

TAXONOMIC AND BIOLOGICAL OBSERVATIONS ON THE BATS OF THE RAJASTHAN DESERT

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(with 5 Tables and 1 Text-figure)

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I—INTRODUCTION

1. *General*

Bats and other mammals were collected from the Rajasthan desert in various seasons during 1953-56 and observations on them were made at Barmer, Gadra Road, Sheo, Jaisalmer, Phalodi, Bap, Bikaner, Ganganagar, Pilani and Jodhpur (Text-fig. 1). The observations include the biology of nine species of bats belonging to six families. Important variations in the colour and skull structure of a form of *Rhinopoma* have been given. Almost all the bats are reported for the first time from the Rajasthan desert. Field notes on their activities, sex-ratios, food,

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breeding and their associations, as well as the body and cranial measurements (which are in millimetres and according to Roonwal, 1950 and Cockrum, 1952) are given. The abbreviations used in the text are :—

<i>HB.</i> , Head & body	<i>ob.</i> , Occipital breadth
<i>T.</i> , Tail	<i>do.</i> , Depth of occiput
<i>E.</i> , Ear	<i>pm.</i> , Postmolar length
<i>HF.</i> , Hind Foot	<i>al.</i> , Auditory length
<i>FA.</i> , Fore arm	<i>ltb.</i> , Length of tympanic bulla
<i>Tr.</i> , Tragus	<i>btb.</i> , Breadth of tympanic bulla
<i>op.</i> , occipitopremaxillar length	<i>ln.</i> , Length of nasals
<i>cb.</i> , Condylc basal length	<i>wn.</i> , Combined width of nasals
<i>on.</i> , Occipitonasal length	<i>pl.</i> , Palatal length
<i>zw.</i> , Zygomatic width	<i>lut.</i> , Length of upper tooth row
<i>io.</i> , Interorbital length	<i>llt.</i> , Length of lower tooth row
<i>cw.</i> , Cranial width	<i>ml.</i> , Mandibular length

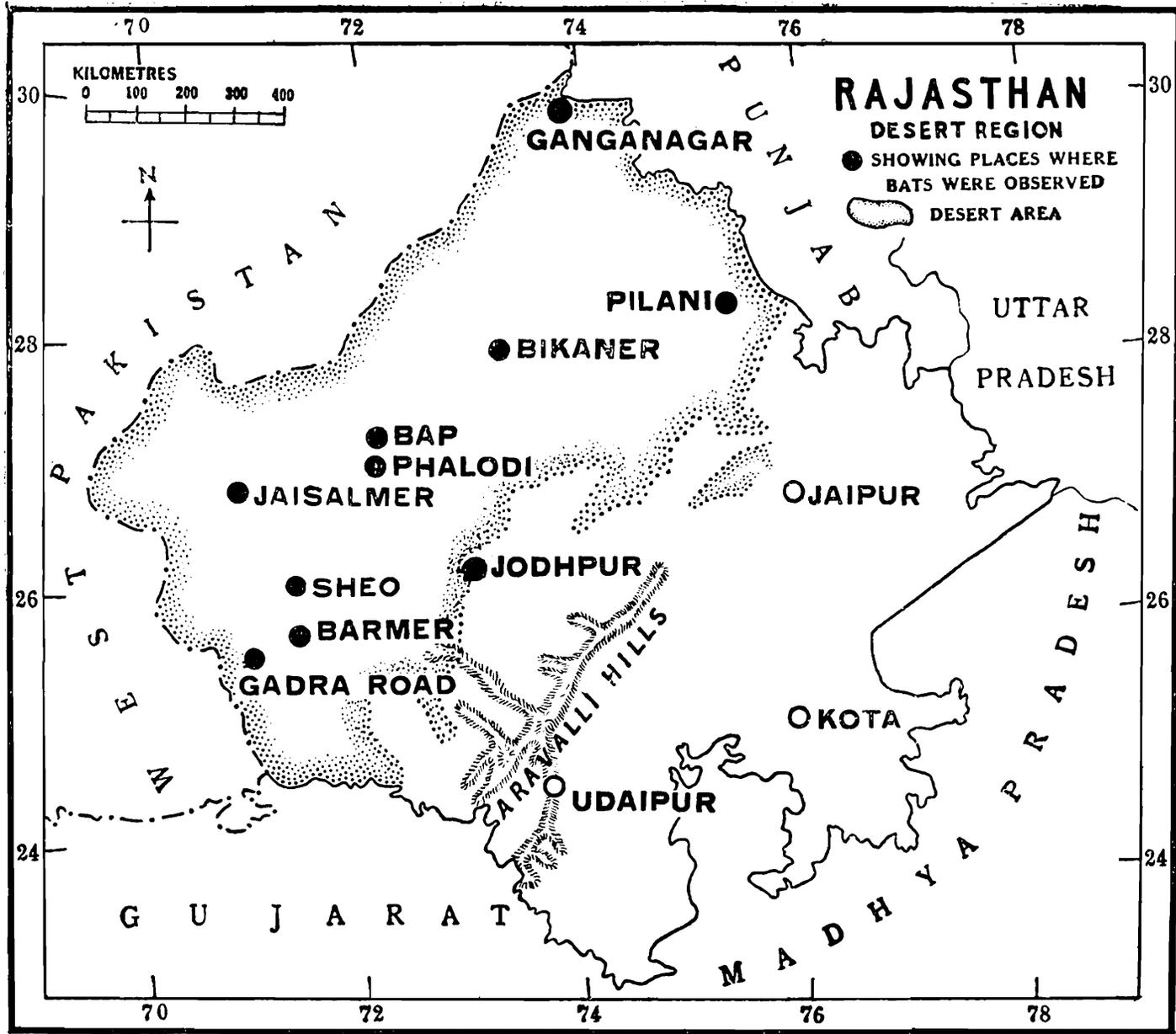
The body colours are described according to the colour schemes of Maerz and Paul (1950).

2. Acknowledgment

The writer is indebted to Professor Daya Krishna under whose supervision the work was carried out. Thanks are also due to Dr. M. L. Roonwal, Director, Zoological Survey of India, for his advice in revising the manuscript ; to Dr. W. W. A. Phillips and Mr. Humayun Abdulali for help ; and to UNESCO for financial assistance.

3. Environment (Ecology of the desert region)

Rajasthan desert lies between 25° and 30° N. lat. and 69·5° and 78°E. long. Covering about 60,000 sq. miles, and is partly arid and partly semi-arid. At certain places it is hilly, otherwise its surface is covered with sand consisting of well-rounded quartz grains, hornblende, felspar as well as foraminiferous shells (Wadia, 1939). According to rainfall, the desert of Rajasthan is divisible into two regions : an arid region in which the rainfall is ten inches or less per year and the mean diurnal temperature is 24° F. or more ; and a semi-arid region in which the rainfall is twenty inches and the annual diurnal temperature is 10° or less. Ninety per cent of the total rainfall is received in the monsoon season (July-September), the rainy days being only about 20 in number. The mean maximum temperature in May is usually 105-108° F. and mean minimum in December is 38° F. The annual humidity ranges from 19-76 per cent from April to August. The vegetation consists mainly of *Capparis aphylla*, *Gymnosporia montana*, and *Prosopis spicigera* and many species of *Zizyphus* and *Calligonum*. The herbaceous cover of the vegetation is represented profusely by *Tephrosia perpurea* in the rainy season. The winter vegetation is characterised by the dominant shrub-like *Capparis aphylla* and the perennial under-shrubs, *Leptadenia spartium* and *Calotropis procera*.



4. Localities where Bat-Colonies are Found

Bats are usually found in dark, unattended buildings (ruins) and caves, natural as well as man-made. In the desert region natural caves are not many. They are found only at Jodhpur, Barmer and Jaisalmer regions where low hills occur. The various bat-localities from where the bats were collected are described below briefly :—

1. JODHPUR : MANDORE.—This place is a garden seven miles north of Jodhpur railway station. Low rocks cover one of its sides. To drain water from these rocks a hung *nullah* (water-course) has been constructed below the Mandore Palace. Its other end opens into the drainage by system of the main road. This *nullah* forms about 600 ft. long dark tunnel which is about 20 ft. broad and 18 ft. high. It is divided by arches into many chambers. It forms an excellent roosting place for bats—*Rhinopoma kinneari*, *Megaderma l. lyra* and *Taphozous p. perforatus*.

2. JODHPUR : BALSAMAND.—It is another garden near a large lake, about five miles north of Jodhpur and is on the way of Mandore. *Pteropus. g. giganteus* is found on *Ficus* trees in the garden. There is also a deserted Palace in which some *Rhinopoma. h. hardwickei* is found.

3. JODHPUR : FORT.—It is situated over a hillock about 1,000 ft. high to the north of Jodhpur City. Today, it is almost unattended. In the dark staircases of the palace were found a large number of *Rhinopoma h. hardwickei*, in two rooms *R. kinneari* and in one cell *Megaderma l. lyra*. In one of the wells in the Fort, males of *R. kinneari* were found.

4. JODHPUR : BHIMBHARAK.—It is about 7 miles west of Jodhpur. It is a hilly area about 1200-1500 ft. high. Bats live here in a natural cave which is extremely dark. It is inhabited by *Rhinopoma kinneari* and *R. h. hardwickei*. *Taphozous k. kachhensis* lives outside the cave in fissures and crevices of the rocks. Some bats *Rhinopoma sp.* are also found in the nearby ruins.

5-7. JODHPUR : (5) KAGA. (6) UDAIMANDIR. (7) JAIN TEMPLE. *R. kinneari*, *R. h. hardwickei* and *T p. perforatus* were also collected and observed in the above mentioned localities. *Pipistrellus mimus glaucillus* was observed clinging in small crevices in houses in the city as well as outside.

8. BARMER : CAVE.—It is a large natural cave about 150 ft. long, 10 ft. broad and 8 ft. high on the southern side of Barmer. It is situated on a hillock about 750 ft. high. The bottom of the cave is muddy and there exists a small pool of water in the blind distal end of the cave. Numerous examples of *R. kinneari* and some of *T p. perforatus* were found to roost in the cave.

9. BARMER : TEMPLE.—The other locality where bats were observed in Barmer was a temple which is situated in the city. In dark rooms of the ground floor and in dark staircases are found *R. h. hardwickei*.

10. JAISALMER : FORT.—There is a small building in the Fort premises, with high ceilings. *R. h. hardwickei* was observed in four rooms, while *R. kinneari* inhabited two rooms ; the latter were not as numerous as the former. In two other rooms specimens of *T p. perforatus* were found.

11. BIKANER : TUNNELS.—There are a large number of man-made tunnels in the earth, which are excavated for “ Fuller’s earth ” The tunnels are sometimes as much as 50 ft. long, 10 ft. wide and 10 ft. deep, and water accumulates in their farther end which sometimes rises to 6 ft. The humidity is, therefore, considerably high in these tunnels. *Rhinopoma h. hardwickei* are found in the nearer apartments which have some light. *Rhinolophus l. lepidus* inhabit the dark distal portions.

II—SYSTEMATIC* ACCOUNT, BIOLOGY AND DISTRIBUTION

Suborder I. Megachiroptera

Family 1. PTEROPODIDAE (Fruit Bat)

Subfamily PTEROPODINAE

1. *Pteropus giganteus giganteus* Brünnich

(Indian Flying Fox)

1782. *Vespertilio gigantea* Brunnich, *Drynes Historie*, 1, p. 45.
(India.)

7♂♂ and 3♀♀, Jodhpur.—March, May and August.

In the desert region the Flying Foxes were observed only at Balsamand, Jodhpur. They roost on *Ficus* trees in the garden where they continue to live throughout the year and also during heavy rains. During summer in the mornings and evenings, they climb the highest branches of the trees, while in the afternoon, when the sun is high and it is hot, they climb down to the lower branches in search of shade. In winter, however, the contrary happens : during the afternoon they are seen on the top of the trees. Throughout the day the bats confine themselves to the trees, but in the evening, when it is sufficiently dark, they leave the trees and fly over the adjoining Blasamand lake and skip over water, generally for drinking it. Their skipping over water was also observed at Mt. Abu in the Nakki Lake. Close observations were made from a boat and from the island in the lake, and it was found that they do open their mouth and gulp water. In May and June their feeding starts at about 7·15 P.M. and during winter at 6·15 P.M. At Jodhpur they have been observed to feed on guava, (*Pasidium guyava*), the Indian blackberry (*Syzygium cumini*), the mango (*Mangifera indica*) and *Ficus* berries. At Jaipur they were observed to feed on a *Ficus* tree which is situated near a cinema hall in the city. It is quite noisy there and bright due to the loud-speakers and the flood-lights, but the bats are not at all disturbed and about a score of them daily visit the tree when it is fruiting.

There breeding season lasts from April to May. Seven females were observed carrying one young each against their breast in May.

This bat has been collected only at Jodhpur. Blandord’s (1888-91) statement that they are not well distributed in western India, is supported by this survey.

*Body and skull measurements are appended at the end of the text.

Suborder II. Microchiroptera

Family 1. RHINOPOMATIDAE (Rat-tailed Bats)

2. *Rhinopoma kinneari* Wroughton

(Rat-tailed Bat)

1912. *Rhinopoma kinneari* Wroughton, *J. Bombay nat. Hist. Soc.*, Bombay, 21, p. 767. (Bhuj, Kutch.)

- 23♂♂, Fort, Jodhpur.—October,
 23♂♂, 30♀♀, Jodhpur.—All the year round,
 36♂♂, Barmer.—June, November, January,
 2♂♂, 1♀, Jaisalmer.—June.

This bat is the most common one in the desert region but is absent from the man-made caverns in loose earth at Bikaner. In every bat locality it is found in large numbers. Usually it inhabits those portions of a building or cave which are not completely dark. In the Mandore tunnel, specimens were found living in association of *Rhinopoma hardwickei*, *Taphozous p. perforatus* and *Megaderma l. lyra*. In the Barmer cave they were found with *Taphozous p. perforatus*, and at Jaisalmer with *Rhinopoma h. hardwickei*. Usually the various species reside in different apartments of the same cave or building. When disturbed they do intermingle but this lasts only for a short period after which they again segregate. When they are caught they make a loud noise—a long *cheen, cheen*, but normally, when not disturbed their vocal note is a single long *chue*. While flying they do not appear to make any noise.

The bats come out of their roosting places between 7-30 and 7-45 P.M. in summer and have been observed to return before dawn. They come out in small groups of 8-12, but afterwards fly singly. In the first two hours, some return to the roost and fly out again. Till about midnight all the bats are out. At about 2 A. M. the bats begin returning though some batches again fly out at intervals. The flight is quite fast, and steady. They fly sufficiently high, but after 11 p.m. they were observed near lamp-posts, catching insects. They usually fly away from trees and buildings, and do not take to the wing when it is raining heavily.

The breeding season is July-August, and the number of young born at a time is always one. Usually the females and the males live together, but in a well in the Fort at Jodhur only males were observed. It was visited in July, August and November and no female was found in this well—it was a male colony.

Wroughton (1912) described the colour of this bat as "brownish drab—warmer in colour than the drab grey of *hardwickei*" Most of the specimens collected and examined exhibit Wroughton's 'brownish drab' (11, Pl. 6—slightly lighter shade of hydrangea Red (K 1, Pl. 6—of Maerz & Paul, 1950) but several were 'drab grey' (A 4, Pl. 47). This colour variation was noted in the Jodhpur and the Barmer material. On further examination it was found that the frontoparietal crest in the

skull of the drab-grey form was poorly developed or in some cases absent, as contrasted with the strongly-crested skull of the typical *kinneari*. The teeth of this form were also found to be smaller than in the typical race. The skulls also show slight swellings in the nasals, a characteristic feature of *Rhinopoma hardwickei*.

Khajuria (1953) reports large fat deposits at the posterior hairless part of the body among the bats collected at Agra and Cutch. The fat deposits particularly on the thighs, were also observed in the specimens collected from Jodhpur and Barmer, and were thinner in females, especially in winter.

The bat is evenly distributed in Rajasthan desert.

3. *Rhinopoma hardwickei hardwickei* Gray

(Lesser Rat-tailed Bat)

1831. *Rhinopoma hardwickei* Gray, *Zool. Miscl.*, p. 37.

(India.)

- 4 ♂♂, 1 ♀♀, Balsamand, Jodhpur.—April
- 12 ♂♂, 7 ♀♀, Kaga, Jodhpur.—May
- 9 ♂♂, 3 ♀♀, Mandore Jodhpur.—April
- 12 ♂♂, 7 ♀♀, Bikaner.—February
- 4 ♂♂, 2 ♀♀, Jaisalmer.—June

The bat inhabits the unattended dark portions of ruins at Jodhpur, Barmer and Jaisalmer and the man-made caverns at Bikaner. Like the *R. kinneari*, it also dwells in poorly lighted places in buildings and is found at the entrance of a bat-locality. At Jodhpur and Barmer its population was rather thin as compared with that at Jaisalmer and Bikaner. It was found living in association of *Rhinolophus l. lepidus* in man-made tunnels at Bikaner. In winter it is quite active except during the cold spell when it appears less active. At Jodhpur, during winter, all specimens appear to gather together in the Kaga ruins.

Usually males and females live together, but during September, 1954, seven males were collected from a cell at Balsamand, Jodhpur, and there were no females. At Bhimbhark, Jodhpur, all the females had one young each on their breasts early in July. About 12 females collected from Kaga, Jodhpur, (May 15) had an early embryo each, about seven days old. In the latter two localities, males were living together with females, where three more females gave birth in July.

The usual colour of the bat is burnt sienna (Maerz & Paul, 1950, Pl. 5, F 12) on both sides. The naked pubic and femoral regions are chrome orange (Pl. 10, J 12). Certain specimen gave the general impression of sepia (Pl. 8, A10) on both the sides. The fur is sepia throughout.

*R. hardwickei** is uniformly distributed in the Rajasthan desert but is not so abundant as the *R. kinneari*.

*Tate (1947) has erroneously mentioned that *Rhinopoma (hardwickei)* has a noseleaf.

Family 2. EMBALLONURIDAE (Sheath-tailed Bats)

Genus *Taphozous* GeoffroySubgenus *Taphozous* Geoffroy4. *Taphozous perforatus perforatus* Geoffroy

(Tomb Bat)

1818. *Taphozous perforatus* Geoffroy, *Description de l'Egypte*, 2, p. 113.
(Egypt.)

4 ♂♂, 3 ♀♀, Udaimandir, Jodhpur.—October.

17 ♂♂, 11 ♀♀, Mandore, Jodhpur.—March.

2 ♂♂, 3 ♀♀, Barmer.—September.

11 ♂♂, 7 ♀♀, Barmer.—June.

The bat lives in association with *R. kinneari*, both in caves and ruins, but the two species occupy separate sections of the same locality. Its number is much smaller than that of *R. kinneari*. In the Barmer cave not more than 30-40 specimens were found; they lived in the distal darkest portion of the cave where water accumulates in a pit sometimes to a depth of 4 ft. The bat was also observed at Mandore and Udaimandir, Jodhpur. It leaves the roosts slightly earlier than *R. kinneari*, but they return together. At Udaimandir, out of five garages occupied by bats, two are inhabited by *T. p. perforatus*.

In nature, its enemy is the False Vampire which eats the head and drops away the body. About 20 examples of headless *Taphozous* were collected from the Mandore *nullah*. In captivity too, these bats were preferred by the vampires. When disturbed in the day, they fly out of their roosts and become prey of the kite (*Milvus migrans* Boddaert) and the crow (*Corvus splendens* Vieillot).

The bat was collected from Barmer and Jodhpur only.

Subgenus *Liponycteris* Thomas5. *Taphozous kachhensis kachhensis* Dobson

(Cutch Sheath-tailed Bat)

1872. *Taphozous kachhensis* Dobson, *J. Asiat. Soc. Bengal*, Calcutta, 41, p.221.
(Cutch.)

13 ♂♂, 17 ♀♀, Jodhpur.—January, February.

2 ♂♂, 4 ♀♀, Jodhpur.—April.

This species lives in caves where it prefers crevices and fissures (as observed at Bhimbharak, Jodhpur) and is the most noisy of all other bats. When captured it utters a long *cheeee*, *cheeee*, *cheeee*. Usually when undisturbed its note is a *cheeak*. In the crevices at Bhimbharak it is a close associate of the swift, *Micropus affinis* Gray, with which it lives side by side. When they were disturbed and allowed to settle it was interesting to observe them returning almost together to enter the same crevice, only with one difference—the swifts entered their nests while the bats clung to the rocks. Some of the bats also usurped the nests of the swifts and were found occupying them. It was observed and collected from Jodhpur only.

Family 3. MAGADERMATIDAE

Genus *Magaderma* GeoffroySubgenus *Lyroderma* Peters6. *Megaderma lyra lyra* Geoffroy

(Indian False Vampire)

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

5 ♂♂ and 8 ♀♀, Jodhpur.—April, November.

The bat has been observed at Mandore and the Jodhpur Fort. In the Mandore *nullah* it occupied a small, dark interior apartment. At the Fort, it lived in a cell. It is found in large numbers, 500 were found in Mandore and about 200 in Fort. It becomes active in the *nullah* after 7 P. M., leaving the roost at about 7-30 P.M., in summer. It flies out in pairs and the flight is a steady one.

The bats fly very near to buildings and trees, probably, to capture food, and they are carnivorous rather than insectivorous. At Mandore they were observed scrunching other bats, *viz.*, *Rhinopoma kinneari*, *R. h. hardwickei* and *Taphozous p. perforatus*. In Ceylon, Phillips (1922) mentioned that they consumed a pipistrelle, *Pipistrellus mimus*, which was put in with them in a wooden box. The False Vampire holds its victim by its head which is eaten and the rest of the body is discarded. This was confirmed by me, as I collected many headless bats from the Mandore *nullah*. On other occasions they were observed to carry away the Wall Lizard (*Hemidactylus flaviviridis* Rüppel) from the shades of lighted electric bulb in the verandah of a house at Jodhpur. In another case a bat was observed eating a full grown sparrow and an orthopterous insect, *Schizodactylus monstrosus*. In captivity, when they were kept in wooden cages with other bats and animals, they consumed the following animals :—Birds : *Passer domesticus*, *Saxicola caprata*, Mammals : *Meriones hurrianae*, *Mus musculus*, *Rattus r. rufescens*, *Rhinopoma kinneari*, *Rhinopoma h. hardwickei* and *Taphozous p. perforatus*.

Aitken (1907), Gleadown (1907), Green (1907) and Primrose (1907) also had observed them eating birds—(sparrow, *Zosterops*, *Cinnyrus* and *Pranticola macrura*), while Mosse (1931) and McCann (1934) observed them eating lizard and pipistrelles. The stomach contents of ten specimens of bats were examined by me just after their feeding time. The contents showed the following :—Remains of insects, bones of Amphibia, fishes and bats, and the entire alimentary canal of a fish (Prakash, 1959).

Ten females had one foetus each on 4th April at Jodhpur. Several others were observed carrying one young each in May.

The bat was collected only from Jodhpur.

Family 4. RHINOLOPHIDAE (Horseshoe Bats)

7. *Rhinolophus lepidus lepidus* Blyth

(Little Indian Horseshoe Bat)

1844. *Rhinolophus lepidus* Blyth, *J. Asiat. Soc. Bengal*, Calcutta, 13, p. 486.
(Calcutta.)

6♂♂, 12♀♀, Bikaner.—November.

This bat was observed in small numbers at Bikaner in artificial caverns and at Pilani in a well. It selects a small pit in the ceiling of the caverns in which it fits so well that it is practically impossible to detect it. Their presence is revealed by a short, sweet *chuwik chuwik* which they utter. They hang like *M. l. lyra* i.e., only with the help of the feet—other bats take the help of the forearm also. If any intruder in the cave disturbs them, they start flying inside the cavern but do not leave it like other bats. They prefer the darkest portions and become wary to slightest light. In mid-November they were found to be very agile.

The occurrence of the bat in Bikaner extends its range considerably to the West. It is interesting that the bat, an inhabitant of the humid area, is found in the desert also.

Family 5. VESPERTILIONIDAE (Pipistrelles and Yellow Bats)

Subfamily VESPERTILIONINAE

8. *Pipistrellus mimus glaucillus* Wroughton

(Indian Pigmy Pipistrelle)

1912. *Pipistrellus mimus glaucillus* Wroughton, *J. Bombay nat. Hist. Soc.*, Bombay, 21, p. 769.

(Multan, Punjab.)

2♂♂, 2♀♀, Jodhpur.—August.

Four small bats were observed flying near one of the houses in Jodhpur, and were recognized as pipistrelles by their characteristic flight, with frequent very quick turns and descents. A thorough search was made for these bats in all the bat localities of Jodhpur, but they were not found in any of them. One evening we sat to observe the 'emerging' place of the bats. At 7-10 P.M. (August 17) one bat was observed to emerge from the wall of the house where we were sitting. The bat took a circular flight and went back to its roost which was later on found to be a small crevice in the wall. At 7-12 P.M. two of them came out and started their circling movements. At 7-14 P.M. another pair emerged and joined the former pair. Next morning all the four were collected. It was observed that they do not hang head downwards as the majority of the bats do, but sit with the head up, grasping the walls with the claws. The pipistrelle is first among the bats to come out after dusk. It flies near trees and houses or over open ground in a small territory. It also enters the verandah or a room in search of insects, and ceases activity late at dawn. Pipistrelles are quite common in Jodhpur but their collection is difficult since only a few live in one crevice.

9. *Scotophilus heathi* Horsefield

(Greater Yellow Bat)

1831. *Nycticejus heathi* Horsefield, *Proc. Zool. Soc. Lond.*, London, 1831, p. 113. (Madras, India.)

1 ♀, Jodhpur.—August.

The single female had its young (about 10 days old) on her breast ; it was collected at flight under a lamp post with the help of a butterfly net at Jodhpur. The bat was not found in any of the bat-localities in the desert region.

Field Key for Identifications of Bats of the Rajasthan Desert.

(All measurements are in mm.)

- (a) Size large (HB 240—350), roosting on trees. *Pteropus g. giganteus* ♂
- (a') Size small (HB 240 or less), found in other localities.
- (b) Nose leaf and Tragus (or antitragus) both present.
- (c) Size large (HB 75 or more), ears very large. *Megaderma l. lyra*
- (c') Size small (HB 38 or more), ears moderate. *Rhinolophus l. lepidus*
- (b') Tragus present, no nose-leaf.
- (d) Tail entirely enclosed in inter-femoral membrane.
- (e) Size large (HB 68), yellow colour. *Scotophilus heathi*
- (e') Size small (HB 34-37), mouse grey. *Pipistrellus mimus glaucillus*
- (d') A portion of the tail free.
- (f) Tail emerging from the upper surface of the inter-femoral membrane.
- (g) Size large (HB 86—94), lower abdomen pink and naked *Taphozous k. kachhensis*
- (g') Size small (HB 69—80), lower abdomen covered with hairs *Taphozous p. perforatus*
- (f') Tail emerging from the end of the inter-femoral membrane.
- (h) Size large (HB 70-86), tail shorter than head and body *Rhinopoma kinneari*
- (h') Size small (HB 53-66), Tail longer than the head and body *Rhinopoma h. hardwickei*

III—DISCUSSION

1. *Relative numbers*

In the desert region Rat-tailed Bats of the genus *Rhinopoma* are found in abundance. The number of *Rhinopoma kinneari* is more numerous in the Jodhpur Division, while *Rhinopoma h. hardwickei*

is more common in the Jaisalmer and Bikaner Divisions. The next in order of numbers are the two *Taphozous* species. While *Taphozous p. perforatus* is evenly distributed over the entire desert area, its number in any particular locality is not so large as that of *Rhinopoma kinneari*. *Taphozous k. kachhensis* is found only at Bhimbharak, Jodhpur, but in large numbers. For *Megaderma l. lyra* it was estimated that 500 specimens occur in the Mandore nullah, and 200 within the Fort, Jodhpur. In all the man-made caverns at Bikaner the number of *Rhinolophus l. lepidus* was not more than 100.

2. Movements

Among "local movements" are the journeys made by bats each night as they leave their roost to secure food. The time at which the bats leave their roost varies with the species as well as the season. The Pipistrelle and the Horseshoe Bat are the first to start their feeding rhythm. During summer they start their routine journey at about 7-15 P.M. and as the season progresses, they leave the roost earlier—in winter at about 6-25 P.M.; and on cloudy day even earlier, at 6-15 P.M. Next in order are the Flying Foxes which follow the Pipistrelles just after 10-15 minutes. The Rat-tailed and the Sheath-tailed Bats and the False Vampires start their flight at 7-30 — 7-45 P.M. in summer and at 6-35—6-45 P.M. in winter.

Local migrations are the movements from one retreat to another. The causes of migration can be several—disturbance by man, the climatic factors, etc. At Jodhpur, it has been observed that during winter the bats migrate to warmer localities and to those which are less exposed to the weather. At the Fort, Jodhpur, the False Vampires aggregate in the cell which has only one exit or entrance measuring 40 × 40 mm.; all the vampires go in and come out through this small hole. Most of the *Rhinopoma kinneari* migrate to the Mandore nullah. The *Rhinopoma h. hardwickei* move to the Kaga ruins. *Taphozous p. perforatus* take shelter in the Mandore nullah.

Regarding the home range of these bats, something definite can be said only about the Pipistrelle which selects its small territory and never goes off the 'track'. *Megaderma l. lyra* moves near the trees and buildings, captures the prey and hangs in any verandah or over a branch of a tree and finishes the meals.

Further work is, however, needed to have a better idea of the summer and winter movements of the bats.

3. Limiting factors

The mortality is high during infancy of the bats since the babies fall down on the floor quite often and cannot fly. In nature, domestic cats and False Vampires have been observed to destroy bats. Ratcliffe (1932) observed in Australia that the crocodiles snap the flying foxes as they fly down to drink water. According to same author, other animals which feed on *Pteropus* are: *Varanus* spp.; the Carpet

Snake, *Python* spp.; the Wedge-tailed Eagle, *Uroeliis audax* ; and the Sea-eagle, *Haliactus leucogaster*. In the day when they are disturbed and fly out of their roost, kites and crows also prey upon them.

4. *Breeding and sex-ratio*

In the desert region the breeding season of the bats lasts from March to May. The majority of births occur by the end of April.

Sex-ratios (Table 1).—Out of seven species of bats collected from the Rajasthan desert, males in four species outnumber the females ; in the other three, females are more common. I found that bats of the genus *Rhinopoma* (*R. kinneari* 52.3 per cent ; *R. h. hardwickei* 61.9 per cent) show a clear preponderance of males, while Abdulali's (1949) results show the males of these species as only 32.6 per cent and 26.7 per cent respectively.

TABLE 1.—*Sex-ratios of bats of the Rajasthan Desert*

	Species	Males	Females	Total	%Males
1.	<i>Pteropus g. giganteus</i>	12	6	18	66.6
2.	<i>Rhinopoma kinneari</i>	157	143	300	52.3
3.	<i>Rhinopoma h. hardwickei</i>	13	8	21	61.9
4.	<i>Taphozous p. perforatus</i>	24	19	43	55.6
5.	<i>Taphozous k. kachhensis</i>	18	45	63	28.5
6.	<i>Megaderma l. lyra</i>	12	26	38	31.6
7.	<i>Rhinolophus l. lepidus</i>	6	12	18	33.3

IV—SUMMARY

1. Bats from the Rajasthan desert were collected during 1953-1956. This paper deals with taxonomy and biology of nine species of bats.

2. Certain variations in the colour and skull structure of *Rhinopoma kinneari* are pointed out.

3. The following bats are reported for the first time from the Rajasthan desert : *Pteropus g. giganteus*, *Rhinopoma kinneari*, *Taphozous p. perforatus*, *Taphozous k. kachhensis*, *Megaderma l. lyra*, *Rhinolophus l. lepidus* and *Scotophilus heathi*.

4. The activities, relative numbers, limiting factors, movements, food, breeding and sex-ratios, etc., of these bats are discussed.

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TABLE 2.—*Body and cranial measurements of bats from Rajasthan.*

Abbreviation	<i>Pteropus g. giganteus</i>				<i>Rhinopoma kinneari</i>			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
	Body : 2 ♂♂		Body : 2 ♀♀		Body : 55 ♂♂		Body : 29 ♀♀	
<i>Hb</i>	300.0—350.0	(325.0)	240.0—260.0	(250.0)	70.0—86.0	(78.3)	73.0—84.0	(78.5)
<i>T</i>	..	..	..	..	53.0—66.0	(59.5)	57.5—66.2	(61.8)
<i>E</i>	25.0—31.0	(28.0)	25.0—27.0	(26.0)	17.0—21.0	(19.0)	15.0—21.0	(18.0)
<i>HF</i>	34.0—44.0	(39.0)	40.0—44.0	(42.0)	13.5—16.0	(14.8)	13.0—16.5	(14.8)
<i>FA</i>	150.0—155.0	(152.5)	150.0		64.5—75.0	(69.5)	64.5—72.5	(68.2)
<i>Tr</i>	..	..	..	..	7.2—10.0	(8.6)	6.5—9.0	(7.8)
	Skull 3 ♂♂		Skull 3 ♀♀		Skull 8 ♂♂		Skull 4 ♀♀	
<i>Op</i>	68.0—74.0	(68.3)	64.0		21.0—22.5	(21.3)	20.5—21.0	(20.6)
<i>cb</i>	65.0—70.0	(67.5)	62.0		20.0—21.2	(20.3)	19.0—20.0	(19.2)
<i>on</i>	63.0—78.0	(70.5)	61.0		18.0—19.8	(18.4)	17.5—18.5	(17.8)
<i>zw</i>	37.5—41.0	(39.7)	34.0		12.5—13.5	(13.1)	12.0—13.0	(12.6)
<i>io</i>	10.5		10.5		3.0—3.5	(3.2)	3.0—3.5	(3.1)
<i>cw</i>	17.2—24.8	(20.0)	14.5		8.5—10.0	(9.1)	9.0—9.5	(9.1)
<i>ob</i>	17.0—18.0	(17.5)	15.0		8.0—9.5	(8.3)	7.8—9.0	(8.2)
<i>md</i>	13.5—14.0	(13.7)	13.8		6.8—7.5	(7.1)	6.0—6.5	(6.3)
<i>pm</i>	36.0—41.0	(39.5)	32.0		11.2—12.0	(11.8)	11.0—11.5	(11.1)
<i>al</i>	14.0		13.0		6.5—7.5	(7.0)	7.0	
<i>ltb</i>	4.0—6.0	(5.0)	7.0		5.0—5.5	(5.1)	5.0—5.2	(5.1)
<i>btb</i>	3.0—4.0	(3.5)	5.0		3.5—4.0	(3.8)	3.2—4.0	(3.6)
<i>ln</i>	23.0—36.0	(29.5)	20.0		6.0—7.0	(6.2)	6.0—8.0	(6.8)
<i>wn</i>	8.0—8.5	(8.2)	6.5		5.0—5.5	(5.3)	4.0—6.0	(5.2)
<i>pl</i>	36.0—40.0	(38.0)	35.0		6.5—7.0	(6.7)	7.0—8.8	(7.8)
<i>lut</i>	30.0—31.2	(30.6)	30.0		8.0—9.0	(8.3)	8.0	
<i>llt</i>	29.0—30.4	(29.7)	30.0		9.0—9.2	(9.1)	8.8—9.1	(8.9)
<i>ml</i>	52.0—57.0	(54.5)	50.0		15.0—16.0	(15.4)	14.0—15.0	(14.5)

TABLE 3.—*Body and cranial measurements of bats from Rajasthan.*

Abbreviation	<i>Rhinopoma h. hardwickei</i>				<i>Taphozous p. perforatus</i>			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
	Body : 3 ♂♂		Body : 2 ♀♀		Body : 3 ♂♂		Body : 2 ♀♀	
<i>HB</i>	53.0—66.0	(61.3)	63.0—65.0	(64.0)	69.0—86.0	(75.5)	80.0	
<i>T</i>	61.0—67.0	(65.0)	65.0—67.0	(66.0)	15.0—28.2	(19.6)	16.2—30.4	(23.0)
<i>E</i>	15.0		15.5—19.0	(17.2)	15.0—17.0	(16.0)	15.5—16.0	(15.7)
<i>Hf</i>	12.0—13.0	(12.6)	12.0		10.0—12.0	(11.0)	12.0	
<i>FA</i>	56.0—59.0	(58.1)	58.0—59.0	(58.5)	60.0—63.0	(61.5)	61.0—61.5	(61.2)
<i>Tr</i>	7.0—8.0	(7.3)	7.5—8.0	(7.7)	5.0—6.0	(5.5)	5.0	
	Skull : 3 ♂♂		Skull : 2 ♀♀		Skull : 2 ♂♂		Skull : 2 ♀♀	
<i>op</i>	18.0—19.0	(18.5)	18.5—19.2	(18.8)	20.4—21.0	(20.7)	19.2—20.0	(19.6)
<i>cb</i>	17.2—19.5	(18.4)	18.2—18.6	(18.4)	19.5—19.8	(19.6)	18.5—19.0	(18.7)
<i>on</i>	16.0—17.0	(16.4)	16.0—16.5	(16.2)	17.0—19.6	(18.3)	16.8—19.2	(18.0)

TABLE 3.—*Body and cranial measurements of bats from Rajasthan—contd.*

Abbreviation	<i>Rhinopoma h. hardwickei</i>				<i>Taphozous p. perforatus</i>			
	Male		Female		Male		Female	
	Range	Mean \bar{x}	Range	Mean	Range	Mean	Range	Mean
	Skull : 3 ♂♂		Skull : 2 ♀♀		Skull : 2 ♂♂		Skull : 2 ♀♀	
<i>zw</i>	11·0		11·0		11·0—11·5	(11·2)	11·0—11·2	(11·1)
<i>io</i>	3·0		3·0		7·0		6·5—6·8	(6·6)
<i>cv</i>	8·0—9·0	(8·3)	8·0—8·5	(8·2)	9·5—10·2	(9·8)	9·2—10·2	(9·7)
<i>ob</i>	6·5—8·0	(7·1)	7·8		9·2—10·0	(9·6)	9·6—9·8	(9·2)
<i>md</i>	6·5—7·0	(6·8)	6·0—6·2	(6·1)	6·5—6·8	(6·6)	6·8—7·0	(6·9)
<i>pm</i>	10·0—11·0	(10·6)	10·0—10·2	(10·1)	11·0		11·0	
<i>al</i>	4·5—7·0	(6·0)	5·0—5·8	(5·4)	5·0—5·8	(5·4)	5·5—6·5	(6·0)
<i>ltb</i>	3·0—4·5	(4·0)	4·0—4·5	(4·2)	4·5—4·8	(4·6)	4·5	
<i>btb</i>	2·0		2·0		4·0		3·5—3·8	(3·6)
<i>in</i>	4·0—5·0	(4·8)	5·0—5·2	(5·1)	5·5		5·2—5·5	(5·3)
<i>wn</i>	6·5—7·0	(6·8)	6·5—6·8	(6·6)	7·6—7·8	(7·7)	7·5	
<i>pl</i>	8·0—8·5	(8·1)	8·0		8·0—10·8	(9·4)	9·2—11·0	(10·1)
<i>lut</i>	7·0		7·0		9·0		9·0—9·2	(9·1)
<i>llt</i>	8·0		8·0		8·0—8·5	(8·2)	8·0	
<i>ml</i>	12·0—13·0	(12·6)	13·0		15·2		14·6—14·8	(14·7)

TABLE 4.—*Body and cranial measurements of bats from Rajasthan.*

Abbreviation	<i>Taphozous k. kachhensis</i>				<i>Megaderma l. lyra</i>			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
	Body : 2 ♂♂		Body : 1 ♀		Body : 4 ♂♂		Body : 2 ♀♀	
<i>HB</i>	94.0—95.0	(94.5)	86.0		72.5—81.0	(75.8)	83.0	
<i>T</i>	32.0		34.0					
<i>E</i>	20.0—21.0	(20.5)	18.0		26.0—32.0	(30.0)	28.0—37.0	(32.5)
<i>HF</i>	16.0—16.5	(16.2)	11.0		14.0—17.0	(15.2)	15.0—16.0	(15.5)
<i>FA</i>	71.5—74.0	(72.7)	74.0		63.0—64.0	(63.5)	66.0—70.0	(68.0)
<i>Tr</i>	5.5—7.0	(6.2)	5.5		15.0—17.0	(16.0)	17.0—20.0	(18.5)
	Skull : 4 ♂♂		Skull : 2 ♀♀		Skull : 2 ♂♂		Skull : 1 ♀	
<i>op</i>	27.2—28.8	(28.0)	18.0—19.0	(28.5)	27.0—30.5	(28.7)	28.0	
<i>cb</i>	25.0—28.0	(26.1)	25.8—26.0	(25.9)	24.0—26.5	(25.2)	26.0	
<i>on</i>	23.0—28.0	(26.1)	24.0—25.0	(24.5)	22.0—22.8	(22.4)	22.0	
<i>zw</i>	12.2—15.0	(14.3)	14.0—16.5	(15.2)	16.0—16.5	(16.2)	16.5	
<i>to</i>	6.5—9.0	(8.0)	8.0—8.4	(8.2)	4.5—5.0	(4.7)	5.0	

TABLE 4.—*Body and cranial measurements of bats from Rajasthan —contd.*

Abbreviation	<i>Taphozous k. kachhensis</i>				<i>Megaderma l. lyra</i>			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	
	Skull : 4 ♂♂		Skull : 2 ♀♀		Skull : 2 ♂♂		Skull : 1 ♀	
<i>cw</i>	10.2—11.0	(10.9)	11.2—12.0	(11.6)	12.0		13.0	
<i>ob</i>	9.0—9.8	(9.3)	9.2—10.0	(9.6)	11.0—12.0	(11.5)	11.5	
<i>md</i>	7.0—8.8	(8.1)	8.5—9.5	(9.0)	6.8—7.0	(6.9)	6.2	
<i>pm</i>	11.0—14.0	(13.0)	14.0		13.8—14.8	(14.3)	14.2	
<i>al</i>	5.5—6.5	(5.9)	5.5—6.0	(5.7)	5.8—8.0	(6.9)	8.0	
<i>tb</i>	3.5—4.5	(3.9)	3.8		3.2—4.0	(3.6)	4.0	
<i>btb</i>	3.0—3.8	(3.2)	3.0		2.0—3.0	(2.5)	2.5	
<i>in</i>	8.5—10.0	(9.1)	9.8—10.0	(9.9)	6.5—7.0	(6.7)	7.0	
<i>wn</i>	8.8—10.0	(9.6)	9.8—10.0	(9.9)	7.8—8.0	(7.9)	8.0	
<i>pl</i>	12.0—14.0	(13.0)	13.0—16.0	(14.5)	10.0—10.8	(10.4)	11.0	
<i>tnt</i>	10.5—11.0	(10.8)	10.2—11.0	(10.6)	11.5—12.0	(11.7)	12.0	
<i>llt</i>	12.0—13.0	(12.3)	12.0—13.0	(12.5)	13.0—13.5	(13.2)	14.0	
<i>ml</i>	20.0—21.0	(20.3)	20.2—21.0	(20.6)	19.0—21.0	(20.0)	18.0	

TABLE 5.—*Body and cranial measurements of bats from Rajasthan.*

Abbreviation	<i>Rhinolophus l. lepidus</i>				<i>Pipistrellus mimus glaucillus</i>	
	Male		Female		Male	Female
	Range	Mean	Range	Mean		
	Body : 3 ♂♂		Body : 4 ♀♀		Body : 1 ♂	Body : 1 ♀
<i>HB</i>	43·0		38·0—40·0	(39·1)	37·1	34·0
<i>T</i>	19·0—23·0	(20·9)	18·0—21·0	(19·8)	24·5	23·5
<i>E</i>	13·0—15·0	(14·0)	12·0—14·0	(13·1)	9·0	8·5
<i>FA</i>	38·0—40·0	(39·0)	37·0—40·0	(39·0)	29·5	28·8
<i>HF</i>	7·0—8·0	(7·6)	6·0—7·0	(6·4)	5·0	5·0
<i>Tr</i>	—	—	—	—	4·0	4·0
	Skull : 2 ♂♂		Skull : 2 ♀♀		Skull : 1 ♂, damaged	
<i>op</i>	16·0—17·5	(16·7)	16·0		11·4	
<i>cb</i>	15·0—16·0	(15·3)	14·0—15·0	(14·5)	10·8	
<i>on</i>	11·5—11·8	(11·6)	11·5—11·8	(11·6)	10·2	
<i>zw</i>	9·0		8·0—8·2	(8·1)	7·2	
<i>io</i>	2·5—3·0	(2·7)	2·5—2·8	(2·5)	3·4	

TABLE 5.—*Body and cranial measurements of bats from Rajasthan—contd.*

Abbreviation	<i>Rhinolophus l. lepidus</i>				<i>Pipistrellus mimus glaucillus</i>	
	Male		Female		Male	Female
	Range	Mean	Range	Mean		
	Skull : 2 ♂♂		Skull : 2 ♀♀		Skull : 1 ♂, damaged	
<i>cw</i>	6.5—6.8	(6.6)	6.0—6.8	(6.4)	6.2	
<i>ob</i>	5.8—6.0	(5.9)	5.8—6.2	(6.0)		
<i>md</i>	5.0		5.0—5.5	(5.2)	4.2	
<i>pm</i>	9.0—9.5	(9.2)	9.0—9.5	(9.2)	6.4	
<i>al</i>	4.8—5.0	(4.9)	4.5—5.0	(4.7)		
<i>ltb</i>	5.0		5.0			
<i>btb</i>	4.0		4.0			
<i>in</i>	4.2—4.5	(4.3)	4.2—4.5	(4.3)		
<i>cb</i>	3.8—4.0	(3.9)	3.5—4.5	(4.3)		
<i>pl</i>	5.0		5.2		4.8	
<i>lat</i>	6.0—6.5	(6.2)	6.0—6.5	(6.2)		
<i>llt</i>	6.5—7.0	(6.7)	6.5—7.0	(6.7)		
<i>ml</i>	9.5—10.0	(9.7)	10.0		7.8	