



# FAUNA *of* AUSTRALIA

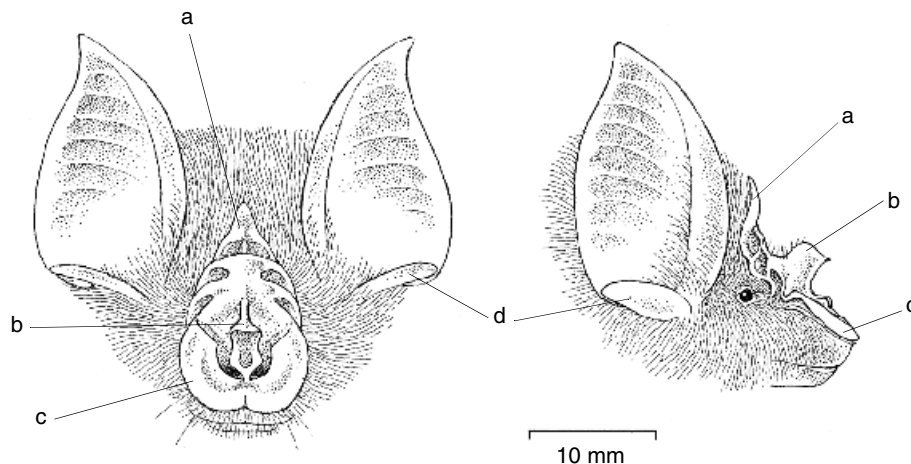
## 40. RHINOLOPHIDAE

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## DEFINITION AND GENERAL DESCRIPTION

Members of this family of bats derive their common name ‘horseshoe bats’ from a characteristic noseleaf with a horseshoe-shaped cutaneous plate that surrounds and surmounts the nostrils. This noseleaf is further complicated by two other elements. The horseshoe merges with a triangular, pointed and pocketed structure, the lancet, which stands erect behind the horseshoe and above the tiny eyes. The sella is a flat, strap-like structure that rises from behind the nostrils and stands erect in the middle of the noseleaf. It is attached to the lancet by a connecting process that acts like a buttress (Fig. 40.1). The noseleaf of rhinolophids superficially resembles that seen in the closely related family Hipposideridae, but there are pronounced differences between the two. Rhinolophids have large, highly mobile ears which curl forward at their base to form an antitragus. They do not possess a tragus.



**Figure 40.1** Head of Eastern Horseshoe-bat (*Rhinolophus megaphyllus*) showing: (a) the characteristic lancet; (b) sella; (c) horseshoe-shaped noseleaf; (d) the antitragus of the ear. (© ABRS) [F. Knight]

The fur of rhinolophids is a light brownish grey, often with a paler tip and more greyish in juveniles. Bright reddish brown moult forms appear regularly in Eastern Horseshoe-bats (*Rhinolophus megaphyllus*) in northern Australia.

One of the most characteristic internal features of the rhinolophids is the degree of fusion in the elements of the shoulder girdle. In this area, fusion of the seventh cervical vertebra and the first thoracic is so complete that their boundaries cannot be detected. This unit is fused with the first rib which in turn fuses with the presternum and ventral half of the second rib; the region between is completely filled with bone. The foot is normal in that the hallux has two phalanges, and the other toes three. The pelvis is unusual in that the ischium and pubis are so reduced that the dorsal and ventral profiles of the innominate bone are nearly parallel. The lumbar vertebrae are not fused, but the centra of the 5th and 6th lumbar have distinctly bifid or double hypophyses. The skull has no postorbital process and the palate is deeply emarginate both anteriorly and posteriorly, such that its median length is less than the least distance between tooth rows.

## HISTORY OF DISCOVERY

Early taxonomists associated horseshoe bats with the Vespertilionidae, and the family Rhinolophidae was first recognised as distinct by Gervais (1854), although it was then combined with the Hipposideridae. Its separation from the latter took place when Dobson (1878) recognised the subfamilies Rhinolophinae and Phyllorhinae. A number of taxonomists have subsequently included the Hipposideridae as a subfamily of the Rhinolophidae, but the current opinion is that they warrant familial distinction. The generic name *Rhinolophus* was first used by Lacépède (1799).

The Eastern Horseshoe-bat was described by Gray (1834) as *Rhinophyllotis megaphyllus* from a specimen collected by G. Bennett from the Moorumbidgee [sic] River, New Holland. Ryan (1965) showed that the type locality was actually Cave Flat, now submerged by the waters of Burrunjuck Dam. Allen (1933) described the subspecies *R. m. ignifer* from Coen, now synonymised with *R. m. megaphyllus* (Koopman 1984a).

The Large-eared Horseshoe-bat (*Rhinolophus philippinensis*) was described by Waterhouse (1843) from a specimen collected in the Philippines. Its presence in Australia was first recorded by Tate (1952a) who called it *R. maros robertsi* from specimens collected at Mount Amos near Cooktown. *Rhinolophus maros* was subsequently recognised as a junior synonym of *R. philippinensis* (Laurie & Hill 1954).

## MORPHOLOGY AND PHYSIOLOGY

### External Characteristics

The complex noseleaf is composed of three parts. Anteriorly, above the upper lip and lying close to the forepart of the face, is the anterior noseleaf (the horseshoe), a thin, flattish outgrowth of skin covering the sides and forward extremity of the muzzle with the general outline of a horseshoe. This leaf is deeply notched at the mid-point of the anterior margin and includes the nostrils in a depression at its inner margin. At its posterior end it passes into the more erect lancet (Fig. 40.1). Between these two, and occupying the centre of the face between the eyes and nostrils, lies the sella which projects forward, and is usually a less foliaceous structure than the others. The purpose of the noseleaf appears to be as a directional beamer of the ultrasonic signals emitted via the nostrils.

The ears are large and widely separated. The deeply recessed shell is of a characteristic shape, the inner margin having an even convex sweep. The outer margin is convex at the base has an abrupt concavity near the apex, forming a sharp outwardly curving tip (Fig. 40.1). No tragus is present, but the antitragus is much enlarged and appears as a broad fold across the bottom of the ear.

The wings are short and rounded. The index finger consists of the metacarpal alone without phalanges, as in the Emballonuridae and Hipposideridae. Digits III, IV and V each have two phalanges, shortening of the wing at rest being achieved by folding their end joints under. The interfemoral membrane is supported at the sides by short curved calcanea and throughout its mid-length by the moderately long tail, which is included in it to the tip or within one vertebra of the tip. At rest, the tail, together with the interfemoral membrane, folds upwards over the lower part of the back.

Rhinolophids are small, insectivorous bats. The pelage is moderately long and soft; in Eastern Horseshoe-bats it exhibits two colour phases, grey-brown and red-brown. The red-brown phase is not permanent and undergoes colour changes that vary according to age and sex (Young 1975). Females possess a



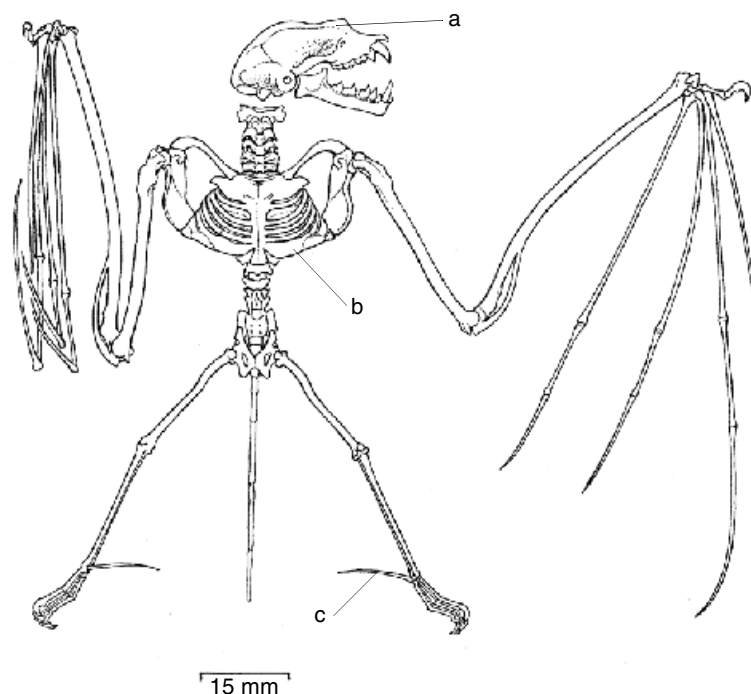
pair of non-functional nipples situated in the pubic region. The functional pair of nipples is in the axillary region. As the bats become older, their fur takes on a gingerish colour, particularly around the face and bordering the interfemoral membrane. Prior to their first moult, young bats are light grey.

### Body wall

The dorsal and ventral surfaces of the body are densely furred. The wings and tail membrane are generally naked, but the ear is lightly furred on the inner margin. Several large vibrissae occur on the face and around the noseleaf and may be species-specific. Skin is thinnest on the wing membranes and is two to three times thicker on the exposed skin of the nose, lips and soles (Ackert 1914). The dermis of bat skin is thinner and more cellular than that of other small mammals (Quay 1970a) and contains large quantities of striated muscle fibres which possibly have a hair erector function, as no smooth muscle arrectores pilorum have been found in the Microchiroptera (Quay 1970a). The facial skin of *Rhinolophus ferrumequinum* contains sudoriferous glands (Sekine 1966) and axillary glands are present. These are associated with hair tufts in several other rhinolophids (Rosevear 1965).

### Skeletal System

The nasal branches of the premaxillae are absent and the palatal branches are not fully developed. The latter are narrowly strap-shaped, partly cartilaginous and not fused with each other or with the maxillaries. Above the nasal aperture the bones are slightly inflated into the bipartite dome. The palate without the loosely attached premaxillaries is so deeply emarginate at each end that it is shorter than it is broad. There are no postorbital processes, but there is generally a low sharply defined sagittal crest (Fig. 40.2). The tympanic bullae are small, the cochleae large and basisphenoid pits are absent. The dental formula is: I 2/4 C 2/2 PM 4/6 M 6/6 = 32.



**Figure 40.2** The skeleton of a rhinolophid bat shows the extreme elongation of the forearm bones compared with those of the hind limb. (a) Characteristic features are the shape of the skull; (b) fused ribs and sternum; (c) prominent calcar or heel spur, which helps support the interfemoral (tail) membrane. (© ABRS)

[F. Knight]

The upper incisor is very small, but usually well formed and has a distinct rounded crown with a slight cusp on the inner side. The lower incisors are trifid, the outer one is larger than the inner and the four teeth form a continuous row between the canines. The upper canines are heavy, simple in form, without secondary cusps or conspicuous cingula, but the lower canines are rather weak. The first upper premolar (PM<sup>3</sup>) and second lower premolar are small, functionless, and usually crowded out of the tooth row. The other teeth show no special peculiarities; M1 and M2 are without a hypocone, M3 has five cusps and three commissures, and in most species there is a rudimentary fourth, the crown area of which is much more than that of M1 or M2. The lower molars have cusps and are all well developed and in a normal position.

The postcranial osteology of rhinolophids reflects a design which increases the efficiency of flight. The vertebral column is typically mammalian but the fifth and sixth lumbar have a distinct double or bifid hypophysis (Miller 1907). The chiropteran sternum (Fig. 40.2) is composed of two basic parts: the manubrium and the body (mesosternum and xiphoid portions). A single vertical and two lateral processes are usually born by the manubrium. The clavicles and costal cartilages of the first ribs articulate with the lateral processes. In rhinolophids the vertical lobe on the presternum is poorly developed. The manubrium is more flattened and shield-like than in other families and two foramina pierce the lateral lobes. A secondary lateral process from the lateral lobes of the presternum is also present.

The ribs are equal in number to the thoracic vertebrae and are noted for their proportional length. All are double headed and Vaughan (1959) reports that the heads of the last two or three merge. The ribs are greatly flattened (Dobson 1878) and the first and second are coalesced. The general outline of the scapula is oval, the length being about twice the width. There is a deep notch and a ventrally directed flange in the coracoid border in rhinolophids. The coracoid process is untapered and has a notch in the axillary border.

The head of the humerus projects medially from the long axis of the shaft in most bats and the head is generally circular in outline. In rhinolophids the head is an elongated oval and what appears to be a vestige of the olecranon fossa is present (Walton & Walton 1970). The shaft of the radius is generally arched slightly and round in cross-section and the ulna is quite small and rudimentary. The sesamoid present in the elbow is apparently unique in the Chiroptera (Walton & Walton 1970). The carpals are generally divided into two rows with the scaphoid and lunar of the proximal row becoming fused during embryonic development (Grassé 1955a). Bat metacarpals are slender, cylindrical bones expanded distally at the articulation with the phalanges and are comparatively shortest in the rhinolophines and pteropines (Allen 1893). The pollex has two phalanges and in rhinolophids there is only the metacarpal present on the second digit. This metacarpal lies close to the metacarpal of the third digit, serving to strengthen the wing's leading edge (Miller 1907). Only two phalanges are present in rhinolophids although the usual number of phalanges present in digits III, IV and V is three.

In bats the ventral portion of the pelvic girdle projects forward slightly and the pubis and ischium are at right angles. In contrast to the well-developed pectoral girdle, the pelvis appears small and weak. In rhinolophids the pubic and ischial elements are reduced in size, in turn reducing the size of the obturator foramen to about twice that of the acetabulum (Walton & Walton 1970). The femur is similar in construction to the basic mammalian pattern and bears two trochanters, both round and nearly equal in size (Dobson 1878). The tibia of rhinolophids is slender and well developed, but has lost many of the grooves associated with muscle attachments present in mammals with quadrupedal locomotion. Miller (1907) describes a complete fibula for rhinolophids. The tarsus is short and composed of seven bones. The fibula articulates with the first

row (calcaneus) rather than with the astrogalus (Grassé 1955a). The toes of bats are equal in length, clawed and laterally flattened. The hind foot is plantigrade and directed caudad on a flat surface. The dorsal surface faces dorsad and the palmar faces ventrad (Grassé 1955a).

### Locomotion

Rhinolophid wings average the lowest overall aspect ratio of all bats (Smith & Starrett 1979). Eastern Horseshoe-bats have a very high wing/uropatagial ratio (17.2), but the limiting effects of this upon manoeuvrability is countered by the combination of a moderately low wing loading (0.18) and a very low aspect ratio (6.4, including uropatagium) (Dwyer 1965a). Dwyer (*op. cit.*) also noted the ability of Eastern Horseshoe-bats to hover. Rhinolophids never crawl on a flat surface, nor do they move more than a step or two while landing at a roost. Almost all positional changes at a roost occur as a result of flying. Eastern Horseshoe-bats can take off from the surface of water.

### Feeding and Digestive System

Eastern Horseshoe-bats are aerial insectivores which hunt near the ground and frequently perch in small bushes from where they will sally forth after insects (Fenton 1982b). Food items are thoroughly chewed by the high cusped molars and the stomach becomes distended after feeding. The gastrointestinal tract is typical of a small mammalian insectivore.

### Circulatory System

The circulatory system is typically chiropteran. The body temperature at rest is similar to the ambient temperature, with a slight lowering of the body temperature occurring during sleep in Eastern Horseshoe-bats in warm caves in tropical areas. The rewarming speed of Eastern Horseshoe-bats is very rapid (Kulzer *et al.* 1970).

### Respiration

Like all bats, the lungs of rhinolophids are large in comparison to their body size and the lungs of other similar sized animals. Large nasal chambers in the upper respiratory system are involved in the production of the nasally emitted ultrasonic calls. The larynx is linked to the nasopharynx by an elongate, rostrally extended glottis. It is probable that rhinolophids would be unable to breathe if their nostrils were occluded (Novic 1977). The repetition rate of ultrasonic calls is associated with the respiratory cycle and Schnitzler (1970) has shown that rhinolophids produce either a single pulse or a clustered group of pulses in each respiratory cycle.

### Excretion

The paired equi-sized kidneys are typically mammalian, lying dorsally in the peritoneal cavity, the right organ the more anterior. The shape is simple, with a single medullary pyramid converging in relatively straight lines to the pelvis to form a papilla on the tip of which the collecting tubes open (Rosenbaum 1970). The calyx penetrates deeply into the renal parenchyma, forming a cleft covered by a thin epithelium. In *Rhinolophus* a papillary sphincter is present about the lumen of the calyx at the fornix, but its significance is obscure (Rosenbaum 1970). The renal pelvis of bats takes a variable shape, but in *Rhinolophus* the hilus protrudes beyond the renal body (Rosenbaum 1970).

### Sense Organs and Nervous System

The rhinolophid eye is typically mammalian, but is very small in relation to overall body size. Rhinolophid bats have difficulty in discriminating shapes and colour, and probably use their eyes to distinguish large shapes (such as predators) and the horizon (Suthers 1970).

The well-developed features of the auditory system have been extensively studied (see Novic 1977). Rhinolophids emit a constant frequency call, often with a number of harmonics, via the nostrils. The returning echo is received by the large ears which alternate from pointing forward to sideways, in synchrony with the call. The structure of the middle ear is unremarkable except for the special enlargement of the basilar membrane and the large size of the middle ear muscles, which are also richly innervated (Henson 1970a). The superior and inferior colliculi of the brain are exposed and the cochlear nerve nuclei are extramedullary. Neurophysiological evidence suggests that rhinolophid bats are capable of making fine discriminations of frequency and intensity differences, particularly within the frequencies included in their sonal signals (Novic 1977).

### Endocrine and Exocrine Systems

Dwyer (1966d) recorded that the testes in Eastern Horseshoe-bats reach their maximal development in April and May. The testes lie just forward of the penis and the caudal epididymides extend onto the base of the penis. Expansion of the epididymides is evident in May and persists in some males until September or October. Although no other details are available for the endocrine or exocrine glands in Australian rhinolophids, it is probable that they are typically mammalian.

### Reproduction

Information on the reproductive habits of Eastern Horseshoe-bats is contained in Dwyer (1966d) and Young (1975). The Eastern Horseshoe-bat is monotocous and monoestrous. Males become sexually mature early in their second year and females in their second or third year. The uterus is bicornuate but only the right ovary and cornu are functional. Graafian follicles develop in the left ovary but degenerate without rupturing. Copulation occurs in May and sperm is stored over winter in vaginal pockets, thus delaying fertilisation. Only a single young is born, from mid-November to early December. Lactation lasts about 5 weeks and is complete by late January, after which the teats regress. Maximum development of the testes occurs in April and May when they measure 5.5 × 4.5 mm. Expansion of the caudal epididymis is evident in May and persists until about September or October.

No detailed studies have been conducted on Large-eared Horseshoe-bats, but its reproductive behaviour is expected to be similar to Eastern Horseshoe-bats.

### Embryology and Development

From the observations of Dwyer (1966d) the mating to birth period for Eastern Horseshoe-bats can be up to 7 months. The actual gestation period is not known, but the similar sized *R. ferrumequinum* from Europe has a gestation period of around 3 months (Hooper 1962). The young are born head first (Carter 1970); the umbilical cord probably serves as a safety line for the newborn and the placenta is eaten after the neonate has attached itself to a nipple. Newborn rhinolophids are almost naked, have greyish wings, and pink bodies covered with a fine fuzz. The ears appear disproportionately large and cannot be held erect. According to Barrett-Hamilton (1910–1911) the deciduous teeth of the Rhinolophidae are resorbed prior to birth. Young rhinolophids can fly at 6 weeks and by 10 weeks are the same size as adults (Hooper 1962).



## Ultrasonics

Rhinolophids have a characteristic constant frequency call that has a short terminal downsweep. The call of Eastern Horseshoe-bats has its maximum energy at 71 kHz, with its terminal downsweep going down to 62.4 kHz (Fenton 1982b). The call lasts about 20 ms and no harmonics are apparent. The call of Large-eared Horseshoe-bats lasts 20 ms with its maximum energy at 30 kHz (Fenton 1982b).

## NATURAL HISTORY

### Life History

Rhinolophids are cave-dwelling bats with generally small colonies consisting of less than 10 individuals. Large aggregations of over 1500 have been observed, however, and represent maternity colonies (Dwyer 1966d). Colony sizes in northern New South Wales are smallest in March/April, increase during winter, and largest in October/November prior to the birth of young (Dwyer 1966d). The overall sex ratio in a given population is 1:1, but this varies with the time of year and roost site such that colonies with a pronounced bias for either sex are not uncommon. The maternity sites are usually composed of females only, but occasionally a small number of males (particularly young males from the previous year) can be found mixed with the females. Individuals have been caught 5 years after being banded (Purchase 1969), but survival rates are unknown. No life history studies have been conducted on Large-eared Horseshoe-bats.

### Ecology

Though characteristically cave-dwelling, substitute roosts have been provided by humans in the form of old railway tunnels, abandoned mines, stormwater drainpipes and culverts (Hall, Young & Spate 1974). Occasionally, rhinolophids are found in houses or a shed, and Eastern Horseshoe-bats have been found roosting amongst tree roots in undercut creek banks. Many roosts have a small, restricted entrance with access via narrow vertical drops (Dwyer 1966d). A variety of surfaces such as sloping walls, flat roofs, or indentations can be used for roosting. Flat vertical walls causing ventral body contact are never used, but deep ceiling domes are frequently occupied by single animals, groups of unclustered individuals, and, occasionally, by small clusters. Roost sites are typified by small dimensions, high temperatures and humidities, and frequently have a dirt floor (Hall *et al.* 1974).

Movements are limited; the longest recorded distance for a banded Eastern Horseshoe-bat is 22 km (Dwyer 1966d). Males appear to be more sedentary than females and roost fidelity is high, with no large scale dispersal or migration being recorded (Dwyer 1966d).

Rhinolophids are known to share roosting sites with a large number of other cave-dwelling bats which include *Macroderma gigas*, *Taphozous georgianus*, *T. australis*, *Hipposideros diadema*, *Hipposideros semoni*, *H. cervinus*, *H. ater*, *Myotis adversus*, *Chalinolobus dwyeri*, *Miniopterus schreibersii*, *M. australis* and *Eptesicus pumilus*. More usually, however, they roost away from other bats in another section of the cave or mine. A number of mammalian predators such as Ghost Bats (*Macroderma gigas*) and Foxes (*Vulpes vulpes*) prey on rhinolophids, as do a variety of birds such as hawks, currawongs, magpies and butcherbirds if they emerge too early, or have been disturbed from their daytime roost.

The diet of the two Australian rhinolophids consists of small insects such as moths and beetles which are caught while flying close to the ground (Vestjens & Hall 1977).

There are several areas in northern Queensland where both species of *Rhinolophus* are found in the same cave or mine, but no studies have been conducted on how, or if, they partition habitat or resources.

### Behaviour

When roosting, rhinolophids generally hang closely separated, clinging to the ceiling or sloping wall by the claws on their toes. During periods of inactivity they wrap their wings around their body, a behaviour that readily distinguishes them from vespertilionids. When approached by humans they gyrate, often hanging by one leg only, and flick their ears alternately. Copulation occurs in autumn and early winter in New South Wales (Dwyer 1966d). A copulating pair hangs from the roof of a cave by their toe claws and the male mounts the female from the rear. Chasing, where one bat flies close behind the other around a cave entrance and amongst shrubs at the time corresponding to the probable copulatory period, is also recorded (Dwyer 1966d). Females congregate in late spring to form maternity colonies. Neonates cling in an upright position to the mother's pubic teats and very small young are carried this way for the first week or so. They grip a pubic teat in their mouth and cling to their mother's fur with their sharp and well-developed toe claws and their thumb claw. After this period, young are left in the roost while females go out to feed unencumbered. The young left at the roost form small clusters and commence high-pitched squeaking when they detect movement of any kind.

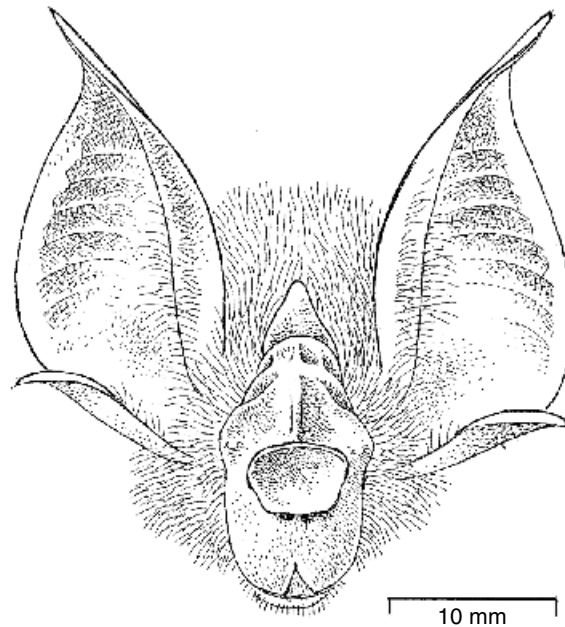
To groom, rhinolophids usually hang by one leg and after moistening the other foot in their mouth, begore using it to comb their fur with a rapid, almost scratching motion. They also use their tongue to lick and clean their wings and the thumb claw is used to scratch in and around their ears and noseleaf.

The feeding behaviour of Eastern Horseshoe-bats was observed by Fenton (1982b) at Chillagoe, northern Queensland. The bat catches insects 1–2 m above the ground after locating its prey from a vantage point, such as a small bush or rock. Most insects are caught initially in the wing or tail membrane and then transferred to the mouth while flying. Most of these flights are of short duration. The flight speed of the Eastern Horseshoe-bats is slow, but it can manoeuvre in confined spaces due to its short, broad wings (Dwyer 1965a). Moth scales are frequently found in the faeces. Limited observations on Large-eared Horseshoe-bats indicate a similar feeding pattern.

### Economic Significance

Although found from eastern Victoria to Cape York, the Eastern Horseshoe-bat (Fig. 40.1) is not particularly common, especially in the southern parts of its range. Because of its dependence on caves with high temperatures and humidities, special consideration needs to be given for the protection of these types of caves and mines in New South Wales and Victoria, particularly ones used as maternity sites. The increasing use of caves for recreation in this part of Australia poses a threat to the long-term survival of this bat.

The Large-eared Horseshoe-bat (Fig. 40.3) has been found as far south as Townsville, but records south of Cooktown are becoming rare. In the more remote areas of Cape York, it does not appear to be under any direct threat.



**Figure 40.3** In Australia Large-eared Horseshoe-bat (*Rhinolophus philippinensis*), the large-eared horseshoe bat is restricted to northeastern Queensland. This cave-dwelling bat also is found throughout southeastern Asia. (© ABRS) [F. Knight]

## BIOGEOGRAPHY AND PHYLOGENY

### Distribution

The Rhinolophidae is found throughout the Old World from Europe and Africa, to south-east Asia and Japan, Philippines, New Guinea and Australia. Within Australia, Eastern Horseshoe-bats are found on the east coast from near Melbourne to Cape York. Most records are from the eastern slopes of the Great Dividing Range, but the species is also found on the western slopes in central and northern New South Wales (Hall *et al.* 1974). It is also found in New Guinea. The Large-eared Horseshoe-bat is found in northern Queensland from about Townsville to Cape York, is widespread in south-east Asia and has been recorded from New Guinea and Timor.

### Affinities with other Groups

With few exceptions, the taxonomic arrangement of bats above the level of species and genera has been erected on the basis of classical studies of the morphology of the bony skeleton (principally the wing, shoulder girdle, sternum and cranium) and, to a lesser extent, on development and structure of the teeth (Dobson 1878; Miller 1907). Although rhinolophids are considered distinct from the hipposiderids on the basis of a number of these features, some authors still merge the two as subfamilies within the single family Rhinolophidae.

From fossil evidence, it appears that the family originated somewhere in the Old World tropics, probably in Africa or southern Asia. Fossil rhinolophids all occur within the present range of the family.

Rhinolophids do not appear to be capable of crossing broad water gaps. They did not spread to Madagascar or extend much beyond New Guinea and Australia in the Indo-Australian Archipelago. The family is not represented in Tasmania and New Zealand.

### Affinities within the Rhinolophidae

The single modern genus, *Rhinolophus*, includes approximately 70 recent species. The sole fossil genus, *Palaeonycteris*, is known only from the Oligocene in Europe. Considering the diversity of *Rhinolophus* in south-east Asia, it is perhaps surprising that only two species are currently known from Australia.

The distribution of the Eastern Horseshoe-bat is thought to be correlated with its preference for roosting in caves which exhibit high temperatures and humidities, have small dimensions, and usually contain rock-falls or dirt-fill. The Large-eared Horseshoe-bat also roosts in warm humid caves, but the precise reason for its limited distribution is unknown.

### Fossil Record

Rhinolophids are known to occur in the Late Eocene to Pleistocene of Europe and the Pleistocene of Asia (Koopman & Jones 1970). The oldest fossil bat from Australia, known from a tooth in the Middle Miocene Etadunna Formation, South Australia, has been tentatively identified as a rhinolophid by Archer (1978d). Further finds in the bat-rich deposits of Riversleigh (Archer & Hand 1984) are likely to give a clearer picture of the fossil history of the family in Australia.

## COLLECTION AND PRESERVATION

### Collection

The collection of Australian rhinolophids is facilitated by their habit of roosting in caves and mines. In winter months, bats are often in a lethargic state and can be easily caught using a small hand-net. When in an active state, rhinolophids can be caught by mist-netting the entrance or a passageway of their roost. Both mist-nets and bat-traps have been successfully used to capture free-flying rhinolophids. Summer months and sites near or above water provide the best conditions for mist-netting or bat-trapping.

Both species of *Rhinolophus* are difficult to keep in captivity and seldom survive more than a couple of days. Other species of *Rhinolophus* have been extensively studied in Europe where elaborate models for high frequency sound analysis have been developed. Cyalume (Buchler 1976) has been successfully used to watch short-term, foraging behaviour (Fenton 1982b). Banding the forearm of Eastern Horseshoe-bats with metal bird bands has caused some inflammatory problems with their propatagium, but fitting the band through a small slit in the propatagium appears to be a successful marking technique.

### Preservation

The most usual method for preserving rhinolophids is in 70% ethyl alcohol containing 2% glycerine. If tissue is to be examined histologically, fixation in 10% neutral formalin is necessary. Preparation of skins is best done from freshly collected material, although frozen specimens can make suitable study skins. During skin preparation, care needs to be taken with the large ears; a cardboard funnel to support the ears while they dry is essential to maintain a life-like shape. The thin tissue of the noseleaf wrinkles and loses its shape after skins are dried. Specimens of the Rhinolophidae, therefore, are best preserved in alcohol.



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