netidhopani, Panchamukhani and Pirkhali-7 blocks.

Prior to this period the incidence of casualty, especially in Chandkhali and Pirkhali-7, was very low, and the maximum was in Chamta, Matla and Gosaba blocks.

(b) The rhythmic activity in the Tiger behaviour pattern as common with many micro and macro-animals owing to daily tidal movement, lunar cycles, etc. In the past 17 years it has been found that the zone of the maximum kill frequently shifted, and that a particular area did not maintain high incidence of casualty for a long period. In the present case the inactive tiger of Netidhopani, Chandkhali and Pirkhali-7 might have burst into activity owing to lunar periodicities or some endogenous oscillations; or the inherent man-eaters migrated from Chamta and Matla blocks.

(c) Increase in tiger population is also indicated, if the aforesaid analyses of migration and rhythmic activity were not accepted.

TABLE – 1
Total Casualty in 'Project Tiger' and Pre-Project Tiger Periods

Forest Block	Chamta 1	Matla 2	Arbesi 3	Gosaba 4	Netidhopani 5	Chandkhali 6	Pirkhali 7	Bagmara 8	Katuashuri 9	Others 10	Total
Pre-Tiger Project period (i) 1960-69 (10 years)	(80)	(41)	8	(37)	17	16	22	22	12	81	336
(ii) 1969-1973 (4 years)	39	36	20	12	13	15	8	—	8	21	172
Total	119	77	28	49	30	31	3	22	20	102	503
Project Tiger period (iii) 1974-1978 upto (Sept.) (5 years)	17 Matla 2 & 3)	25	16	1	(27)	(52)	(37)	—	17	Pancham-ukhani 32	224

N.B. Bold figures show high incidence of kill of human being during pre and post Project Tiger period.

Table shows casualty figure in 9 blocks out of 15, the last column shows total casualty in 6 blocks (except Panchamukhani). Of the 9 blocks, Chamta, Matla, Gosaba & Bagmara ae in core area of Project Tiger where no permit-holders were allowed to enter; obviously the casualty figure was very low in these four blocks.

In columns 6, 7 & 10, i.e. the blocks, Chandkhali, Pirkhali & Panchamukhani record sudden burst in high casualty figures. It shows that Pirkhali-7 and Netidhapani 1,2 & 3 register 64 casualties. Chandkhali 1, 2 & 3 adjacent to Chamta, register 52 casualties. Analysis may be seen in the body of the article.

TABLE – 2
Fluctuations of Casualty in Different Blocks

Block/Year	1961-63	1963-64	1964-65	1965-66	1966-67	1967-68
Chamta	9	13	7	15	5	10
Gosaba	5	5	4	7	1	3
Matla	4	3	2	—	3	5
	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74
Chamta	17	2	4	—	1	5
Gosaba	4	5	4	—	—	3
Matla	2	5	14	10	2	2
	1974-75	1975-76	1976-77	1977-78	1978-79 (upto Sept.)	
Chamta	9	8	1	4	3	
Gosaba	—	—	—	—	—	
Matla	1	1	—	—	—	

(d) The entire land area of all these blocks was not regularly inundated by tidal water.

(e) Salinity and tiger activity might have some positive correlations, but this might be a controversial issue unless proved with sufficient data.

2. It was a conspicuous factor that the Chamta and Netidhopani blocks of forests with an open crop of low height and patches of *Phoenix* (Hental) formation which were above daily tidal inundation level, have recorded high concentration of the tiger.

3. Another very conspicuous fact was that the three blocks-Netidhopani, Chamta and Pirkhali-7, which flank the rivers Netidhopani, Naubanki and Panchamukhani, the entry and exit water route to central and southern Sundarban blocks, record the maximum human casualty.

4. These factors also proved high degrees of intelligence and diabolical understanding of human behaviour by the man-eater of the area. The salinity concentration, therefore, may not be a deciding factor in high human casuality although the Gosaba river flanking Chamta, Netidhopani and Pirkhali has the maximum salinity. Strict protection of the 'core' area of the 'Project Tiger' from the permit-holders were sure to reveal more facts. It is essential that anatomical and biochemical examination of blood, liver and kidney of the man-eaters are made in detail.

5. It should be possible to isolate the inherent man-eaters and deal with them separately to save loss of precious human lives.
6. Aerial photographs of the Tiger habitat showed limitation of suitable territory, smaller number of saline blanks (such blanks are many and big-sized in Namkhana Range west of the Tiger Reserve). There were too many creeks which made the movement of tigers extremely difficult.
7. There was adequate cover all over the forests.

Discussion and Conclusion.

1. Predatory aberration of Sundarbans Tiger must be looked into carefully and steps taken to mitigate the circumstances leading to acquisition of such behaviour.

The genesis and the tragic death of human being due to predatory aberration of estuarine tiger is perhaps due to combined effect of environmental attributes and human activity pattern. The saline water, muddy terrain, recurrent high tide, dense vegetation etc. coupled with difficulty in preying upon animals bring about a psychological change in the tiger behaviour. This type leads to be cyclic and chronic giving the tiger predatory proficiency.

Habitat amelioration is not possible in this tract but the human activity pattern has to be changed. It may be a necessity to isolate the man-eaters.

2. It follows, therefore, that the study of the habitat and behaviour pattern of Sundarbans tiger is a subject of research and deep study. It is a difficult task. It should be possible to isolate the man-eaters and study their nature. Creation of large enclosures (if at all possible) in the forest habitat and releasing captured man-eaters to study their behaviour should be the subject of present investigation. Investigation on the blood, urine, kidney, liver, etc. of this animal is an immediate necessity. It is the research, and not management, on tiger which is of prime necessity in this estuarine tract. Fantastically high death rate in Chandkhali, Pirkhali-7 and Netidhopani-5 leads one to accept either of the three theories(i) migration of inherent man-eaters or (ii) increase or concentration of tiger population or (iii) man-eating tendency revitalised in the dormant ones showing a *rhythmic pattern* of activity.

Photo 5 A pair of fledglings of little egret in Sajnekhali Bird Sanctuary

AVIFAUNA

Breeding Biology of Birds

The vast expanse of mangrove swamps, studded closely with a net work of tiny islands of mud flats, supporting low wooded forests of very high density and virgin beauty, have been chosen by several species of water and marsh birds as their breeding habitat. The authors chose a representative section of such an area in the Sajnakhali Wild Life Sanctuary for the study of the habitat and the breeding behaviour of the Open-bill stork, the Large egret and the Little cormorant. It covers some behavioural and functional roles of plant and animal communities that form an integral part of the entire ecosystem of the Sundarbans. It includes nests and pattern of nesting, laying of eggs, hatching, growth of fledglings, food and food habits, action of predators, parasitism, mortality and survival patterns of the birds. Common information relating to the birds, that are obtainable in text books, have not been described. The data in this article are the result of three seasons study which is to be continued. Here, the breeding behaviour of these three widely occuring species of birds are expected to differ from those elsewhere because of the peculiar nature of the terrain.

In recent years there has been considerable interest in the study of the breeding biology of Indian birds. Although some work has been done on (i) the little Cormorant (*Phalacrocorax niger* Vieillot), (ii) the open-bill stork (*Anastomus oscitans* Boddaert) and (iii) the Solitary Large Egret (*Egretta alba* Linn.), the present study has been undertaken in great details as the situation of the breeding site was found advantageous for such a study. It was intended to ascertain if the locality factors have any bearing on the breeding biology in such an uncommon habitat. The paper reflects the various qualitative and quantitative aspects and the habitat of the above three bird species in the Sajnakhali Wild Life Sanctuary.

The Sanctuary which is a part of a vast ecosystem peculiar to the mangrove forests, has numerous species of water birds (some of which are resident), mammals, water and land lizards, snakes, crocodiles, sharks and very many species of fish, crustaceans and molluscs and many other species of lower groups of animals.

HISTORY

The reserved forests of the Sundarbans cover an area of 4,17,126 hectares cut up by innumeable streams and water courses. The maximum concentration of the breeding birds has been at the Sajnakhali Wild Life Sanctuary, though there are three other spots of smaller concentrations. All these breeding groups have been selected at the fringes of the forests

facing villages. The breeding areas were spread over about 360 hectares in the Sajnakhali Wild Life Sanctuary. This place has been the large scale breeding grounds of birds since 1955.

The three species of birds viz. the Little cormorant, the Open-bill stork, and the Large Egret, are the principal visitors during the months from June to September. Night herons are also regular visitors but not a single nest was seen during 1971 although a good number bred during 1970. The reason is not apparent. Other bird species that visited the Sanctuary during the period of study were herons, egrets, paddy birds, darters, one or two individuals of spotted pelicans, but none built nests.

OBECT OF STUDY

The object of study was primarily two-fold. Firstly, it was intended to study the main structure and gradients in the plant and animal communities of the ecosystem in this mangrove forest; secondly, it was designed to study the sexual, parental and ingestive behaviours with stress on nest construction and pattern, egg-laying, brooding, fledging mortality, training and other related aspects of the lives of the three species of birds. It was possible to ascertain the trend of the survival pattern of the birds. Simultaneously, a population count has also been attempted. It is expected that the present study will help in planning the management of the Sanctuary to meet the optimum needs of various species of birds and other big and small animal populations.

METHODS OF STUDY

A well represented portion of the nesting areas was selected and fifty well dispersed trees with nests of the three species of birds, were marked serially. The nests on each such tree were given a sub-number and observations were made daily for a period of 90 days, from nesting to the final flight of the fledglings. Eggs in each nest and fledglings were marked and numbered with different colours.

Observation were made from fixed and portable ladders, fixed towers and from boats at high tide; a binocular (prismatic) of 11×50 was used for such observations. Actual measurements and weighments of nests, eggs and fledglings were made by the use of tapes, divider and spring balance, and tabulated in charts specially made for the purpose.

HABITAT

The plant and animal communities, both form a complex habitat

in the entire ecosystem of the Sundarbans forests and are described as follows :

Plant Community

The low lying swampy islands cut up by innumerable streams and creeks are inundated daily during high tide. The water is brackish and the forests are low and poor. Most of the trees, except *Sonneratia apetala*. are hardly 10 metres tall, but very dense and almost impenetrable. Water-logging, salinity, high humidity, soil devoid of humus, surface soil, at places full of decaying molluscs, annelidas, larvae and exuviae of insect are the salient features of the forests.

The forests are of two principal types viz. (a) Salt-water *Heritiera* type and (b) low mangrove type. The principal formations under these types are :

Heritiera minor-Phoenix paludosa formation

Night herons have been found to build breeding nests, in large numberson *Phoenix paludosa*. No such birds were found doing so in 1971.

Heritiera minor-Excoecaris agallocha formation

No nests have been observed on *Heritiera* or in this formation.

Heritiera minor-Excoecaria agallocha-Cereops roxburghiana formation

No nests have been observed in this formation.

Pure Phoenix paludosa formation.

Except night herons no other birds have been found to select this formation for building nests.

Pure Cereops formation

Such areas are practically devoid of nesting birds. In 1969 and 1970, not a single nest was found on *Cereops* but, in 1971, nine such trees with nests were observed.

Avicennia alba Porteretia coarctata formation

Avicennia alba and *A.officinalis* trees are obvious choices for the nesting of breeding birds. The maximum number of nests are built on these two species. The crown of *Avicennia* trees appears most convenient for nest construction. *Porteretia coarcatata* is a grass one metre tall.

Avicennia sp. *Sonneratia apetala* formation

It is not known why Sonneratia is not selected as a nesting tree. No nests were seen on this species. *Sonneratia* is absent from the study area but present elsewhere in the forest fringes.

Rhizophora mucronata Bruguiera gymnorhiza formation

No nests have been seen in this formation. Individually *Rhizophora*

does have nests, as in the Sajnakhali Sanctuary (0.8% of host plant).

Excoecaria agallocha-Cereops roxburghiana formation

In this formation *Excoecaria* has nests. The breeding areas of the Sajnakhali Sanctuary show that the birds prefer *Avicennia* trees (83.4%), then *Excoecaria* (13.7%), while *Rhizophora* (0.8%), *Xylocarpus* sp. (1.8%) and *Aegiceros* (0.3%) have very few nests on them. Birds other than Night herons have a disinclination for *Phoenix*. There is a complete absence of ground flora in the locality. This helps the Openbills and Egrets to retrieve the dropped food during low tide.

The habitat hectarage for the census area was as follows:

Census area	*Porteretia coarctata* and tidal flat	Avicennia area	Phoenix area	Cereops area	Mixed crop	Blank and other areas	*Excoecaria*-*cereops* mixed crop
360.0 Hec.	4 Hec.	100 Hec.	80 Hec.	56 Hec.	20 Hec.	20 Hec.	80 Hec.

ANIMAL COMMUNITY AND THE ENVIRONMENT

The habitat of the breeding birds in the present site is a complex one. Strong winds (mechanical environment) and rain affect the nests and birds; salinity (chemical environment) affects the source of food collection, the low tide provides mud banks for some food and space for training, high tide reduces the space and brings the aquatic animals close to the breeding birds. Most important is the association of various animals and birds in the breeding sites. Though not directly connected or concerned with the breeding birds, monkeys (*Macaca mullata*) spotted deer, pigs, various species of fish, fauna, sharks, and crocodiles (estuarine) occur in the area. Most harmful are the presence of the Jungle crow, osprays, buzzards, owls and wild cats, in the area. Most harmful among the reptiles are land and water lizards (*Varanus* species) and some snakes. Several species of molluscs and Crustaceans form the food of the breeding birds including various sweet water fish. Tigers also track the area in search of men and animals; they prey upon injured birds that fall to the ground and stomach analysis have shown half disintegrated feathers and breaks.

HOST PLANTS

Avicennia is the tree species of obvious choice. One *Avicennia* tree with a crown of 12 sq. metres had 34 nests of all the three species of birds; many nests touched each other and there was perfect balance

and co-existence among different species. In 1970, actual counting revealed 336 nests on 50 well dispersed trees, while in 1971, 500 nests were counted on 50 well dispersed trees. The following statement shows the percentage of host plants :

Tree species	Percentage of host tree in breeding areas	Species of birds that built nests
1. *Avicennia* sp.	83.4	All species of birds
2. *Excoecaria* sp.	13.7	Openbill Stock only
3. *Xylocarpus* sp.	1.8	—do—
4. *Rhizophora* sp.	0.8	—do—
5. *Aegiceros* sp.	0.3	—do—

Most of the nests were hardly 3 metres above ground level.

NESTS

Their Construction

Nest construction starts from the first week of June and continues for 10-15 days in each case; but as new pairs regularly come and construct nests, the entire operation lasts for 1-2 months. Egrets and cormorants construct their nests once for all and after hatching of the eggs, repairing stops; but in the case of Openbills, patch-repair of the nests continue, till the fledglings are ready for their final flight.

Soft and leafless branches of *Excoecaria* are the principal nest-building material. The next choice is *Avicennia* with a fair percentage of *Phoenix* (Cormorants and egrets avoid this). The fibrous nature of leaflets is no hindrance to the collection. Branches of *Derris*, *Cereops* and *Xylocarpus* have been found in the construction. Green leaves are used as a soft cushion for egg-laying. This is more rigidly observed by the Openbills than the others.

As the nests are constructed very close to each other, there is hardly any reconnaissance for site selection. The nests are built 3-5 metres above the ground, but at high tide they are hardly 2 metres above the water surface. Nest building continues throughout the day by both the parents till the laying of eggs. Openbills come first, followed by egrets while cormorants come last. Fresh nests are built every year.

Nest Size

The following are the sizes of nests of different types of birds.

Photo 6 A niche of birds at Sajnekhali in breeding season.

Species	Size of nests in centimetre			Weight of nest in grams	Period taken to construct nest in days
	Length	Width	Circum-ference		
1. Openbill stork	45	36	130	1,200	15
2. Large egret	45	40	126	1,146	14
3. Little cormorant	30	30	120	580	12

N.B. The figures are averages of 10 nests of each species selected at random among 150 nests measured.

The nests of the cormorants are more compact and neater than the others. The Open-bills are rather careless and docile birds and their nests are comparatively delicate and are prone to storm and other damages. There is, however, great uniformity in the construction of nests.

Fate of Nests

The table shows the fate of different categories of nests : .

	In percentage			Remarks
	Openbill	Large egret	Little cormornt	
1. Nests with viable eggs which hatched successfully	50.5	58.0	81.0	
2. Nests destroyed by storm	21.0	23.0	9.0	
3. Nest deserted	18.5	9.0	nil	Reason unknown
4. Nest with dead embryos	10.0*	10.0*	10.0*	

*In the severe storm of September, 1970 about 10% of the nests were destroyed and many fledglings died in the nest due to cold and starvation.

The desertion may be due to death, either of the parents being trapped in the villages or killed by lizards.

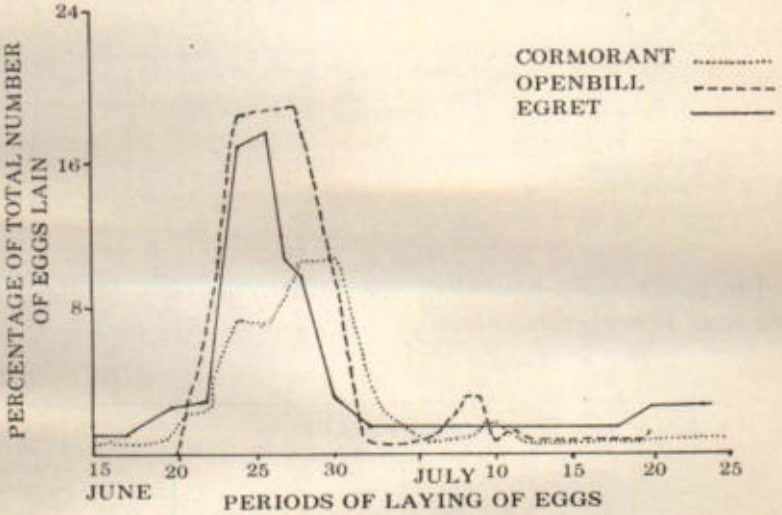
EGG LAYING, HATCHING AND TRAINING OF FLEDGLINGS

Eggs are not found in all nests. The reason may be that either the

male or female birds are killed during food collection or eggs are eaten by predators.

Date range of the laying of eggs (Graph-1)

PEAK PERIOD OF LAYING OF EGGS
(HATCHING CURVES SHOW SAME TEND)
GRAPH — 1



Observations were made on 150 nests in three species of birds and random selection of ten nests of each species were made and the date range was noted as follows:

Species	Openbill	Egret	Cormorant	Remarks
First lay	1st day	1st day	1st day	The peak
Second lay	3rd day	3rd day	3rd day	period of
Third lay	5th day	5th day	5th day	laying is
Fourth lay	7th day	7th day	7th day	from 22.6.71
Fifth lay	9th day	—	9th day	to 7.7.71.

N.B. It was only when the eggs were destroyed, that a few pairs of openbills were found to have 6th or 7th lays but this happened rarely.

The size and weight of eggs

This is shown in Table 1. As the size and weight of the eggs did not differ much among the individuals of each species, fractional

measurements have been avoided. Such fractions would not have given any special indications.

Incubation period

This is calculated as the interval between the laying of the first egg till its hatching.

The pattern is as follows :

Species of birds	Incubation period in days	Weight of eggs in grams	Weight of nestling on hatching in grams
1. Openbill	31	60	60
2. Large egret	21	40	40
3. Little cormorant	28	20	20

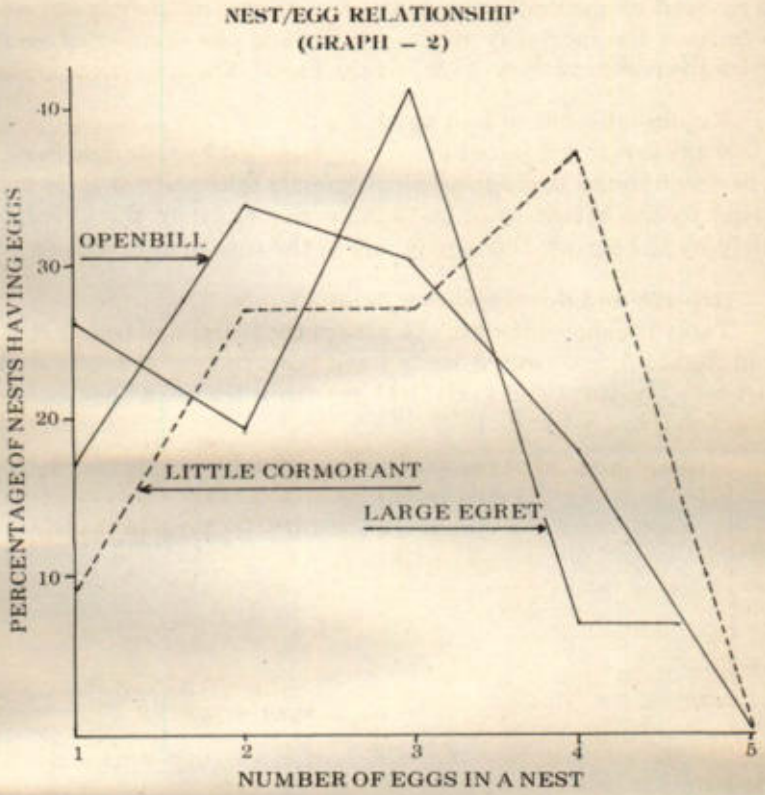
The time taken by different species of birds from hatching till flying stage is reached is as follows :

Species of birds	Start of first flying in days after hatching	Final flight from nests in days	Remarks
1	2	3	4
1. Openbill	37	47 to 52	After leaving the nests, the fledgings stay on for a month on the tree top before leading independent lives.
2. Large egret	37	47 to 52	
3. Little cormorant	23-27	33 to 42	

Between the start of first flying and the final flight from the nest, cormorants train their fledglings in water once, for an hour, in the morning during low tide. The Openbill and egret fledglings hop about from tree to tree, following their parents. Egret fledglings also go to the mud banks with their parents during low tide. Openbills prefer the tree tops.

Table II shows the incubation period and weight at hatching of a few fledglings. Fractions in weight have been rounded up.

Pattern of laying eggs. (Graph2)



More than 300 nests were examined and the pattern, as percentages, was found as follows :

Species	Number of eggs in each nest (in percentage)					Remarks
	1	2	3	4	5	
1. Openbill	17.2	33.4	30.3	18.0	0.7*	In 90% of the cases, eggs were laid on alternate days
2. Larget egret	26.4	19.8	40.6	6.6	6.6	
3. Little cormorant	9.0	27.0	27.0	37.0	—	

* Among openbills, the 6th and 7th hatch covers 0.4%.

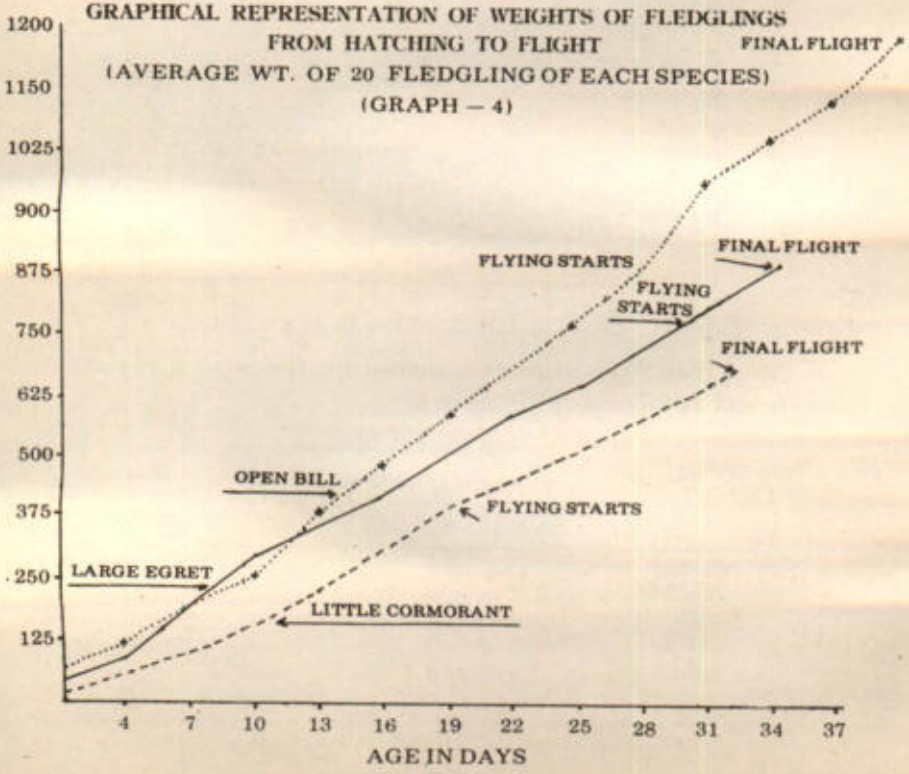
What are the reasons for such differences in the clutch size? Could it be (i) physiological capabilities of egg production, (ii) eggs that can be covered by incubation surface (iii) adjustment by natural selection to balance the mortality in the species and the number of young for which the parents can provide enough food? These have to be studied.

Replenishment of lost eggs

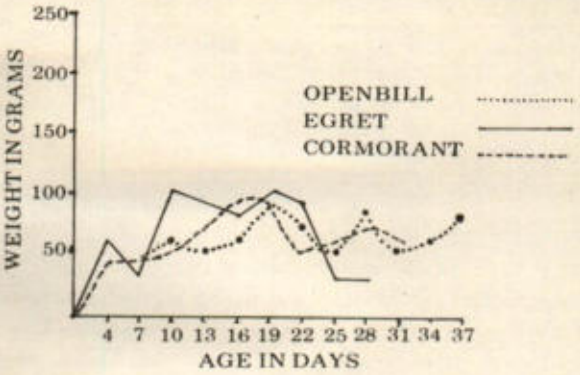
Eggs lost to predators are not replenished by re-laying in all cases. It has been found that such replenishments take place at early stages of laying to the extent of only 13.2% and mainly by the openbills and rarely by the egrets. Damage is rare in the case of cormorants.

Growth and development

Table III shows the growth rate of the fledglings from hatching to final flight. A few elected nests have been chosen at random for this purpose. The total and periodical growth rates have been represented on graph (Graph 4 and 5).



PERIODICAL INCREMENT IN WEIGHT
(GRAPH – 5)



PARASITISM

Not a single case of nest parasitism has been observed, either inter-specific or intra-specific.

PREDATORS

Land and water lizards and Jungle crows are the worst enemies of the eggs, nests and fledglings. The population of crows is kept at a very low level by shooting them down but the shooting of lizards is banned and therefore there is no check on their predatory activities.

Actual counts supported by footprints have resulted in the assessment of 73 (seventy-three) lizards of three species viz. *Varanus salvator* (water lizards), *V. flavescens*. *V. bengalensis* (land lizards) and they numbered 41, 25 and 7, respectively.

The following methods were adopted for the enumeration of different species of lizards (*Varanus* spp.) :

1. Counting of footprints.
2. Visual observations by way of actual counting.
3. Sight records of the different species when they mounted the trees during high tide, from boats and observation towers.

Several staff members were stationed at different vantage points along the entire boundary of the breeding area. Observations were made twice a week for 4 weeks by all the three methods described above.

The following are the details of observations and enumeration during the aforesaid eight times.

	1st	2nd	3rd	4th	5th	6th	7th	8th
V. salvator	40	41	35	41	38	41	39	41
V. flavescens	23	24	25	25	24	25	24	25
V. bengalensis	5	7	6	7	7	7	6	7

The counting of foot prints was made during low tide. Visual observations were easily made during high tide since the entire area could be negotiated by boats, and sight records at tree heights were facilitated by the fact that the lizards mounted the trees during high tide. *V. salvator*, being large in size (1 to 1.5 metre) were easily identified.

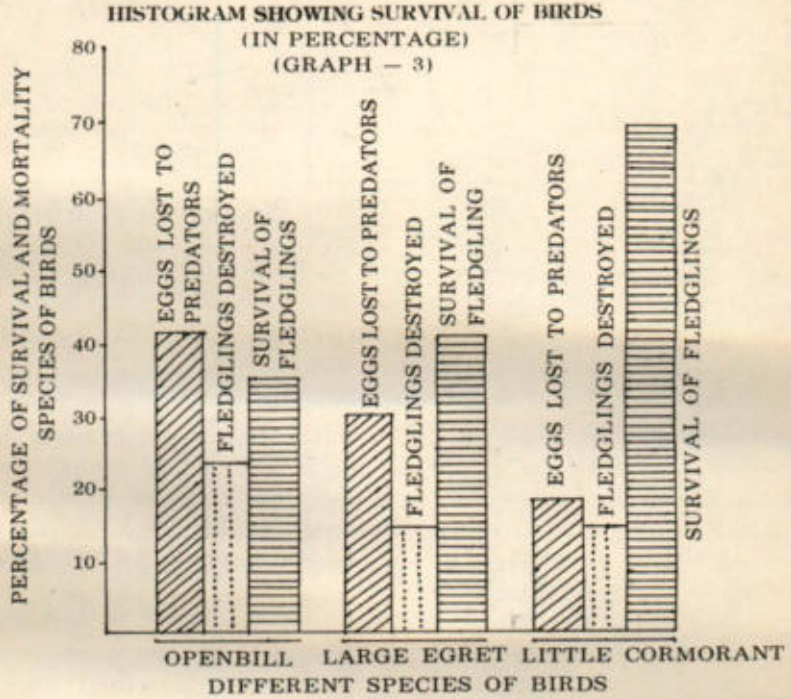
The lizards were found climbing trees most efficiently and the *Cereops* bushes suited them most, others less, and *Phoenix* least. The spreading crown of *Avicennia* afforded them a concentrated supply of food as the lizards could select eggs and fledglings of all sizes. Lizards have been observed damaging the eggs and fledglings in nest after nest and the openbills in large numbers were helpless and silent spectators against these powerful predators. The lizards were more active during low tide.

The following statement shows the loss of eggs, nests and fledglings due to predators and other reasons:

(Observation on 150 nests).

	Openbill	Large Egret	Little Cormorant	Remarks
1	2	3	4	5
1. Number of nests examined	81	44	32	These figures show that cormorants are most efficient.
2. Number of eggs counted	288 (3.6 per nest)	133 (3 per nest)	119 (4 per nest)	
3. Number of eggs lost to predators	119 (41.3%)	40 (30.0%)	23 (19.3%)	
4. Fledglings destroyed	25% of hatched eggs or 42	20% of hatched eggs or 19	15% of hatched eggs	
5. Survival per cent of fledglings	35.4% or 127	45.7% or 77	70.2% or 82	

Damage to fledglings is very little. The survival figure among the different species of birds is quite high considering the survival percentage of various other species of animals and birds. (Graph-3)



The survival of the fledglings within the whole of the Sajnakhali Sanctuary is as follows :

Species	Nests	Eggs	Fledgling that finally survived	Days from hatching to flight
1	2	3	4	5
1. Openbill	4334	15602	6878	50
2. Large egret	226	678	393	50
3. Little cormorant	215	860	593	40

FEEDING INTERVAL

The birds have a habitual dislike for brakish water food and they travel 5 to 9 Kms. or more on each occasion to collect food from sweet water marshes. The rate of feeding the fledgling, therefore, slows down. The following are the feeding intervals :

Species	Age of fledglings				Remarks
	1st & 2nd week	3rd week	4th week	5th week	
1. Openbill	4 times	3 times	3 times	3 times	There is no
2. Large egret	4 "	3-4 ,,	2 ,,	2 ,,	fixed time of
3. Little cormorant	4 ,,	3 ,,	2 ,,	2 ,,	feeding.

On moonlit nights birds of all the species collected food from village marshes but not frequently.

Mouth-feeding is done by the egrets and cormorants. Fledglings thrust their entire head into the mouth of their parents and collect food. In case of openbills, however the broken shell of the molluscs are regurgitated on the nests and the fledglings collected food from the nests. Cormorants and Egrets have been found to eat fish viz. puti, tengra, koi, khalsi, chingri, parse, mourala, and bhangon but the openbills feed mainly molluscs.

FOOD & FOOD HABITS

Although the openbills have been found to take food other than gastropods, the present observations show that 90% of the food consisted of the latter.

The Little cormorants were found to take fish mostly; small amounts of crustaceans, frogs, water insects, molluscs and vegetable matters have also been observed in their diet.

The following data have been recorded by A.K. Mukherjee of Zoological Survey of India.

	Percentage of wt. of commericial fish in relation to total wt. of food	Percentage of wt. of crustaceans in relation to total wt. of food	Total
1. Openbill	4.59	25.37	2.96
2. Large egret	72.00	3.00	75.00
3. Little cormorant	91.09	0.87	91.96

Analysis of food contents

Little cormorants: Almost 100% of the food consisted of fish. The daily consumption by the 430 adults and about 593 fledglings in the breeding area would be as follows :

(i) By the adults 100 Grams. × 430 or 43,000 grams.

(ii) By the fledglings 30 Grams. × 593 or 17,790 grams.

Therefore, the consumption of fish during (i) 100 days of the breeding period, by the adults is 43,000 Kg (ii) 40 days by the fledglings is 7116 Kg. (Adults food consumption of 100 gm has been quoted from A.K. Mukherjee's Ph.D. thesis).

This shows that the Little cormorant is harmful to pisciculture.

Large egrets: They also chiefly eat fish and the consumption by 452 adults and 393 fledglings would be about another 50,000 Kg., during the breeding period.

This species is also harmful to pisciculture.

Openbills

An analysis of the food contents made by A.K. Mukherjee of the Zoological Survey of India indicates the following:—

Mollusca	— 53.64%	Insects	— 4.35%
Crustacea	— 25.37%	*Oligochaecta* (earth worm)	— 2.09%
Reptiles (Snakes)	— 7.40	Fish	— 4.59%
Amphibia (toads & frogs)	— 2.55%		

This species, it seems, is beneficial to pisciculture.

The above calculation has not taken into consideration the food consumed by the fledglings that have died during development. It has also not taken into consideration the food consumed by the fledglings during the post-nesting stage in the forests. The above estimate is, therefore, rather conservative.

ASSESSMENT OF POPULATION

The following statement shows the result of a total count of nests in the study area (360 hectares):

Species of birds	Number of trees used for nests	Number of nests	Number of parent birds
1. Openhill	411	4334	8678
2. Large egret	59	226	452
3. Little cormorant	43	215	430

This shows a total of 9,560 birds that bred in the Sajnakhali Sanctuary; on Swan Island, 1500 breeding Openbills were counted; in Herobhanga and Ajmalmari blocks 500 Openbills were also counted. It was, therefore, found that in the breeding season of 1971, about 11,560 breeding birds came to the reserved forests of the Sundarbans. There were, however, about 1000 stray Openbills counted on different trees at Sajnakhali Sanctuary, which did not have any nests. This brings the total to 12,560 in the reserved forest area a very conservative estimate.

The Sajnakhali Sanctuary produced 6864, 338 and 329 new fledglings of the openbills, egrets and cormorants respectively, to flying stage in the 1971 breeding season.

Taking another 10% as casualties during the period of stay in the Sanctuary till migration, the total number that left the Sanctuary and its neighbourhood at the end of the breeding season was around 21,000 birds.

APPENDIX – I

ITEMS OF FOOD OF THE BIRDS (Obtained from the Ph.D. Thesis of Dr. A.K. Mukherjee of Z.S.I.)

	Openbill	Large egret	Little cormorant
1.	Reptiles: *Ptyas mucosus, Natrix piscator*	1. Reptiles: *Acrochordus graulaus, Natrix stolata*	1. Reptiles: Nil
2.	*Amphibia: Rana tigrina, Bufo melanostictus*	2. *Amphibia* Nil	2. *Ampibia: Ranasp.*
3.	*Pisces: Channa punctata, Anabas testudineus*	3. *Pisces Pangasius panagasius, Mystus gulio, Mystus* sp., *Aplocheilus panchax, Angulla bengalensis, Muraena tile, Murdenesox cinereus, Sk ongylura strongylura, Chelon* sp., Several other species	3. *Pisces: Mystus gulio, M. vittatus, M.* sp. *Chela* sp., *Puntius sarana, P ticto, Catla catla, Labeo bata, Mugil tade, Anabas testudeneus. Channa punctata Channa punctata*
4.	*Mollusca: Pila* sp., *Viviparus bengalensis, Melonoides* sp., *Lymnaea* sp.	4. *Mollusca: Lymnaea* sp., *Nerita* sp. *Viviparus bengdiensis, Melanoides* sp., *Pila* sp.	4. *Mollusca: Melanoides scabra, Lymnata acuminata Lymnata acuminata*
5.	*Crustacea: Scylla serrata,*	5. *Crustacea: Metapennaeus* sp.,	5. *Crustacea: Macrobrachium*

	Paralelphursa jacquemonti	*Scylla serrata; Varuna litterata*	*lamarrei, Metapeneus brevicornis*
6.	Insects: Grass-hopper, Crickets, Long-horned grasshoppers	Insects: *Ceriagrion* sp., *Crocothemis* sp., *Pantala* sp., Several other species.	

TABLE – I

The size and weight of eggs and nests

Nest No.	Serial Number of egg	Circumference in cm. Individual of egg length × width	Average	Size & Wt. of nests in cm. & gm.	Wt. of eggs	Remarks
1	2	3	4	5	6	7
		Little cormorant				
I	1	12 × 10		25 × 32 580		
	2	12.5 × 10.5		25 × 30 580		
II	1	12 × 10		30 × 30 570	20 gm	As there is striking uniformity, only average data of all three species are shown in the Table.
	2	12 × 10	12 × 10	32 × 30 580	in Av.	
	3	12 × 10		30 × 30 590		
III	1	12.5 × 10		30 × 30 570		
	2	12 × 10		30 × 32 580		
	3	12 × 10		30 × 30 590		
		Openbills				
I	1	16 × 14		45 × 36 1200		
	2	16.5 × 14		35 × 35 1150		
	3	16 × 14		45 × 36 1200		
II	1	16 × 14		30 × 32 1250	60 gm.	
	2	16 × 14	16 × 14	45 × 36 1250	in Av.	
II	1	16 × 14.5		40 × 36 1300		
	2	16.5 × 14		45 × 36 1200		
	3	16 × 14.5		45 × 36 1100		
		Large egret				
I	1	15 × 12		40 × 45 1140		
	2	15 × 12		45 × 35 1190		
II	1	15.5 × 12		45 × 40 1150		
	2	15.5 × 12		45 × 35 1140	40 gm.	

1	2	3	4	5	6	7
	3	15.5 × 12	16 × 14	45 × 40 1100	in Av.	
III	1	15 × 12.5		45 × 40 1140		
	2	15 × 12		45 × 40		
	2	15 × 12		45 × 40 1160		
	3	15 × 12		45 × 40 1130		

TABLE –II

Incubation period and weight at hatching of a few fledglings

Nest No.	Serial Number of egg	Wt. in Grams of eggs at laying	Dates of		Incubation period	Wt. in grams of fledglings at hatching; individual Wt. in gm. average	
			Laying	Hatching			
1	2	3	4		5	6	
			A. Littlecormorant				
1	1	20	24.6.71	24.7.71	30	20	
	2	20	27.6.71	25.7.71	28	20	
	3	20	30.6.71	29.7.71	29	20	20
	4	20	02.7.71	30.7.71	28	20	
2	1	20	30.6.71	28.7.71	28	20	
	2	20	02.7.71	30.7.71	28	20	
	3	2	04.7.71	2.8.71	28	20	20
	4	20	06.7.71	4.8.71	28	20	
3	1	20	22.6.7*	19.7.71	28	20	
	2	20	24.6.71	21.7.71	28	20	
	3	20	26.6.71	23.7.71	28	20	20
	4	20	28.6.71	26.7.71	28	20	
	5	20	30.6.71	28.7.71	28	20	
4	1	20	24.6.71	21.7.71	28	20	
	2	20	26.6.71	23.7.71	28	20	
	3	20	28.6.71	26.7.71	28	20	20
	4	20	30.6.71	28.7.71	28	20	
	5	20	02.7.71	1.8.71	29	20	
5	1	20	24.6.71	23.7.71	29	20	
	2	20	26.6.71	25.7.71	29	20	
	3	20	28.6.71	30.7.71	28	20	
	4	20	30.6.71	30.7.71	30	20	20
	5	20	02.7.71	29.7.71	27	20	
	6	20	04.7.71	2.8.71	28	20	

1	2	3	4	5	6	
6	1	20	22.6.71	21.7.71	29	20	
	2	20	24.6.71	24.7.71	30	20	
	3	20	26.6.71	24.7.71	28	20	20
	4	20	28.6.71	26.7.71	28	20	
7	1	20	22.6.71	21.7.71	29	20	
	2	20	24.6.71	24.7.71	30	20	20
8	1	20	26.6.71	24.7.71	28	20	
	2	20	28.6.71	26.7.71	28	20	
			B—Openbills				
1	1	60	28.6.71	28.7.71	30	60	
	2	60	30.6.71	1.8.71	31	60	
	3	60	2.7.71	3.8.71	31	60	60
	4	60	4.7.71	4.8.71	30	60	
2	1	60	24.6.71	24.7.71	30	60	
	2	60	26.6.71	27.7.71	31	60	
	3	60	28.6.71	29.7.71	31	60	60
	4	60	30.6.71	31.7.71	31	60	
3	1	60	24.6.71	24.7.71	30	60	
	2	60	26.6.71	26.7.71	30	60	
	3	60	28.6.71	29.7.71	31	60	60
	4	60	30.6.71	31.7.71	31	60	
4	1	60	24.6.71	24.7.71	30	60	
	2	60	27.6.71	28.7.71	31	60	60
	3	60	30.6.71	31.7.71	31	60	
5	1	60	28.6.71	28.7.71	30	60	
	2	60	30.6.71	2.8.71	32	60	60
	3	60	3.7.71	4.8.71	31	60	
6	1	60	8.7.71	7.8.71	31	60	
	2	60	11.7.71	9.8.71	30	60	
	3	60	14.7.71	13.8.71	31	60	60
	4	60	17.7.71	15.8.71	30	60	
7	1	60	28.6.71	29.7.71	32	60	
	2	60	2.7.71	1.8.71	31	60	
	3	60	4.7.71	5.8.71	32	60	60
	4	60	6.7.71	6.8.71	31	60	
8	1	60	24.6.71	26.7.71	32	60	

1	2	3	4		5	6	
	2	60	27.6.71	28.7.71	31	60	
	3	60	30.6.71	2.8.71	32	60	60
	4	60	3.7.71	4.8.71	33	60	
			C—Large egret				
1	1	40	14.6.71	5.7.71	21	40	
	2	40	16.6.71	7.7.71	21	40	40
2	1	40	24.6.71	14.7.71	21	40	
	2	40	26.6.71	16.7.71	21	40	40
	3	40	28.6.71	18.7.71	21	40	
3	1	40	20.7.71	11.8.71	22	40	
	2	40	22.7.71	12.8.71	21	40	40
	3	40	24.7.71	14.8.71	21	40	
4	1	40	20.7.71	10.8.71	21	40	
	2	40	24.7.71	13.8.71	21	40	40
5	1	40	24.6.71	14.7.71	21	40	
	2	40	26.6.71	16.7.71	21	40	40
	3	40	28.6.71	18.7.71	21	40	
6	1	40	24.6.71	14.7.71	21	40	
	2	40	27.6.71	17.7.71	21	40	40
	3	40	30.6.71	22.7.71	23	40	
7	1	40	24.6.71	14.7.71	20	40	
	2	40	26.6.71	15.7.71	19	40	40
	3	40	28.6.71	18.7.71	20	40	
8	1	40	24.6.71	14.7.71	20	40	
	2	40	26.6.71	15.7.71	19	40	40
	3	40	28.6.71	18.7.71	20	40	
9	1	40	24.6.71	14.7.71	20	40	
	2	40	26.6.71	16.7.71	20	40	40

A—Little cormorant
Weight of fledglings from hatching to final flight
(Two representative nests selected out of 32)

Nest No.	Age in days	Weight in grams of fledglings			
		1	2	3	4
I	1st day	20	20	20	20
	4th „	40	40	40	40
	7th „	60	60	100	100
	10th „	80	100	160	200
	13th „	200	150	220	320
	16th „	280	200	300	410
	19th „	340	300	400	500
	21st „	375	390	480	590
	25th „	450	435	540	680
	28th „	530	500	570	740
	31st „	—	550	—	—
	*Weight Index	4.0	3.6	3.7	2.7
VIII	1st day	20	20	20	—
	4th „	40	60	60	—
	7th „	100	130	100	—
	10th „	200	180	150	—
	13th „	320	230	220	—
	15th „	410	290	310	—
	19th „	500	380	400	—
	22nd „	590	470	450	—
	25th „	680	520	510	—
	28th „	740	580	580	—
	31st „	—	—	—	660
	*Weight Index	27	3.7	3.0	

*Weight on the first day expressed as a percentage of the weight on the final day.

B—Openbills

Weight of fledglings from hatching to final flight.

Nest No.	Age in days	Weight in gramsoffledglings			
		1	2	3	4
I	1st day	60	60	60	
	4th ,,	120	100	100	
	7th ,,	180	140	150	
	7th ,,	180	140	150	
	10th ,,	260	200	210	
	13th ,,	380	280	290	
	16th ,,	480	390	370	
	19th ,,	590	480	480	
	22nd ,,	680	600	580	
	25th ,,	770	720	700	
	28th ,,	890	810	800	
	31st ,,	980	920	910	
	34th ,,	1060	1030	1020	
	37th ,,	1120	1170	1200	
	40th ,,	1200	1230	1230	
	43rd ,,	1280	—	—	
Weight Index		4.7	4.9	4.9	
VIII	1st day	60	60	60	60
	4th ,,	90	100	120	120
	7th ,,	110	150	100	150
	10th ,,	140	210	240	220
	13th ,,	200	320	310	300
	16th ,,	260	400	390	400
	19th ,,	340	490	470	490
	22nd ,,	420	580	570	560
	25th ,,	520	680	660	640
	28th ,,	590	720	760	720
	31st ,,	660	880	810	810
	34th ,,	750	920	900	900
	37th ,,	840	1020	980	960
	40th ,,	920	1100	1080	1080
	43rd ,,	1000	1200	—	—
	46th ,,	1100	—	—	—
Weight Index		5.4	5.0	5.5	5.5

C—Large egret

Weight of fledglings from hatching to final flight

(Two representative nests selected out of 44)

Nest No.	Age in days	Weight in grams of fledglings			
		1	2	3	4
	1st day	40	40	40	40
	4th ,,	90	90	100	100
	7th ,,	140	140	175	180
	10th ,,	190	190	250	250
	13th ,,	240	290	320	310
	16th ,,	300	350	400	380
	19th ,,	365	410	490	450
	22nd ,,	430	485	570	550
	25th ,,	480	520	610	610
	28th ,,	540	565	680	700
	31st ,,	620	600	710	720
	34th ,,	700	700	760	790
	37th ,,	790	780	800	final flight taken place
Weight Index		5.0	5.1	5.0	5.0
VRI	1st day	40	40	40	40
	7th ,,	100	110	100	90
	10th ,,	180	190	175	120
	13th ,,	250	230	250	195
	16th ,,	330	300	325	250
	19th	390	360	385	310
	22nd ,,	440	410	450	400
	25th ,,	500	480	500	500
	28th ,,	600	540	600	580
	31st ,,	680	610	690	610
	34th ,,	720	700	720	650
	37th ,,	750	740	—	700
	40th ,,	—	760	—	860
Weight Index		5.3	5.3	5.5	5.0

It is worthwhile to give an account of avifauna of the locality.

General Observation on the Birds of Sajnakhali area

Herons, egrets, storks, ibises, cormorants, darters etc, which nest in colonies, find the forest areas safe for breeding. Common water birds that breed in the sanctuary are white ibis, open bill stork, black necked stork and night heron. Two species of pheasants have been observed such as jungle fowl and swamp partridge. The kingfishers are resident in the mangroves and the common species are black capped king fisher, white collared king fisher and the brown winged king fisher.

This sanctuary is visited by a number of seasonal visitors like whimbrel, blacktailed Godwit, the little stint, the eastern knot and the curlew sandpiper. The Green shank, the terek sandpiper and the snipe billed Godwit flock to the swamps with the onset of winter in November and remain till the season gets warmer.

The giant heron and the spot billed pelican also casually visit the area.

Some sea birds like Herring gull, Lesser crested Tern, the Shooty tern etc. visit the forests.

Birds of Reclaimed Areas

The marshes and swamps in the reclaimed areas have many species of bird as these habitats provide a permanent home to many marsh birds and attract many which migrate to this area. The marsh birds that are found throughout the year are herons, egrets, bitterns, storks, rails, cranes etc. The cattle egret is often associated with other egrets, bitterns and paddy birds such as smaller egrets, little egrets, large egrets, purple heron,grey heron, night heron,little green bittern and pond heron.

The fresh water marshes in the reclaimed area have pheasant tailed jacana, the white-breasted water hen, the painted snipe and the little ringed plover. In the swampy clearing there are cotton teal, the dabchick, the lesser whistling teal all of which are resident birds.

Migratory birds that visit the area are ducks, teal, geese, sand piper, plover, snipes etc. The common teal, the brahminy duck, the pintail, the white eyed pochard and the red crested pochard are seen there in winter. Near the mud-banks of tidal water large and small flocks of sand pipers, the common red shank and the whimbrel are found.

In the cultivated areas openbilled stork feed on snails closely associated by redwattled lapwing.

There are birds of prey to maintain equilibrium in nature and they are crested serpent eagle, pallas fishing eagle, the white bellied sea eagle, the Brahminy kite, the pariah kite, the shirka, the crested Goshawk, the grey headed fishing eagle, Osprey, the marsh terrior, the peregrine falcon, the krestrel and white backed vultures.

Of the owls commonest are Barn owl, the scops owl, the spotted owl, the brown hawk owl, the brown fish owl and the great horned owl.

Some terns and the skimmers are found all the year round. They are the gull billed tern, the large crested tern, the Indian lesser crested tern. The seasonal visitors are the great black headed gulls, the brown headed gull, the black headed gull, the whiskered tern, the caspean tern, the river tern, the common tern the little tern and the shooty tern. Common king fishers are the pied king fisher, the white breasted king fisher, the white collared king fisher, the black caped king fisher and the brown-winged king fisher.

Common birds during the flowering and fruiting seasons (March to September) are parakeet, doves, bulbuls and barbets. Most of them feed on the fruits of keora, hental and gnewa. Other birds are cuckoos, rollers, wood peckers, larks, swallows, drongos, crows, treepie, crow-pheasant, shrikes, babblers, flycatchers, thrushes, pipits, sea birds, flower peckers and finches.

Food habit of birds of reclaimed area

From the stomach analyses of large number of birds it has been found that most of the species are carnivorous; few frugivorous,. Dove, parakeet and barbets have been found to eat fruits of keora, hental and gnewa. Food habits of some species of birds change as they move in the reclaimed area or go deep into estuarine area.

Three species of birds under special study have the following pattern of food habit.

In the reclaimed area observations have been made on the food habits of about 20 species of birds and it has been found that their food selection is rather specific. Some take snails, crabs, insects, reptiles and tadpoles, some mainly snails, some mainly vegetable food, some mixed food as above along with fish. Taking all these together, fish is found to form the principal item of food of most of the birds; next comes perhaps crabs, then snail. Insects, reptiles, toad and spiders form specialised food of several species.

It is, therefore, seen that every family of vertebrate and invertebrate that occur in the marshes and ponds has to be preserved along with their habitat.

HONEY BEE (APIS DORSATA)

Honey Production and Behaviour Pattern of the Honey Bee

The tract dealt with

The vast expanse of tidal swampy forests of the Sundarbans studded closely with fantastic labyrinths, bifurcations of rivers around tiny mud-flats are one of the thickest and impenetrable where the honey bee (*Apis dorsata*) migrate during March to June every year. Numerous swarms of bees are flung into ceaseless activities in collecting nectar from vast tracts of forests flushed with fragrant flowers and forming huge low comb, contrary to high level ones, close to the ground level. In a tract where venomous snakes, sharp toothed sharks, lusty crocodiles, mysterious flambyont tigers and delicate spotted deer add fury and beauty, the behaviour pattern of the honey bee is a very fascinating study. Honey collection in this animal infested terrain, where the forests are impenetrable, mud extremely soft, lands inundated twice a day by high tide, innumerable sharp and hard pneumatophores point dangerously above ground level, is the most hazardous, laborious and risky of all types of works in the Sundarbans forests.

Object of study

The study has been initiated to ascertain (i) the percentage of different plant species that form the host plant of the honey bees, (ii) if the bees are selective of any particular plant or plants for making combs and what is the percentage of different host plant species, (iii) if the comb size has any relation with the yield of honey and wax, (iv) if the height of combs from the ground level has any relation with yield of honey and wax, (v) if the pollen analysis of honey samples can indicate the nectar preference for any particular flower or flowers, (vi) the peak period of production, and (vii) the death pattern of the honey collectors and other permit holders from the maneaters.

Methods of study

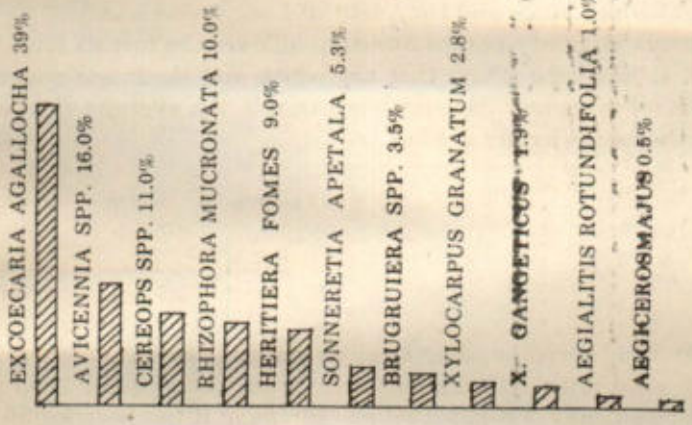
Innumerable honey combs were inspected in different parts of the forests over wide area. The measurement of length, width and thickness were noted and honey and wax production for each comb was measured. These observations were also made by the field foresters and

forest guards all over the forests (the tract is extensive and difficult) and recorded in statements specially made for this purpose. Innumerable honey collectors were also interrogated and their observations recorded. All these observations were later summarised. Samples of honey were microscopically examined and the host plants were identified from the pollen grains. Total collections from time to time were enumerated and correlated with flower production; fortnightly collections of honey were measured and continued for a period of 75 days.

Host Plant

The histogram (No. 1) shows the following percentage of the host plant (of honey comb):

Avicennia species	16.0%
Heritiera fomes	9.0 ,,
Xylocarpus granatum	2.8 ,,
X. gangeticus	1.9 ,,
Rhizophora mucronata	10.0 ,,
Cereops species	11.0 ,,
Aegialitis rotundifolia	1.0 ,,
Excoecaria agallocha	39.0 ,,
Aegiceros corniculatus	0.5 ,,
Sonneretia apetala	5.3 ,,
Bruguiera gymnorrhiza	3.5 ,,



Graph No. 1

Histogramic Representation in Percentage of different host plants of Honey comb.

Excoecaria trees are of obvious choice although this tree does not either form suitable crown or have spreading branches. *Phoenix excoecaria* formation forms an ideal habitat for the honey comb formation. The cool atmosphere and moisture laden tunnel formed by *Phoenix* palm with the *Excoecaria* branches hanging over the thickets have maximum number of combs per unit area. Contrary to this, *Sonneratia apetala*, the tallest and branchy tree of the Sundarban forests does not have sufficient number of combs. *Xylocarpus* species are preferably avoided although the trees have thick dense crown and are branchy; yet *Heritiera* with its sporadic occurence and light thin crown have quite good percentage of comb in them. *Cereops* species which occupy 90% of the forest areas have only 11% of the combs; the reasons may be the shrubby bushes of *C. roxburghiana* and unbranched thick crown of *C. candolleana* of which both are found unsuitable for comb formation. The *Rhizophora* and *Avicennia (A. alba* and *officinalis)* have proportionately high percentage of comb although the trees grow only along the island boundary and beside the creeks, khals and rivers. The honey bees avoid such trees growing open or along a wide khal and is evident from complete absence of the combs from the trees standing along the boundary of islands that generally form the inspection route of the forest staff; contrary to this, these species when occuring along narrow creeks inside the islands have good number of combs.

Comb sizes and the yield of honey and wak

Innumerable honey combs occuring all over the forests have been measured. It has been found that the width and thickness are rather constant in all cases and the length is variable. An average idea can be had from the measurements below :

	Length	*Width*	*Thickness*
Maximum	120 cm.	95 cm.	7.5 cm.
Average	75-90 cm.	37-45 cm.	6 cm.
Minimum	37-45 cm.	25 cm.	6 cm.

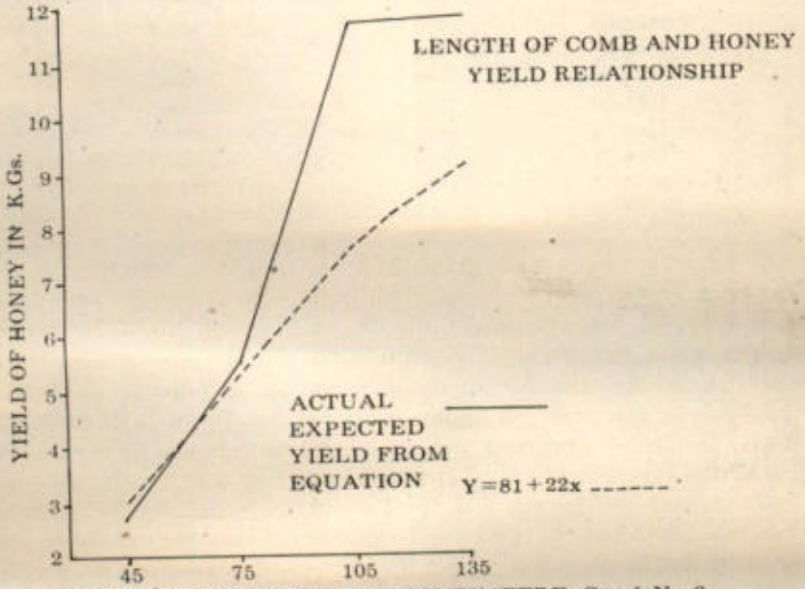
Honey yield corresponding to all available sizes was noted and the results of yield with size and distance from the ground level were analysed statistically. From actual measurement it has been found that combs of one cft. volume yield about 3 kg. of honey, combs of 1.25 cft. yield about 4-6 kg., combs of 1.5 cft. yield about 10 kg. and 2 cft. about 14 kg. of honey, but the last two sizes are not of general occurence.

But the honey output possibly depends on various factors like *(i)* proper strain of honey bee, *(ii)* ideal weather condition, *(iii)* size of comb, *(iv)* first or second formation, *(v)* distance from ground level and *(vi)* optimum flowering of tree species, and other factors.

A swarm of bees generally form only one honey comb on a tree however branchy and wide crowned the trees might be. It is only in 5 to 10% cases that two honey combs are formed on a tree. In such cases one becomes bigger and another smaller. This perhaps is formed when there are two queen bees in a swarm. Not a single tree was found with three combs. Generally all the combs are constructed on a new site; although the waxy bases of honey combs are left out on the branches to invite the honey bees to form combs for the second time, it is only in 7.3% cases that a second comb has been found constructed on the left out waxy base of the first hive. The combs on the slanting branches, have been found to yield more honey than those on horizontal branches. Honey accumulates on the lower portions of the comb.

It has been found that the combs which are made early in the season are bigger in size. Combs those face right angle to the rays of the sun have high honey contents.

The overall trend of the yield of honey and the length of comb are shown in graph No. 2.



Graph No. 2

Comb distance from the ground level and honey yield

The honey combs are formed at a very low height contrary to the comb formation by this very species elsewhere. The trees in these forests are 5 to 10 metres tall, yet few combs are made above 4-5 metres from the ground level. Optimum height is 1.5 to 2.0 metres from the ground level. A survey of 406 trees showed that only ten trees had combs above 2.5 metres from the ground level, the rest were at heights from 1.5 to 2.5 metres.

TABLE I

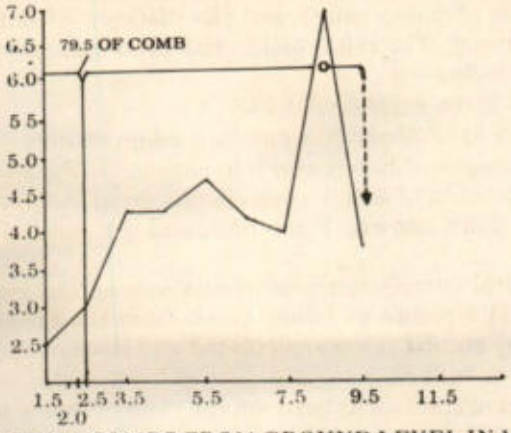
Table showing the quantity of honey, wax collected during 1963-64 to 1971-72, corresponding number of honey collectors and the number of casualties due to maneater.

Year	Total No. of collectors of honey and wax	No. of casualties amongst (2) due to maneater	Qn. of honey collected in quintals	Qn. of wax collected in quintals
1	2	3	4	5
1963-64	1352	11	1323.8	100.1
1964-65	913	6	599.6	34.2
1965-66	1070	10	959.2	67.8
1966-67	944	10	773.0	62.6
1967-68	1140	13	889.5	128.5
1968-69	1107	19	718.6	71.0
1969-70	1016	11	680.5	57.3
1970-71	1476	7	912.9	74.7
1971-72	1495	9	890.0	72.1

Effort has been made in the table 1 to find out a definite relationship between honey yield with length of honey comb and distance from the ground level. The relationship is shown in graph No. 3. It shows that honey yield has definite relation with the size. Normally, with the increase in the distance of comb from the ground level there is an increase in the yield of honey upto the height of 2.59 metres. Any increase in height beyond that meant decrease in the yield of honey.

Another clear observation made was that during the last phase of honey comb formation low level branches were avoided and higher branches selected. It is owing to forest environment close to ground getting hot in the lower region. For the comb formation for the second time *Avic ennia. Sonneretia. Bruguiera* and *Rhizophora* species are

DISTANCE FROM GROUND LEVEL/HONEY YIELD RELATIONSHIP



DISTANCE OF COMBS FROM GROUND LEVEL IN METRES

Graph No. 3

NB. This shows that some manipulation is necessary is induce the Honey Bees to make combs at least for 5.5 to 8.5 metres from the G : L.

selected. Honeycombs formed in the *Excoecaria-Phoenix* formation were found at a height as low as 60 cm. to 240 cm. from the ground level. (In *phoenix* area the high tide water does not reach the tree level. Crabs have been found to eat honey in these combs.)

The honey combs that are made for the second time have four characteristics as follows :

(i) They are made far above ground level.

(ii)They are smaller in size, but

(iii)They yield comparatively more honey.

(iv)The quantity of wax is proportionately more than the first formation.

Honeycombs those are formed at the fag end of the season from *Excoecaria agallocha* nectar are smaller in size but the honey content is comparatively more. Statistical analysis of random sample of 60 combs suggests that in 98% cases the distance of honey comb from the ground level lies within 1.5 metre to 2.1 metre. But the optimum distance of honey comb which yields the maximum quantity of honey has been found to be 2.5 metre, other factors remaining constant.

Statistical analysis of the yield of honey relating to comb length and comb distance from the ground level

The results of analysis summarized indicates the following:

(1) The yield of honey in a comb has definite relationship with the size of honey comb and the distance of honey comb from the ground. The relationship has been statistically established as the following :

$Y = -2.105 + 2.696X + .003Z$ (A)

Y = Yield of honey in a comb in kilogrammes

X = Length of honey comb in cm.

Z = distance of honey comb in cm. from the ground level.

If X and Z are known, Y can be found out easily from the above equation.

All the total correlation coefficients among the yield of honey in honey comb (1) distance of honey comb from the ground, (2) and the length of honey comb (3) were calculated and the correlation coefficient are calculated as follows :

$r12$ = Correlation coefficient between the yield of honey in comb and the distance of honey comb from the ground = 0.26

$r13$ = Correlation coefficient between the yield of honey in comb and the length of honey comb = 0.80

$r23$ = Correlation coefficient between the distance of honey comb from the ground and the length of honey comb = 0.32

All the correlation coefficients have been statistically tested applying 't' test of significance and the comparison of observed values of 't' with the corresponding table values of t at .05 level of significance implies that a definite mathematical relationship exists amongst the three variables. Several partial correlation coefficients have also been calculated and suitable tests of significance support the following facts :

(1) The coefficients of correlation between the yield of honey in comb and the distance of comb from the ground is due to the influence of the length of comb upon both the yield of honey in comb and the distance of comb from the ground level.

(2) The correlation coefficient between the distance of honey comb from the ground level and the length of honey comb is due to the influence of yield of honey in a comb upon both the distance of honey comb from the ground level and the length of honey comb.

The partial correlation coefficients were calculated as follows :

$r12.3 = 0.007$

$r23.1 = 0.197$ where

$r12.3$ signifies correlation coefficient between the yield of honey in comb and the distance of comb from the ground eliminating the effect of the length of comb and $r23.1$ signifies similar meaning.

Multiple correlation coefficient of the yield of honey in comb upon the distance of comb from ground level and the length of comb is

computed as follows:

$$r1.23 = \frac{r^2 12 + r^2 13 - 2r12r13r23}{1 - Y^2 23}$$

$$= 0.79$$

To test the significance or otherwise of $r1.23$, 'F; test of significance is employed. The corresponding 'F' was found to be highly significant at 1% level of significance.

If the $r1.23$....P = 0 or in other words the population correlation coefficient is zero, then

$$F = \frac{r^2 1.23 .... P/(P-1)}{(1 - r^2 1.23 .. P)/(n-P)}$$ is distributed

as F with P – 1 and n – P degrees of freedom.

The fact that the distance of comb from the ground and the size of comb have considerable influence upon the yield of honey in comb has been established. In other words, the multiple regression equation obtained as in (A) serves as an excellent formula for predicting the yield of honey from given values of distance of comb from the ground and the length of comb.

Phenology and Honey Production

The peak period of flowering of different species of flowering plants can be divided into several 15-days phases as follows :

Phase I. March 20th to April 5th *Aegiceros corniculatus, Acanthus illicifolius, Suaeda maritima* and *Sisuvium portulacustrum*
March 31st to April 15th *Phoenix paludosa;*
April 5th to April 20th *Cereops* species.

Honey formed from the first four flowers has thick consistency and is creamy white in colour. Honey made from *Aegiceros* nectar is considered best and is cream coloured. Honey from *Cereops* is a bit reddish.

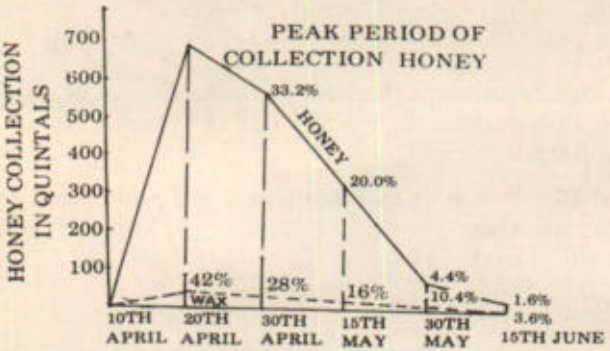
Phase II. April 15th to May 5th *Sonneratia apetala.*
Honey derived out of these flowers is yellowish and slightly light.

Phase III. May 1st to May 20th *Avicennia* species.
The honey has reddish tinge and is light.

Phase IV. May 20th to June 5th *Excoecaria agallocha.*

The honey has reddish colour and taste is slightly aidic and hot. It has an effect of fermented burn throat. Bulk collection of honey occurs in the following sequence from April to June. The results are graphically

represented in graph No. 4, as follows :



Graph No. 4

Best Period of Production of Honey and Wax

April 1st to April 15th40.8%; April 16th to April 30th33.2%; May 1st to May 15th20.0%; May 16th to May 31st4.4%; June 1st to June 15th1.6%.

This gives an impression that bulk honey is produced from *Aegiceros corniculatus, Xylocarpus* species, *Acanthus illicifolius* (a shrub), *Phoenix paludosa* and *Cereops.*

Similarly the honey that are collected during the latter half of April is mainly from *Sonneretia* and *Cereops.* The last phase of collection is from a mixture of many species of which *Excoecaria agallocha* contributes maximum (verified from the pollens study).

But analysis of a few samples of honey under the microscope also shows the pollengrains of several species that do not even occur in the reserved forests area or in the vicinity. Such analysis show good quantity of *Cereops* pollen and the pollens of *Crotalaria* and several other species that do not occur in the Sundarban forests.

Nectar Pollen Production and Weather

Nectar is a product of glandular secretion. All the flowering trees of the Sundarbans have small and fragrant flowers (*Acanthus illicifolius* and *Derris* species have bigger flowers). Nectar and pollen grains are food of the bees. The colouration in honey, it is held by some experts, is due to climatic conditions and also owing to the chemical composition of the nectar. The pollen grains of the following species have been found mixed with honey:

Acanthus illicifolius Yellow pollen grain; *Rhizophora mucronata* Cream coloured grain; *Bruguiera gymnorrhiza* Vermillion coloured grain; *Xylocarpus species* Yellow to deep brown grain; *Cereops species* Cream coloured grain; *Phoenix paludosa* Red coloured grain. They do impart some colour to the honey.

Why does the honey bee, *Apis dorsata* migrate to the Sundarban forests during March to July? Do the vast low forests with profuse, nectar yielding, fragrant flowers attract them? In migrating to these forests they have to cover hundreds of miles and work in an atmosphere where humidity varies from 75% to 85%. They work during the period in tropical humid climate, yet the bees detest continuous rain on bright sunny days, the former being detrimental to flush of flower and nectar formation and the latter for changing the optimum humidity and temperature level. Sunny days with intermittent optimum rains are ideal for honey production. Excessive rain or lack of rain affects normal honey production. Storms in the flower flushing season damage the flowers. The best nectar, it is said, is produced under the influence of suitable soil and in favourable climate; the Sundarbans perhaps provide such a soil and climate.

Honey Bee and Wild Life

The honey bee operates in an area where entire land mass is flooded in high tide and the land animals have to lead an amphibious life. Most important land animals are tigers, spotted deer, pigs and monkeys (*Macacca mullata*). It has been observed that the monkeys and tigers are interested in honey and they do break the low lying combs; the monkeys are said to smear the body with a thick layer of silt before approaching the combs; crabs (*Scylla* sp., *Portunnus* sp., and Mutata species), have been found to cling on the combs. Even though some acquatic mammals like little porpoise, Lizards (*Varanus* sp.), Brackish water snakes (*Natrix* sp., *Enphdris* sp., *Gerardia* sp.), Terrestrial snakes (*Naja* sp., *Dryophis* sp., *Phython* sp) and *Crocodilus porosus* live near the lowlying combs, yet the honey bees, it seems, are unconcerned. It is not known why the combs are made within easy reach of the animals. Gastropods (*Nerita* sp., *Telescopium* sp., *Melongena* sp., *Lymnaea* sp., *Orchidium* sp.) must be associated with the comb in some way or other.

Wax production

Wax is a secretory substance that comes from the body of the honey bee. The relationship between wax and honey in a comb has been found out and has been graphically represented.

In order to find out relative proportion of honey and wax, a random

sample of 66 honey combs was statistically analysed.

In order to find out the linear regression equation of yield of honey upon wax, let us assume the equation in the following form:

$$Y = a + bx$$

Where Y = Quantity of honey

X = ,, ,, wax

and a, b are constants to be found from the solutions of the following normal equations derived by the method of least squares.

The following normal equations are to be solved to find out 'a' and 'b'.

$246.6200 = 66a + 16.9250b$ ... (1)

$155.9980 = 16.9250a + 11.1698b$. (2)

Solving equations (1) and (2), we find, a = .265, b = 13.564.

The constants a, b being known the linear relationship between the quantity of honey and corresponding quantity of wax can be found out from the relationship:

$$Y = .265 + 13.564X \quad \text{....'C'}$$

Where Y = quantity of honey in quintals.

X = corresponding quantity of wax in quintals.

If one of the variables is known, other can be found out easily from 'C'.

Honey and wax production versus Human casualties

The number of collectors of honey and wax, the quantity of honey and wax collected and the number of human casualties during the year 1963-64 to 1971-72 were analysed statistically. This signifies the extreme problematic and dangerous area where the daring honey collectors have to work.

Conclusion

The present study is by no means final and it is intended to continue further investigation. It has enabled the authors to find out the principal plant species responsible for best honey production, the best size and height of the combs from the ground level that yield maximum honey, and many other relevant information not so far recorded from this area. The findings have immense economical significance and it should be possible to manage the forests and formulate better work schedule for the honey collection.

FISH

Bio-Ecological Study on Fish and Fish Resources and Biological basis of a Rational Fishery

Statistical analysis of the data collected for the study has clearly indicated that a rational and scientific exploitation of fish species inhabiting the rivers and creeks of Sundarbans estuary has immense economic potentialities.

West Bengal holds an important position in fish development as she has all types of Captive and Culture fisheries, Beach fisheries and Brackish water fisheries also occupy a very important part.

A survey of forest areas of Sundarbans indicates a total annual catch of fish to be 2500 metric tonnes. On an average 4000 persons are engaged in daily fishing with 1.5 kilogrammes of fish catch per fisherman per day and during the 6 months from September to February on an average 6000 persons are engaged in fishing. About 70% of total catch of fish is collected during this period.

The following facts account for the sharp decline in fish catch in Sundarbans estuaries :

(i) There is a sharp competition amongst the fishermenthe number having been increased 8 times since 1962 (500 fishermen) were daily engaged every year between 1962 to 1965 (as per Shri. G.N. Mitra's report). The sharp competition induces over-fishing which in a biological sense is a condition of the stock in which, due to excessive catches, the numbers of individuals which are capable of reproducing under the optimal (average) conditions cannot ensure the maintenance of the stock i.e. when the reproductive capacity of the population cannot compensate for the losses due to fishing.

TABLE I

Catch of fish during the different months

		Catch in Tonnes
January	—	305
February	—	300
March	—	125
April	—	115
May	—	90
June	—	95
July	—	150
August	—	175
September	—	294
October	—	276
November	—	285
December	—	290

(ii) Rate of siltation ohas made rivers/creeks rather shallow and difficult for fishing.

(iii) Salinity percentage has showed a steady rise in all the rivers/creeks which is detrimental to fish breeding.

(iv) Catch of brood and immature fish in the estuaries.

Length weight relationship

Statistical analysis was carried out to find length weight relationship if any, and coefficients of condition were established for 4 economic fish species viz., Hilsa, Parse, Bhangan and Bhetki.

The following length weight relationships were obtained :

(1) $W = 166.0\,(L)^5$ for Bhetki

(2) $W = .015\,(L)^3$ for Parse

(3) $W = 0.46L^2$ for Hilsa

where W is weight in grammes and L is length in centimetre.

Hilsha (Hilsa ilisha)

Average length of fish catch varies between 24 to 48 centimetres while the weight varies between 125 grammes to 1950 grammes; the coefficient of condition is 1.29 at 29 cm. length while it is 1.93 at length 46 cm. which is maximum.

Bhetki (Lates calcarifer)

Average length varies between 20 cm to 97 cm, and the weight varies between 100 gms to 4100 gms.; the coefficient of condition is 2.55 at length between 38 to 46 cm; then the value falls off.

Bhangan (Mugil tade)

Average length varies between 15 cm to 62 cm., while the weight varies between 30 gms. to 3000 gms.; the co-efficient of condition is 2.74 (a maximum value) at length 28 cm.

Parse (Mugil parsia)

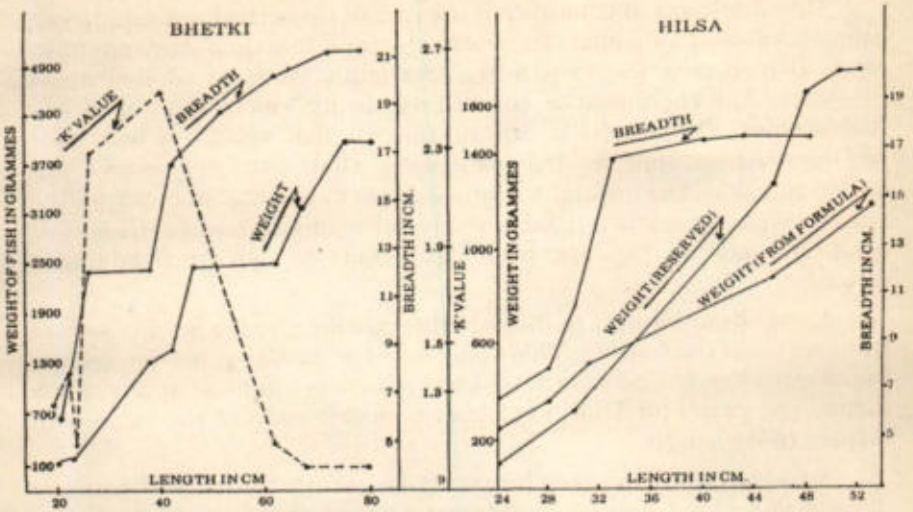
Average length varies between 12 cm. to 19 cms., while the weight varies between 20 gms. to 110 gms.; the coefficient of condition is 2.19 (a maximum value) attained at a length of 16 cm.

Significance of coefficient of condition :

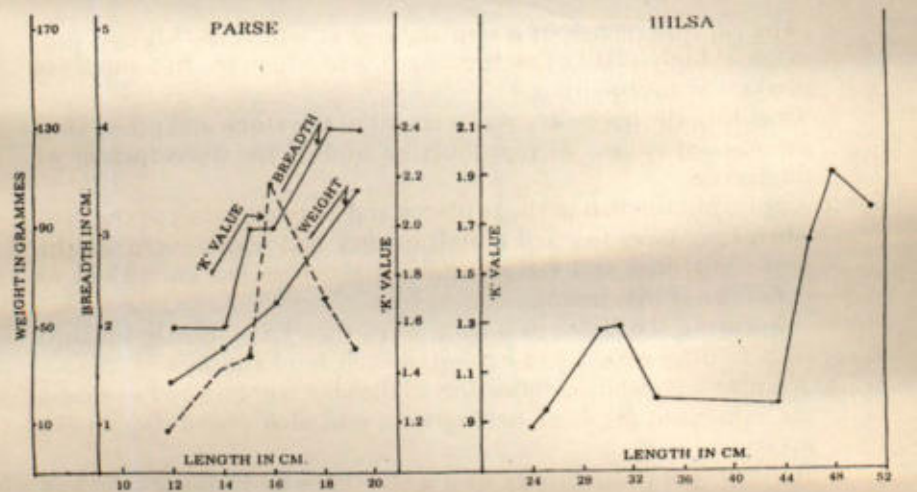
The coefficient of condition is given by the formula :

$$K = \frac{10^5 \times W}{L^3},$$

where W is weight in grammes and L is the length in millimetre.



Graphs



Graphs

The coefficient of condition is dependent upon the food supply and calorific value of food apart from other factors. It is thus uneconomic to catch fish before they reach the optimum value of coefficient of condition. The coefficient of condition is being calculated for other fish species. For scientific exploitation of fish species a ban may be imposed so that no fish is caught that does not attain the optimum value. The optimum coefficient of condition also indicates the age of attaining maturity. Such study for evaluation of coefficient of condition has, so far, not been calculated for fish of Sundarbans estuaries.

It may be of interest to find whether coefficient of condition suffers from seasonal fluctuation. This value may be calculated for fish species found elsewhere to find out the effect of saline environment upon the fish fauna. The graph for Hilsa explains the distribution of the value with respect to its length.

A further study has been initiated to ascertain the length frequency distribution of fish species at different seasons of the year.

Similarly the coefficient of condition is under calculation on spotted deer, wild pig etc. to find out how in these animals this 'K' value varies with seasons.

Thus, in organizing a rational fishery, which would ensure a high productivity of the stock of commercial fishes, besides establishing the permissible size of the catch, it is essential to institute the following measures :

1. The capture of fish of a size and age at which the highest production of high quality fish is ensured, and where the fish supply is used most rationally.
2. Ensuring the necessary replacement of the stock and preserving the normal course of reproduction and of the development of the larvae.
3. Capturing the fish in those places and at those times of the year when they have reached a high quality and where there are the best nourished and fattest individualswhere the coefficient of condition is maximum.
4. Capturing the fishes at a time when they have mostly finished their feeding period and exploited their food supplies.
5. A suitable legislation reflecting all the above points and adopting the minimum mesh of fishing nets and also restricting to the rotational fishing.
6. Raising the productivity of a water-mass by introduciong and acclimatizing new commercial fishes and even food organisms for

the fish and identifying quickly the regions of maximum fish concentrations.

Technology alone cannot lead to the improvement of fish resources without recourse to biology. The problem is to find the factors which govern this process, and to develop methods of controlling them with the aim of increasing the productivity of the stocks of commercial organisms.

Sample Survey

In order to determine zones of maximum concentration, a sample survey was conducted in some of the rivers/creeks of Sundarbans estuaries during December, 1971 and then a table was formed showing the quantity of fish species versus places of catch (collection). A suitable analysis of variance table was then formed to indicate the zone/zones of concentration from the statistical analysis.

Analysis of variance table

Sources of variation.	Degree of freedom	Sum of squares.	Mean square	F Observed	F P = .05	P = .01
Places	11	13601861.3	1236532.8	3.02	1.79	2.25
Fishspecies	13	7290091.2	560776.2	1.37	1.71	
Error	143	58571679.5	409592.2			
Total	167	79463632.0				

Total Sum of Squares

$$: \quad 81194410 - \frac{(17052)^2}{14 \times 12}$$

: 79463632 d.f. : 167

Place Mean Square : 1236532.8 d.f. : 11

Fish Species Mean Square : 560776.2 d.f.: 13

Error Mean Square : 409592.2

Thus it is seen from the analysis that the observed F ratio for places is highly significant even at 1% level of significance, but for fish species the observed ratio is slightly less than the table value of F for 5% level of significance.

It is seen (Table II) that the maximum concentration of fish species

is noticed in Thakuran river. Thakuran river is significantly more abundant in fish species than those in other rivers/creeks appeared in the sample.

Fish and vegetable food

Preliminary investigations have shown the presence of about 50 species of Diatoms, 30 species of green algae and about 18 species of blue-green algae in the eastern Sundarbans region. Further investigation is necessary to register the presence of many more speciesevidences of which have been recorded by the authors.

Available fishery literature does not mention one Coelathrum species and one Ulva species which are very abundant on the pneumatophores and tree trunks of those which are periodically inundated. These two algae have been found in stomachs of Periopthalmus and Bolepthalmus (mud-skippers), Pangash, Paira chanda, Lacho, Bhangon, Pankhaki and several other fish species.

Kan magur and Pangas fishes have been found to eat avidly the fruits of the Keora (*Sonneratia apetala*) and Bain (Avicennia species).

In fact during August, September and October tonne and tonne of fruits fall on water when these fishes concentrate near the bank to feed on them. One pangas fish weighing 12 kgs. was found to have about 1 kg. of Bain fruit in its stomach. This fish had layers of yellow fact deposition.

The growth of fishes and fat contents indicate that these vegetable food are responsible for (i) fat deposition and (ii) growth. These data have been statistically analysed and a suitable coefficient of correlation was calculated which has evidenced the relationship.

A new type of non-nitrogenous growth hormone tetrahydrogibberallic acid has been found in the leaves of Keora (communicated by Dr. S.M. Sircar, Director, Bose Institute, Calcutta).

It has to be verified if this growth hormone has any significant effect on fish and even on deer, birds, monkeys and men that feed either on leaves or fruits of Keora. Dr. Sircar has been requested to examine Bain fruits. In fact several University authorities are working on root bark, stem bark, leaves and fruits of most of the mangrove species for alkaloids, steroids etc. Their findings could have tremendous significance if combined with bio-ecological observations. The Bain leaves are heavily infested by an insect pest (Hymenoptera). The defoliation is likely to affect flower and fruit production; as a result owing to dearth of fruit,o migration of Pangas and Kan magur may be seriously jeopardised.

TABLE – II

Showing the quantity of fish collected (Sp. wise) in kgs. during December 1971 in the rivers/creeks of Namkhana Range West of Matla – Vidya River)

Place of collection	Chingri	Parse	Bhetki	Hilsa	Pompret	Bhola	Topse	Chandan	Datne	Sale	Bhangan	Fesha	Medh	Sankar	Total
Thakuran	8,272	3,193	537	20	20	1,295	25	72	9	61	75	134	35	–	13,741
Saptamukhi	225	130	17	–	–	77	8	–	–	–	–	–	–	25	482
Vidya	75	30	10	–	–	10	–	15	–	–	17	5	–	–	162
Chhotovidya	80	20	8	80	–	10	–	–	–	–	40	30	–	–	268
Kalash	60	80	50	50	–	–	–	–	–	10	15	–	–	–	265
Bainchapi	180	15	40	40	15	–	–	10	–	–	5	–	–	–	305
Dhuli Bhasani	60	75	15	15	20	80	–	–	–	15	25	25	–	–	330
Banifuli	358	508	–	–	10	80	–	–	–	–	10	–	–	–	966
Matla	20	25	–	–	3	–	–	–	–	–	30	20	–	–	98
Herobhanga	–	10	25	25	15	30	–	–	–	10	20	40	–	–	175
Maipit	25	30	–	–	25	15	–	20	–	–	–	–	–	–	105
Dhainchi	10	30	20	20	15	15	–	30	–	–	5	10	–	–	155
	9,365	4,146	722	250	116	1,612	33	147	9	96	242	264	35	25	17,052

Fish and Bird

Fish forms the principal food for many bird species of this tract. Almost 100% of food of little cormorant consists of fish. An adult little cormorant consumes about 100 gms. per day, while the estimated food of its fledgling is about 30 gms. *Channa punctate. Anabas testudineus* form the food for openbill. While *Pangasius pangasius. Mystus gulio. Aplo cheilus panchax. Anguilla bengalensis. Muraena tile. Strongylura strongylura. Chelon* spp. and several other species of fish form the food of large egret. In case of little cormorant, the food consists mostly of the following fish species : *Mystus gulio. M. vittatus. Mystus* spp., *Chela* spp., *Puntius sarana. P. ticto. Catla. Labeo bata. Mugil tade. Anabas testudeneus. Channa punctate* etc.

Piscivorous fish and column feeder

Dissection of stomachs of most of the fish have shown that chingri and small molluscs are primary ingredients of food.

Hilsa Fisheries

Life history of this fish in the Bay of Bengal has not so far been studied in detail and little has been done on its food, feeding and breeding habits. Methods of catch render scientific studies most difficult.

Even in 1962-63 annual hilsa catch was 1158890 kgs. or 1158.89 tonnes from the Sundarbans, but gradually the quantity of catch showed a declining trend and at present the catch is very meagre. A survey indicates annual catch of 150 tonnes of Hilsa from the estuaries during 1971-72.

Reasons for such low output may be due to :

(i) Siltation of river mouths near the sea and formation of sand bank.

(ii) No closed season has been observed in rivers/creeks during July September to save brood.

This calls for immediate and thorough research on this dwindling fish species.

Dry fish industry at Jambudwip

During June to October enormous masses of water run into the rivers carrying into them huge quantities of biogenic material. These biogenic materials when enter into the sea, enormous masses of planktonic algae attract crustaceans from places far distant from the river mouth. These planktonic algae and crustaceans form food of Bombay duck (Harpodon species, Trichiurus species; also of. Chakul, Nuroli, Camet, Medh and Phal fishes).

Therefore mass collection of Bombay duck may be made during the rains, although at present collection is done during winter months only. This may be investigated.

The vast quantity of fish (2,000 metric tonnes) collected by the fishermen (12,000 in number) dried and disposed of through middle men. We could help the fishermen by directly buying from them; also try helping them to catch fish during rains.

The success of catch and improvement of financial status of the fishermen are intimately connected with their safety inside the Reserve Forests. They are not afraid of man-eaters, crocodiles, but they want dacoities be completely stopped.

Organizing a Rational Fishery for Estuarine tract of Sundarbans

In organizing a rational fishery which might ensure a sustained productivity of the stock of commercial fishes, the following measures need be instituted :

(i) Capture of fish when K. value is maximum.

(ii) Ensuring the necessary replacement of the stock and preserving the normal course of reproduction and of the development of the larvae.

(iii) Imposing restrictions on the size of nets to be used in fishing and only the nets allowing the permissible size of the catch need be employed in fishing.

(iv) Capturing the fish at those places and at those periods when the K-value is maximum.

(v) A suitable legislation need be enforced reflecting all the points dealt with in the aforesaid paragraphs and adopting minimum mesh of fishing nets, and

(vi) Raising the productivity of a watermass by introducing and accilimatizing the new commercial fishes and even food organisms for the fish and identifying quickly the regions of maximum fish concentration.

(vi) The idea of rotational fishing can be given suitable trials to obviate overfishing and the statistical analysis of the data on period sampling enumerations of zone/fish species frequently need be immediately initiated to find out the optimum quantum of stochastic fish exploitation in various zones (rivers/creeks etc.) of the Sundarbans estuary.

Conclusion

It is thus clear that in Sundarbans, the study of fish fauna cannot be made in isolation. On the other hand, any such study forms only a part of the entire mass of a closely knit string. Only an integrated scientific

investigation of plant and animal can be significant in respect of such a study. The organisation of a rational fishery in Sundarbans does not brook any delay and holds bright promise for the future to make a significant headway in the economy of West Bengal.

ESTUARINE CROCODILES

Statistico-Ecological Study on *Crocodilus porosus* in Mangrove Forests.

Tiger on land and crocodile (*Crocodilus porosus*) in water are the horror and beauty of Sundarbans.

Crocodiles are well distributed all over 2500 sq km in Sundarbans, but there are some concentrated Zones of occurrence. Saptamukhi river, Chhoto Vidya river, Nawabanki and Mechua Khal and water areas near the Revenue Stations of Dhainchi, Patharprotima, Saptamukhi, and Kultali are the concentrated zones. In past three years at least 60-70 have been sighted each year at different parts of the forests during the winter months.

Every year at least 6 persons get killed and taken away by these man-eating crocodiles operating in Saptamukhi and Dhainchi areas.

No measurements of length, head, girth, width and height of the animals killed have been kept in the past. Even the measurement of brain weight and skull length were necessary. While 5 metre long crocodiles are quite common, animals of length of 7 to 8 metres are also sighted. The girth of an average corcodile measuring 4 metre in length was found to be 1.20 metre.

Much study is yet to be made about the behaviour pattern of the animals. Two crocodiles have been registered to have fought near Dhainchi Station in the winter of 1971; while fighting they stood on their tails and slapped each other. They are exceedingly cunning, their mode of attack at the prey differs sharply; they often bask on the sunny mud flats keeping their mouths open (many theories are ascribed to this behaviour).

During the months of April and May, eggs (30-70 eggs laid at a time) and croclings have been slighted and although high salinity might have affected their population expansion in the estuarine tract, no where in the world such associations between hundreds of varieties of fish, water and land lizards, pigs, spotted deer, birds and tigers (man-eaters) could be found. Naturally enemies destroy the majority of croclings at birth as otherwise the streams and marshes would be choked with the teeming mass of crocodiles as they lay large number of eggs at a time. Eggs hatch after 3 months. At birth a baby is 20 cm. long, aggressive and fierce from the moment they quit the shell and snap viciously at

anything in the vicinity. They eat water insects, small crustacea and fish; when about 3 m. long a crocodile will like to take meat. Like tiger once he has killed a man, human flesh is the only meat that seems to satisfy his voracious appetite. To the authors' estimation the crocodiles of Sundarbans are man-eaters, but more is to be investigated.

A scientific study should be initiated to observe their breeding habits, sex distribution, food and feeding habits, sizes and behaviour pattern in their estuarine tract with suggestions for their protection before it is too late. However, the present study centres round size & weight of the animal.

STUDY DATA:

The tables (1 and 2) show the data of 8 males and 16 female crocodiles (Table 1) and 5 male and 11 female crocodiles (Table 2) with respect to their length, weight, snout, length, skull length, and tail length. These 40 crocodiles which are reared at Bhagabatpur crocodile farm of Sundarbans were released in the tiger project area of Sundarbans. 24 crocodiles (8 males and 16 females) which were born in August, 1977 (data as per Table 1) were released on 12th May 1979 and the observations as per Table 1 were recorded on the same date before release and 16 crocodiles (5 males and 11 females) which were born in August, 1976 (data as per Table 2) were released on 11th May, 1979 and the observations as per Table 2 were recorded also on the same date before release. In order to find out if there is any statistically significant discriminant character between the two sexes, t-test of hypothesis was applied for each of the character with respect to the data obtained from both the samples. The basic assumptions made for testing of this hypothesis are:

(1) that in each population the characters are normally distributed.
(2) that the unknown population standard deviations of the distributions of characters are equal and
(3) that the sample observations in each set are random and mutually independent, one set being independent of the other.

In this testing of hypothesis, we are to test the null hypothesis Ho: $(\mu_1 = \mu_2)$ against all alternatives H: $(\mu_1 \pm \mu_2)$ where μ_1 and μ_2 are the population means of two characters under study, the test criterion can be formulated as,

$$t = \frac{\bar{x}^1 - \bar{x}^2}{S^1\sqrt{\frac{1}{n^1} + \frac{1}{n^2}}}$$ under null hypothesis which follows

t = distribution with n1 + n2-2 degrees of freedom.

Where x1 = sample mean of the character with respect to one set.

x2 = sample mean of the character with respect to other set under comparison.

n1, n2 are the sizes of samples which for the first sample are 8 and 16 and for the second sample are 5 and 11 in the present case.

$$\text{and } s^1 = \frac{\{(\Sigma jx^2 1j\text{-}n1 \times 1^2) + (\Sigma jx^2 2j\text{-}n2 \times 2\text{-}^2)\}}{n^1 + n^2 - 2}$$

Where x1j and x2j are the individual observations for the first and second sets of sample.

COMPUTATION OF INDEX OF DISCRIMINATION AND TESTING OF HYPOTHESIS.

Let us now proceed to find out the test criterions for testing of hypothesis and hence to determine the index of discrimination between male and female crocodiles.

(A) ANALYSIS OF DATA FROM TABLE 1.

(1) Data on length :

From the data the following are calculated as follows :

x1 = 122.625 $\quad \Sigma xij^2 = 120915$
x2 = 116. 625 $\quad \Sigma x2j^2 = 213752$
$S^1 = 28.35$ and t = .489

Comparing this with table values of t,
t .075 with 22 degrees of freedom = 1.360
t .05 with 22 degrees of freedom = 1.717
t .01 with 22 degrees of freedom = 2.508

So, Ho is accepted as the observed t (=.489) is far less than those of table values at 7.5%, 5% and 1% levels of significance. In other words it may be concluded that male and female crocodiles cannot be discriminated with respect to criterion of length.

(ii)Data on weight :

From the observed data, the following are calculated :

x1 = 7.106 : $\Sigma x1j^2 = 425.1725$
x2 = 5.809 $\quad \Sigma x^2 2j = 574.2225$
s1 = 1.5886

t=1.885 which was found to be significant at 5% level of significance, and we are to reject the null hypothesis Ho: (u1 = u2). In other words it may be concluded that weight of male crocodiles is significantly more than that of female crocodiles and as such the weight may be taken as an index of discrimination.

TABLE – 1
DATE OF RELEASE : 12.5.79

Sl.	Male with date of birth in August, 1977 (C. porosus)					Female with date of birth in August 1977 (C. porosus)				
	Length (L) in centimetre	Weight (W) in kilogram	Snout length (S.L.) Centimetre	Skull length (SK.L.) Centimetre	Tail length (T.L.) in Centimetre	Length (L) in centimetre	Weight (W) in Kilogram.	Snout length (S.L.) in centimetre	Skull length (SK.L) in cm.	Tail length (T.L.) in cm.
1.	125	8.0	12	21	67	120	7.0	12.0	20.5	64.5
2.	128	8.0	13	21.5	68	128	8.0	13.0	21.0	69.0
3.	128	8.0	13.5	22	66	107	4.0	11.5	18.5	57.0
4.	128	7.0	13	21	68.5	101	3.5	10.0	17.0	53.0
5.	129	9.0	13.5	21	68	119	6.5	18.0	19.0	53.0
6.	128	8.0	13	21.5	67	128	7.0	13.0	20.0	68.0
7.	108	4.5	11.5	17.5	56.5	113	5.5	11.0	19.0	58.0
8.	107	4.35	11.5	18.5	56	106	3.5	11.0	17.8	56.0
10.						125	8.0	13.0	20.5	66.5
11.						113	5.0	11.5	19.0	59.0
12.						112	5.5	11.0	18.0	58.0
13.						125	7.5	12.5	20.5	66.0
14.						117	5.6	12.0	19.5	61.0
15.						126	6.4	13.0	20.0	66.0
						122	5.95	12.5	21.0	63.5
Average	122.625	7.106	12.625	20.5	64.625	116.625	5.809	12.1875	19.629	60.875

TABLE – II
DATE OF RELEASE : 11.5.79

	Male with date of birth in August, 1976					Female with dateofbirth in Aug. 1976				
Sl. No	Length (L) in centi-metre.	Weight (W) in kilo-gram.	Snout length (S.L.) in cm.	Skull length (Sk.L.) in cm	Tail length (T.L.) in cm.	Length (L) in centi-metre	Weight (W) in kilo-gram.	Snout length (S.L. in cm.	Skull length (Sk.L.) in cm	Tail length (T.L.) in cm.
1.	145	9.5	15.0	22	72	114	3.5	12.0	19.0	61.0
2.	151	11.0	14.5	22	72	135	7.0	14.0	21.5	70.0
3.	154	11.0	15.0	25	73	144	8.5	15.0	24.0	70.0
4.	140	8.5	14.0	23	70	144	9.0	14.5	24.0	70.0
5.	141	7.5	15.0	21	71	153	6.5	15.0	24.0	72.0
6.						141	8.0	14.5	23.5	70.0
7.						136	7.5	14.0	21.5	70.0
8.						138	8.0	14.5	22.0	70.0
9.						130	11.0	14.0	20.5	69.0
10.						125	5.5	14.0	20.0	68.0
11.						151	6.5	14.0	24.0	72.0
Average	146.2	9.5	14.7	22.6	71.60	137.36	7.36	14.136	22.18	69.27

(iii) Data on snout length and skull length:

Similarly test criterions for both snout length and skull length were computed which are as follows :

Observed t for snout length = 0.17

Observed t for skull length = 0.29

Both of these t- values are found to be non-significant even at 7.5% level of significance. Null hypothesis in these cases are to be accepted.

(iv) Data on tall length :

Similarly t-value on tail length was computed which is found to be 1.63, a value greater than table value of t at 7.5% level of significance (=1.360) at 22 degrees of freedom. So Ho is to be rejected in this case and tail length can be taken as an index of discrimination for male and female crocodiles with a fair degree of accuracy.

(B) Analysis of Data from Table 2

The following table shows the observed values of t against different characters:

Character	Observed value of 1	Remarks on statistical significance.
Length	1.61	Significant at 7.5% level of significance.
Weight	2.146	Significant at 5% level of significance
Snout length	0.275	Not significant even at 7.5% level of significance.
Skull length	0.79	
Tail length	1.67	Significant at 7.5% level of significance Not the value greater than that of length.

Table Values of t

t7.5% level of significance with 14 degrees of freedom 1.377

t 5% level of significance with 14 degrees of freedom 1.761

Thus comparing the observed values of t with those of table values it may be concluded that the characters weight and tail length may be taken as statistical indexes of discrimination to discriminate male crocodiles from the female ones.

Computation of Correlation Coefficients :

From the table 1 and analysing the data, the following correlation co-efficients could be computed for male crocodiles :

	Length	Weight	Snout length	Skull length	Tail length
Male	—	0.9547	0.88	0.956	0.987
Length	—	0.9547	0.88	0.956	0.987
Weight	—	—	0.8435	0.918	0.939
Snout length	—	—	—	0.854	0.823
Skull length	—	—	—	—	0.924
Tail length	—	—	—	—	—
Female					
Length	—	0.94	0.581	0.919	0.878
Weight	—	—	0.566	0.872	0.815
Snout Length	—	—	—	2.295	0.152
Skull length	—	—	—	—	0.864
Tail length	—	—	—	—	—

It is thus evident from the above tables of correlation Co-efficients that while in case of male crocodiles, length maintains statistically significant correlations with weight, snout length, skull length and tail length and weight with snout length, skull length and tail length and snout length with skull length and tail length and skull length with tail length but in case of famale crocodiles the correlation co-efficients of length with weight, skull length and tail length and of weight with skull length and tail length and of skull length with tail length are only statistically significant but all other correlation co-efficients are not statistically significant.

CONCLUSION :

The statistical analysis of the data tends to indicate that the characters, weight and tail length may be taken as indexes of discrimination for male and female crocodiles (*Crododilus porosus*) in the swampy tract of Sundarbans. Such bio-ecological studies on *Crocodilus porosus* were never made in this estuarine tract and as such this might throw some light into hither to unknown biological properties of this fast dwindling species namely Crocodile. Similar detailed studies on this species in Sundarbans and in other areas might be interesting to confirm this observation.

ESTUARINE CRAB (*Scylla serrata*)

Breeding Biology of Sundarbans Crab Growth Study of Forsk in Mangrove Forests

Methods and Materials

Sample surveys were conducted to find out the length, breadth, frequency and weight distribution of *Scylla serrata* in the Sundarbans. A predetermined optimum number of catchers with the pre-fixed number of water crafts was employed for this study which covers a period of above five years in the vast water areas of Sundarbans. The study was so designed that the relative frequencies of crab species of different length, breadth and weight could be statistically appraised. Data on different sexes (male and female) were also obtained so that results could be compared between the male and female crab species. It was also the objective as to whether the sexual variation in the crab species has got any statistical significance in these bio-metrical observations. Special precaution was taken so that all the rivers/creeks of Sundarbans form the domain of study and simple random samples were taken from each river and creek. The sampling was so designed that each river and creek was traversed by the catchers for any hour of the day and night which facilitates the stochastic measurements of crabs.

Calculations and Results

The following table gives the length and frequency distribution of 1073 male crab *scylla serrata* and 1061 female crab *Scylla serrata* of the Sundarbans.

TABLE – 1

Length in centimetres	Percentage frequency of male crabs	Percentage frequency of female crabs
4—6	8.2	4.9
6.1—8	13.7	3.1
8.1—10	30.0	44.3
10.1—12	45.3	29.7
12.1—14	2.7	18.0

The measurements of sample of 1073 male crabs and 1061 female crabs indicate the following :

TABLE – 2

Number of observations	Number of samples	Length in centimetres (L)	Weight of male crab (W_1) in grammes	Weight of female crab (W_2) in grammes	Co-efficient of condition (K-value	
					Male	Female
1	140	5	30	25	24.0	20.0
2	180	7	70	55	20.4	16.0
3	793	9	175	130	24.0	18.0
4	601	11	325	205	24.4	15.4
5	200	12	400	300	23.2	17.3
6	188	13	475	350	21.6	16.0
7	32	14	550	—	20.1	—

The co-efficient of condition is given by the formula :

$$K = \frac{10^5 \times W}{L^3}$$

where W is the weight in grammes, and L is the length in millimetres.

The co-efficient of condition is dependent upon the food supply and calorific value of food apart from other factors.

Now in order to fit regression equations of length and weight of male and female crabs, let us assume that the regression would take the form :

$W = CL^n$ where W is the weight of the crab in grammes, L is the length of the crab in centimetres while C and n are the constants to be found from the data by the method of least squares.

So in order to solve the equations formed by way of method of least squares the Table 3 has been derived from the data shown in Table 2.

Separate regression equations had been found out for both male and female crabs.

Regression equation in the case of male crab was found out as follows :

$$W = 0.2816\ L^{2.9}$$

Regression equation in the case of female crab was found out as :

$$W = 0.6645\ L^{2.3811}$$

The observed values of weights of male and female crabs had been plotted against length and the expected values of weights of male and female crabs as obtained from the above formulae had also been shown against the corresponding length in the graph attached. The curve fitting as it has become evident from the graph has been extremely satisfactory.

The following table has been formed in connection with the curve fitting :

Table – 3

Number of obser vations	Log L =X	Log W_1 =Y_1	Log W_2 =Y_2	X^2	XY_1	XY_2	Y_1^2	Y_2^2
1	.6990	1.4771	1.3979	.489	1.032	.9771	2.181	1.9541
2	.8451	1.8451	1.7404	.714	1.559	1.4706	3.404	3.0290
3	.9542	2.2430	2.1139	.911	2.140	2.0171	5.031	4.4686
4	1.0414	2.5119	2.3118	1.085	2.616	2.4075	6.310	4.8966
5	1.0792	2.6021	2.4771	1.165	2.808	2.6733	6.770	6.1360
6	1.1139	2.6767	2.5441	1.241	2.982	2.8339	7.165	6.472
7	1.1461	2.7404	—	1.313	3.140	—	7.508	—
Total	6.8789	16.0963	12.5852	6.918	16.277	12.3797	38.369	26.95674

In order to proceed for analysis of variance it is necessary to derive the suitable test criterion for testing the linearity of regression. So we are to formulate a table showing the observed and expected weight of male and female crabs against the corresponding length data (Table 4).

To derive the test criterion for testing the linearity of regression, the following computations were made :

(A) *In the Case of Male Crab*

$W = 0.2816\ L^{2.9}$

Sum of squares due to regression and residual sum of squares were computed and the following analysis of variance table is formed :

Sources of variation	Sum of squares	Degrees of freedom	Mean squares	F
Due to regression	1.31	1	1.31	131.0
Residual	0.05	5	0.01	
Total	1.36	6		

So the result is obviously significant. An alternative test crition would be to use $t = \frac{b-\beta}{\sqrt{v(b)}}$ follows t distribution with $(k-2)$ degrees of freedom under the null hypothesis $\beta = 0$, t is computed as $t = 11.1$ consulting t – table we find

t_{05} with 5 d.f. = 2.015

t_{01} with 5 d.f = 3.365

So in this particular example there is no reason to doubt the significance of regression.

Similarly, in going to test null hypothesis $\beta = 1$, $\beta = 2$ we conclude that these two hypotheses are also to be rejected and the hypothesis $\beta = 3$ is to be accepted.

The following statistics could be established about the male crab :

(i) The estimated regression line could be computed as $Y = 2.30 + 2.90\ (X 0.98)$

(ii) 95 per cent confidence limits for the regression co-efficient are (3.4057, 2.3943) and the null hypothesis $\beta = 3$ is acceptable.

(iii) The intercept on the Y-axis has 99% confidence limits (1.378 and + 0.298) and the null hypothesis that the intercept is zero is acceptable.

(iv) The estimated variance of an observation around its true value is 0.01.

(B) *In the Case of Female Crab*

The regression line fitted is

$W = 0.6645\ L^{2.3811}$

Analysis of variance table could be formulated as :

Sources of variation	Sum of squares	Degrees of freedom	Mean squares	F
Due to regression	0.3490	1	0.3490	6.70
Residual	0.2099	4	0.05247	
Total	0.5589	5		

Comparing this with table value

F (1.4) at 1% = 21.20

So the observed value of F is not significant at 1% level of significance. The same conclusion can be also be derived by the alternative test criterion of t – distribution.

So the following statistics could be derived in respect to female crab :

(i) The estimated regression line is given as $Y = 2.0975 + 0.983$ (X 0.9554).

(ii) 95% confidence limits for the regression co-efficient are (1.787 and 0.179) and that the hypothesis $\beta = 1$ is to be accepted.

(iii) The intercept on the Y – axis has 99% confidence limits (2.5673 and – 0.2505) and the hypothesis that the intercept is zero is acceptable.

(iv) The estimated variance of an observation around its true value is 0.05247.

TABLE – 4

Table showing the observed and expected weight of male and female crabs against the corresponding length data.

Number of observation	Length of crab in cm (L)	Observed weight in grammes		Log L	Expected weight of crab from formulae in grammes					
					Male crabs			Female crabs		
		Male crab (W_1)	Female crab (W_2)		2.9 log L	Log W = −.5503 + Col. (6)	W	2.3811 Log L	Log W = −.1755 + Col. (9)	W
1	2	3	4	5	6	7	8	9	10	11
1	5	30	25	.6990	2.0271	1.4768	29.97	1.6644	1.4869	30.68
2	7	70	55	.8451	2.4508	1.9005	79.52	2.0122	1.8347	68.34
3	9	175	130	.9542	2.7672	2.2169	164.7	2.2720	2.0945	124.3
4	11	325	205	1.0414	3.0201	2.4698	294.9	2.4797	2.3022	200.5
5	12	400	300	1.0792	3.1297	2.5794	379.1	2.5706	2.3931	247.3
6	13	475	350	1.1139	3.2303	2.6800	478.6	2.6524	2.4749	298.5
7	14	550	—	1.1461	3.3237	2.7734	593.4	—	—	—

Observation

This study is by no means, final. It contains the preliminary observations on male and female crabs in the waters of Sundarbans. The statistical analysis of the data collected has indicated a definite correlation of weight with the length of the crab species, the percentage frequency of male and female crab against length could also be derived from the study. The co-efficients of condition determined for both male and female crab species have also thrown some light into the field of biometry. It was observed that a male crab attains the maximum value of co-efficient condition when his length is 11 cm and the weight is 325 grammes. While the trend of co-efficient of condition in any case of female crab does not show any definite pattern. More indepth study is required to find out if the co-efficient of condition follows any definite trend in case of female crab. But the available indication obtained tends to show that the maturity in case of female crab comes earlier than her male counterpart, if the co-efficient of condition is recognised as the index of maturity.

This preliminary study can form the basis for further detailed bio-ecological studies for *Scylla serrata*.

WILDLIFE BIOLOGY OF OTHER ANIMALS

Grotesque

Land and Water Liazards (Sonagadi and Ramgadi) of Sundarbans

Yellow coloured *Varanas flavescans* (Land Monitor) and *V. salvator* (water monitors) are two animals whose skins are much sought after by poachers for export purposes.

No scientific studies on the biology of these lizards have been undertaken in this tract. Visitors to Sajnakhali Bird Sanctuary in July-August will register their unqualified views about their grotesque look, cautious movement and peculiar behaviour in the bird breeding area where predator - pray relationship is very distinctly visible. They eat hundreds of eggs and fledglings in the bird sanctuary area in breeding season.

The authors collected some data on the total length and weight, length from snout to vent, length of tail etc. of the monitors. More measurements are under scrutiny. Water lizards grow to a much bigger size than the land ones. 73 such lizards were counted in 1971 inside a small area of the bird sanctuary. They are all carnivorous and are well dispersed in the forests. They breed during early rains.

From the count of foot prints on mud flats in different blocks the authors are of opinion that there is no cause for alarm about their extinction.

Since the skins are exceedingly valuable and these animals do not

cause harm to any resident fauna, complete ban on their shooting should be continued.

SUNDARBANS : THE WORLD OF CRABS SNAILS AND OTHER ANIMALS

Innumerable species of crabs, snails, marine borers, amphibia, insecta, arachnida and annelida occur in the reclaimed and tidal areas of Sundarbans. Of these animals, snails and crabs are wide spread and most important. Much work is yet to be done on the dispersion and associations of these species. Most of the fishes, birds and marine animals feed on innumeable species of crabs and snails. Some of the common types of animals are described below:—

Marine borer and damage of trees:

i) *Teredo manii (Kuphus manii)*
ii) *Bankia campenellata*
iii) *Bactoronophorus thoracites*
iv) *Nausitora lanceolata*
v) *Nausitora sajnakhalensis*

These borers have been found to damage timber extensively. To what extent the damage is done has not yet been ascertained.

It is necessary to ascertain their population as the larvae form food for various marine animals and fish. The authors think that investigations will reveal much important facts.

In this connection it is worthwhile to mention about several species of *Balanas* (barnacles) that from peculiar types of structures on trees.

Amphibia:

Amphibians are few in the reclaimed areas. The load *Bufo melanostictus* is rarely seen. The tree frog *Raconhorus maculatus* is common.

In sweet water reservoirs *Rana hexadactyla* (Pati-beng), *Rana limnocharis* (Dhani-beng), *R. tigrina* (Sona-beng) sometimes occur. The toad, *Bufo melanostictus* (Kunobeng) is very common and found everywhere. *Microhyla ornata* is the smallest amphibian found in the area.

Mullusca:

In fresh water *Vivipara bengalensis, Melanoides tuberculatus, M. scarbra, Lymnaea acuminata, Indoplanonbis exustus* and *Pila* species are found.

Some of them, *Pila*, in particular, form food materials for many water birds.

Telescopium Sp are found in abundance in selected moist pockets

near the sea. They form close associations with various species of crabs.

There are several species of limpets *(Cellana* sp.), earshell, hermitcrab, periwinkles, wormshell, screwshells, wingshells, beakshells, *Netica* (sand borowing mollusc), violet snails, tun shell, harp shell in the area which are of immense biological interest.

Crustacea:

In fresh water *Macrobachium lamarrei, Leander styliferus* and *Cardina gracilipes* are found. During monsoon however, *Metapenaeus brevicornis* and *Metapenaeus monoceros* are found in the paddy fields. These are very useful to the birds and carnivorous fish population as they form bulk of their food.

Graspid crab *(Varuna litterata)* is common in sweet water. In brackish water common crabs are *Scylla serrata, Portunus pelagicus, Portunus sanguinolentus* and *Matuta victor;* these are sometimes found in tidal water.

Many crabs live as commensals in the body cavities of bivalves. Crabs are scavengers of sea shore. They form food of innumerable varieties of fish, birds, animals and also of men.

Fiddler crab *(Uca triangularis, U. acutus U. Sp)* is a colourful and most interesting creation of nature. Their behaviour pattern has been studied in detail. They form animal and fish food. Inter tidal gastropods demonstrate various stages of adaptations to terrestrial life. In the same stress of shore there are several species each in its particular zone (highest to lowest).

A sample enumeration of crabs shows that one square metre quadrat recorded 200 numbers of crabs at lowest tide near the water level. But at 10 metre distance from the water level the number per square quadrat was reduced to 55 and again at 20 metre away from the water level, the number was further reduced to 32. This clearly shows that this crab species has got an affinity with formation of crab holes near the water level. Such studies are being continued in different kinds of soil and at different forest blocks of Sundarbans.

Sand-bubbler crab (*Dotila* species) is a cute animal to watch while in action. The study of their movement will definitely be distinct from elsewhere and invites closer attention.

The fiddler crab sieve the sand in the same way as sand bubblar. It will be interesting to study the quantity of protein taken from a grain of sand.

Mud skippers - goggle-eyed fish semi terrestrial, feed on crustaceans, insects and small animals.

Limulus. the horse shoe-crab feed on bivalves worms.

Ocypoda Sp (pink coloured crabs) on sea beach are of immense interest. They feed on organic matters in the sand and are active only in daytime. They are very much fond of tiger as food; One of the authors found pugmarks over and close to 60-70 *Ocypoda* holes in sea beach. This revealed a trick played by the tigers to feed on the crabs which clung to the pads placed on the hole.

There are varieties of Sand crabs of which *Metopograpsus messer, Sesarma bidens, Macrophthalmus* Sp., *Neosarnatium* Sp. and *Macrobrachium* species are common and are associates of Uca.

Insecta :

Insecta form substantial part of the food of water birds in areas adjacent to the forests.

The Dragonflies, Dameselfies, Nepidbug, Belostomid bug, water beetles, are of importance.

There are hundreds of aquatic species in marine, estuarine and intertidal zones. The order Diptera has many marine insects belonging to the family Culicidae, Ceratopogonidae, Chiromomidae, Ephydridae and Tabanidae which are found in mangrove forest.

Three genera viz. *Eulicoides, Leptoconop* and *Lasioherlea* feed on vertebrate blood (of mammals & birds). Rich mangrove mud offers ideal breeding place for some Ceratopogonids. The coastal areas of mangrove swamp have about 125 Sp. of mosquito. For detail information on such insects the work of Dr. A. Choudhury of Calcutta University may be referred to.

Arachnida :

Several species of spiders viz. *Leucage decorata. Araneus mitific a. Equata javanica. Lycosa* Sp. *Hippasa* Sp., form food of water birds.

Annelida :

Common species that form food of birds are *Pheretima. Perinovx. Eutyphoeus. Dischogaster. Megascolex. Helodrilus* and *Chaetogaster* species.

A small polychaeta worm viz. *Mercierella* which burrows in the mud is found in abundance.

All the species of vertebrate and invertebrate animals of the tract interact very closely with each other. Each one of them is a thread that puts thrusts and counter thrusts, stress and strains as predator or prey organism and destruction of a single species may upset the entire delicate fabric of balance that exists in nature.

Zoo plankton :

Of the zoo plankton (work of Dr. A. Chaudhury, Calcutta University) Copepoda form the principal component and forms 85% of the total population. More common forms according to Dr. Chaudhury are *Acartia spinicauda. A erythraea A.centrura Acrocalanus gracilis Paracalanus aculeaturs Labidocerca minuta L acuta. Eucolanus monachus. Pontellopsis herdmani* and Pseudodiaptomus tollingarae.

An examination of Benthos (Mud flats) revealed the abundance of *Cirithidea c ingulata* out of fourteen common species. He also has studied the role of Protozoa in the litter soil ecosystem of Sundarbans.

DEER AND PIGS

Among the mammals, the spotted deer and pigs are very conspicuous and they exceed all other big animals in number.

The number of spotted deer has not been scientifically assessed. In the chapter on "Observations on tigers" the authors have made an assessment of their population.

No detailed study has been made on (i) antler development (ii) gestation period (iii) rate of reproduction (iv) mortality (v) food habit (vi) social behaviour and other aspects of their lives. Density of their population per ha. has been assessed by the authors but these need further study.

One of the peculiar food habit of the deer of this tract is that they occasionally eat fiddler crabs; but keora leaves and fruits (most favourite) gnewa leaves and Dhani grass (*Porteretia coarctata*) are most favourite. Keora leaves and fruits are slightly acidic and the gibrallic acid (recently discovered) contents in the leaves might be the cause for much attraction for the deer. Even several fish species eat keora and Been fruits avidly.

Similar study is necessary in case of pigs, which along with deer form a complex biota and staple food for tigers. The authors think (from faecal analysis) that pigs might form bulk of tiger food.

Deer is found in abundance and their strict protection is necessary. They are abundant in the coastal region where they get variety of food, they are sighted in large numbers in Chulkati, Mechua, Bagmara and Narayantala areas. Maintenance of the habitat coupled with strict protection will enable to create ideal habitat condition for their safe breeding.

Closer studies on the behaviour of both the animals are necessary.

WILL THE MAMMALS OF SUNDARBANS SURVIVE?

Only about 150 years ago the Sundarbans were the home of wild

animals viz., Javan Rhinoceros (*Rhinoceros sondaicus*), the wilf buffalo (*Bubalus bubalis*) which no longer exist. It is also said that Swamp deer (*Cervus duvacelli*). the Muntjac (*Muntiacus muntiak*), the fishing cat (*Felis viverrina*) existed on these swamp islands.

A single species of Primate, the Rhesus Monkey (*Macaca mulatta*) occurs at present. The authors have made some observations on these monkeys. The study involved (i) population in each herd (ii) sex including age-class, determination (iii) extent of daily cruise (iv) food and feeding habits (v) breeding habits etc. They are resident in forest areas and are well distributed in the entire forests.

In the tidal rivers, the commonest aquatic mammal is the little porpoise or the Black finless Porpoise. Other cetacea are *Orcella brevirostris* and *Stolia plumba*.

In the reclaimed areas close to the Reserved Forests there are few mammals. The insectivora is represented by the House shrew (*Suncus murinus*) Among the cats the common Jungle cat (*Felis bengalensis*). the jackal (*Canis aureus*) the Indian civet (*Viverra Zibetha*) and the small Indian civet (*Viverricula indica*) occur. One species of mongoose, the common grey mongoose (*Herpestes edwardsi*) is found in grassy areas. The rodents are represented by five-stripped squirrel (*Funambulus pennanti*), Field mouse (*Mus booduga*), the Molerat (*Bandicota indica*) the common rat (*Rattus rattus*) and the house mouse (*Mus musculus*). Bats (Chiroptera) are common. The flying Fox (*Pteropus giganteus*), the short nosed fruit bats (*Lynopterus sohinx* & *Taphozous longimanus*) are found on *Phoenix palludosa*. Other species are Indian False vampire (Megadermalyra), the lesser rat-tailed bat (*Rhinopoma hardwickii*), the bicoloured leaf nosed bat and *Hipposideros bicolar*.

Although the above shows the occurence of nany species, they are not abundant owing to destruction of habitat and want on destruction of the animals resulting in population decline.

7

Estuary — A Dynamic Site for Biosphere Reserve

Estuaries are special bio-tope in littoral zone. They are most dynamic, complex and rich ecosystem. Here the opposite currents meet, oscillatory tidal currents are formed and sedimentation system is complicated. Estuaries are complex biological environment which also provide aesthetic enjoyment and recreational sites. They are priceless natural assets and are dynamic ecological system, nursing grounds, sheltering place, source of nutrients for the marine life.

Of all estuaries of the world the 'Sundarban' estuary is the most complex - one of the largest and has vast assemblages of vertebrate and invertebrate with Royal Bengal tiger at the apex of animal pyramid.

In this ecosystem a scientist is to determine.

(i) Salinity in soil and its effect on plants and animals.
(ii) Salinity in water and its effect on plants and animals.
(iii) P.H. value of soil and its effect on plants and animals.
(iv) Various mineral nutrients in water and their effect on plants and animals.
(v) Oscillating water currents and their effect on plants and animals.
(vi) Various temperature ranges in water and their effect on plants and animals.
(vii) Light and its effect on plants and animals in water.
(viii) Moon and its effect on plants and animals behaviour and reproduction.
(ix) Tide and its effect on plants and animals behaviour.
(x) Temperature and its effect on plants and animals.
(xi) Salinity and osmoregulation.
(xii) Wind velocity and its effect on plants and animals.
(xiii) Sandy clay and rocky shore and annual dispersion of micro animals.

(xiv) Inter tidal mudflat and animal association.
(xv) Effect of salinity and other factors on the behaviour of animals and especially of tiger.
(xvi) Density and pressure of water and its effect on plants and animals.
(xvii) The cause and effect of bioluminescence.
(xviii) Various plant and animal zones.
(xix) Wide fluctuations of tidal level.

Salinity of water and soil is of prime consideration as on it depends the variety of plants and animals and their physical, physiological and chemical adjustments. Not only the plant species are specific and limited, animals also in such areas have to develop various physiological adjustment. A special chemical environment is produced owing to mixing up of various concentration of salts. In summer, salinity increases. There is steep vertical salinity gradient (high at surface and low towards bottom).

Endomosis and exosmosis must be regulated (Osmoregulatory action by all categories of animals and plants). Animals response to sudden changes in salinity and the following results:

(i) Immediate death
(ii) Autotomy (self amputation of a part as in certain worms, anthropods and lizards)
(iii) Violent contribution or irregular movement
(iv) Tropism
(v) Abnormal physiological function
(vi) Establishment of a balance
(vii) Acclimatization of the surroundings.

8

Ecological Biochemistry in Estuaries

A new interdisciplinary subject - ecological biochemistry or sometimes named as chemical ecology or phyto-chemical ecology - is of prime concern in this tract. More and more chemical chemical techniques are being used in biological systems. It is also due to awareness of ecologists that chemical substances - and particularly secondary metabolites such as alkaloids, flavonoids and terpenoids have significant role in the complex interactions occuring between animal and animal, animal and plant or plant and plant in the natural environment. In this respect the study of flowers and leaves of plants and of aquatic animals is indicated.

Ecotone region - Estuarine/Marine region

Geographic distribution of marine organisms depends on their responses to current, temperature and physical barriers, their local distribution is affected by waves and tides, type of bottom salinity and depth.

Major communities reorganised are the oceanic plankton and nekton biome in the open sea, the balanoid - gastropod thallopsite biome on rocky shore, the pelecypod - annelid biome or sand and mud bottom, and the coral reef biome (coral reef are found only in the tropics). The warm water fauna are richest in species, especially in the Indo Malaysian and West Indian sub-regions.

Marine plankton includes a greater variety of forms than does fresh water plankton. Abundance of plankton varies from place to place from season to season. Plankton is much more numerous in coastal water than in the open sea. Dial movements between the surface at night and greater depths during the day are pronounced.

Benthos (bottom) includes a great variety of sessile creeping and burrowing forms. It is very abundant in littoral zone and decreases as depth increases. There is considerable difference in life form and species composition of benthos occuring on rocky shores and on sand and muddy ones. Zonation of species is most prominent in rocky than in depositing shores.

Diurnal changes

Diurnal changes in the movement of planktonic animal which rise to the surface of water at night and by day move into deep zones.

Current and Oxygen

Current of air and water are predominant feature of many habitats and they are among the environmental factors that determine the distribution of animals.

Daily occurrence of high and low tide twice a day and also due to innumerable creeks and rivers anastomosing horizontally and vertically cause various complicated reversing currents. The animal and plant organism have to develop special modifications to adjust to such environement.

Influence of moon

The moon is associated with fertility, reproductive processes and growth. More of fish catch has been recorded immediately before full and new moon. Endogenous and exogenous systems in animal are concerned in various physiological activities.

Tidal and lunar fluctuations exert influence on organisms inhabiting the tidal zones. They may be subject to daily rhythm, seasonal cycle or in coastal areas to the turns of the tide and the phases of the moon. Internal physiological changes (endogenous) in most cases and not external circumstances (exogenous) are related to the change. Endogenous self sustaining oscillation (ESSO) is the term used to explain the phenomenon (Example - Uca sp)

Sites for environmental forestry in estuaries

The dynamic estuarine regions differ widely among themselves. Of all estuaries of the world the 'Sundarbans' stand supreme in its peculiar type of estuary. Wide difference in low & high tide level, amphibian Royal Bengal tigers which are man-eaters and having an assemblage of wide variety of animals (Vertebrates & Invertebrates) make the area a distinct type. It is possible to isolate specific areas having diverse plants & animal species and having wide characteristics. Such estuaries are facing destruction and pollution owing to human ignorance and apathy. In order to solve problem involving physical, chemical and animate environment in the estuary multidisciplinary approach is imperative.

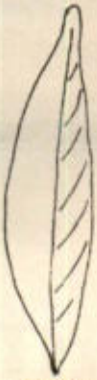
IDENTIFICATION OF PLANTS IN MANGROVE

(25 Plates)

CHARACTERISTIC LEAF BLADE OF SOME SPECIES OR SUNDERRANS

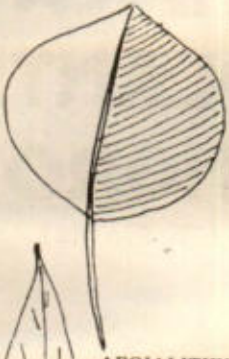
EXCOECARIA AGALLOCHA
(GNEWEA)
1.3

VISCUM MONOEICUM
XI



SONNERETIA APATALA
(KEORA)
X 1.3

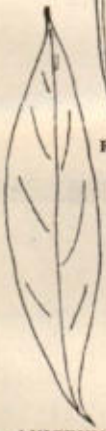
CLERODENDRON INERME
(BANJAI)
XI



AEGIALITIES
ROTUNDIFOLIA
(TORA)
X

SUAEDA NUDIFLORA
(NUNAGIRI)
XI

GLORRIOSA SUPERBA
(ULAT KAMBAL)
XI

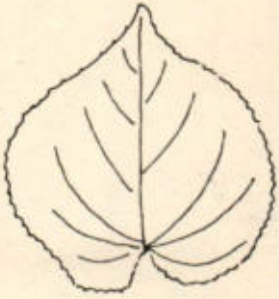


AVICENNIA
ALBA
(KALA BAEN)
X 1.2

ILLICIFOLIUS
ACANTHUS
(HARGOZA)
X 1.2

CHARACTERISTIC LEAF BLADE OF SOME PLANT SPECIES OF SUNDERBANS.

THESPESIA POPULNEA
(PARASPIPAL)
X 2



HIBISCUS TILIACEUS
(BHOLA)
X 2

AMOORA CUCULATA
XI

XYLOCARPUS S.P.
XI

DERRIS ULIGINOSA
XI

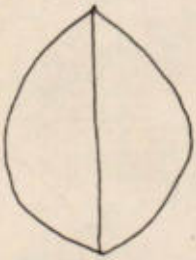
XYLOCARPUS MOLUCCENSIS
XI

PONGAMIA PINNATA
(KANRANJA)

Each of these five diagrams represents a leaflet of compound leaf of the species.

CHARACTERISTIC LEAF BLADE OF SOME SPECIES OF SUNDERBANS

BRUGUIERA
(KANKRA)
X 1.5



RHIZOPHORA
(GARJAN)
X 1.3

KANDELIA
X 1.5

AVICENNIA OFFICINALIS
(SADA BAIN)
X 1.3

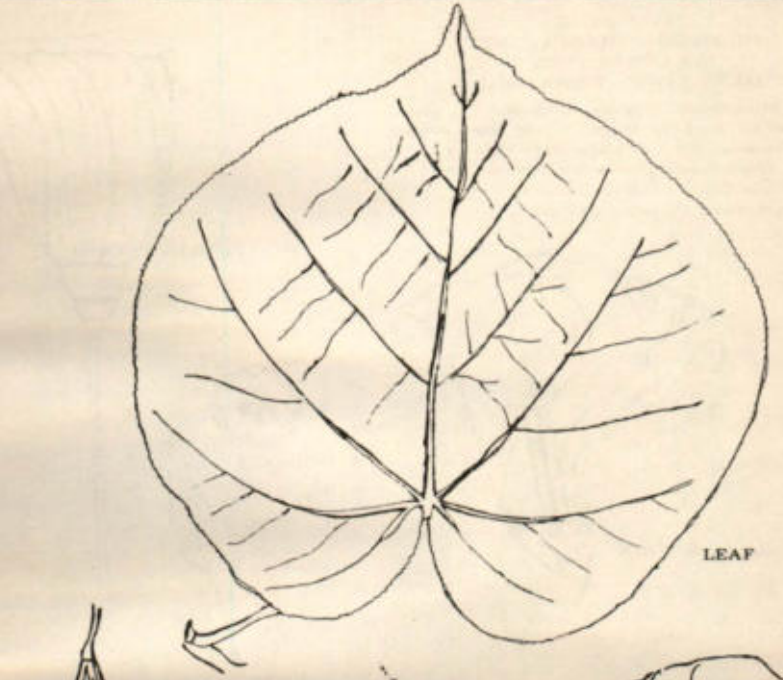
CERIOPS TEGAL
(MOTH GORAN)
X 1.3

LUMNITGERA
(KIRPA)
X 1

AEGICEROS
(KHALSI)
X 1

CERIOPS DECANDRA
(JUMTI GORAN)
X 1.2

SONNERETIA ACIDA
(ORA)
X 1



MALVACEAE

HIBISCUS TILIACEUS LINN.

LOCAL NAME — BOLA

A small tree. Leaves orbicular 8 × 20 cm. deeply cordate, crunelate. Flower Bell shaped, yellow with purple centre. Capsule 2 cm. diameter. Staminal tube long. On sandy sea coast

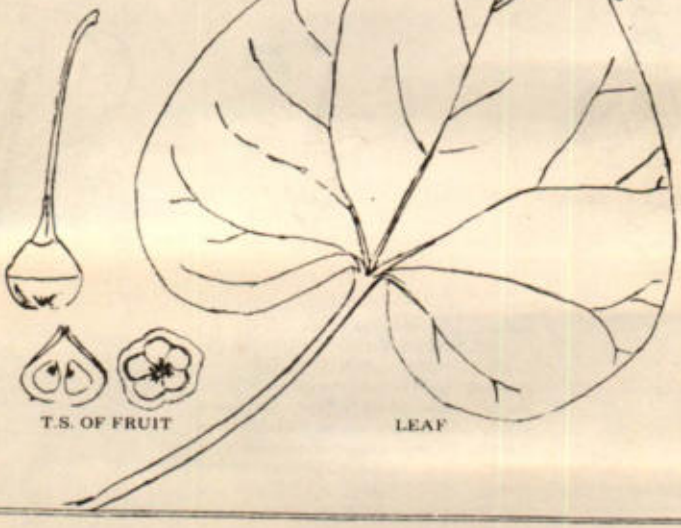
MALVACEAE
THESPESIA POPULNEA (LINE)
SOLAND EX. CORR.
LOCAL NAME — PORES PIPAL

Leaves cordate, triangular, acuminate, petiole 3 cm. to 10 cm. Flower large, axillary, bracteoles 5-8. Calyx-5-toothed Petals - 5 yellow with purple centre. Stamens many in a tube. Ovary 4-5 locular. Capsules 3-4 cm. in diameter. On sandy sea coast.

FLOWER IN SECTION

T.S. OF OVARY

FLOWER



T.S. OF FRUIT

LEAF

STERCULIACEAE
HERITIERA FOMES BUCH.
LOCAL NAME — SUNDRI

A small tree. Leaves lanceolate, leathery, lepidote beneath. Flower unisexual in axillary panicle, pinkish yellow. Sepals, petals 0. Stamens in a column with a ring of stigma. Fruit a cluster of woody winged fruit. seeds.

CLUSTER OF FRUITS

C.S. OF FRUIT

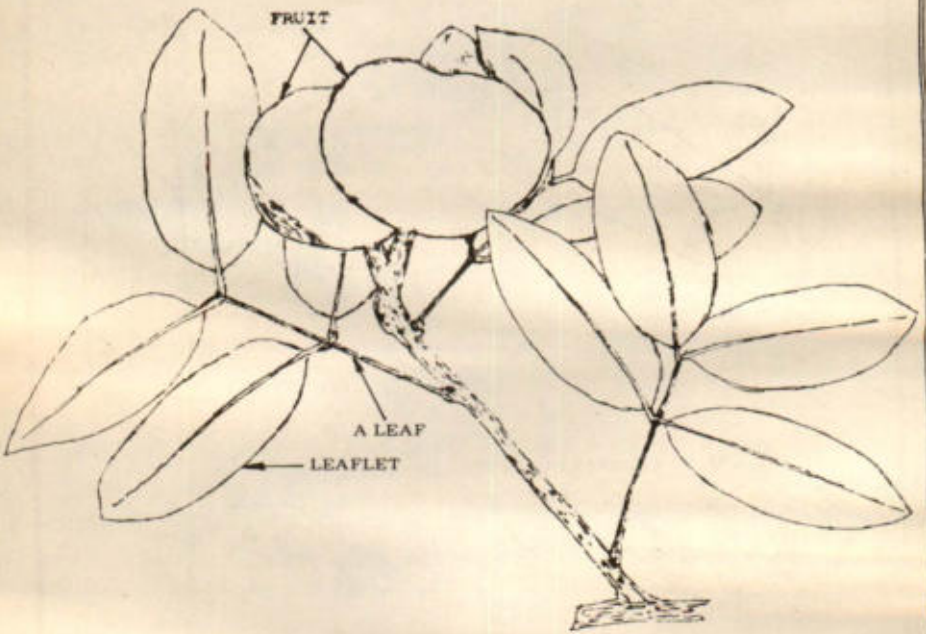
MELIACEAE

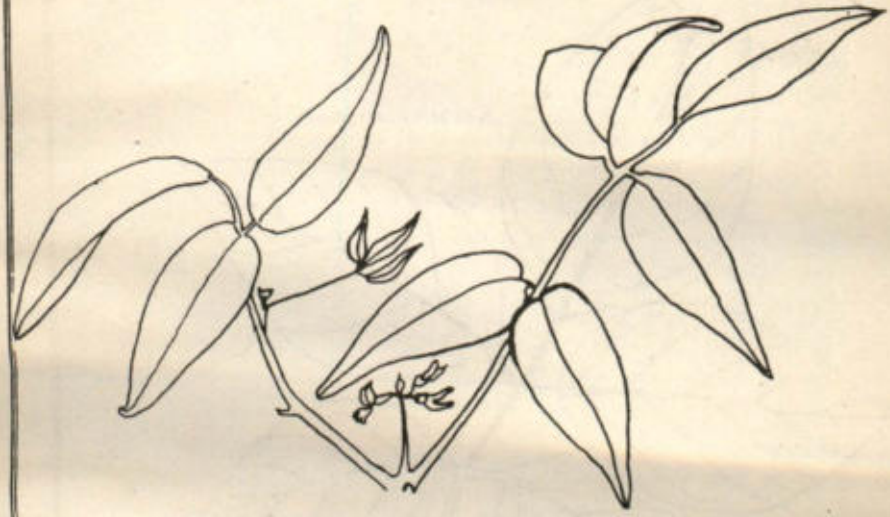
XYLOCARPUS MOLUCCENSIS

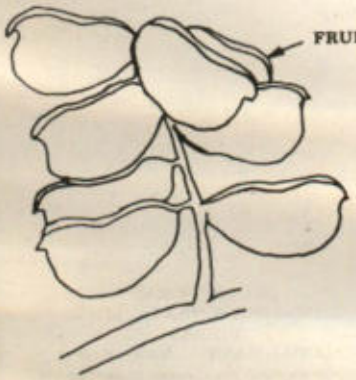
ROENI

LOCAL NAME – PASUR

Leaves - compound 10-25 cm. long. **Leaflets** 2-3 pairs., thinly coriaceous ovate. **Panicles** 7-15 cm., slender, few flowered, pinkish yellow. **Fruit** 8-13 cm., in diameter. A grooved, brown valvety.



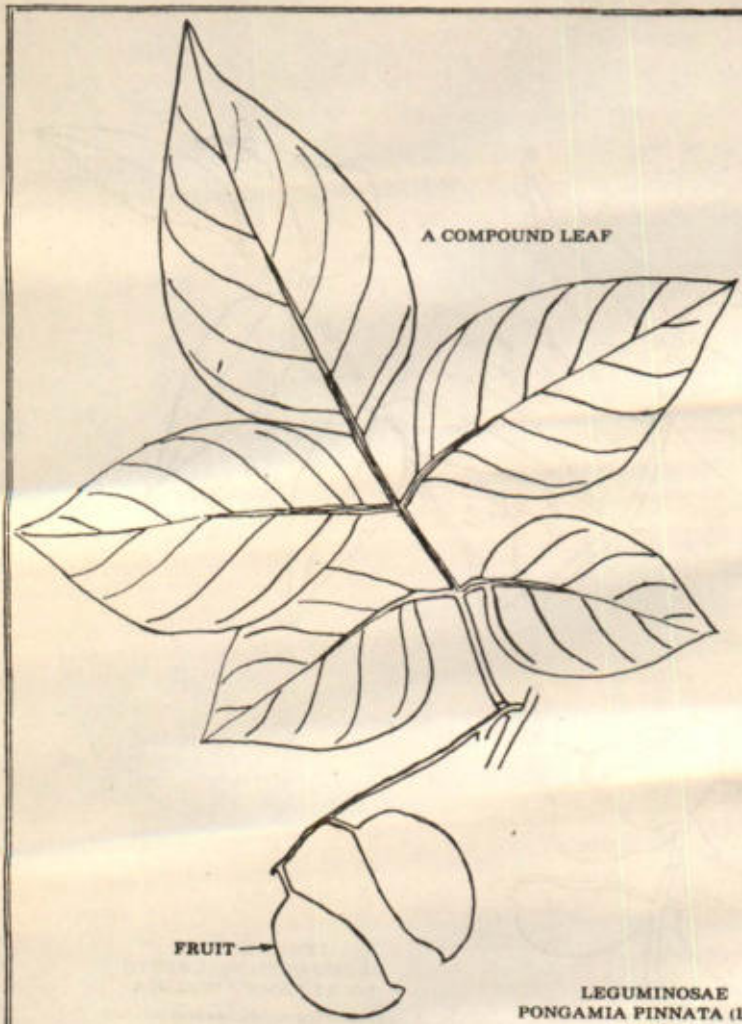




LEGUMINOSAE
DERRIS ULIGINOSA BENTH
LOCAL NAME – PONLOTA

A large climbing shrub. Leaflets 5-7, each 3-7 cm. long. Pods winged at edges, very common in creeks.

Flower - pinkish. Pods broad, orbicular 2.5 to 3.5 cm. long, 1-2 seeded



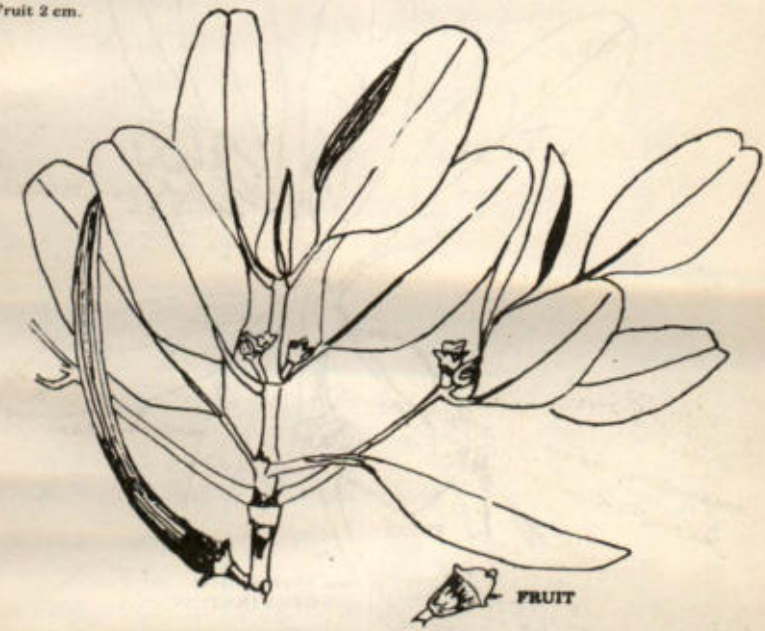
LEGUMINOSAE
PONGAMIA PINNATA (LINN)
PIERRE
LOCAL NAME — KARANJA

A moderate sized tree. Leaves imparipinnate, leaflets 8-22 cm., by 7-15 cm. 5 in number ovate, acuminate. Flower 1.5 cm. pink or violet. Stamens 10 Pods 5-7 cm. long, woody, oblique; in seabeach.

RHIZOPHORACEAE
CERIOPS DECANDRA (GRIFF)
DING HOU.

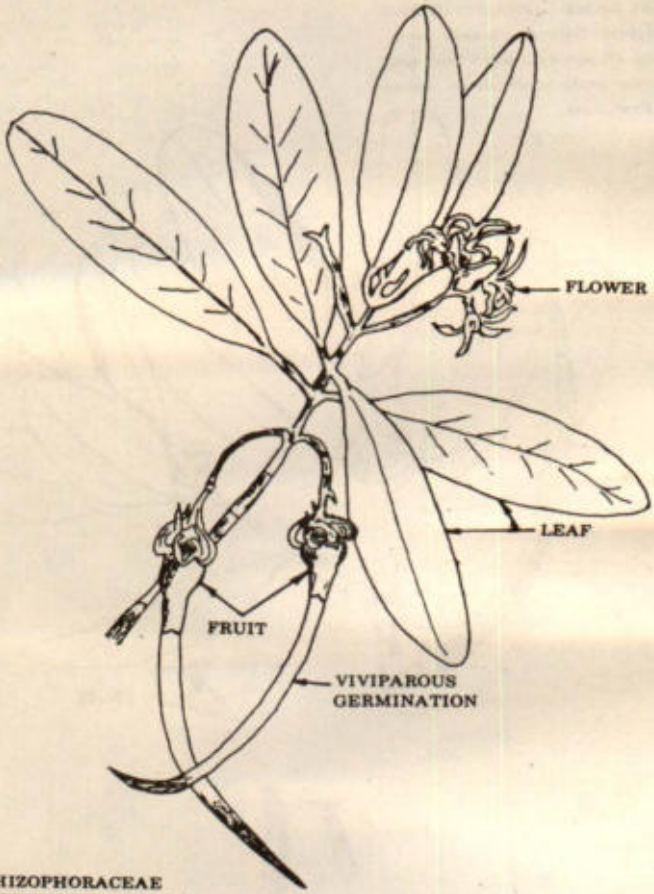
LOCAL NAME — JHAMTI GORAN.

A tall shrub. Leaves coriaceous, ovate 7-10 cm. Flower - each with a bract and 2 bracteoles. Sepals 4-6, Petals 4-6, stamens 8-10. Fruit 2 cm.



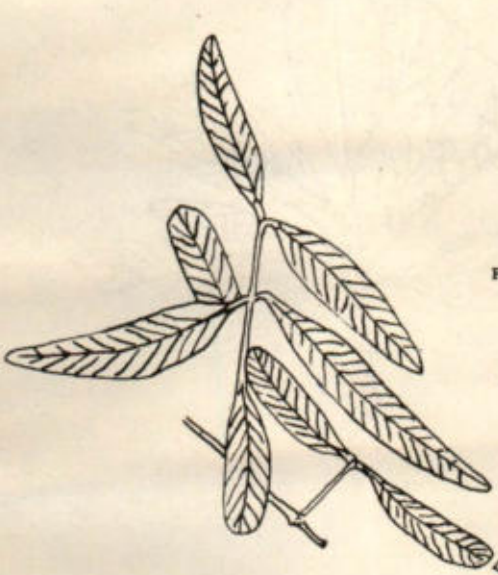
FRUIT

VIVIPAROUS GERMINATION

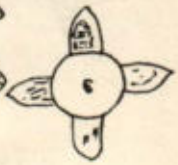


RHIZOPHORACEAE
KANDELIA CANDEL W & A.
LOCAL NAME — GORIA

A small tree. Leaves opposite, coriaceous, oblong, obtuse, stipules interpetiolar, caducous. Flowers few, axillary, dichotous cyme. Sepals 5-6, petals 5-6, bifids, white, Stamens many carpels 3 connate in a inilocular ovary. Fruit 1-celled. 1-seeded.



PERSISTENT CALYX



SONNERETIACEAE

SONNERATIA APETALA BUCH

LOCAL NAME – KEORA

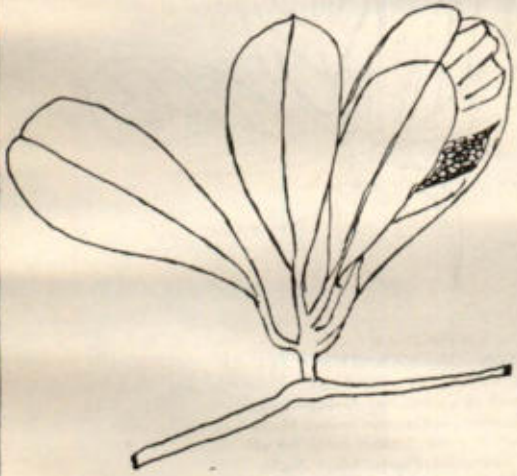
A gregarious tree, 16 m. Tall; bark fissured in square, branches pendulous Leaves lanceolate, petiole 1-2 cm, Calyx 4 equal, Petals 0, Capsule globose, 2 cm., edible.

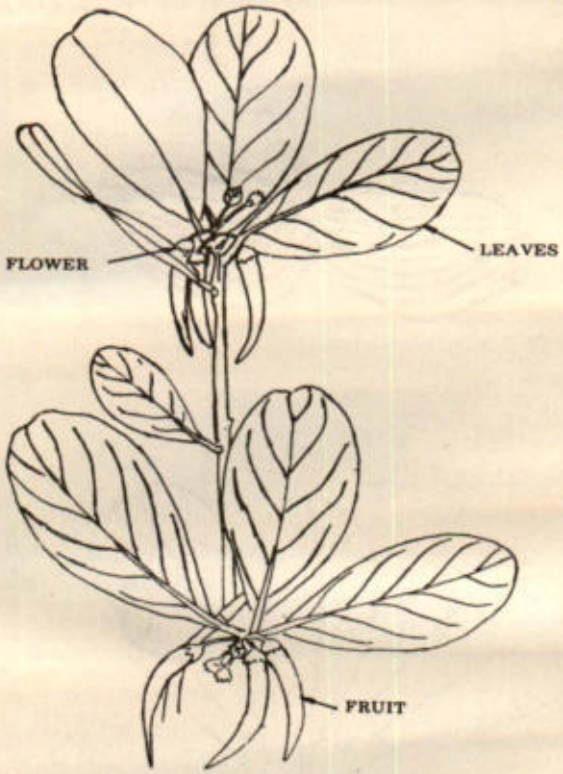
COMBRETACEAE
LUMNITZERA RACEMOSA WILLD
LOCAL NAME — KRIPA

A straight stemmed tree. Leaves 5 to 7 cm. long., ovate, crenate Leaves clustered at the end of branches, spathulate, fleshy, small, sessile flower white in axillary racemes.

Fruit — with persistent calyx.

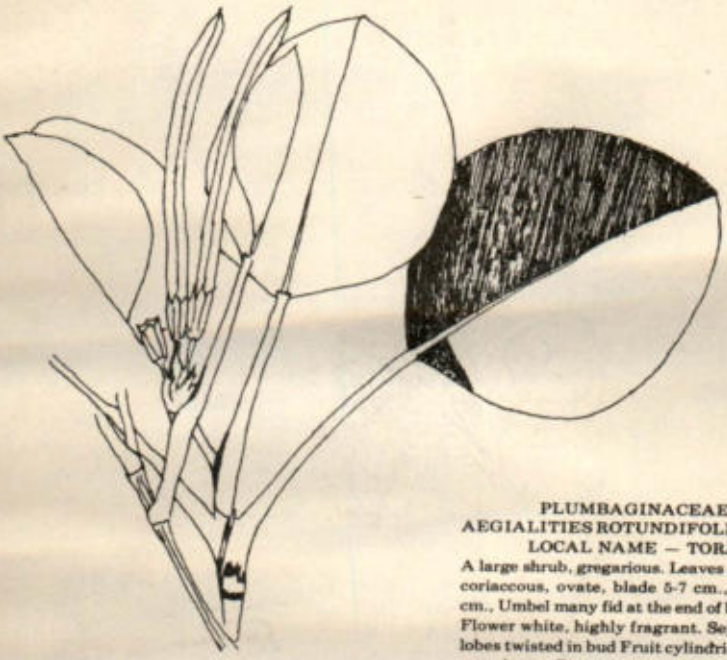
ASCLEPIADACEAE
FINLASONIA OBOVATA WALL
LOCAL NAME – DUDHI LATA
A large glabrous climber. Leaves opposite. Flowers 2,3 chotomous, yellow and purple, sepals 5, petals 5, stamens 5, carpels 2.





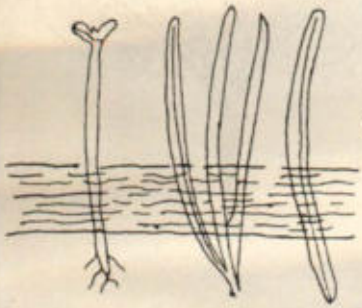
MYRSINAE
AEGICEROS CORNICULATUM (L) BL
LOCAL NAME — KHALSE

A large shrub or a small tree. Greagarious. Leaves scattered, coriaceous ovates blade 5-7 cm., petiole 5 cm., Umbel many fed at the end of branchlet. Flower white, highly fragrant Sepals - twisted in beed. Fruit cylindric, curved, acuminate, gregarious on stream bank slopes.

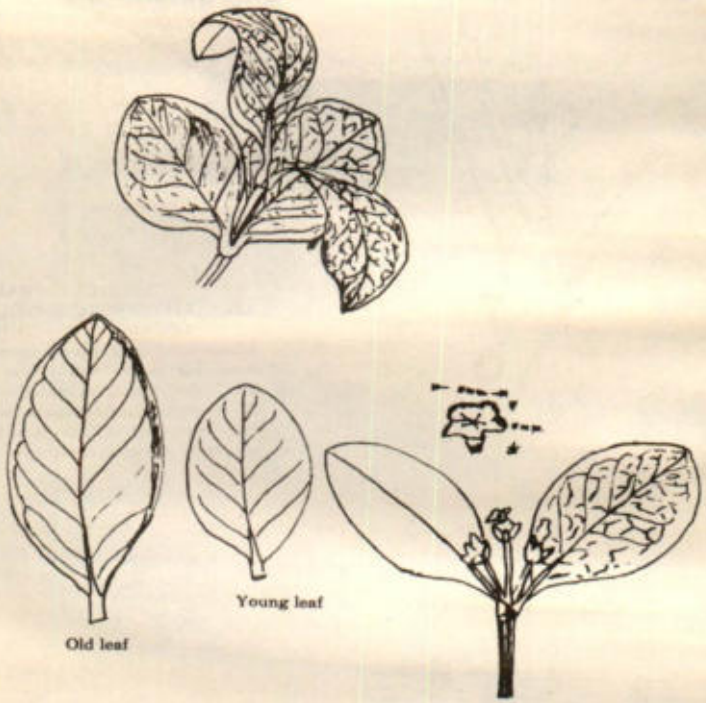


PLUMBAGINACEAE
AEGIALITIES ROTUNDIFOLIA (L) BL
LOCAL NAME — TORA

A large shrub, gregarious. Leaves scattered, coriaceous, ovate, blade 5-7 cm., petiole 5 cm., Umbel many fid at the end of branchlet. Flower white, highly fragrant. Sepals petal lobes twisted in bud Fruit cylindric, curved. acuminate. Gregarious on river slopes.

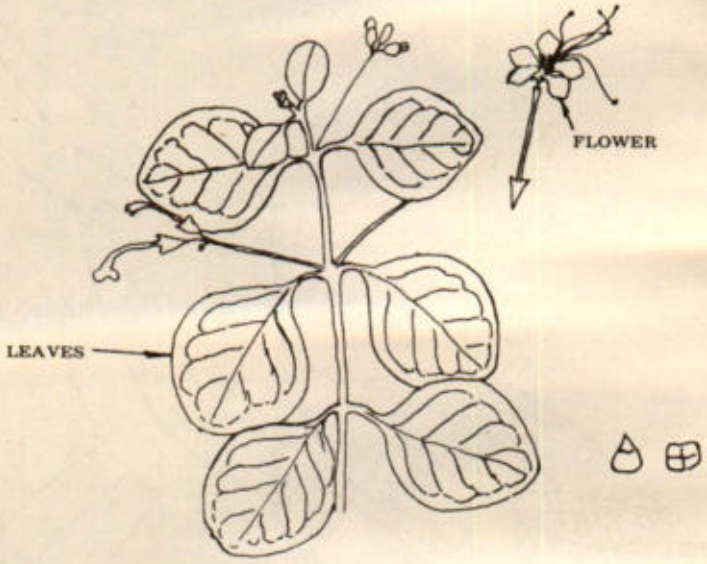


GERMINATION



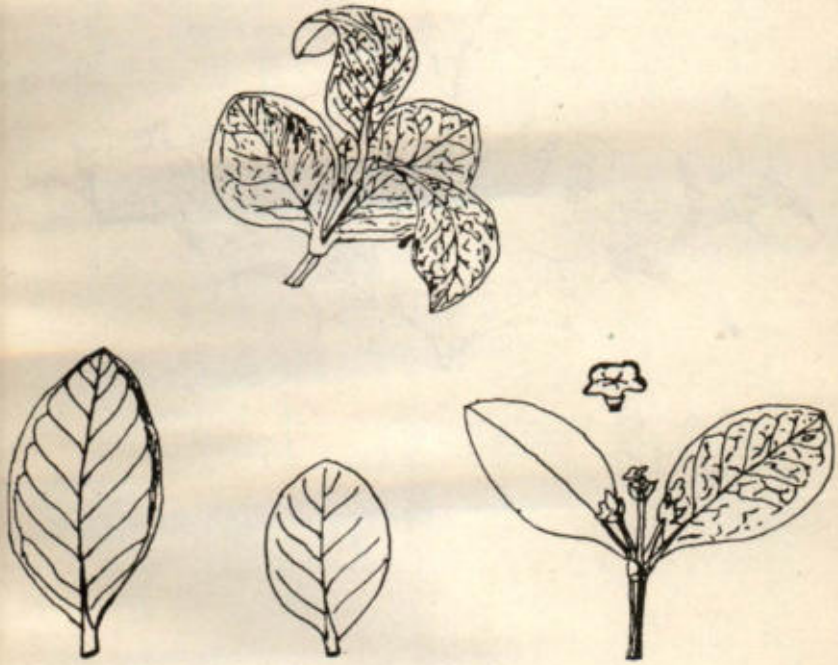
VERBENACEAE
AVICENNIA MARINA (FORSK)
LOCAL NAME – PIARABAEN VIERH
Leaves acute at apex, ovate cunneate at base, minutely pubescent at beneath, upto 7.5 cm., capsule ovoid. about 2 to 2.5 cm.

VERBENACEAE
AVICENNIA ALBA BL.
LOCAL NAME – KALA BAEN.
A shrub. Leaves acute, lanceolate alternate or decurrent at base closely whitish pubescent beneath, upto 10 cm. by 3.5 cm. capsule conical and beaked.



VERBENACEAE
CLERODENDRON INERME (L.F)
GAERTN
LOCAL NAME – BANJAI

A straggling shrub, branches at right angle to stem. Leaves 3-7 cm., ovate, entire, strong smelling when crushed, elliptic ovate, rounded tip Petiole short. Flower white, stamen purple Drupe pear shaped, 4 grooved, gregarious on stream banks

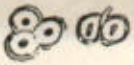


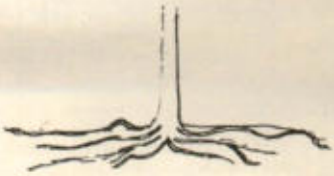
VERBENACEAE
AVICENNIA OFFICINALIS LINN
LOCAL NAME — SADA BAEN

A medium sized tree. Leaves opposite, oblong, elliptic tip rounded, midrib dark yellow, 3-chotomous. Panicle 8 cm. long. capitulate, calyx-5, corolla 4, stamens - 4 Fruit yellow opaque, wrinkled 3 cm. long ovary 4- celled

ACANTHACEAE
ACANTHUS ILLICIFOLIUS LINN
LOCAL NAME – HARGOJA
A shrub, forming clump in maritime swamp. Leaves toothed or pinnatifid, Spinous. Corolla-blue, supported by 2 pairs of bracteoles capsules 5 cm. long

EUPHORBIACEAE
EXCOECARIA AGALLOCHA LINN
LOCAL NAME — GNEWA
Leaves entire or sub-serrate, Flowers dioecious or monoecious, MALE FLOWER — Sepals 3 fid, Petals 0, Stamens — 3 FEMALE FLOWER Pistillode 0, Disc 0,- Carpel 3 celled Fruit - Capsule 3 celled Stems & leaves yield poisonous milky juice. Bark has prominent lenticels, spikes catkin like.





CHENOPODIACEAE

SUAEDA FORSK

1. S. NUDIFLORA Moq.

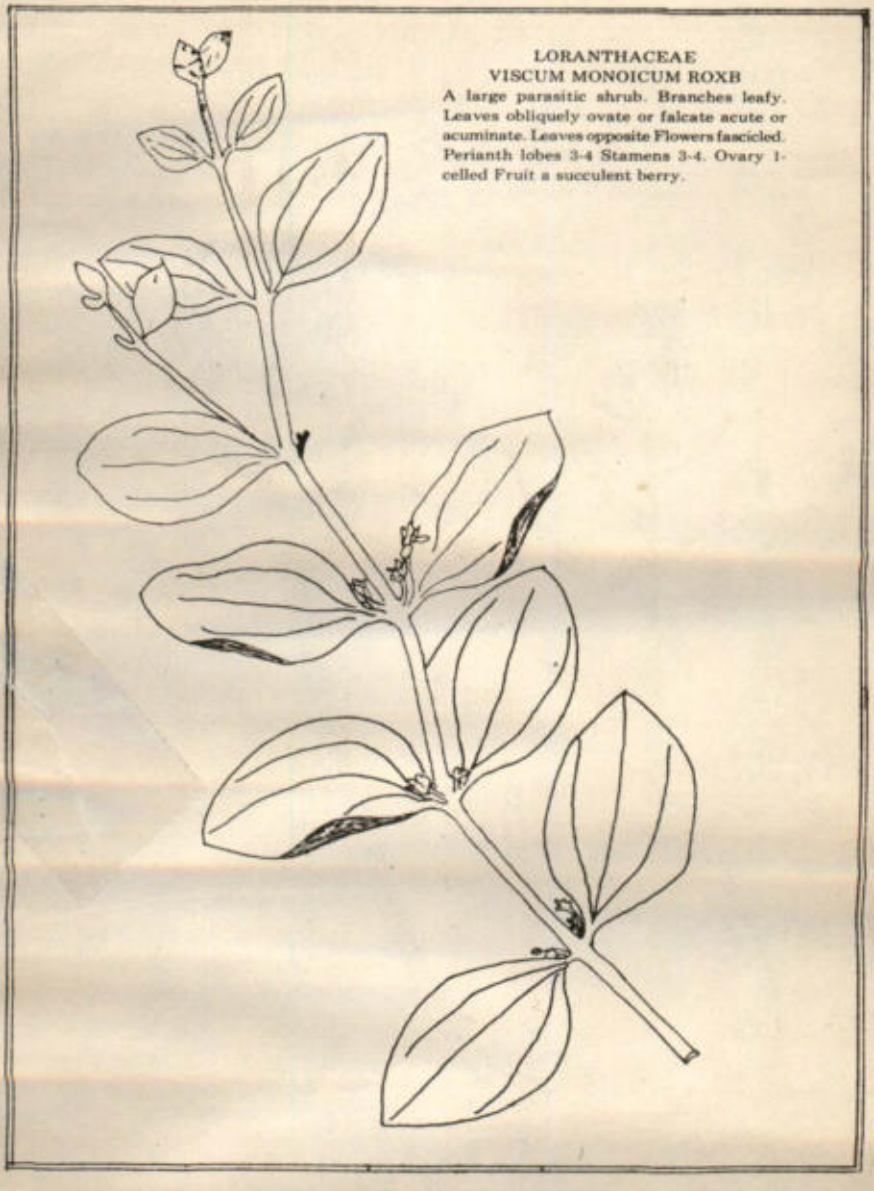
LOCAL NAME — MONAGIRI

A branched undershrub Perennial, 24-30 cm., branches spreading close to the ground. Leaves fleshy. Flowers many in cluster, globose in long spikes, Styles 3

2. S. MARITIMA (LINN) DUMORT.

LOCAL NAME —

An erect annual herb branching from ground level, Flowers minute, axillary, bisexual perianth 5-lobed stamens - 3. Carpel 1 celled Styles 2.

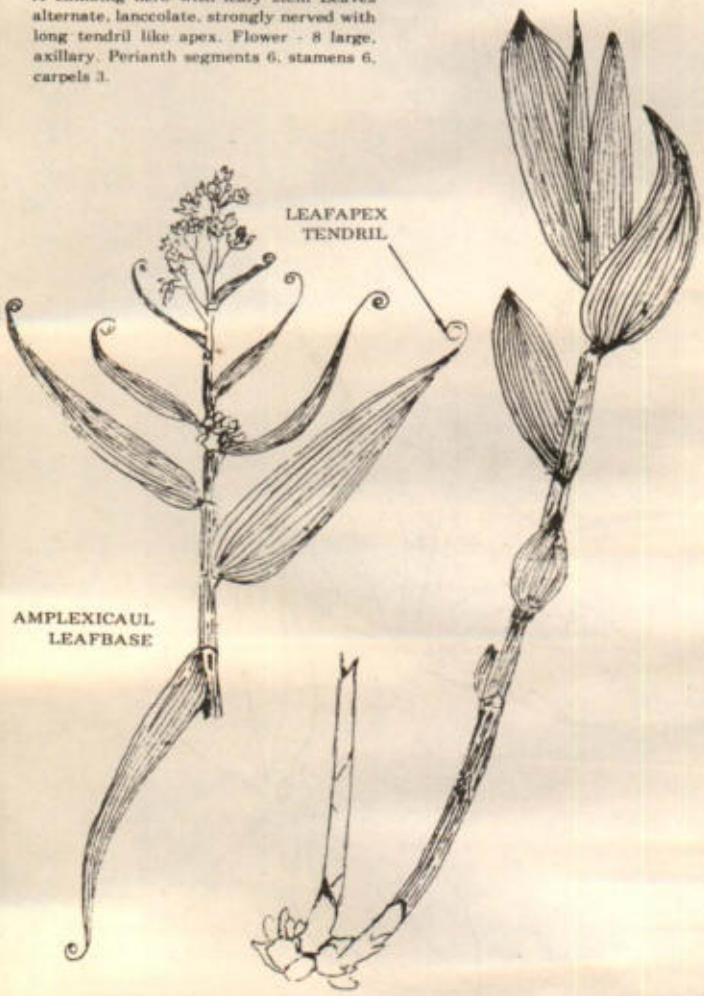


LORANTHACEAE

VISCUM MONOICUM ROXB

A large parasitic shrub. Branches leafy. Leaves obliquely ovate or falcate acute or acuminate. Leaves opposite Flowers fascicled. Perianth lobes 3-4 Stamens 3-4. Ovary 1-celled Fruit a succulent berry.

LILIACEAE
GLORIOSA SUPERBA
LOCAL NAME — ULAT KAMBAL
A climbing herb with leafy stem Leaves alternate, lanccolate, strongly nerved with long tendril like apex. Flower - 8 large, axillary. Perianth segments 6, stamens 6, carpels 3.



Errata

Item/Page	*Omission/wrong printing*	*Correct situation*
Contents	Roman to Arabic i.e. Chapter I, II, III	Chapter 1, 2, 3.
Contents	Chapter 6, Item 5	Statistico-Ecological
	Crocodiles	Crocodilus
Contents	Estuarina	Estuarine
Chapter VI	Crocodiles porosus	Crocodilus porosus
under 5	Statistic	Statistico
Under 6	'of Forsk' should be deleted	The word 'Forsk' should be put after Scylla serrata
Page No :		
2 (ii)	diel	dial
2 (iii) second line from the last	belowing	blowing
4 (iii)	compartively	comparatively
8 (tenth line from bottom)	hand	land
11 first line	litteral	littoral
14 Type 1	Hight	Height
	Hentol	Hental
Type 2	Hight	Height
	Goram	Goran
	Gnewea	Genwa
	Rastricted	Restricted
Type 3	Keore	Keora
	Bajn	Baen
	Hight	Height
	Coarciata	Coarctata
14 Type 4	Hight	Height
15 Type 5	Kankure	Kankra
Type 6	Hight	Height
	Eritiera	Heritiera
Type 7	Hight	Height
	Stemps	Stems
17 (b) (vi)	Phenumatophores coarctata occurs twice after Porteresia	Pneumatophores one coarctata should be dropped

Item/Page	*Omission/wrong printing*	*Correct situation*
25 (1st line)	Bruguier	Bruguiera
28	It has been reverse 28 27	27 should come after 26 28 should go to next page
30 (8th line from bottom)	Petals fleshy	delete
31 (1st line	Shrubs	Shrub
36 (9th line)	CUTTIFERAE	GUTTIFERAE
37 Under compositae	Launeass	delete
39 (17th line)	DENDROBIUM SP. OBERONIA Sp.	should be in small italics.
41	Grewa E. agallocha (Grewa) at 5 places,	Genwa E. agallocha (Genwa) Drop. Agallocha is in the tenth line
46	Sonneratia acede (Ora) is not can be yet Tannin extracted	S. acida (Ora) has not yet been Tannin is extracted
46 A	Rhizophera	Rhizophora
49	Netidupenni	Netidhopani
52 (under Forest	Nlixed	Mixed
59 (10th line in para)	Sonneratia apetata	Sonneratia apetala
73 (13th line from bottom)	Aeigialitis	Aegialitis
74	Classis	Classes
91	honey among recoverable after full stop in the last column	among honey word should be deleted
100	$t=\frac{0.91\times 7}{0.414}$	$t=\frac{0.91\times\sqrt{7}}{\sqrt{0.414}}$
103 (last but 1&2 column)	Oryza tia	Oryza (drop 'tia')
118, 101, 14, 15,	Cereops	Ceriops
143, 117 (3rd para)	OBECT	OBJECT
132 (last column of Sl.No.2	Ampibia	Amphibia

Item/Page	*Omission/wrong printing*	*Correct situation*
under Appendix-1)		
149	Denominator of r1.23	$1-r^2_{23}$
	$1-Y^2_{23}$	$1-r^2_{23}$
158 9th line	Species evidenes	Species evidences
21st line (5th para)	fact	fat
14th line	Bolepthalmus	Boleopthalmus
162	slighted	sighted
174 (12th line from bottom)	pray	delete 'Grolesque' prey
179 (last but two lines)	nany	many
181 (last but 3 lines)	Tropism	Trophism
186	Gnewea	Genwa
	Apatala	Apetala
	Aegialilies	Aegialitis
190	LINE	LIME
	porespipal	Paraspipal