Rec. West. Aust. Mus., 1976, 4(4).

FURTHER OBSERVATIONS ON REPRODUCTION IN THE COMMON SHEATH-TAILED BAT, *TAPHOZOUS GEORGIANUS* THOMAS, 1915 IN WESTERN AUSTRALIA, WITH NOTES ON THE GULAR POUCH.

D.J. KITCHENER*

[Received 19 July 1976. Accepted 28 September 1976. Published 31 December 1976.]

ABSTRACT

Reproductive cycles of adult *T. georgianus* from the south Murchison area are similar to those of this species from more northern localities reported in Kitchener (1973).

Over its range in Western Australia female *T. georgianus* are thought to be monoestrous. There appears to be a brief anoestrus during mid autumn to mid winter before females assume reduced activity in reproductive organs. The depth of the gular pouch in adult males is correlated with testicular activity and enlargement of accessory glands.

INTRODUCTION

Aspects of the reproduction of *Taphozous georgianus* have been described from histological preparations of Museum specimens collected principally from the Pilbara and Kimberley districts of Western Australia (Kitchener 1973). From that study it appears that *T. georgianus* females are monotocous with young born from October through to February; only the right ovary is functional and pregnancies occur only in the right horn. They are considered monoestrous. Sperm are not stored in the reproductive tract of females. In males spermatogenesis appears to occur throughout the year; testes descend to scrotal sacs in summer and ascend abdominally in autumn, winter, and spring.

Although changes have been observed in aspects of reproduction within species of Australian bats at different localities (Dwyer 1968, 1970; Douglas 1967, and Kitchener 1975), Kitchener (1973) observed no such changes in *T. georgianus* from the Kimberley, with its reliable summer

*Western Australian Museum, Francis Street, Perth, Western Australia 6000.

rainfall, and the Pilbara, which has a markedly different climate of unreliable rainfall in all seasons. In late 1972 a population of *T. georgianus* was discovered at Tallering Peak, 28°06′S, 115°38′E. This is the most southern known population of this species in Western Australia (400 km north east of Perth). Further, the climate at Tallering Peak, which is on the boundary of Gaffney's (1970) Southern Region of reliable winter rainfall and Central Region of unreliable rainfall, is different from other Western Australian localities from which *T. georgianus* had been previously collected. Because reproduction of *T. georgianus* at Tallering Peak may differ from that previously recorded (Kitchener 1973), a collection was made throughout 1973 at this locality, and during June of that year from Murgoo (27°22′S, 116°25′E).

This collection of fresh specimens of *T. georgianus* from the south Murchison area should provide a more detailed description of their reproduction and allow comparison with the previous study (Kitchener 1973), which was based on specimens collected opportunistically from many localities during the preceding fifteen years.

Taphozous georgianus has a glandular area beneath the throat (Ride 1970). This gland is visible in adults of both sexes from Tallering Peak and Murgoo but is only pouched in males. It may be that it is involved in agonistic or mating behaviour because glandular areas on several other species of bats appear to play a role during such behaviour by disseminating an olfactory signal. For example, Pearson *et al.* (1952) record that the very glandular snout of *Corynorhinus rafinesquei* (Lesson) is rubbed over females of that species during precopulatory behaviour, apparently to induce submission. Bradbury and Emmons (1974) have observed male *Saccopteryx bilineata* (Temminck) voluntarily open the muscular orifice of their wing gland and then sharply shake their wings (in an action they refer to as *salting*) during territorial displays against females, and during interactions within their territories with females.

This paper also reports on the possible function of the gland in male *T. georgianus* by comparing development of the gular pouch with male reproductive condition.

MATERIALS AND METHODS

This study is based principally on a collection from Tallering Peak of 25 adult females, 3 attached young, and 19 adult males. They were collected by mist netting and shooting with .22 dust shot, from an exploratory tunnel for iron ore more than 50 m long. However, because they were not seen at Tallering Peak during June 1973, 3 adult females and 4 adult males were collected during that month at Murgoo from a lateritic breakaway. Table 1 shows the number of adult *T. georgianus* from each month used in this study and their date of collection. All specimens have been accessed into the Western Australian Museum collection and have the numbers M 10115-30, M 10191-2, M 10239-42, M 10244-6, M 10673-88, M 10693-8, M 10938-9(A & B), M 10940, M 11030-1, M 12715-7, M 12719.

Table 1: Number of adult *T. georgianus* collected at Tallering Peak during 1973, and date of collection. Numbers in brackets indicate those examined histologically.

Date	Adult Males	Adult Females
13 January	1 (1)	1 (1)
21 April	6 (6)	9 (7)
14 May	0	2 (2)
* 3 June	4 (4)	3 (2)
12 August	9 (8)	7 (4)
1 October	3 (3)	3 (0)
15 December	0	3 (3)

*Collected at Murgoo

All specimens were fixed in 10% formalin and preserved in 75% alcohol. Adult condition was judged from absence of swelling of digital joints and general size. Forearm lengths of adult males and adult females ranged from 64.3 to 70.3 mm, and 66.1 to 71.3 mm respectively. Table 1 also shows number of specimens from each monthly sample selected for histological preparation; no October females were thus selected because their condition was obvious — they were carrying moderately large foetuses; juveniles were not included in this aspect of the study. In addition to those shown in Table 1, histological preparations were made of ovaries of 4 females with enlarged teats collected at Tallering Peak on 13 January 1975.

Reproductive organs were placed in Bouin's fluid after formalin. Sections were stained in Erlich's haemotoxylin and counterstained in eosin. With females, sections were cut from vagina, corpus uteri, uterine horns, ovaries, and occasionally uterine glands. With males, sections were cut from testis, the head, body and tail of epididymis, vas deferens, vesicula seminalis, prostate, and bladder. All sections were cut at 10 μm and every twentieth section was retained, except for ovaries where every tenth section was retained.

Measurements from histological preparations were recorded as follows: diameters of seminiferous tubules for each male by averaging measurements of 30 tubules; the diameters of each tubule is an average of the length of its longest axis through cross section and length of axis at right angles to this. The diameter of nuclei of interstitial cells of each individual is an average of 30 measurements. Size of male accessory glands and uterine horn endometrium is the maximum width measured from sections; because only every twentieth section was retained, some of these measurements could be slightly less than their actual width. Diameters of corpora lutea and ovarian follicles were measured as nearly as possible through their centres and are the average of a measurement through the long axis and another at right angles to this. Counts and measurements were taken only from secondary follicles which have more than two layers of follicle cells.

Depth of gular pouch is an average of two measurements recorded with a probe from the bottom of the pouch to the opposite corners formed by the lip of pouch with throat.

OBSERVATIONS

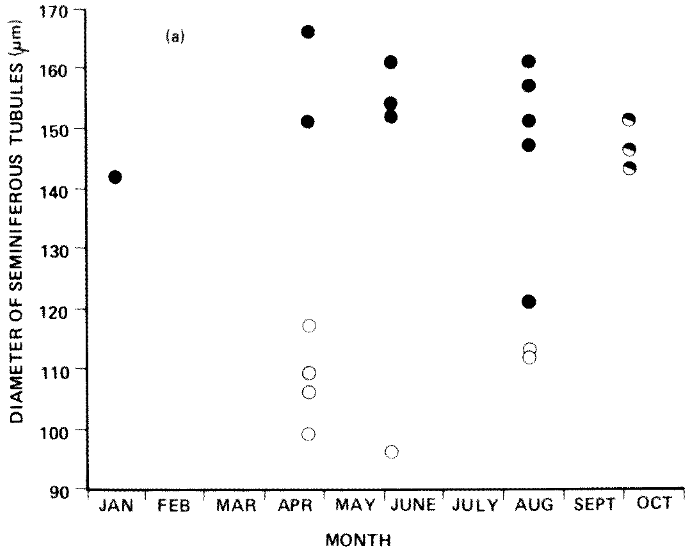
(a) Male reproduction.

(1) Spermatogenic cycle.

As shown in **Table 1**, adult males were captured in January, April, June, August, and October. An indication of male reproductive condition throughout the year was given by these specimens and this information is summarized in Figs 1 and 2. The first of these figures indicates that in all monthly samples males were found with active testes, that is with developed sperm in seminiferous tubules, or with numerous early to late spermatid stages. Further, in all these samples (only one male from January) there were some males with inactive testes, that is with spermatid stages lacking or infrequent. Males with few or no sperm in testes had no sperm in the reproductive tract, suggesting that sperm were not stored in tubes or accessory glands during cessation of spermatogenesis.

The observation that there was no interstitial tissue in testes of adult male *T. georgianus* (Kitchener 1973) was mistaken; this was clearly observed in the present study.

Figs 1 and **2**, in addition to indicating testicular activity in monthly samples, show the diameter of seminiferous tubules (**Fig. 1a**), and interstitial cell nuclei (**1b**), maximum width of prostate (**2a**), vesicula seminalis (**2b**),



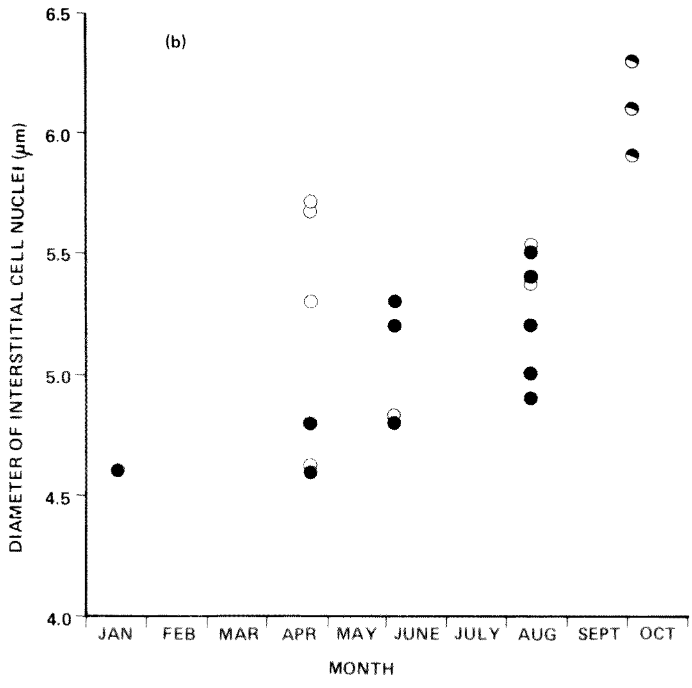
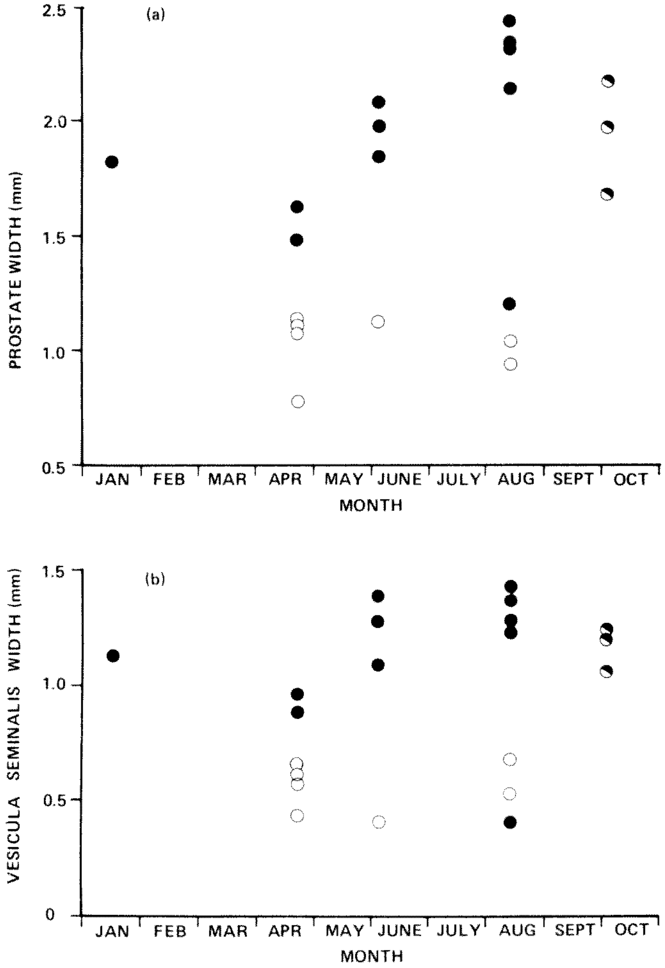


Fig. 1: Testicular activity of adult male *T. georgianus* from Tallering Peak in monthly samples collected during 1973. (a) diameter of seminiferous tubules, (b) diameter of nuclei of interstitial cells. Males with spermatozoa (●), numerous early to late spermatid stages (◔), and absence of spermatids or presence of only occasional spermatid stages (○) are indicated.



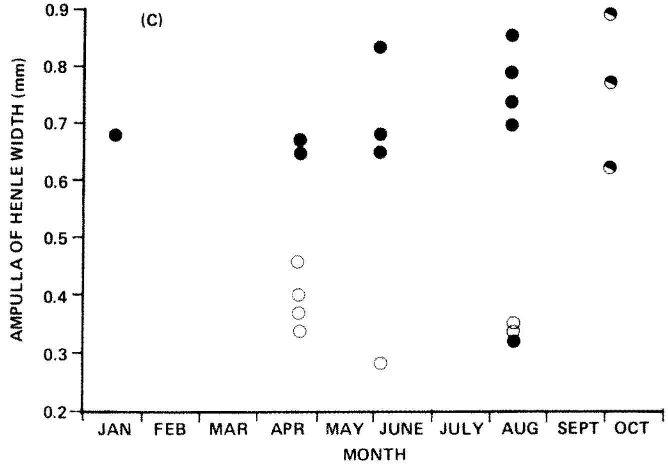


Fig. 2: Width of accessory glands in adult male *T. georgianus* from Tallering Peak in monthly samples collected during 1973. (a) prostate, (b) vesicula seminalis and (c) ampulla of Henle. Males with spermatozoa (●), numerous early to late spermatid stages (◔), and absence of spermatids or presence of only occasional spermatid stages (○) are indicated.

and ampulla of Henle (**2c**), in each month. From **Figs 1a** and **2a-c**, it is apparent that males with spermatazoa or early to late spermatid stages in testes have considerably larger seminiferous tubules than those with inactive testes. The exception is the single autumn specimen which is thought to have declining testicular activity. Further, accessory glands of males with active testes tend to be smallest in April and increase in size in June and August. It is likely that in the field population accessory glands of males from October onward would further enlarge as their testes become more active. From **Fig. 1b** there appears to be a trend for interstitial cells to increase from January through to October. However, there is in each monthly sample an indication that interstitial cells are larger in inactive testes than they are in active testes, possibly suggesting imminent commencement of spermatogenesis in inactive testes. Certainly, with the exception of the male collected in June which has only spermatogonia and Sertoli cells, inactive testes have numerous spermatogonia and primary spermatocytes, and some have early spermatid stages.

Although males were not collected at Tallering Peak during early summer it is thought that they are reproductively active at that time. This is suggested by the collection of a female at this locality on 13 January 1973 which had a developing corpus luteum of diameter 110 μm, and a small blastocyst of diameter c. 1.1 mm in the horn. This pregnancy was presumably from a very recent copulation because there is no evidence in this or the previous study of sperm storage in females or delayed blastocyst development.

The position of the testes of male *T. georgianus* in this study suggests a similar seasonal pattern as noted in Kitchener (1973). At Tallering Peak and Murgoo, testes were located inguinally in April and June, abdominally in August and October, and in the scrotum only in January.

(2) Gular pouch.

The pouch at the posterior part of the glandular area of male *T. georgianus*, shown in **Fig. 3**, varies considerably in its depth. It is, then, of interest to record that in males with active testes the average depth of this pouch is 3.9 mm which is very significantly greater than its average depth in males with inactive testes of 3.0 mm (Student T test: $t = 13.8$, df. = 20, $p < .001$). These statistics include a male (M 10681) in which the histological preparation is poor but nevertheless adequate to recognise numerous sperm in tubules. This male is not referred to elsewhere in this study. From **Fig. 4** and **Table 2** it is seen that development of the pouch is closely correlated with enlargement of seminiferous tubules and accessory glands.

Fig. 3: Ventral surface of throat region of male *Taphozous georgianus* (M 10683) from Tallering Peak showing the glandular area with posterior facing pouch. X 4.

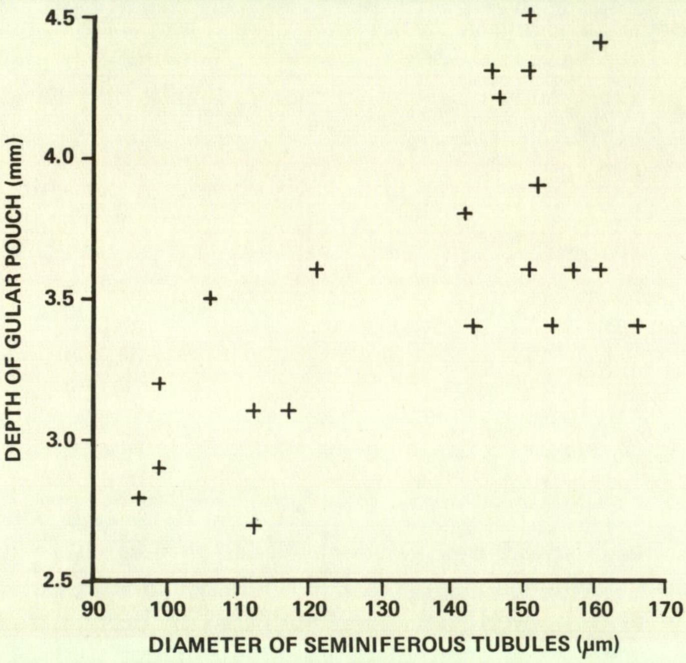


Fig. 4: Relationship between depth of gular pouch and diameter of seminiferous tubules in male *T. georgianus* from Tallering Peak during 1973.

Table 2: Correlation coefficients between depth of gular pouch of adult males at Tallering Peak (and Murgoo) and diameter of seminiferous tubules, and maximum width of accessory reproductive organs.

	r	d.f.	p	significance
seminiferous tubules	0.762	19	$p < .001$	+++
vesicula seminalis	0.735	19	$p < .001$	+++
prostate	0.702	19	$p < .001$	+++
ampulla of Henle	0.695	19	$p < .001$	+++

(b) Female reproduction.

(1) Period of births.

At Tallering Peak females are monotocous but of the twelve females in which the pregnant horn could be recognised, two showed evidence of recent pregnancy in the left horn from the left ovary. These two females, which were lactating when caught on 21 April, had only recently given birth; they had swollen uteri and left ovaries with large corpora lutea 120 and 190 μm in diameter respectively.

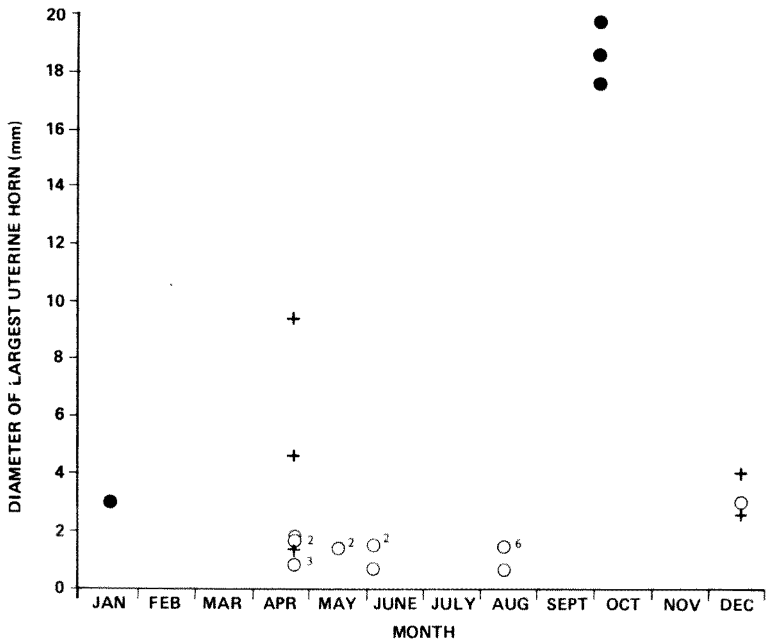


Fig. 5: Maximum diameter of largest uterine horn of pregnant (●), non pregnant (○), and lactating (+) *T. georgianus* from Tallering Peak, and date of capture during 1973.

An indication of the period of births for this species at Tallering Peak can be obtained from Fig. 5 which records date of capture of adult females, maximum diameter of largest horn and whether or not they were pregnant or lactating when collected. Three females collected in early October were pregnant and had uterine horns 17.5 to 18.7 mm in diameter. At term the uterine horn has a diameter of about 33 mm (Kitchener 1973). Two females collected in mid December were lactating and had relatively involuted horns; one had no luteal tissue in either ovary, the other had a small degenerating corpus luteum 51 μm across. These females probably gave birth in late November or early December, one to three weeks prior to their capture. Another female was in early pregnancy in January, and on 21 April three females were collected still lactating and these had recently given birth; a young with attached umbilical cord was collected with these April females.

These observations suggest that births occur between late November and late April.

(2) Lactation.

Of the females used in the histological study, two collected in April and two in December were lactating. The April females had large deteriorating corpora lutea of 610 and 970 μm diameter in left ovaries, and one of the December females had a small corpus luteum 260 μm across in the right ovary. Ovaries with a corpus luteum had only small follicles, none of which was tri-laminar; contralateral ovaries had numerous (12-31) secondary follicles, some vesicular; the largest was 326 μm in diameter. Several bi-, tri- and quadri-ovular follicles were also present. The lactating female with ovaries lacking luteal tissue had numerous primary follicles but only a few moderate sized secondary follicles. Their uterine horns were swollen and full of detritus from the breakdown of endometrium, blood vessels, and tissue resulting from pregnancy and parturition. Their vaginal tracts were lined by 2-4 layers of cuboidal epithelium with many leucocytes.

(3) "Relative quiescence" to early pro-oestrus.

These females, collected from April, May, June and August, are diagnosed by their reduced endometrium which averages 185 μm (100-260 μm) in thickness, and lack of stratification or cornification of vaginal epithelium. The term 'relative quiescence' is applied here because some of these females had an endometrium that was proliferating (mitotic figures were common) and had ovaries which, with one exception, had 6 to 54 secondary follicles with vesicles, some of which were well developed and range in maximum diameter from 245 to 383 μm. Only one female, collected in April, had no large follicles in the right ovary and apart from a single large vesicular follicle 428 μm in diameter, this was the situation in its left ovary. Only one of these females lacked numerous atretic follicles throughout; this is a May specimen which had small secondary follicles without developed vesicles. The vaginal epithelium varies from 2 to 4 layers of cuboidal epithelium to 2 to 3 layers of stratified epithelium. Leucocytes were frequent amongst the cuboidal epithelium.

(4) Pro-oestrus.

This condition was found in two females, one from June and the other from August. It was diagnosed by the proliferation of the endometrium to a thickness of 230-310 μm, and stratification with some cornification of vaginal epithelium. Right ovaries of the two specimens had 19 and 21 moderate sized secondary follicles with a mean diameter of 240-265 μm (122-326 μm). Numerous atretic follicles occurred throughout both ovaries.

(5) Oestrus.

This condition is observed in two females, one collected in August, the other December. It is diagnosed by continuing cornification of vaginal epithelium, increased proliferation of endometrium to a thickness of 310-400 μm, and the presence of 16 to 42 moderate sized vesicular follicles, with mean diameter of 231 and 251 μm, including several very large follicles of 408 and 536 μm diameter in the right ovaries. The largest of these follicles was atretic; numerous small atretic follicles occurred throughout both ovaries.

DISCUSSION

Females at Tallering Peak gave birth to young over a five month period between late November and late April suggesting that the period of births at this locality is similar to that recorded previously at more northerly localities in Western Australia (Kitchener 1973).

It was suggested in the previous study of this species (Kitchener 1973) that females with small uterine horns during the period late autumn to early winter were in anoestrus, and that the absence of any truly reproductively quiescent females at that time reflected the nature of the collection and not the probable reproductive cycle of individuals. However, in the present study only one female, collected almost at the completion of its lactation, approached anoestrus and most of the females collected in autumn and winter (April, May, June and August) showed only reduced activity in the reproductive tract and ovaries. These observations, coupled with those of the earlier study, suggest that the mid autumn and winter period for females is one of reduced activity of reproductive organs, but not one of total inactivity.

Observations on the reproduction of males collected from Tallering Peak are consistent with the conclusions of the earlier study (Kitchener 1973), namely that some have active spermatogenesis throughout the year. However, in several of the monthly samples from Tallering Peak, males were collected with inactive testes and small accessory glands. Further, these males had larger interstitial cell nuclei than males with active testes and enlarged accessory glands. If size of interstitial cell nuclei measured from histological preparations reflects levels of androgen production (although according to Racey and Tam (1974) this is contentious), then males with inactive testes may soon commence spermatogenesis and those with active testes may soon cease production of sperm. It is interesting that although males appear to be fertile all year, sperm were not recorded from the reproductive tract of females during this study, and from only one female in the previous study.

In examining the possibility that the glandular area beneath the throat in male *T. georgianus* plays a role in their social (particularly mating) behaviour, it has been presumed that the degree of development of the pouched part of this glandular area reflects the level of activity of the gland. This being so it would appear that its activity is closely influenced by levels of androgens because increase in its depth is correlated with testicular activity and closely parallels enlargement of seminiferous tubules and accessory glands.

Bradbury and Emmons (1974) stated that the development of the wing gland in *Saccopteryx bilineata* has 'some bearing on maturational processes', and that at 2½ months of age the glands of males are small and similar to adult females in development, while at 6 months of age the glands of the majority of males are fully developed. Similarly it is possible that the size of the gland in these *T. georgianus* relate to nothing more than their sexual maturity. This is not, however, thought to be the case because males used in this study were adult in that they were fully grown and lacked swelling of digital joints. Further, the four males with the deepest gular pouch were amongst those with the least tooth wear and presumably, then, amongst the most recently adult. In conclusion, it is felt that the glandular area in *T. georgianus* males is influenced by their reproductive condition and probably plays some role in male social behaviour.

ACKNOWLEDGEMENTS

I am indebted to A.M. and M.J. Douglas for collecting most of the bats used in this study. I am also exceedingly grateful to Professor H. Waring, Zoology Department, University of Western Australia, Dr M. Renfree, School of Environmental and Life Sciences, Murdoch University, and Dr R.W. George and Mr A. Baynes, Western Australian Museum, for their constructive advice during preparation of this manuscript.

REFERENCES

BRADBURY, J.W. & EMMONS, H.L. (1974)—Social organisation of some Trinidad bats. I. Emballonuridae. *Z. Tierpsychol.* **36**: 137-183.

DOUGLAS, A.M. (1967)—The natural history of the Ghost bat, *Macroderma gigas* (Microchiroptera, Megadermatidae), in Western Australia. W. Aust. Nat. **10**: 125-38.

DWYER, P.D. (1968)—The biology, origin and adaptation of *Miniopterus australis* (Chiroptera) in New South Wales. *Aust. J. Zool.* **16**: 49-68.

DWYER, P.D. (1970)—Latitude and breeding season in a polyestrus species of *Myotis*. *J. Mammal.* **51**: 405-410.

GAFFNEY, D. (1970)—Commentary accompanying the map-sheet 'Rainfall' in *Atlas of Australian resources*. 2nd ed. Canberra: Commonwealth Government Printer.

KITCHENER, D.J. (1973)—Reproduction in the common sheath-tailed bat, *Taphozous georgianus* (Thomas) (Microchiroptera : Emballonuridae) in Western Australia. *Aust. J. Zool.* **21**: 375-389.

KITCHENER, D.J. (1975)—Reproduction in female Gould's wattled bat, *Chalinolobus gouldii* (Gray) (Vespertilionidae), in Western Australia. *Aust. J. Zool.* **23**: 29-42.

PEARSON, O.P., KOFORD, M.R. & PEARSON, A.K. (1952)—Reproduction of the lump-nosed bat (*Corynorhinus rafinesquei*) in California. *J. Mammal.* **33**: 273-320.

RACEY, P.A. & TAM, W.H. (1974)—Reproduction in male *Pipistrellus pipistrellus* (Mammalia : Chiroptera). *J. Zool. Lond.* **172**: 101-122.

RIDE, W.D.L. (1970)—*A guide to the native mammals of Australia.* Melbourne: Oxford University Press.