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**TAXONOMICAL AND ECOLOGICAL STUDIES
ON THE BATS OF JABALPUR DIST. MADHYA
PRADESH, INDIA. Pt. II.**

(FAMILIES *Megadermatidae*, *Rhinolophidae* and *Vespertilionidae*)

By
H. KHAJURIA

Issued by the Director
Zoological Survey of India, Calcutta

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TAXONOMICAL AND ECOLOGICAL STUDIES ON THE BATS OF JABALPUR DIST. MADHYA PRADESH, INDIA. PART II. FAMILIES MEGADERMATIDAE, RHINOLOPHIDAE AND VESPERTILIONIDAE

By

H. KHAJURIA

Zoological Survey of India, Solan.

(with 2 text figures and 8 plates)

I. INTRODUCTION

The first part of this work (Khajuria, 1979) dealt with eight species belonging to the families Pteropidae, Rhinopomatidae, and Emballonuridae. It also included general introduction, resume of literature, scope of the work, acknowledgements, ecological conditions in the area of study, material and methods, explanation of abbreviations and methods of measurements, etc.

The present work deals with twelve species belonging to the families Megadermatidae, Rhinolophidae and Vespertilionidae. The discussion and the summary given in this part covers both parts I and II.

II. TAXONOMICAL AND ECOLOGICAL ACCOUNT

Family Megadermatidae

1. *Megaderma lyra lyra* E. Geoffroy

• Indian False Vampire

(Pl. I, fig. 1,3)

1810. *Megaderma lyra* E. Geoffroy, *Ann. Mus. Hist. Nat. Paris*, 15: 190. (India, East coast, Madras).

Type material.—Possibly in Paris Museum

Synonyms.—*Vespertilio (Megaderma) carnatica* Elliot, *Megaderma spectrum* Wagner, *Megaderma schistacea* Hodgson, *Eucheira lyra caurina* Anderson and Wroughton.

Material collected.—♂ : 43 ad., 20 sub. ad. ♀ : 37 ad. ♀, 1 young Guwarighat, Lamataghat. Katanga, Parasia

Morphological notes.—The wing (Pl. I, fig. 1, 3) is very broad. The fifth digit is much longer than the forearm. The third digit is much less than $1\frac{1}{2}$ times the fifth digit. The antebrachial membrane is also broadened. The tibia is long (Table, VI). Some discrepancies from the description given by Blanford (1891) have been noted. Colour, as in the other species, is variable. In some roosts (temples), action of ammonia in bleaching of colour is appreciable. Older specimens are paler. An important point to be noted in colouration is that hair has practically lost the paler basal band which is very common in other bats studied. In some hairs it is represented by a minute whitish band confined to the very root of the hair. The ashy

or slaty grey dorsal colouration is due to the great development of middle slaty grey band. The terminal band is light brown on the dorsal surface and whitish on the ventral surface. The longest hair in an adult male collected on 23rd January is on the back and measures upto 14 mm. The young is noticeably darker. The wing membrane arises from the base of the outermost toe in some specimens and not from that of the two outer toes. This character is variable (Khajuria, 1953). A character which has not been recorded before is that the pad of the thickened skin at the base of thumb is indistinct. The teats in a female (alcoholic material) collected on 10th January are dorso-ventrally flattened with their flattened surface at right angle to the long axis of the body. There are 6.5 mm. from the axilla, 4 mm. long and 1.5 mm. broad, in a specimen examined.

The external genitalia and baculum have been described by Khajuria (in press, b). The area containing enlarged papillae on the tongue present in many species examined is absent. The stomach does not show any specialization. In young ones (forearm 54-57 mm) the milk dentition has been replaced by permanent one.

Measurements.—Tables VII and VIII. Histograms show that there is no sexual dimorphism in size (text-fig. 1; and Khajuria, 1979, text-fig. 5)

Distribution.—From West Pakistan (Murree, Baluchistan, Siddiqi 1961 a), Rajasthan (Prakash, 1963) to Burma, South to Karnataka (India) and to Sri Lanka ¹ (Phillips, 1922).

Habitat selection.—The bat is eclectic in selection of its diurnal roosts. It has been found in well-lighted dilapidated buildings, shallow soap stone mines just away from direct sunlight, dark underground artificial cave, dark ceiling of a deserted temple, (pl. 1 fig.3) and in front portion of an artificial cave (cf. Brosset, 1962 b). All roosts were near the Narbada river at comparatively quieter places. The temperature in the roosts ranged from 22°C to 38°C. Surfaces of occupied roosts varied from smooth (cemented ceiling of the temple) to mud walls. The bat shifts to more protected places in unfavourable weather such as storms, severe winter and summer. In the temple the air was surcharged with smell of ammonia and the layer of droppings was $\frac{1}{2}$ mt. thick at places showing that the species has occupied the roost for a long time.

At night the bat appears to fly about in varied types of habitat including foliage and rocks, hunting and occasionally resting at any suitable place as shown by its droppings.

General habits.—On account of its aggressive habits, the bat was not found to mix with any other species of bats. However, it was rarely found in wider front portion of an artificial cave narrower and remoter portions of which were occupied by *Hipposideros f. fulvus*. Brosset (1962 b) mentions its association with a number of species, but it is not clear whether it mixed with other species freely or occupied

1. Ellerman and Morrison Scott (1951) and Brosset (1962 b) do not include Sri Lanka in the distribution of this species.

separate corners of the haunt. It was experimentally allowed to mix with *T.m. melanopogon*, in their natural roosts but the bats were not found together next day. In the temple, the colony started urinating when an observer remained inside the roost for about 10 minutes. This may be due to panic or it may be a deliberate effort on the part of the animal to keep off the intruder.

The colonies contained from 10 (shallow soap stone mine) to about 350 individuals (temple). Brosset (1962b) recorded colonies from 2 to about 2000 individuals. The individuals may be placed quite close to each other but were never seen one above the other in the natural state. In captivity they were sometime found huddled together in corners of the cage.

Time of emergence as noted on 18th September (sunset, 6-30 P.M) and 15th October (sunset, 5-47 P.M.) was about $\frac{1}{2}$ an hour after sunset. The bats start coming out one by one or in small groups of two to about five. They flew into foliage of the trees in front of the roost for a short time and then left in various directions. They were not seen to go to the nearby river for an immediate drink. The night is spent hunting in the foliage of plants or elsewhere resting occasionally in suitable places as shown by their droppings.

Flight is noted for much flapping and manoeuvring in the foliage and in rocks in which the bat appears to hunt. It can hardly crawl on all fours. In captivity it takes to flight to cover even short distances. It can swim rather awkwardly. It is not vociferous and very rarely gives out any sound. The only sound heard in captivity resembles *chin-chin*. It was found to remain active in all seasons.

Breeding habits.—These habits were described by Khajuria (in press, a) and Gopalakrishna et.al (1977) who give other earlier references.

Feeding habits.—In captivity it fed on guava fruit, geckoes and the bats, *Rousettus l. leschenaulti* and *Taphozous m. melanopogon*. An interesting habit recorded for the first time is that it may also turn cannibal feeding on weaker or dying or dead specimens (pl. VIII, fig. 3). Although no observation could be made in the natural state, it was a common habit in captivity. If the flesh of the dead prey was exposed, the bat could be induced to feed more easily. The prey was generally first attacked on the throat possibly in an attempt to sever off the head (cf. Pradash, 1963). For literature see Khajuria (in press, a)

Movements.—If not disturbed, the colony continues to occupy the same diurnal roost as shown by the collection of marked specimens. If too much disturbed, as for instance by burning fire under the roost, it may leave the roost for a short time but may again return if the roost is very suitable (temple at Lamhetaghat). In several other cases, it was not found to return to the roost, if the disturbance was too violent.

Enemies, parasites and disease.—No dead specimen or its parts could be collected. Goatley (1963) mentions a dead specimen caught in the zizyphus bush which it probably visited to secure its food. The bat is, however, found to be heavily infected with a species of

streblid ectoparasite (*Raymondia lobulata* Speiser). Five adult males and three adult females collected on 29th April '63 suffered from a skin disease on the ear pinnae probably because of burns caused by the fire burnt under the roost by villagers.

Population.—The total population of the species in the area is estimated at about 500 specimens after parturition and about 350 just before parturition. The variations in the size of the colony in the same roost is possibly due to occupation by some of the bats nearby roosts due to human disturbance. In all 192 males and 320 females including all age groups were examined. Marked preponderance of females may be due to collection of specimens from colonies consisting of females and young only. In some cases (Table I) collections show roughly equal number of males and females. The following samples, though inadequate, give the sex and age composition just before and after parturition.

A. Before parturition		
Sex	S. adults	Adults
♂	6	13
♀	4	13
B. After parturition		
Sex.	S. adults	Adults
♂	3	—
♀	13	13

Pending availability of further information, the sex ratio is provisionally taken as 50 per cent males. Since a single young is born in a year the annual birth rate is 50%. Since the population is more or less stable, the death rate is 33 $\frac{1}{3}$ % and the survival rate 66 $\frac{2}{3}$ %.

Economic importance.—Because of its small population, the bat does not appear to play any important role in human affairs. Animals of special economic importance such as insects, fish, birds and small mammals only form a small portion of its diet. However, its attacks on exposed wounds of large mammals need further investigation by veterinarians in connection with transmission of disease. It can easily be removed from places of archaeological interest by closing exists or by occasionally introducing enough smoke inside the roost.

TABLE 1—Data from the diurnal roost of *Megaderma l. lyra*

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	General remarks
31-8-60	Dilapidated building (Parasia)	50	6 ♂, 1 ♂	---	
24-10-60	-do-	50	2 ♀	—	
6-1-61	-do-	50	9 ♂, 1 ♀	—	
10-1-61	Ruined temples (Lamataghat)	350	22 ♂ young, 18 ♂	—	
23-1-61	-do-	-do-	2 ♂ s.ad, 2 ♀	—	
15-3-61	-do-	-do-	1 ♀	—	
21-3-61	-do-	-do-	-do-	—	
6-4-61	-do-	-do-	1 ♀	—	
21-4-61	Underground artificial cave (near Lamataghat)	100	2 ♂, 6 ♀ pregnant	—	
21-4-61	Ruined temple (Lamataghat)	50	5 ♀ (pregnant)	—	
20-5-61	-do-	3	1 young ♂, 3 ♀	—	

TABLE I—Data from the diurnal roost of *Megaderma l. lyra* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	General remarks
20-5-61	Well lighted dilapidated corridor of a temple (near Lamataghat)	100	10 ♂ 20 ♀	—	
26-6-61	Ruined temple (Lamataghat)	150	2 ♀	—	Young not found on the breast of the mother.
29-8-61	-do-	100	1 ♀	—	
29-8-61	Underground artificial cave (near Lamataghat)	50	—	—	
15-9-61	-do-	-do-	—	—	
15-9-61 &) 29-9-61)	Ruined temples do (2 Nos. near Lamataghat)	50 in each temple	—	—	
24-10-61	-do-	50	—	—	

TABLE I—Data from the diurnal roost of *Megaderma l. lyra* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	General remarks
13-11-61	Ruined temples (3 Nos.)	About 70 in each temple	3 ♀	—	
29-11-61	-do-	-do-	1 ♂	—	
30-12-61	-do-	-do-	—	—	
30-1-62	-do-	-do-	1 ♂, 1 ad. ♀	—	
9-2-62	-do-	-do-	1 ♂, 2 ♀	—	
28-3-62	-do-	-do-	4 ♀ (pregnant)	—	
21-4-62	-do-	-do-	1 ♂, 2 ♀ (pregnant)	—	
30-5-62	-do-	-do-	—	—	
13-6-62	-do-	3 specimens	—	—	
15-7-62 (?)	-do-	100	6 ♀, 4 ♂ young	—	
21-8-62	-do-	-do-	24 ♀ young, 5 ♂ 1 young ♀	—	
29-8-62	-do-	150	15 ♂, young 20 ♀	—	
15-10-62	-do-	150	10 ♂, 5 ♀	—	
28-10-62	-do-	-do-	15 ♂, 18 ♀	—	
25-11-62	-do-	200	32 ♂, 27 ♀	—	

TABLE I—Data from the diurnal roost of *Megaderma l. lyra* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	General remarks
22-12-62	-do-	-do-	3 ♂, 3 ♀	—	
7-1-63	-do-	-do-	5 ♂, 1 ♀	—	
29-1-63	-do-	-do-	2 ♂, 3 ♀, 2 young ♀	—	
27-2-63	-do-	70	6 ♂, 6 ♀	—	
28-3-63	-do-	-do-	12 ♂, 15 ♀ (pregnant) 2 young ♀	—	
29-4-63	-do-	50	5 ♂, 3 ♀	—	
5-5-63	-do-	Absent	—	—	
24-5-63	-do-	60	2 young ♂, 18 ♀	—	
24-6-63	-do-	-do-	4♂, (2 young); 1 ♀, 8 young ♀	—	
27-6-63	-do-	-do-	1 ♂	—	
11-7-63	-do-	200	3.s ad ♂, 4 young ♀, 1 young ♀	—	
23-8-63	-do-	-do-	1 ♂, 6 ♀	—	
18-9-63	-do-	100	—	—	
27-12-63	-do-	-do-	3 ♂	—	

TABLE I—Data from the diurnal roost of *Mcgaderma l. lyra* (continued)

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	General remarks
3-2-65	Ruined temple (Lamataghat).	70	1 ♂, 4 ♀ (2 pregnant)	—	
15-3-65	-do-	50	3 ♂, 3 ♀	—	
15-4-65	Artificial cave on a hillock (Katanga).	-do-	1 s.ad. ♂, 4 ♀	—	
19-5-65	Ruined temple (Lamataghat)	Absent			
10-7-65	-do-	100	—	—	
18-10-65	-do-	100	3 ♂, 2 ♀	—	
17-5-65	Artificial cave on a hillock (Katanga)	50	—	—	
18-3-66	-do-	-do-	1 ♂	—	
23-3-66	-do-	20	1 ♀ (pregnant)	—	
23-4-66	-do-	-do-	1 ad. (pregnant)	—	
5-9-67	Ruined temple (Lamataghat)	Absent	—	—	

TABLE I—Data from the diurnal roost of *Megaderma l. lyra*

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	General remarks
3-7-67	Artificial cave on a hillock (Katanga)	10	1 ♀, 1 young ♀	— —	Female lactating
7-9-67	Ruined temple (Lamataghat)	15	2 ♂	—	Urination on disturbance.
14-6-67	Soap stone mines (Gwari)	10	3 ♂, 3 ♀	—	Kept in captivity.

Family Rhinolophidae
Subfamily Rhinolophinae

2. *Rhinolophus*¹ *lepidus lepidus* Blyth

(Pl. II, fig. 1)

1844. *Rhinolophus lepidus* Blyth, *J. Asiat. Soc. Beng.*, 13 : 486., ? Calcutta.

Type material.—Unknown.

Material collected.—

8 ad. ♂; 12. ad ♀ ; Bheraghat, Katanga, Richhai.

Morphological notes.—The general form of the wing resembles that of *M.l. lyra* but the antebrachial membrane is not much broadened. The tibia is rather short (Table, VI). The colour is generally brown but the basal band of the hair is much paler. The ventral side is noticeably paler. The young as usual is darker than the adult. The fur of an adult female collected in March measures upto 8 mm. in length. The tip of the tongue in alcoholic material has a mid-dorsal groove and its posterior portion is broader and thicker with enlarged papillae. The teats in a female (alcoholic material) collected on 4th May are flattened with their flattened surface at right angle to the long axis of the body. They are about 5mm. from the axilla, 2.5 mm. long and 1.2 mm. broad. External genitalia and bacula have been described by Khajuria (in press to)

The hairy clitoris does not present any special modification.

Measurements.—See tables VII and VIII.

Distribution.—Afghanistan (Aellen, 1959), Rajasthan (Parkash, 1963), to Bengal (not recorded from East Pakistan, Siddiqi, 1961 a) south at least to Karnataka but possibly widely distributed in peninsular India.

Habitat selection.—The bat is a permanent resident of dark, cool and quiet cells of a dilapidated building just on the bank of the Narbada river and was occasionally found in an artificial cave on a hillock and in boulder caves. In the latter two habitats also it occupies the darker, cooler and quieter parts of the habitat. It suspends itself from the surfaces which may be rocky, cemented or earthen. At night the hunting territory does not appear to be far from the diurnal roost. The roost was found to be completely unoccupied from 9 P.M. to 9-45 P.M. on 13th May.

General habits.—The bat has been found in association with *R.h. hardwickei*, *T.m. melanopogon*, *T. theobaldi secatus* and *H. f. fulvus* but in the roost which is permanently occupied, it lives alone. The colonies have been found to consist of about 20-30 specimens. Brosset (1962 b) recorded colonies consisting of about 400 individuals. They may place

¹For a discussion of the Indian bats of this genus see Sinha (1973)

themselves very close to or at some distance but they were never found one above the other. No aggressiveness towards other individuals of same species, other species or to human beings was observed in captivity except that it may defend itself by biting when captured.

This is one of the most delicate bat the writer has ever handled. Any rough handling and or exposure to rough weather may result in death. The agitated movements of its nose and ears in the presence of an intruder have also been noted by others.

The time of emergence on 23rd September (sunset, 6.08 P.M.) was 6.40 P.M. They flew out from different exits one at a time or in groups of two or three individuals. As observed by Brosset, it hunts in the foliage of nearby trees, near lamp posts and may enter houses. It may rest temporarily at a suitable place at night.

Its flapping flight is very fast and erratic marked by several turns and twists in different directions. It has never been observed to crawl in captivity. Like *Megaderma l. lyra*, it takes to flight to cover even short distances. It has always been found hanging by its hind feet and does not appear to use the claw of the thumb for clinging to surfaces.

Its sound resembles *chik chik* or *chin-chin*. Parakash (1963) and the writer found no specimen hibernating in November. In February also all specimens observed were active¹. However Brosset (1962 b) observed both hibernating and active individuals in 'whole annual cycle' in Western Ghats and elsewhere. According to him "hibernating rhythms are individual and not due to climate and other external factors"

Breeding habits.—These habits were described by Khajuria (in press, a).

Feeding habits.—No useful information could be collected. According to Brosset (1962 b) it apparently takes 'mosquitoes, small moths and Coleoptera' To confirm this, specimens were kept in captivity and supplied with these insects (Khajuria 1979) and were also forced fed on them but without success.

1. Five specimens (3♂, 2♀) collected in January in Hoshangabad District, Madhya Pradesh were active and no specimen was seen hibernating in the roost.

TABLE II. Data from diurnal roost of *Rhinolophus l. lepidus*

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	General remarks
19-9-63	Artificial cave on a hillock (Katanga)	20	2 ♂, 1 ♀	<i>H. f. fulvus</i> , <i>R.h. hardwickei</i> .	
15-11-64	Boulders cave (Richhai)	?	1 ♂	-do- and <i>T.m. melanopogon</i> , <i>T. theobaldi secatus</i> .	
16-2-65	-do-	?	1 ♀	-do-	
23-9-65	Katanga.	10	1 ♂	—	
5-4-67	Small temple (Bheraghat)	1	1 ♂	—	
4-5-67	Dark parts of dilapidated building (Bheraghat)	25	2 ♂ (pregnant)	—	
20-10-67	-do-	-do-	3 ♀	—	
13-5-67	-do-	—	—	—	
19-6-68	-do-	3	2 ♂, 1 ♀	—	

3. *Hipposideros fulvus fulvus*¹ Gray

1838. *Hipposideros fulvus* Gray, *Mag. Zool. Bot.*, 2 : 492, Dharwar, India.

Type material.—Type in B. M.

Synonyms.—*Hipposideros murinus* Gray, *Rhinolophus fulgens* Elliot, *Phylorhina aurita* Tomes.

Material collected.—

27 ad. ♂; 10 ad. ♀; Bheraghat village, Katanga, Katangi.

Morphological notes.—The form of the wing resembles that of *R. l. lepidus*. The tibia is rather long. The colour of this form has been discussed by Brosset (1962 b). It is as usual very variable. The young is darker. The individual hair has whitish basal band. The ventral surface is paler. The fur of an adult male collected in March measures upto 7 mm. in length. The fur extends sparsely on the margins of the ear. The teats in a female (alcoholic material) collected on 30th August are similar in appearance to those of *R. l. lepidus*. They are about 6 mm. from the axilla, 3 mm. long and 1 mm. broad.

The external genitalia and bacula have been described by Khajuria (in press b)

Measurements.—Tables VII and VIII

Distribution.—Peninsular India as far north as Varanasi (Khajuria, 1953), absent in western desert areas, possibly in Andaman Islands (Hill, 1967).

Habitat selection.—The species was found only in two places. In both cases the habitat was very similar, artificial cave on hillocks and animals occupied darker parts of the caves. In both cases the roosts were situated in quieter places. According to Brosset the species is very eclectic in selection of diurnal habitat. At night the hunting territory does not appear to be very far from the diurnal roost. It was found to hunt quite close to the ground. No specimen was observed on 11th May in the diurnal roost at Katanga from 11 P.M. to 11.40 P.M.

General habits.—The bat was found in association with *R. h. hardwickei*, *M. l. lvea*, *R. l. lepidus*, *H. c. durgadasi*. It was not found to mix with *R. h. hardwickei* and *Megaderma l. lyra* which occupied different parts of the caves. In one of the caves, it was found associated with only *H. c. durgadasi*. Some individuals were kept in a small cage with *M. l. lyra* and found dead after some time. Possibly they were attacked by the latter. It lived with *R. h. hardwickei* in captivity peacefully. The reaction towards humans was similar to that of *R. l. lepidus*, i.e., agitated movements of ears and nose on closer

1. Ellerman and Morrison-Scott (1951) provisionally considered *H. fulvus* Gray as a subspecies of *H. bicolor* Temminck but Hill (1967) considers *H. fulvus* as a separate species.

TABLE III. Data from the diurnal roost of *Hipposideros f. fulvus*

Date	Habitat and locality	Estimated size of the colony	Specimens examined	Association with other species	General remarks
19-9-63	Artificial cave on a hillock (Katanga)	60	2 ♂	<i>R.l.</i> , <i>lepidus</i> , <i>Rhinopoma h. hardwickei</i> .	
30-3-64	-do-	—	8 ♂, 1 ♀	—	
17-12-64	-do-	Absent	—	—	
15-4-65	-do-	50	4 ♂, 4 ♀ (pregnant)	—	
6-5-65	-do-	50	3 ♂, 2 ♀	—	
23-9-65	-do-	-do-	4 ♀, 4 ♀	—	
19-3-66	-do-	20	1 ♂	—	
17-9-66	-do- (Katangi)	50	1 ♂	—	
9-3-67	Artificial cave on a hillock (Katanga)	70	2 ♀ (pregnant)	—	
29-3-67	-do-	-do-	4 ♂, 6 ♀ (pregnant)	—	
30-7-67	-do-	30	1 ♀	—	
31-7-67	-do-	-do-	3 ♂, 4 ♀	<i>Megaderma l. lyra</i> .	
11-9-67	-do-	15	—	—	
18-11-67	Artificial cave on a hill (Katangi)	50	5 ♂	<i>H.c. durgadasi</i>	All males.
20-3-68	-do-	50	2 ♂	—	
29-5-68	Artificial cave on a hillock (Katanga)	50	4 ♂	—	

approach of the former. They avoid mist nets very effectively. The individuals may place themselves very close to or at some distance from one another but not one above the other.

The time of emergence, nocturnal activity and other habits are similar to those noted under *H. c. durgadasi*. It was found active in all seasons.

Breeding habits.—These habits were described by Khajuria (in press, a) and Madhavan *et al* (1978).

Feeding habits.—Several types of insects (Khajuria, 1979) were tried but the bat took only small beetles, *Orophus parvus* and *Aphodius* sp. and a species of cricket, *Gryllus* sp. In hot weather they were frequently found clinging to the outer surface of earthen pot containing water. Detailed observations on their feeding habits could not be made because they could not be kept in captivity for more than a week. After this period many specimens either died or showed peculiar trembling movements of body. The trembling movements also appeared in some other species of bats studied but generally disappeared when the animal was made to fly in fresh air by tying a thread to its foot. This bat is delicate to handle and generally did not survive after the above exercise. Sometime they were found to lick the wet surface of the pots. They were also seen with their mouths near water but actual mode of drinking water could not be observed.

Population.—Total population in the area does not exceed 150 specimens. Out of the total of 68 specimens examined, 40 were males and the rest females. However, there is some possibility of sexual segregation and different behaviour of sexes so that the above figures cannot be taken as correctly indicating the sex ratio. Males and females in almost equal number, although not in sufficient number, were also collected on occasions. In seven young specimens examined, three were males and four females. No appreciable increases or decreases in population have been observed.

Economic importance.—Some small species of Coleoptera (*vide supra*) are eaten. The population is small and, thus, no special importance can be given to its role as controller of insect population in the present state of our knowledge.

4. *Hipposideros cineraceus durgadasi* Khajuria

Durgadas, bat

(Pl. I, fig. 2)

1970. *Hipposideros cineraceus durgadasi* Khajuria, *Mammalia*, 34 (4): 622-627. near Katangi village, Jabalpur Dist., M.P., India.

Type Material.—Holotype in Z.S.I.

Material collected.—♂: 16 ad, 1 young; 9 ad., ♀;

Richhai, Katangi, Katanga

Morphological notes.—The general form of the wing resembles that of *R. l lepidus*. The tibia is comparatively long (Table, VI). The

TABLE IV Data from the diurnal roost of *H. cineraceus durgadasi*

Date	Habitat and locality	Estimated size of colony	Specimens examined	Association with other species	General remarks
19-9-63	Artificial cave on a hillock (Katanga)	?	1 ♀	—	
23-9-65	-do-	?		—	
29-9-65	-do-	?	1 ♂, 1 ♀	—	
13-5-66	Boulder caves (Richhai village).	20	2 ♂, 1 s. ad ♂	—	
17-9-66	Artificial cave on a hill (Katangi)	50	4 ♂	—	
4-3-67	-do-	20	10 ♂, 1 ♀	—	
14-3-67	-do-	-do-	15 ♂	—	
29-3-67	Artificial cave on a hillock (Katanga)	20 ?	2 ♀ (pregnant)	<i>H. f. fulvus</i> , <i>h. hardwicki</i>	
18-11-67	-do- (Katangi)	100	7 ♂, s. ad, 2 ♀	<i>H. f. fulvus</i> .	
20-3-68	Artificial cave on a hill (Katangi)	30	6 ♂, 1 ♀	<i>H. bicolor fulvus</i> .	

colour is practically as variable as in *H. f. fulvus*. It varies from brown to reddish brown on the dorsal surface. The ventral surface is almost whitish, but brown tips to the hair are present on the chest, the throat, the shoulders and the sides of the whole of the ventral surface in many specimens. The shoulders and the muzzle are darker. The individual hair has a paler basal band. The fur of an adult male collected on 4th March reaches 7 mm. in length. The teats in a female collected on 19th September are similar to those of *R. l. lepidus*. They are 4.5 mm. from the axilla, 3 mm. long and 1 mm. broad. External genitalia and bacula were described by Khajuria (in press, b)

Measurements.—Tables, VII and VIII

Distribution.—So far known from Jabalpur Dist.

Habitat selection.—In addition to its occurrence in the diurnal roosts occupied by *H. f. fulvus*, the species was once collected in the boulder caves at Richhai. Because of the nature of last habitat, exact position of its roost could not be located but many caves in this locality have more or less the same ecological conditions as those prevalent in the roosts of *H. f. fulvus*. Other requirements in habitat selection appear to be similar to those of *H. f. fulvus*.

General habits.—In addition to the species mentioned as living in association with *H. f. fulvus*, it apparently lives close, though possibly not exactly in the same spot, to the roosts of *R. h. hardwickei*, *T. m. melanopogon*, *T. theobaldi secatus* and *R. l. lepidus* in Richhai boulder caves. Other general habits are similar to those of *H. f. fulvus*.

Breeding habits.—These habits were described by Khajuria (in press, a).

Feeding habits.—These habits appear similar to those of the *H. f. fulvus*. For the list of insect species tried as food see Khajuria (1979).

Population.—The total number of specimens in the area slightly exceeds that of *H. f. fulvus* but does not appear to be more than 200.

5. *Hipposideros galeritus brachyotus* Dobson

(Pl. II., fig. 2)

1874. *Phyllorhina brachyota* Dobson, *J. Asiat. Soc. Beng.*, 43 (2) : 237. Central India.

Type material.—Type in B. M.

Material collected.—♀: 3 ad. ; 2 young; Gwari near Bheraghat, Jabalpur Dist.

Morphological notes.—The general form of wing resembles that of *R. l. lepidus*. The description of the specimens agrees with that given by Blanford (1891, p. 287). However, no specimen is deep reddish brown or bright ferruginous. In the dried up alcoholic material the hair is brownish at the base with whitish tips on the ventral

side. On the dorsal side, the tip of hair is brownish so that there is a middle whitish band. The fur of an adult female collected on 1st March reaches 13 mm. in length. The teats in a female (alcoholic material) taken on 6th June are similar to those of *R. l. lepidus*. They are about 5 mm. from the axilla, 2.5 mm. long and 1 mm. broad.

The wing membranes are blackish brown. Brosset (1962 b) distinguished two types : (1) brown with blackish membranes from humid area of Konkan and; (2) grey with sepia coloured membranes from drier areas of Deccan and Karnataka. Stomach is of normal type.

Measurements.—Tables VII and VIII

Distribution.—Sri Lanka, probably all over Western and Central India (Brosset, 1962 b), Bengal.

Remarks.—A small colony (2 ad. ♂, 2 young ♀) was met with in the dark corners of 4½ metres deep soap stone mine about 2½ km. from the Narbada river on 14th June. An adult female was collected from a crack in the wall of a house in Jabalpur city, on 1st March. Brosset (1962 b) mentioned some other types of but similar diurnal roosts of this bat.

The specimens captured on 14th June were kept in captivity along with a few specimens of *Rhinolophus l. lepidus* for 46 hours but died of unknown cause, possibly of rough handling during forced feeding. The flight as observed in its natural habitat at the bottom of soap stone mine appears to be similar to the preceding species. The two young ♂ collected on 16th June were possibly born in the preceding spring. In captivity they were force-fed on small grass hoppers and moths but without success. On account of the rarity of the species, no further observation could be made. The present report confirms earlier observations that bat is rare in India.

Family Vespertilionidae

Subfamily Vespertilioninae

6. *Myotis peshwa* Thomas

1915. *Leucone peshwa* Thomas, *J. Bombay nat. Hist. Soc.*, 23 : 61. (Poona, Bombay, India.)

Type material.—Type in B. M.

Material collected.—1 ad ♂; 1 ad ♀; Jabalpur city.

Distribution.—Poona and Elephanta (Brosset, 1962 c), Western India, Jabalpur, Central India (Khajuria, 1978) Specimens examined from Mandla Dist., M. P. Gwalior, M. P. Satara, Maharashtra, Manglore, Mysore (Hill, 1977).

Remarks.—On the ventral side, the hairs have longer whitish-tips. There is no light rufous on the ventral aspects as mentioned by Brosset. Only two specimens, one adult male and one adult female, were collected from the drooping branches of the palmyra palm on 20 December from the premises of church. The whole colony consisted

of about 30 specimens as reported by hired collector, and was spread over the other nearby trees. They were hardly three metres above the ground. The place was comparatively quiet. They were not found to be present in this habitat again. The species appear to be rare in the area. Brosset (1962 c) could also collect a single specimen. The baculum has been described by Khajuria (in press, b). The identified material for comparison could not be obtained despite a good deal of effort and the identification is, thus, provisional.

Measurements.—

Body : 1 ad. ♂ : f, 36.5; p, (broken); p(mt), 5; p(phl), 6.0; d2(mt), 34.5; d2(phl), 3.5; d3(mt), 36.0; d3(phl), 15.5; d3(ph2), (broken); d4(mt), 34.5; d4(phl), 11.0; d5(mt), 33.5; d5(phl), 10.0; ft, 8.5; t, 18.5; tl, 38.0; ear, (broken); 1 ad. ♀ : f, 35.5; p, (broken); p(mt), 4.0; p (phl), 5.5; d2 (mt), 34.0; d2 (phl), 5.0; d3 (mt), 36.5; d3 (phl), 16.0; d3 (ph2), (broken); d4 (mt), 35.0; d4 (phl), 11.5; d5 (mt), 34.0; ft, 9.5; t, 17.0; tl, 37.5; ear, (broken).

Skull : 1 ad. ♂ : c¹-c¹, 4.2; cb, 14.0; c¹-m₃, 5.6; c₁-m₃, 6.2; cr, 3.0; cw, 7.2; iw, 4.1; i, 15.2; mdo, 5.0; ml, 11.2; m3-m3, 5.5; on, 13.6; pl, (?); pml, 8.0; zw, (broken).

1 ad. ♀ : c¹-c¹, 4.2; cb, 13.3; c¹-m₃, 5.5; c¹-m₃, 6.0; cr, 3.0; cw, 7.3; iw, 4.0; i, 15.6; mdo, 5.0; ml, 11.0; m3-m3, 6.0; on, 13.8; pl, 5.2; pml, 8.0; zw, 8.5.

7. *Pipistrellus coromandra coromandra* Gray

Indian Pipistrelle

Plate III, fig. 1.

1838. *Scotophilus coromandra* Gray, *Mag. Zool. Bot.*, 2 : 498 (Pongicherry, Coromandel Coast, India).

Type material.—Unknown, perhaps in Paris Museum.

Synonyms.—*Vespertilio coromandelicus* Blyth, *Myotis parvipes* Blyth, *Vesperugo blythii* Wagner; *Scotophilus coromandelianus* Blyth, *Vesperugo micropus* Peters.

Material collected.—♂: 12 ad., 3 young; 24 ad. ♀; Jabalpur city.

Morphological notes.—The wing is broad. The fifth digit is longer than the forearm. The third digit is less than 1½ times the fifth. The tibia is rather short (Table VI). The colour is dark brown above with yellowish tinge here and there. On the ventral side hair have whitish tips. About half of each hair is blackish at the base. On the dorsal side the black band is longer. The fur of an adult female collected on 14 March reaches 7 mm. in length. The teats in a female (alcoholic material) taken on 1st July are flattened, with flattened surface at right angle to the axis of the body. They are 4 mm. from the axilla, 2.5 mm. long and 1.5 mm. broad. The external male genitalia have been described by Khajuria, (in press, b). The posterior part of the tongue is prominently raised with larger papillae on the anterior part of the raised portion. Some differently shaped enlarged rounded

papillae are also present on the posterior part of the raised portion. The stomach is of normal insectivorous type but the cardiac portion is not enlarged (one female examined just after death). External female genitalia and baculum are illustrated in Pl. V, fig. 1 and 2. They do not show specialization.

Measurements.—Tables VII and VIII

Distribution.—Sri Lanka, north to Kumaon and Bhutan Dusra (Ellerman and Morrison Scott, 1951); Car Nicobar (Bhattacharjee 1977) Siddiqi (1961a) and Prakash (1963) did not record it from, West Pakistan and Rajasthan respectively.

Habitat selection.—From the information so far available, any dark hiding place (a crevice, crack or a hole in buildings or trees) appears to serve as diurnal roost. It has not so far been recorded from rocky substratum. The following roosts were more thoroughly investigated :—

(i) In one roost examined on 3rd August, the hole was in the upper corner of a door of an uninhabited hut. The opening of the hole was about 4 cm. in diameter. The hole led into an extensive crack with several ramifications in the mud wall. The hut was situated in the middle of a row of inhabited huts. About 15 specimens (2 adult females examined) were found in this roost.

(ii) In another very similar roost examined on 13th August, the hole had two openings, one in each of the adjacent hut, and some smoke entered continually in both of the openings from hearths nearby. As the animals are quite sensitive to smoke, they appeared to roost in deeper parts of the crack where smoke did not reach. One adult female was examined.

(iii) A small colony of six individuals (1 adult female, purchased) was found by a collector on 29th October in a hole about 5 cm. in diameter and 35 cm. deep in a peepal tree (*Ficus* sp.) near a village.

(iv) A colony of about 8 individuals was met with on 31st May, under a small wooden board on the mud wall of an office building (2 adult females examined). Two specimens (an adult male and an adult female) were collected on 29th October from a hole in a wall from which they could be seen from outside.

Although avoiding direct exposure, they do not appear to be very sensitive to sun, winds and sounds. At night, the species have been found to hunt near houses, trees and lamp posts especially when it is drizzling.

General habits.—The species have been found in small colonies of about 2 to 15 specimens. No association with other species has been observed. When disturbed, it is more aggressive than *P. m. mimus* attempting to bite at slightest provocation. The individuals have been found to roost very close to one another. They may also be found one above the other.

No observations could be made on the time of its emergence in the evening and that of its return to the roost. According to Brosset (1952 c), it returned to its roost "quarter of an hour after the day was beginning to dawn" He also states that it flies away very early at sunset" During day time it was found to pass its time in sleep. The flight is fluttering marked by sharp turns in directions. It can walk rapidly on all fours and can swim well with rapid strokes of wings. In clinging to surfaces it uses claws of thumb and feet and can be seen with its head directed in any direction.

The sound resembles *krin-krin*, *kir-kir*, *kar-kar* but was often difficult to imitate. A sound resembling *ak*, *tak* or *thak* was usually given out with an upward jerk of head when they were dissatisfied particularly with food or methods of its administration.

It is difficult to collect. In two cases, bats did not leave their roosts as long as nets were tied around the exits of their roosts. In one case they did not come out when sufficient smoke was introduced inside the roost which was a deep crack in a mud wall. Perhaps, because of the extensiveness of the crack, smoke did not reach the animals.

Breeding habits.—The females with young were kept in captivity for four days. The mothers were very fierce. One of the females escaped at about 9 P. M. but left its young ones behind. About an hour later, a small bat was found hovering over the jar containing the remaining specimens. It flew off whenever an attempt was made to capture it but again returned. It was brought down with a net and struck the ground with some force whereby it became somewhat unconscious. It, however, soon regained its senses and became quite active trying to free itself. It was found to be a lactating female of the subspecies under consideration; and because of its behaviour towards the young ones appeared, in all probability, to be the same specimen which had escaped earlier. When brought near the young ones it readily accepted all of them. In fact it appeared to be so much 'moved' by coming in contact with the young that it became motionless for a while and did not move even when turned upside down with the young on its body. The young in captivity were found mostly clinging to the back of the females. They gave out a continuous low purring sound possibly due to hunger. They were not seen being suckled during confinement. Data on segregation of sexes is insufficient. The data collected in natural state has been discussed by Khajuria, (in press, a).

Feeding habits.—They are similar to those of *P. m. mimus* as observed in captivity but the specimens were difficult to handle because of their more fierce disposition.

Movements.—It was found to change its haunt if disturbed in two instances.

Population.—It is rare in the area. Because of the nature of its roosts, no estimate of its number could be made. Out of 42 specimens examined, 12 are adult males, 3 young males, 24 adult females and 3 young females. However, no definite conclusion can be drawn from the above inadequate data regarding the sex and age composition.

Economic importance.—The bat has food habits similar to those of *P. m. mimus*, but on account of its small population does not appear to exercise any special control over the population of its prey.

8. *Pipistrellus mimus mimus* Wroughton

Indian Pigmy-Pipistrelle

Plate IV, fig. I.

1899. *Pipistrellus mimus* Wroughton, *J. Bombay nat. Hist. Soc.*, 12 : 722. Mheskatri, Dangs, Surat Dist., Western India.

Type material.—Type in B. M. (ad. ♀, Siddiqi, 1961 a).

Material collected —♂:18 ad., 1 young; ♀ : 37 ad., 3 young, Jabalpur city.

Morphological notes.—The general form of the wing resembles that of *P. c. coromandra*. The tibia is rather short (Table, VI). The colour is darker than that of *P. c. coromandra* being brownish black on the dorsal surface. On the ventral surface the hair has silvery tips. The lactating females observed in September were browner and paler than the young ones. The basal paler band to the hair is greatly reduced but the middle dark brown band is much enlarged. The terminal paler band is longer on the ventral surface. The fur of an adult male collected on 14th March measures upto 5 mm. in length. External genitalia and baculum were described by Khajuria, (in press, b). The teats in a female (alcoholic material) collected on 21st September are tubular about 5 mm. from the axilla, 1.3 mm. long and 1 mm. in diameter. They are blackish in colour. The tongue, the stomach, and the female generative organs are more or less similar to that of *P. c. coromandra*. In two young ones (forearm, 13 to 17.5 mm.) there are eight milk teeth in the upper jaw and four in the lower. The glans of young specimen is illustrated in Pl. IV, fig. 2.

Measurements.—Tables, VII and VIII.

Distribution.—Sri Lanka, north to Kumaon (India) not extending to western desert areas, east to western Burma and Annam.

Habitat selection.—The species is known to live in small holes, cracks and crevices in building or trees (Phillips 1922, Brosset, 1962 c). In the present study the following habitats were thoroughly investigated :—

(i) On 29th July, 7th, 21st and 28th September, a colony of about thirty individuals was found in a small hole, about 5 cm. in diameter, under the tile roof of an office building about 7 metres above the floor level. But in all these cases the roosts were in different places although in the same building or similarly constructed buildings.

(ii) On 5th September, a colony of six individuals was found in a hole about 4 cm. in diameter below a tin sheet in the ceiling of a bath room about 3 metres above the floor level. The tin sheet was covered over by tiles.

(iii) A colony of ten individuals was found in a crevice ca. 3 cm. × 15 cm. × 25 cm. in an upper corner of the window of an office building.

Other habitats were more or less similar to those described above. A colony was found below the dried up bark of a tree near a village in a nearby district. Phillips (1922) also refers to its occurrence in tree holes in Sri Lanka. There appears to be no record of its occurrence in rocky cavities. Although some darkness is essential, it is not so sensitive to sunlight or heat as some other bats. It is eclectic to quietness also. At night it has been seen to hunt near trees, houses, or lamp posts. It is much more common near houses and lamp posts, when it is drizzling possibly because of easy availability of shelter nearby if weather becomes more inclement.

General habits.—The species has not been found in association with any other species. In captivity it lived with *Scotophilus h. heathi* occupying different corners of the cage. No fights or aggressiveness by either species was noticed. It is less fierce towards human beings than *P. c. coromandra*. The colony has been found to consist of about 5 to 30 individuals often crowded together (Pl. IV, fig. 1) or a little distance from one another.

Parkash (1963) has studied the time of emergence of a very closely allied form, *P. mimus glaucillus* Kaup in Rajasthan and found that time of emergence is dependent on the duration of twilight. The animal appeared earliest in December and latest in May and June. The time of emergence of the first specimen as noted on 21st September (sunset, 6.10 P. M.) was 6.25 P. M. and that of return to roost of the five specimens on 30th September was 5.50 A. M. (sunrise, 6.02 A.M.) The bats usually leave their haunt one by one with varying amount of intervals, and if the colony is large it may take about $\frac{1}{2}$ hour for the whole colony to leave. If the roost has more than one exits, all may be used. They were not seen to return to the roost after they had left but they flit about the roost for sometime before leaving for hunting territory. The method of return is interesting. They make several false attempts to enter the roost before actually entering it. If the observer is nearby these false attempts are increased. The bats appear to fly deliberately near the observer. This habit along with that of leaving or entering the roost one by one helps to camouflage the location of the roost. The daytime is passed mostly in sleeping while at night it appears active in hunting most of the time.

The flight is fluttering and rapid marked by sudden change of directions in pursuit of the prey. The specimens which have not taken anything continuously for two days except water remained continuously on wing in a room for 15 minutes before showing signs of exhaustion. However, after a rest for few moments, they again resumed their flight when attempt was made to capture them. It can run on all fours quite rapidly. It clings to surfaces with claws of feet and thumb with head down or head up (Pl. IV fig. 1). It can swim well with rapid strokes of wings. The sounds produced are similar to those mentioned in the case of the previous species. They tried to bite off threads tied to their hind feet in initial stages of captivity. If kept for long in a jar, they showed trembling movements which

disappeared after their transfer to fresh air. A specimen accidentally hit on the head suffered from convulsions during which its head with mouth open was bent backward upon the back.

In winter, torpid specimens have been observed. They were not seen hunting at night in this season. They are most active from March to October. For a brief account of its habits in Sri Lanka. see Philliips (1922).

Breeding habits.—These habits were described by Khajuria (in press, a) and Gopalakrishna et al (1975).

Feeding habits.—In captivity the bat took practically all kinds of small nocturnal Lepidoptera (Khajuria, 1979), mosquitoes, *Anopheles* sp. and *Culex* sp. and the housefly. It relished mosquitoes the most. Houseflies were not accepted when brought near their mouth but were relished when forced feeding was tried for sometime.

A hungry specimen when forced fed on a cockroach suffered from peculiar convulsions, possibly due to some intestinal disorder, and died. They did not reject ripe mango and banana when put in their mouth. They took water by licking thin films of water sticking to sides of the jar in which they were kept.

Movements.—Three colonies kept under observations changed their roosts within 2-3 weeks even when there was no human disturbance. They were not seen in winter months during which they hibernate.

Population.—It is difficult to estimate the total population of the species in the area because of difficulty of accurate counts in the diurnal roost. The population is fairly large and may exceed 100 specimens in one square mile in Jabalpur city after parturition. In all 19 males including 5 infants and 41 females including 9 infants were examined. The collection supports results of earlier authors that females are more numerous. However, there is a good possibility of sexual segregation after parturition. Also the colonies of females with immature individuals are much larger after the young have started flying and are more likely to be spotted for collections. The question of overall preponderance of females cannot, thus, be settled just now. An intensive collection during mating season is necessary but very difficult. Since the females with two young are commonly met with, the birth rate is high but the mortality rate must also be high since the population appears to be stable.

Economic importance.—On account of its large population, the bat exercises biological control over several species of Diptera particularly mosquitoes and small Lepidoptera.

9. *Pipistrellus ceylonicus*¹ *indicus* Dobson

Pl. III, fig. 2

1878. *Vesperugo indicus* Dobson, *Cat. Chiroptera Brit. Mus.*, p. 227. Mangalore, Malabar coast, India.

¹Hill (1963) has given a good taxonomic discussion of the species.

Type material. In B. M.

Synonyms. *Pipistrellus chrysothrix* Wroughton (*Vide* Brosset 1962 c); Type in B. M., ad. ♂, (Siddiqi, 1961a).

Material collected.—2 ad. ♂; 4 ad. ♀, Jabalpur city.

Morphological notes.—The general form of the wing is similar to that of *P. c. coromandra*. The tibia is short (Table, VI). The colour of dorsal surface shows rufous tinge here and there. The hair on ventral surface and in some specimens even on the dorsal surface has silvery tip. The colour of individual hair resembles that of *P. m. mimus*. The length of the fur of an adult male collected on 5th November, measures upto 6 mm. in length. The glans of a young specimen is illustrated in pl. V, fig. 3. It is encircled by a ridge in the adult and a middorsal ridge can also be distinguished in alcoholic material. The clitoris appears faintly bilobed in a alcoholic specimen. The tongue resembles that of *P. m. mimus*. The baculum was described by Khajuria (in press, b). Because of the scarcity of the material other characters could not be studied.

Measurements.—Tables, VII and VIII

Distribution.—Peninsular India extending towards north upto Jabalpur, M.P. (Present record) and Bhuj, Gujarat (Brosset, (1962 c), Bengal.

Remarks.—Only two adult males and five adult females were collected on 5th November from Jabalpur city. Exact habitat is not on record. The bat appears to be rare in the area but Brosset (1962 c) states that it was more common than other species of the genus in the area of his collection. On account of its rarity, further observations could not be made. Phillips (1922) and Brosset (1962 c) have given further information on habits which may also possibly be true for the present race. Madhavan (1971) and Gopalakrishna (1972) described its breeding habits.

10. *Scotozous dormeri* Dobson

Dormer's Bat.

1875. *Scotozous dormeri* Dobson, *Proc. zool. Soc. Lond.*, p. 373. Bellary Hills, India

Type material—Type in B. M.

Material collected.—♂: 16 ad.; 3 sub ad.; ♀: 38 ad, 3 young; Jabalpur city.

Morphological notes.—The colour agrees well with the description given by Blanford (1891), but the lactating females were much lighter almost yellowish at places than the males. There is some difference from the description of tragus given by Blanford (1891). The upper end is

rounded, the anterior margin is concave and the posterior convex. Blandford described it as "straight and pointed". The character of glans are illustrated in pl. IV fig 3 & 4 (alcoholic material). It is four-lobed and can easily be distinguished by this character from glans of other Central Indian pipistrelles. The citoris is more clearly marked off, than that of other Central Indian pipistrelles. The baculum was described by Khajuria (in press, b). In the young ones (forearm 24 to 25 mm.), there are ten milk teeth in the upper and four in the lower jaw. The tongue and the stomach are similar to that of genus *Pipistrellus*. The dentition was discussed by the writer (Khajuria, 1965 a). Since then some more skulls with second upper incisors have been found. The development of this tooth varies. In one of the skulls, it can be made out with a lense with difficulty. In the other it exceeds the cingulum of the first incisor. In skulls prepared by inexperienced workers, the tooth is very likely to be removed during cleaning.

Measurements.—Tables VII and VIII

Distribution.—Peninsular India (Dharwar, Bellary, Gujarat, Jabalpur) to Bengal and Bhutan Duars, Formosa (Kuroda).

Habitat selection.—The diurnal roosts and nocturnal territory are similar to those of *P. c. coromandra* and *P. m. mimum*. The following were more thoroughly investigated.

(i) A colony of about ten individuals was found on 20th March, 3rd August, 12th September and 11th October under a small wooden board, about 25 cm. x 30 cm., on a rough mud wall about 2½ metres above the floor. The habitat was once found occupied by *P. c. coromandra* towards the end of May.

(ii) A colony of about 20 individuals was found in a small hole about 5 cm. in diameter in a peepal tree (*Ficus* sp.) with a brickwork at its base. The tree was near a village; and the hole was placed about 2 metres above the ground level.

(iii) A colony of about 30 individuals in a hole near the tile roof of a building. The hole was about 2 metres above the ground.

General habits :—The species is not found in association with other species in nature but lived with *S. h. heathi* and *R. h. hardwickei* in captivity without any aggressiveness on the part of any of the species. However, a specimen of *P. m. mimum* kept over night in a jar containing three specimens of this species was found dead next morning. The cause of death could not be ascertained. A colony living under wooden board left its haunt because of occupation of the roost by wasps. Another colony did not leave the roost till late at night because of lot of human disturbance around. The bat, particularly the mother and the newly born young, are very fierce and aggressive biting savagely anything brought near their mouths. The size of the colony has been found to vary from one (an old male collected on 3rd August) to about 30 individuals. The spacing of the individuals and method of clinging to surfaces appears similar to *P. c. coromandra* and *P. m. mimum*.

The time of return to the roost and that of emergence as noted on 5th June (sunrise 5.25 A.M., sunset 6.54 P.M.) was 4.50 A.M. and 7.15 P.M. respectively. Flight appears to be less fluttering and erratic than *P.m. mimus*. Methods of running and swimming and seasonal activities are similar to those of the said species. It is one of the noisiest species found in Jabalpur and has been found to produce several types of sounds in captivity. The sounds are difficult to imitate; but the usual sound produced when disturbed was *chi-chi, chick-chick*. Sounds resembling *cho-cho, krin-krin, kroon-kroon* were frequently heard. The sound resembling *thak* given out under some sort of dissatisfaction as noted under other species was also heard. They are very sensitive to tobacco smoke and several were collected by blowing the smoke into the holes. Two specimens (♂ and ♀) were kept in captivity from 18.8.63 to 25.8.63. On the second night of captivity, a lot of noise was heard in the jar containing the specimens at about midnight. However, the cause of the noise was not investigated immediately. In the morning it was found that the female had escaped loosening the thread tied around the neck of the jar for fastening the net.

It is quite possible that the cause of the noise was the advances of the male. Next night, a small bat, apparently the species under consideration, was seen flying over the jar containing the specimen, which was resting quietly inside the jar. It would rest on the ceiling for a short while and then fly away. Because of already recorded habits of the allied *P. coromandra*, it is possible that the specimen was the female which had escaped the previous night.

The docility of the remaining specimen gradually increased with the passage of time. After five days the specimen became quite tame. It made no attempt to fly away when kept outside its jar. It appeared to like caressing and grooming making no attempt to bite.

The specimen showed trembling movements when kept for long in its jar but transfer to fresh air invariably stopped such movements. It was seen licking the wing membranes and lower parts of body frequently. The body was also scratched with claws of foot. However no ecto-parasite was found on the body

Breeding habits.—These habits were described by Khajuria (in press, a) and Madhavan (1978)

Feeding habits in captivity.—A specimen took a variety of small insects in captivity (Khajuria, 1979). Moths, grass hoppers, cockroaches (*Periplanata* and *Blatta* spp.), mosquitoes (*Anopheles* sp. and *Culex* sp.), housefly, beetles, ants and even spiders were taken. A specimen tried to bite small mutton bones when put into its mouth but did not succeed in crushing them. Bread and rice if put in its mouth were thrown out after some licking. Another captive specimen was quite healthy on 25.8.1963 at 12 A. M. when it was given a moth and a few black ants. When examined at 4 P. M., it could move only with difficulty. It was kept in fresh air but did not survive. The cause of death could not be ascertained because it had taken similar food before. A starved specimen took the abdomen of a dragon fly but was found dead after about twelve hours. The method of taking

food in case of a specimen kept in captivity for about three weeks is described below.

After being in captivity for about a week, the specimen used to sit with its front quarters raised on its forearm, outside the cage. A thread was, however, always kept tied to one of its feet. If the food was brought near its mouth, it would try to sieze it by moving its head forward with a rush. If it would find it difficult to swallow it, it would sometime push the food against the ground or some other support to have a bite at it. When inside the mouth, the prey was crushed with considerable sound, some part of it, *e.g.*, wings and legs protruding from the toothless front portion of the upper jaw of the bat. In case of larger prey, some parts like wings, legs, etc., were not eaten and dropped out. The quantity of the food consumed by the specimen in a single day was 9.4 grams. The spindle shaped droppings were upto 11 mm. long with a diameter of about 2 mm.

While drinking it dipped its snout in water and then lifted it making some movements of lips. It also licked thin films of water sometimes.

Movements.—The bat changes its diurnal roost even without human disturbance and bats may appear where these were none before. Three adult females were ringed and released on 20th March. One of them was recovered in the same roost on 7th November, 1969.

Population.—The estimation of density of population is difficult to make, because of the nature of roosts and its close resemblance while on wing with larger species of *Pipistrellus*. It is more common than *P. c. coromandra* but rarer than *P. m. mimus*. Since there is no evidence as yet regarding the segregation of sexes, the number may be taken provisionally to represent sex ratio. The population appears stable in the area.

Economic importance.—The bat appears to excercise control over a variety of nocturnal insects.

11. *Scotophilus rubli wroughtoni* Thomas

Lesser Yellow Bat

Pl. III, Fig. 3

1897. *Scotophilus wroughtoni* Thomas, *J. Bombay nat. Hist. Soc.*, II, p. 275. (Kim, Surat district, Western India).

Type material.—Type in British Museum.

Material collected :—

♂ : 19 ad (?), 46 sub. ad, 4 young; ♀ : 34 ad (?), 3 s. ad., 25 young, Sasan and Jabalpur city.

Morphological notes—The wing is both broad and pointed. The fifth digit is longer than the forearm. The third digit is more than 12

times the fifth digit. The tibia is rather short (Table, VI). The colour on the dorsal surface ranges from brownish with yellowish tinge to rufous brown, and on the ventral side from whitish to yellowish or brown. The individual hair has a lighter basal band. The length of the fur of an adult male collected on 17th February reaches 7 mm. in length. The young is darker. The teats in a female (alcoholic material) collected on 10th July are peculiar in having a prominent collar around their bases. They are 6 mm. from the axilla, 4 mm. long and 2 mm. in diameter as in *S. h. heathi*. The external genitalia and baculum were described by Khajuria (in press, b). In young ones (forearm 39 and 42 mm.) there are 6 milk teeth in the upper jaw and 44 in the lower jaw. The tip of the tongue is provided with larger papillae. The enlarged but smaller spined papillae are also present on the posterior raised portion of the tongue, the stomach has enlarged cardiac portion.

Measurements.—Tables, VII and VIII

Distribution.—Ellerman and Morris on Scott (1951) gives the distribution as "Ceylon, Peninsula of India, where widely distributed, north to Kathiawar Palanpur, Bengal, Kumaon, Sikkim, Bhutan Duars, Mt. Popa in Burma" According to Siddiqi (1961b) the range includes "Ceylon, Indo-Pakistan subcontinent (excluding Northern and North-Western dry areas" Sinha (1970) recorded it from Rajasthan (Bharatpur) but does not identify the subspecies. Khajuria (1953) recorded it from 1350 mt. alt. from Bombay state.

Habitat selection.—The species has only been recorded from under the drooping branches of palmyra palms near human habitations and is, thus, rather less sensitive to sun, light, storms and to human noises. In one case the roost was situated near a very noisy flour mill. In very stormy weather, the branches along with a large number of young bats use to fall on the ground. The trees occupied were not less than 3 metres in height. Once on 16th July, a colony of about six individuals was seen in a corner of a verandah. These have apparently strayed into the building because of bad weather during previous night. Brosset (1962 c) also recorded a small colony from under a roof and from holes of walls. Probably they were also stray individuals. Wroughton (*vide* Brosset, 1962 c) has stated that Crump collected 32 specimens from palmyra palms in Kathiawar. Gopalakrishna (1947) collected it from hollows of large trees.

General habits.—The species was found in association with *Cynopterus sphinx gangeticus* and *Taphozous l. longimanus*. Gopalakrishna (1947) recorded its association with *T. longimanus* and a form he called *Scotophilus temmincki*. An individual has once been seen chasing a screaming pipistrelle in verandah of a house. A specimen appeared at night near a captive *Scotophilus h. heathi* which was being given exercise in open air. The common Myna (*Acridotheres tristis*) have been seen to roost in palm trees occupied by this bat. A specimen of this bird was seen to pick up something from the spot

Siddiqi (1961 b) has revised the southern Asian bats of this genus and Hill and Thonglongya (1972) consider all smaller *Scotophilus* including the Indian form as *kuhli*.

where a small colony of this bat had spent the night, It is quite possible that this bird feeds on the ecto-parasites (which are in plenty) of the bat. The sizes of the colony varies from about 5 to about 100 individuals. The colonies of about 25 individuals are common. They are decidedly more aggressive than *S. h. heathi*. They were seen in their diurnal roost quite close to one another but some individuals may be placed quite apart. The same habit was observed in captivity also.

The time of return to the roost on 5th June was 4-30 A.M. (sunrise 5-25 A.M.) and that of emergence on the same date 7-30 P.M. (sunset 6-54 P.M.) The first specimen emerged at 6-30 P.M, on 27th August followed by about ten after an interval of about half an hour. They were not seen to return to the roost immediately after leaving but some specimens were seen to return and leave again at 11-30 P.M. After a few turns in flight, they were seen to make for some place outside the town, possibly for a drink, flying in the same direction every day. On their way they would pick up an insect flying nearby but again resumed their flight in the same direction. Such fixed routes have also been observed in other species (Cockrum, 1956)

The hunting territory appears to be in the fields nearby. The flight is more or less straight, moderately fast and with much flapping. The animals have frequently been seen to fly a little above the level of tree tops. They cling to the surface of walls or tree trunks with the claws of the thumb and toes. They can move on all fours with speed. During swimming, the wing strokes are slow but long. The sound produced resembles *krin krin* or *kin kin* with *n* given out more clearly. The sound resembling *thak* or *tak* is also given out under condition of dissatisfaction. It also has the habit of urinating over the intruders. It may be due to panic but more probably it is a deliberate effort on the part of animals to keep off the intruder. Individuals have been seen to fly over the intruder and urinate. The species also carry on heavy infection of ectoparasites which drop over the intruder who tries to climb the trees occupied by them. The fall of ectoparasites is probably accidental because of shaking of trees during climbing but it appear to serve as a check on enemies which may try to climb occupied trees.

The species appears to hibernates in winter since they are not on wings during this season.

Breeding habits.—An adult male and subadult female were kept in captivity on 10th October. The male was once seen to place itself close to the female with its head near the belly of the latter. The head was moved up and down. The female gave out screams now and then as if in protest. No mating was observed. The data collected in natural state was described by Khajuria (in press, a). Embryology and histological study was very ably carried out by Gopalakrishna (1947, 1948, 1949).

Feeding habits.—Several types of insects (Khajuria, 1979) were tried in forced feeding but without success. However, the softer parts of the beetle, *Heliocopris bucephalus* were found eaten during night by the species in captivity. It freely licked small quantities of water in its

jar. It is shier and more ferocious than *S. h. heathi* possibly because it is not a house dwelling form.

Enemies, parasites and disease.—Two species of ectoparasites are commonly found all over the body. They are the bed bug, *Cimex rotundatus* and a Nycteribiid, *Cyclopodia (Paracyclopodia) roylei (Westwood)*. Former species falls down in large number on the intruder if climbing of the occupied tree is attempted,

Population.—Total population in 1½ km sq. area approximates to about 200 before parturition. As there are generally two young in a litter, population is more than doubled after parturition. The mortality in young is very high because many die during storms because of the fall of branches to which young ones are clinging. The population appears stationary because of high rate of mortality. There is a high percentage of females in both age groups. No definite proof of sexual segregation could be obtained although some possibility of sexual segregation exists because of collection of some specimens of one sex only from one particular roost.

12. *Scotophilus heathi heathi* Horsfield

Greater Yellow Bat

Pl. III, VI & VII

1831. *Nycticejus heathi* Horsfield, *Proc. zool. Soc. Lond.*, p 113. (Madras, India).

Type material.—Cotypes and Lectotypes in B.M.

Synonyms.—*Scotophilus kuhli* Leach, *Nycticeius heathi* Horsfield, *Vespertilio belangeri* Geoffroy *Nycticeius luteus* Blyth, *Scotophilus flaveolus* Horsfield (see Siddiqui, 1961).

Material collected :—

♂ : 15 ad (?), 14 young ; ♀ : 23 ad (?), 14 young ; Lamataghat, Jabalpur city.

Morphological notes—The general form of the wing resembles that of *S. kuhli wroughtoni*. The tibia is rather short (Table, IV). The colour is yellowish brown on the dorsal surface and pastel yellow (Kornerup and Wanscher, 1963) on the ventral aspects. The individual hair on the dorsal side is light yellow at the base with black tips. The length of the fur of an adult male collected on 4th March measures upto 9 mm. in length. The teats in a female (alcoholic material) collected on 21st July are more or less similar to those of *S. kuhli wroughtoni*. They are about 7 mm. from the axilla, 4.5 mm. long and 4 mm. broad.

Measurements.—Tables, VII and VIII

Distribution.—“Sri Lanka, India, Pakistan, Burma, Siam and Java.” (Siddiqui, 1961).

Habitat selection.—Ten diurnal roosts examined were holes, large enough to allow the entry of the bat, just below eaves of the buildings

which have their ceilings of canvas, tin or of other material allowing sufficient space between the ceilings and roof. Brosset (1962 c) has given description of some of the roosts of this species. In one case, movements of bats could actually be observed from below the canvas ceiling. In two cases, the bats were seen on the walls outside their roosts during very hot weather. In one case they were in shade only a few cm. away from direct sunlight. In another case; a lonely bat was seen on 20th May on the external surface of the temple occupied by *M. l. lyra*. During rainy season (19th June), two small colonies of lactating females with young ones were observed in the verandah of an office bulding. They probaly could not return to their roost because of stormy weather.

Above observations show that the bat, though preferring very dark cavities as its diurnal roost, is much more tolerant to sunlight; but appears more sensitive to heat than many other species. It appears to seek shelter at night only when weather becomes too rough. Being a house dwelling form, it does not mind noises produced by human agency. At night its hunting territory appears close to its roost. It has been observed hunting in verandahs of houses and close to trees in vicinity of human dwellings.

General habits.—It does not associate itself with other species in its diurnal roost. It is one of the most powerfully built bat found in the area, but is not aggressive. In captivity, it has lived peacefully with *R. h. hardwickei*, *P.m. mimus* and *S.d. dormeri*. It is not aggressive towards humans. When approached during daytime, it does not make any serious attempt to escape or bite. If touched, it may simply open its mouth in protest and then again go to sleep. Tempers may, however, vary somewhat individually. In the diurnal roost, the bats may be close together or one above the other or there may be considerable space among them, e.g., when they come out of their roosts and cling to the walls in hot weather. Possibly the spacing may depend upon temperature. They usually live in small colonies of two to about 15 specimens. Lonely specimens have also been found.

On 1st April, two males from two different roosts were kept in captivity. They showed hostility towards each other by giving out low purring sound when in close proximity; but after 48 hours they developed friendly relations and were frequently found one above the other. Flying specimens of this species and *S. kuhli wroughtoni* were attracted to captive specimens kept in a net which were touched by the former a number of times.

The time of emergence as noted on 24-9-68 (sunset, 6.07 P.M) was 6.40 P.M. and that of return to roost was 5-50 A.M. on 30-9-68 (sunrise, 6.02 A.M). The daytime is passed mostly in sleeping. In winter they hibernate. At night they spend their time in hunting occasionally resting in verandahs of houses. The ground below spots where they have rested are considerably dirty because of their droppings.

The flight is rather slow and straight with much flapping of wings and is very different from the erratic fluttering flight of pipistrelles.

Claws of both feet and thumb are used in clinging to surfaces. The head has always been seen directed downward. It runs rather slowly on all fours and can swim like *S. kuhli wroughtoni*. The sound produced resembles *krin*, The usual sound resembling 'thak' mentioned under preceding species was also produced. Flying specimens returning to their roosts in the morning, if closely observed, try to fly over the intruder and in one case urinated.

In winter the bat undergoes deep hibernation. This was confirmed by keeping a specimen in captivity from 10th January to 7th February. No specimen was seen to come out during night upto end of 20th February. They usually stop leaving their roosts in the beginning of November. Their nocturnal activity, however, depends upon temperature which is variable in these months. Out of the five females (including 2 young ones), kept in captivity on 22nd July, one adult was found showing dominance over the other. It was the first to start feeding. If there was a struggle to take away the prey, it always succeeded in snatching it away.

Breeding habits in captivity.—These habits in natural state were described by Khajuria (in press, a). A lactating female with a grown-up female young (forearm 55 mm) was collected on 20th July. They were netted as they flew away separately from their roost at dusk. The young was found being suckled during captivity. It did not take any interest in capture of prey and stayed behind at the upper corner of the cage when its mother descended to capture insects placed at the floor of the cage. Another young male of the same age (forearm 56 mm) was taken from a different roost and placed in the cage to study the behaviour of specimens to one another. The second young was marked with colour to distinguish it from the first young. Although no aggressiveness was shown towards the newcomer, it was not suckled by the adult female. It also did not make any attempt to feed itself and died after eleven days. Above observations show that suckling of the young is continued even when it can fly about along with the mother during her hunting trips. It may also continue to live entirely on mother's milk till it has reached the adult size. The mother does not appear to suckle young other than her own. No increase in weight or in measurements of the young ones were noted in captivity.

Two subadults, a male and a female, were collected on 26th August. They were put in a cage where an adult male was being kept. There was no fight. All the three gave out purring sound for sometime. The adult male was sometime found to lick the wing membrane of the female. Sometimes loud shrieks were also heard, the cause of which could not be ascertained. Possibly it was the advances of the male towards the female because the former was always found sleeping in close contact with the female in daytime. The subadult male was always found resting some distance away. This again suggests that there is some sexual activity at least in adult males in autumn. The adult male after the death of the female and the subadult male was found to give out occasional shrieks.

Feeding habits in captivity.—These habits in natural state were described by Khajuria (in press, a). It feeds on the large insects and

seldom cares to feed on smaller ones which are taken by pipistrelles. Its favourite prey are large beetles (*Heliocoprís bucephalus*) the fleshy abdomen of which can provide substantial food to it. The giant bug, *Lethocerus indicus* is also preferred. It feeds, in addition, on smaller beetles, moths, bugs, and grasshoppers (Khajuria, 1979). The method of feeding on *Heliocoprís bucephalus* was studied in detail in captivity during daytime and photographed (pl. VI, VII). A full grown specimen of the beetle was put in the cage. The beetle, while in cage, almost continuously gives out shrill cries resembling *krin-krin*. It took 2-3 minutes before the bat took notice of the prey. The bat came down and moved near the prey but again returned to its resting place, one of the upper corners of the cage. After a few minutes the bat came down again and made an attempt to bite the beetle but the latter with its large size, hard upper parts, legs and jaws, proved more than a match for its enemy. It quickly got under the wings and belly of the bat and successfully warded off all attacks. The bat again returned to its resting place. The third attempt made by the bat after a few minutes was more determined. It was almost like a wrestling match when the bat and the beetle rolled over each other. The bat tried to get the beetle into the cavities which can be formed by flying membranes in posterior under parts of the animal and succeeded to a considerable extent. The bat cut off the legs of its prey one by one proceeding from anterior to posterior parts. After the legs had been bitten off, the prey became a helpless struggling mass unable to move. It was turned upside down and the soft parts of the abdomen and thorax were gradually devoured while the prey struggled and uttered shrill cries. Although cries ceased after sometime, the movements of the body continued till whole of the soft parts were devoured.

The above observations were confirmed four times. There was only a slight differences in the behaviour of the bat and the prey depending upon their strength and size. An adult male bat collected on 29th August was found particularly lazy. It tried to bite the beetle but later gave up the attempt. A specimen which fed on a stale specimen of the said beetle which was covered with some dirt died soon after. Guava fruit and a dead lizard kept with the specimens overnight were not taken. Forced feeding has always been unsuccessful.

While drinking water, it dipped its mouth in the thin films of water in its bottle cage and then lifted the mouth to lick it. The feeding activity in captivity is maximum during night.

Enemies, parasites and disease.—The bat has always been found infected by a Nycteribid ectoparasite, *Cyclopodia (Paracyclopodia) roylei* Westwood. A specimen was seen being carried away by the jungle crow, *Corvus macrorhynchos*, in the evening. It was caught by the bird when it flew away from its roost in the evening. However, the crow let it go when some stones were thrown. It was bitten on its forearm which was found broken. Eight specimens of a nematode parasite were found inside its stomach which was punctured and had a hard nodule on its external surface. It was probably sick and was thus picked up by the crow. The writer has observed several times *S. kuhli wroughtoni* and *P. m. mimus* successfully avoiding any approach by the crow while leaving their roosts early in the evening.

Generally the crow makes no attempt to attack bats which are too dextrous in their flight for the bird.

Population.—The population of the bat in $1\frac{1}{2}$ sq. km. square area in Jabalpur city does not exceed 200 specimens before parturition. There appears to be predominance of females at least in adults; but since there is a possibility of segregation of sexes, the above figures cannot be taken to represent true sex ratio. Since all females observed soon after parturition were with two young ones, the rate of increase in population is high. The death rate is also high since the population appears stable at least in $1\frac{1}{2}$ km sq. area which was more thoroughly studied.

Economic importance.—The species is a useful destroyer of larger insects and because of its large population can be considered as an effective control over its prey. It does not appear to feed on very small insects. It is thoroughly a house dwelling form and may cause considerable nuisance by its smell and faecal droppings in the verandahs. The faecal droppings are thrown on the floor when the animals come out of the roost and when they rest temporarily below the ceilings during night. However, because of its usefulness, it has to be tolerated. It can easily be got rid off, if necessary, by blocking the exits usually only one of its roosts with some material.

III. Discussion¹

This discussion covers twenty bats collected in Jabalpur district including species discussed in part I of this work (Khajuria, 1979). Rarely information available on other allied species has been discussed to evaluate the present observations.

1. Methods of collection and observations.

Methods of collection and observations for Central Indian bats, are beset with some special difficulties which are largely responsible for the paucity of ecological observations on several species. Briefly they are :

(i) Because of warmer climate, several species remain active throughout the year, and winter conditions do not facilitate collection and observations. Even those species which hibernate do not appear to congregate in large number in spacious cavities.

(ii) There is no reliable method of collection and observations in a systematic way of species living in small colonies in obscure and inaccessible haunts.

(iii) Failure of attempts to keep most of them in captivity for any appreciable length of time particularly for want of information on food and other habits specially of insectivorous species.

(iv) Several species change the roosting places frequently.

(v) Insufficient appreciation of their economic importance.

1. After this paper had been sent to press, Wimsatt's (1970-1977) excellent review of biology of bats came to hand. Present observations could not, thus, be discussed in detail in light of Wimsatt's review.

An easy point in the study of these bats is, however, that most of them live near human habitations and are, thus, comparatively easy to observe. This habit is obviously due to their general unmolestation by religious-minded Indians and protections from their enemies because of proximity to humans. Also, in view of the habit of many species to change the roosting places frequently, one need not change the area of observation frequently because the species absent in an area during a particular period are likely to appear in the area at a later period.

The methods of collection generally used at present are discussed by Allen (1939), Brosset (1962 a), Jackson (1926), Stores (1926), and Van Tyne (1950). They appear to be generally applicable to the species whose haunts are easy to locate. Also they may not succeed in securing sufficient number of specimens of rarer species or of those living in very small colonies. In many cases the collection depends too much on chance. The only good systematic method to locate the haunts of rare species at present in use is to look for their droppings Brosset (1962 a). In many cases, however, the droppings may not fall on the ground or may be difficult to detect because of vegetational cover or may fall on spots difficult for examination. In several cases the presence of droppings may only indicate a temporary roost of the animals during night. Even when the haunt is located, the present methods may not succeed if the number of specimens in the haunt is small. A new method was, therefore, developed for this purpose and very successfully used for collection of rare species (Khajuria, 1976 b).

For species inhabiting colder countries, the difficulty may not be as great as for those found in warmer latitudes because the former are reported to congregate in large number in suitable caves in winter, greatly facilitating their collection and observation. However, it is, by no means likely that all the species pass winter in caves. Some species living in small colonies which can accommodate themselves in deep crevices and holes may not migrate to caves in winter and the method recommended here, it is hoped, will facilitate their collection also,

There are many difficulties in observing the bats in their natural environment. Again in colder countries, they can be observed at close range during hibernation in caves. Some of the species under report also hibernate in winter but they do so in holes and crevices too deep for observation. Also during hibernation, there is little activity and no detailed observations can be made. Some species, because of the nature of their roosts (temples, caves), can be observed from a close range but they become so much agitated on closer human approach that they cannot be considered, strictly speaking, as being observed under natural environment. While flying at night, they are, except a very few species, very difficult to identify with certainty even in moon light or lamp light. It is, therefore, necessary to keep them in captivity for more detailed observations and to confirm the observations made under natural conditions.

Insectivorous species are very difficult to keep in captivity because real nature of food is practically unknown in most cases. The artificial diet recommended by some, e.g., Ramage (1947), Albißson and

Dorst (1951), Orr, (1958) was not found successful for the present species. Several attempts to rear larval food (Orr, 1958) ended in failure. Modified methods have to be used and are described by Khajuria (1975). These methods have proved to be quite successful in the majority of species where natural food could be determined. Raswieler's (1977) masterly work on various methods used for care and management of bats in the laboratory deserves serious consideration but it became accessible only after author's work (Khajuria, 1979) had well advanced in press.

Taxonomy.—A resume of literature on taxonomy of India bats is given by the author (Khajuria, 1979) and includes on excellent attempts to study this difficult group with available facilities. However, sound taxonomic knowledge of a group obviously depends on effectiveness of methods of collection. The writer is not aware of any good method used by previous collector at least in India which could have accounted for thorough survey of rare species living in small colonies in obscure places. Although Mammal Survey very efficiently conducted by Bombay Natural History Society (ca 1912-1920) and results of which were summarized by Wroughton (1918) resulted in very large collection of bats, sufficient attention could not obviously be paid to rare species. Brosset's (1962-63) admirable investigation also apparently met with the same difficulty because of shortage of time at his disposal. New methods of collection have now been developed during the present study (*vide supra*) and have successfully been used for the conduction of a thorough survey in a restricted area. It is interesting to note that an intensive survey in a restricted area (about 130 sq. km.) and still more intensive survey in about 1½ km. sq. area have resulted in the discovery of one new subspecies, and extension of ranges of four bats (Khajuria, 1978) and collection of all species recorded from whole of central India except three poorly known bats. Further work on taxonomy of Indian bats, it is suggested, may, therefore, be based on a more intensive survey in a suitable restricted areas by using methods of collection suggested here. Another investigation which needs attention is validity of races based on colouration which is very variable as is generally the case, in all bats. This was also emphasized by Brosset (1962 a). Unfortunately good series of specimens could not be obtained to settle the question in case of a few such cases involved in the present study.

2. Morphology

(i) *Colour.*—The variation in colour of bats is well known but its causes are little understood. In many cases the colour appears to be bleached by excessive amount of ammonia and water vapour in the diurnal roosts because of the accumulation of the faeces (Constantine, 1958, Mitchell, 1964). The colour changes may also be due to moulting (Constantine, 1957). The variations in colourations are generally confined to the tips of hair which are more exposed to the action of atmospheric gases in the roost. It is significant that the tree dwelling bats, *P. g. giganteus*, *C. sphinx gangeticus*, *T. longimanus*, *S. kuhli wroughtoni*, do not show marked colour variation except in erythrisms in adult specimens collected at the same time, possibly because there is no accumulation of faecal matter in the roosts.

The variation in erythrism in the pelage in several species appear to be due to some other causes. A study of this type of colour variation was undertaken in *Rhinolophus rouxi*, a common Indian species, by Andersen (1917). However, it could not be ascertained why many specimens do not develop the rufous colouration. The reddish phase has been found during the present investigation in *R. h. hardwickei*, *T. l. longimanus*, *T. m. melanopogon*, *T. k. kachhensis*, *H. f. fulvus*, *H. cineraceus durgadasi*, *R. l. lepidus* *(Khajuria, 1979), *P. c. coromandra* and *S. kuhli wroughtoni*.

The phase is absent in juveniles as in the other bats. All lactating females collected were more brightly tinted and reddish. Most of the adult males collected during breeding season in the above species are also brightly tinted. Since the colour remains rufous from autumn to summer in the more thoroughly studied species, *R. rouxi*, it may have something to do with the sexual activity. The specimens which do not show this character may be inactive sexually because of age or other reasons. But the present observations are inadequate to arrive at a definite conclusion. Because of difficulties of collection and marking, it could not be ascertained whether the rufous tint is a Mendelian character, *i. e.*, only particular individuals are capable of developing this hue. This line of enquiry can be pursued further. Brosset (1962 a) recorded sexual colour differences in *R. l. leschenaulti* and *Cynopterus sphinx*.

The small variations in rufous tint in the pelage of *P. g. giganteus* and *S. temmincki wroughtoni* are apparently individual.

All insectivorous bats studied have paler ventral sides; but in *S. h. heathi* the ventral surface is pastel yellow (Kornerup and Wanschler, 1963). The significance of this character is not understood.

(ii) *Characters associated with feeding habits.*—The various adaptive radiations in bats, at least in the bats studied, appear to have taken place mainly for obtaining food. Their nocturnal habits, dextrous flight mechanism, well protected diurnal roosts and sharp teeth and claws have left them, except parasites and other disease, with very few enemies and climatic hazards. The characters under study which show adaptations to feeding habits are the general body form, flying membranes, accessory appendages on nose and ear, teeth, skull, tongue, stomach and methods of carrying young. These characters are best considered together. No adequate discussion of adaptations of the above characters is available for Indian species. Allen (1939) has given a good general discussion of modifications of flying membranes including some Indian species. Although such a discussion obviously involves considerable speculations, it is worthy of serious consideration.

A. *Megachiroptera.*—The absence of accessory nose and ear appendages in fruit bats is well known. Considerable reduction in size of the interfemoral membrane is obviously due to its disuse. However, the great reduction of interfemoral membrane in fruit bats has given two advantages to the group : (1) The free movements of

*The specimens were, however, collected outside Jabalpur Dist.

the hind legs needed for more efficient crawling on branches of trees in search of food and for scratching of body with hind feet because of large number of ectoparasites; and (2) better consummation of copulatory act in normal quadrupedal manner.

Tongue has enlarged papillae with spines on much larger area than in Microchiroptera. Its function is not only in licking of body and vulvar orifice but also in removal of fruit pulp. The stomach has the cardiac end much enlarged. In *R. l. leschenaulti*. and *C. sphinx gangeticus*, it is a simple much elongated tube followed by a very long intestine (measured 505 mm. in one adult male of *R. l. leschenaulti*). In *P. g. giganteus* it is somewhat enlarged in diameter. The simplicity of teeth as an adaptation to crushing of soft food is well-known. Although the food does not need much crushing its actual absorption needs long digestive tract. Flattened teats, with their flat surfaces parallel to long axis of the body, keep the head of the young towards and well protected by the wings during movements particularly within the foliage.

Two radiations can be recognized : (1) short-distance flight mainly below the level of tree tops in search of berries and other fruit chiefly in the foliage (*R. l. leschenaulti* and *C. sphinx gangeticus*) (2) Long-distance flight mainly above the level of tree tops (*P. g. giganteus*)

In the first group the size is smaller and the wing comparatively broader. A reduced interfemoral membrane and a short tail is present. All these characters are good adaptations for flight inside the foliage. The reduction in number of teeth and consequently the jaws in *C. sphinx gangeticus* is probably due to harder food possibly hard nuts but no definite proof for this suggestion could be obtained during the present study.

The second group although capable of rapid movements inside the foliage by crawling is adapted for both short and long flight outside the foliage. The wing is both broad and pointed at the tip, the size much larger and the interfemoral membrane is reduced to small expansions, on the inner side of the legs which, however, when brought together in flight performs the function of tail which is absent.

B. Microchiroptera.—Most of the common adaptations for Microchiroptera as a group with regard to the characters under consideration are well known. The significance of the nose-leaf is not clearly understood. During the present study, they have been found in bats which are capable of picking up stationary or running prey. This means that they probably locate and follow the prey by smell. The stomach has been found to be of normal insectivorous type (Allen, 1939) with insignificant variation in all the bats studied.

Each family of Microchiroptera represent a distinct adaptive radiation with regard to the characters under study. In *R. h. hardwickei* (Rhinopomatidae) which has been observed to hunt near and among the boulders, the wing is moderately broad with third digit comparatively short (Table. VII). There is a simple appendage representing nose-leaf but ears and ear appendages are enormously developed. The species appears to be capable of pursuing both low flying, sitting or running

prey in the rocks but possibly not in the foliage. The significance of long free tail projecting beyond rather poorly developed inter femoral membrane and absence of calcar is not properly understood. Possibly they are primitive characters and the inter-femoral membrane is not used with the help of calcar in the capture of flying insects. It has not been possible to determine the nature of its food but the dentition suggests soft food (Brosset, 1962 a). The young are carried attached to the public false teats so that their heads are possibly protected from striking against rocks and other substrata during hunting. The true teats, are, thus not laterally flattened as in fruit bats.

In the genus *Taphozous* (Emballonuridae) the adaptive significance these characters was discussed by the author (Khajuria, 1975 b).

In *M. l. lyra* (Megadermatidae) both the nose leaf and tragus are well-developed. The ears are much enlarged. The wings are broadened. There is even widening of antebrachial membrane. The interfemoral membrane is well-developed but there is no tail. The young are carried in the manner described under *R.h. hardwickei* and the true teats are not laterally flattened as in that bat. The bat is more or less omnivorous and all the above adaptations appear to be suited for the capture of sitting, running or low flying prey (occasionally even fruit) in foliage and among rocks by smell or echolocation. The interfemoral membrane is most likely not converted into a pouch for catching fast flying insects because there is no tail. The tongue is without any enlarged papillae. The dentition is suited for omnivorous diet.

In Rhinolophids two radiations are easily distinguishable :

(a) In *R. l. lepidus*, there is a noseleaf and an anti-tragus. The wings are broad and there is a well-developed tail enclosed in an extensive interfemoral membrane. The method of carrying the young and character of teats are similar to those of *R. h. hardwickei*. The bat is apparently adapted for hunting in foliage. The dentition appears to be adapted to feeding on smaller insects.

(b) Species of *Hipposideros* which bear general external resemblance to the preceding species have been seen hunting quite close to the ground and probably prey upon sitting, running or low flying prey possibly including even small vertebrates. They have been found to feed on small beetles in captivity. A specimen of *H. cineraceus durgadasi* was found to be carnivorous in captivity.

Vespertilionids are apparently well-adapted for hunting at low levels in open air near houses and trees. They do not have nose leaves and broad wing membranes. There is no special protection for the young during flight. They are incapable of undertaking very fast gliding flight but have developed another type of equally efficient flight for capture of the prey. This is the well-known fluttering or erratic flight characterized by the sudden change of direction. Three radiations can be distinguished: (1) *Pipistrelles* which feed mainly on smaller and softer Diptera and Lepidoptera; (2) *Scotophilus* which mainly feeds on larger and harder insects, particularly beetles, and bugs; and (3) *Scotozous* which apparently feeds on variety of small

insects both soft and hard. The dentition is well-adapted in each group for the type of food taken. In pipistrelles, there are two incisors; in *Scotozous*, the second upper incisor is very small and sometimes absent. It may also frequently be lost during cleaning. In *Scotophilus*, the second upper incisor and the first upper premolar are always absent. In the genera *Pipistrellus* and *Scotozous*, the tongue has enlarged papillae on posterior portion only but *Scotophilus* has, in addition, enlarged papillae on the tip of the tongue also. Since *Scotophilus* has large number of ecto-parasites, the enlarged papillae at the tip of tongue have possibly something to do with frequent licking of body because of itching caused by ectoparasites. The size of the forearm of Vespertilionidae which is a good diagnostic character for distinguishing species is possibly regulated by the size of the prey.

(iii) *External genitalia, bacula and secondary sexual characters.*—The above characters help to distinguish bats upto generic levels in the bats studied. Their development may possibly be dependent mainly on the selection of the mate by the female after the taxon has established itself as a genetic entity. A very good account of secondary sexual characters in Indian bats was given by Brösset (1963). Statistical study of the detailed measurements of body parts and skull has shown that there is no sexual dimorphism in the size of the species studied.

A. *External male genitalia and bacula.*—Very little work has been done in the study of external male genitalia of Indian bats briefly reviewed by Khajuria (1979). Sinha (1976 b) has given very good account of bacula of Rajasthan bats and Harrison and Brownlow (1978) have undertaken a detailed comparative study of bacula of genus *Scotophilus*.

Except in *Pteropus* and *Scotophilus* where the glans is parctically naked, the glans is enclosed in a hairy prepuce and is more or less caudally directed. This caudal direction of penis appears to be an important adaptation to avoid fall of urine on the body. The urine and faeces are probably passed in all cases by suspension of body by the claws of the thumb as observed in *P. g. giganteus* and *T. m. melanopogon* and *M. l. lyra*. The study confirms the earlier findings on foreign species by Wood Jones (1917), Mathews (1937), Davis (1947), Hamilton (1949), Topal (1958), Krutzsch and Sulkins (1958), Krutzsch (1959, 1962), Didier (1965) that glans and bacula provide good diagnostic characters. Species of genus appears to have one common form with well established specific characteristics. Unfortunately there are only four genera in which more than one species could be studied. There are *Taphozous*, *Hipposideros*, *Pipistrellus* and *Scotophilus*.

In the genus *Taphozous*, the glans is more or less oblong with a protuberance at the tip. The baculum is roughly triangular in shape with a blunt anterior end, small, and confined to the tip of the glans. In the genus *Hipposideros*, the glans is elongated with the largest breadth in the middle and with the tip more or less pointed. It is covered with longitudinal rows of spines (copulatory spurs) to a greater or a lesser degree. The baculum is

rod-like with anterior end pointed and posterior end swollen and pulley shaped. In the genus *Pipistrellus* and closely allied *Scotozous*, there is a hairless tract on the dorsal surface of prepuce. The glans is more or less oblong with swollen tip. The baculum is rod-like tapering towards the anterior end, and bifurcated at both the ends. In *Scotophilus*, the glans is naked as in *Pteropus g. giganteus*. It is globular and surrounded by a thickened rim. The prepuce is much thickened and covers the glans to much greater extent on the ventral side. The baculum is flattened and more or less rhomboidal in outline. The glans of *R. l. lepidus* appreciably resembles that described by Mathews (1937) for *Rhinolopus ferrumequinum insulanus* Barret-Hamilton. The baculum of this bat conforms to the general type described by Topal (1958) for the genus *Rhinolophus*. Other genera are represented by a single species and details of these characters for them will be found under their respective accounts.

B. Female external genitalia.—All bats studied can be referred to Type I of Wood Jones (1917). The vulvar orifice is, however, transversely elongated because of projection of clitoridial pad into it. In the bats with false dugs (*R. h. hardwickei*, *M. l. lyra* and *Rhinolophids*), the vaginal orifice is placed on a raised area with much enlarged clitoridial pad. It is possible that enlargement of clitoridial pad is an adaptation for protection of vaginal orifice against the snout and hence breath of young which is carried with its mouth fixed to false dugs placed just anterior to clitoridial pad. The clitoridial pad may be specialized by its division into lobes (*C. sphinx gangeticus*, *T perforatus durgadasi*, *S. kuhli wroughtoni*). In one case, *C. sphinx gangeticus*, the vulvar orifice is surrounded by a special pouch with highly glandular margin.

Distribution and zoogeography.—Study of distribution like that of taxonomy depends on a thorough collection. Ellerman and Morrison Scott's (1951) checklist based as it is on the collection made by experienced collectors engaged by Mammal Survey conducted by Bombay Natural History Society, has gone a long way to complete our knowledge of distribution of Indian bats. Further notes on distribution of some species have subsequently been provided by Khajuria (1953), Siddiqi (1961), Brosset (1962 a, 1962 b, 1962 c, 1963), Prakash (1963), Hill (1967), Bhat (1967, 1968) and in a few other stray notes. The distribution of the bats discussed here as given by Ellerman and Morrison-Scott (1951) has been revised in the light of above works. More intensive collection even in a small area has extended the distribution of four bats, *H. lankadiva unitus*¹, *H. c. durgadasi*, *Myotis peshwa* and *Pipistrellus ceylonicus indicus*. Except two, rather poorly known bats, *Saccolaimus crassus*, and *P. babu*, all bats so far recorded from Central India, have been found to occur in a small 130 sq. km. area. About 5% of the total number of species, 40% of total number of genera and all the families so far recorded from India, Pakistan and Ceylon are represented in the area.

All the bats, except one, *Myotis peshwa*, are Oriental in distribution. Typical desert and Northern Palaearctic forms are absent.

1. Distribution of *H. lankadiva unitus* which occurs on the periphery of the area of study has also been extended. This bat has not been discussed in this work.

Because of the close proximity of the area to the desert of Rajasthan, complete absence of desert bats is interesting. This again shows that humidity plays important part in the distribution of bats. A point to be noted is the distribution of *H. c. cineraceus* which has been given by Ellerman and Morrison-Scott (1951) as Salt range, Panjab (West Pakistan) and Darjeeling. Examination of specimens from the collection of Bombay Natural History Society shows that the bat has also been collected from Salem District, Maharashtra. There are also specimens from Cherrapunji, Assam. The altitudes from which this bat has been collected range from about 650 mts. to about 1100 mts. Possibly it occurs at suitable altitudes in the intervening areas. In Jabalpur District a form of *Hipposideros cineraceus*, *H. c. durgadasi*, has been found at lower altitudes ranging from 200 to 500 mts.

Habitat selection :

(1) *Diurnal roost.*—An account of diurnal roosts occupied by some of the species found in Western India and Rajasthan desert was given by Brosset (1962 c, 1963) and Parkash (1963) respectively. More detailed information on those of the above bats which are found in the area under study has been provided. Besides new information on a number of bats not discussed by these authors is also given.

There are mainly three types of adaptive radiations shown by the bats studied :—

(A) *Small cavities.*—These include narrow holes, crevices and cracks and is considered as primitive habitat. It has apparently produced several modifications in the bats occupying it. This habitat is occupied by bats living in small colonies, e. g., most of the *Vestertilionidae*. If, however, the size of the bat is small, e. g., *P. m. mimus* and *S. d. dormeri*, the colony may include 30-40 individuals. This habitat, although giving good protection against many enemies and weather, limits the size of the colony or that of the bat itself. Being, thus, well protected, the bats sleep well during daytime. The whole ventral surface is in contact with the substratum and, thus, in addition to foot, thumb is also used in clinging to surfaces. Accordingly the thumb is enlarged and has a well developed pad on the ventral surface. They can also crawl well on the ground. The head is not always directed downward during resting. There is a tendency to lie one above the other while resting. There is no record of two species living in the same roost, possibly because of easy availability of such cavities. *S. h. heathi* has been observed to come out of its roost and cling to walls, fully exposed, in sultry weather. Some pipistrelles are also seen partially exposed in such weather.

(B) *Large cavities.*—These include small and large caves, both natural and artificial, abandoned buildings and other constructions and any other large cavities. There are a number of bats which have taken to this habitat which was probably selected for enjoyment of better social life since it allows large number of individuals to gather to-gether. The restriction on size is also considerably relaxed. The bats occupying this type of habitat are: *R. l. leschenaulti*, *R. h. hardwickei*, *T. m. melanopogon*, *T. theobaldi secatus*, *T. k. kachhensis*, *M. l. lyra*, *R. l. lepidus*, *H. f. fulvus*, and *H. cineraceus durgadasi*. However, such species are more exposed to the attack of enemies and

vagaries of weather. They are accordingly active throughout the day and shift to more protected places only in rough weather. At least whole of the colony cannot afford to sleep at a time. They are quickly awakened if an intruder happens to enter the haunt. The fact that at least some of the individuals are always active in such colonies is evident from their voices or sounds of flights which can be heard at a considerable distance. Such sounds and smell of large quantities of guano further expose them to enemies by making their presence known at a distance. In colder countries, many species must be entirely defenceless during hibernation in such, habitats. Despite all these handicaps the species occupying this habitat are very successful. The causes for this success are not far to seek. Most of their enemies are nocturnal and since the roosts are abandoned at night, predation by them is, thus, automatically avoided. The danger during hibernation in colder countries is possibly avoided because of the probable inactivity or migration of most of the enemies during this season. Many places occupied, e. g., ceiling of temples and other constructions are quite inaccessible. The animals bite severely and also leave the roost, if disturbed, for alternative places, which are generally available nearby. The offensive odour of huge amount of droppings may also help to avoid enemies. There are a number of adaptations resulting from this habitat. The colonies may be very large including thousands of specimens. There is also a tendency to develop larger size as in *R. l. leschenaulti*, *T. k. kachhensis*, *M. l. lyra*, etc., without decreasing the size of the colony. Most of the species generally use their feet for suspension. During resting the head is directed downward. Except some species, e. g., bats of genus *Taphozous* and *R. h. hardwickei* which use their thumb for clinging, there is little tendency to lie one above the other. Since the habitat is not easily available, a number of species live in the same roost although generally occupying different portions of the cavity, if available. In sultry weather, the bats occupying such cavities, may seek more open places, for instance *R. h. hardwickei* which lives in dark cavities is found in more open places in boulder caves in summer. Similarly (*T. k. kachhensis* and *M. l. lyra*) have been found in more open places in such weather. *T. l. longimanus* is also usually found in exposed places in very small colonies.

(C) *Trees*.—This habitat is the easiest to find and accommodate large species and colonies of any size but it lacks protection from enemies and weather. The only bat met with in the present study which has been able to exploit this habitat fully is *P. g. giganteus*. The large size and thick flying membranes of the bat with its powerful teeth and claws have provided protection against both enemies and weather. The bat overcomes the vagaries of hot weather by moving to more shady places. In winter it wraps itself in flying membranes. Other species met with in this habitat are *C. sphinx gangeticus*, *T. l. longimanus*, and *S. kuhli wroughtoni*. None of them is strong enough to occupy open places. All of them are found on the palmyra palms and occasionally all of them together. The tree has broad drooping leaves under which the bats lie hidden. Besides, these trees are very tall with the trunk too smooth to allow any enemy to climb. Since young are still unable to fly when rains set in, many die during storms especially when dead branches of palm trees fall to the ground in such weather. This was observed in *S. kuhli wroughtoni*. Further, a common feature of trees occupied by the bats is that they are located near human

habitations which provide further protection. Except, *P. g. giganteus*, the size of the colony is limited because of nonavailability of sufficient space. Colonies of *C. sphinx gangeticus* hardly exceed 20 individuals but those of the other two smaller species may contain over 50 individuals. Except *P. g. giganteus*, other species are not vociferous. Their presence is only betrayed by their droppings which may also be hidden by the vegetation. *C. sphinx gangeticus*, *T. l. longimanus* and *S. kuhli wroughtoni* cling to surfaces of leaves with both feet and thumb. They can crawl on all fours easily. The species which have noticeably been found to react to changes in temperature are *P. g. giganteus*, *R. h. hardwickei*, *T. k. kachhensis* and *S. h. heathi*. *P. g. giganteus* fan itself with vigorous movements of one wing and move to sheltered places in hot weather. *R. h. hardwickei* and *T. k. kachhensis* have been seen to move to more open rocky caves in summer and more secluded places in winter. Prakash (1963) found similar movements in a closely allied *Rhinopoma kinneari* (*R. microphylum*). *S. h. heathi* has been seen clinging to fully exposed outer surfaces of the walls of building in very sultry weather. The only bat which has been found fully exposed to sunlight is *P. g. giganteus*, while the bats found only in more or less darkness are *R. l. leschenaulti*, *T. m. melanopogon*, *T. theobaldi secatus*, Rhinolophidae and pipistrelles.

The bats which have been found very noisy are *P. g. giganteus*, *C. sphinx gangeticus*, *T. l. longimanus* and *S. kuhli wroughtoni*. Obviously the species living in trees are less sensitive to storms although they try to avoid them by moving to more sheltered places on the same trees.

(ii) *Nocturnal habitat*.—While the selection of diurnal roosts depends mainly on the availability of suitable protection against enemies, weather and for enjoyment of social life, the selection of nocturnal habitat depends on availability of food. In inclement weather, the animals may pass considerable time in the diurnal roost. They also utilize it for occasional rest and food consumption during night where the feeding ground is not far off. Temporary resting places may also be selected during night for the purpose as shown by droppings. It is, however, the feeding territory which is of special interest because the animals is well adapted to it. Brosset (1963) has given an account of various types of feeding territories occupied by some Indian species but has not except a few passing remarks, discussed how the bats are adapted to it.

The following types of main feeding territories are here recognized in view of findings made during the present study. Their corresponding adaptations have already been discussed.

- (1) Foliage of trees in search for fruits (*P. g. giganteus*).
- (2) Foliage of trees and shrubs in search of fruits (*C. sphinx gangeticus* and *R. l. leschenaulti*).
- (3) Foliage of trees and shrubs in search for insects and small vertebrates and fruit? [*M. l. lyra*, *R. l. lepidus* (insectivorous)].
- (4) At the level of tree tops and in between trees and houses in search of insects occasionally fruit? (Vespertilionidae).

(5) At ground level in search of insects mainly beetles and grass hoppers and possibly very small vertebrates (*Hipposideros*).

(6) Among rocks in search for insects and small vertebrates [*R. h. hardwickei* and *M. l. lyra* (Insectivorous)].

(7) Higher levels of atmosphere in search of high flying insects (Emballonuridae).

General habits.—

(i) *Interspecific relations.*—The association of a number of bats in the same roost appears to be due to the unavailability of other suitable roosts in the area and tolerance of bats towards one another, so that species which occupy large cavities which are not easily available tend to roost together. However, *M. l. lyra*, which occupies large cavities was always found alone, except on one occasion when it temporarily occupied more lighted part of a cave occupied by *H. f. fulvus* and *H. cineraceus durgadasi*. The species preys on other bats and this may be the reason why it is left alone. Another uncommon habitat occupied by some bats, *i. e.*, *C. sphinx gangeticus*, *T. l. longimanus* and *S. kuhli wroughtoni* is drooping branches of palmyra palms. All these bats are frequently found on the same tree. Vespertilionids are found alone, except *S. kuhli wroughtoni*, where the roost is specialized and not easily available. Except *P. g. giganteus*, *C. sphinx gangeticus*, *T. l. longimanus* and *P. ceylonicus indicus* which could not be collected, alive, all other bats were kept in captivity. Only *M. l. lyra* and *S. d. dormeri* showed aggressiveness. A specimen of *P. m. mimus* was found dead when kept with three specimens of *S. d. dormeri* possibly on account of bites inflicted by the latter. Several other animals were found to live along with bats in the rocky caves at Richhai village (Khajuria, 1979).

Most of the species do not mind human presence from a distance of 3-4 metres or even less since they have become used to it by living near human dwellings. *R. h. hardwickei*, *T. m. melanopogon*, *M. l. lyra* and species of *Scotophilus* have been found to urinate on closer human approach. *T. m. melanopogon* and *T. theobaldi secatus* also bare their teeth frequently and show their bearded throat when closely approached. The movements of ears and of Rhinolophids on closer human approach are well known. In daytime sleeping Vespertilionidae can even be touched with hand. The most sleepy bat is *S. h. heathi* which in some cases have been picked up with hands. A mild protest is, however, shown by this species by opening its mouth and some movements. Some individuals may make some attempt to bite.

(ii) *Intraspecific relations.*—There is a great variation in number of specimens present in a colony. The number may range to only one (which appear to be stragglers or old individuals) to about 3000 (*T. m. melanopogon*). Colonies consisting of about 10 to about 100 individuals are common. The species of genus *Taphozous* and Vespertilionids studied in this work tend to lie one above the other. Other bats while crowding together sometime do not show this habit. This appears to be due to their methods of suspension. That the flying bats are

attracted towards the captive ones have been observed by some (Allen, 1939). It was observed by Phillips (1922) in case of *Saccolaimus saccolaimus* and by Parkash (1963) in *R. kinneari*. In the present study it was observed only in the case of two species of *Scotophilus*. Whether the habit is due to simple inquisitiveness or to social attraction could not be ascertained. The attraction does not seem to be confined to the individuals of the same species. Flying specimens of *S. kuhli wroughtoni* and *S. h. heathi* were attracted towards captive individuals of the latter. Whether more distantly related species also show such behaviour could not be ascertained. The only case of dominance of one individual was seen in *T. k. kachhensis*. Some of the social habits have been discussed under breeding habits. Bradbury (1977) has given a very good review of social organization and communication in Chiroptera.

(iii) *Daily activity*.—The time of emergence and that of return to roost varies and may depend upon several factors such as temperature, storms, presence of human disturbance near the roost, health of specimens, etc. The usual time is about half an hour after sunset and about the same time before sunrise. The variations have been recorded under each bat. All bats in a colony never leave or return to the roost together. In many cases only 2-3 individuals, leave or return to roost at a time. Several false attempts to enter the roost are made by individuals and they increase in number if kept under close observation. Obviously such habits help to camouflage the roost and makes its location difficult. This is of considerable adaptive value. This habit is usually found in bats living near human dwellings. The day is passed mainly in sleeping (Vespertilionidae), squealing (*T. m. melanopogon*, *T. theobald secatus*), occasional short flights within the roost (all bats except Vespertilionidae) and in mating during mating season. The night is spent in search for food with occasional short periods of rests. It is, however, possible that some bats (Vespertilionidae) also mate during flight as they have frequently been seen chasing each other in flight during mating season. The daily activity also obviously depends on several external factors such as temperature, light, rain, storms and disturbance under the influence of which the duration of time spent in the roost may vary.

(iv) *Flight*. — Four types of flights can be distinguished: flapping, fluttering, hovering and gliding. Flapping is the primitive type of flight but can be developed as an efficient long distance flight much above the tree tops as in strong-winged, large-sized, *P. g. giganteus*. The species is not only fearless in its diurnal roost but also in its nocturnal flights and other two species of fruit bats undertake flapping flights at the level of tree tops or at lower level but are also capable of flight within the foliage. This is possibly achieved by greater breadth of their wings and small size which helps sharp turns. *P. g. giganteus* move from branch to branch mainly by crawling but smaller fruit bats can also fly quite efficiently within the foliage.

In Microchiroptera, the flight is a combination of flapping, fluttering, hovering or of flapping and gliding types. The last type is practised by the bats of genus *Taphozous*. The flapping type is resorted to at lower levels and the gliding type at higher levels. Other species resort to the first type. Large-sized bats of genus *Scotophilus* have

very rarely been observed to resort to fluttering flight. In fact their large size and moderately broad wing prevent them from undertaking sharp turns characteristics of smaller species of genus *Pipistrellus*. Hovering flight is undertaken by species which hunt in rocks and foliage to pick up stationary or running prey. All these bats have comparatively broad wings (*R. h. hardwickei*, *M. l. lyra*, *Rhinolophids*). The flight in foliage (*M. l. lyra*, *R. l. lepidus*) is obviously more specialized of the two. Special broadening of wings is seen in *M. l. lyra* where even antibrachial membrane is enlarged.

(v) Suspension.—*crawling and swimming*.—Khajuria (1975 c) has given an account of these habits.

(vi) Sounds produced, for an account of sounds of the species under report see Khajuria (1974).

(vii) *Means of defence*.—In addition to wounds inflicted by their sharp teeth and claws, certain species (*R. h. hardwickei*, *T. m. melanopogon*) *M. l. lyra*, *S. kuhli wroughtoni* and *S. h. heathi*) have been found to urinate on intruders. Khajuria (1975 a) has given more details of this habit.

(viii) *Hibernation*.—Only *R. l. lepidus* and Vespertilionidae have been found to hibernate. *R. h. hardwickei* could not be collected in winter so that it is not certain whether it hibernates but it does store good amount of fat providing for a restricted winter activity. Bats of genus *Taphozous* found in the area do not hibernate but like *R. h. hardwickei* store fat for difficult winter when food is not available. Fruit bats and *M. l. lyra* neither store fat nor hibernate and are active throughout winter. However, *R. l. leschenaulti* was found in captivity in a state of torpor in January (temperature, 18° c) but became active at the time of feeding in the evening. The activity was also restored when the specimens were placed in the sun. Brosset 1962 a) however, states that artificially cooled specimens never survive. Brosset (1963) has given an account of hibernation in some Indian species.

7. *Breeding habits*

Definite courtship display was observed only in *R. h. hardwickei* (Khajuria, 1972 a). In *P. g. giganteus*, male licks the vulva for a long time before mounting under continuous protests from the female (Khajuria, 1971). A few similar attempts by the male were also observed in a colony of *T. m. melanopogon*. This bat and the closely allied *T. secatus theobaldi* have well-developed beard which is well-exposed by raising the head if an intruder enters the haunt. Possibly it also serves to attract the female. Odour given out from the gular pouch of the male in the genus *Taphozous*, particularly *T. longimanus*, appears to serve the same purpose. Secondary sexual characters are also present in males in the form of colouration (*R. l. leschenaulti*, *C. sphinx gangeticus*, *T. m. melanopogon*); and secretion of glands (*T. k. kachhensis*, *H. f. fulvus*) may also possibly serve as sexual attraction. In breeding season, specimens of pipistrelles and *S. h. heathi* have been seen chasing each other in flight. Fighting was observed in *R. h. hardwickei*.

In *R. h. hardwickei*, *T. m. melanopogon* and *T. k. kachhensis*, the females in captivity has been observed to give out sounds and even try to bite the male in breeding season. This may serve to attract the male.

There is very little information about the position of the male and the female during copulation. The writer (1971) clarified the position regarding *P. g. giganteus*. Andersen (quoted by Wood Jones, 1917) reported the same behaviour in *Rousetus leachi*. The same condition possibly obtains in *C. sphinx gangeticus* as the interfemoral membrane is not so extensive as to present any difficulty in copulation in normal quadrupedal manner. Peterson (1966) suggests that interfemoral membrane of the female is 'raised over the back by the tail'. The tail cannot be bent upward except at its root in bats where it is entirely enclosed in the interfemoral membrane. Possibly it is first rolled downward and then bent upward at its root by the female during copulation but this is purely a conjecture. There are, however, bats (*M. l. lyra*) where this appears to be an impossibility because there is an extensive interfemoral membrane but no tail. Brosset (1962 b) observed that copulation takes place in face to face position when animals are hanging. This was confirmed in captivity but no servicing movements were observed nor Brosset observed them. There is a possibility that the same method is adopted by *H. f. fulvus* and also by other Rhinolophids because of extensive interfemoral membrane and methods of suspension. In *R. h. hardwickei* and bats of genus *Taphozous*, the interfemoral membrane is not extensive and mating in normal quadrupedal manner is possible. In fact it has actually been observed in *R. h. hardwickei*. No observation was made on Vespertilionids. The interfemoral membrane in this group is enlarged and entirely encloses the long tail. In the resting position, the belly is applied to the substratum making mating from the ventral side difficult. If the copulation takes place in face to face position, the resting position has to be changed to that adopted by *M. l. lyra*. This is an interesting point for investigation. There is some possibility that mating in this group may take place in flight (Peterson, 1966 p. 168) in some species.

Detailed information on breeding cycles based on histological investigation is now available on some Indian species representative of important families (Khajuria, 1979).

After this paper had been sent to press, a number of highly praiseworthy papers on breeding biology with detailed histological data came to hand : Gopalakrishna (1969), Gopalakrishna *et al*, 1970, 1975, 1977a-d; Khaparde 1976, 1977; Madhavan 1971, 1978a-b.

Although the above work is very commendable in broad understanding of breeding biology of Indian bats, yet more bats will have to be studied in each group and from different areas since there appear to be considerable variations possibly related to food supply, climate, etc. For instance Gopalakrishna (1955) found that *T. longimanus* has, no restricted breeding season and breeds all the year round. However, *T. melanopogon*, *T. theobaldi secatus* and *T. kachhensis* have only one parturition in spring. On the basis of present information the Jabalpur bats can be distinguished into two groups

(i) species with more than one parturition in a year, e. g., *R. leschenauti*, *S. dormeri*, and (ii) other species with only one parturition in spring or summer. The second group is divisible into two subgroups : (a) species which start mating in autumn or early winter, e. g., fruit bats and *M.l. lyra*; (b) species which mate in early spring or summer. However, the breeding rhythm can be altered by climate, upon which is also dependent food supply, even in the same species. For instance, *P. minus* breeds throughout the year in Ceylon (Phillips, 1922) but in the area under study it has only one parturition in spring. In *P. giganteus* the breeding activity starts in December in Ceylon as shown by histological investigation undertaken by Marshal (1947); but in Central India, Moghe (1956) showed with similar investigations that it starts in August.

In several European species which hibernate, it is now well-known that although mating takes place in autumn the ovulation and fertilization is delayed to spring.

An aspect which needs further investigation is that writer has often observed behaviour very similar to sexual activity in *R. h. hardwickei*, *T m. melanopogon*, *S. h. heathi* in autumn during which specimens have been seen chasing each other, fighting and even licking genital organs of others (*T m. melanopogon*). Since this has always been observed only in a restricted period there is a good possibility that it has something to do with the sexual activity. Sexual activity is also expected because of abundance of food in this and preceding rainy season and favourable climate. It is quite possible that a small percentage of females which have suffered abortion or have failed to mate due to immaturity during the normal season may now be in heat. This, however, could not be confirmed by histological study because sufficient number of specimens could not be collected. Whether or not autumn mating is followed by pregnancy in the above cases also needs further study.

In two species, *H. f. fulvus* and *H. c. durgadasi*, where abortion was observed in captivity, the female was seen to pull out the foetus with its teeth while lying on the floor of the cage. In one case, *H. cineraceus durgadasi*, the foetus could not be traced in the cage. It was probably eaten by the mother. The bat has been observed to have carnivorous habits. Except in *P. c. coromandra*, *S. kuhli wroughtoni* and *S. h. heathi*, where twins were observed, all other species have been found to bear single young. No observations were made on *T k. kachhensis*, *M. peshwa*, *P. ceylonicus indicus*. Moghe (1958) recorded a case of monozygotic twins in *C. sphinx gangeticus*. John (1962) recorded twins in *Scotophilus nigrita*. According to Cockrum (1955), number of young in Vespertilionidae varies from one to four. The newly born young in all Microchiroptera under report is blind and covered with very short hair to varying degree and is attached to teats or to false dugs (*R. h. hardwickei*, *M. l. lyra* and Rhinolophids). It is aggressive. It is carried by the mother apparently as long as it is not too heavy but suckling is continued for much longer period as shown by the collection of lactating females without young. It is probably first fed on softened food (Peterson, 1966, p. 171). This belief is strengthened by the fact that a grown up independently flying

young of *S. h. heathi* did not show any interest in hunting captivity. Except in *P. g. giganteus* where the age of maturity appear to be more than one year, all females examined in other species in the breeding season were found pregnant, with young, or lactating, showing that age of maturity of females is probably less than one year where sufficient number of specimens were available for examination, *i.e.*, *R. l. leschenaulti* (*T. m. melanopogon*, *M. l. lyra*, *H. f. fulvus*, *H. cineraceus*, *durgadasi*, *P. m. mimus*, *P. c. coromandra*, *S. d. dormeri*, *S. kuhli wroughtoni*, *S. h. heathi*). The mother has been observed to make special effort to take away the grounded young in *S. d. dormeri* and *P. c. coromandra* during present study and in *P. mimus* by Phillips (1922). The male apparently takes no interest in care of young.

Feeding habits ;

Smaller fruit bats are better adapted for search for fruit as they can move about in the foliage of both trees and shrubs with greater ease while the flying fox usually visits trees. According to Brosset (1962 a, 1963) the flying fox feeds on higher branches of trees and smaller fruit bats (*R. leschenaulti*, *C. sphinx*) on lower branches. To find out whether the fruit bats may also eat vegetables, some ripe tomatoes were placed in cage of *R. l. leschenaulti*. They were found partially eaten but the specimen were found dead next morning. The cause of death was, however, probably low temperature (15°C). Guava was eaten by *M. l. lyra* in captivity and *S. h. heathi* was observed to feed on jambolin fruit. It is possible that other insectivorous species also occasionally feed on fruits. No information on food of *R. h. hardwickei* and various species of genus *Taphozous* could be obtained. The former probably feeds on some soft insects found among rocks as shown by the characters of its upper incisors and hunting territory while the latter appear to feed on some high flying hard prey. Food of *M. l. lyra* has been studied by a number of workers (Khajuria in press, a). Since it takes fruit, insects, fish, frogs, birds, small mammals and has even cannibalistic habits, the species can be considered more or less as omnivorous rather than insectivorous. While *R. l. lepidus* appears to pick up insects mainly in the foliage, various bats of genus *Hipposideros* feed mainly at ground level. The latter have been found to feed on small beetles in captivity. *H. cineraceus durgadasi* has also cannibalistic habits.

Three types of food preferences can be recognized among Vesperilionids : (1) pipistrelles which appear to feed mainly on small Diptera and Lepidoptera; (2) *Scotophilus* which appears to feeds on large and hard insects; and (3) *S. d. dormeri* occupies an intermediate position feeding practically on all kinds of insects which could be supplied to it.

In captivity bats have been seen to lick with their tongue thin films of water spread on the ground or on the floor of the cage.

Defecation was observed only in a few cases (*Pteropus g. giganteus*, *T. m. melonopogon*, *M. l. lyra*) and in no case the urine or faeces was allowed to fall on the fur (see details under the species).

Movements.—Movements of bats could not be studied adequately because the marked specimens could not be followed outside the

restricted area on account of certain difficulties. All bats except those living in large cavities with several exits, e.g., boulder caves, have been observed to abandon their roosts periodically. The reason for change of roosts may be persistent disturbance, climate, breeding season or availability of food. In large cavities with several exits all the above factors can be eliminated. If disturbed animals are able to escape through several exits or move to inaccessible portion of cavities. Climatic factors (temperature, light, storms, etc.) are also easily avoided by movements to different parts of the cavities. Segregations of sexes and young can also be achieved by movement to different parts of the same cavity. Food factor in the case of insectivorous species obviously offers no difficulty.

All bats abandon their roosts on continuous disturbance; *P.g. giganteus* leave the roost, at least temporarily on firing. The frequent changing of roost by small Vespertilionidae is probably due to appearing of enemies, particularly snakes in the roosts. In one case, *S.d. dormeri* abandoned its roost under a wooden board on appearance of wasps. *P.g. giganteus* has definite seasonal movements. The vast majority of individuals leave their roosts from May to August. A few may sometime be found on these roosts in shady places. Out of six specimens collected from a colony of such individuals, 5 were found to be adult males and one subadult female which was not pregnant. Allen (1939, p. 258) has given somewhat similar habits for *P. boliocephalus* in Australia. Possibly non-breeding and sick individuals do not migrate. The migration is obviously undertaken to some more protected places, for protection of young from bad weather.

R.h. hardwickei and *T.k. kachhensis* have been observed to move to open places in hot weather. The former, Rhinolophids and Vespertilionids are difficult to locate in severe winter. They probably pass this season in more secluded parts of their usual roosts (Rhinolophids and Vespertilionids) or sometime in more protected different roosts (*R.h. hardwickei*).

Enemies, parasites and disease.—No dead bat was found below the roosts or elsewhere showing that they are quickly removed by predators if they fall on the ground. In the biggest boulder caves harbouring *R.h. hardwickei*, *T.m. melanopogon*, *T. theobaldi secatus* and *H. cineraceus durgadasi*, several types of potential predators were found (Khajuria, 1979.) The Common Pariah kite, *Milvus migrans* Boddaert, Jungle Crow, *Corvus macrorhynchos* Wagler and the Black winged kite, *Elanus caeruleus* Desfontaines, have been found to attack *R.I. leschenaulti*, *T.m. melanopogon* and *R.h. hardwickei* but without success. However, once the Jungle Crow was observed to capture *S.h. heathi* which was rather found not to be in good health. Pipistrelles have been found to successfully avoid attacks by the crow, *S. kuhli wroughtoni* which leaves its roost when crows are still out is left unmolested. McCann (1933) states that the Brown Hawk owl (*Ninox scutulata* Raffles) feeds on bats but the pellets of owls (unidentified) collected near roosts of the bats failed to show the remain of bats in them. *M.I. lyra* is known to feed on bats (McChann, 1934, Prakash, 1963, Green, 1907, 1910).

Ectoparasites have been found on *P.g. giganteus* (one species), *R.l. leschenaulti* (two species), *R.h. hardwickei* (one species), *M. l. lyra* (one species), *S.kuhli wroughtoni* (two species) and *S.h. heathi* (one species). Details are given under each species. Mitchell and Punzo (1976) recorded ectoparasites from five bats discussed in this paper from specimens collected in Nepal.

No thorough search was possible for internal parasites. However, the stomach of a specimen of *S.h. heathi* was found heavily infected by a nematode parasite (unidentified) which has punctured a hole in it. Whether Indian bats are responsible for the transmission of dangerous diseases is a problem which still needs an answer (p. 59).

11. Population.—

The area harbours a large population of bats. Average density of population per square kilometer area before parturition is roughly estimated as follows.—

Fruit bats—4 specimens

Vespertilionidae-400 specimens (in thickly populated area of Jabalpur city)

Others, 55 specimens.

Some authors (Abdulali, 1949) have commented on the greater number of females than that of males in Indian bats. The present study shows that the correct ratio is difficult to determine because in all bats examined, there is a possibility of sexual segregation after parturition and, thus, colonies containing adults of one sex only may be met by the collectors. Behaviour of males is also different from that of the females at least in some cases, e.g., *T.m. melanopogon*. As far it can be estimated at present, the sex ratio in most cases can roughly be taken as 50:50. Except in Vespertilionidae where twins are common, only one young is born and the rate of increase in such cases the population is about 50%. Since the population appears more or less stationary (except in those bats which have left their roosts because of human disturbance) the mortality rate is also fairly high.

Economic Importance.—

Beneficial bats.—Role of insectivorous bats in reducing the number insects is well known. Several bats, particularly *T.m. melanopogon*, *P. m. mimus*, *S. d. dormeri*, *S. kuhli wroughtoni*, *S. h. heathi* are very common and must be exercising effective control over the population of their prey. Further study on food specificity is needed. *P. g. giganteus* can serve as source of cheap meat and fur. The species can easily be caught by a net (Khajuria, 1965 b). Its meat is also considered of considerable medicinal value for curing rheumatic pains and is even taken by high cast Hindus for the purpose. Other species of fruit bats, can also easily be caught for meat because closely allied species are eaten (Allen, 1939, p. 55) but it could not be ascertained whether the bats, are actually being killed for food. Such habits are generally kept secret. Since the fruit bats, particularly *P. g. giganteus*,

are also cunning fruit pests, their capture for meat will be very beneficial to the horticulturist. Other species which is being taken as food in the area, but under secrecy, is *T m. melanopogon*. According to Peterson (1966, p. 15) all bats can be eaten. Despite the food shortage in India, it is, however, very difficult to make people take meat to which they are not used. Bats are also important agents in pollination and seed dispersal (McCann, 1931; Piple, 1956 a, b). The guano of species living in large colonies (*T m. melanopogon*, *M. l. lyra*) can be used as manure. They provide several highly instructive problems of animal behaviour (Khajuria, 1976 a)

Harmful bats.—The role of fruit bats as horticultural pests and method of their control has been referred to above. Even some insectivorous species such as *S. h. heathi*, *R. l. lyra* have been found to take fruit. Some species (*R. h. hardwickei*, *T m. melanopogon*, *M. l. lyra*) have been found to be of considerable nuisance in places of archaeological interest. They can be got rid off by introducing smoke in their roosts and continued disturbance. Some house dwelling Vespertilionidae, particularly *S. h. heathi*, have been found to drop considerable excreta on undesirable places particularly under their temporary roosts during night. Their holes should be located and plugged. How far these bats are responsible for spread of disease by acting as intermediate hosts could not be ascertained. Some fruit particularly gauva, partially eaten by bats is commonly used for human consumption without disinfection. *M. l. lyra* has been reported to attack exposed wounds of domesticated animals. Medical and veterinary investigations are necessary to throw further light on the subject particularly with regard to spread of rabies through bats (Kumar, et al, 1969), Editors (1962) and leptospirosis (Khajuria, 1975 a), Harrison (1959). For a highly commendable review of role of bats in health, welfare and economy of man see Constantine (1976).

IV Summary

1. Taxonomy and ecology of twenty bats found within about 130 sq. k.m. area around Jabalpur city (text. fig. I) have been studied. Report of nine of the species/subspecies belonging to families Pteropidae, Rhinopomatidae and Emballonuridae are given in part I of this work (Khajuria, 1979). The bats studied in both parts of the work are : *Rousettus l. leschenaulti*, *Pteropus g. giganteus*, *Cynopterus sphinx gangeticus* (family Pteropidae); *Rhinopoma h. hardwickei* (family Rhinopomatidae); *Taphozous longimanus*, *T m. melanopogon*, *T theobaldi secatus*, *T k. kachhensis* (family Emballonuridae); *M. l. lyra* (Family Megadermatidae); *Rhinolophus l. lepidus*, *Hipposideros f. fulvus*, *H. cineraceus durgadasi*, *H. galeritus brachyotus* (family Rhinolophidae), *Myotis peshwa*, *Pipistrellus c. coromandra*, *P. m. mimus*, *P. ceylonicus indicus*, *Scotozous d. dormeri*, *Scotophilus kuhli wroughtoni* *Scotophilus h. heathi* (Family Vespertilionidae). One bat, *Tadarida* sp. (family Mollosidae) was seen but could not be collected. Nearly 2,400 specimens were examined. Thirteen body measurements of specimens and fifteen measurements of skulls were taken and statistically analysed, wherever possible, to understand sexual dimorphism and intraspecific variations. The observations were continued for little more than ten years beginning from November, 1960. A large number of illustrations have been provided mostly from the fresh material which is generally not available to the taxonomists.

2. The taxonomic work includes studies on classification, synonymies, location of Type Material, re-examination of external morphology, skull and dentition. In addition, a number of other characters which a taxonomist might possibly study and which, with a few exceptions, have not so far been examined in Indian bats, were also studied and illustrated mostly from the fresh material. They include the form of wings, the size of tibia, teats, external generative organs, bacula, tongue and stomach. A good deal of useful new information has been collected.

3. Ecological observations have been made in as much detail as the habits of bats permitted during the period. Such observations include the following studies :

- (i) Methods of collection and observation.
- (ii) Elucidation of distribution and zoogeography in the light of recent literature.
- (iii) Habitat selection : detailed description of diurnal roosts, nocturnal habitat, reaction to heat, light, storms, sounds, etc.
- (iv) General habits : interspecific and intraspecific relations, time and method of return to and emergence from the roost, diurnal and nocturnal activity, method of suspension, seasonal activity, means of defence, etc.
- (v) Feeding habits, nature of food in the wild and in captivity, identification of stomach contents and remnants of food left in roosts. Food tried in captivity include common insects, other small animals and fruit found in the vicinity of the roost.
- (vi) Breeding habits : behaviour of sexes, mating habits, pregnancy, gestation, parturition, lactation, behaviour young, its growth and maturity.
- (vii) Movements : seasonal, sexual or otherwise within the area of the study.
- (viii) Enemies, parasites and disease : parasites, mainly ectoparasites, predators and disease.
- (ix) Population dynamics : population density, sex ratio, age and group composition, rate of increase and decrease in population, survival rate, etc.
- (x) Possible economic importance of each bat has been discussed.

4. The large amount of new information collected is rather difficult to summarize adequately and can fruitfully be studied under each species/subspecies but the following points arranged in sequence in which they are mentioned under the each taxon, deserve special notice :

- (i) Since the methods of collection so far used in India are not adequate for a systematic intensive survey of rarer species living in small colonies in inaccessible places, new methods

of collection for such purpose have been developed and have yielded fruitful results. New methods of observation and keeping bats in captivity have also been developed.

- (ii) After successful completion of mammal survey conducted by the Bombay Natural History Society (ca 1912-1920), chance of discovery of new bats was considered to be very remote. However, by the use of new methods, an intensive survey of small area (ca. 130 sq.km.) has led to the discovery of one new subspecies and extension of ranges of distribution of three bats, *T theobaldi secatus*, *M. peshwa*, and *P. ceylonicus indicus*. Besides all the bats, except three rather rare ones, so far reported from Central India have all been collected from a very restricted area of study. This study, it is hoped, may provide an incentive for more intensive surveys of smaller suitable areas.
- (iii) Photographs of Indian bats with wings spread are practically unavailable. These have been provided for the most of the bats from the fresh material to show the details of external morphology especially the shape of wings. Adaptation of important external morphological characters have been discussed.
- (iv) Descriptions and illustrations of external genitalia from fresh material and some bacula have been provided for the first time in most cases. These characters have provided good diagnostic characters and will also help in classification of the group.
- (v) No previous ecological data was available for *T theobaldi secatus* and *H. cineraceus durgadasi* and, thus, all ecological information given under these bats is new. For other bats also, no information was available regarding several interesting points discussed here. This has been provided. Findings of older authors have further been elucidated in the light of present study.
- (vi) Distribution of several species/subspecies has been revised in the light of present study and recent literature. No typical desert or palaeartic bat has been found in the area. They all belong to oriental region or to peninsular India.
- (vii) Mating habits of, *T m. melanopogon*, *T theobaldi secatus*, *R. l. lepidus*, *S. kuhli wroughtoni* and *S. h. heathi* have been studied, and wherever possible illustrated for the first time.
- (viii) Reaction of the mother towards the young was studied in the case of *P. c. coromandra*, *S. d. dormeri* and *S. h. heathi* for the first time.
- (ix) There is a good possibility of segregation of sexes after parturition in practically all cases although it could only be demonstrated in a few cases. The disparity between number of males and that of females in bat collections as observed by

several workers appears almost certainly due to collection of specimens from colonies consisting exclusively of one sex with some immature individuals and to different behaviour of sexes. e. g., in *T. m. melanopogon*. Correct figures for sex ratio can only be obtained by collecting specimens during the mating season after studying the difference in behaviour pattern of sexes.

- (x) There is some possibility of autumn sexual activity at least in males of some species even in insectivorous bats (*S. kuhli wroughtoni* and *S. h. heathi*) as shown by the presence of sperms in epididimides and behaviour of males. This aspect of problem needs further investigation.
- (xi) Food and feeding habits were studied for the first time in *H. f. fulvus*, *H. cineraceus durgadasi*, *P. m. mimus*, *P. c. coromandra*, *S. d. dormeri*, *S. kuhli wroughtoni*, *S. h. heathi*. Cannibalistic habits have been recorded for the first time in the cases of *M. l. lyra* and *H. cineraceus durgadasi*. Feeding habits of *R. l. leschenaulti* and *S. h. heathi* have been photographed. *M. l. lyra* and *S. h. heathi* which were hitherto considered as entirely carnivorous or insectivorous have also been found to be frugivorous. There is a possibility of attack by *M. l. lyra* on the exposed wounds of larger mammals.
- (xii) It is possible that bats reverse their upside down position during urination. This was observed in the case of the *P. g. giganteus* (Khajuria, 1971) and *T. m. melanopogon*. In *M. l. lyra* the faecal droppings were thrown away with a forward jerk of the pubic region. In no case the urine or faeces was allowed to fall on the body.
- (xiii) A detailed comparative discussion of the characters and habits of all the twenty species is given with special reference to various adaptive radiations shown by them.
- (xiv) Some observations regarding characters of external genitalia, bacula, sound produced, urination, methods of suspension, crawling and swimming, ranges of distribution, methods of collection, feeding and breeding habits etc. have to be published in advance because of unavoidable delay in publication of this monograph (vide references under author's name) particularly about species dealt in part II of this work.

Table V. Comparison of 't' values of some cranial characters of
H. c. ethiæus (A) and *H. cineræus durgadasi* (B)

Subspecies	Characters	Mean	Number of specimens	't'	Significance
A	ml	8.8	6	5.1724	Significant
B		9.1	11		
A	pl	3.5	6	6.3240	-do-
B		4.4	8		
A	m-m	4.8	6	23.3337	-do-
B		5.5	11		
A	cr	1.8	6	5.6862	-do-
B		2.5	11		
A	mdo	3.7	6	12.8348	-do-
B		5.1	11		

Table VI. Length of tibia as percentage of length of forearm in various bats.

Name of the bat	Sex	No. of specimens studied	Tibia/Forearm X 100
<i>R.l. leschenaulti</i>	Male	7	44.6
	Female	9	47.38
<i>P.g. giganteus</i>	Male	9	50.13
	Female	4	51.13
<i>C. sphinx gangeticus</i>	Male	1	40.85
	Female	2	40.2
<i>R.h. hardwickei</i>	Male	18	49.1
	Female	15	47.64
<i>T.l. longimanus</i>	Male	3	41.09
	Female	5	40.52
<i>T.m. melanopogon</i>	Male	78	40.7
	Female	81	38.4

Table—VI (continued)

Name of the bat	Sex	No. of specimens studied	Tibia/Forearm X 100
<i>T. theobaldi secatus</i>	Male	6	38.62
	Female	3	36.6
<i>T.k. kachhensis</i>	Male	2	43.31
	Female	4	41.15
<i>M.l. lyra</i>	Male	23	51.49
	Female	37	51.44
<i>R.l. lepidus</i>	Male	3	41.03
	Female	8	42.51
<i>H.f. fulvus</i>	Male	22	47.76
	Female	8	46.07
<i>H. cineraceus durgadasi</i>	Male	9	48.33
	Female	9	49.01

Table—VI. (continued)

Name of the bat	Sex	No. of specimens studied	Tibia/Forearm X 100
<i>H. galeritus brachyotus</i>	Female	2	43.33
	Male	1	50.68
<i>Myotis peshwa</i>	Female	1	47.89
	Male	6	39.67
<i>P. c. coromandra</i>	Female	18	37.45
	Male	15	40.44
<i>P. m. mimus</i>	Female	34	40.15
	Male	2	37.84
<i>P. ceylonicus indicus</i>	Female	4	35.76
	Male	6	35.0
<i>S.d. dormeri</i>	Female	23	37.2
	Male	5	35.5
<i>S. kuhli wroughtoni</i>	Female	17	34.8
	Male	7	41.39
<i>S. h. heathi</i>	Female	8	40.6

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TABLE VII
External measurements of some central India Microchiroptera.

Sl. No.	Name of Subspecies	Sex	Range	Abbreviation of measurements.														ear	wt
				f	p(mt)	p(ph1)	d2(mt)	d2(ph1)	d3(mt)	d3(ph1)	d4(mt)	d4(ph1)	d5(mt)	d5(ph1)	ft.	t	tl		
		23♂	61.0-67.5	6.0-11	5.3-11	53.0-58.0	5.0-9.0	44.0-50.5	26.0-30.5	49.0-55.5	14.8-17.5	54.0-58.5	18.0-22.5	15.0-20.0	31.2-36.5	—	32.0-39.0	36.5-52.0	
		Mean	65.2	8.8	7.0	54.6	6.8	46.6	29.0	52.0	16.7	55.7	19.3	17.0	33.9	—	36.5	45.4	
1.	<i>Megaderma l. lyra</i>	37♀	64.0-69.5	5.0-11.5	5.0-11.0	53.0-58.5	5.0-9.5	45.0-51.5	26.9-29.5	49.0-55.5	14.0-18.0	54.0-58.5	17.0-20.5	15.0-19.0	30.0-36.5	—	35.0-39.0	35.0-50.0	
		Mean	65.4	9.3	7.6	55.6	6.7	48.0	28.1	53.1	16.5	57.0	19.1	17.3	34.0	—	37.4	45.0	
		3♂	40.0-40.0	4.0-4.5	—	32.0-34.0	—	31.0-31.5	12.5-17.5	32.0-32.5	9.0-10.0	30.0-32.0	10.5-10.5	6.0-8.0	16.0-17.0	20.5-23.5	16.5-—	7.0-8.5	
		Mean	40.0	4.1	—	32.6	—	31.3	14.1	32.1	9.5	31.0	10.5	7.1	16.5	(2)	(1)	7.8	
2.	<i>Rhinolophus l. lepidus</i>	8♀	39.0-42.0	4.0-5.5	—	33.1-—	—	30.5-32.5	12.0-13.5	31.5-34.5	9.5-11.0	30.5-33.0	10.0-11.5	16.0-18.5	19.6-22.0	16.5-18.0	4.5-6.0		
		Mean	41.0	4.5	—	33.1	—	31.6	12.7	32.6	10.1	28.1	10.8	17.4	20.6	(7)	(5)	5.5	
		27♂	36.0-42.0	3.0-6.0	3.0-4.5	29.0-33.5	—	26.5-30.5	15.0-20.0	28.0-33.0	6.0-14.0	25.5-32.5	11.5-14.0	6.5-8.5	17.5-20.5	15.0-23.5	6.0-9.0		
		Mean	39.0	4.9	4.2	31.5	—	26.2	18.5	30.5	11.2	29.9	12.9	7.5	18.9	(16)	(14)	7.6	
3.	<i>Hipposideros f. fulvus</i>	8♀	39.0-41.5	4.0-5.5	4.5-5.0	30.0-35.0	—	27.0-29.5	18.0-18.5	29.5-33.5	10.5-12.0	20.0-33.0	12.5-13.5	7.0-8.5	18.0-19.5	21.5-—	7.0-9.0		
		Mean	40.8	5.2	4.0	30.0	—	28.2	19.3	31.0	11.5	31.2	13.3	7.8	18.8	(6)	(4)	8.1	
		9♂	35.5-37.5	2.5-4.5	2.5-3.5	23.5-30.0	—	25.5-27.5	15.0-16.0	28.0-30.0	8.5-10.0	24.5-27.5	11.5-12.5	5.5-7.0	16.5-18.0	21.5-25.5	13.5-16.0		
		Mean	36.3	3.6	2.9	29.5	—	26.6	15.3	28.7	9.3	26.3	11.9	6.3	17.5	23.7	(4)	(5)	
4.	<i>Hipposideros cineraceus durgadasi</i>	9♀	36.0-37.0	3.0-4.5	2.5-3.5	29.0-30.5	—	26.0-28.0	15.0-16.5	28.5-30.0	8.5-10.0	25.5-27.0	11.0-12.5	6.0-7.5	16.5-19.0	22.5-26.5	14.0-16.0		
		Mean	36.5	3.8	3.0	29.6	—	26.9	15.6	28.8	9.3	26.3	12.0	6.6	17.8	24.6	(3)	(4)	
5.	<i>Hipposideros galeritus brachyotus</i>	3♀	46.5-47.5	4.5-5.0	3.5-4.0	39.0-40.0	—	35.5-36.5	15.0-15.5	35.5-36.5	11.0-11.5	31.5-32.5	12.5-13.5	6.0-7.0	20.0-21.0	32.5-37.5	—		
		Mean	46.8	4.8	3.8	39.5	—	36.0	15.3	35.8	11.1	32.0	13.0	6.5	20.5	35.3	—	—	
		♂	29.5-31.0	3.5-5.5	—	25.0-29.5	—	24.0-29.5	9.5-12.5	25.0-30.5	8.5-11.4	25.0-29.5	7.5-8.5	5.5-8.0	10.5-14.0	25.5-30.0	6.5-11.5		
		Mean	29.9	4.3	—	26.9	—	27.2	11.3	27.8	10.0	27.1	7.9	6.2	11.4	27.1	(9)	(5)	
6.	<i>Pipistrellus c. coromandra</i>	♀	29.5-32.5	3.5-5.0	—	24.0-30.5	—	25.5-31.0	10.0-13.5	25.5-31.0	9.0-12.0	25.5-30.5	6.0-9.5	4.0-7.5	10.5-13.5	19.0-32.5	6.5-10.5		
		Mean	30.7	3.5	—	27.9	—	28.7	11.8	28.4	10.9	27.9	8.0	6.0	11.5	28.7	(12)	(13)	
		♂	26.0-28.5	3.5-5.5	—	20.0-26.5	—	20.0-26.5	8.5-12.0	20.0-26.5	8.0-11.5	21.0-26.5	6.5-8.5	4.0-7.5	9.0-12.0	21.0-30.5	8.0-10.0		
		Mean	26.9	4.4	—	23.1	—	23.8	10.1	23.6	9.5	23.5	7.5	5.4	11.0	25.8	(10)	(5)	
7.	<i>Pipistrellus m. mimus</i>	♀	20.5-29.0	3.0-5.5	—	20.5-28.0	—	20.5-28.5	8.5-12.5	21.5-28.0	8.0-12.0	21.5-27.5	6.5-9.0	4.0-7.0	9.5-12.5	22.5-31.5	7.5-10.5		
		Mean	27.9	4.4	—	24.7	—	25.4	10.9	25.3	10.2	24.9	8.0	5.5	11.4	27.9	(25)	(14)	
		♂	37.0-37.0	—	—	35.0-35.0	—	36.0-36.0	13.5-13.2	36.0-35.0	14.0-13.2	33.5-33.2	9.0-8.5	7.0-7.0	14.0-14.0	34.5-34.5	—		
		Mean	37.0	—	—	35.0	—	36.0	13.2	35.0	13.2	33.2	8.5	7.0	14.0	34.5	—	—	
8.	<i>Pipistrellus ceylonicus indicus</i>	4♀	37.0-38.5	—	—	35.0-36.5	—	36.0-37.0	14.0-15.0	36.0-37.0	13.0-13.5	33.0-35.0	8.0-8.5	6.0-8.0	14.0-15.0	36.0-37.5	—		
		Mean	37.7	—	—	35.7	—	36.5	14.3	36.2	13.2	34.2	8.1	6.7	14.5	37.1	—	—	
		16♂	33.0-38.0	—	—	31.0-34.0	—	32.0-35.5	12.0-14.0	31.5-33.5	12.5-13.5	31.0-34.0	8.5-10.5	6.0-8.5	12.0-14.5	28.5-40.5	8.5-9.5		
		Mean	34.5	—	—	32.2	—	33.5	13.0	33.0	12.5	32.5	7.9	7.5	12.1	34.9	(2)	(5)	
9.	<i>Scotozous d. dormeri</i>	37♀	33.0-37.5	—	—	30.5-35.5	—	21.5-36.0	12.0-16.5	30.5-36.0	11.0-32.5	30.5-36.0	8.5-11.0	6.0-8.5	9.5-14.5	30.5-39.0	8.5-11.5		
		Mean	34.0	—	—	33.0	—	34.0	13.7	33.9	13.1	31.7	9.5	7.3	12.7	32.5	(13)	(15)	
		5♂	50.0-50.3	—	5.0-8.0	46.0-51.0	—	43.0-52.0	17.0-19.0	41.0-50.5	9.0-15.5	41.5-47.5	7.0-10.5	8.5-11.0	18.0-22.5	—	11.5-14.5		
		Mean	50.3	—	6.7	47.7	—	48.1	18.2	46.8	13.1	44.8	9.6	9.5	20.1	—	12.7	15.5	
10.	<i>Scotophilus kuhli wrightoni</i>	17♀	49.0-53.5	—	5.5-3.5	43.5-49.5	—	42.0-51.0	15.0-18.0	41.5-49.5	12.5-15.0	41.0-48.0	8.0-10.0	8.0-11.0	14.0-20.0	—	11.5-14.5		
		Mean	50.0	—	4.6	46.5	—	48.0	16.6	41.2	13.6	44.4	9.0	9.2	18.2	—	13.0	22.2	
		8♂	58.0-60.5	—	—	55.0-57.5	—	55.0-59.5	19.5-21.5	52.5-57.5	15.5-18.5	51.5-54.5	10.0-12.5	10.0-12.5	23.0-25.5	—	13.5-15.5		
		Mean	58.8	—	—	55.8	—	57.3	20.2	55.3	16.5	52.4	11.4	11.3	24.3	—	14.1	29.5	
11.	<i>Scotophilus h. heathi</i>	8♀	59.0-62.5	—	6.0-9.5	55.0-60.5	—	49.0-61.5	17.0-22.5	48.0-59.5	13.5-17.5	47.5-57.5	9.5-12.5	9.0-12.5	21.0-26.5	—	14.0-17.0		
		Mean	60.1	—	9.4	53.7	—	56.9	20.0	55.9	15.9	53.3	11.1	11.0	24.3	—	15.0	28.6	

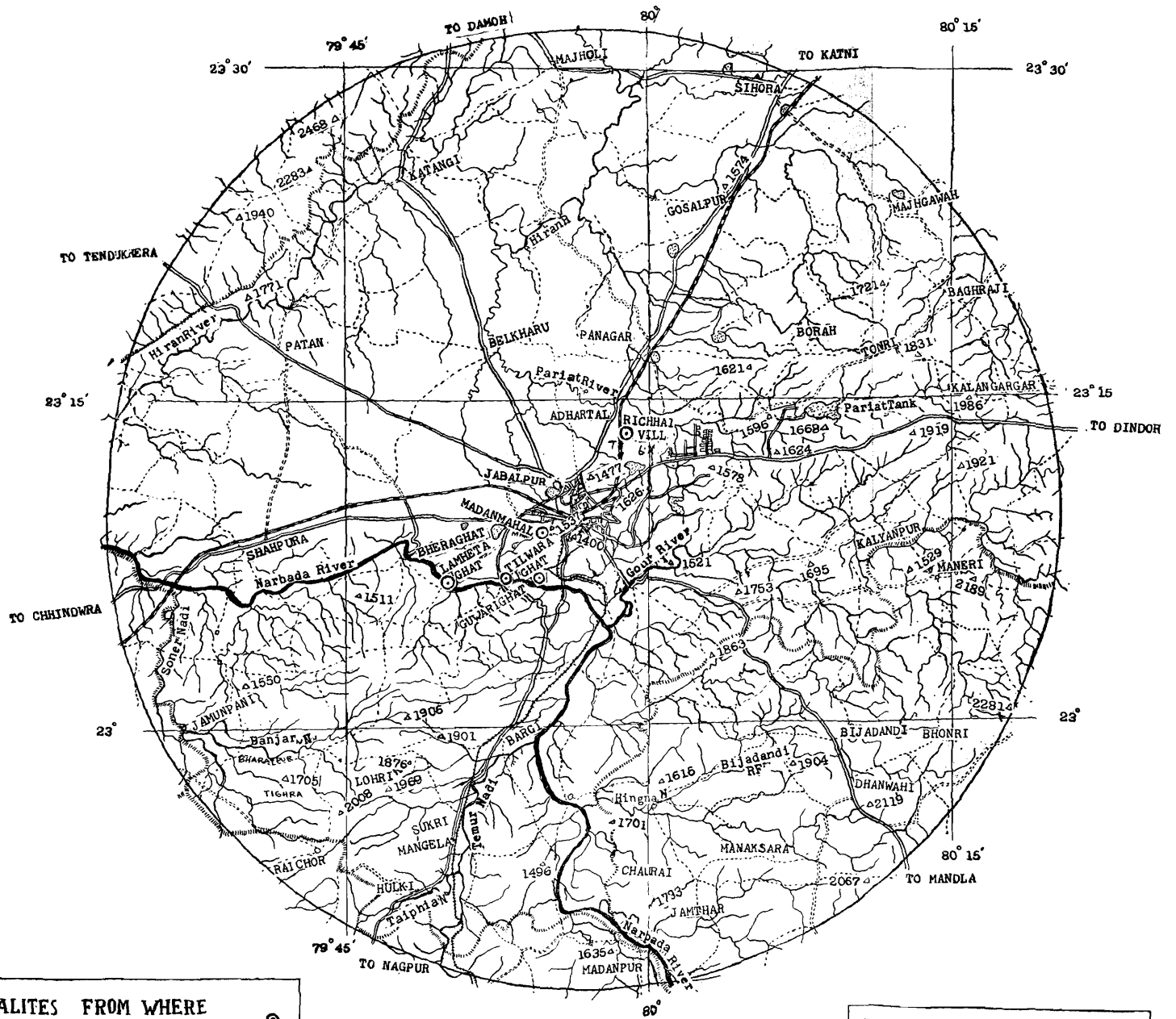
TABLE VIII
Cranial measurements of some Central Indian microchiroptera.

Note : The figures within brackets after the range show the number of specimens measured.

Sl. No.	Name of Subspecies	No. & Sex	Abbreviation of measurements.															
			c ¹ -c	cb	c ¹ -m	c ₁ -m	cr	cw	iw	i	mdo	ml	mm	on	pl	pml	zw	
1.	<i>Megaderma l. lyra</i>	28♂	Range-	5.5	24.6	10.6	11.8	5.5	12.0	4.9	26.4	6.9	18.5	9.5	20.0	7.5	14.0	14.6
				7.0	26.1	12.5	12.0	6.6	13.6	5.4	28.0	9.0	21.1	11.5	23.5	9.8	15.3	17.2
			Mean	6.1	25.4	11.5	12.3	6.2	13.0	5.1	27.4	8.3	20.2	10.8	22.2	8.5	11.2	15.8
		♀	Range-	5.2	24.7	10.6	12.0	4.6	11.5	4.9	26.1	6.2	19.0	9.4	21.5	7.6	14.0	14.9
				6.7	26.0	12.4	13.0	6.5	13.1	5.3	27.6	9.0	20.8	11.6	22.7	9.0	15.1	16.6
			Mean	5.5	25.1	11.0	12.3	5.1	11.9	5.0	27.0	7.2	19.5	9.9	22.1	8.3	15.4	15.0
		5♂	Range-	4.0	13.9	6.3	6.7	2.0	6.8	2.5	15.4	4.2	10.3	6.0	13.9	6.0	8.3	7.2
				4.1	15.0	6.7	7.9	3.0	7.0	2.8	17.0	4.7	11.6	6.3	14.5	—	9.1	7.3
			Mean	4.0	14.3	6.4	7.2	2.4	6.9	2.6	16.1	4.4	10.8	6.1	14.1	—	8.0	7.2
2.	<i>Rhinolophus l. lepidus</i>	♀	Range-	3.8	14.3	6.3	7.0	2.3	7.0	2.0	15.9	4.1	10.7	5.9	14.0	5.6	8.1	6.8
				4.4	15.0	6.7	7.6	3.5	8.0	2.5	16.8	4.7	11.3	6.3	14.5	6.1	9.4	8.0
			Mean	4.1	14.6	6.5	7.2	2.9	7.3	2.3	16.3	4.4	11.0	6.1	14.2	5.8	8.2	7.5
		♂	Range-	3.3	15.0	6.0	6.8	2.5	7.1	2.5	16.0	4.6	10.7	5.8	14.6	6.2	9.3	7.5
				4.0	15.6	6.5	7.5	3.2	8.2	3.1	17.3	5.1	11.7	6.6	15.6	7.0	10.0	8.7
			Mean	3.7	14.3	6.1	7.1	2.8	7.6	2.8	16.8	4.8	11.1	6.2	15.1	6.5	9.7	8.0
3.	<i>Hipposideros f. fulvus</i>	♀	Range-	3.1	15.0	6.0	7.0	2.3	7.3	2.3	16.1	4.5	10.7	6.0	14.1	6.1	9.4	7.6
				4.0	15.6	5.4	7.5	3.1	8.2	3.1	17.2	5.1	11.4	6.5	15.7	6.9	10.0	9.0
			Mean	3.6	15.2	6.2	7.2	2.7	7.6	2.8	16.7	2.8	11.1	6.2	15.0	6.5	9.5	8.1
		9♂	Range-	3.0	13.0	5.0	5.0	2.1	7.0	2.2	14.5	4.9	9.0	5.0	13.0	4.0	8.0	6.9
				3.4	13.3	5.3	6.0	2.6	7.8	2.9	15.3	5.2	9.3	5.8	13.6	5.0	8.5	7.1
			Mean	3.1	13.0	5.1	5.3	2.4	7.3	2.5	14.9	5.0	9.1	5.4	13.4	4.5	8.2	7.1
4.	<i>Hipposideros c. durgadasi</i>	3♂	Range-	3.0	13.0	5.0	5.1	2.3	7.2	2.5	15.0	5.0	9.0	5.4	13.0	4.0	8.1	6.8
				3.5	13.1	5.2	5.2	2.6	7.8	2.8	15.2	5.2	9.3	5.7	13.5	4.4	8.5	9.0
			Mean	3.2	13.0	5.0	5.1	2.4	7.4	2.6	15.0	5.0	9.1	5.5	13.3	4.2	8.3	7.6
5.	<i>Hipposideros galeritus brachyotus</i>	3♀	Range-	3.6	13.0	5.0	5.2	3.0	7.5	2.9	14.5	5.1	9.2	5.5	13.4	5.5	8.2	7.0
				4.0	15.0	5.7	7.0	3.2	8.0	3.0	17.0	5.9	11.0	6.2	15.1	6.0	9.5	8.2
			Mean	3.8	14.2	5.3	6.0	3.0	7.7	2.9	16.0	5.5	10.3	5.9	14.5	5.7	8.9	7.7
		5♂	Range-	3.0	10.0	4.0	4.6	2.3	5.8	3.0	11.0	3.8	7.1	5.0	10.0	5.2	6.2	7.3
				4.1	11.4	4.3	5.2	2.8	6.5	3.9	11.6	4.3	8.9	6.0	10.7	5.7	7.7	7.5
			Mean	3.8	10.8	4.1	4.8	2.9	6.1	3.7	11.4	4.0	7.8	5.3	10.2	4.4	7.0	7.2
6.	<i>Pipistrellus c. coromandru</i>	15♀	Range-	3.0	8.5	3.0	4.2	2.0	6.0	3.5	9.5	3.4	6.5	4.4	9.9	4.0	6.3	6.8
				4.3	11.4	4.7	5.3	3.4	6.7	4.0	12.8	4.9	9.0	6.1	11.0	5.0	7.5	7.6
			Mean	3.8	10.8	4.1	4.8	2.9	6.1	3.7	11.4	4.0	7.8	5.3	10.2	4.4	7.0	7.2
		8♂	Range-	3.0	9.6	3.4	4.2	2.0	5.4	3.4	10.5	3.0	6.8	4.3	9.1	3.7	6.2	5.5
				3.8	10.5	4.0	4.8	3.0	6.0	3.6	11.0	4.2	7.9	5.4	10.1	4.5	7.0	6.5
			Mean	3.3	10.0	3.7	4.4	2.5	5.7	3.5	10.8	3.5	7.6	4.8	9.7	3.9	6.6	5.9
7.	<i>Pipistrellus m. mimus</i>	♀	Range-	2.8	9.0	3.3	4.2	2.0	5.5	3.0	9.8	3.0	7.1	4.4	8.8	3.0	5.5	5.8
				3.7	10.7	5.0	5.0	3.0	6.1	3.8	11.8	4.2	8.2	5.1	10.4	4.5	7.2	7.0
			Mean	3.3	10.1	3.8	4.5	2.6	5.8	3.2	10.8	5.9	7.7	4.8	9.8	3.9	6.6	6.4
		2♂	Range-	5.0	14.0	5.3	6.0	3.0	7.1	4.6	15.1	5.0	11.0	6.4	12.4	5.0	8.7	—
				5.1	14.2	5.4	6.0	3.0	7.3	4.7	15.1	5.1	11.2	6.5	13.2	5.0	9.0	—
			Mean	5.0	14.1	5.3	6.0	3.0	7.2	4.6	15.1	5.0	11.1	6.4	12.8	5.0	8.8	—
8.	<i>Pipistrellus ceylonicus indicus</i>	4♀	Range-	5.0	14.0	5.4	6.0	3.0	7.2	4.3	15.0	5.0	11.0	6.1	12.1	5.1	8.4	9.0
				5.4	14.0	5.5	6.2	3.1	8.8	4.5	15.2	5.2	11.1	7.0	13.2	5.3	9.0	9.4
			Mean	5.1	14.0	5.4	6.0	3.0	7.6	4.4	15.0	5.1	11.0	6.6	12.3	5.2	8.7	9.5
		♂	Range-	4.0	12.9	5.0	5.3	3.0	6.8	4.0	12.6	3.6	8.8	5.5	10.9	5.0	7.0	9.2
				5.2	13.5	6.0	6.9	4.5	7.9	4.5	14.2	5.1	11.0	7.0	12.2	6.0	8.5	9.6
			Mean	5.3	12.8	5.5	5.9	4.0	7.2	4.2	13.4	4.3	7.2	4.6	11.7	5.4	8.0	9.5
9.	<i>Scotozous d. dormeri</i>	♀	Range-	4.2	12.5	3.4	5.2	2.0	6.4	3.5	12.4	3.9	9.5	6.0	10.8	4.2	6.8	8.7
				5.2	13.9	6.0	6.5	4.6	8.0	4.8	14.5	5.0	11.2	7.1	12.2	5.9	8.9	10.0
			Mean	4.8	13.0	4.5	5.9	3.7	7.2	4.2	13.5	4.4	10.3	6.6	11.5	5.1	8.1	9.2
		♂	Range-	6.0	16.5	6.4	6.7	4.2	9.0	5.2	16.8	4.7	12.5	7.8	11.6	6.5	10.5	12.2
				6.7	17.1	8.5	8.0	7.0	10.0	5.5	18.9	5.5	14.0	8.7	15.8	7.0	11.5	13.0
			Mean	6.3	16.8	7.0	7.6	6.1	9.3	5.2	17.5	5.1	13.0	18.6	14.8	6.8	11.2	12.7
10.	<i>Scotophilus temminckii wroughtoni</i>	♀	Range-	4.5	13.6	5.2	6.0	3.8	8.4	4.5	15.4	4.5	9.8	7.0	13.0	4.7	8.2	4.0
				6.9	17.5	7.0	7.5	7.2	9.5	5.5	18.5	6.0	13.5	9.0	16.0	7.5	11.5	13.5
			Mean	5.6	15.8	6.3	7.1	5.0	9.3	5.0	16.5	5.0	12.4	7.5	14.5	6.5	10.1	12.1
		10♂	Range-	6.8	18.2	7.2	8.1	4.1	9.5	5.4	19.5	5.4	14.3	9.2	16.7	6.2	12.0	13.2
				7.5	20.0	8.0	8.9	7.9	10.5	5.8	20.5	7.7	16.0	10.0	18.0	8.0	13.5	15.0
			Mean	7.2	19.2	7.6	8.4	6.9	9.8	5.6	20.3	6.2	15.0	9.7	17.5	7.2	12.7	14.0
11.	<i>Scotophilus h. heathi</i>	♀	Range-	6.5	17.2	7.0	8.1	4.0	9.4	5.0	19.0	5.0	14.0	8.9	16.0	6.3	11.2	13.2
				7.6	20.0	8.1	8.9	7.5	10.5	6.0	21.1	7.2	15.7	10.1	18.0	7.8	13.0	14.7
			Mean	7.1	19.0	7.5	8.4	6.8	10.0	5.4	20.0	5.8	14.9	9.5	17.2	7.1	12.2	13.8

Text-fig. 1
Map of the study area.

Text-fig. 1



LOCALITIES FROM WHERE
BAT HAVE BEEN COLLECTD ⊙

SCALE 1CM = 2.6 KM

DISTRICT BOUNDARY - - - - -
RAILWAY TRACK - - - - -
ROADS, ACCORDING
TO IMPORTANCE } - - - - -
RIVERS, NULLAHS, ETC - - - - -
PONDS OR LAKE ⊙

Text-fig. II

Twin histograms comparing the cranial measurements of 28 adult males with 18 adult females of Megaderma l. lyra. Numbers in histograms indicate millimetres.

Text-fig. II

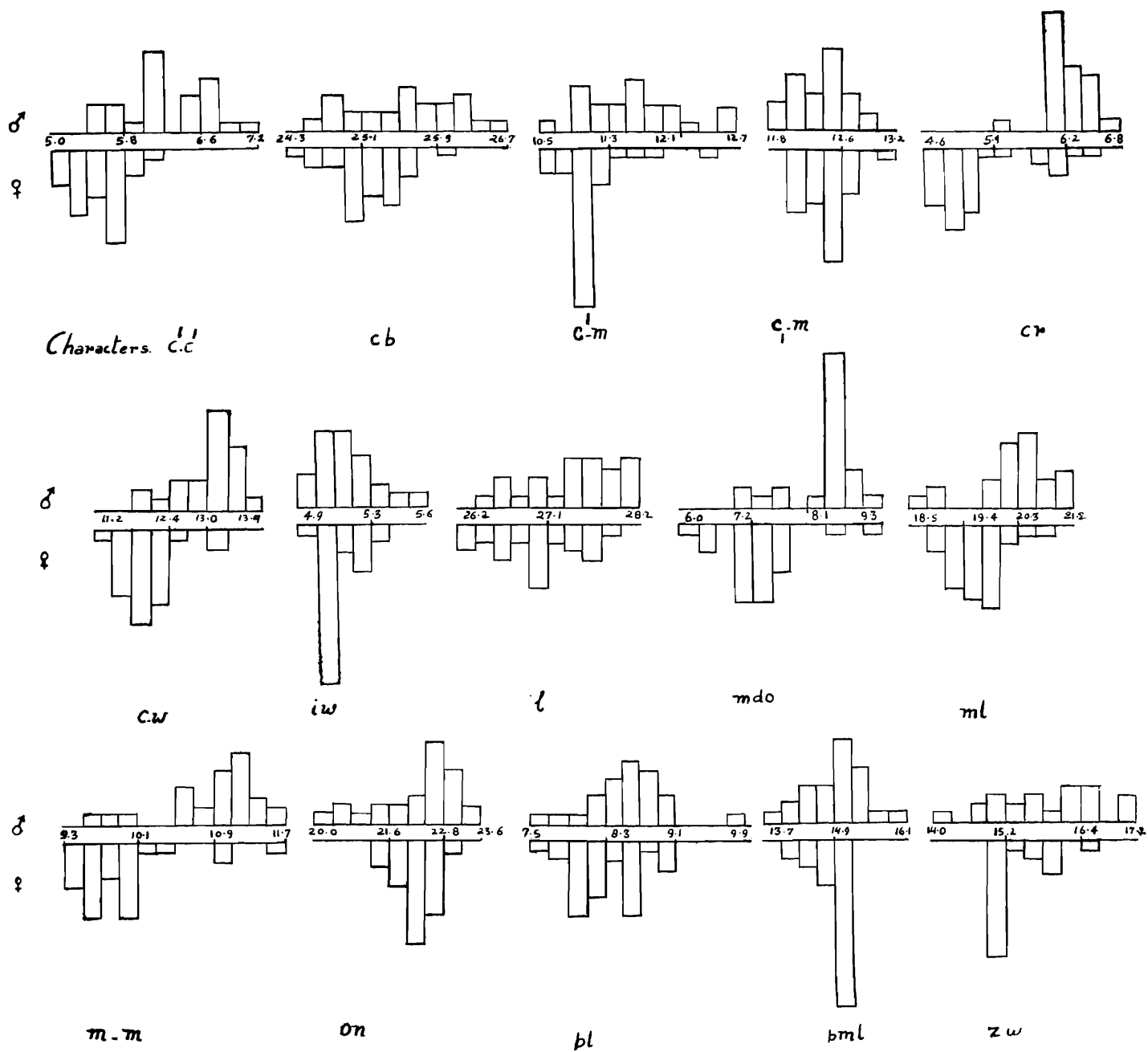


Plate I

1. *Freshly killed specimens of Megaderma l. lyra.*
2. *Freshly killed specimens of H. cineraceus durgadasi.*
3. *A colony of Megaderma l. lyra on the ceiling of a ruined temple.*

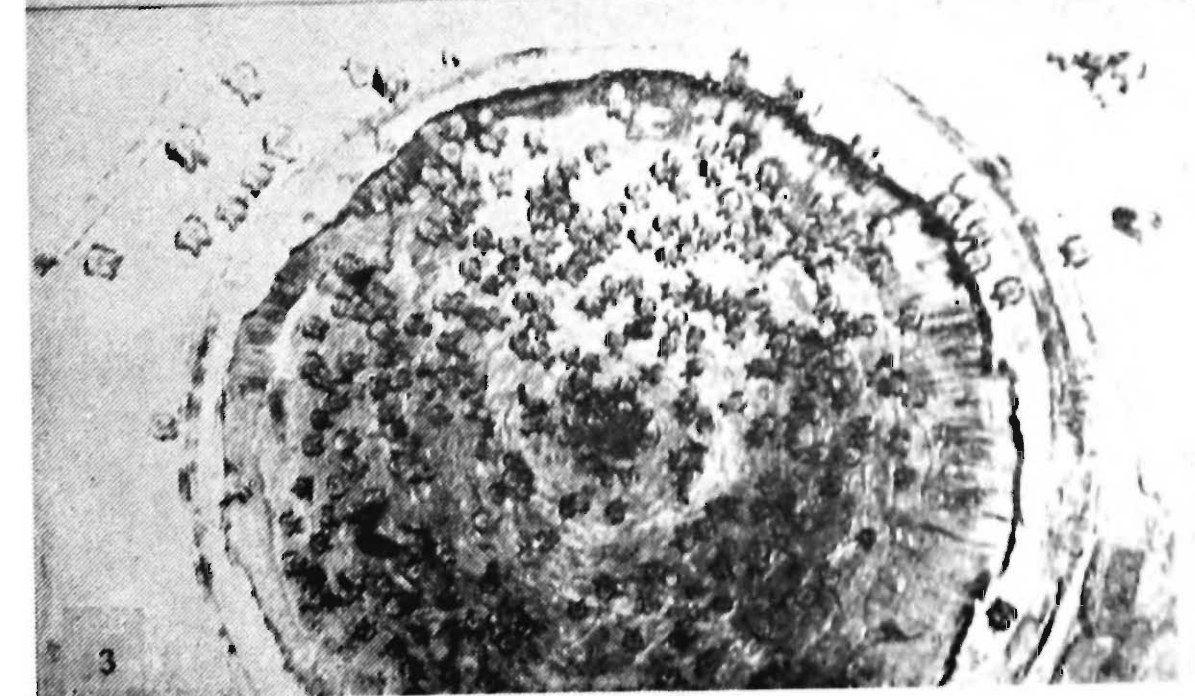
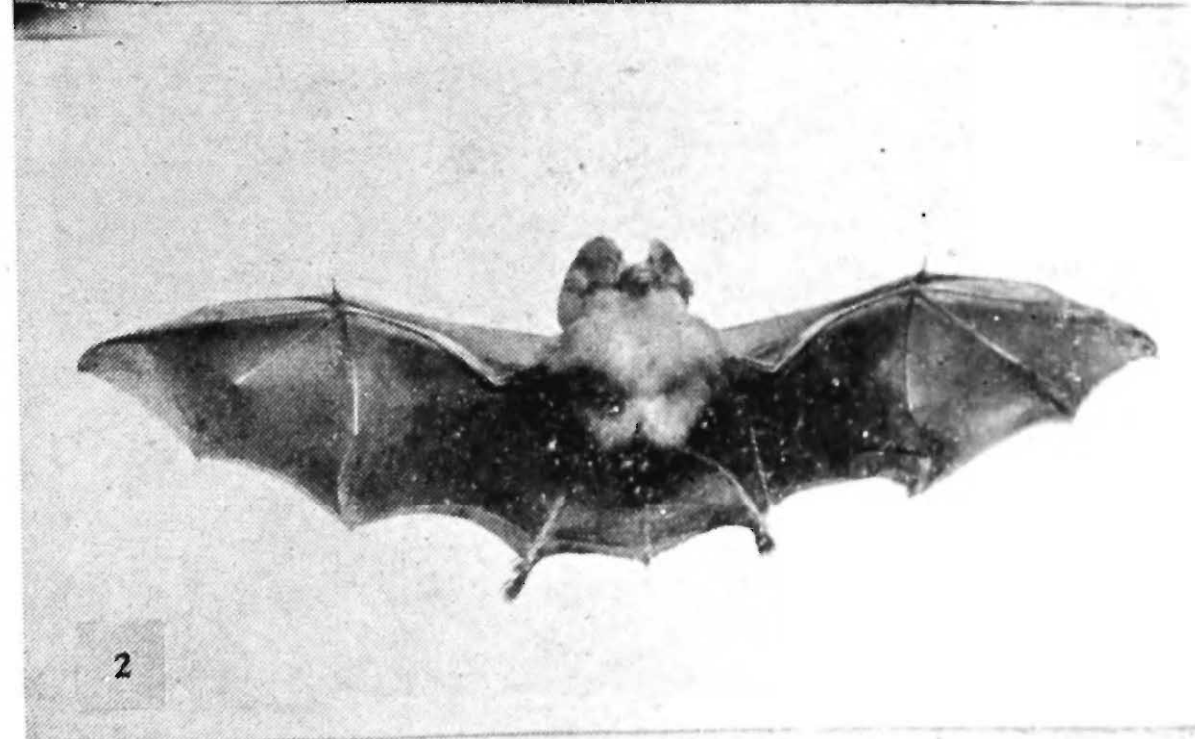
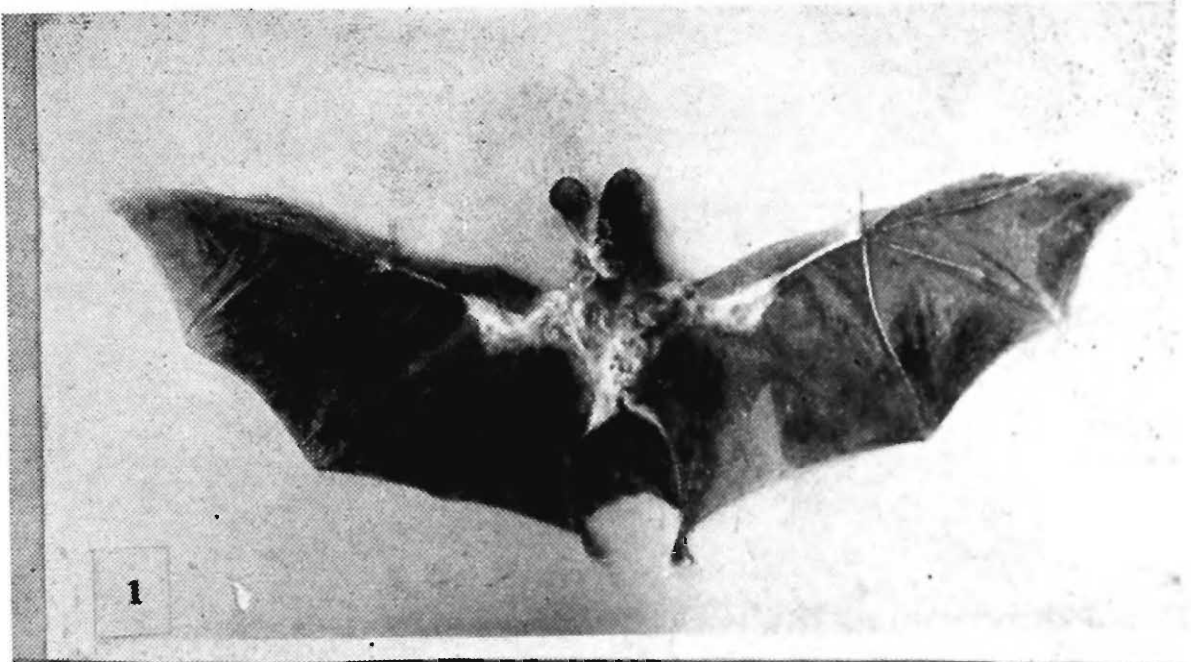
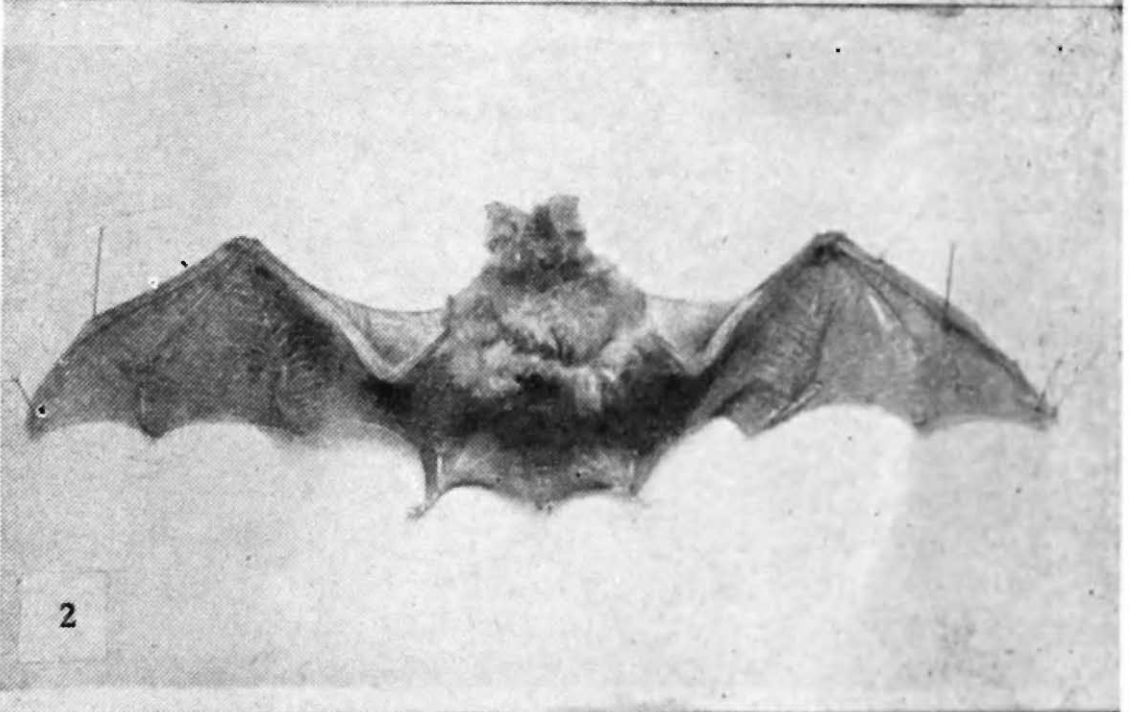
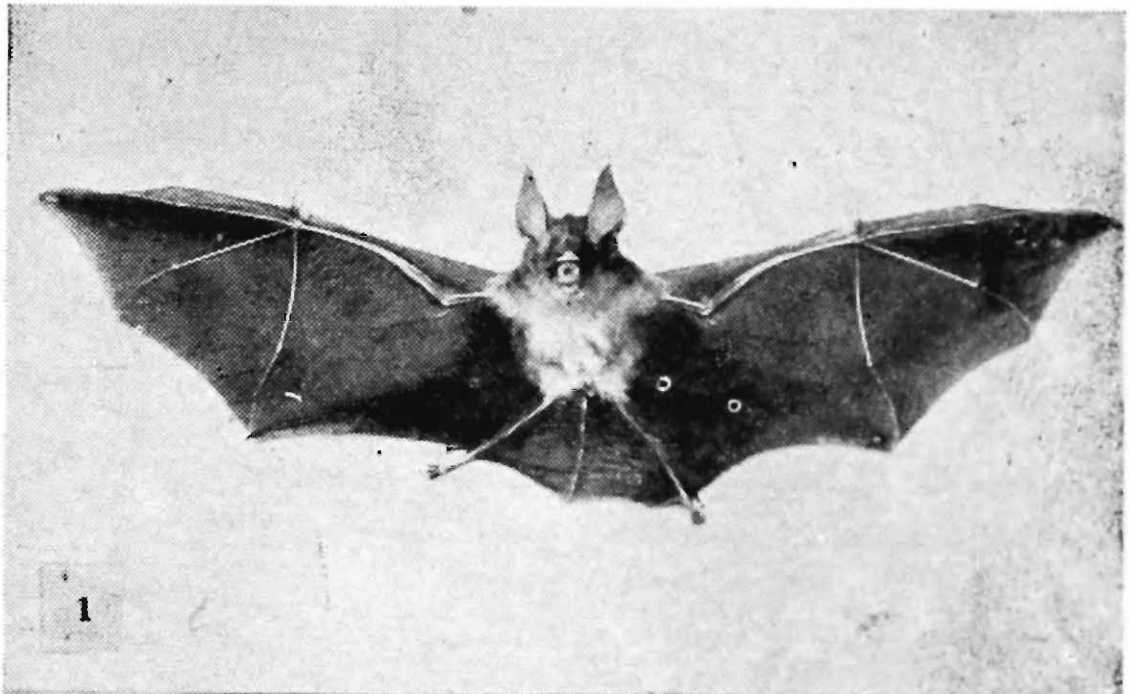


Plate II

1-3. Freshly killed specimen of Rhinolophus l. lepidus, H. galeritus brachyotus and aliving specimen of Mlyotis peshwa respectively.



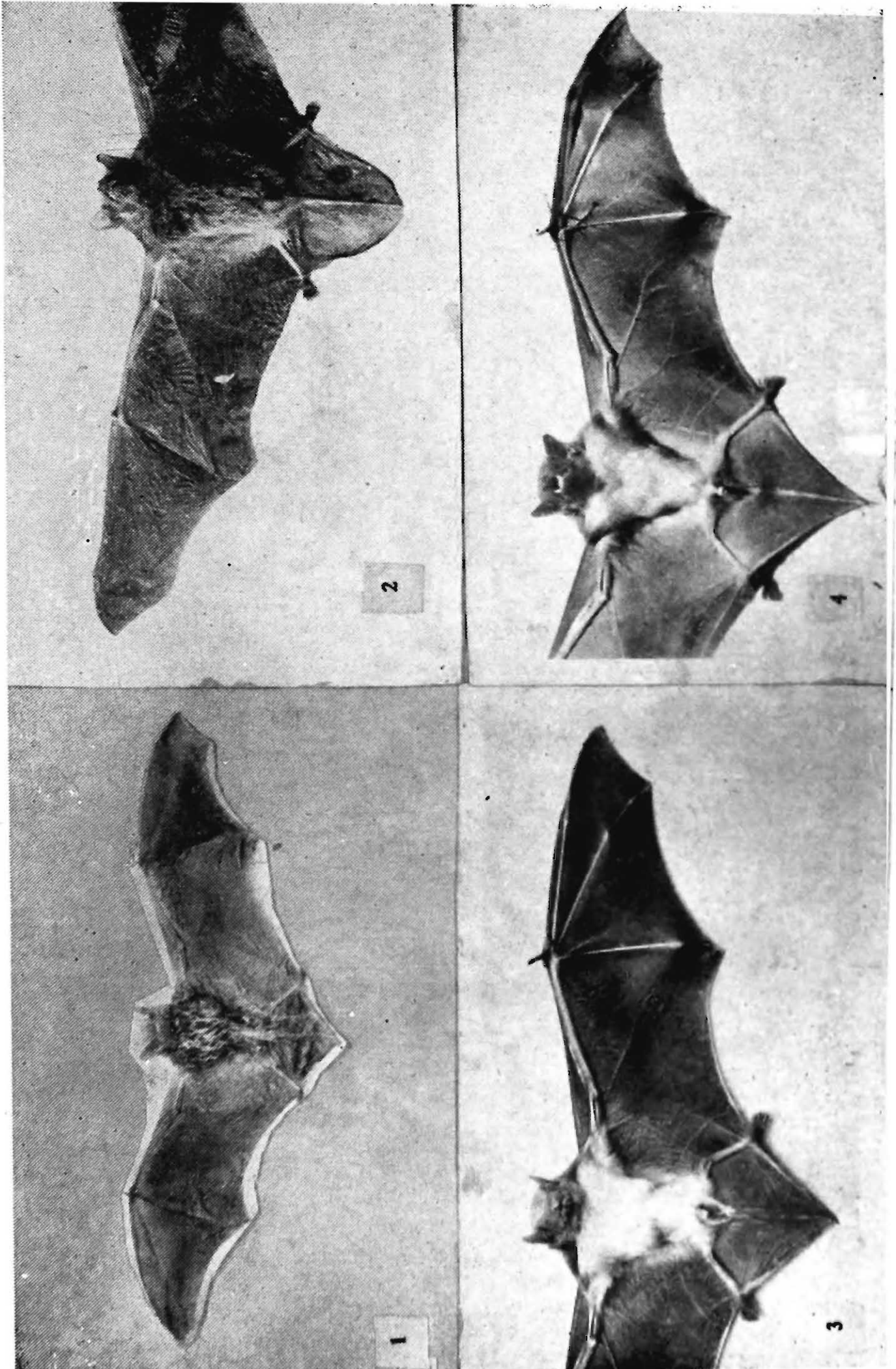


Plate IV

1. *A colony of Pipistrellus m. mimus in corner of wooden cage.*
2. *Glans of a young specimen of Hipposideros galeritus brachyotus.*
3. *Lateral view of the glans of Scotozous dormeri.*
4. *Front view of the same.*

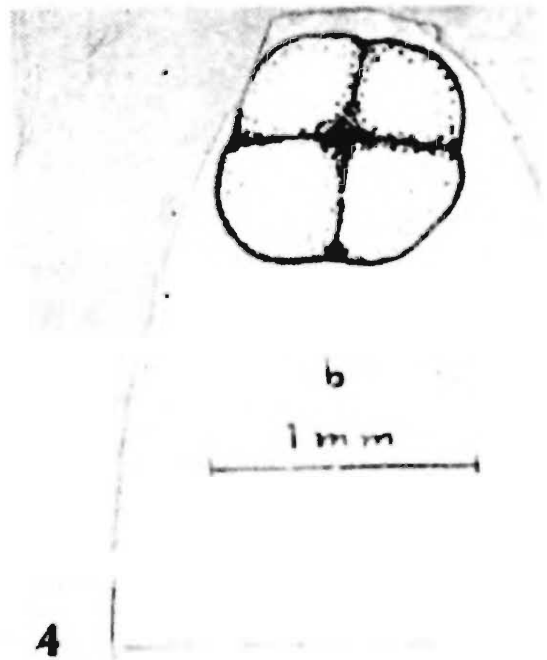
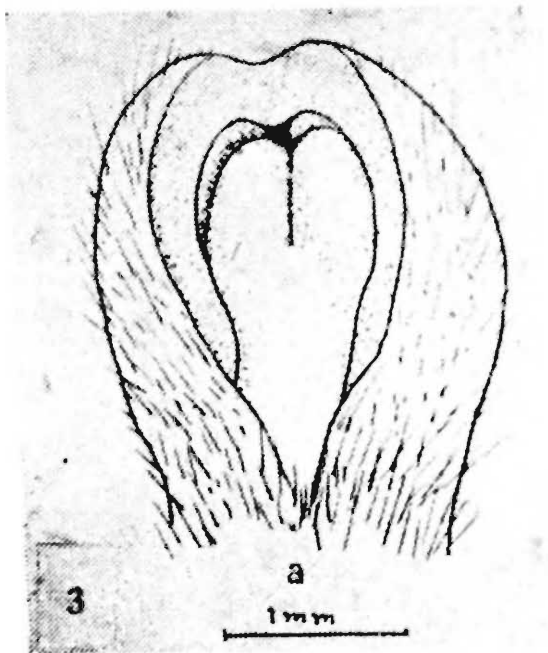
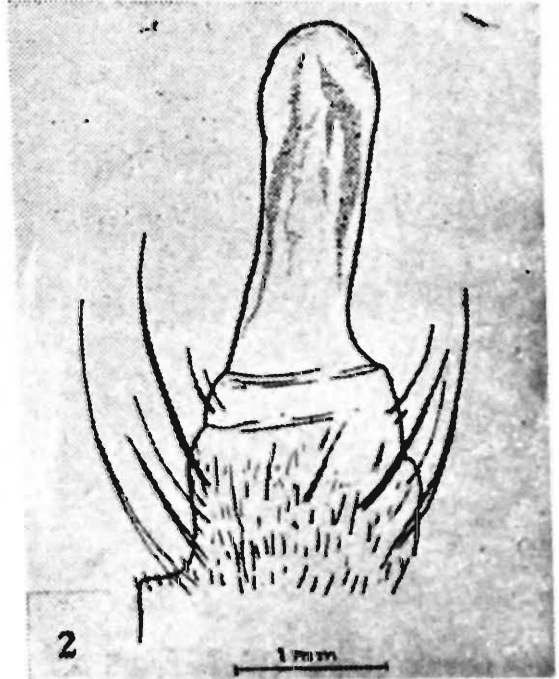
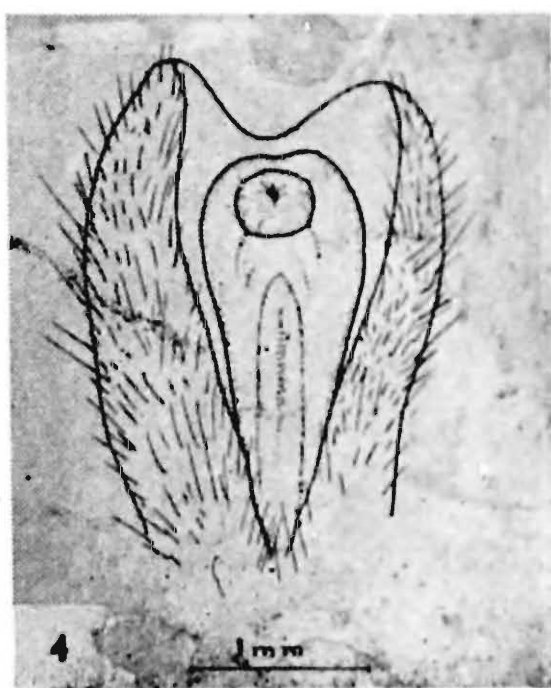
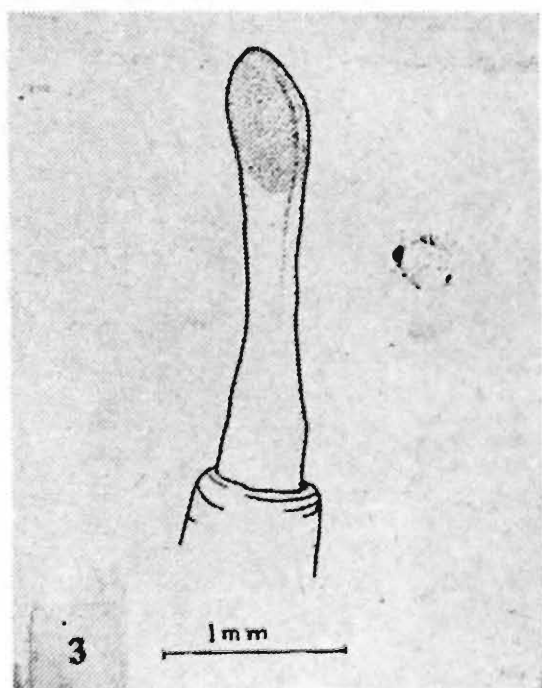
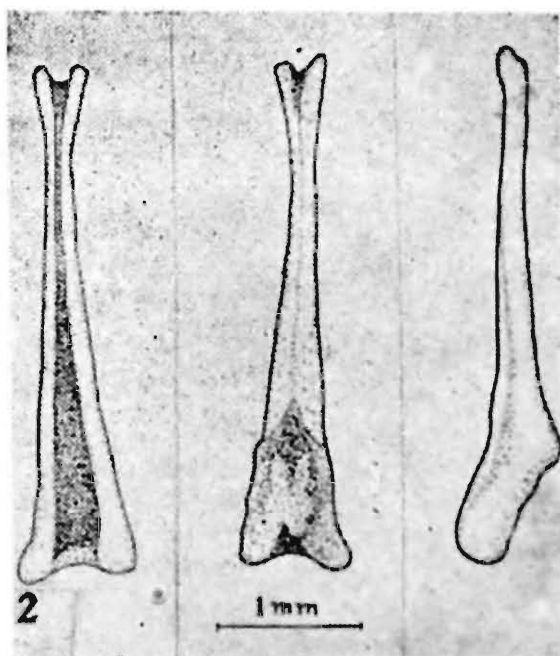
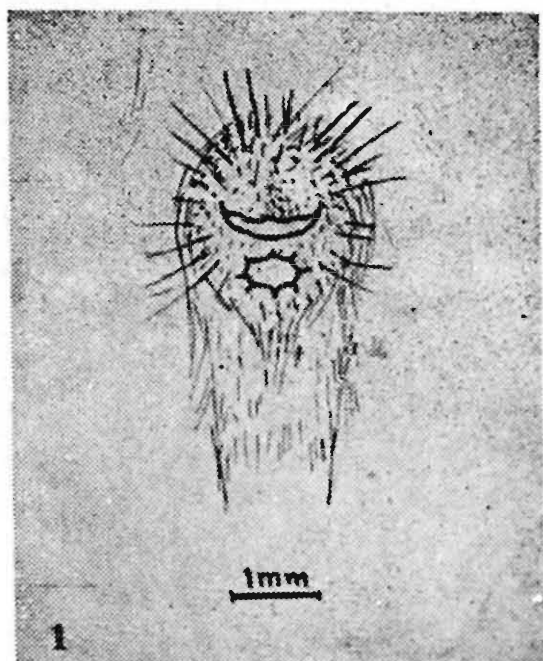
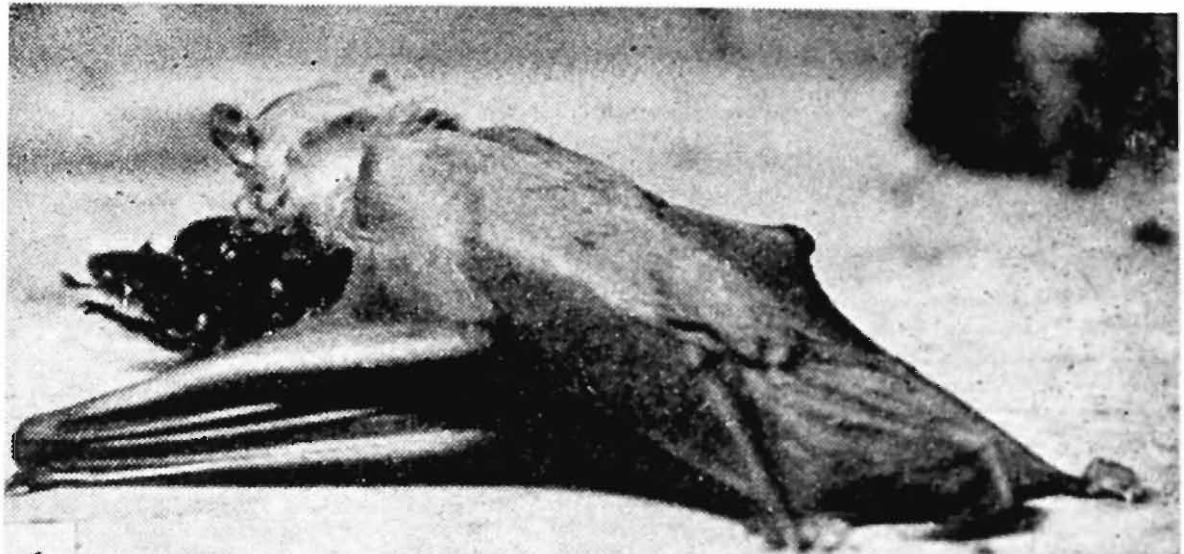


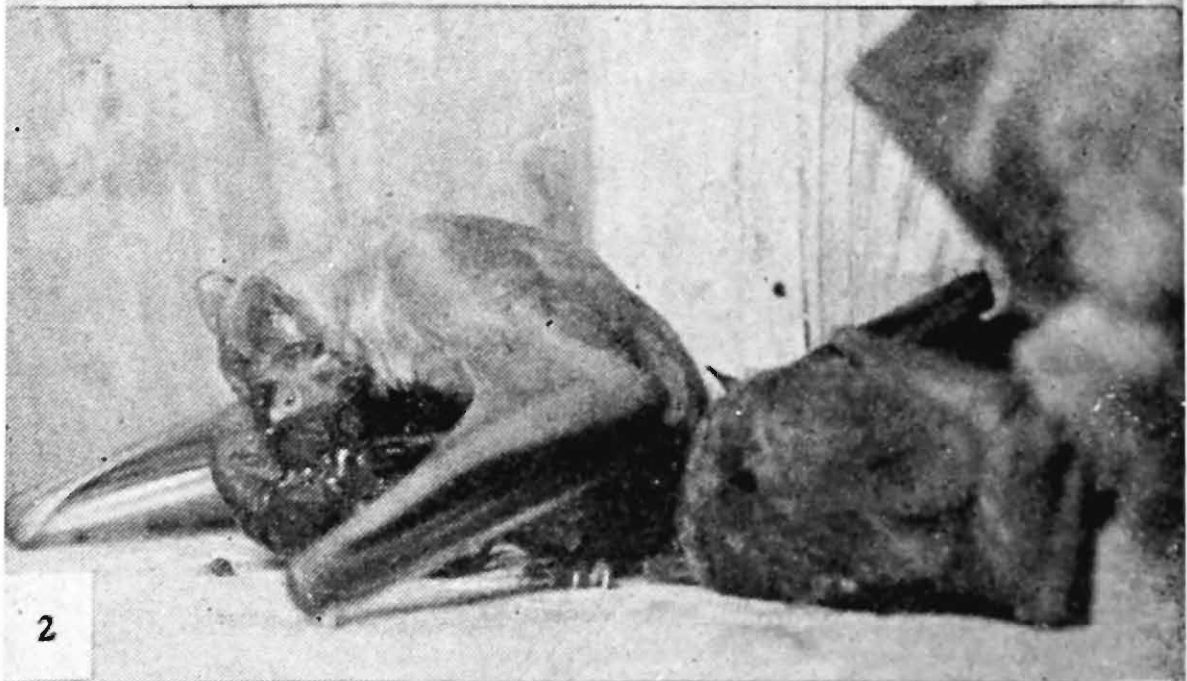
Plate V

- 1 *Female external genitalia of Pipistrellus c. coromandra.*
- 2 *Dorsal, ventral and lateral views of the baculum of the same.*
- 3 *Glans of a young specimen of Pipistrellus m. minus.*
- 4 *Glans of P. ceylonicus indicus.*

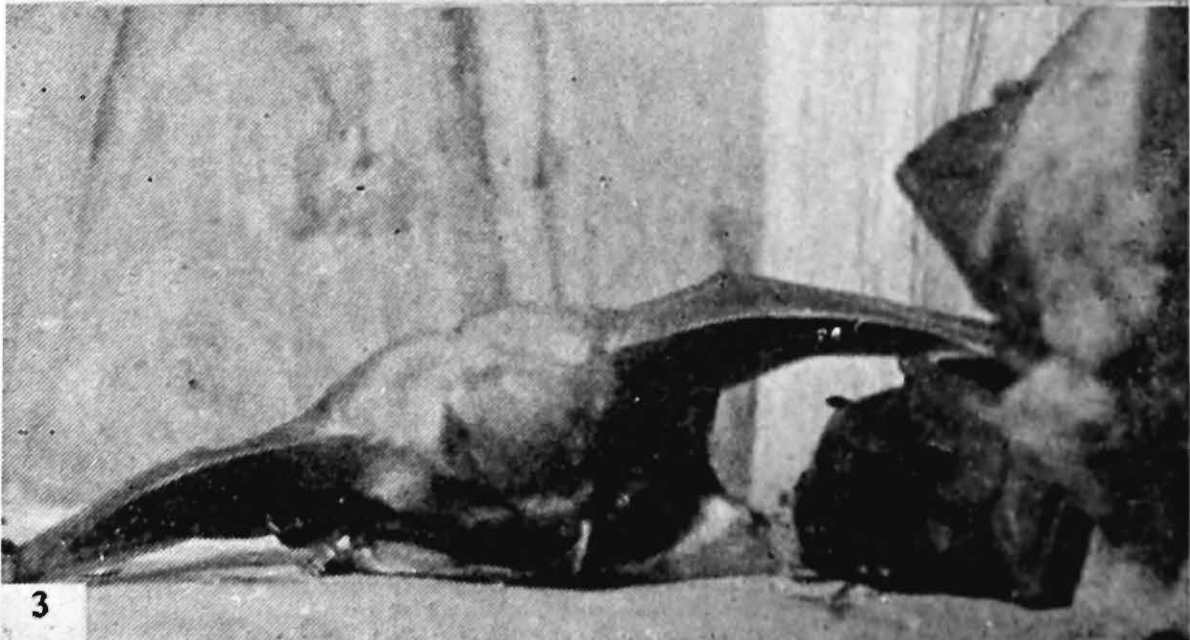




1



2



3

Plate VII

- 1-2. *Scotophilus h. heathi* feeding on the beetle, *Heleoscopus* sp.; in 2, the bats are resting before starting feeding after the prey had been deprived of its legs and upturned.
3. A female of *Scotophilus h. heathi* with grown up young.

