# FAUNA *of* AUSTRALIA

## 39. MEGADERMATIDAE

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## DEFINITION AND GENERAL DESCRIPTION

The family Megadermatidae, which comprises four genera and five species, is represented in Australia by the endemic Ghost Bat (*Macroderma gigas*) (Dobson 1880). With a weight of about 150 g and a wingspan of about 600 mm, it is the largest species of the suborder Microchiroptera in Australia. Worldwide, the only larger species of the suborder are *Vampyrum spectrum* (about 190 g, family Phyllostomatidae) and *Cheiromeles torquatus* (about 170 g, family Molossidae). The maximum recorded weight for a Ghost Bat is 165 g (sex not stated, McKean & Price 1967). Adult males average 146 g (N=40) and non-pregnant females 154 g (N=27). The maxima were 182 g (male) and 216 g (female) (J. Toop personal communication).

Externally, the members of the family can be recognised by the very large ears which are joined at their bases across the head and have very large and bifurcate tragi (Figure 39.1). The tail is very short or absent and a large, well-developed noseleaf is present. The only other family in their geographic range which has such a well-developed noseleaf, the Rhinolophidae (including hipposiderids), has no tragus (see Hall & Richards 1979; Strahan 1983 for illustrations of Ghost Bats).

Freeman (1984), in a comparison of animalivorous bats, commented on the skull and other features of *Macroderma* that are related to carnivory (Figure 39.2). Internally, the premaxillary bones are attached loosely to the maxillaries and are usually cartilaginous. The last cervical vertebra is fused with the first thoracic and the presternum is greatly widened anteriorly and fused to the first rib which is fused with these vertebrae to form a solid ring of bone. There is a single phalanx in the second digit. The dental formula is I 0/2 C 1/1 P 2/2 M 3/3 = 28. There is no epinasal chamber. The trochiter is poorly developed. Some of these features are used by Koopman (1984) in his key to bat families.

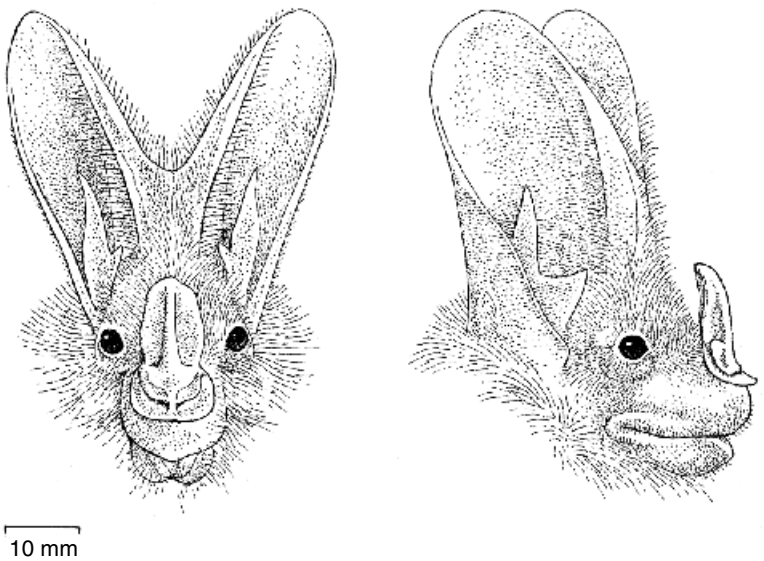


**Figure 39.1** Frontal and lateral views of the head of a Ghost Bat (*Macroderma gigas*). (© ABRS) [F. Knight]

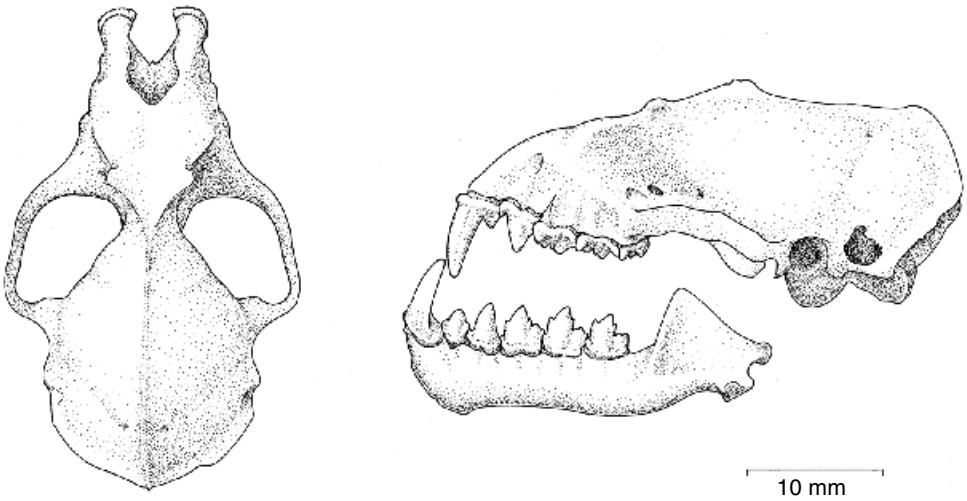


**Figure 39.2** Dorsal and lateral views of the skull of a Ghost Bat (*Macroderma gigas*). (© ABRS) [G. Milledge]

## HISTORY OF DISCOVERY

*Megaderma spasma* was described by Linnaeus as *Vespertilio spasma* in 1758 (Miller 1907), but the family Megadermatidae, although proposed by Allen (1864) when only three of the present species were known, was not accepted fully by taxonomists until Miller published his monograph in 1907. Prior to this work, the generic names applied to the species were changeable and the group was placed by various authors on its own or as a part of the Rhinolophidae or the Nycteridae. These three families are often grouped as the Rhinolophoidea (see Koopman 1984).

The Ghost Bat was first described by Dobson (1880) as *Megaderma gigas*. Miller (1906) proposed the genus *Macroderma*. Dobson's type specimen was in the Göttingen Museum where it had been sent by a Dr Schuette. The specimen cannot be found in the Museum and is considered to have been lost, probably destroyed, when the Museum was bombed during World War II.

Dobson's paper and the catalogue of the Göttingen Museum give the habitat of *Macroderma* as 'Mount Margaret, Wilson's River, central Queensland, Australia (captured by Mr. Wilson)'. Although the locality is not in central Queensland, but in the far south-west of that State, the Wilson River is considered to be that which joins Cooper Creek in the region of 141.5°E, 27.6°S. There was no Mount Margaret in this area before 1880 although there is now a pastoral station with that name at the headwaters of the Wilson River.

According to Jones (1925), two further specimens were obtained from Alice Springs in 1890, another from a cave in the McDonnell Ranges near Alice Springs in 1894 and two more from the same cave at a later unspecified date. Waite (1900) described a female specimen from the Pilbara district of northern Western Australia and compared it with the male type of Dobson's species.

Douglas (1962) described a subspecies, *Macroderma gigas saturata*, from Kalumburu Mission, Western Australia, on the basis of a dark, rather than the more common white, ventral surface. On the basis of the wide variation in the colour on the ventral surface throughout the species range, he (as have bat researchers generally) decided that this character is not a subspecific one (Douglas 1980).

Ghost Bats have a patchy distribution across Australia north of 28°S. Hamilton-Smith (1966) and Molnar, Hall & Mahoney (1984) have published maps of known locations of modern populations of the species and also of fossil sites.

## MORPHOLOGY AND PHYSIOLOGY

The genus *Macroderma* is separated from other members of the family by the presence of only one upper premolar, giving a dental formula of I 0/2 C 1/1 PM 1/2 M 3/3 = 26. In addition, the extremity of the second finger extends beyond the first phalanx of the third finger. Waite (1900), Jones (1925) and Douglas (1962) give measurements for head, ear, noseleaf and the bones of the forelimb and hind limb. Apart from the brain and the skull (Figure 39.2), there are no published descriptions of any soft or hard tissues in *Macroderma*.

Strickler (1977) examined *Megaderma spasma* in his comparative study of the shoulder of Chiroptera. His observations on this species showed parallels with those on *Nycteris* that probably could also apply to *Macroderma* (Figure 39.3), as all species are intermittent slow-flying foragers that are highly manoeuvrable and utilise terrestrial locomotion in feeding. The supraspinatus is relatively large in these species and Strickler suggested that this may be associated with terrestrial locomotion. It may also increase control over movements of the wings. In all rhinolophoids (only one species from each family examined), the latissimus dorsi is divided into two parts (*Rhinolophus* and *Megaderma*) or three (*Nycteris*) rather than undivided as in other bats. This and the reduction of the trochiter allow more control over the movements of the humerus than in other bats, and may be related to the slow and highly manoeuvrable flight of these bats.

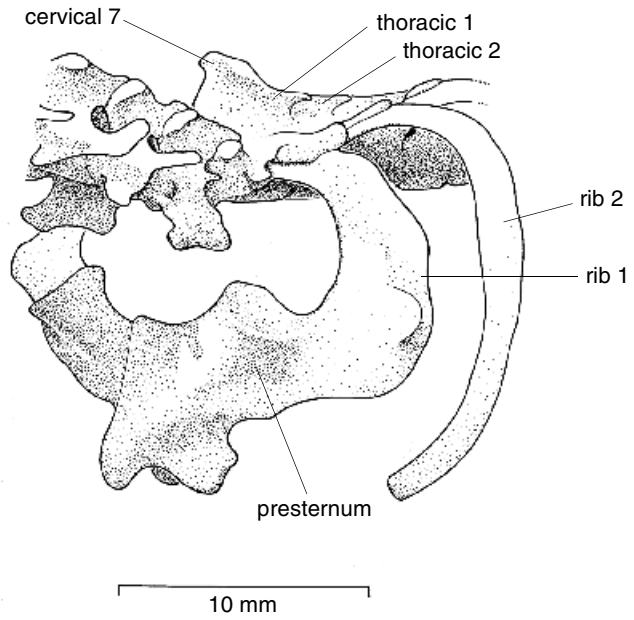


**Figure 39.3** Shoulder girdle of the Ghost Bat (*Macroderma gigas*). (© ABRS) [G. Milledge]

Measurements of body temperature, oxygen consumption and heart rate of *Macroderma* were made by Leitner & Nelson (1967). The species maintains a body temperature of 35°–39°C over ambient temperatures of 0°–35°C, and that there was no evidence for daily torpor or seasonal hibernation. In the thermal neutral zone (30°–35°C) minimal oxygen consumption was 0.94 $cm^3$ $0_2$/g/h, resting heart rate was 235 beats/min. (35°C) and mean breathing rate was 55 breaths/min.

The eyes are large in *Macroderma* and they achieve a spatial resolution of 2.5 cycles per degree (Pettigrew *et al*. 1983a; Pettigrew, Coles & Guppy 1983b). Single neurone recordings by the same authors indicated an auditory sensitivity in the inferior colliculus from 2 kHz to more than 70 kHz. A large number of neurones exhibited the greatest sensitivity to frequencies below 15 kHz. Some of these neurones had response thresholds as low as -15 dB SPL which is below the sensitivity of human hearing at the optimum frequency for sensitivity. The social calls of the species are in the 5–8 kHz band whereas the ultrasonic pulses are in the 20–80 kHz range. The acoustic axis aligns with the eyes at the audible frequency range, but at 60 kHz it is 30° above the visual axis. Freeman (1984) reported that carnivorous bats (including *Macroderma*) produce nasal sonic emissions with their heads tilted negatively to the basicranial axis and that this affects several characters of the skull and jaws. Pirlot & Nelson (1980) made a volumetric analysis of parts of the brain of *Macroderma* and compared them with some other species. The values for the olfactory bulb and the smell cortex (rhinencephalon) are close to the level of the insectivorous bats, suggesting that smell is not a very important sense system in this species.

Stephan & Nelson (1981) figured the brain of *Macroderma* providing brain weights and (see also Stephan *et al*. 1981) a calculated encephalisation index. On this scale, the Megadermatidae, together with the Mormoopidae and the Nycteridae, have an intermediate value between essentially insect-eating species (low values) and fruit and flower-eating species (high values). A stronger correlation was found to exist between the encephalisation index and diet than between the index and taxonomic affinity. Within the Megadermatidae, *Macroderma* had the lowest index: 142. The other four species had values of 165 (*Megaderma lyra*), 165 (*Cardioderma cor*), 169 (*Megaderma spasma*) and 182 (*Megaderma lyra*). Within the Australian Microchiroptera examined, the brain of Ghost Bats was the most highly developed in *Macroderma* with a well-developed cerebellum and neocortex.

Female *Macroderma* have both pectoral and inguinal mammae. In the Pilbara region of Western Australia the young are born towards the end of October or early in November (Douglas 1967). In a study at Mt Etna Caves and Fitzroy Caves National Park (near Rockhampton, Queensland) Toop (1985) found that both sexes aggregate in the warmest caves in spring (September). Females give birth from mid-October to late November, then move the young to other caves as these get warmer through summer. Mating occurs throughout April. Males and females may segregate in May, but reassemble in the warmest caves in June before most of the population disperses at least 50 km during July. The young are carried initially by the mothers, but are later left in the nursery caves at night. The young fly at 7 weeks of age (January) and then accompany their mothers during foraging. They are weaned by March.

## NATURAL HISTORY

There is no published information on longevity. Two Ghost Bats were kept in the Zoophysiologie Department of the Tübingen University for just over 16 years (1969–1985). No other aspects of population dynamics have been studied.

Stomach contents of Ghost Bats were examined by Douglas (1967) and Vestjens & Hall (1977) who found fur, feathers and flightless insects. Pettigrew *et al*. (1986) and Schulz (1986) examined prey remains at feeding trees and day roasts. Douglas (1967) reported on Fr. S. Saz's observations that insects, frogs, geckos and other lizards were captured from the walls of buildings and carried to a particular perch (‘church porch’) by Ghost Bats to be eaten. A resident in Camooweal, Queensland, reported to the author a similar perch on his verandah. In the former case, gleaning from walls was seen in the wet season, but never during the dry season (winter). A seasonal shift in feeding location was

suggested by Douglas (1967). Large young are left in the roosting place (caves, rock crevices, deserted mines) and the bats bring food back so that bits of food accumulate on the floor of the cave. Douglas (1967) examined these and found remnants of house mice, native rodents, small dasyurids, bats, 20 species of birds (up to Red-plumed Pigeon size), reptiles and insects. Jones (1925) and Douglas (1967) observed Ghost Bats capturing bats.

Cave temperatures at Marble Bar of 20 and 21°C were recorded by Douglas (1967) and Kulzer *et al*. (1970) recorded 26°C for Pine Creek. Toop (1985) found that at Mt Etna, Ghost Bats warmed ovens (inverted cones on the roof of caves) to 3–4°C above ambient rock temperatures and had a preferred range of 23–26°C. It is noteworthy that all the above values are below the thermal neutral zone measured by Leitner & Nelson (1967). Ghost Bats leave the Mt Etna caves shortly after sunset and return shortly before sunrise, although individuals may leave or return at any time of the night. In May 1983 12 Ghost Bats were radiotagged by Tidemann *et al*. (1985) at Pine Creek and it was found that on average they travelled 1.9 km from the day roost to a foraging area that could be used by several bats. These flights were fast (average speed 20.7 km $h^{-1}$) and direct. Bats usually returned to the same foraging area on successive nights. Here they foraged for about 2 hours; then they passed 3 or 4 hours of inactivity before resuming foraging in the early morning. During feeding activity the bats produced loud audible bird-like chirps.

Hunting behaviour consisted of observation from a vantage point, (usually on tree trunks within 2 metres of the ground), brief sallies to capture prey (yellow-winged locusts) which were located mostly on the ground and then a return to the observation perch where the prey was eaten.

The prey-catching behaviour of the Ghost Bat in captivity was examined by Douglas (1967), Guppy & Coles (1983) and Kulzer *et al*. (1984). The latter found that Ghost Bats made few echolocation pulses from their observation perches. They appeared to listen for sounds made by the prey then flew one or more reconnoitre flights towards or over it. During these flights and just before takeoff, Ghost Bats emitted echolocation pulses. This 'hawking' method of catching prey is common to all megadermatids, but the methods differ between species. All megadermatids occur in tropical and subtropical areas where there are wet and dry seasons. Kulzer *et al*. (1984) suggest that passive acoustic location of prey may have evolved in association with the dry periods when movement on any dry vegetation can be heard easily.

Kulzer *et al*. (1984) also found that Ghost Bats, like all megadermatids, emit short echolocation pulses of low intensity and of up to four harmonics which are downwardly modulated. The first harmonic (about 20 kHz) was usually weak while the second and third were strong. At the beginning of a prey catching flight the pulses were short (0.8µs) with most energy at about 60 kHz. As the bats landed on the prey the pulses were long (1.7µs), the reverse situation of most insect-catching bats (most energy at about 40 kHz). These emissions were usually in bursts of two to six pulses (see also Guppy, Coles & Pettigrew 1985).

The final attack on the prey was very brief, usually less than a second for mice, which were killed very quickly by a bite about the head-neck region (Figure 39.4). A large prey item was usually dragged as the bat crawled backwards to the observation perch, where the prey was eaten.

The author considers that the Ghost Bat usually roosts in areas receiving twilight rather than complete darkness. Although it is a large bat, its alertness and inconspicuous avoidance of intruders make it difficult to locate in rock crevices. When disturbed they may utter audible sounds (this appears to be associated with squabbles as disturbed bats crawl past other roosting bats). More commonly, disturbed bats silently fly away and, when in small numbers, they are more likely to be seen by someone outside the cave as they fly out than by

**Figure 39.4** A Ghost Bat (*Macroderma gigas*) in flight with prey. (© ABRS) [K. Hollis]

the person in the cave (Douglas 1967). This species may roost singly or in small groups. The largest known roosts are at Mt Etna, Queensland and Pine Creek, Northern Territory where up to 500 may be in the cave. Both are known maternity caves.

Hoogstraal *et al*., (1977) described the bat tick *Argas macrodermae* from the Ghost Bat and Moorhouse, Bain & Wolf (1979) described a filarial nematode, *Josefilaria mackerrasae*, from the pectoral muscles.

The Ghost Bat is listed as an endangered species by the International Union for Conservation of Nature and Natural Resources.

Of the other species of Megadermatidae, *Megaderma spasma* (25 g) is found from India and Sri Lanka through south-east Asia to Java, Sulawesi, the Philippines and the Moluccas. *Megaderma lyra* (about 32 g) is found from Afghanistan to southern China and southwards to Sri Lanka and Malaysia and *Cardioderma cor* (about 25 g) in Ethiopia, Somalia, Kenya, Uganda, eastern Sudan, Tanzania and Zanzibar. *Lavia frons* (about 23 g) is found from Senegal to Somalia and south to Zambia and Zanzibar (distribution from Corbett & Hill 1980; Honachki, Kinman & Koeppl 1982; body weights from Stephan, Nelson & Frahm 1981). All five species of the Megadermatidae are gleaners, mainly of insects, but also (except for *L. frons*) of small vertebrates.

Hand (1985) reported a closely-related fossil from the Riversleigh Miocene deposit. This form is one-half to two-thirds the size of a Ghost Bat. Hand (1985) suggested from observations on the dentition that the Australian megadermatid lineage had diverged from the rest of the family by the Miocene. The earliest fossils of the family are from the late Eocene in Europe.

Molnar *et al*. (1984) reviewed the literature on the present and fossil distribution of the Ghost Bat and discussed various speculations about the fact that all fossil sites, except for two in northern coastal Queensland, are south of the present distribution.

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