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(FAMILIES *Pteropidae, Rhinopomatidae and Emballonuridae*)

By
H. KHAJURIA

Issued by the Director
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TAXONOMICAL AND ECOLOGICAL STUDIES ON BATS OF JABALPUR DISTRICT MADHYA PRADESH, INDIA. PART I. FAMILIES PTEROPIDAE, RHINOPOMATIDAE AND EMBALONURIDAE

By

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(with 6 text figures and 7 plates)

I. INTRODUCTION

Besides several peculiarities in their morphology and physiology, Indian bats are of considerable economic importance in being important predators of insects and serious pests of garden fruit. Some species are a great nuisance in places of archaeological interest and a few are a good source of meat which is also supposed to be of some medicinal value. They also help in pollination and seed dispersal. Some may also be agents in spread of dangerous diseases to man and livestock. It is, however, a poorly known group of Indian mammals and there has been a great demand for information about them, particularly on their habits.

(i) *Resume of literature.*– With successful completion of Indian Mammal Survey conducted by Bombay Natural History Society (1912-1920) and the study of collection by experienced mammalogist in British Museum followed by an authoritative checklist by Ellerman and Morrison Scott (1951), the taxonomy of Indian bats was considered to have been placed on a firm footing at least as far as 'skin and skull' study is concerned. However, knowledge about their habits continued to be imperfect. Earlier works like Dobson (1876) and Blanford (1891), although providing very good descriptions, had very little material on habits of these animals. Phillips (1922, 1923, 1927) made a brief but interesting study of the habits of a few species of Ceylonese bats, but, on account of quite different ecological conditions prevalent in the area of his study, his observations may not apply strictly to at least North Indian species. Sterndale and Finn (1929) did not materially change the position. Mc Cann (1931, 1933, 1934, 1942) provided a few short notes. As late as 1948, Abdulali in an interesting report on bats remarked : "Bats are abundant in India and of many kinds but so little is known of their habits that any information which members (of Bombay Natural History Society) may be able to offer from their own experience would be of considerable interest" Some additions to knowledge was made by notes supplied by Abdulali (1948, 1949, 1963), Ramakrishna (1950, 1951), Khajuria (1953, 1965, 1970, 1971, 1972, 1973, 1974a-b, 1975a-c, 1976, in press a-d), Prakash (1956, 1959a-b, 1960, 1962, 1963), Prater (1965), Hill (1967), Bhat (1967, 1968), Thonglongyla (1972) and by a few others. Gopalkrishna (1947, 1948, 1949, 1955, 1964, 1969a, b), Gopalkrishna and Madhavan (1971), Moghe (1952, 1956), Ramaswamy (1961) and Kumar (1965) made a very detailed study of the breeding biology of some species along with histological investigations. Bhatnagar (1967) studied the bacula and related structures in some fruit bats. Vamburkar (1958) studied the male genital tract of *C. sphinx gangeticus*. Murthy (1970) investigated male reproductive organs of *Taphozous longimanus*. Agarwal

and Sinha (1973) have excellently described bacula of a number of oriental species. It was, however, Brosset (1962a, b, c, 1963) who made an admirable attempt to study the habits of a number of species inhabiting Western India and a few places in Central India from several aspects of the subject. His main study area was, however, restricted to Bombay city and its environs. The limited time at his disposal did not permit him to make it exhaustive and he (1962a, p. 7) remarked : "Often the conclusions that I propose are provisional because data recorded are not enough. More information is to be collected to confirm or deny my suggestion"

Miller (1907), Anderson (1912), Wroughton (1918) and Ellerman and Morrison-Scott (1951) have been followed in identification and classification of the species and subspecies.

(ii) *Scope.*—Brosset visited only three places in Madhya Pradesh and personally collected only five species from the area. The present study is confined to Jabalpur District, the most centrally situated district of Madhya Pradesh and will, thus, be more representative of the chiropteran fauna of Central India. The area of study was restricted to about 130 sq. km. around Jabalpur city. A still smaller area within about 1½ km. radius around the writer's laboratory was more thoroughly examined for rare species living in small colonies. Occasional trips were also extended to an area within about 40 km. radius of Jabalpur city The area selected is suitable for the study. There are several places which can serve as good diurnal roosts of bats. These are : ruined temples, artificial and natural caves, tile roofs of houses, and palm and banana trees. Tanks and streams serve as good source of water supply. No large collection of bats had been made from the area so far.

It is interesting to note that in addition to the discovery of a new subspecies, (Khajuria, 1970) four subspecies not so far recorded from Central India have also been collected from this small area (Khajuria, in press). Except three rather rare bats, *Taphozous saccolaimus crassus* Blyth, *Hipposideros lankadiva unitus* Anderson, *Pipistrellus babu* Thomas, all species and subspecies so far recorded from Central India have been found to occur in the area. *H. lankadiva unitus* has now been recorded from outside the limits of study area but within Jabalpur Dist.

As was expected, an intensive collection in a small area has proved highly rewarding. In all twenty one species/subspecies have been collected. One species *(Tadarida* sp.*)* was seen but could not be obtained.

Brosset (*op. cit.*) did not name the subspecies except in three cases where he had sufficient material. Although the evidence in recognition of subspecies in many cases may be inadequate, it has been thought advisable to retain the subspecies recognised by Ellerman and Morrison Scott (1951) unless sufficient evidence to the contrary is available. Subspecies have so far mostly been based on colour and body measurements. Colour, as rightly noted by Brosset, is very variable. In the case of measurements, observations on large samples need to be statistically examined. In both cases, study of a series of specimens from suitable areas is necessary. The present collection will, it is hoped, meet the need from the area under study.

The study of taxonomy of Indian bats at lower levels has so far been based mostly on 'skin and skull' material. Structure of external genitalia, tongue and stomach have been studied mostly from the fresh material which is rarely available in a museum study. At least three specimens were examined to study the variations of the characters. Milk dentition was examined, wherever possible, and was found to agree with the accounts given by Miller (1907) and Allen (1939). However, a full set of milk teeth was never met with. Only the number of milk teeth with the corresponding forearm length have been recorded.

Where about thirty or more specimens of each sex are available, measurements have been statistically analysed to study sexual dimorphism.

In all 452 specimens were ringed, but ringing was unsuccessful as there was practically no recovery. This was probably because ringed specimens changed their roosts and could not be followed in the restricted area of study. In captivity, ringed specimens injured themselves by constantly pulling and biting the rings. Many of the ringed specimens may, therefore, have died of infection. However, a few specimens marked with fast colours or gently stamped on the wing without annoyance to the animals were sometimes recovered in the case of *T.m. melanopogon* and *M. l. lyra*. Also, most of the species changed their roosts, if disturbed, thus making prolonged observations difficult. In several cases, particularly in boulder caves, roosts have several exits which could not be blocked and bats escaped through them during collections. Although the work was continued for about ten years (November, 1960 to December, 1970), sufficient data particularly for population studies, could not be collected in view of the above difficulties. Census estimates were made by actual counting of all specimens of colonies (small colonies) or from individuals present in a small portion of a colony (large colonies).

This work, limited as it is, will, it is hoped, focus attention of the future investigations on various aspects of the subject more detailed information about which could not be obtained during the present study.

(iii) *Acknowledgements.*- I am deeply indebted to Director, Z. S. I. for providing facilities for undertaking this work and for his constant encouragement and suggestions. Thanks are due to the members of the staff of the Central Regional Station, Z. S. I. who rendered help in various ways in the completion of this study and to the concerned sections of the Z. S. I., Calcutta, who carried out identifications of animals other than mammals mentioned in this study. Authorities of the Nagpur and Jabalpur observatories very kindly supplied meteorological data. Shri J. C. Daniel, Curator, Bombay Natural Hisotry Society, was kind enough to loan some collection for comparison. Illustrations were prepared under my supervision by the departmental artists and photographer Shri A. Paul. The Botanical Department of the Science College Jabalpur and Shri V S. Agarwal of the Botanical Survey of India were kind enough to supply information on important species of flora in the area. Dr. S. Rao, of the Geological Department of Jabalpur University, was consulted on the geology of the area.

The author is highly grateful for useful suggestions to Dr. M. L. Roonwal, former Director, Z. S I., Dr. B. S. Chauhan, then Deputy Director-In-Charge, Central Regional Station, Dr. B. Biswas, Deputy Director, Z. S. I., Prof. G. P. Sharma, Senior Professor and Head of the Department of Zoology, Punjab University, Chandigarh, Dr. J. C. Moore, Curator of Mammals, Field Museum of Natural History, Chicago, U. S. A., Dr. G. Topal, Curator of Mammals, Hungarian Museum, Budapest, and Dr. V C. Agarwal, then Officer-in-Charge, Mammal Section, Z. S. I.

Abbreviattons.- B. M.=British Museum (Natural History), London; Z. S. I = Zoological Survey of India.

II. ECOLOGICAL CONDITIONS IN THE AREA OF STUDY

The area of study lies within 40 kms. radius of Jabalpur city (23°.10' N. lat. and 79°.56' E. Long.), The area is notable for its many geological formations important among which are the Narbada alluvium, Deccan Trap, Lamata, Gondwana, Vindhyan, Dharwar and Gneissose. Huge boulders, among which small caves are present, are common.

Some parts of the area are hilly, reaching a maximum height of about 360 m. The hills belong to the Vindhyachal trend of mountains. They are distinguishable into a north western Bhauser range and Kaimur ridge and southwestern Bhitrigarh hills which run through the middle of Jabalpur District to the north.

The area is drained by the Narbada river and its tributaries. The important ones are the Hiran, the Gour, the Temur and the Soner. There are several large perennial tanks. Five seasons can be distinguished : spring from March to the third week of April, summer from the fourth week of April to the third week of June, the rainy season from the fourth week of June to the end of September, autumn from October to middle of November, and winter from middle of November to end of February. The meteorological data as recorded from 1954 to 1963 are given in Table VI.

Some parts of the area, particularly the Bhitrigarh hills, are forested. The forests are deciduous, and from February to May the majority of the trees are leafless. The important species of the flora are : *Shorea robusta, Terminalia chebula, Madhuca indica, Schleichera oleosa, Syzygium cumini, Mangifera indica, Ficus religiosa, F. bengalensis, Anogeissus latifolia, Anthocephalus indicus, Nyctanthus arbotristis, Carissa spinarum, Cassia fistula, Cochlospermum religiosum, Bauhinia variegata, Cicer orientinum, Lantana camera, Carissa spinarum, Flacourtia* sp., *Cynodon dactylon, Eragrostis pilosa, Themeda laxa, Azadirachta* sp., *Acacia* sp., *Opuntia* sp. *Butea* sp., The cultivated fields mainly grow wheat, rice and pulses.

Important habitats which were used as diurnal roosts by a number of bats are described below. Other habitats are described under each species and subspecies.

Boulder caves.- Special types of caves under huge boulders are found at Richhai village (Pl. I, fig. 4) and at Madan Mahal (Pl. I, fig. 3).

At Richhai village, the boulders formed a hillock covering about 8 acres of land and rising to a height of about 200 m. The hillock is surrounded by agricultural fields and is only about $\frac{1}{4}$ km. from a small railway station. It is well-covered over by earth and overgrown with herbs, shrubs and a few trees except on a portion, about 5,000 sq. m., on the northern face which presents a bizzare appearance, being a confusion of disorderly, huge granite boulders some of which have dimensions reaching about 40 m. The spaces among boulders take the form of countless zigzag caves and crevices of various dimensions ramifying in the interior of the hillock upto a depth of about 50 m. These caves and crevices some of which were so narrow for investigation have several outlets through which bats can leave and enter thus making their capture very difficult. The temperature, light and humidity varied considerably in different parts of the interior of the hillock. The conditions in the external parts of the caves are the same as recorded in case of ruined temples. The bats shift to different parts of the caves in different seasons. They were found in deeper parts in severe winter and summer. An interesting feature is that the habitat is also occupied by other vertebrates both large and small the following of which were identified : *Varanus monitor* Linnaeus, *Python molurus* Linnaeus, *Naia naia* Linnaeus, *Crocidura* sp. (Khajuria 1972), *Canis aureus* Linnaeus, *Vulpes bengalensis* Shaw, *Herpestes edwardsi* Geoffroy, *Hyaena hyaena* Linnaeus, *Felis chaus* Guldenstaedt, *Panthera pardus* Linnaeus (very rare visitor), *Hystrix indica* Kerr., *Funambulus pennanti* Wroughton, *Bandicota bengalensis* Gray and Hardwicke. Five bats, *R.h. hardwickei, T m. melanopogon, T theobaldi secatus, R. l. lepidus* and *H. cineraceus durgadasi,* are found in this habitat.

At Madan Mahal, these caves are not so extensive and are scattered here and there over the Madan Mahal hill. They are visited by *R. h. hardwickei* and *T.k. kachhensis* and some rhinolophids.

Ruined temples.– These temples (Pl. I, fig 1 & 2), all of which are used as diurnal roosts by bats, are situated on the banks of the Narbada river. They are of varying sizes but all have a high dome-shaped ceiling with only one exit so that the interior becomes very dark. No bats are generally found in those temples where worship is still undertaken. The most important group of these temples from the point of view of occurrence of bats is near Lamataghat, a small village on the bank of the Narbada river. These temples are surrounded by a number of fruit trees, *e. g.*, the Custard Apple *(Annona squamosa)* and the *bel (Aegle marmelos)*, and some other plants. They are used as roosts by *R.l. leschenaulti, R.h. hardwickei, T.m. melanopogon,* and *M.l. lyra.* The temperature near temple ceiling is about 3°C less in June and by about the same degrees higher in January than the temperature taken in the open.

Artificial caves.– These caves were found on hillocks near Katanga and Katangi villages at a height of about 200 m. Their length is difficult to measure because they gradually become narrower and narrower towards the farthest ends which are too narrow for human entry. The variation in temperature, light and humidity could not be recorded in these parts of caves. In parts near the exits, conditions are similar to those recorded in temples. The main opening of the one at Katanga is converted into a small room and the interior is used for worshipping. There are a number of other openings. The cave is a permanent roost of

H. f. fulvus,and *H. cineraceus durgadasi*. It is occasionally visited by *R. h. hardwickei* and *M. l. lyra* which, however, occupy spaces near its main opening. The only difference in the other cave is that, it is less humid and its narrow portion is extensively ramified in the interior of the hill. It has three main external openings. The most spacious part is about 1½ m. in diameter and was found occupied by young ones, mainly males, of *H. f. fulvus* and *H. cineraceus durgadasi*.

III. MATERIAL AND METHODS

(i) *Collection and treatment of the material*.– The following methods were used for the collection of specimens :

Since the methods of collection of Indian bats in use at present were found inadequate for a thorough survey of rare species, a new method was developed for location of roosts of such bats and used very successfully (Khajuria, 1976).

Besides the following methods were found useful.—

(a) The species living in the open on trees (*P. g. giganteus, C. sphinx gangeticus, T longimanus, S. temmincki wroughtoni)* were collected by shooting. Occasionally *S. h. heathi,* which may come out of its roosts in holes in very hot weather, was also collected by this method. Smaller, less vigilant species were collected by a hand net by a closer approach with the help of a ladder, if necessary.

(b) The bats living in large colonies in constructions or holes with one or a few exits *(R. l. leschenaulti, R. h. hardwickei, T l. longimanus, T m. melanopogon, T. k. kachhensis, M. l. lyra,* Rhinolophidae and Vespertilionidae) were collected by placing a suitable net just outside the exits when the animals leave their roosts in the evening. If the exist is narrow, a butterfly net was used (Pl. II, fig. 2). If it is wide a long mist net was tried. If a mist net is not available an ordinary fishing net can be helpful. Animals generally fall to the ground by striking the net and can easily be collected. The rhinolophids, however, may only touch the net and fly away. They were collected by a butterfly net as soon as they strike the mist or the fishing net.

(c) The roosts with several exits, *e. g.*, the caves formed by spaces among boulders (p. 5) presented special difficulty in collection. In such cases collection would only be made during daytime with a hand net where the caves were narrow and with fewer exits.

Immediately after collection the specimens were examined for ectoparasities, sex and age, and were weighed. Some were ringed or marked with fast colours or stamped on wings and released. The rest were brought to the laboratory in slightly damp cloth bags to prevent the escape of ectoparasites and exposure to varying external temperature to which they are very sensitive. Some of the specimens brought to the laboratory were kept in cages for future observations and the rest were sacrificed and preserved.

The age of the specimens was estimated by the state of the wear of the canine, as recommended by Twente (Hall, 1957). This method

is simpler than that recommended by Andersen (1917 a). Specimens with worn out tips of canines are taken as adults (ad.) and those with unworn tips of canines but approximating in size to adults are taken as subadults (s. ad.); others are taken as young.

Bacula were prepared by boiling the material in water to which a few drops of KOH had been added. The boiled material was then dissected under a stereoscopic microscope. The boiling was continued for varying periods to completely softened flesh. Bacula were stained with alizarin red S by the methods used by Topal (1958) and Bhatnagar (1967), with slight modifications. If the material was preserved in formalin, it was kept, before staining, in 70% alcohol to which two drops of commercial HCL had been added, for two days. If the material was found overstained, excess of the stain was removed by 0·5% H_2SO_4 solution. The material was washed in 1% KOH before preserving in glycerine. It was kept for 24 hrs. each in 30%, 50%, 70%, 90% glycerine before finally storing in 100% glycerine to which a little thymol had been added.

(ii) *Methods of observations*

A. *Observations in the natural state.*– Several trips were undertaken to make observations in the natural habitat of the animals at different hours of the day and in different seasons. In some cases the haunt consisted of dark very narrow cavities, making observations in natural state very difficult. Some vespertilionid and rhinolophid species were frequently observed hunting near lamps posts in hot weather.

B. *Observations in captivity.*– It was soon realized during the study that observations in captivity are necessary for collection of detailed information. Practically no information was available regarding keeping Indian bats in captivity. Methods recommended for foreign species (Ramage, 1947, Albisson and Dorst, 1951, Orr, 1958) were not found quite effective particularly regarding the rearing of insect food in the laboratory; and, thus, modified methods were successfully developed for the purpose.

(a) The animals were kept in captivity in wooden cages, *ca.* 45×45×60 cm., with wire-netting doors. Some wires from which animals could suspend themselves were fixed inside the cage. Water was provided in earthen pots. Cages were kept in a cool place in summer and were covered up with cloth in winter and during cold nights. Some species, *Scotozous dormeri* and species of *Pipistrellus,* were not found to take food and had to be force-fed. This was achieved by opening the mouth by gently pressing the neck and the food was put into the mouth with the help of a pair of fine forceps. If the animal does not start masticating, its forearm or any other part of the body was pressed with some force which forced it to bite anything in its mouth. After it had taken two or three bites, it generally continued the process if the food was to its taste even when the said annoyance was removed. The food should always be living or freshly killed. In the case of the just mentioned species the following method in the initial stages of captivity was found successful :—

The animals were kept in large kilner jars of about 7 lbs. capacity, with the mouth covered by a net held light by the metallic ring of the kilner jar (Pl.II, fig. 4). The net allowed sufficient fresh air and at

the same time furnished support for the feet of animals during their usual resting position. The glass walls of the jar allowed observation from outside. Because of this advantage, the method was used for observing other species also particularly during mating season. In summer, the jars were kept in the open at night. Food or water could be kept very close to the animals so that they could be induced to take it. Metallic ring around the neck of the jar excludes all possibilities of escape of animals. Jars could thoroughly be cleaned with soap and water to avoid infection of the animals from excreta. Even if the mouth of the jar is kept uncovered the animals are unable to escape except by some accident which may bring them near the mouth of the container. This is because they are unable to crawl up the glass wall of the jar. The only disadvantage was the lack of opportunity to fly. This was overcome by allowing them to fly in a room or in the open with a long tough thread tied to one of the hind feet (Pl.II, fig. 3). The specimens generally took food if kept in the bottle during night. Forced feeding was, however, found to be necessary in most cases in initial stages of captivity.

Water was supplied by placing the animal on thin film of water spread on the ground. In cases the animal did not respond to this method, their mouth was forcibly dipped in the film of water spreads on the ground or water was poured into the mouth with the help of a pipette. The thin film of water sticking to the washed jar was also licked by many thirsty specimens. In most cases, this has, in fact, been the best way of making them drink without force. If all precautions are followed and proper attention is paid to individual specimens especially with regard to food, water, evening flights and cleaning of cages and jars, these bats can apparently be kept in captivity for any length of time.

(b) Species which could live in temples and other monuments were placed in a small room which may simulate the natural diurnal roost. Water was provided in a basin. Windows were provided with wire-netting shutters so that fresh air could be allowed during night. Electric light (20 watts) was kept burning to attract small insects through the wire-netting shutters and prevent larger insects thrown inside the room from escaping. The attraction provided by the light also prevented escape of insects during the night. The bats of course, could fly about in the room. The bats which were not found to feed died within a week or so.

The following insects which could easily be collected in hot season near bat roosts at night with the help of lamp light were tried as food for various bats :—

Order Lepidoptera
Family Nymphalidae
Precis orithyia swinhoei Butler
Family Noctuidae
Achaea ianata (Linn.)
Thermesia rubricans Bolisduval
Caradrina sp.

Order Hemiptera
Family Belostomatidae
Lethocerus indicus (Lep. & Serv.)
Family Pentatomidae
Aspongopus obscurus Fabr.
Family Cydnidae
Cydnus indicus Westw.

Chariclea lanceolata Walker
Family Lymantriidae
Thiacidas postica Walker
Family Arctiidae
Creatonotus lineolus Fb.
Family Pyralidae
Ancylolomia chrysographella(Koll.)
Zinckenia fascialis Cramer.
Order ORTHOPTERA
Family Acrididae
Hieroglyphus concolor Walk
Atractomorpha crenulata Fabricius
Order COLEOPTERA
Family Scarabaeidae
Heliocopris bucephalus (F.)
Orophus sp.
Aphodius sp.
Orthophagus sp.
Family Lygaeidae
Dieuches uniguttatus
Aphanus sordidus Fabr.
Eucosmetus insignis Dist.
Family Coreidae
Leptocorisa varicornis Fabr.
Family Reduviidae
Tribelocephala indica Walk.
Ectomocoris cordiger Stal
Family Cercopidae
Aphrophora sp.
Family Cicadellidae
Tettigoniella spectra Dist.

(iii) *Measurements.*– The external measurements were taken from specimens preserved in alcohol. It has been found that there is negligible difference between measurements taken on fresh and preserved materials because of bony nature of characters measured. In case of the ear, measurements are about 1 mm. less in preserved material. The ear has been measured only when it was found preserved in well expanded condition. The length of the forearm gives a much more accurate measure of the size of the animal than the head and body length which was not, therefore, measured. The recommendations of Roonwal and Agrawal (1966) for taking measurements of rodents were kept in view as far as possible. Measurements were mostly taken under a magnifying glass with the help of vernier callipers with a scale reading upto o.1 mm. The last phalanx was not measured because its distal end is more or less curved and even worn out in old specimens. The proximal end of the tail was taken as anus and measurements were taken by stretching it on a flat surface along a straight line. The length of the ear was measured from the lowermost point on the base of the intertragal notch to the tip of the ear. All measurements are in millimetres and represent the shortest distances between the two points defined. Unless otherwise stated, only adult specimens were measured. The following abbreviations have been used in measurements. —

Body.– d2 (mt), metacarpal of second digit; d2 (phl), first phalanx of second digit; d2 (ph2), second phalanx of second digit; d3 (mt), metacarpal of third digit; d3 (phl), first phalanx of third digit; d4 (mt), metacarpal of fourth digit; d4 (phl), first phalanx of fourth digit; d5 (mt), metacarpal of fifth digit; d5 (phl), first phalanx of fifth digit; f, forearm; ft, foot; p, pollex; p (mt), metacarpal of pollex; p (phl), first phalanx of pollex; t, tibia; tl, tail; wt, weight.

Skull.– c^1-c^1, the shortest distance between the outer surfaces of the roots of the upper canines; cb, condylobasal length, measured from the

hindermost point of the occipital condyle of one side to the anteriormost point of the premaxilla* of that side; c^1-m, maximum length between the anterior surface of the root of the upper canine and the posterior surface of the root of the last upper molar of that side; c_1-m, similar distance between the lower canine and the last lower molar; cr, coronoid height, measured from the highest point of the mandibular condyle to the lowermost point on the under surface of the mandibular ramus of that side; cw, cranial width, the maximum width of the cranium measured just above the squamosal roots of the zygomatic arches; iw, the least interorbital width, measured between the inner borders of the orbits at right angles to the axis of the skull; l, maximum length of the skull, measured from the hindermost point of the occipital surface in the middle line to the anteriormost point of the premaxillary symphysis or of the maxilla if the premaxillae are absent; mdo, median depth of the occiput, measured from the highest point on the upper surface on the occiput to the lowermost point on the lower border of the foramen magnum; ml, mandibular length, the distance between the hindermost point of the mandibular condyle to the anteriormost point on the symphysis of the two rami; m-m, the distance between the outer surfaces of the last upper molars; on, occipitonasal length, measured from the hindermost point of the occiput to the anteriormost point on the nasals; pl, palatal length, measured from the posterior border of the root of the upper incisors to the hindermost point of the palate; pml, postmolar length, measured from the posterior surface of the last molar to the posterior surface of the condyle of that side; zw, the greatest zygomatic width, the greatest distance between the outer surfaces of the zygomatic arches at right angles to the long axis of the skull.

IV. TAXONOMICAL AND ECOLOGICAL ACCOUNT

Family Pteropidae

Subfamily Pteropinae

1. **Rousettus leschenaulti leschenaulti** Desmarest

(Pl. IV, fig. 2)

1820. *Pteropus leschenaulti* Desmarest, *Encyl. Meth. Mamm.*, p. 110 (Pondicherry, India).

Type material.– Cotypes in Paris Museum.

Synonyms.– *Pteropus pyrivorus* Hodgson, *Pteropus pirivarus* Hodgson; *Cynopterus marginatus* Gray, *Cynopterus affinis* Gray; *Eleutherura fuliginosa* Gray, *Eleutherura fusca* Gray; (Types of all in B. M.); *Cynonycteris infuscata* Peters.

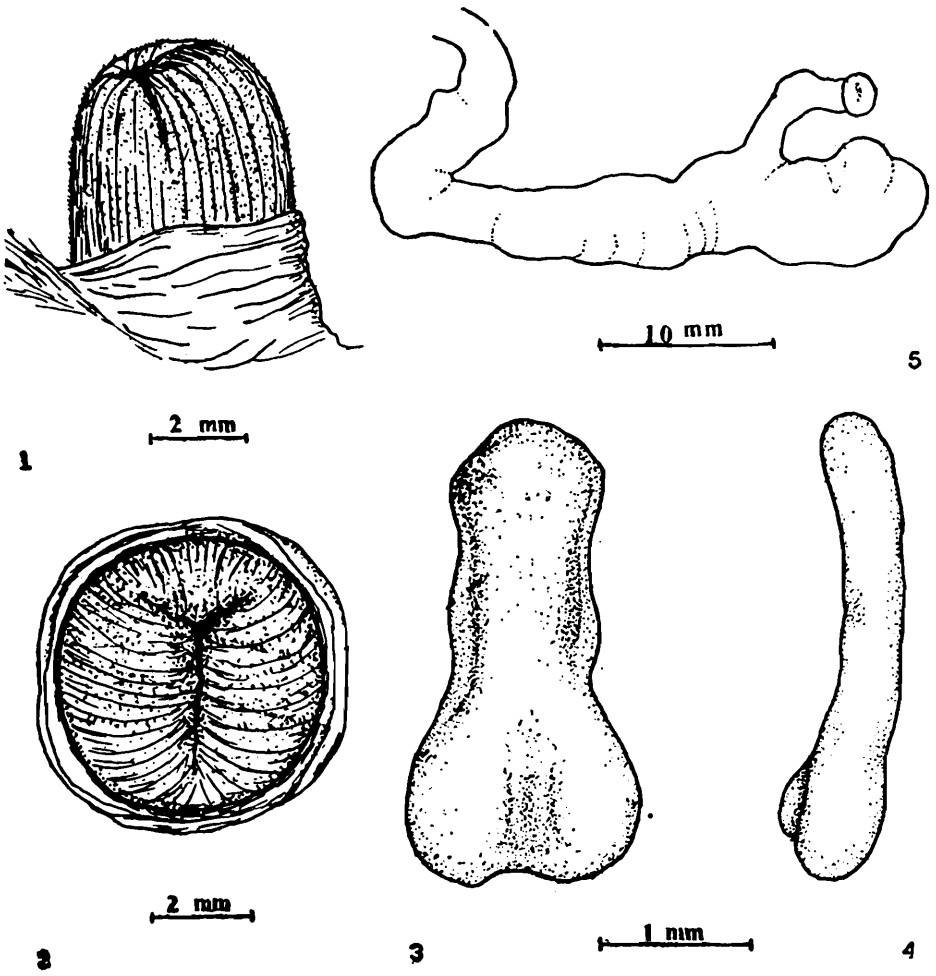
Material collected—♂ : 7 ad., 1 sub. ad., 4 juv; 11 ad. ♀;

unsexed : 1 skeleton, 1 damaged; Lamataghat.

Morphological notes.– Brosset (1962a) mentioned some unrecorded characters. The wing is broad, the fifth digit is longer than the forearm and the third is less than 1½ times the fifth. The tibia is long. In this alcoholic collection the colour is a tint or shade of reddish or yellowish brown with underside paler. Hair on dorsal surface has paler base. Fur

*Maxilla is substituted where premaxilla is absent.

of an adult male collected on 16th January measured upto 7 mm. in length. Some specimens are noticeably darker than others. No naked (moulted) specimen was collected (*cf.* Brosset, 1962a). Brosset's (1962a, p. 13) remark that "absence of tail is distinctive" is obviously a printing mistake. Wing membranes in many individuals are marked with whitish spots. Teats in an adult female collected on 22nd July are greatly flattened (6.5 mm long, 5.5 mm. wide). The distance from axilla is about 9 mm. The penis is enclosed in a prepuce and directed slightly towards



Text-fig. 1. *Rousettus l. leschenaulti.* Fig. 1, lateral view and fig. 2, anterior views of the glans; fig. 3, dorsal view and fig. 4, lateral views of the baculum; fig. 5, lateral view of stomach of a female.

the cranium.* The glans (Text-fig I, figs. 1-2) is short and cylindrical with triradiate terminal urethral orifice. Its surface is marked with longitudinal shallow grooves radiating from the orifice. Its shape is very different from the glanses of *P. g. giganteus* and *C. s. gangeticus*, the other two species of fruit bats found in the area. Vulvar aperture is transversely elongated with a clitoridial pad projecting into it. The baculum (Text-fig. 1, figs. 3-4) is thin, broader at the proximal end with long axis curved. The broader end is pulley shaped. There is a rounded expansion on eirher side in the middle. Bhatnagar's (1967) and Agrawal and Sinha's (1973) detailed discussion of the description of the baculum of this bat is slightly different and probably refer to younger specimens or show individual

*Various views of the external male genitalia and bacula mentioned here are in relation to the normally erected penis when the glans becomes cranially directed. Unless stated otherwise, all illustrations are of adult specimens.

variations. The tongue is more or less similiar to that of the flying fox (Text-Fig. 2, fig. 6). The stomach (Text-fig. I, fig. 5) is a simple tube with well-developed cardiac end. The length of intestine in an adult male measured 505 mm.

Measurements.– Tables VII and VIII.

Distribution.– From Nepal to Coorg (Western Ghats, India) from Rajasthan (India) to Burma, (Tenasserim), Java. North Siam, Tonkin (Indo-China), Amoy (Southern China).

Habitat selection.– The species was met with only in one of several ruined temples (Pl. I, fig. 1) on the bank of the Narbada river, hardly about 150 m. from a village. The temple is one of the biggest among the lot and has a high dome-shaped ceiling with a single narrow entrance. Although there was little human disturbance inside the temple, the villagers visit the immediate surroundings very often. When first observed in January 1961, the colony consisted of about 100 individuals which, dispite great disturbance due to collection after an interval of 1-2 months, continued to occupy the roost upto the end of October, 1961. Thereafter, except on two occasions when the colony contained about 100 individuals, the species was seen rarely and the number varied from two to about ten individuals for a period of eight years. However, it could not definitely be ascertained whether specimens from the same colony are involved in all these observations since no marked specimens were recovered. The position during the intervals between the visits to the roost could also not be known. The decrease in number was apparently due to the occasional repairs to the temple. The bat apparently avoids human disturbance to the extent normal for other species of bats on the basis of the above observations (*cf.* Brosset, 1962a). It, however, becomes quite noisy on human approach, as also observed by Brosset. The bat is quite sensitive to cold. On 14 January (temperature, 18°C), an adult male and two young males kept in a wooden cage with wire-netting door were found with their heads well tucked up in their wings and were quite motionless when handled. They became active at night and fed on fruit but were found dead next morning. Another adult male immediately became active when placed in the sun.

The haunt is surrounded by a number of fruit trees (custard apple and bel) supporting the statement of Brosset (1962a) that "it requires ripening fruit nearby". However, since some haunts appear to be occupied throughout the year by a greater or lesser number of individuals, as observed by Brosset and the writer, the presence of ripening fruit in the vicinity is not a necessity but only a preference. The diurnal habitat is specialized and the animal may not always be able to find it in proximity to fruit trees. It appears to be a good flier and, thus, is in a position to find food at a distance. Although the Indian flying fox is apparently able to find its diurnal habitat without difficulty, it is not known to leave it merely in search for food. For other types of habitats occupied by the species see Brosset (1962a). Prater (1965) and Brosset (1962a) state, that it is found at fairly high altitudes (upto about 2150 m.). However, Bhat (1968) found it only upto 1,000 m. in the Himalayan Region of Uttar Pradesh.

TABLE I—Data from the diurnal roost of *Rousettus l. leschenaulti*

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
23–1–61	Ruined temple (Lamataghat)	100	2 ♂, 5 ♀	*Taphozous m. melanopogon*	
15–3–61					
21–3–61					
6–4–61					
15–4–61	–do–	—	—	—	Absent
21–4–61					
20–5–61					
26–6–61					
22–7–61	–do–	60	20 ♂, 5 young ♂, 5 ♀	*T.m. melanopogon, Rhinopoma h. hardwickei*	Females lactating
29–8–61	–do–	–do–	1 ♂	*T m. melanopogon*	
15–9–61	–do–	100	1 ♀	–do–	
29–9–61	–do–	–do–	5 ♂, 3 ♀	*R. h. hardwickei* (1 specimen only)	
24–10–61	–do–	–do–	1 ♀	*R. h. hardwickei* (2 specimens only) and *T. m. melanopogon*	

TABLE I—Data from the diurnal roost of *Rousettus l. leschenaulti* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
13-11-61	Ruined temple (Lamataghat)	3	3	Nil	
29-11-61	-do-	—	—	—	Absent
30-12-61	-do-	—	—	—	Absent
30-1-62	-do-	50	1 ♂	—	
21-8-62	-do-	2 specimens	—	*R. h. hardwickei* (1 specimen), *T m. melanopogon*	
25-11-62	-do-	100	39 ♂, 37 ♀	*T. m. melanopogon*	
22-12-62	-do-	10	Nil	*T m. melanopogon*	
7-1-63	-do-	5	Nil	do-	
27-2-63	-do-	12	5 Young ♂	-do-	
24-4-63	-do-	—	—	—	Absent
5-5-63	-do-	—	—	—	Absent
23-2-65	-do-	8	1 s. ad. ♂, 2 ♀	—	The specimens in poor health. Females pregnant
19-5-65	-do-	—	—	—	Absent
16-3-66	-do-	5	2 ♂ (1 s.ad.), 2 ♀	—	

General habits.– Although temples in close vicinity of its roost are occupied by *Megaderma l. lyra*, the two species were never found in the same haunt. The two species were kept in a small room overnight and heads of two specimens of the present species were found missing. Parkash (1959) has already reported that *M. l. lyra* feeds on head portion of *T p. perforatus*. The occurrence of the two species together in a cave was recorded by Brosset (1962a). Possibly they occupied different corners of the cave. The species was frequently found with a large colony of *T. m. melanopogon* and a few specimens of *R. h. hardwickei*. Its association with *R. h. hardwickei* does not appear to be recorded. Its reaction to human beings has been discussed before. About ten individuals in a colony of about fifteen did not leave the roost despite continuous human disturbance for about half an hour.

The maximum number of individuals met with together was about 100 and the minimum two. Brosset recorded the number as varying from 2 to 2,000. It is difficult to say at present as to what factors determine the number of individuals in a colony. Possibly human disturbance, the availability of space, food, mating, segregation of sexes and young ones are some of the factors, as will be seen later. The spacing of individuals in a colony could not be observed satisfactorily since the natural arrangement was disturbed as soon as the observer enters the haunt. In captivity most of the individuals remained apart from one another when kept in a room and there is no reason to doubt that the same arrangement prevails under natural conditions. No individual was seen falling to the ground when leaving the haunt (*cf.* Brosset 1962 a). The time of emergence as observed on 22nd July was 7.45 P.M. (sunset, 6.58 P. M.), and the bats left the roost in small parties of one to three individuals but some continued to occupy it upto 8.30 P.M. It appears that the bat occasionally returns to its roost at night as shown by the remnants of fruit in the roost. The flight is fairly fast and flapping at the level of tree tops or below. Its method of suspension as observed in captivity is peculiar. It has frequently been seen using both feet and the shank for clinging to surfaces, with the face turned away from the wall of the cage. The use of the shank appears necessary to support its heavy weight during suspension from smooth surfaces. It can move easily on all fours and swim well. Several types of sounds, resembling *krin-krin, kron-kron,* were heard in captivity but the sound resembling *thak* given out by many insectivorous bats as an expression of annoyance was not heard in this species. According to Brosset it does not hibernate and artificially cooled individuals do not survive. As stated earlier, specimens kept in captivity were found in a condition of torpor when the temperature touched 18°C but revived when placed in sun. They also became automatically active in the evening (temperature, 22°C).

Breeding habits.– Four females each with a single foetus (forearm, 8-16 mm.) were collected on 23rd February. However, a female (forearm, 74 mm.) examined on 23rd January was not pregnant. Although there is definitely a parturition in spring, no data could be collected on the autumn parturition which has been suggested by observations of Brosset (op. cit) and Gopalakrishna (1969). In a large colony observed at the end of November, many individuals were seen in pairs. Two adult males examined on 23rd January had the epididymides choked with spermatozoa. The abdominal testes measured 20–22 mm. in length. Females collected on 22-7-61 were still lactating and were taken along

with four young males. Brosset's observation that young grows to maturity in about two years appears to be correct because immature individuals were collected in February (forearm, 65 mm.). Collection of only females with immature individuals in March, June and July suggests that segregation of sexes may occur. McCann (1942) also made similar observations. Collection of only three young ones in February from a colony of ten lends some support to Brosset's views that the young ones after weaning may sometime live apart from adults; but the data provided by this study is too meagre to arrive at a definite conclusion. No mortality among young ones was observed.

Food habits.- McCann (1942) has studied the food habits of the species and has provided a list of fruit eaten by it. According to Brosset (1962a), the species lives mostly on forest berries and wild figs but he also reports that a specimen was caught eating a banana in a house. As stated above, the present haunt was surrounded by a large number of trees of the custard apple and the 'bel' and there is every possibility that the species feeds on them because their parts were found in the roost. A tomato placed in the cage was also found half eaten.

A subadult female in captivity ate wild berries and guavas. The berries were picked up from the floor of the cage and generally held in one of the foot or in the wing membrane. They were eaten or licked in various poses while the animal hung from a corner of the cage, Pl. III, figs. 2-4. The guava was licked. The food is quickly digested and passed out as faeces within less than an hour.

Movements.- There is a great fluctuation in the number of individuals in the roost (Table, I). Such movements of the species have also been noted by Brosset (1962a). There appears to be a number of causes for these movements, *e. g.*, violent disturbance, availability of food, segregation of sexes and young, etc.

Enemies, parasties and disease.- Bats which left their roost during daytime due to human disturbance were attacked by the Jungle Crow *(Corvus macrorhynchos* Wagner*)* but none was seen being captured. The possibility of *M. l. lyra* preying on it has already been mentioned. Two ectoparasites *(Thaumapsylla* sp. and *Eucampsipoda* sp.) were found on all parts of body.

Population.- The population in a 130 sq. km area did not exceed 100 specimens at any one time. Out of 131 specimens, examined, 64 were adult males, 2 subadult males, 10 young males and 55 adult females. This shows preponderance of males; but it appears that males are the first to leave the roost on disturbance while females may continue to occupy it even after continuous disturbance. Males are, thus, more easily collected. The sex ratio is difficult to determine. The population has shown considerable decrease in the study area (Table, I) possibly because of human disturbance.

Economic importance.- On account of its food habits, the species appears to be a fruit pest although not of as much importance as the flying fox. It may cause nuisance in places of archaelogical interest. Some people are reported to burn fire under the roost to get rid of the

animals. However, the best way to decrease its number, if too large, is probably to induce poorer section of community to catch it with net and utilize its meat. The animal appears to be useful agent in seed dispersal and pollination.

2. **Pteropus giganteus giganteus** Brunnich

Indian Flying Fox

(Pl. IV, fig. 1)

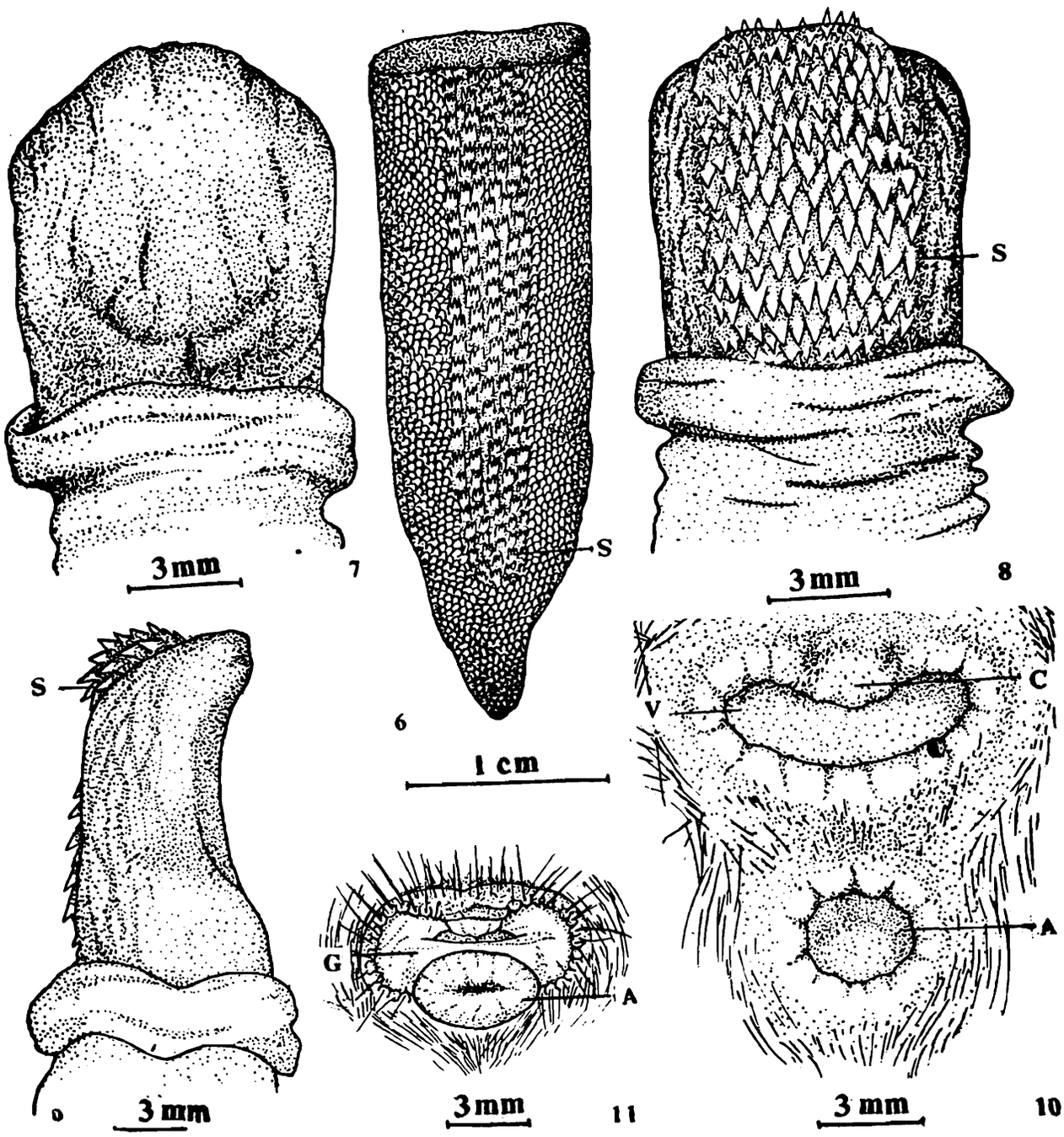
1782. *Vespertilo gigantea* Brunnich, *Dyrene Historie*, 1 : 45 (Bengal, India).

Type material.– Type in Copenhagen Museum.

Synonyms.– *Pteropus medius* Temminck, *Pteropus edwardsi* I. Geoffroy, *Pteropus kelaarti* Gray.

Material collected.– ♂ : 9 ad, 2 s. ad : ♀ : 6 ad. 1 s. ad., 1 juv ; Jabalpur city, Gwarighat, 1 s. ad ♂, purchased.

Morphological notes.– The wing (Pl. IV, fig. 1) is broad and pointed. The fifth digit is longer than the forearm and the third digit is about 1½ times the fifth. The colour is known to be variable. The main variation is in colour of whole of ventral surface and in that of the head, the neck and the shoulders. The colour on these parts varies from almost wholly black to very dark reddish brown. However, the colour on posterior parts of the shoulders is paler than other parts and on posterior ventral surface and the head darker than other parts in all specimens. It is difficult to correlate these variations with age, sex or season on the basis of this material. The colour of the individual hair is also variable on different parts of the body. The basal band to the individul hair is generally darker on brightly coloured parts. Darker parts of the body may or may not have a paler basal band to the hair. Some white hairs ars found mixed up with black ones. The fur of an adult male collected on 27 November measures upto 33 mm. on the throat where the hair is the longest. The shortest hair is on the posterior back. The fur is woolly on the posterior-most parts of the body. In the preserved specimens, it is not possible to distinguish "a circular tuft of rigid greasy hairs, bright reddish in colour, on the sides of the neck" which is reported to be generally present in males (Blanford, 1891, p. 257). In an adult female collected on 3rd September, the flattened teats are situated at a distance of 22 mm. from the axilla and measure 8.5×7.5 mm. They are placed as described under *R. l. leschenaulti*. Tibia is long. The structure of external genitalia and the tongue are shown in text-figures 6-10. The presence of spines or copulatory spurs on the ventral side and a large bony baculum on the dorsal side of glans is noteworthy. The baculum of some fruit bats (Pteropidae) was studied by Davis (1947) and Didier (1965). Bhatnagar (1967) has figured and described in detail the baculum of the this bat. The foetus with a forearm 27 mm. is toothless. In two adult male skulls, there is a peculiar cranial abnormality. The anterior ends of the nasals project beyond the pre-maxillary symphysis and the upper incisors are absent. Allen (1939, p. 142) has described and figured the stomach of the species and emphasized its resemblance with that of the fruit eating members of the family Phyllostomidae in the enlargement of the cardiac portion.



Text-fig. 2. *Pteropus g. giganteus.* Fig. 6, dorsal view of a portion of the tongue; fig. 7, dorsal, fig. 8, ventral and fig. 9, laternal views of the glans; fig. 10, vulva of a pregnant female immediately after copulation;fig.11, grandular pouch surrounding the vulvar aperture of a pregnant female of *Cynopterus sphinx gangeticus.* A, anus; C, elitoridial pad; G, glandular area. S, spines; V, vulvar aperture.

Measurements.– Tables VII and VIII.

Distribution.– Sri Lanka and practically throughout India in suitable localities; Burma (Pegu).

Habits.– Several authors (Blanford, 1891, Prater, 1965, Brosset, 1962a) have given some account of its habits. Neuweiler (1968) and Khajuria (1971) have given a detailed account of the habits of this flying fox in Madras city and central India respectively. The following further information has been obtained :—

A copulating female was found to carry an embryo 5 mm in diameter on 25th October (Text-fig. 2, fig. 10; Pl. IV, Fig. 3). A colony observed on 29-3-67 appear to consist only of males as far

as it was possible to determine the sex with a pair of binoculars, further showing that sexual segregation possibly takes place after mating. A neem tree (*Azadirachta* sp.) was well occupied on 18th November but found to be deserted on 20th March. Similarly a peepal tree, *Ficns* sp., well occupied in winter was found deserted on 20th July. In some cases some adult males and immature individuals may be found on winter roosts even in the beginning of summer as shown by the collection of 5 adult males and 1 subadult female towards the end of March.

Marshal (1947) could not obtain any specimen in June and July in Sri Lanka. The exact cause of shifting of quarters in summer could not be ascertained but it appears to have some relation with bearing of the young and weather.

Enemies, parasites and disease—The bat appears to have practically no predators at least during daytime. This is shown by its roosts which are completely exposed, and by its large population. A few people catch it with nets for food in some parts of India. A cause of death is the live electric wire by which individuals get electrocuted while flying at night. It carries heavy infection of the ectoparasitic species, *Cyclopodia sykesi* Westwood.

Population.– The population in 130 sq. km. area was about 250. Before parturition season, the sex ratio appears about 50 : 50 as determined by counting 50 individuals with field glasses. A single young is born.

Economic importance.– A net slightly different from that described by the auhor (Khajuria, 1965) was found to be in use in a gauva garden near Jabalpur. The main difference was in tying of strings with the hooks. This was due to the fact that the net was used at ground level because of the small size of guava trees. It has been reported that some people secretly take the flesh of this bat as medicine. Economic importance of the species was discussed by the author (Khajuria, *op. cit.*). The average cost of one animal is about one rupee.

3. **Cynopterus sphinx gangeticus** Anderson

The Short-nosed Fruit Bat

(Pl. IV, fig. 3)

1910. *Cynopterus sphinx gangeticus* Anderson, *Ann. Mag. nat. Hist.*. **6**, p : 623 (Lucknow, Uttar Pradesh, India).

Type material.– Type in B. M.

Material collected.– ♂ : 2 ad; 1 young; 2 ad ♀; Jabalpur city, Sasan (Bherghat-Patan Road); ♀ : 2 ad., near Shahpura.

Morphological notes.– The form of the wing is more or less like that of *R. l. leschenaulti* (Pl. IV, fig. 3). The tibia is rather short. The colour in adult males is yellowish brown on dorsal surface, bright rufous on the throat and its sides, chest and flanks on the ventral side. The lower abdomen is yellowish grey. The individual hair has rufous tip with short pale base. The fur of an adult male collected on 12th February measures upto 9 mm. in length. In females the colour is much less red on the parts which are bright rufous in males. The young is brownish

grey on the dorsal surface with short rufous tips to the hair on the back. On the ventral surface the colour is whitish grey. Whitish margin to the ear is indistinct in the young. The teats in a pregnant females are 14 mm. from axilla, 5 mm. long and 4 mm. broad placed as described under *R. l. leschenaulti.* Vamburkar (1958) has described the male genital tract and has given a detailed account of the glans and the baculum. The external genitalia in pregnant females are peculiar : the vulvar orifice is placed in a pouch with glandular margin (Text-fig., 2); the clitoridial pad is transversely divided and each portion shows further longitudinal divisions into smaller lobes.

The young has all the cheek teeth erupted but the first premolar in both jaws is represented by both milk and permanent teeth. The forms of the tongue and the stomach are as in *R. l. leschenaulti.*

Measurements.–

Body : 2 ad. ♂: f, 71.0-72.5; p(mt), 6.5-7.5; p(phl), 17.5; d2(mt), 29.5-31.0; d2(phl), 9.0-10.0; d2(ph2), 7.5; d3(mt), 47.0-49.0; d3(phl, 29.5; d4(mt). 46.0; d4(phl), 24.0-24.5; d5(mt), 46.5-47.0; d5(phl), 21.0-23.5; t, 28.0-29.9; ft, 18.0-18.5; tl, 17.5-18.0; ear, 20.5-23.5; wt, 57.0-60.5. 1 young ♂: f, 55.3, p(mt), 9.5; p(phl), 11.5; d2(mt), 23.4; d2(phl), 7.7; d2(ph2), 5.4; d3(mt), 31.0; d3(phl), 20.0; d4(mt), 29.0; d4(phl), 16.0; d5(mt), 31.9; d5(phl), 14.9; ft, 13.0; t, 22.0.

2 ad. ♀ : f, 74.5-75.5; p(mt), 9.0-10.0; p(phl). 17.5-18.0; d2(mt) 31.5-33.0; d2(phl), 10.0-11.0; d2(ph2), 7.5-8.0; d3(mt), 47.0-49.0; d3(phl), 33.5-35.0; d4(mt), 44.5-46.5; d4(phl), broken; d5(mt), 47.5; d5(phl), 22.5; t, 29.5-31.0; ft, 15.0-16.0; tl, 16.5; ear, 21.5-23.0; wt, 60.0.

Skull : 1 ad. ♂ : c^1-c^1, 7.9; cb, 30.7; c^1-m, 12.0; c_1-m, 12.6; cr, 8.7; cw, 13.9; iw, 7.0, i, 32.3; mdo, 8.6; ml, 26.0; m-m, 10.3; on, 31.5; pl, 16.0; pml, 19.1; zw. 18.7. 1 young ♂ : c^1-c^1, 5.5; cb, 21.5; c^1-m, 9.9; c_1-m, 12.6; cr, 8.7; cw, 13.9; iw, 7.0; l, 32.3; mdo, 8.6; ml, 26.0; m-m, 10.3; on, 31.5; pl, 16.0; pml, 19.1; zw, 18.7. 2 ad. ♀ : c^1-c^1, 7.1-7.2; cb, 30.4-31.4; c^1-m, 11.3-11.5; c_1-m, 12.8-13.0; cr, 11.9-12.2; cw, 13.5-14.2; iw 6.1-7.0; l, 32.2-32.9; mdo, 5.1-5.6; ml, 25.2-25.3; m-m, 9.6; on, 31.4-31.7; pl, 15.1-15.4; pml, 18.2-18.9, zw. 21.3.

Distribution.– Uttar Pradesh; Central India (Nimar, Palanpur, Nagpur).

Habitat selection.–Four colonies were met with under the leaves of palmyra palms; all but one colony were near human habitations (one very near to a noisy flour mill, and two near a railway line). Blanford (1891) and Brosset (1962 a) mentioned a number of other habitats for this bat. Bhat (1968) found it upto 1,000 m. in Himalayan Region of Uttar Pradesh.

General habits.– This bat was met with in association with a large colony of *T. l. longimanus* and *S. temmincki wroughtoni* in two places. The size of the colony varied from about three to fifteen individuals. Brosset's (1962 a) remark that the bat is not social needs qualification; They rest very close to one another. They did not fly away even after a number of shots were fired at random at the roost. A few left the roost when the shots actually hit the colony. The flight is flapping and fairly fast at the level of tree tops. They usually cling to smooth

surfaces of leaves with the claws of the feet and the thumbs but may also suspend themselves from the branches. The time of emergence on 28th August (sunset), 6.34 P.M.) was 7.10 P.M. It does not hibernate.

Breeding habits.– The collection of pregnant females (forearm of foetus 16 to 24 mm) on 12the February and of a grown up young in September indicates that the parturition takes place in spring. This confirms my earlier observations (Khajuria, 1953) and of other authors (Brosset, 1962 a). More information on the subject is given by Ramakrishna (1950), Moghe (1956) and Vamburkar (1958).

Food habits.– According to villagers it is a pest of guava fruit.

Movements.– The form was not met with in haunts where it was once disturbed.

Enemies, parasites and disease.– None recorded.

Population.– The total number of specimens in 1½ km. sq. area was estimated to be about 30.

Economic importance.– The species is reported to feed on garden fruit like *chikoos* (Brosset, 1962 a), plantain, mangoes (Blanford, 1891), guava and possibly on other fruit also. It may also feed on wild fruit. It may be caught with a net like that described for the flying fox (Khajuria, 1965), or shot. The species obviously helps in pollination and seed dispersal.

Suborder Microchiroptera

Family Rhinopomatidae

4. Rhinopoma hardwickei hardwickei Gray

Lesser Rat-tailed Bat

(Pl. V, figs 1 & 2)

1831. *Rhinopoma hardwickei* Gray, *Zool. Misc.*, 37 (India).

Type material.– Type in B. M. (ad. ♂, in alcohol, Siddiqui, 1961).

Material collected.– ♂ : 11 ad, 1 s. ad, 2 juv; 19 ad ♀; Katanga, Madan Mahal, Lamataghat, Richhai.

Morphological notes.– The wing is moderately broad : the fifth digit approximates to forearm in length. The length of the third digit is much less than 1½ time the length of the fifth digit (Pl. V, fig. 1). There is no calcar. The tibia is rather long. The colour varies from dull greyish to reddish or yellowish brown on dorsal side with paler ventral surface. The young is darker. An albino has been recorded (Khajuria, 1973). Individual hair has a prominent whitish base. The fur of specimens collected in October measures upto 8 mm. in length. The teats of a female collected on 21st August are tubular and measure 4.5 mm. in length and 1.5 mm. in diameter. They are situated at a distance of about 8 mm. from axilla. Large fat deposits are present in all specimens collected from June to November. These specimens are more brightly tinted than others being more yellowish with reddish tinge here and there. An adult male kept in captivity from 12th October to 6th

November without food did not show an appreciable decrease in fat but a female kept along with the male grew considerably thinner.

The caudally directed penis is enclosed in a more or less naked prepuce. The glans (Text-fig. 3, fig. 12) is longer than broad with a whitish protubrance on the upper edge of the anterior truncated extremity. The orifice runs veritically along the anterior extremity. The clitoridial pad (Text-fig. 3, fig. 14) is much enlarged. The baculum (Pl. V, fig. 2) is an elongated thin spicule with its posterior broader end forked. In some cases, the anterior end is rounded and the shaft shorter. It is placed inside the glans dorsal to the urethra with anterior end projecting on the dorsal tip of the glans. The tongue has a row of rounded enlarged papillae present on either side. The cardiac end of the stomach is reduced (Text-fig. 3, fig. 15).

Measurements.- Tables VII & VIII

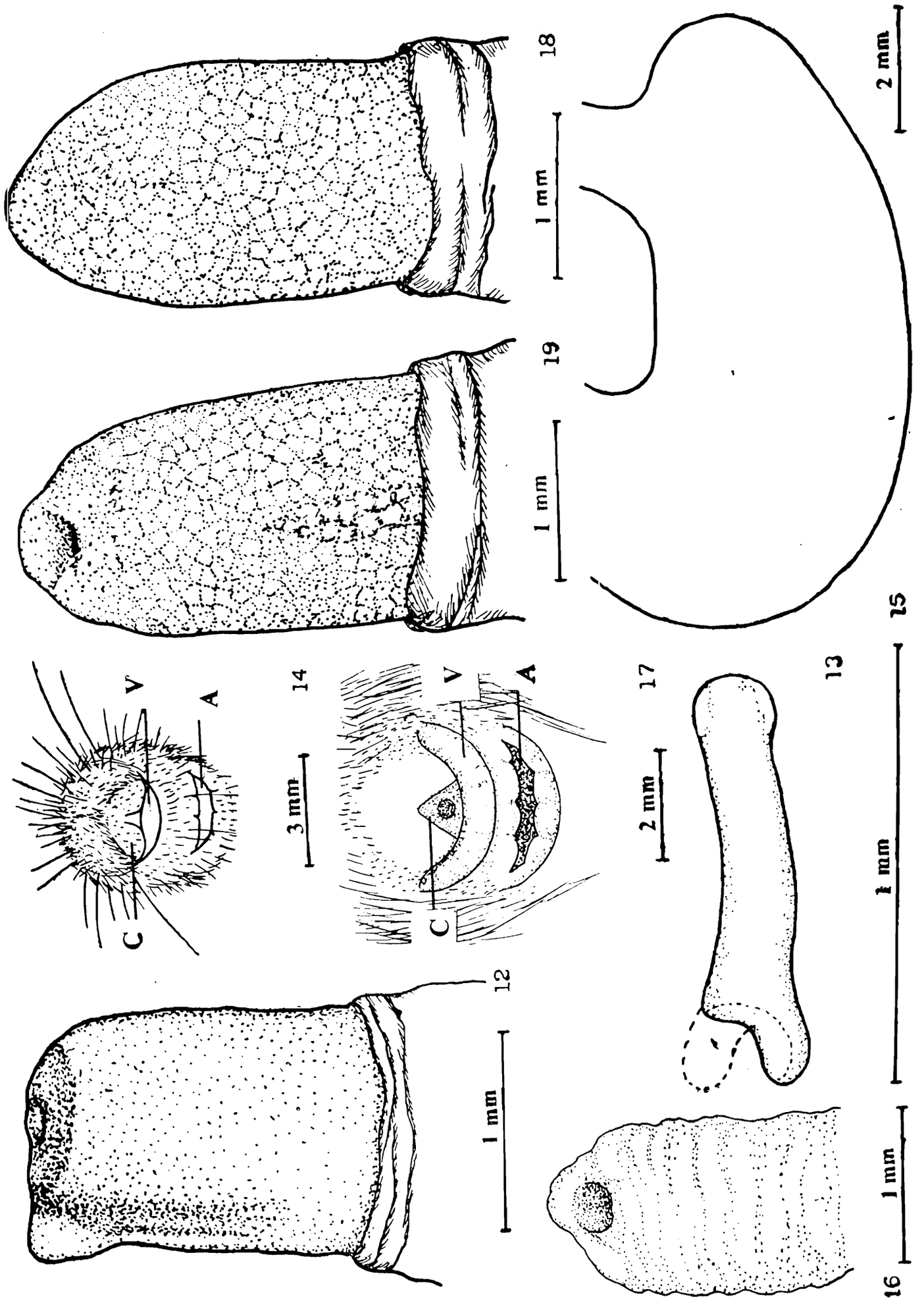
There is no sexual dimorphism in size.

Distribution.- Pakistan and Peninsular India to Burma and Lower Thailand.

Habitat.- The species was met with in three different types of habitats : (1) the ruined temple, as in *R. l. leschenaulti ;* (2) an artificial narrow cave on a hillock one end of which was used for worshipping ; (3) natural small caves (well lighted or dark) under huge granite boulders; but never in human dwellings as observed by Brosset (1962 a) in Gujarat. No specimens were obtained in winter ; possibly the bat seeks more sheltered quarters in that season. In the hot weather it has been found in well lighted spaces among boulders. At night it was observed to hunt near rocks. Siddiqui (1961) states that it inhabits subtropical dry evergreen and tropical thorn forests in Pakistan. Brosset (1962 a) and Prakash (1963) has provided further information on its habitats. Bhat and Sreenivasan (1972) recorded it from humid areas of costal Mysore.

General habits. - It associates with a number of other bats such as *R. I. leschenaulti, T m. melanopogon* (ruined temple), *H. f. fulvus, H. cineraceus durgadasi, R. I. lepidus* (artificial cave), *T m. melanopogon, T theobaldi secatus, R. I. lepidus* (dark natural caves under huge granite boulders), *T k. kachhensis* (well lighted caves under huge granite boulders on a hillock). According to Brosset it is also found with *T. longimanus* and *Hipposideros speoris*. However, Prakash (1963) refers to its association with only *R. I. lepidus* in Rajasthan. The bat appears quite eclectic in its association with other species in the area but probably occupies separate corners of the cave, if available. A large number of specimens (*ca.* 100) found hanging from huge boulders in September, urinated when disturbed by the collector.

They are generally not found crowded together. In captivity, one adult male and two adult females hung themselves from fixed positions without moving for seven days. The number of individuals found together varied from 1 to about 100. No definite observation could be made on the time of its emergence from and that of return to the roost; but there is no reason to doubt that it is markedly different from that of *T. m. melanopogon* with which it commonly associates itself. In September when the bat inhabits open places, a number of individuals were seen to spread their wings and chase one another. Some were seen figthing. Night is



Text-fig. 3. Fig. 12-15. *Rhinopoma h. hardwickei.* Fig. 12, lateral view of glans; fig. 13, dorsal view of baculum; fig. 14, eternal female genitalia; fig. 15, lateral view of stomach.

Figs. 16-17. *Taphozous l. longimanus.* Fig. 16, posterior view of the teat; fig. 17, exernal female genitalia.

Figs. 18-19. *Taphozous k. kachhensis.* dorsal and ventral views of the glans.

A, anus; C,clitoridial pad; V, vulvar aperture.

TABLE II. Data from the diurnal roost of *Rhinopoma h. hardwickei*

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
21-4-61	Ruined temples (Lamataghat)	20	1 ♀	*Taphozous m. melanopogon*	—
26-6-61	–do–	30	2 young ♂, 4 ♀	*Taphozous m. melanopogon*	All females with a single young each
29-8-61	–do–	—	—	—	Absent
15-9-61	–do–	—	—	—	Absent
29-9-61	–do–	1	1 ♀	*Rousettus l. leschenaulti*	—
29-9-61	–do–	10	2 ♀	—	—
24-10-61	–do–	2	—	—	—
13-11-61 29-11-61 30-12-61 30-1-62	–do–	—	—	—	Absent
21-8-62	–do–	1	1 ♀	*R. l. leschenaulti* (2 specimens) *T m. melanopogon*	—
25-10-62	A crevice in the wall of a temple (Lamataghat)	1	1 ♀	—	—
25-11-62	Temples in Lamataghat	—	—	—	Absent

TABLE II. Data from the diurnal roost of *Rhinopoma h. hardwickei* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
28-3-63	Temple in Lamataghat	—	—	—	Absent
29-4-63	–do–	—	—	—	Absent
5-5-63	–do–	—	—	—	Absent
17-5-63	Boulder caves (Richhai)	—	1♂	—	—
24-5-63	Temples in Lamataghat	—	—	—	Absent
6-6-63	Boulder caves (Richhai)	10	—	—	—
2-8-63	–do–	—	1♂	—	—
14-9-63	Artificial cave on a hillock (Katanga)	100	1♂, 6♀	*Rhinolophus l. lepidus* and *Hipposideros f. fulvus*	—
–do–	Boulder caves (Madan Mahal)	500, 100 (two colonies)		*Taphozous k. kachensis*	—
16-1-64	–do–	—	—	—	Absent
25-7-64	–do–	10	1♀	—	—
4-6-65	–do–	20	1♀	—	—
16-7-65	–do–	20	1♂, 1♀	—	Absent
19-8-65	Artificial caves (Katanga)	70	—	—	—

TABALE II. Data from the diurnal roost of *Rhinopoma h. hardwickei* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
12-10-65	Boulder caves (Richhai)	?	1 ♂, 2 ♀	—	Absent
17-12-65	Artificial caves (Katanga)	—	—	—	Absent
-do-	Boulder caves (Madan Mahal)	—	—	—	Absent
1-4-66	-do-	10	1 s. ad, ♂,	—	—
13-5-66	Boulder caves (Richhai)	?	1 ♀	—	—
20-1-67	Boulder caves (Madan Mahal)	—	—	—	Absent
13-3-67	Boulder caves (Richhai)	?	1 ♂, 1 ♀	—	—
11-9-67	Boulder caves (Madan Mahal)	60	—	—	—
20-3-68	Boulder caves (Richhai)	?	1 ♂, 1 ♀	—	—
12-9-68	-do-	?	2 young ♂, 3 ♀ 14 young ♀	—	—

apparently passed in hunting near its diurnal roosts as the flight is weak. It also probably hovers to pick up stationary food. It generally uses both its feet and thumbs for suspension but the forequarters are raised from the substratum. It can also suspend itself from feet only. It can crawl and swim well. When tired, it floats on the surface of the water. Sounds, as heard in captivity, resembles *chin-chin, chirrin-chirrin.* In addition to biting, it appears to defend itself by urinating on intruders.

Breeding habits. - Khajuria (1972) described in detail courtship and mating in this species in another locality. Two stages in the process are shown in by arrows Pl. VII, figs 1 & 2. A female taken on 21st April carried a foetus with forearm 7mm. while the one taken on 13th June was heavily pregnant. Three females taken on 26th June had one young each while the fourth had not delivered. These observations show that conception takes place towards the end of February or beginning of March and parturition takes place towards the end of June or beginning of July. Earlier observations (Prakash, 1960, Brosset 1962, Reuben, 1963) suggested a restricted breeding period. Perhaps it may vary slightly, depending upon the locality. Two adult females taken on 12th September were still lactating and were collected along with young ones which weighed about two grams less. An adult male and an adult female were kept in captivity from 16-3-67 to 10-4-67. The female sometime showed aggressiveness towards the male and chased it, biting its tail. No mating was observed. Since no food was taken by the specimens, possibly the male was unable to respond. Segregation of sexes may take place (Table II). This is also suggested by the observations of Prakash (1963) and Brosset (1962 a). Kumar (1965) made more or less similar observations on the closely allied species, *R. kinneari.*

Feeding habits.– Brosset reports that remains of Diptera were seen in the guano and that the weak dentition of the bat is only "fit for the mastication of small and soft insects". Prakash(1959a) states that the stomach contents showed "wings of moths, chitinous parts of neuropterous insects and beetles" No definite information could be obtained about the kind of the food taken by this bat in the present study. Identification report on droppings and stomach contents supplied by Entomology Division of Z. S. I. revealed only remains of Orthoptera and Coleoptera. Several attempts were made on forced feeding but without success. Several types of insects (see p. 8) were tried but the animal spat out the insect from its mouth. Possibly the food is specific. The rejection of food was generally followed by a peculiar sound resembling *tak* or *thak* with upward jerk of the head. Milk was also not liked. The animals lived without food in captivity for about a month. Water was always provided. Death always occurred because of the absence of water in the cage.

Movements.– The bat has some definite movements (Table II) which may be due to causes similar to those found in *R.l. leschenaulti.* It was not collected during winter and it is very likely that it migrates to some more secluded quarters in that season as suggested by the detailed work of Kumar (1965) on the closely allied species, *R. kinneari.*

Enemies, parasites and disease.– Small orange-yellow masses of rounded egg-like bodies (not identified) are found on the external surface, including the wing-membranes, of some specimens.

Population.– The total population in 130 sq. km. area was about 300 before parturition. In all, 14 adult males, 26 adult females, 4 young males and 14 young females were examined, showing the predominence of females in both age groups.

Economic importance.– The bat is a great nuisance in places of archaeological interest and is difficult to eradicate. Perhaps the only effective method to do so is by blocking the exits by wire-netting. It, preys on insects.

Family EMBALLONURIDAE

5. **Taphozous longimanus longimanus** Hardwicke

Tomb Bat

(Pl. V, fig. 3)

1825. *Taphozous longimanus* Hardwicke. *Trans. Linn. Soc.* London, **14**:525 (Calcutta, Bengal, India)

Type material : Unknown.

Synonyms.– *Taphozous fulvidus* Blyth and *Taphozous brevicaudus* Blyth (Types in Z. S. I., *Taphozous cantori* Blyth)

Material Collected.– ♂ : 8 ad; ♀ : 13 ad, 3 s. ad; Jabalpur city, Sitapahar, Sasan (Bheraghat–Jabalpur Road),

Morphological notes.– The wing is narrow and pointed. The fifth digit is smaller than the forearm. The third digit is longer than 1½ times the length of fifth digit. The tibia is rather short. The general colour is brownish black above, paler below with sides of throat darker. The individual hair is whitish at the base with a middle long dark brown band and a paler tip. The dark brown band is paler on the ventral surface. In an adult male collected on 12th December, the longest hair was on the neck and measured 11 mm. The teats in an adult female collected on 12th November are 9 mm. from axilla, 4 mm. long, and 1.9 mm. wide. They are slightly pigmented (blackish) and are obliquely attached to the body (text-fig. 16). The male generative organs have been described by Murthy (1970). A well-defined clitoris is placed in an inverted V-shaped area (Text-fig. 3, fig. 17). The tongue has enlarged papillae at the tip. The stomach does not show any specialisation.

Measurements—Table VII and VIII.

Distribution.– Sri Lanka, Peninsular India, Burma (Tenasserim), Malaya to Sumatra, Java, Borneo.

Habitat and general habits.– Brosset (1962 a) and Khajuria (1975) have given an account of these habits. A peculiar habitat occupied by it was a verticle cavity in pillar of bridge (Pl.VII, fig. 3)* The time of emergence, as recorded on 28th August, was 7.10 P.M. (sunset, 6.34 P. M.). The bats flew out in small parties of 1 to 4 individuals at the level of tree tops. Flight at the time of leaving the roost is of the flapping type. The

* This habitat was in an adjoining District.

bat clings to leaves or tree trunks with the claws of its feet and thumbs, but can also suspend itself from hind feet only. It can crawl rapidly.

Breeding habits.- Pregnant females were found on Ist February (embryos 3-5 mm.) and on 20th July (embroys 4-17 mm.). Newly born young were found along with their mothers on 28th June. A female collected on 21st September still had a grown-up young on its belly. Blanford (1891) states that a female was found to carry a single embryo in early August in Calcutta. Gopalkrishna (1955) has made a detailed study of the breeding habits of this species and states that it breeds all the year round in Nagpur.

Feeding habits.- None of the insects given on p. 9 were taken in captivity.

Movements.- It was collected from the same roost in December, Feburary and July despite disturbance caused by firing. Further observations could not be made in this roost as the occupied tree was felled. A similar new roost was found occupied on 1st February. No males could be collected along with the pregnant females eleven of which were examined on 20th July and 1st February. The above observations show that the bat move to new roosts only under compelling circumstances. Sexual segregation also seems to occur.

Enemies, parasites and disease.- A bed bug, *Cimex rotundatus,* was once found on the body of a specimen. This ectoparasite has always been found on *S. temmincki wroughtoni* which lives in association with this bat. The transfer of the specimen to the present species was probably accidental.

Population.- The total population in a 1½ km. sq. area was about 100 immediately after parturition. In all 2 adult males, 1 young male and 16 adult females were examined. Since there appears to be segregation of sexes after mating, the above figures do not give the sex ratio.

6. **Taphozous melanopogon melanopogon** Temminck

Black-Bearded Tomb Bat

(Pl. VI, fig. 1 & 2)

1841. *Taphozous melanopogon* Temminck. *Mon. Mamm.*, 2,p.287 (Bantam, Western Java).

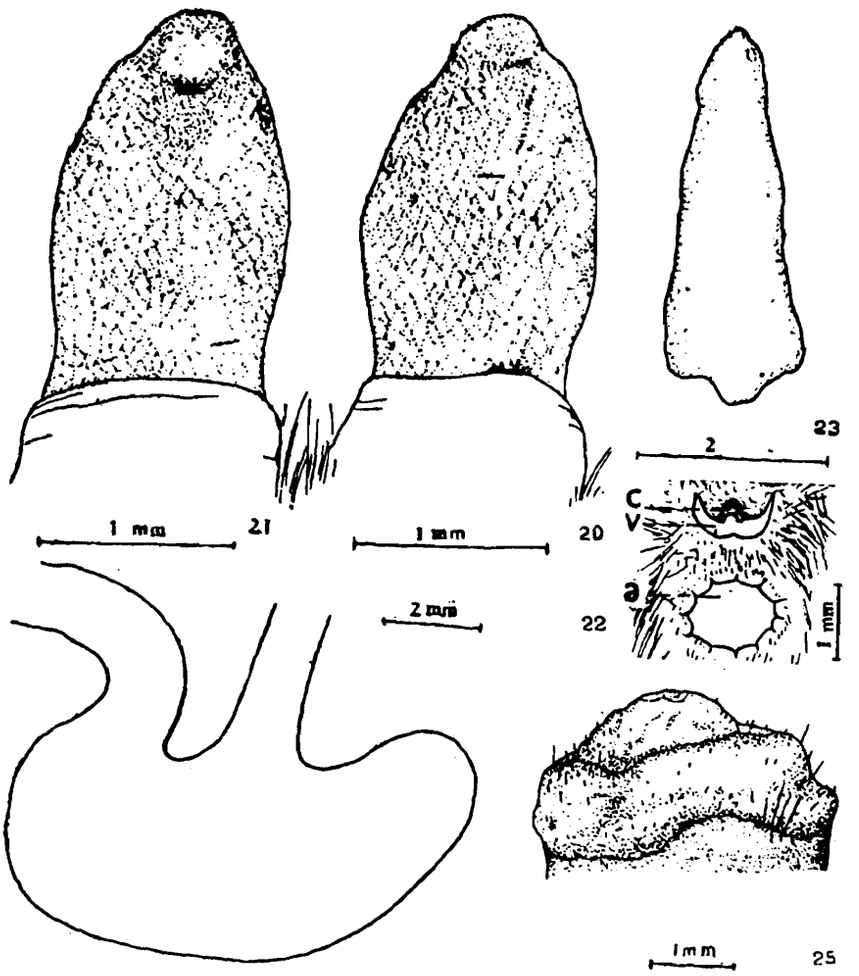
Type material.- Type in Leyden Museum.

Synonyms.- *Taphozous bicolor* Temminck, *Taphozous solifer* Hollister.

Material callected.- ♂ : 86 ad; ♀ : 81 ad; Jabalpur city, Lamataghat, Richhai.

Morphological notes.- The general form of the wing is like that of *T longimanus.* The tibia is rather short. The colour generally tallies with that described by Blanford (1891) and Brosset (1962 a), but there are many variations. They appear to be associated with moulting or bleaching (Constantine, 1957) resulting from the presence of high amount of ammonia in the haunts, age and possibly to sex. Unfortunately, because of the preservative used, it is not possible to determine to

what extent the above factors are responsible for the colour variations. Adult males with well developed black beard taken on 26-2-66 were very pale. Young specimens are darker. One year old males are still without beard. The character appears as a few black hairs and seems



Text-fig. 4. *Taphozous m. melanopogon.* Fig. 20, dorsal and fig. 21, ventral view of the glans; fig. 22, external female genitalia ; fig 23. dorsal view of baculum. A, anus; C, clitordial pad; V, vulvar aperture.
Fig. 24. Stomach of *Hipposideros cineraceus durgadasi.*
Fig. 25. Lateral view of a teat of *Scotophilus h. heathi.*

to expand gradually to cover whole of the throat. The indivdiual hair has whitish base, which shows up as white collar when animals lift their heads in defiance on approach of intruders. The longest hair of an adult male collected on 23 rd January is on the neck and measures upto 9 mm. in length. The ventral surface is paler and chest and throat are generally darker in all specimens. There are a few glandular papillae on either side of the snout.

The species accumulates a large amount of fat in summer, particulary in rainy season when food is plentiful. The weights of 12 adult males, taken on 7th January, 1963, varied from 25-28 gms. (mean, 26.2) and of 10 adult females, taken on the same date, from 23-28 gms. (mean, 25.7). Weights of 12 males taken from 13th May to 11th July varied from 36-40 gms. (mean, 38.8), and of 8 females taken on the same dates from 35-43 gms. (mean, 37.5). The teats of a female (alcoholic material) collected on 20th February are tubular, about 8 mm. from axilla and measure 3.5 mm. in length and 1.5 mm. in width. The

penis is enclosed in a hairy prepuce and is somewhat caudally directed. The glans in the adult (Text-fig. 4. figs. 20-21) is ovoid in outline. The glans is covered by fine striations arranged in an irregular pattern. The baculum (Text-fig. 23) is placed inside the glans with its narrow end reaching the tip of glans. It is minute, hardly visible to the naked eye, spearshaped with rather irregular outline. Agarwal and Sinha (1973) have described the baculum of an unidentified subspecies of T. *melanopogon* from Burma. There are some individual variations. The clitoris (Text-fig.4, fig. 22) is inverted V-shaped with a raised point in the limb of V as in *T longimanus.* The clitoridial pad is globular and elevated. The tongue resembles that of *T longimanus.* The stomach has an enlarged cardiac end. Milk teeth are absent in a young male (forearm, 31.2 mm.) and the permanent teeth are just erupting.

The young is indistinguishable from that of *T theobaldi secatus* with which the bat is commonly found except in size, provided the age is known.

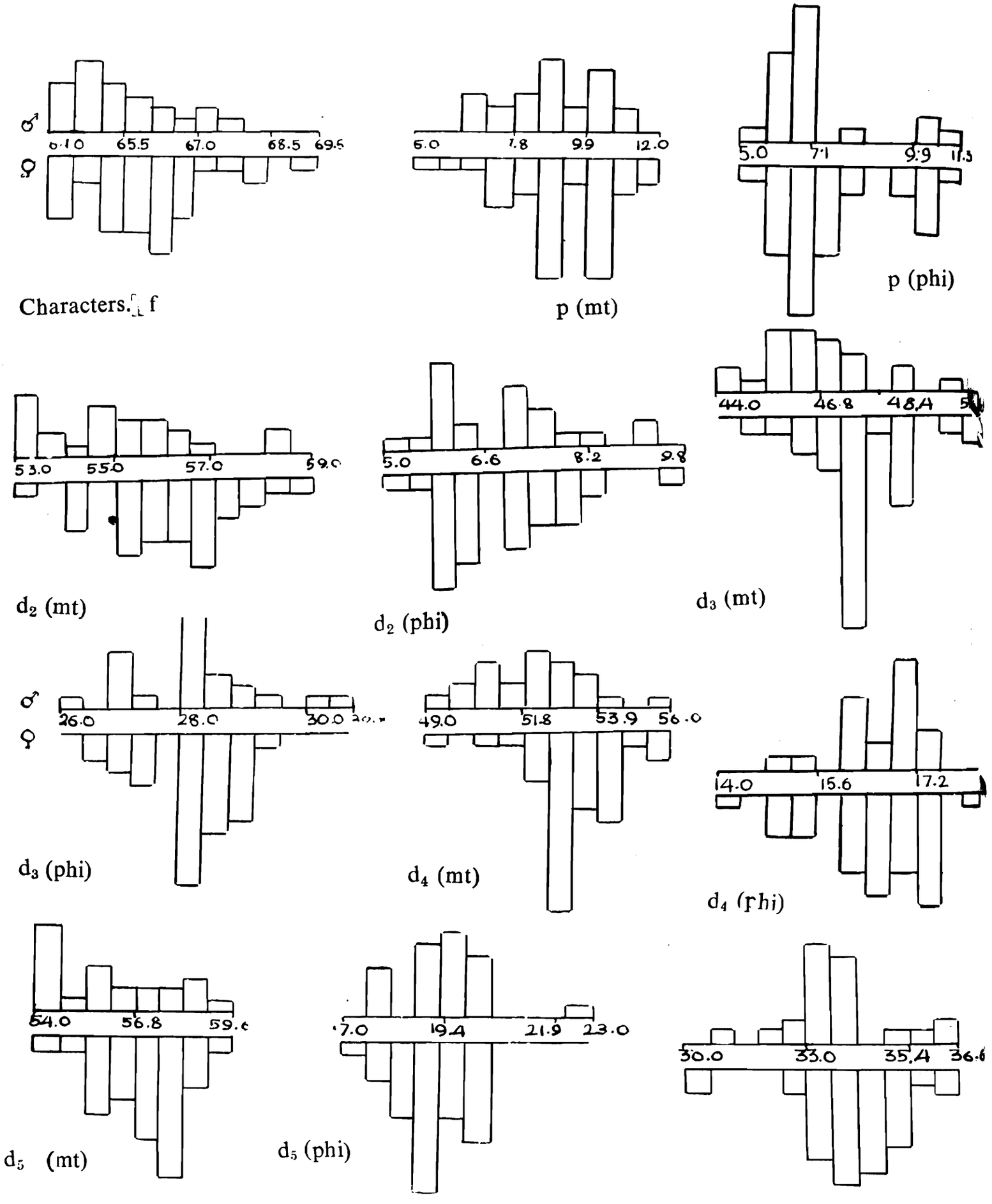
Measurements.– Tables VII & VIII. There is no sexual dimorphism in size (Text-fig. 5 & Text-fig. 6).

Distribution.– Sri Lanka[1] (Phillips, 1922), Peninsular India (below 800 m alt., Brosset, 1962 a), Andaman Islands[2] (Khajuria, 1953; Hill, 1967) not extending into western desert areas in India; also absent in Ahmedabad, northern Gujarat (Siddiqui, 1961, Brosset, 1962 a, Prakash, 1963), Burma, Malaya, Yunnan, Laos.

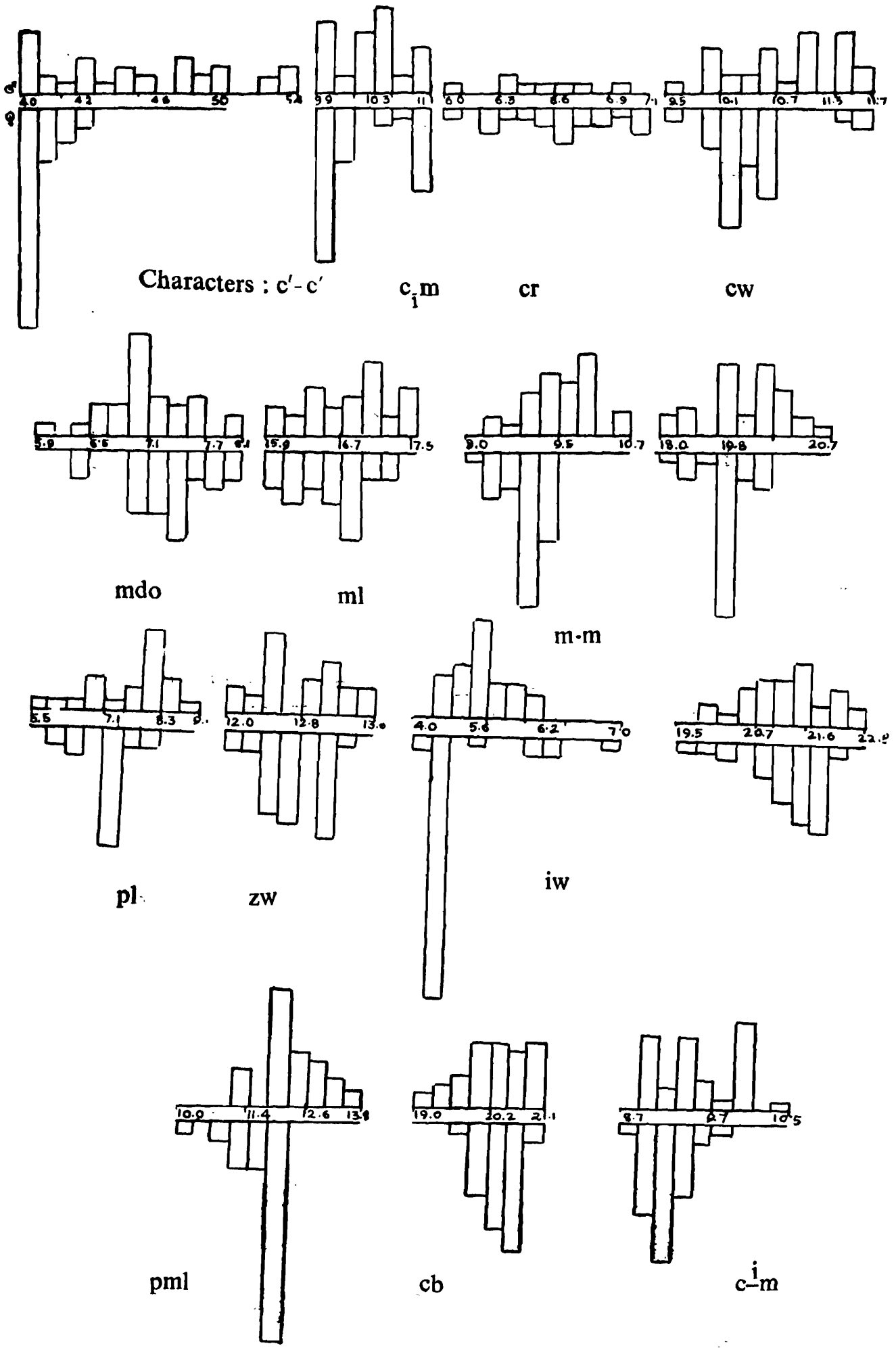
Habitat.– The species was met with in three different types of habitats : a ruined temple on the bank of the Narbada river (Pl. I, fig. 1); tiled ceiling of a church in the city, and caves under huge granite boulders, all habitats near or in human habitations. Brosset (1962 a) describes some other types of diurnal roosts and states that hills and portion of Ghats with heavy rainfall do not appear to be suitable. The temperature inside the roosts varied from 22°C to 38°C. Several specimens died when transported in hot weather in cages. In the places selected for diurnal roosts, light intensity varies a great deal. In the caves under boulders, some parts are so dark that bats cannot be located without light. Below the ceiling of the church, they are just sheltered from the direct sunlight. In the temple they are easily visible without torch light.

Although normally found in comparatively quieter places, moderate human noises appear to be tolerated by them. At Richhai, the roost is only about $\frac{1}{4}$ km. from a small railway station. The roosts are protected from winds, rains and storms. The surfaces of attachment were quite smooth, being rocky, cemented or tiled. A high percentage of ammonia could be smelled inside the roosts in caves and temples. A thick layer of guano, at places about $\frac{1}{2}$ m. deep, was present in the roosts in some places showing that bats have occupied the roost for a long time. During night the species is supposed to hunt at higher levels of atmosphere but may rest temporarily, particularly during unfavourable weather in any suitable place as shown by their droppings.

1, 2, : Ellerman and Morrison Scott (1951) and Brosset (1962 a) do not include Sri Lanka (Ceylon) and Andaman Islands, in its distribution.



Text-fig. 5. Twin histograms comparing the external measurements of 78 adult males with 80 adult females of *Taphozous m. melanopogan*. Numbers in histograms indicate millimetres.



Text-fig. 6. Twin histograms comparing the external measurements of 78 adult males with 80 adult females of *Taphozous m. melanopogon*. Numbers in histograms indicate millimetres.

TABLE III. Data from the diurnal roost of *Taphozous m. melanopogon*

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
15-10-60	Tiled ceiling of a church (Jabalpur city)	100	1 ♀	Nil	—
18-11-60	-do-	125	3 ♂, 6 ♀	-do-	—
24-11-60	-do-	-do-	5 ♂, 6 ♀	-do-	—
1-12-60	-do-	-do-	1 ♂	-do-	—
7-12-60	-do-	-do-	3 ♂, 2 ♀	-do-	—
15-12-60	-do-	75	1 ♀	-do-	—
16-12-60	-do-	-do-	1 ♀	-do-	—
19-12-60	-do-	-do-	1 ♂, 1 ♀	-do-	—
6-1-61	-do-	-do-	1 ♂, 1 ♀	-do-	—
9-1-61	-do-	50	2 ♀	-do-	—
16-1-61	-do-	125	2 ♀	-do-	—
23-1-61	-do-	75	1 ♂	-do-	—
-do-	Ruined temple (Lamataghat)	75	4 ♂	*Rousettus l. leschenaulti*	—
15-3-61	-do-	150	—	—	—

TABLE III. Data from the diurnal roost of *Taphozous m, melanopogon* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
15-4-61	Tiled ceiling of a church (Jabalpur city)	—	—	—	Absent
21-4-61	Ruined temple (Lamataghat)	75	10 ♂, 1 ♀	*Rhinopoma h. hardwickei*	—
20-5-61	Ruined temple (Lamataghat)	—	—	—	Absent
16-6-61	Tilled ceiling (Jabalpur city)	70	1 ♂	—	—
26-6-61	Ruined temples (Lamataghat)	100	10 ♂	*R. h. hardwickei*	—
29-8-61	-do-	-do-	1 ♀	*R. l. leschenaulti*	—
15-9-61	-do-	-do-	3 ♂	-do-	—
20-9-61	Tiled ceiling (Jabalpur)	-do-	1 ♂, 1 ♀	—	—
29-9-61	Ruined temple (Lamataghat)	-do-	—	—	Absent

TABLE III—Data from the diurnal roost of *Taphozous m. melanopogon* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
30-9-61	Tiled ceiling of a church (Jabalpur city)	20	—	—	—
24-10-61	Ruined temple (Lamataghat)	100	21 ♂	*R. l. leschenaulti* *R. h. hardwickei*	—
13-11-61	do-	—	—	—	Absent
24-11-61	-do-	100	4 ♂	—	—
29-11-61	-do-	—	—	—	Absent
30-12-61	-do-	60	16 ♂. 14 ♀	—	—
30- 1-62	-do-	—	—	—	Absent
9-2-62	-do-	50	—	—	—
17-3-62	-do-	20	2 ♂	—	—
28-3-62	-do-	—	—	—	Absent
21-4-62	-do-	—	—	—	Absent
30-5-62	-do-	—	—	—	Absent
13-6-62	-do-	1 specimen	1 ♂	—	—

TABLE III—Data from the diurnal roost of *Taphozous m. melanopogon* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
15–7–62	Ruined temple (Lamataghat)	50	25 ♂	—	—
21–8–62	-do-	120	24 ♂, 6 ♀	*R 1. leschenaulti* (2 specimens) *R. h. hardwickei* (1 specimen)	—
28–9–62	-do-	150	49 ♂. 6 ♀	—	—
25–10–62	-do-	-do-	—	—	—
25–11–62	-do-	100	43 ♂. 46 ♀	*R. l leschenaulti*	—
22–12–62	-do-	200	29 ♂, 52 ♀	*R. l. leschenaulti*	—
7–1–63	-do-	-do-	13 ♂, 10 ♀	-do-	—
27–2–63	-do-	20	12 ♂	—	—
28–3–63	-do-	-do-	1 ♂	—	—
25–4–63	Boulder caves (Richhai)	—	1 ♂	—	Absent
29–4–63	Ruined temple (Lamataghat)	—	—	—	Absent

TABLE III. Data from the diurnal roosts of *Taphozous m. melanopogon* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
5–5–63	Ruined temple (Lamataghat)	—	—	—	Absent
7–5–63	Boulder caves (Richhai)	2000	4 ♂, 6 ♀ (4 pregnant)	—	—
13–5–63	–do–	–do–	3 ♂, 6 ♀	—	—
17–5–63	–do–	–do–	3 ♂, 5 ♀	*R. h. hardwickei*	—
6–6–63	–do–	–do–	1 ♂, 5 ♀ (with young)	–do–	—
26–6–63	–do–	–do–	3 Juv.♂, 3 Juv.♀	–do–	—
11–7–63	Ruined temple (Lamataghat)	200	14 ♂, 2 ♀	—	—
2–8–63	Boulder caves (Richhai)	1000 ?	2 ♂	*R. h. hardwickei*	—
23–8–63	Ruined temple (Lamataghat)	150	15 ♂, 1 ♀	—	—
18–9–63	–do–	—	—	—	Absent
27–12–63	–do–	70	4 ♂	—	—

TABLE III. Data from the diurnal roosts of *Taphozous m. melanopogon* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
16-1-64	Ruined temple (Lamataghat)	70	5 ♂	—	—
25-1-64	Boulder caves (Richhai)	'2000 ?	6 ♀	—	—
2-2-64	-do-	?	1 ♂	—	—
15-2-64	-do-	-do-	—	—	—
20-2-64	-do-	-do-	6 ♂, 6 ♀ (pregnant)	—	—
19-5-64	-do-	3000 ?	1 ♂. 3 ♀	—	—
22-6-64	-do-	—	2 ♀	—	—
15-11-64	-do-	3000 ?	1 ♂. 3 ♀	*Rhinolophus l. lepidus*, *T theobaldi secatus* *R. h. hardwickei*	— —
20-1-65	Ruined temples (Lamataghat)	25	1 ♂, 7 ♀	—	—
16-2-65	Boulder caves (Richhai)	2000 ?	1 ♂, 1 ♀	—	—
20-4-65	-do-	-do-	1 ♂, 12 ♀	—	—

TABLE III. Data from the diurnal roost of *Taphozous m. melanopogon* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
19–5–65	Ruined temples (Lamataghat)	—	—	—	Absent
24–5–65	Boulder caves (Richhai)	-do-	3 ♀, 6 young	*T. theobaldi secatus*	—
10–12–65	Ruined temples (Lamataghat)	10	—	—	Absent from usual temple
9–2–66	Boulder caves (Richhai)	2000 ?	4 ♂, 4 ♀	*T. theobaldi secatus*	—
16–2–66	-do-	-do-	1 ♂	—	—
23–2–66	-do-	-do-	1 ♀	—	—
26–2–66	-do-	-do-	6 ♂, (5 s.ad.), 8 ♀ (pregnanat)	—	—
				—	—
13–4–66	-do-	-do-	3 ♂, 3 ♀	*Hipposideros cineraceus durgadasi*	
20–12–66	-do-	-do-	1 ♂, 3 ♀	—	—
16–3–67	-do-	-do-	31 ♂,(1 s.ad), 6♀	—	—
12–8–68	-do-	3000 ?	3 ♂, 4 young ♂, 16 ♀ (lactating), 9 young ♀	*T. theobaldi secatus*, *R. h. hardwickei*	—

Generat habits.- The bat was generally found in association with others but was also found alone in one place (a tiled ceiling of a church in Jabalpur city). The bats with which it was found in association are : *R. l. leschenaulti, R. h. hardwickei, T theobaldi secatus, R. l. lepidus, H. cineraceus durgadasi, H. f. fulvus.* Brosset (1962 a) also mentions its association with *R. microphyllum, H. speoris* and *T. kachhensis.* The number of individuals in a colony varied from about 20 to 3000. In boulder caves the number was very difficult to estimate. To study its reaction to another species, *M. l. lyra,* which lived in a nearby temple but was never found to mix with it, 40 specimens of the bat under report were released in the temple occupied by the said bats. The specimens settled down on the lower portions of the walls not occupied by *M. l. lyra.* There was no show of any alarm by any of the bats. After four minutes, 3 specimens of *T m. melanopogon* left the temple. Others continued to live till dusk when all of them left. Four specimens of *M. l. lyra* were released in the temple occupied by *T. m. melanopogon.* The introduced specimens placed themselves near the original occupants which gave out their usual sound. The introduced specimens were not found in the temple next day. The latter species was fed on dead specimens of *T. m. melanopogon* in captivity during the present study on several occasions. An adult was kept in a cage with 3 adult males and 3 adult females of *M. l. lyra* and lived there for 2 days. It was found eaten on the third day, possibly when it became weaker by starvation. The boulder caves at Richhai are frequented by several species of animals (p. 13).

On close human approach, the short flights in which the bat indulges in their diurnal roosts become frequent, and animals become more noisy. On still closer approach, they open their mouths and bare their teeth frequently, possibly to frighten off the intruder. They crawl with ease in all directions, stand on all fours for short intervals and move their tails. The head is bent up, showing the beard prominently in adult males and a white collar, formed by the exposed white bases of hairs, in other specimens. The animals bite only if disturbed too much. The presence of man is tolerated more readily than by many other bats.

On one occasion, in Mandla District bats flew close to the observer who was only 2½ m. away and urinated. This habit of urination, possibly to keep off the intruder, has also been observed in other forms.

In the temple at Lamataghat, the colony consisted of a central cluster of about 50 individuals closely huddled together and the rest of the specimens were scattered on the ceiling but there was generally some space among the latter. In the church the specimens were all scattered here and there. In the boulder caves at Richhai they were generally found in deep crevices quite close together and sometimes one above the other. In captivity several individuals may form a thick cluster in a corner of the cage. Brosset states that a ringed male was found to occupy the same place during daytime for 4 months.

A couple of individuals were seen to reverse their head-downward position and hung themselves with the claws of thumb only for a few seconds. Another bat in which this posture was observed in the flying fox *(Pteropus g. giganteus)* (Khajuria, 1971) but in this case the posture was assumed to pass out excreta. The significance of this habit in the present species is not properly understood, but may also be to pass out excreta.

The time of emergence, as observed on 25th October, was 6-19 P.M. (sunset, 5-39 P.M.), but only five specimens left the haunt during the succeeding two hours, and the rest continued to occupy it. After leaving the roost, the bats possibly hunt at higher levels of atmosphere. They probably come down to rest in suitable places other than the roost as shown by their droppings. During daytime they are found quite active, giving out several types of sounds and undertaking short flights. They can move about on all fours with ease and crawl back to deep crevices if available. They can suspend themselves well with their hind feet and also cling to flat surfaces with ease using claws of thumb also. The flight is fairly swift, straight, with forearm bent forward at an angle of about 45°. There is a good deal of flapping of wings. Eleven specimens were released at dusk. They flew straight at the level of tree-tops for about 500 m. and then disappeared in the sky. The specimens gave out sound, resembling *chin-chin*, while flying. When put in water, an adult female tried itself to keep above the surface by constant flapping of wings or simply floated on the surface, or swam with awkward wing strokes, with the body half-submerged.

The species was not seen to seek more sheltered places in severe winter and was active in all seasons. The sound is varied and difficult to imitate. It resembles *chur-chur, chi-chi, chen-chen, cho-cho, chin-chin, chik-chik, chrin-chrin,* etc. A peculiar sound resembling *tak* or *thak* is sometimes given out with an upward jerk of head when the animal is annoyed by continuous disturbance (in natural habitat) or unable to escape from the cage, or some unpalatable food is put inside its mouth. When annoyed or excited, the skin over the frontal depression is thrown into violent movements. Phillips (1923) also states that it gives out a 'shrill cry' while flying.

Breeding habits.- The mating season appears to be prolonged, and extends at least from about beginning of February to the beginning March. Sperms are absent in female genital tract in specimens examined on 15th November, 20th December and 20th January, and pregnant females were obtained on 15th, 19th, 20th and 26th February, 20th March, 13th and 20th April and 17th May. The embryos measured 25 mm. in diameter on 28th February. Two females collected on 15th February were not pregnant while other two taken on the same date had just conceived. Six females taken on 19-2-68 were all pregnant. An adult female kept in captivity along with an adult male from 16th to 22nd February still appeared receptive. The male was always found on the back of the female (Pl. VII, fig. 1&2) but no servicing movements were observed. After a few days the male became sick. On 20th February female was observed to give out loud sounds resembling *chik-chik* or *chin-chin*, but finding no response from the male, approached it, licked and bit it gently on the neck and tried to mount it. Upon this the male mounted. The female immediately stopped the calls and was found in a relaxed condition as shown by the drooping ears. Young specimens (forearms 25.7 to 36 mm.) were collected on 24th May. Some of these young might have belonged to the allied form, *T. theobaldi secatus* which also live in the same caves but is rare. On the same date reddish discharge from the vulva was observed in some females, suggesting recent parturition. In some specimens reabsorption of foetus was observed in captivity (20th April to 3rd May). Each of the eight females taken on 6th June carried a single young firmly attached to a teat. The

young was placed longitudinally on the belly. However a fimale was found to carry twins (Pl. VII, fig. 5). Verify

The young ones collected were still naked but very active, protesting violently on the slightest provocation with shrieks and bites. The females collected along with the young ones did not accept them. The young probably did not belong to them. Phillips (1922) states that females collected in Ceylon in September still had the young clinging to them while grown up young were also present.

The growth of the young is rapid, and within about four months they are practically indistinguishable from the adults in size. The age of maturity could not be determined with certainty. Collection of a large number of females, all pregnant, shows that in females it may be one year only. A black beard, so characteristic of adult males, appears at least after one year because during mating some adult-sized young males are without beard. Whether these specimens are sexually mature could not definitely be ascertained. Four specimens of this age-group examined during the mating season lacked sperms in the epidydemis. Lactation continues for about four months after delivery.

Brosset has provided data on the segregation of sexes. In boulder caves, small colonies consisting exclusively of one sex were found on 16th March. However, a few immature individuals may be found in the colony of the opposite sex. In the temple at Lamataghat, the females formed a central cluster and the males were found scattered around this cluster. If disturbed for the purpose of collection, the males were first to come out so that in earlier stages of observations, the catches consisted exclusively of males (Table III). However, if the disturbance was continued the females started leaving the roost after the males. In the church the segregation of sexes could not be observed with accuracy.

Feeding habits.– Little is known about its food. Since it is a fast flier and possibly hunts at upper levels of the atmosphere, some high flying insects are likely to constitute its principal food. In captivity it refused to take several types of insects (see p. 23), boiled eggs, cheese, and guava, but sometimes took a little banana if it was put inside the mouth. It was kept alive for a few days by forced feeding on diluted buffaloe milk but always showed signs of ill health after a few days, and died within ten days. If water was not provided, particularly in hot weather, it died within 36 hours. It was frequently found to lick the wet surfaces of the earthen pots in which water was provided.

Several analyses of stomach contents were carried out in the early morning just after the animals have returned to the roost after feeding, but no identifiable food material was obtained. The droppings were mixed up with those of the other forms and could not be identified with certainty. No uneaten parts of prey were found inside the roost.

Movements.– In the caves at Richhai, the bat is a permanent resident, but in other two places it was an occasional visitor. This was probably so because in caves it can find several hiding places, if disturbed. In the ttemple he colony continued to live despite occasional disturbance due to collection for about a year but became an occasional visitor later. It has completely disappearcd since January, 1966. It also disappeared

from the church at the end of 1961. The temple at Lamataghat was fitted with a door and fire was burnt inside it occasionally. This appears to be the principal reason for the disappearance of the bat from this place. Recovery of three marked specimens, 2 ♂, 1 ♀, at Lamataghat shows that possibly the same colony visited the temple. In all, 148 specimens were marked and released but in boulder caves, the possibility of recovery is considered to be very remote. So far no specimen has been recovered.

Enemies, parasites and disease.– The populations under study appears to be healthy, and no parasite or dead specimen was seen. Possibly the dead animals are removed by predators soon after they fall to the ground. No remains of the bat were found in pellets of owls and droppings of small carnivorous mammals (p. 8) collected in the vicinity of the haunt. However, the bat was attacked by the common Jungle Crow, *Corvus macrorhynchos,* and the Black-winged kite, *Elanus caeruleus* when they left the haunt during day time because of human disturbance. No specimen was seen being captured by the predators, which because of their diurnal habits, are ill-adapted for capture of such a prey.

Population.– In caves and crevices under boulders, the number of specimens was very difficult to estimate but the total number of bats in the area just after parturition may be roughly put at about 5,000 (or about 38 per sq. km.). In caves, adult males and females appeared segregated into small colonies located in deep crevices in non-breeding season, but immature animals of both sexes are found along with adult females. From the actual observasions of animals before collection (Lamataghat) and even from some collections made with modified techniques (Table 13, collections of 30-12-61, 25-11-62, 7-7-63. etc.) the adult sex ratio is roughly 1:1. The adult male can easily be distinguished in the field by its prominent black beard. The sex and age composition of 74 specimens collected, with allowance for different sexual behaviour, from 13th May to 12th September is as follows :

Sex	*Less than 1 year old*	*Less than 2 years old*	*More than 2 years old*
♂	12	9	17
♀	13	8	15

There is remarkable uniformity in the above sex ratio even in different age groups. Females bear a single young. The bat is reported to be eaten by poorer people (Kol tribe) in places where it is easy to collect with hands from the crevices. However, the habit is kept secret from strangers.

7. **Taphozous theobaldi secatus** Thomas

(Pl. V, fig. 4)

1872. *Taphozous theobaldi secatus* Thomas, *J. Bombay nat. Hist. Soc.,* 24, 60 (Asirgarh, Nimar Madhya Pradesh, India)

Type material.– Type in B. M.

Material collected–. ♂ : 5 ad., 2 s. ad; ♀ : 3 ad., 1 s. ad.; Richhai.

Morphological notes. – The general form of the wing resembles that of *T longimanus*. The tibia is short. The colour is a shade or tint of brown with a reddish tinge in adult specimens but is noticeably darker in younger specimens. Ventral surface is slightly paler. There is a whitish basal band to each hair. In older specimens a brownish beard is present in males as pointed out by Brosset. An important distinctive character from the closely allied species, *T m. melanopogon*, is the extension of fur over the interfemoral membrane for some distance in the latter while in the present species, the interfemoral membrane is naked. This important distinguishing character can help to distinguish the females and young animals of the two bats which look very much alike except the size. This character does not appear to have been recorded before. There is a glandular area behind the chin even in females and subadults. The ear is comparatively longer. It has also somewhat different markings on ventral surface but exact extent of variation in the pattern could not be studied in the preserved material. The teats in a female (alcoholic material) collected on 7th May are 10 mm. from the axilla. They are 2.9 mm. long and 1.5 mm. in diameter and are similar in appearance to those of *T m. melanopogon*. The external genitalia are similar to those of *T. m. melanopogon* in general shape in alcoholic material. The surface of the glans of a subadult is studied with numerous rounded tubercles. The baculum appears similar to that of *T m. melanopogon*, in one preserved specimen examined by an assistant but is obliquely truncated at the broader end. The tongue is similar to that of *T. m. melanopogon* in having a spout-shaped tip with enlarged papillae in its middle portion. The stomach does not show any specialization.

Measurements. – Tables, VII and VIII.

Distribution. – Central India, Maharashtra (Belgaon Dist., Brosset, 1962 a). Persian Gulf ? (Blanford, 1891).

Habitat. – The bat was met with rarely in boulder caves at Richhai only and lives in dark deep crevices in small colonies. Whether there is any difference between the exact habitats occupied by *T m. melanopogon* and this form could not be ascertained because of the inaccessibility of deep crevices for closer examination and the difficulty of identification of specimens, except adult males, in the field. Although *T m. melanopogon* has adapted it self to other types of habitats, this bat continues to occupy the habitat which is possibly primitive for the two forms. Brosset (1962 a) recorded it from a natural cave in forested country. The bat is indistinguishable in flight from *T m. melanopogon*. The other data are the same as given under *T. m. melanopogon* under habitat selection.

General habits. – The bat occurs only in boulder caves at Richhai village along with *T m. melanopogon, R. h. hardwickei, R. l. lepidus* and *H. cineraceus durgadasi* (Khajuria, in press). Because of the habitat, it was not possible to determine the exact relation of the various bats in habitat selection; but from the examination of collection from different points, it could be inferred that, while it probably mixes with *T. m. melanopogon,* other forms live in different crevices.

It is much rarer than *T m. melanopogon*. Only 27 specimens could be collected against 203 of *T m. melanopogon* from the same habitat. Elsewhere also it appears to be rare (Brosset).

TABLE IV. Data from the diurnal roost of *Taphozous theobaldi secatus*

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
7-5-63	Boulder caves (Richhai)	400 ?	1 ♂, 3 ♀	*Taphozous m. melanopogon*	—
15-2-64	-do-	-do-	4 ♀	-do-	—
20-2-64	-do-	-do-	1 ♂, 6 ♀ (pregnant)	-do-	—
19-5-64	-do-	-do-	4 ♀	-do-	—
26-5-65	-do-	-do-	1 ♂, 1 ♀, 6 young	-do-	—
12-10-65	-do-	-do-	1 ♂, 1 ♀	-do-	—
19-3-67	-do-	-do-	1 ♂	-do-	—
12-9-68	-do-	-do-	1 ♂, 1 ♀ (lactating), 3 young ♀	*T m. melanopogon* *R. h. hardwickei*	

Spacing of individuals in a colony is also similar to the latter bat. However, no central cluster of females surrounded by actively moving males were observed in this bat. An adult male and an adult female were kept in captivity from 12th to 19th October. The male occasionally showed trembling movements possibly due to some sickness. The female was always found on the back of the male except on two occasions when the position was reversed. Other general habits appear to be similar to those of *T m. melanopogon.*

Breeding habits. – The breeding habits (table 16) appear to be similar to those of *T m. melanopogon.* Segregation of adults of both sexes in the nonbreeding season, on the basis of the present data and from that provided by Brosset, is a possibility.

Food and feeding habits. – These are similar to those of *T m. melanopogon.*

Movements. – The bat is found in all seasons in the same haunt in the area.

Enemies, parasites and disease. – An adult male collected on 16th March appeared to be sick and carried unidentifiable infection on the throat. Other specimens collected were healthy. Other remarks given under *T m. melanopogon* are also applicable to the present bat.

Population. – Only 27 specimens could be examined. Of these, 6 were adult males, 20 adult females and 1 young female.

Subgenus **Liponycteris** Thomas

8. Taphozous kachhensis kachhensis Dobson

(Pl. VI, fig. 3-4)

1872. *Taphozous kachhensis* Dobson *J. Asiat Soc. Bengal* **41** (2) : 221 (Kutch, India).

Type material.– Type in Z.S.I. (ad. ♂, skull only) a syntype (According to Siddiqui, 1961, a Type, possibly a syntype, ad. ♀, skin in alcohol, skull base slightly broken) is in B. M.

Material collected.–2 ad ♂; ♀ : 6 ad, 2 s. ad.; Madan Mahal, Richhai.

Morphological notes.– The form of the wing resembles that of *T l. longimanus.* The tibia is rather short. The colour more or less agrees with that given by Brosset for this bat but specimens collected in September and October are noticeably reddish and those collected in March are much darker. The individual hair has a whitish yellowish basal band. Ventral hair has silvery tip. The longest hair in a male collected in March is on the side of the belly and measure upto 7 mm. in length. The teats in a female (alcoholic material) collected on 24th September resemble those described for *T m. melanopogon.* They are about 13 mm. from axilla, 3 mm. long and 2 mm. wide.

Blanford's (1891) remark that the gular pouch is absent in females is an error. In males gular pouch is much deeper. The fat deposits are present in specimens collected in August, September and October and in some taken even in March. Fat possibly accumulates during the season when food is plentiful.

The glans (text. figs. 18–19) is oblong with roughened surface and blackish tip. The clitoris resembles inverted v in shape. The tongue has enlarged papillae at the tip. The stomach is unspecialised.

Measurements.– Tables VII and VIII

Distribution.– Pakistan (Sind and Punjab), (Siddiqui, 1961), Rajasthan (Prakash, 1963), to Sikkim and Bengal, southwards to Mysore, but absent in Konkan, Ghats and Kanara (Brosset, 1962 a).

Habitat. It is a permanent resident of a deep fissure in a rock on a hill about a kilometer away from human habitations. The fissure about 10 cm. wide occupies an area of about 50 sq. m. with several outlets. A small cave nearby was once occupied by a hermit. On two occasions (24th November, temperature 29°C; and 2nd February, temperature, 26°C), it was found in well lighted nearby boulder caves and on one occasion (10th October, temperature 30°C), on the ceiling of a church. It confined itself to the warm interior of the fissure in severe winter, summer and in stormy weather. Brosset (1962 a) and Prakash (1963) also recorded it from similar habitats. According to Brosset, it is found where the annual rainfall is less than 125 cm.

General habits.- The bat lives in colonies of about 10 to 100 individuals and is found in association with *R. h. hardwickei* (boulder caves at Madan Mahal) and with *Tadarida sp.* (in the rocky fissure. The conclusion about its possible association with the latter species is based on sounds produced and observations of two specimens at a distance.) with *R. h. hardwickei* in it lived peacefully in.

The colonies contained from 3–50 individuals (Brosset, 1962 a, recorded colonies of about 800). In the boulder caves the individuals were seen at a distance not less than 5 cm. from one another. In the rocky fissure they were often very close to one another but not one on top of the other as often happened in captivity.

On close human approach, the animals retracted themselves in the deeper parts of the fissure and became more noisy. Although some baring of front teeth was noticed, the reaction was much milder than in the preceeding two bats.

On 13th March, the first specimen left the roost at 7–35 P. M. (sunset at 6.20 P. M.) and was followed by about ten more, one by one, at intervals of about 10–15 minutes till 9.30 P. M., when observations were abandoned. However, animals appear to know the presence of collectors outside the roost and this may have had some effect on the departure behaviour. On 24th September the first specimen left at 7 P. M. (sunset at 6.07 P. M.). The animals after leaving the haunt are reported not to return to their diurnal roost (Brosset, 1962 a) during night but the author's observations in this regard are incomplete.

The flight at the time of emergence is straight and fast. The animal can crawl well on all fours in all directions, The usual sound, *thak* or *chak*, recorded in the case of *T m. melanopogon,* was also heard in this species in its natural state after the net was spread in front of the roost. Other sounds emitted by it are difficult to imitate but

TABLE V. Data from the diurnal roost of *Taphozous k. kachhensis*

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	Remarks
14-9-63	A fissure in a rock (Madan Mahal)	100	Nil	*Tadarida sp. ?*	—
24-9-63	Boulder caves (Madan Mahal)	15	1 ♂, 2 ♀	*Rhinopoma h. hardwickei*	—
14-10-63	Church (Jabalpur city)	3	1 ♀	—	—
16-1-64	-do-	—	—	—	Absent
-do-	A fissure in a rock (Madan Mahal)	50	—	—	—
2-2-65	-do-	50	—	—	—
-do-	Boulder caves (Madan Mahal)	10	—	—	—
17-12-65	A fissure in a rock (Madan Mahal)	50	—	—	—
1-4-66	-do-	-do-	1 ♂	—	—
13-3-67	-do-	-do-	1 ♂, 1 ♀	—	—
30-3-67	-do-	-do-	2 ♂	—	—
3-4-67	-do-	-do-	2 ♂	—	—

TABLE VI

Summary of weather data in Jabalpur city for ten years ending 1963.

1. Temperature in c

	January		February		March		April		May		June	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Max.	24.1-27.9	25.9	27-31.9	29.30	30.6-36.2	34.3	37-40.2	38.8	41-44.2	42,1	33.9-39.6	37.5
Min.	7.3-12	10.0	9.9-12.9	11.60	15.4-16.9	16.3	19.1-23.9	21.2	25-27.6	25.1	25.1-27.5	26.5

	July		August		September		October		November		December	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Max.	30.1-23	31.8	27.9-31	29.7	29.3-32.7	30.6	29.1-33.6	31.0	26.4-31.2	29.3	23.9-28.8	26.90
Min,	23.3-24.7	24.0	23.3-24.3	23.7	22.2-23.7	23.2	16.3-21.0	19.2	10.3-16.0	12.60	8.5-11.6	9.9

(contd) TABLE VI

2 Rain fall in mm.

January		February		March		April		May		June	
Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
0.8-97.8	30.1	0.0-35.6	9.7	0.0-128.7	18.4	0.0-28.6	10.2	0.0-54.4	14.9	19.3-320.3	127.4

July		August		September		October		November		December	
Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
233.8-557.1	316.6	260.5-658.9	415.0	53.3-576.0	234.5	0.9-127.2	54.5	0.0-93.5	10.60	0.0-43.6	8.1

(contd) TABLE VI

(3) Relative humidity at 8.30 AM ISI (I) and at 5.30 PM ISI (II).

	January		February		March		April		May		June	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
I.	63-81	72.5	52-72	59.1	31-65	42.9	22-44	31.2	21-37	29.7	48-74	58.3
II.	35-56	45.0	28-38	31.5	16-41	22.9	12-23	18.1	12-25	18.1	35-64	43

	July		August		September		October		November		December	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
I.	83-91	85.2	85-94	89	79-91	84.5	61-81	73.5	58-77	67.2	65-89	73.5
II.	75-85	79.0	77-87	81.2	63-85	73.9	43-65	55.6	39-56	45.2	41-57	47

TABLE VII

External Measurements of some central Indian Chiroptera.

Sl. No.	Name of species	No. & Sex	Range & Mean	Abbreviation of measurements												
				f	p (mt)	p (ph1)	d2 (mt)	d2(ph1)	d2(ph2)	d2(mt)	d3(ph1)	d4(mt)	d4(ph1)	d5(mt)	d5(ph1)	t	ft
		7♂	Range	82.0–86.0	9.0–11.0	12.5–15.5	37.0–39.0	9.0–10.0	6.0–7.5	53.5–56.0	35.0–38.0	52.0–55.0	28.0–31.0	50.0–53.5	26.5–28.0	38.5–41.5	17.0–19.0
			Mean	84.3	9.8	13.7	37.9	9.4	6.4	54.8	36.9	53.6	29.3	51.8	27.1	37.6	18.1
1.	*Rousettus l. leschenaulti*	9♀	Range	78.0–84.5	7.5–10.5	10.0–16.5	34.5–40.5	8.5–10.0	4.0–7.0	51.0–55.0	32.0–37.5	50.5–54.5	25.5–29.5	48.5–52.5	22.0–26.0	35.0–40.5	15.0–18.5
			Mean	80.4	9.1	13.5	36.5	9.2	5.8	53.2	35.1	51.6	27.4	49.3	25.0	38.1	18.0 (8)
		9♂	Range	165–170	15–22	33.5–46.5	81.5–94	19–24	12–19.5	110–119.5	80–91.5	106.5–118	65–73.5	114.5–125	49–58.5	77.0–87.5	40–54.00
			Mean	168 (8)	17.1	41.9 (8)	85.7	21.8	16.4	115.1	84.6	112.8	69.4	119.1	52.3	84.22	44.5
2.	*Pteropus g. giganteus*	6♀	Range	145.0–170.0	11.0–21.0	38.0–47.5	79.5–90.0	19.0–24.5	14.5–21.0	100.0–121.0	77.5–86.5	98.5–118.5	61.5–73.0	105.5–119.5	45.0–55.0	75.0–96.0	41.0–53.0
			Mean	161.0 (5)	17.3	44.3	86.8	21.2	17.2	111.3	83.6	111.3	69.1	116.6	51.4	82.8 (5)	45.0 (5)
		11♂	Range	56.00–61.00	4.0–6.5	4.6.5	43.5	37-45	4.5-7	37-45.5	8-10.5	31–38.5	10–14	36–42.5	9–12	22.0–33.0	14.5–15.5
			Mean	59.1	5.7 (9)	5.2	44.1	5.6	42.5	42.5	9.1	35.4	12.3	40 8	10.6	28.3	15.0 (10)
3.	*Rhinopoma h. hardwickei.*	15♀	Range	57–62	4–6	4-8	39–45 46.8	4.5–10	—	37.5–45	8-10.5	32–38.5	8-13	36–44	9-11.5	20–30.5	65–67.0
			Mean	59.4	5.0	7.8	45.3	6.9	—	43.6	9.5	36.0	12.6	41.1	10.6	28.3	65.7 (13)
		5♂	Range	58–62	4–6	2-4	51-56	—	—	56–58.5	19-21	36-9 –46.0	11–12	33-36	11.5 12	8-13	22-25
			Mean	59.4	4.8	2.8	55.0	—	—	57.0	20.0	42.4	11.8	34.3	12.0 (4)	10.6	23.5
4.	*Taphozous l. longimanus*	13♀	Range	57-61.5	4-6	2-6-5	46-58.5	—	—	49-61.5	17-23	37-43.0	39-50	31.0-36.5	10.5 -13.0	21-27	9-14
			Mean	59.3	5.7	4.8	54.8	—	—	58.5	21.2	40.1	12.5	35.0	13.0	24.8	12.3
		6♂	Range	72.0–73.5	5.0–7.0	4.0–9.0	59.0–61.5	—	—	63.0–66.5	23.0–24.5	51.5–54.0	14.5–16.5	41.0–43.5	14.5–16 0	14.0–16.5	27.0–29.5
			Mean	72.8	6.5	7.4	60.6	—	—	64.9	23.6	52.8	15.0	42.1	15.1	16.0	28.0
5.	*Taphazous theobaldi secatus*	3♀	Range	72.0–76.0	4.0–5.0	4.5–5.0	61.0–62.0	—	—	64.0–65.5	21.8–23.0	51.0–55.0	14.0–15.0	40.5–43.0	13.0–15.5	15.0–16.0	27.0–28.0
			Mean	73.3	4.3	4.6	61.6	—	—	64.8	22.1	53.1	14.5	41.5	14.5	15.3	27.3
		2♂	Range	68.5–74.0	—	5.0–9.0	57.0–61.5	64.7	27.2	61.0–68.5	26.0–28.5	49.0–56.6	46.0–47.5	9.0–9.5	43.0–47.5	15.0–17.0	10.0
			Mean	71.2	—	7.0	59.2	64.7	27.2	62.7	26.7	49.2	45.2	9.0	40.0	15.5	
6.	*Taphozous k. kachhensis*	4♀	Range	70.0–74.0	—	4.0–8.5	57.0–63.5	61.0–68.5	—	24.0–28.5	50.0–56.5	15.0–17.5	8.0–9.5	42.0–45.5	14.0–16.5	8.0–10.5	15.0–17.0
			Mean	72.0	—	5.6	59.8	63.6	—	26.4	53.3	16.1	9.3	42.8	15.1	9.1	15.5
		78♂	Range	63.0–68.5	4.0–7.0	2.0–7.0	51.0–58.5	—	—	54.0–61.0	20.0–22.0	43.0–51.0	12.0–16.0	34.0–40.0	—	22.0–27.0	9.0–24.0
			Mean	65.15	5.3 (77)	3.2 (77)	54.7	—	—	64.5	21.2	46.5	13.4	37.2 (77)	—	24.7	21.9
7.	*Taphozous m. melangopogon*	81♀	Range	63.0–68.5	4.0–7.0	3.0–7.0	51.5–59.5	—	—	54.0–62.5	19.5–23.0	42.0–50.0	9.0–16.5	33.0–46.0	—	22.0–27.0	8.0–15.5
			Mean	65.15	5.75	5.15	55.25	—	—	58.90	21.74	46.86	14.05	37.95	—	24.96	12.51

* If the number of specimens differ from the figure given in column under "No. and Sex", the correct number is given within brackets after the mean.

	ft	tl	ear	Wt in grams
5–	17.0–	13.5–	16.0–	10.1–
5	19.0	21.0	19.0	11.0
5	18.1	16.8	17.7	10.6
		(3)	(5)	(5)
)–	15.0–	14.5–	16.5–	92.0–
	18.5	18.0	18.0	102.0
	18.0	16.3	18.2	97.0
	(8)	(7)	(4)	(5)
)–	40–	—	34.0–	67.5–
5	54.00		36.5	69.0
2	44.5	—	35.4	67.8
			(5)	(5)
0–	41.0–	—	34.5–	66.7–
0	53.0		36.0	67.2
3	45.0	—	35.2	66.9
	(5)		(2)	(2)
)–	14.5–	62–	18.5–	15.5–
)	15.5	76	19.5	2–0.
	15.0	70.0	18.8	17.2
	(10)	(10)	(6)	(6)
	65–	12.5–	17.0–	14.0–
	67.0	15.5	19.5	18.5
	65.7	14.6	18.3	15.8
	(13)	(14)	(6)	(7)
3	22-25	20-27	15.5	20–
			18.5	29.5
	23.5	24.1	17.3	27.3
			(3)	(4)
'	9-14	21-27	14-0	23–
			18.5	28.0
	12.3	24.2	17.2	26.5
			(7)	(10)
-	27.0–	28.5–	21.5	22.0–
	29.5	34.5	23.0	37.0
	28.0	31.3	22.2	32.0
			(5)	(5)
-	27.0–	28.5–	—	30.5–
	28.0	31.0		35.0
	27.3	29.6	—	32.3
-		34.0-	29.0–	40.0–
	10.0	37.0	32.5	48.5
		31.5	44.0	44.0
-	15.0–	28.0–	33.0–	34.0–
	17.0	31.5	37.5	39.0
	15.5	29.6	34.2	36.5
)–	9.0–	21.0–	18.5–	36.5–
)	24.0	30.5	22.5	45.0
'	21.9	26.6	21.1	38.1
		(74)	(49)	(39)
)–	8.0–	22.0	18.5–	33.0–
)	15.5	32.0	22.5	45.0
6	12.51	26.31	20.0	32.0

TABLE VIII

Cranial measurements of some central Indian Chiroptera.

me of cies	No. & Sex		Abbreviation of measurements													
			c^1–c^1	cb	c^1–m^3	c_1–m_3	cr	cw	iw	i	mdo	ml	m–m	on	pl	pml	zw
	7♂	Range	8.0–8.8	35.0–37.2	14.6–16.0	16.0–17.2	11.8–13.0	15.5–16.5	8.4–10.0	37.0–39.0	8.7–10.0	30.0–31.8	11.7–12.5	37.0–39.0	19.8–20.5	20.0–22.0	21.4–22.7
		Mean	8.3	36.4	15.1	16.4	12.4 (6)	15.9	8,9	38.2	9.3	30.5	12.9	28.0	20.1	21.3	22.7
ettus *sche-* *ulti.*	9♀	Range	7.2–8.0	34.5–36.4	13.5–15.3	15.2–16.4	11.0–13.0	14.7–16.2	6.3–9.2	36.0–38.5	7.2–10.2	28.8–31.0	11.2–13.3	34.2–38.5	19.2–20.3	20.0–21.6	20.0–24.0
		Mean	7.5	35.2	14.2 (7)	15.7	11.8 (8)	15.4	7.7	37.4	8.1	29.6	11.6	36.3 (8)	19.8 (6)	20.4	21.5 (8)
	9♂	Range	11.5–15.3	56.8–69.5	23.5–30.2	26.0–32.1	12.1–18.0	22.7–26.5	7.5–10.3	60.7–73.2	12.0–15.0	48.1–58.3	16.2–19.2	60.0–73.5	32.0–41.4	34.0–42.8	36.0–44.8
		Mean	14.0 (8)	65.9 (6)	27.5 (8)	29.6 (7)	16.3 (8)	25.0 (6)	8.7 (7)	72.2 (4)	14.02 (5)	55.7 (8)	18.1 (7)	69.3 (6)	37.9 (4)	39.1 (6)	39.8 (5)
opus *ganteus*	6♀	Range	12.7–14.6	62.6–65.3	26.3–26.7	29.3–30.1	15.1–16.5	22.8–24.7	8.4–11.6	68.0–71.0	13.2–14.1	53.3–55.5	18.0–19.2	66.0–71.0	37.2–38.0	36.0–39.9	35.8–39.0
		Mean	13.7	63.4	26.5	29.8	15.9	23.7	9.7	69.5	13.7 (2)	54.6	18.4	68.5 (2)	37.6 (2)	37.9	34.9
	11♂	Range	3.7–5.2	13.8–18.0	6–7.1	7.2–8.3	3.8–6	7.5–9	3–4.3	17–19.8	5.5–6.7	12.5–14	6.8–9	15–17.9	5.3–7.4	8.1–11.3	11–12.1
		Mean	4.8 (11)	16.9 (10)	6.7 (11)	7.7 (10)	4.9 (9)	8.4 (11)	3.2 (11)	18.4 (10)	5.8 (9)	13.4 (10)	8.3 (11)	16.6 (9)	6.8 (6)	10.5 (9)	11.6 (8)
opoma *rdwickei.*	17♀	Range	3.9–5.3	15.3–17.6	6.3–7.0	7.0–8.0	3.2–5.4	7.5–8.6	2.8–3.2	17.2–19.0	5.0–6.4	12.0–14.0	8.0–9.0	15.2–17.5	6.1–7.1	9.4–11.1	10.3–11.5
		Mean	4.7 (16)	6.8	6.7	7.1	3.9	8.4	3.1	18.3 (15)	5.8	13.0	8.6 (16)	16.6 (16)	6.7 (11)	10.5	11.2 (14)
	4♂	Range	3.7–4.9	18.8–20.6	8.4–9.3	9.5–10.3	6.5–7.0	9.4–10.5	5.0–6.2	18.0–20.8	5.9–7.6	13.0–16.0	8.0–9.0	17.0–18.3	6.4–6.8	11.6–12.2	11.5–12.3
		Mean	4.1	19.5	8.67	10.0	6.8	10.0	5.5	19.3	6.5	14.5	8.6	17.5	6.5	11.2	11.9
ozous *gimanus*	11♀	Range	3.5–4.3	18.7–20.2	8.2–9.1	9-10.6	5.5–7.3	9.2–10.6	18–19.5	5.5–7.3	13.3–16.6	7.8–9.3	17.18.5	6.2–7	10.5–12.5	9.2-13.1	8.6
		Mean	4.1	19.5	8.7	10.0	6.5	9.8	18.2	5.6	15.5	7.3	17.7	8.5	11.5	6.7	11.9
ozous *ildi* *s*	1♂		4.5	22.6	10.1	11.2	8.0	10.5	6.2	23.0	6.5	18.5	10.2	20.4	7.1	13.9	14.0
	3♀	Range	4.5–4.7	22.0–23.0	9.4–10.2	11.2–12.0	7.9–8.1	10.4–11.0	6.4–	22.0–22.4	6.5–7.0	17.8–18.6	10.0–10.2	20.0–20.5	7.0–7.5	13.0–14.0	13.2–14.0
		Mean	4.6	22.3	9.8	11.3	8.0	10.7	6.4 (1)	22.1	6.9	18.1	10.0	20.2	7.3	13.5	13.6
	2♂	Range	5.4–6.0	25.0	11.0–12.0	13.0–13.3	8.4	11.5–12.4	5.8–6.0	24.0–26.6	6.6–8.9	20.4–20.8	10.8–11.7	21.2–24.0	—	14.0–	17.1
			5.7	25.0	11.5	13.15	—	11.9	5.9	25.3	7.7	20.6	11.25	22.6	—	14.0	—
zous *hhensis*	4♀	Range	5.4–6.0	24.0–24.5	10.5–11.3	12.0–13.0	5.0–8.0	8.5–11.9	5.0–5.9	24.0–26.5	6.9–8.0	19.5–20.5	10.5–11.5	21.1–24.0	8.5–10.0	14.0–14.5	14.0–16.0
		Mean	5.6 (5)	24.1	10.9 (5)	12.5 (5)	6.8 (5)	10.6	5.4	25.0	7.4	19.9 (5)	10.9 (5)	22.1	9.2 (3)	14.2	15.1
	35♂	Range	2.5–5.4	15.0–21.4	5.0–10.4	8.0–11.0	6.0–6.6	9.5–11.6	5.0–6.0	16.2–22.4	5.9–7.9	11.9–17.4	6.5–10.6	15.0–20.4	5.5–8.7	10.0–13.5	12.0–13.5
		Mean	4.4	20.0	9.3	10.2 (34)	6.4 (6)	10.6	5.5	20.9	7.0 (33)	16.5 (33)	9.4	19.4 (34)	7.6 (27)	12.3 (34)	12.8 (30)
zous *ano-*	37♀	Range	4.0–4.3	19.7–20.7	8.8–9.7	9.9–11.0	5.5–9.5	9.5–11.5	4.8–7.0	19.5-22.0	6.3–8.0	15.9–17.1	8.0–9.4	18.0–20.0	6.0–8.0	10.0–12.2	12.0–13.2
		Mean	4.0	20.3	9.1	10.3 (35)	6.8 (21)	10.7	5.1	21.1 (35)	7.3	16.5	89.1	19.1	7.0 (22)	11.8	12.6 (36)

* If the number of specimens differ from the figure given in column under "No. and Sex", the correct number is given within brackets after the mean.

resemble those in *T. m. melanopogon*. According to Prakash (1963), it utters a *'cheee cheee'* when captured.

The bat is active in all seasons but probably does not leave the roost in very cold weather.

Breeding habits.– Because of the nature of the habitat (a narrow deep fissure) observations could not be made. Five adult males and three pregnant females were collected from separate roosts on 29th February. Males and females live together in spring and autumn.

An adult male and an adult female were kept in captivity from 13th March to 15th April. 4 adult males were introduced in the same cage between 30th March and 3rd April. The introduced specimens climbed to the corner occupied by former pair and were received by the latter without any aggressiveness. The first specimens, particularly the female, uttered some calls on the seeing the new comers (which belonged to the same colony) and the female immediately rode over the newly introduced males. Later on they were frequently seen one above the other. The female was very noisy. An adult male, on hearing the sounds, became rather excited, licked its generative organs and mounted, bat no servicing movements were noticed. (For further information on breeding habits see Brosset (1962 a).

Feeding habits. – The bats did not take any food in captivity. When forced-fed on diluted buffalo milk with a little sugar, it survived for about four weeks but gradually lost weight. Identification report of stomach contents and droppings was supplied by Entomology Division Z. S. I. and listed only remains of Orthoptera and Coleoptera.

Movements. – The rocky fissure was found occupied permanently. Other habitats (boulder caves and buildings) appeared to be visited only occasionally.

Population. – The total population in the area does not exceed about 200 individuals. In all 12 adult males and 7 adult females were examined.

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Sl. No.	Name of Species	No. & Sex	
			Range
		7♂	
			Mean
1.	*Rousettus l. leschenaulti.*		Range
		9♀	
			Mean
			Range
		9♂	
			Mean
2.	*Pteropus g. giganteus*		Range
		6♀	
			Mean
			Range
		11♂	
			Mean
3.	*Rhinopoma h. hardwickei.*		Range
		17♀	
			Mean
			Range
		4♂	
			Mean
4.	*Taphozous l. longimanus*		Range
		11♀	
			Mean
5.	*Taphozous theobaldi secatus*	1♂	
			Range
		3♀	
			Mean
		2♂	Range
6.	*Taphozous k. kachhensis*		Range
		4♀	
			Mean
			Range
		35♂	
			Mean
7.	*Taphozous m. melanopogon*		Range
		37♀	
			Mean

* If the number of spe

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Plate I

Fig. 1. Ruined temples on the bank of Narbada river, v. Lamataghat. Larger temple with higher ceiling is frequently occupied by Rousettus l. leschenaulti and Taphozous m. melanopogon and smaller one is occasionally occupied by Megaderma l. lyra.

Fig. 2. A small ruined temple on the bank of the Narbadā river, v. Lamataghat very frequently occupied by Megaderma l. lyra.

Fig. 3. Boulder caves at Madan Mahal.

Fig. 4. The same at Richhai village.

AJURIA

PLATE I

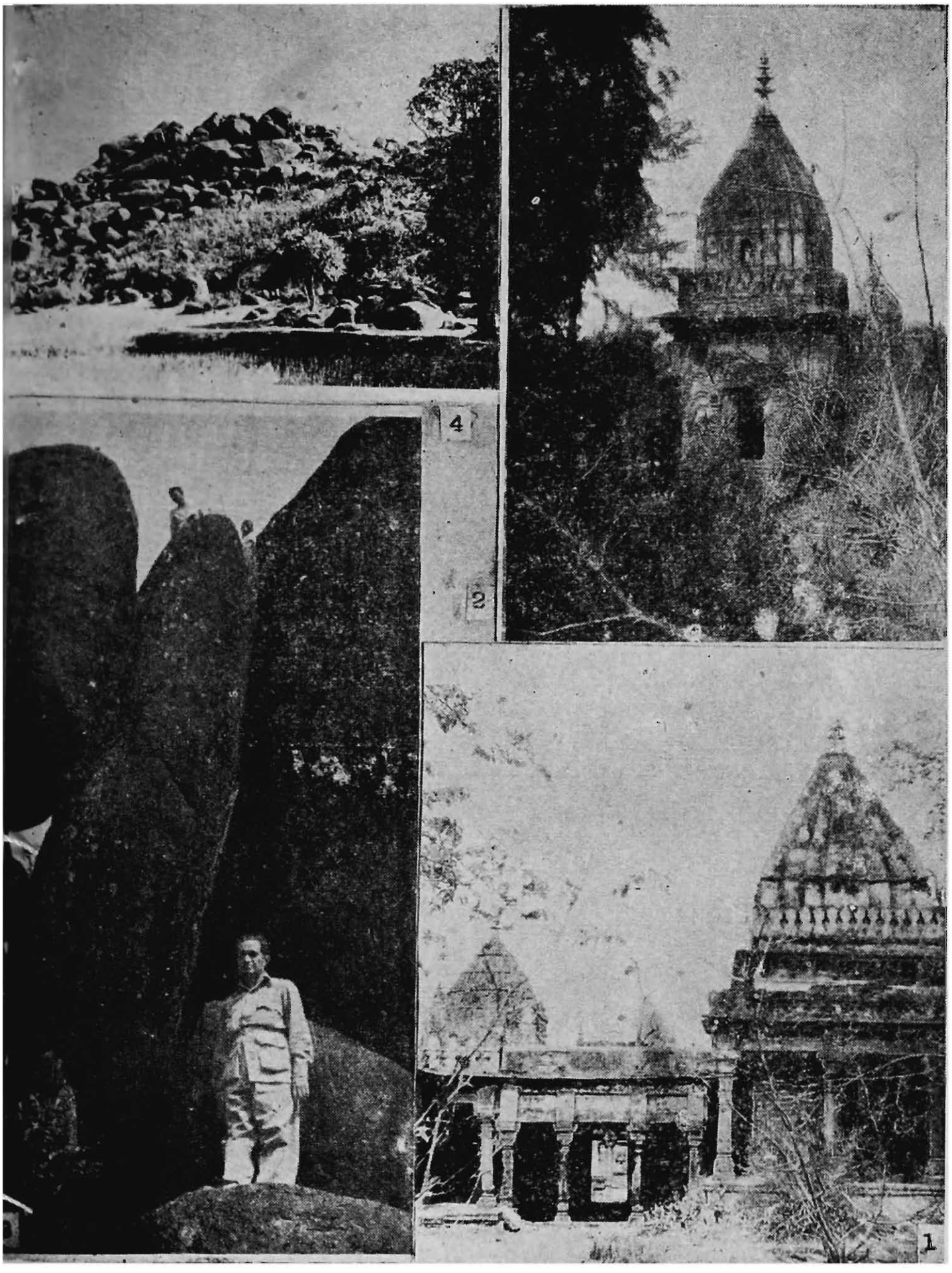


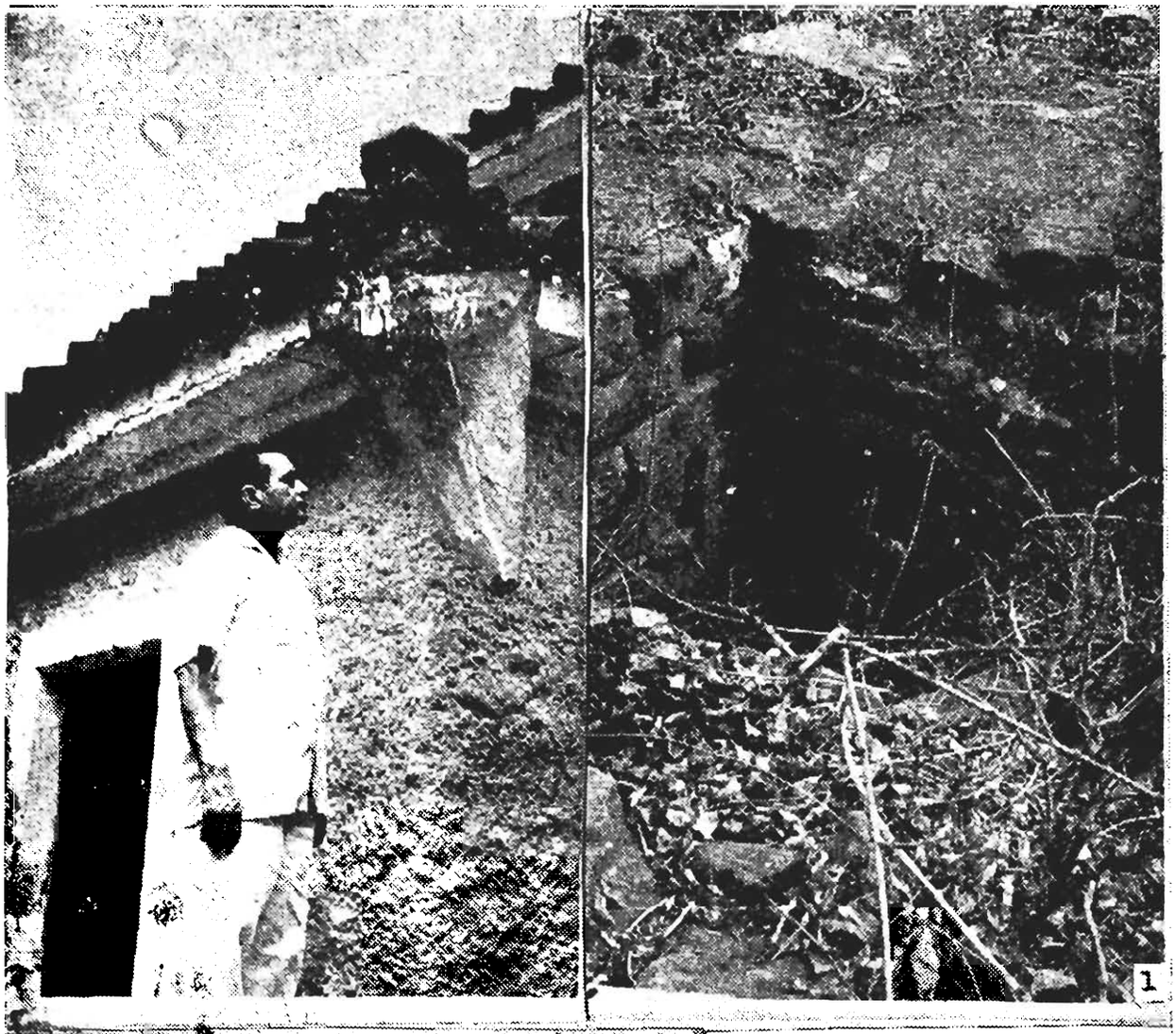
Plate II

Fig. 1. An underground artificial cave near Lamataghat village occasionally occupied by Megaderma l. lyra.

Fig. 2. Method of collection of rare species of bats by tying a butterfly net around the occupied hole in a tiled roof.

Fig. 3. A captive specimen of P.m. mimus being flown in open air for exercise.

Fig. 4. A bat kept inside a glass 'cage' for closer observations.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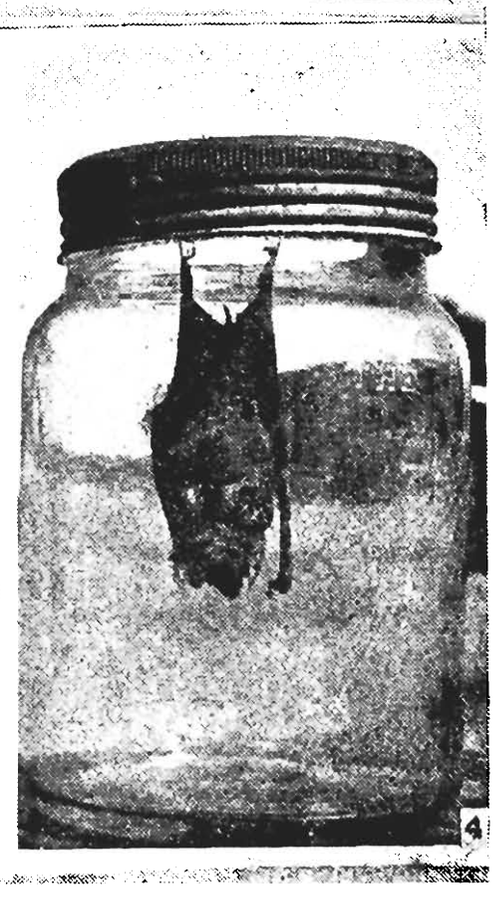
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Plate III

Fig. 1. A colony of Pteropus g. gigantius in flight.

Fig. 2. Rousattus l. leschenaulti. A captive young female with a berry hidden in the wing membrane.

Fig. 3. The same in the act of feeding

Fig. 4. A resting position on the floor of the cage.

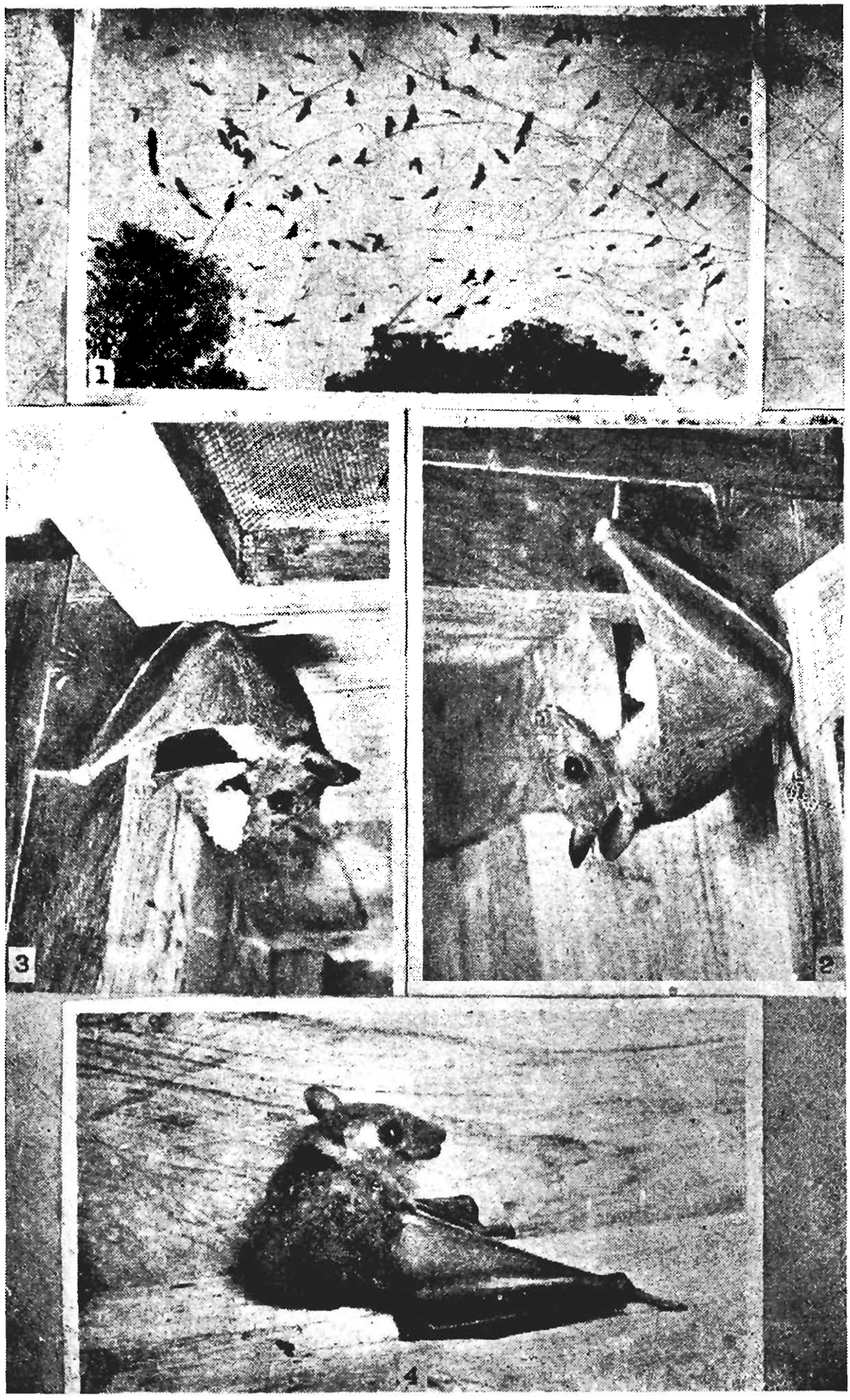
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Plate IV

Fig. 1. A freshly killed adult male of Pteropus g. giganteus.

Fig. 2. The same of Rousettus l. leschenaulti.

Fig. 3. The same (female) of Cynopterus sphinx gangetieus.

Fig. 4. Foetus from a female of P. g. giganteus shot in act of copulation.

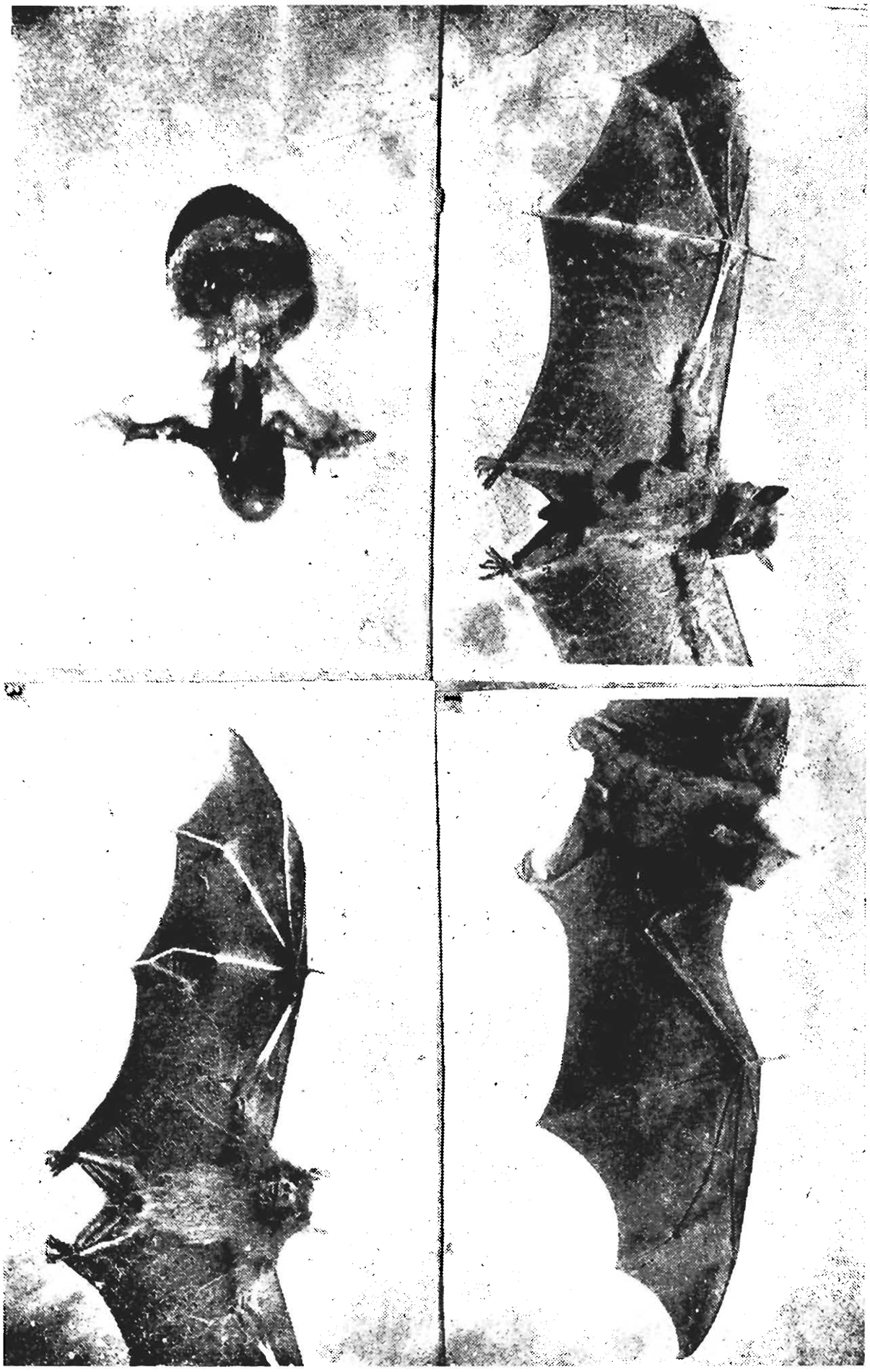

Plate V

Fig. 1. Rhinopoma h. hardwickei A freshly killed adult female.
Fig. 2. The same. Head Portion enlarged.
Frg. 3. Taphozous l longmanis. An adult female.
Fig. 4. Tophozous theobaldi secatus. An adult male.

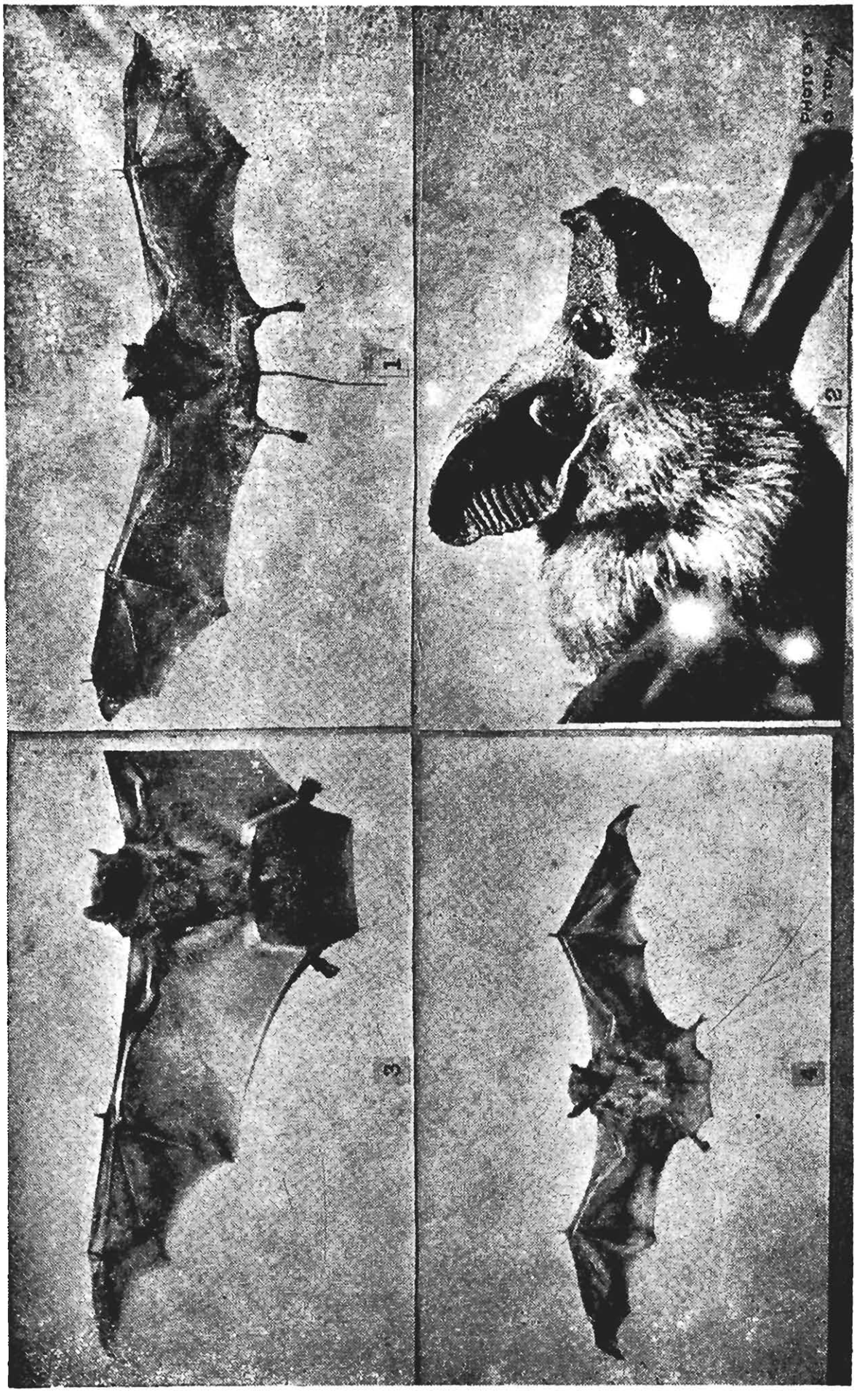
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Plate VI

Fig. 1. Taphozous m. melanopogon. A freshly killed adult male.
Fig. 2. Same. Enlarged head portion of a living specimen.
Fig. 3. Taphozous k. kachhensis. A stuffed adult female.
Fig. 4. Same. Enlarged head portion of a living specimen

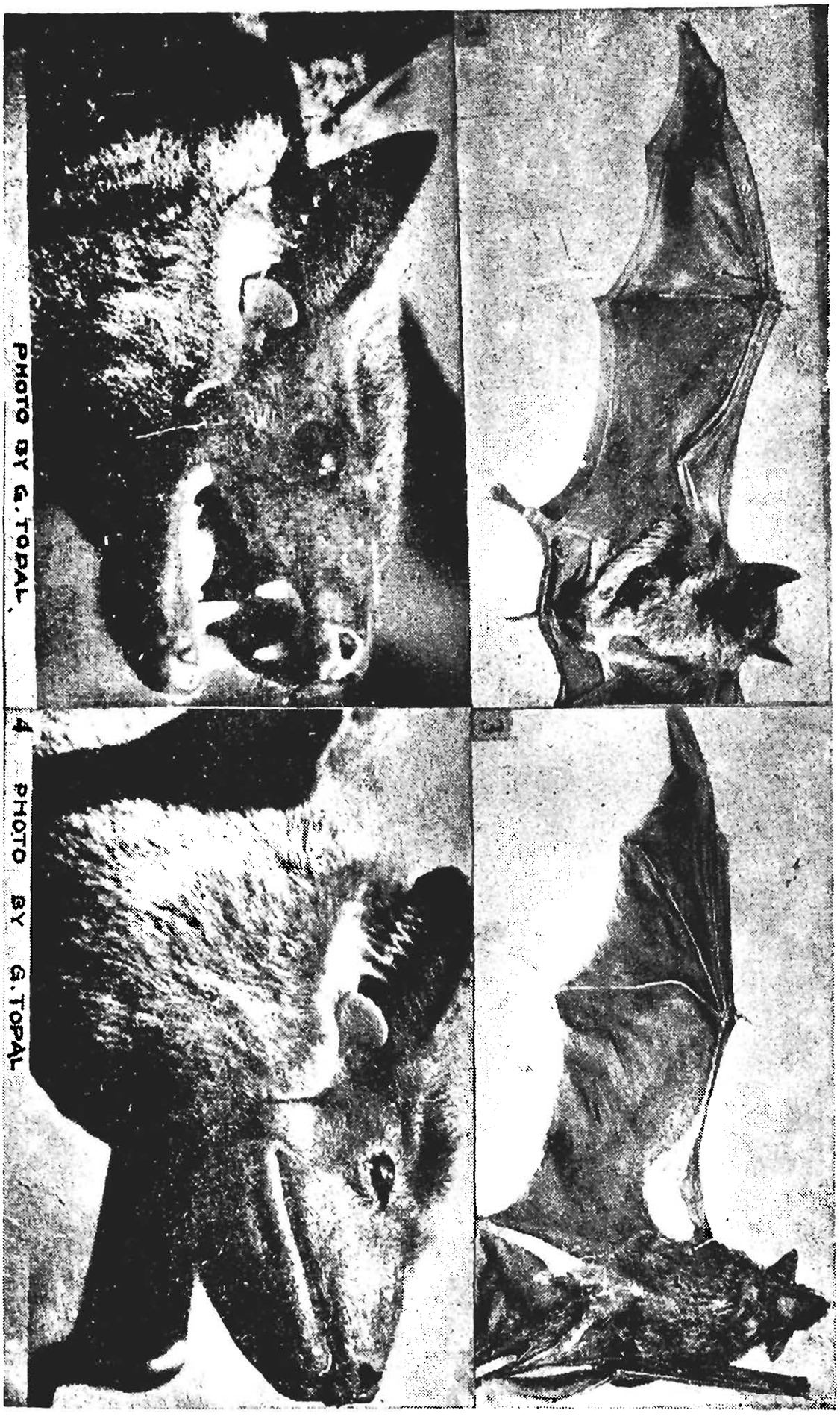
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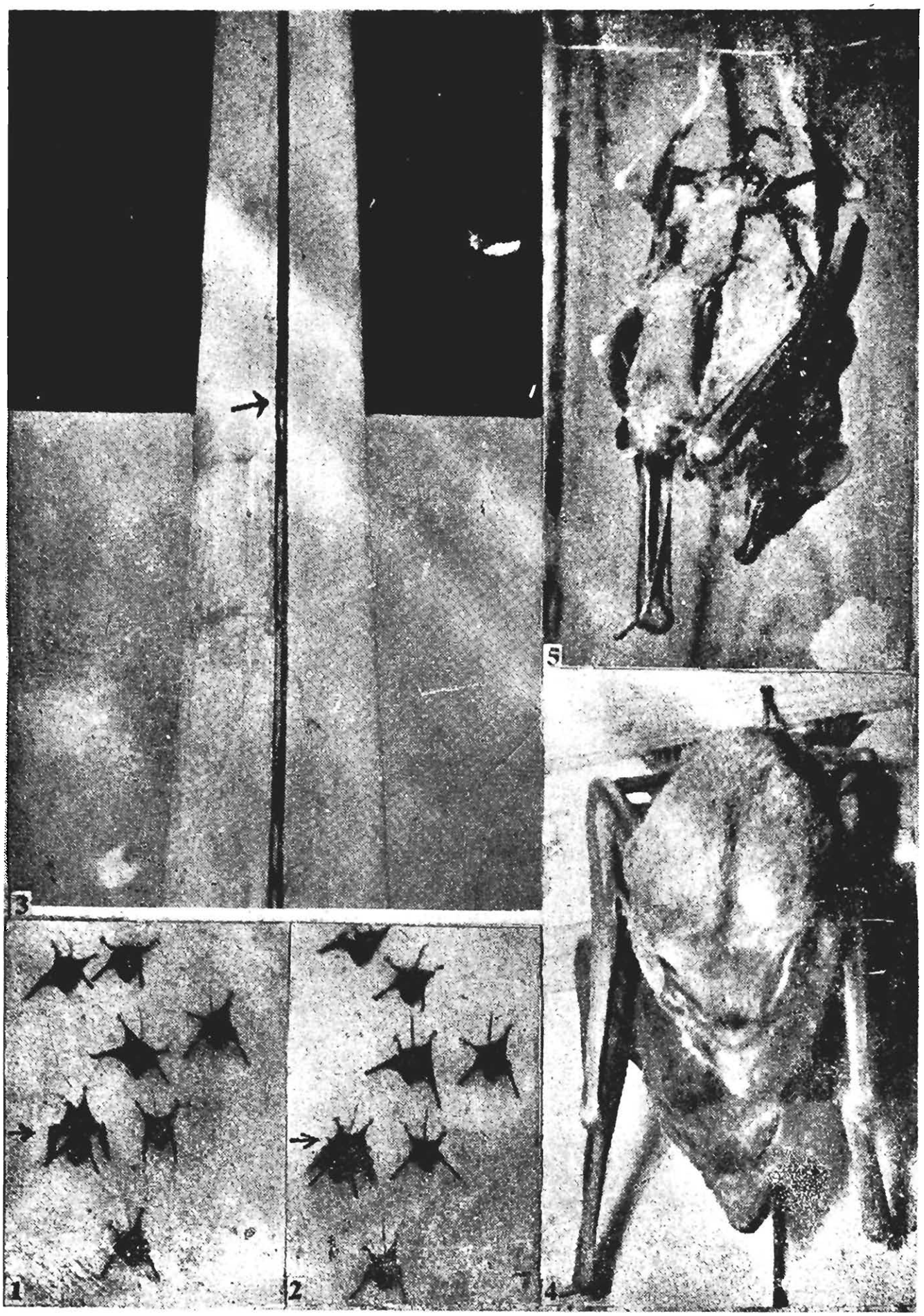
Plate VII

Fig. 1–2. A mating colony of Rhinopoma h. hardwickei showing two stages of courtship display by the male (indicated by arrows) in natural environment.

Fig. 3. A peculiar habitat (indicated by arrow) of Taphozous l. longimanus

Fig. 4. A mating pair of Taphozous m. melanopogon in captivity.

Fig. 5. A female of the same form with twins.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