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Breeding in the Australian Yellow-bellied Sheath-tailed Bat, *Saccolaimus flaviventris* (Peters, 1867)(Chiroptera: Emballonuridae).

C.T. Chimimba* and D.J. Kitchener†

Abstract

Saccolaimus flaviventris pregnancies were almost always restricted to the right uterine horn. This horn first increased in diameter in August, and the maximum enlargement was observed in November. The horn regressed rapidly following parturition. Over the species range the parturient season was between December and mid March. Teats and mammary glands were regressed by the end of May. A pregnant female collected in February had a corpus luteum that was deeply embedded in the right ovary and occupied *ca.* 65 percent of the ovary; the contralateral ovary had numerous large atretic secondary and graafian follicles.

In males, there was no significant difference throughout the year in testis size, weight and position or in epididymis weight; nor was there a significant correlation between these parameters and the depth of the throat pouch - which also showed no significant variation in depth.

Introduction

Emballonurids are widely distributed in the tropical and subtropical regions of the world (Nowak and Paradiso 1983). The family has 11 recent genera comprising about 51 species (Honacki *et al.* 1982). In Australia there are only two genera; *Taphozous* and *Saccolaimus*, although some modern authorities do not recognize *Saccolaimus* as distinct from *Taphozous* (Hill and Smith 1984).

Information on reproductive patterns of emballonurids is not particularly extensive compared to that available on other bat families (Rowlands and Weir 1984) and is limited to several New World species of *Saccopteryx*, *Cormura*, *Peropteryx* and *Centronycteris* (Arata and Vaughan 1970, Flemming *et al.* 1972, Bradbury and Emmons 1974, La Val and Fitch 1977), *Taphozous longimanus* and *T. melanopogon* in India (Gopalakrishna 1955, Brosset 1962, Khaparde 1976, Mokkapati and Dominic 1976, Lekagul and McNeely 1977, Krishna and Dominic 1982, Swami and Lall 1982, Lall and Biswas 1983, Sapkal and Khamre 1983), *T. nudiventris* in Pakistan (Roberts 1977), *T. mauritianus* in Zaire (Kingdon 1974), the Asian *Saccolaimus saccolaimus* (Medway 1978), *T. georgianus* (Kitchener 1973) and *T. hilli* in Australia (Kitchener 1976). There is no study on the reproduction of Australian *Saccolaimus*, apart from the single observation of

*Zoology Department, University of Western Australia, Nedlands, Western Australia 6009. Present address: Museums of Malawi, P.O.Box 30360, Blantyre, Malawi.
†Western Australian Museum, Francis Street, Perth, Western Australia 6000.

breeding by Compton and Johnson (1983), who observed that *S. saccolaimus* females collected in mid December in Queensland had advanced pregnancies or attached young.

At least three families of bats have throat or gular pouches and associated glands (Quay 1970). Dobson (1875) recorded that throat glandular structures were characteristic of bats in the genus *Taphozous* and much importance was placed on these structures when Troughton (1925) revised the genus. As in most emballonurids, the gular pouch in *S. flaviventris* occurs only in males and is represented by small folds in the skin of the throat of females (Hall and Richards 1979). Hall and Gordon (1982) report that this pouch is devoid of any glandular secretory material but speculate that it may be used during territorial marking. In Western Australia, Kitchener (1976) found that in males of *T. georgianus* size of the pouch varied seasonally and that there was a correlation between the depth of the gular pouch and some reproductive parameters. Hall and Gordon (1982) suggested, from a small number of individuals, that the depth of the throat pouch may not vary seasonally. Our large sample size enabled us to investigate this suggestion and to examine correlations with some testis and epididymis parameters.

By reporting on aspects of the reproductive biology of *S. flaviventris*, this paper attempts to increase the knowledge of this little studied bat and of emballonurids in general.

Materials and Methods

This study was based on 54 female and 48 male specimens of *S. flaviventris* from the Queensland, Australian, Victorian, South Australian and Western Australian Museums, CSIRO Wildlife Collection and the Central Australian Wildlife Collection. These specimens (except one) were fixed in 10 percent formalin and preserved in 70 percent ethanol. These specimens were collected over a period of 20 years from widely distributed localities (Figure 1) encompassing a variety of habitats and climates. Specimens from most months of the year are present in the collections, although there are no females from December and only two subadult females from January, and no males from May and December.

Ovaries of the pregnant female collected in February were fixed in Bouin's fluid and preserved in 70 percent ethanol. They were embedded in paraffin and serial sections cut at 6 μm; these were stained and counter stained with Gill's haemotoxylin and eosin, respectively.

The reproductive tract was examined *in situ*. In females, maximum diameters of both uterine horns, length, shape and extent of dark pigmentation of teats and extent of mammary development were recorded. The foetuses of more advanced pregnancies were dissected from their uterine horn to record forearm and crown to rump lengths.

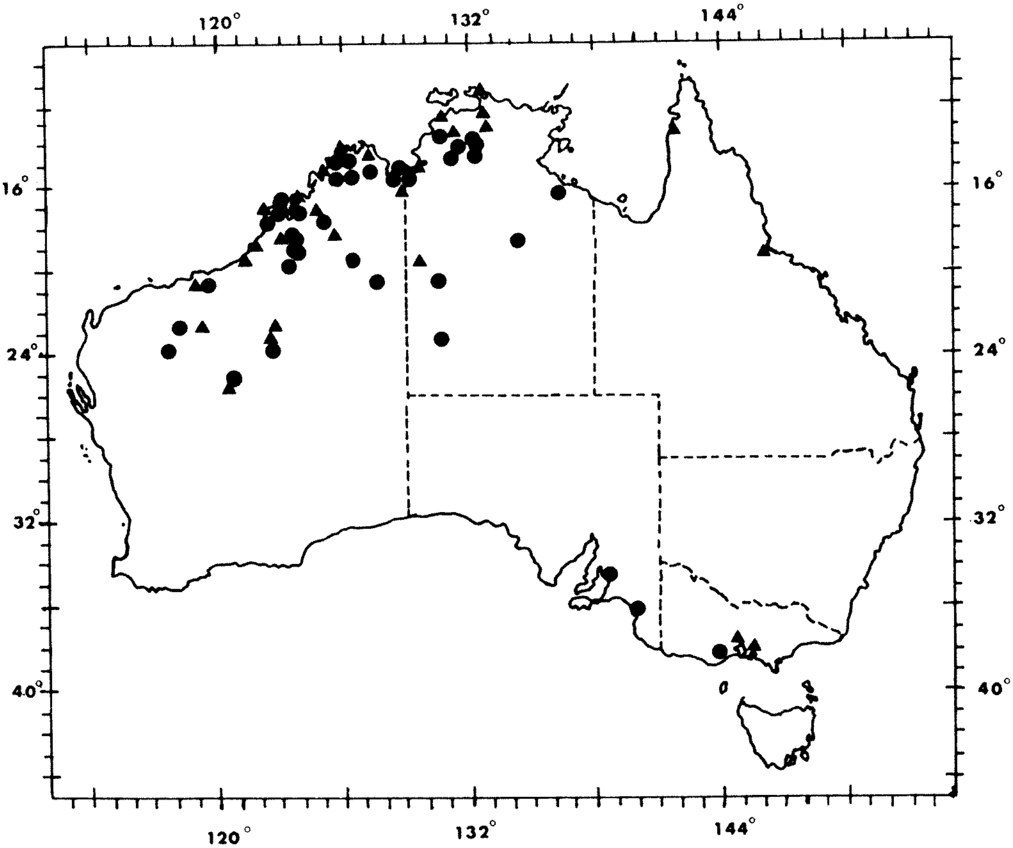

Figure 1 Distribution of *Saccolaimus flaviventris* specimens used in this study. (▲), males; (●), females. Some localities have multiple specimens.

In males, forearm length, position of testes (whether scrotal, base of penis, inguinal or abdominal), testis weight, length and breadth, epididymis weight and the depth of the gular pouch were recorded.

Adult condition was judged by the absence of swelling of the epiphyses in the joints of the digits. Recently parturient and probably lactating females were judged by the presence of an enlarged right uterine horn and/or by enlarged and pigmented teats or enlarged mammary glands.

A one-way analysis of variance was carried out to assess significant seasonal differences in testis length, testis breadth, testis weight, epididymis weight and pouch depth. Correlations between depth of the gular pouch and reproductive parameters were tested by stepwise multiple regression (Nie *et al.* 1975, and Hull and Nie 1981). All statistical analyses were performed through ONE-WAY and REGRESSION subprograms of the Statistical Package for the Social Sciences

(SPSS) (Nie *et al.* 1975 and Hull and Nie 1981) on a Cyber 70 at the Western Australian Regional Computing Centre.

Results

Female Reproduction

Period of birth

All but one of the 16 obviously pregnant females had the foetus in the right uterine horn. The contralateral horn showed little enlargement and ranged in diameter from 0.8 to 3.1 mm. In non-parous females, the size of both uterine horns was almost equal and ranged from 0.8 to 1.4 mm in diameter.

In *S. flaviventris*, embryos were dissected from horns with diameters greater than 7 mm; perceptible swelling in horns of this species was first recorded in August (Figure 2). Diameter of the right uterine horn (d) closely reflects the crown to rump length of the foetus (f): $d=1.0f - 1.6$ ($r=0.95$, $df=8$ $p<.001$). The horn appears to increase rapidly in diameter from *ca.* 6 to 16 mm between September and October. Larger foetuses occurred in females collected in November, (foetal forearm lengths 20.3 and 25.9 mm) and mid February (foetal forearm length 10.0 mm). The presence of a foetus in a female collected in mid February that is smaller than those in females from late November indicates a season of births of at least three months duration, extending from approximately

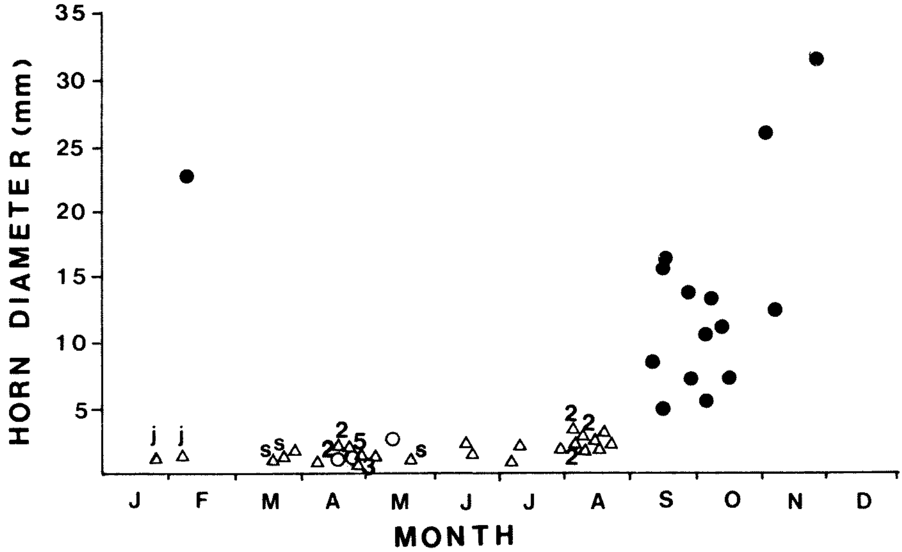

Figure 2 Diameter of right uterine horn (mm) versus month of collection. (●), obviously pregnant; (△), pro-oestrus or recently pregnant; (○), recently parturient – lactating; and [s], southern Australian specimens; [j], juvenile. In some cases more than one specimen with the same sized horns was collected on the same date. The number of such specimens is shown.

early December to mid March. The pregnant female collected in mid February had a large corpus luteum with diameter *ca.* 800 μm deeply embedded and occupying *ca.* 65 percent of the right ovary. The contralateral ovary had numerous large atretic secondary and graafian follicles (up to 210 μm in diameter).

Rapid regression of the right uterine horn followed parturition and left no obvious externally visible implantation scar such that recently parturient or recently lactating females were often detectable only from enlarged, darkly pigmented pubic teats and swollen mammary glands. Females collected at the same localities at the same time showed close synchrony in reproductive condition; we did not detect any obvious geographic trends in reproductive patterns.

Male reproduction

Reproductive cycle

Left and right testes were in the same position in all but three males. In these three males we recorded the position of the testes as that of the most caudally located one. Testes of the subadult male were abdominal.

The caput and cauda epididymis were clearly distinct. The length of the epididymis varied depending on the position of the testis because the cauda epididymis were always located in the scrotal sac. An analysis of variance showed that on a seasonal basis there were no significant differences in testis length ($F_{3,44}$= 0.99), testis breadth ($F_{3,44}$=1.29), testis weight ($F_{3,44}$=0.56), and epididymis weight ($F_{3,44}$=0.05). Similar results were obtained when the analysis was performed by pooling all data or grouping it on a two monthly basis.

Gular pouch

There was no significant seasonal difference in the depth of the gular pouch using data pooled on a seasonal ($F_{3,42}$=1.06), or two monthly basis ($F_{5,42}$=0.70). Pouch depth was not significantly correlated, using stepwise multiple regression analysis, with testis length (r=0.254), testis breadth (r=0.059), testis weight (r= 0.245) or epididymal weight (r=0.039)(df=6).

Discussion

From studies cited earlier, the reproductive patterns of emballonurids are quite variable. The Australian *Taphozous* species studied by Kitchener (1973, 1976) give birth to young over a relatively long period. Although Kitchener (1973, 1976) concluded that *T. georgianus* and *T. hilli* (as *T. georgianus*) were monoestrous, there is the possibility that they may give birth to young a second time during this long breeding season. This fact may not be detected in Museum specimens if corpora lutea persist for only a short period following parturition. Females of several Australian bats give birth to young twice a year (i.e. *Myotis adversus* and *Eptesicus pumilus caurinus* (Dwyer 1970, Maddock and McLeod 1976). Our observations on *S. flaviventris* also suggest the possibility of two periods of birth

— one about December and the other during February. Interestingly, these two periods coincide with when the two above mentioned polyoestrous species give birth to young.

There is no indication of an old corpus luteum in either the left or the right ovary of the pregnant *S. flaviventris* female collected in February. This suggests that it is not breeding a second time in the one season. However, examination by histological preparation of a number of female *S.flaviventris* from the late summer months is required before concluding as to the polyoestrous or monoestrous nature of this species.

There was no evidence of seasonal change in testis and epididymal parameters considered in this study. Histological studies show that the extent of spermatogenic activity is directly proportional to both maximum tubular diameter and testicular weight (Racey 1974). If use of testis weight and testicular dimensions are suitable measures of general changes in annual spermatogenic activity, then *S.flaviventris* males appear to be in active reproductive condition throughout the year, This pattern conforms with that of the other Australian male emballonurids studied (Kitchener 1973, 1976).

Australian vespertilionid males, however, show marked seasonal changes in their reproductive cycle. Phillips and Inward (1985) found that the onset of testticular enlargement in *Nyctophilus gouldi* coincided with spermatogenesis, which occurred only in summer. Spermatozoa were stored in the epididymides during the hibernating season. Schlawe (1983) found that activity in the primary and secondary reproductive organs in male *Chalinolobus gouldi* was asynchronous. Testicular activity was highest in autumn while accessory organ activity was highest in winter.

S. flaviventris differs from the Indian emballonurid *T. longimanus* which gives birth to young throughout the year, and has both ovaries functional with pregnancies alternating between both the left and the right uterine horns (Gopalakrishna 1955).

This study confirms the findings of Hall and Gordon (1982) by showing that there was no significant seasonal difference in the depth of the gular pouch, nor is this depth correlated with indicators of male reproductive condition such as was exhibited by *T. georgianus* in Western Australia (Kitchener 1976).

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