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Notes on the breeding biology, gular gland and roost habits of *Molossus sinaloae* (Chiroptera, Molossidae)

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Abstract

Greasy, odoriferous marks on the dorsum of female *Molossus sinaloae* are apparently produced through contact with the male gular gland. Male gular glands were largest and produced the most secretory material around the time of parturition, when most marks were observed and when lacerations on males were also most frequently observed. The ecological and evolutionary significance of marking is not yet clear.

Introduction

A distinctive morphological feature of many species of molossid bats is the gular gland, a conspicuous structure on the throat (Werner and Lay 1963; Horst 1966; Quay 1970) that produces an oily, musky-smelling exudate. Although the gland is usually apparent only in males, it has been reported to be equally well developed in males and females of a few molossid species (Quay 1970). Horst (1966), observed seasonal fluctuations in male gland size corresponding to breeding cycles in *Molossus rufus* (= *M. ater*), and observed involution of the gland following castration; on the basis of these observations he speculated that the gland's secretions had some role in reproduction. Rasweiler (1987) noted that female *Molossus ater* often nuzzled the gland of a male prior to mating, and (1988) that males sometimes rubbed their gland against females.

In this paper we present observations on the gular gland of male *Molossus sinaloae*, presented in the context of the breeding biology and roosting habits of this species.

Materials and methods

Data were collected in or near Merida, Yucatan, Mexico during ten field seasons (March–May 1971, 1973, 1975; June 1978, May–August 1979; September–November 1976, 1977, 1979, 1983; December–January 1979–1980). The two principal study sites after 1976 were a large, clay-tiled, suburban dwelling (La Casa, in the north-central part of the city) and a man-made pond at a country club on the northern edge of the city, approximately three km NNW of La Casa (Campestre-see Birney et al. 1974, for a detailed description). *Molossus sinaloae* and two other molossids (*M. ater* and *Eumops bonariensis*) roosted in roof crevices at La Casa; Campestre was a *M. sinaloae* drinking site.

Bats were captured in mist nets; bats were either tattooed (Bonaccorso and Smythe 1972) or tagged with numbered, color-coded plastic wing bands (males banded on the left forearm, females on the right forearm). For each capture we recorded: capture time, band or tatoo number (if present), sex, age (neonate, juvenile, subadult, and adult; based upon weight and epiphyseal fusion), forearm length (recorded only once/year/individual), weight, gular gland size (small, medium, or large) and gular gland condition in males (no secretions present, low level of secretion, copious secretions), teat size and lactational status, and presence/absence of embryos by palpation (detectable only during late gestation). Beginning in 1979, we recorded the presence/absence and position of wounds and distinct areas of fur that appeared moistened with light oil (see below). For La Casa captures, precise capture location was also recorded.

Activity within roosts was observed using headlamps and binoculars and, from December 1979 to January 1980, a nightviewing scope. Observations were limited to events at the front of the openings created by the overlapping (pantiled) roof tiles.

Voucher specimens of *M. sinaloae* were deposited at the Biology Department, Central College, Pella, Iowa; The Museum, Texas Tech University, Lubbock, Texas; and Departamento de Conservación, Mexico D. F., Mexico.

Rainfall and other climatic data were recorded daily at the study site during our field seasons. Annual rainfall data for Merida were taken from the world-wide Airfield Summary, National Climate Data Center, Ashville, NC, USA.

Statistical analyses were carried out using the MIDAS computer program of the University of Michigan Terminal System (Fox and Guire 1976), using the SPSS statistical package on a PDP-11 computer at Central College, or on a hand calculator following Sokal and Rohlf (1981).

Results

Only one *Molossus sinaloae* roost area was found in the Merida area, at which bats roosted in gaps beneath ornamental roof tiles on a house (La Casa) (Bowles et al. in press). The roosts were 2.5 to 15 m high and ranged from fairly shallow (< 0.15 m) to moderately deep (0.5–1.0 m).

There was a daytime mean of 20 adult bats present at La Casa during 1979–1980, the year for which our data are most complete. However, typically at least twice that many individuals were captured at La Casa during any given field season, and in one year, 1977, 106 individuals were captured there (vegetation blocked access to some roosts in later years, causing a decline in the number of bats present). There was substantial variation in population size both within and between years. One of the 106 bats banded at La Casa in 1977 was recaptured there six years later, and 15 recaptures (approximately 8 % of the total marked with bands) were made two or more years after marking. However, many bats left La Casa roosts for periods ranging from a single night to many nights, indicating that fidelity to this single roost site was rather low.

Females in this population gave birth to single young synchronously in June in 1978 and again in 1979 (Bowles et al. in press). Macroscopically visible embryos (conceptus size of 2–3 mm) first appeared in March or April (Fig. 1). The very small number of reproductively inactive females (10 of 358) captured either at La Casa or at Campestre during this period suggests that female *M. sinaloae* are reproductively active during their first year. The duration of lactation is approximately 6–8 weeks (Bowles et al. in press). None of 40 adult females captured from September 1979 through January 1980 had embryos detectable by palpation, nor were any lactating. Thus, *M. sinaloae* in the Merida area apparently have a single annual birth period (Bowles et al. in press).

The size and secretory activity of the gular gland in *M. sinaloae* varied through the year, with a high proportion of males with large, copiously secreting glands in May–August (193 of 207 secreting), and a lower proportion in September–January (12 of 25 secreting) (G-test for independence, $G = 29.81$, $df = 1$, $P < 0.0001$; Sokal and Rohlf 1981).

The secretions from the gular gland were highly distinctive: greasy or oily in appearance, viscous, and with a very characteristic and pungent odor. The skin and hair around a copiously secreting gland became matted and greasily moist or wet in appearance. A slight pressure on the edges of the gland often produced a drop of the gland's contents.

In June of 1979 we noted that many captured bats had patches of dorsal fur that appeared matted and wet or greasy. These patches smelled very strongly of the distinctive odor of male gular glands, suggesting that bats might somehow be smeared with the glands during incidental or intentional contact with secreting males. On 23 July 1979, a male within a roost was observed apparently sniffing or searching the dorsum of a female, after which he climbed atop her dorsum and pressed closely against her in a manner which must have forced the gular gland into contact with the inter-scapular region of the female. During this time, the female's 4 week-old pup was roosting within a few cm of the pair. It was not possible to determine if the adult pair was mating, but if the male's gular gland was secreting copiously (as was true of over 90 % of all males at that time) his actions would

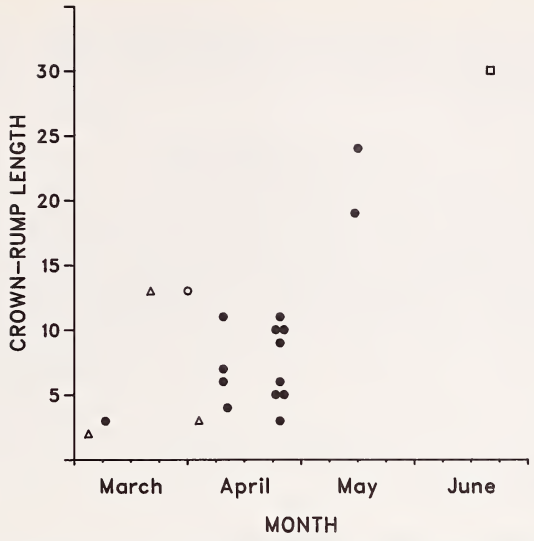

Fig. 1. Crown-rump length of embryos of autopsied female *Molossus sinaloae* from May through June (1971–1978). (Open circle = 1971 [from Bowles 1973]; open square = 1973 [from Birney et al. 1974]; solid circles = 1975; open triangles = 1978.)

have resulted in the smearing of fluid from the gland onto the female. Also in July 1979, an unmarked female was observed to enter a roost containing a secreting male and leave with a dorsal mark. On six subsequent occasions, freshly marked females were captured exiting a roost within 20 minutes of the departure of a secreting male. These observations suggest that the viscous, pungent exudate from the gular gland of adult male *M. sinaloae* is used to mark other individuals.

The marks were oily, strong-smelling spot(s) covering up to four cm^2 of the fur of the marked bat, usually on the dorsum. Marked females that were released immediately after capture and then recaptured within 30 minutes always retained a mark (although it was often less extensive in area, suggesting that marks may have dried or been incompletely groomed away), but on those recaptured after longer intervals marks were often dried, with the fur matted, or were no longer apparent. All but two of the 134 marked animals we captured were females ($P < 0.01$; binomial test, Sokal and Rohlf 1981), and none were neonates or juveniles. Marked females were more common from June to August (132 marked of 236 adult females examined) than from September to January (2 of 29 females) (G-test for independence, $G = 28.94$, $df = 1$, $P < 0.0001$). It is possible that the gland may also be used to mark other substrates (e.g. roosts), but we never found marks near or within roosts at La Casa.

Injuries were uncommon on *M. sinaloae* at most times. Most types of injuries (e.g. broken phalanges and torn wing membranes) were rare, and equal in frequency on both sexes. One category of injury, deep lacerations (typically 2–5 mm in length), were most commonly observed on males, and were a common occurrence for only a small part of the year. Fewer than 1 % of all captured animals had lacerations, but almost all the lacerations observed occurred in June and July. There were significantly more wounded males (11 of 155) than females (4 of 280) at Campestre during this period in 1979 (G-test for independence with Williams correction for small cell sizes [Sokal and Rohlf 1981]; $G = 8.89$, $df = 1$, $P < 0.01$). In nine of the males the lacerations were on the head (v.s. only one female). The proportion of males with lacerations was less than 2 % (2 of 85) from 6–22 June, was 18 % (7 of 39) from 28 June–8 July, and 6 % (2 of 31) from 25–31 July. The

variation among periods was significant (G-test for independence with William's correction, G = 8.28, df = 2, P < 0.05; Sokal and Rohlf 1981). Males with lacerations were very uncommon during other months in which data were collected (January, May and August through December).

There were three classes of roost associations at La Casa: (1) resident males that were always solitary (N = 5), (2) multiple male groups (mean = 2.5 males, range = 2–3, N = 2 groups), and (3) female groups (rarely occupied by only one of the resident females) with occasional or frequent male visitors (mean = 3 females, range = 1–8, N = 4 groups). Three of the five resident solitary males and the members of the multiple male groups were never found visiting female groups. In contrast, the other two resident solitary males were frequent visitors to the four female groups, one male visiting at least three of the four female groups and the other visiting at least two. Relationships among the bats were complicated by occasional non-resident male visits to all of the female groups, frequent appearance at La Casa of non-resident solitary males, moves of individual resident females to different groups or away from La Casa for one or more nights, and occasional appearances of non-resident females, usually in one of the female groups, but occasionally in otherwise-unused roosts. Some members of the groups were not recorded at La Casa for periods of weeks or months.

Discussion

The gular glands of male *Molossus sinaloae* are apparently the source of the marks observed on females. It is not clear if the marks were an incidental effect of contact between males and females, or if the marks are deliberately placed by the males. It appeared that both males and females were interested in scents on the dorsum of other bats, as both sexes often sniffed or nuzzled the dorsum of bats newly arrived at the entrance to a roost. Other investigators have hypothesized that male molossids may use the gland to mark roosts (Horst 1966; Quay 1970); we have no evidence to support this hypothesis for *M. sinaloae,* but cannot reject it.

The greater frequency of lacerations in males than in females, particularly on the head, suggests that lacerations are incurred during some behavior that is more common in males. In *Molossus sinaloae,* males are 20 % heavier than females, an unusual degree of sexual dimorphism in a small insectivorous bat (Findley and Wilson 1982; Ralls 1976; Myers 1978). It is possible that lacerations are incurred in aggressive encounters with males. In a captive colony of a related species, *Molossus ater,* J. J. Rasweiler IV (pers. com.) observed that captive mature males can normally be held in groups, but when males that have recently mated are returned to cages holding other males, fights erupt rapidly. These generally include biting attacks at the face, and males often lock jaws, suggesting that facial wounds are a likely outcome. In *M. sinaloae,* the peak of observed lacerations on males fell within the period immediately following parturition and within the period when gular glands were most active and the proportion of marked females was highest.

The evolutionary and ecological significance of *M. sinaloae* marking is uncertain. The peaks in gular gland activity and of marks on females were in May/June through August, which include the second half of pregnancy and the first two months after parturition. It is possible that males attempt to sequester mates during this time of the year; but why this should occur months before the appearance of macroscopically visible embryos in March (Fig. 1) is problematical unless there is some form of post-copulatory delay mechanism such as sperm storage or other post-copulatory delay mechanism. Although Molossids have, heretofore, been thought to lack such delays, two recent studies have reported prolonged periods of mating and/or presence of spermatazoa in the female reproductive tract of two neotropical molossid species (*Molossus ater*, Rasweiler 1987; and *Molossus fortis,* Krutzsch and Crichton 1985) but this has not been reported in *M. sinaloae*. In

addition, if males do mark females in an attempt to sequester mates, it is not clear why the roost associations at La Casa did not reflect female defense by males (e.g. a male defending each female group) instead of the rather loosely structured female groups which were visited by more than one male.

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Zusammenfassung

Beitrag zur Reproduktionsbiologie, Gulardrüse und zum Sozialverhalten von Molossus sinaloae (Chiroptera, Molossidae)

Fetthaltige, stark duftende Marken auf dem Rücken von weiblichen *Molossus sinaloae* entstehen offenbar durch Kontakt mit der Gulardrüse männlicher Tiere. Während der Gebärphase weiblicher Individuen waren die Gulardrüsen der Männchen am größten und produzierten am meisten Sekret. In dieser Phase wurden bei den Weibchen die meisten Duftmarken und bei den Männchen die meisten Fleischwunden festgestellt. Die ökologische und evolutive Bedeutung dieser Duftmarkierung ist ungeklärt.

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