

## SPERM STORAGE IN A TROPICAL NECTAR-FEEDING BAT, *MACROGLOSSUS MINIMUS* (PTEROPODIDAE)

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Storage of spermatozoa in the mammalian female reproductive tract has been widely reported in shrews (Soricidae—Pearson, 1944), rodents (Muridae—Dewsbury, 1984; Ullman, 1976), hares (Leporidae—Martinet and Raynaud, 1975), and bats (Krishna and Dominic, 1978; Mori and Uchida, 1980; Mori et al., 1982; Racey et al., 1975). In this paper, we report the first example of sperm storage in the nectar-feeding bat *Macroglossus minimus*. These observations extend the occurrence of sperm storage in bats to a tropical, noninsectivorous species of the family Pteropodidae and raise questions about traditional explanations of this phenomenon in Chiroptera.

Observations on sperm storage in *Macroglossus minimus* were based on specimens collected during the summer of 1979 and 1981 in Papua New Guinea. Samples were obtained from islands of the Bismarck Archipelago (Manus, New Britain, New Ireland, and Duke of York) and from Central Province, Papua New Guinea. Specific locality data were provided by Hood (1986). One hundred and forty female specimens were examined by gross anatomical dissection; reproductive tracts from 24 specimens were prepared by standard histological techniques for light microscopic examination. Voucher specimens are deposited in the Division of Mammals, Natural History Museum of Los Angeles County.

Spermatozoa were found in the uterine cornua of eight nonpregnant specimens of *M. minimus*. Stored spermatozoa were restricted to the gestational uterus and were not found within the vagina, cervix, oviduct, or uterotubal junction. Free spermatozoa were not found in any portion of the female reproductive tract. Spermatozoa were arranged consistently in parallel, their heads oriented toward the endometrium, forming an intimate contact with maternal epithelial cells (Fig. 1).

In each specimen examined histologically, both ovaries contained undeveloped follicles; no specimens contained preovulatory (mature) follicles or corpora lutea. Together with observations on the distribution of attached spermatozoa, these data support the conclusion that these females possessed stored sperm.

Elimination of spermatozoa from the female reproductive tract following fertilization apparently is extremely rapid. In specimens that contained unimplanted and early implanted blastocysts, no traces of intact tree or attached spermatozoa were observed. The uterine lumina in these specimens contained a small amount of cellular debris; numerous phagocytic cells were observed in the lumina and interstitial spaces. Because our material was prepared for light microscopic study only, we could not determine if elimination was through phagocytosis by leucocytes, maternal epithelial cells, or through some other mechanism of cellular disintegration. However, the observation of a dramatic increase in the numbers of phagocytic cells and amount of luminal debris following fertilization is consistent with elimination by leucocytic phagocytosis.

In the order Chiroptera, sperm storage has been reported previously in 23 species of the families Vespertilionidae and Rhinolophidae (Fenton, 1984; Racey, 1979). The site of prolonged storage of spermatozoa in most bats is the oviduct or uterotubal junction. In *M. minimus* the site of storage is the gestational uterus; attached spermatozoa were absent from oviductal and cervical regions. Special morphological relationships between spermatozoa and maternal tissues, principally involving epithelial cells, have been observed in most chiropteran examples. Orientation and attachment of spermatozoa to uterine or oviductal epithelia has been described in many vespertilionid sperm-storing species (Krishna and Dominic, 1978; Medway, 1972; Mori and Uchida, 1974; Racey et al., 1975). In *Myotis lucifugus* and *M. velifer* studied by Krutzsch et al. (1982), the uterine corpus and cornua were filled with spermatozoa that had no special orientation or attachment, whereas sperm found in the uterotubal junction were attached firmly to oviductal epithelial cells. The morphological relationships of stored spermatozoa in *Macroglossus minimus* generally appear to be similar to those observed in other species of bats.

Many workers have argued that heterothermy and sperm storage in bats are intimately related, because most examples involve temperate species that hibernate (Fenton, 1984; Medway, 1972; Racey, 1982; Racey and Potts, 1970). It seems unlikely that extrinsic environmental factors related to heterothermy or resource

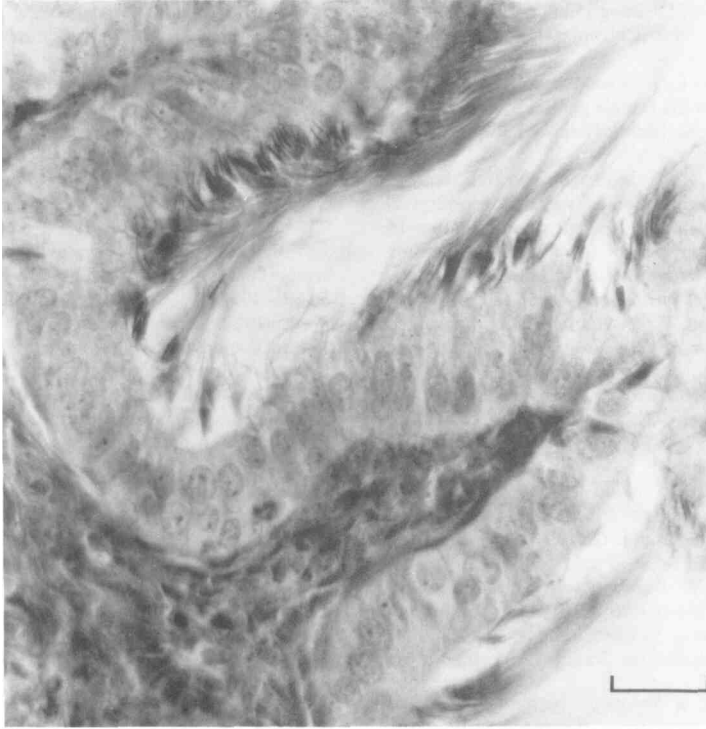


FIG. 1.—Photomicrograph of spermatozoa attached to the endometrium within the uterus of *Macroglossus minimus*. Bar represents 25  $\mu$ m.

availability are sufficient to explain sperm storage in the pteropodid bat *Macroglossus minimus*. *Macroglossus minimus* is not known to exhibit thermoregulatory responses to environmental stimuli, is active throughout the year, and feeds on aseasonally flowering-plant species (Start and Marshall, 1976).

No simple explanation for the function of sperm storage in *M. minimus* is evident from our limited knowledge of reproduction in this species. Breeding is asynchronous, young are born throughout the year, and at any specific locality it is possible to collect females nursing young, pregnant with an early implanted blastocyst or near-term fetus, or nonpregnant with stored spermatozoa (Hood and Smith, 1984; McKean, 1972). The asynchrony in reproduction confounds field estimates of gestation time and of the length of sperm storage.

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#### LITERATURE CITED

- DEWSBURY, D. A. 1984. Sperm competition in murid rodents. Pp. 547-571, in *Sperm competition and the evolution of animal mating systems* (R. L. Smith, ed.). Academic Press, Orlando, Florida, 687 pp.
- FENTON, M. B. 1984. Sperm competition? The case of vespertilionid and rhinolophid bats. Pp. 573-587, in *Sperm competition and the evolution of animal mating systems* (R. L. Smith, ed.). Academic Press, Orlando, Florida, 687 pp.
- HOOD, C.S. 1986. Phylogenetic relationships of Old World nectar-feeding bats (Pteropodidae: Macroglossinae) based on features of the female reproductive tract. Unpubl. Ph.D. dissert., Texas Tech Univ., Lubbock, 81 pp.
- HOOD, C. S., AND J. D. SMITH. 1984. Histology of

- a sexually dimorphic integumentary gland in *Macroglossus lagochilus* (Chiroptera: Pteropodidae). *J. Mamm.*, 65:1-9.
- KRISHNA, A., AND C. J. DOMINIC. 1978. Storage of spermatozoa in the female genital tract of the vesperilionidbat, *Scotophilus heathi*. *J. Reprod. Fert.*, 54:319-321.
- KRUTZSCH, P. H., E. G. CRICHTON, AND R. B. NAGLE. 1982. Studies on prolonged spermatozoa survival in Chiroptera: a morphological examination of storage and clearance of intrauterine and cauda epididymal spermatozoa in the bats *Myotis lucifugus* and *M. celifer*. *Amer. J. Anat.*, 165:421-434.
- MARTINET, L., AND F. RAYNAUD. 1975. Prolonged spermatozoan survival in the female hare uterus: explanation of superfetation. Pp. 134-144, in *The biology of spermatozoa: transport, survival, and fertilising capacity* (E. S. E. Hafez and C. G. Thibault, eds.). Karger Press, Basel, Switzerland, 256 pp.
- MCKEAN, J. L. 1972. Notes on some collections of bats (order Chiroptera) from Papua-New Guinea and Bougainville Island. CSIRO Div. Wildl. Res. Tech. Paper, 26:1-35.
- MEDWAY, L. 1972. Reproductive cycles of the flat-headed bats *Tyionycteris pachypus* and *T. robustula* (Chiroptera: Vespertilionidae) in a humid equatorial environment. *Zool. J. Linnean Soc.*, 51: 33-61.
- MORI, T., AND T. A. UCHIDA. 1974. Electron microscopic analysis of the mechanism of fertilization in Chiroptera. II. Engulfment of spermatozoa by epithelial cells of the fallopian tube in the Japanese house bat, *Pipistrellus abramus*. *Zool. Mag.*, 83: 163-170.
- . 1980. Sperm storage in the reproductive tract of the female Japanese long-fingered bat, *Miniopterus schreibersii fuliginosus*. *J. Reprod. Fert.*, 58:429-433.
- MORI, T., Y. K. OH, AND T. A. UCHIDA. 1982. Sperm storage in the oviduct of the Japanese greater horseshoe bat, *Rhinolophus ferrumequinum nippan.* *J. Faculty Agri. Kyushu Univ.*, 27:47-53.
- PEARSON, O. P. 1944. Reproduction in the shrew (*Blarina brevicauda* Say). *Amer. J. Anat.*, 75:39-93.
- RACEY, P. A. 1979. The prolonged storage and survival of spermatozoa in Chiroptera. *J. Reprod. Fert.*, 56:391-402.
- . 1982. Ecology of reproduction. Pp. 57-104, in *Ecology of bats* (T. H. Kunz, ed.). Plenum Press, New York, 425 pp.
- RACEY, P. A., AND D. M. POTTS. 1970. Relationship between stored spermatozoa and the uterine epithelium in the pipistrelle bat (*Pipistrellus pipistrellus*). *J. Reprod. Fert.*, 22:57-63.
- RACEY, P. A., F. SUZUKI, AND L. MEDWAY. 1975. The relationship between stored spermatozoa and the oviductal epithelium in bats of the genus *Tyionycteris*. Pp. 123-133, in *Biology of the spermatozoa: transport, survival, and fertilising capacity* (E. S. E. Hafez and C. D. Thibault, eds.). Karger Press, Basel, Switzerland, 256 pp.
- START, A. N., AND A. G. MARSHALL. 1976. Nectarivorous bats as pollinators of trees in West Malaysia. Pp. 141-150, in *Tropical trees: variation, breeding, and conservation* (J. Burley and B. T. Styles, eds.). Academic Press, London, 243 pp.
- ULLMAN, S. L. 1976. Anomalous litters in hybrid mice and the retention of spermatozoa in the female tract. *J. Reprod. Fert.*, 47:13-18.

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