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Chalinolobus gouldii.

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Chalinolobus Peters, 1866

Vespertilio Gray, 1843. Type species *V. tuberculatus* Gray, 1843 (as *V. tuberculatus* Forster) by monotypy.

Scotophilus Tomes, 1857:135. Renaming of *V. tuberculatus* Forster.

Chalinolobus Peters, 1866:680. First use of current name.

CONTEXT AND CONTENT. Order Chiroptera, suborder Microchiroptera, family Vespertilionidae, subfamily Vespertilioninae, tribe Vespertilionini (Koopman 1984). The African taxon *Glauconycteris* may be a distinct genus (Dixon and Huxley 1989; Nowak 1994) or a subgenus of *Chalinolobus* (Koopman 1984). *Chalinolobus* has 6 recognized species (with *Glauconycteris* as a separate genus). A key to the species (adapted from Churchill 1998 and Strahan 1995) follows:

1 Geographic range limited to New Zealand .... *C. tuberculatus*
  Geographic range does not include New Zealand 2
2 Fur black, except for white stripes along junction between abdomen and wing membranes, joining at groin to form a white "V" 3
  Fur brown or grey without white abdomen stripes 4
3 Forearm length 38–42 mm .... *C. dwyeri*
  Forearm length 31–36 mm .... *C. picatus*
4 Forearm length usually >40 mm (37.5–47.2 mm); lobes around mouth well developed; fur brown with a distinctly darker, almost black, head and shoulders .... *C. gouldii*
  Forearm length 34–39 mm; lobes around mouth poorly developed or small; fur on body not distinct in color from fur on head and shoulders 5
5 Fur gray, dark at base with white tips; forearm length 31.6–37.1 mm; lobes at corner of mouth and on lower lip poorly developed .... *C. nigrogriseus*
  Fur brown all over, paler abdomen in some individuals; forearm length 34.8–39.1 mm; lobe at corner of mouth small, lobe on lower lip easily seen .... *C. morio*

Chalinolobus gouldii (Gray, 1841)

Gould's Wattled Bat

Scotophilus gouldii Gray, 1841:405. Type locality not given but considered to be either "Launceston, Tasmania" (Thomas 1905) or "Tasmania or the southern mainland" (Tidemann 1986).

Chalinolobus gouldii Dobson, 1878:250. First use of current name combination.

Chalinolobus neocaledonicus Revilliod, 1914:355. Type locality "Nouvelle-Calédonie."

CONTEXT AND CONTENT. Same as for genus. Subspecific distinctions are disputed. *C. g. venatoris* was recognized as a small, dark form from northern Australia, distinct from *C. g. gouldii* in southern Australia (Thomas, 1908), and Koopman (1971) recognized *C. g. neocaledonicus* from Norfolk Island. Although these names are in use (e.g., Dixon 1995), the most recent comprehensive analysis of specimens from the entire range of the species concluded that differences among populations reflect a latitudinal and longitudinal character gradient and that subspecies designations are unwarranted (Tidemann 1986).

DIAGNOSIS. *Chalinolobus* can be distinguished from other genera of bats by distinct fleshy lobes that project downward at the corners of the mouth. *C. gouldii* is the largest species of genus *Chalinolobus*. It has brown fur on back and abdomen, contrasting with blackish fur on head and shoulders. Other *Chalinolobus* have more uniform fur color on body, head, and shoulders (Churchill 1998). Back edge of ear in *C. gouldii* extends down producing prominent lobe or wattle at corner of mouth, and a 2nd narrow lobe is present along lower lip. In contrast, *C. nigrogriseus* and *C. morio* have poorly developed lobes at corner of mouth (Churchill 1998).

GENERAL CHARACTERS. Fur is fine and velvety (Jones 1925). Color gradation occurs through gradual lengthening of rust-colored tips of individual hairs toward tail. Northern form, *C. g. venatoris*, tends to be darker in color than southern form, *C. g. gouldii* (Troughton 1926). Middorsal hairs on a South Australian specimen are 7 mm long (Jones 1925). Membranes are dark brown, almost purplish. Tail is fully enclosed in uropatagium and has 7 free vertebrae.

Face (Fig. 1) is short and flat. Muzzle is broad with a prominent pad on either side of nostrils (Jones 1925). Skin of face is dusky in color. Nostrils face outward. Two glandular elevations occur under chin on either side of midline. Ears are small and round. Tragus is blunt and enlarged at its outer limit. Ear length in specimens from South Australia is 12 mm in males and 12.5 mm in females (Jones 1925), and in 30 specimens from northern Australia it averaged 10.5 mm (range 7.2–13.3 mm—Churchill 1998). Tragus length in specimens from South Australia is 4 mm (Jones 1925) and in 28 specimens from northern Australia averaged 5.4 mm (range 3.7–6.6 mm—Churchill 1998).

Skull (Fig. 2) has a large braincase and a broad low rostrum, two-thirds the length of braincase (Jones 1925). Relative to body size, braincase is large, and this proportion is high for a nonprimate mammal. Means ± *SD* of selected skull characters (in mm) from 18 sites across mainland Australia, Tasmania, New Caledonia, and Norfolk Island for 39 males and 50 females, respectively, are: greatest length of skull, 14.38 ± 0.65, 14.41 ± 0.67; length of maxillary toothrow, 5.67 ± 0.22, 5.70 ± 0.26; basal length of skull, 10.90 ± 0.57, 11.03 ± 0.59; length of palate, 5.23 ± 0.35, 5.19 ± 0.33; maximum width across upper molars, 7.16 ± 0.34, 7.16 ± 0.30; width across upper canines, 5.28 ± 0.23, 5.28 ± 0.30; length of auditory bulla, 3.61 ± 0.20, 3.63 ± 0.26; interorbital breadth, 4.71 ± 0.22, 4.68 ± 0.21; zygomatic breadth, 10.65 ± 0.43, 10.65 ± 0.50; height of braincase, 6.00 ± 0.36, 5.98 ± 0.32; maximum height of skull, 8.01 ± 0.52, 7.90 ± 0.47; length of dentary, 11.38 ± 0.54, 11.46 ± 0.48; moment arm of superficial masseter, 2.41 ± 0.54, 2.46 ± 0.43; and moment arm of medial temporalis, 3.44 ± 0.14, 3.45 ± 0.20 (Tidemann 1986). Means (with parenthetical range) for other selected characters are: length of head and body (mm), 70 (65–75); length of tail (mm), 45 (40–50); length of forearm (mm), 44 (40–48); and mass (g), 14 (10–18—Dixon 1995). Means

FIG. 1. Gould's wattled bat, *Chalinolobus gouldii*, from Picola, Victoria, Australia. Photograph courtesy of L. F. Lumsden.

FIG. 2. Dorsal, ventral, and lateral views of cranium and lateral view of mandible of an adult female *Chalinolobus gouldii* ([Queensland Museum] JM-6328, collected 1 October 1981, 42 km SSW of Cloncurry, Queensland, Tap Camp Diggings; formerly in Los Angeles County Museum). Greatest length of skull is 14.8 mm.

for the same characters for bats from northern Australia are: length of head and body (mm), 52.4 (46.0–60.4; $n = 30$); length of tail (mm), 40.1 (31.0–46.0; $n = 28$); length of forearm (mm), 41.2 (36.6–45.9; $n = 106$); and mass (g), 9.8 (6.8–15.8; $n = 98$—Churchill 1998). Wingspan for 28 bats from northern Australia was 295 mm (273–330—Churchill 1998).

Sexual dimorphism is not evident in the skull and axial skeleton (Taylor et al. 1987; Tidemann 1986). However, a population from Melbourne, Victoria, was sexually dimorphic in mass (mean female mass, 16.9 g; mean male mass, 14.9 g—Dixon and Huxley 1989). Mass varied seasonally in both males and females, with a peak occurring just before winter. Similarly, in the semiarid Mallee region of Victoria, females ($n = 201$) were significantly larger than males ($n = 365$; mean length of forearm ± *SD*: female 44.1 ± 1.2 mm, male 43.5 ± 1.2 mm; mean mass ± *SD*: female 15.3 ± 1.8 g, male 13.0 ± 1.4 g); mass also varied seasonally (Lumsden and Bennett 1995a). In both males and females, mass decreased in late summer and early autumn (January–March) and increased in mid- to late autumn (April–May). Female mass was highest during October, corresponding to the period of pregnancy. In Tasmania sexual dimorphism was not present (mean mass of females 15.0 g, $n = 7$; mean mass of males 14.4 g, $n = 9$—Taylor et al. 1987). *C. gouldii* increases in size from north to south and from west to east (Tidemann 1986). Variation in central Australian populations may be a cline between northern *C. g. venatoris* and southern *C. g. gouldii* (Dixon 1995). Average length of forearm of female and male *C. gouldii* of the semiarid Mallee region of Victoria (see above) was significantly shorter than for individuals captured in the temperate environs of southern Victoria (mean length of forearm ± *SD*: female 46.2 ± 1.5 mm, $n = 67$; male 45.5 ± 2.0 mm, $n = 107$—Lumsden and Bennett 1995a).

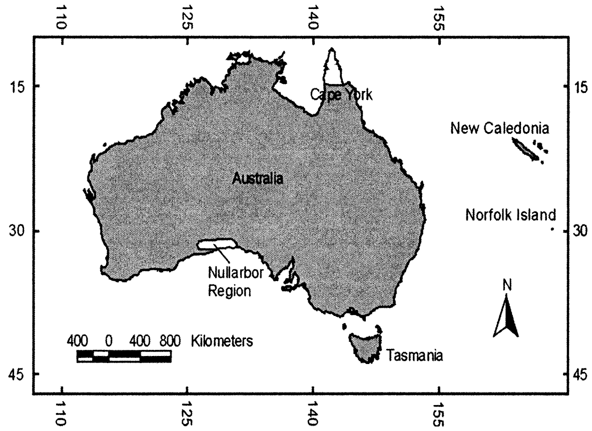

FIG. 3. Distribution of Gould's wattled bat, *Chalinolobus gouldii* (modified from Churchill 1998 and Dixon 1995).

Upper incisors lie in a straight line, with the outer 2 considerably smaller than the inner 2 and separated from canines by a gap. Lower incisors increase in size from i1 to i3, and the series is continuous between canines. Canines are simple and well developed, and cheek teeth are strictly normal (Miller 1907).

DISTRIBUTION. *Chalinolobus gouldii* is widely distributed across mainland Australia but is absent from the top of Cape York Peninsula (Churchill 1998) and possibly the Nullarbor region (Fig. 3; Tidemann 1986). Gould's wattled bat occurs in Tasmania, New Caledonia, and Norfolk Island. Fossils of *C. gouldii* are unknown.

FORM AND FUNCTION. *Chalinolobus gouldii* is a fast flier with limited maneuverability (Fullard et al. 1991). Aspect ratios and wing loadings from individuals from Western Australia, calculated using the methods of both Norberg and Rayner (1987—NR) and McKenzie and Rolfe (1986—MR), are relatively high (aspect ratio ± *SD*, 5.5 ± 0.9, $n = 2$ (NR), 6.6 ± 0.1, $n = 15$ (MR); wing loading ± *SD*, 9.1 ± 1.9 N/m^2, $n = 2$ (NR), 6.9 ± 0.6 N/m^2, $n = 15$ (MR)—Fullard et al. 1991). *C. gouldii* from Tasmania has a comparable aspect ratio (6.1 ± 0.29, $n = 10$—O'Neill and Taylor 1986). *C. gouldii* flight muscles are intermediate in their dependence on anaerobic respiration relative to other species of bats (Muller and Baldwin 1978). Alveolar surfactant levels (a mixture of lipids and proteins on the respiratory surfaces) increase 1.5-fold immediately after arousal. Cholesterol levels in the surfactant increased 1.5-fold during torpor, although overall they are 6 times lower than in other mammals (Codd et al. 2000). Dental formula is i 2/3, c 1/1, p 2/2, m 3/3, total 34.

ONTOGENY AND REPRODUCTION. Although naked young were observed in January in a maternity colony in Melbourne, Victoria, young usually appeared in November or December (Dixon and Huxley 1989). Pregnant females were most common during September and October, lactating females during November and December, and fledged young during December and January (Dixon and Huxley 1989). Initially naked and pink, young have short sleek gray fur after 1 week (Dixon and Huxley 1989). After 1 month, juvenile appearance is similar to that of adults. At this time juveniles have attained adult dimensions (length of forearm) and are able to fly, but they do not attain adult mass until 2–3 months of age (Dixon and Huxley 1989). A similar reproductive pattern occurs in the semiarid Mallee region of Victoria (Lumsden and Bennett 1995a). In this region females can breed in their 1st year but do not breed every year. In December and January, 31% and 19%, respectively, of captured females were nonreproductive. Males have enlarged testes from December through April. Subadult males show testicular development within their 1st months of flying (Lumsden and Bennett 1995a).

In Western Australia the period of birth varies with latitude. It commences from November to December in the southwest region, from early October to early November in the central region, and from late September to early October in the northern region. The birthing period extends for 6–8 weeks (Kitchener 1975).

Females are monoestrous in Western Australia. Pre-estrus occurs from January to March or April (Kitchener 1975); mating starts in May but may occur as late as August. Females store sperm over the winter in a vaginal plug, in uterine glands, and in the uterine part of the oviduct. Ova (2–9) are released from each ovary during ovulation at the end of winter when conception occurs. Gestation lasts ca. 3 months. Pregnancy occurs in both uterine horns, usually resulting in twins. Female *C. gouldii* can store fertile sperm for at least 33 days (Hosken et al. 1996). In males, 60% of sperm is motile and have stable membranes 6–7 months after peak spermatogenesis (Hosken et al. 1996).

ECOLOGY. *Chalinolobus gouldii* uses a variety of habitat types, including open forest, mallee, dense forest, and tall shrubland, as well as urban areas (Dixon 1995). In Victoria it is most abundant in dry forests, woodlands, and mallee scrub (Lumsden and Bennett 1995b). It occurs from sea level to 1,500 m but may be more common at lower altitudes (Lumsden and Bennett 1995b). Predominantly a tree-dweller, *C. gouldii* has also been found roosting in a stump (Tidemann and Flavel 1987), in the nests of birds, in the ceilings and basements of buildings, in a rolled-up canvas blind (Dixon and Huxley 1989), and in the exhaust pipe of a tractor (Dixon 1995). In Victoria *C. gouldii* roosted predominantly in the hollow limbs of living mature *Eucalyptus camaldulensis* (Lumsden and Bennett 1995b). Roost switching was common in individuals faithful to a roost area. Roosts used on successive days were usually within 300 m of each other. Colonies often contain about 30 individuals (Dixon and Huxley 1989; Reardon and Flavel 1987) but reach numbers of up to 200 (Young 1980). Some individuals (primarily males) roost solitarily (Churchill 1998; Lumsden and Bennett 1995b).

Over most of its range, *C. gouldii* is active throughout the year. In cooler climates, however, it may enter hibernation over the winter (Dixon 1995). In Victoria most bats were torpid throughout winter (May to early September), although some awakened every few days and left the roost after dusk (Dixon and Huxley 1989). Torpid bats were also observed in December, indicating that torpor is not restricted to winter. *C. gouldii* can enter and spontaneously emerge from torpor at ambient temperatures as low as 5°C (Hosken and Withers 1997). Above 10°C, *C. gouldii* tends to thermoconform, allowing body temperature to drop to ambient temperature. Below 10°C, torpid *C. gouldii* regulates body temperature by increased metabolic heat production (Hosken and Withers 1997). The metabolic rate at an ambient temperature of 10°C is 0.10 ml O_2 g^{-1} h^{-1}, which is 2% of the mean euthermic value at the same ambient temperature (Hosken and Withers 1997). Thermal conductance is low in *C. gouldii* when it thermoconforms at ambient temperatures of 7–15°C (mean ± *SE* dry thermal conductance = 0.65 J g^{-1} h^{-1} $°C^{-1}$) but increases to normothermic levels in bats that thermoregulate at 5°C (2.48 J g^{-1} h^{-1} $°C^{-1}$—Hosken and Withers 1997).

In Victoria, in summer (December to February), clusters of bats occurred at 4–5 sites and ranged in size from 2 to 44 bats (mostly females and juveniles). In early autumn (March and April) small numbers of clusters of 2–3 bats or 1 large cluster of 7–30 bats were formed. During winter, Gould's wattled bats occupied inaccessible locations, so clustering behavior could not be assessed, but after winter they clustered in 1–2 large groups. Temperature in the vicinity of clustered bats was higher than in the rest of the roost or outside (Dixon and Huxley 1989).

Young usually remained at the maternity roost for <1 year. Long-term residents were all females, with a maximum residency of 5 years. Females outnumbered males 3:1. Adult males were not recorded in the area for >1 year. Many residents (male and female) left the colony before hibernation, and only 9% of banded juveniles remained there after winter (Dixon and Huxley 1989).

Chalinolobus gouldii emerges from its roosts ca. 20 min after sunset (Dixon 1995). In South Australia they are the 1st bats out of their roosts at dusk and forage above and below the forest canopy (Reardon and Flavel 1987). In Tasmania they fly in the open area just below the forest canopy. Flight is direct and rapid, and maneuverability is limited (O'Neill and Taylor 1986). They tend to stay below 20 m and may descend to a height of 1 m above the ground (Dixon 1995).

In northern Victoria *C. gouldii* uses large tracts of protected forest as roosting habitat but readily forages in a woodland–farmland mosaic (generally <5% tree cover—Law 1996). Foraging distances range between 4 and 11 km from the roost, and bats fly directly across open paddocks to forage in woodland patches and clumps of trees in paddocks. Individuals may travel up to 17 km from their roosts (Dixon and Huxley 1989; Lumsden and Bennett 1995b).

Insects of the following orders occurred in a sample of 149 *C. gouldii* stomachs collected from throughout Australia: Blattodea, Plecoptera, Orthoptera, Hemiptera, Coleoptera, Diptera, Lepidoptera, and Hymenoptera (Vestjens and Hall 1977). Moths were the most prominent food item. Ants were identified as both winged and wingless, and several species of the genus *Iridomyrmex*. Scat samples from a maternity colony in Victoria contained lepidopteran fragments during all months of the year and coleopteran fragments in all months except November (Dixon and Huxley 1989). Scarabaeid beetle remains were common. Dipteran fragments, larval dipterans, unidentified caterpillars, and orthopteran fragments (black crickets, *Teleogryllus commodus*) were also present. Tasmanian *C. gouldii* from riparian woodlands fed largely on Coleoptera (O'Neill and Taylor 1989). Caterpillars formed the other major component of the diet. Grass seeds and tiny fragments of twigs were also found in the feces of these bats (O'Neill and Taylor 1989).

Chalinolobus gouldii emits loud, shallow, frequency-modulated echolocation calls (Woodside and Taylor 1985). In southwestern Australia 10 pulses from each of 2 bats averaged 2.7 ± 0.1 ms long, with an average minimum frequency of 29.6 ± 0.5 kHz, an average maximum frequency of 106.1 ± 16.2 kHz (frequency including harmonics), and an average peak frequency of 41.3 ± 0.5 kHz (the frequency of maximum spectral power—Fullard et al. 1991). Although the frequency design of these pulses was similar to that of pulses emitted by New South Wales *C. gouldii*, pulse duration was different (2.7 ms versus 1.3 ms—Fullard et al. 1991; Woodside and Taylor 1985). Other than echolocation calls, *C. gouldii* emits high-pitched "chirps" when in flight, low chittering noises when roosting, and squeaks, chirps, clicks, and a loud, high-pitched buzz when handled (Dixon 1995).

In a maternity colony in Victoria, 2 types of mites (both adults and nymphs) were found on the wings of most bats. These were *Dermanyssus gallinae*, the poultry or bird mite, and *Acarus*, the itch mite. Neither is normally associated with bats. Unidentified nymphal nycteribiids were also present (Dixon and Huxley 1989). Predators of *C. gouldii* include owls (Strigidae), domestic cats (*Felis sylvestris*), lace monitor (*Varanus varius*), tiger snake (*Notechis scutatus*), wedge-tailed eagle (*Aquila audax*), pied butcherbird (*Cracticus nigrogularis*), and pied currawong (*Strepera graculina*—Dixon 1995; Lumsden and Bennett 1995b; Tidemann and Flavel 1987; Young 1980).

REMARKS. *Chalinolobus gouldii* has been known since the early exploration of the interior of southern Australia (Dixon and Huxley 1989). The generic name *Chalinolobus* is Greek for lobe-mouthed, and the species name *gouldii* is a patronymic in honor of John Gould, an English naturalist, author, and artist. Tidemann (1986) questioned the utility of the subspecies *C. g. neocaledonicus* and *C. g. venatoris*, but *C. g. gouldii* and *C. g. venatoris* were recognized by Dixon (1995). The population on New Caledonia was considered a separate species, *C. neocaledonicus*. The population on Norfolk Island may be extinct (Tidemann 1986). We thank L. F. Lumsden, C. R. Pavey, and G. C. Richards for suggesting or providing relevant literature. C. R. Pavey, J. H. Dixon, and L. F. Lumsden provided instructive comments on an earlier draft of the manuscript. L. F. Lumsden provided the photograph of *C. gouldii*.

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