## NOTES ON REPRODUCTION AND DEVELOPMENT IN THE FOUR-EYED OPOSSUM, *PHILANDER OPOSSUM*, IN NICARAGUA

The four-eyed opossum, *Philander opossum*, occurs from Tamaulipas, México, southward through Central America into South America. The natural history of this marsupial is not particularly well known and, with the exception of recent publications by Enders (1966) and Biggers (1966), much of the information available on reproduction is scattered in the mammalogical literature. Inasmuch as we have new information concerning reproduction and development of *Philander opossum* in Nicaragua, we have endeavored to bring together the pertinent previously published comments on these subjects and present them with our own data.

On several occasions in the past 12 years, field parties from the Museum of Natural History, The University of Kansas, have collected vertebrates and their ectoparasites in Nicaragua. Among the mammals obtained were 23 adult female four-eyed opossums for which data on reproductive condition, taken at time of capture, are available; an additional 78 specimens of pouch young were stored in alcohol and are available for laboratory study. The specimens listed in Table 1 are from the following seven localities in Nicaragua: (1) 3–6 mi. S or SW Managua, about 400 m, Managua; (2) Santa María de Ostuma, 1250

TABLE 1.—*Reproductive condition of 22 adult females of* Philander opossum *from Nicaragua.*

| KU catalogue number (parenthetical number refers to locality of origin mentioned in text) | Date | Weight (g) | Reproductive condition (sex of young given where known) | Average length of head and body of young (mm) |
|---|---|---|---|---|
| 70164 (1) | 16 February | — | no embryos or pouch young | — |
| 70165 (1) | 2 March | — | 7 pouch young | 20.0** |
| 70166 (1) | 4 March | — | 7 pouch young | no meas. |
| 70167 (1) | 5 March | — | 7 pouch young | no meas. |
| 70170 (1) | 8 March | — | 6 pouch young | no meas. |
| 79427 (1) | 8 March | — | 6 pouch young | no meas. |
| 70173 (1) | 10 March | — | 7 pouch young | 24.0** |
| 70176 (1) | 13 March | — | 3 pouch young | 43.0** |
| 114493 (6) | 17 March | 355.0 | 5 pouch young (2♂, 3♀) | 44.8 |
| —* (4) | 29 March | — | 4 young, out of pouch (3♂, 1♀) | 107.0 |
| 114527 (4) | 31 March | 420.2 | 5 pouch young (1♂, 4♀) | 35.2 |
| 114564 (7) | 31 March | 402.4 | 5 pouch young (3♂, 2♀) | 31.0 |
| 114533 (4) | 2 April | 546.3 | 7 pouch young (5♂, 2♀) | 63.8 |
| 114541 (4) | 2 April | 674.5 | 6 pouch young (4♂, 2♀) | 65.5 |
| 114548 (4) | 2 April | 361.8 | 6 pouch young (2♂, 4♀) | 38.5 |
| 114499 (3) | 15 April | — | 7 pouch young (4♂, 3♀) | 48.0 |
| 114507 (3) | 15 April | 521.3 | 7 pouch young (3♂, 4♀) | 44.0 |
| 114522 (3) | 15 April | 464.9 | 7 pouch young (3♂, 4♀) | 47.1 |
| 114561 (5) | 24 April | 352.1 | 6 pouch young (4♂, 2♀) | 57.0 |
| 105887 (2) | 2 July | 256.3 | 7 pouch young (2♂, 5♀) | 40.5 |
| 110660 (2) | 6 July | 550.0 | lactating, no pouch young | — |
| 97346 (4) | 15 July | 590.0 | 7 pouch young (5♂, 1♀, 1?) | 89.0 |
| 97354 (4) | 27 July | 282.7 | 5 pouch young | no meas. |

* Female alive, in captivity.
** Probably crown–rump length.

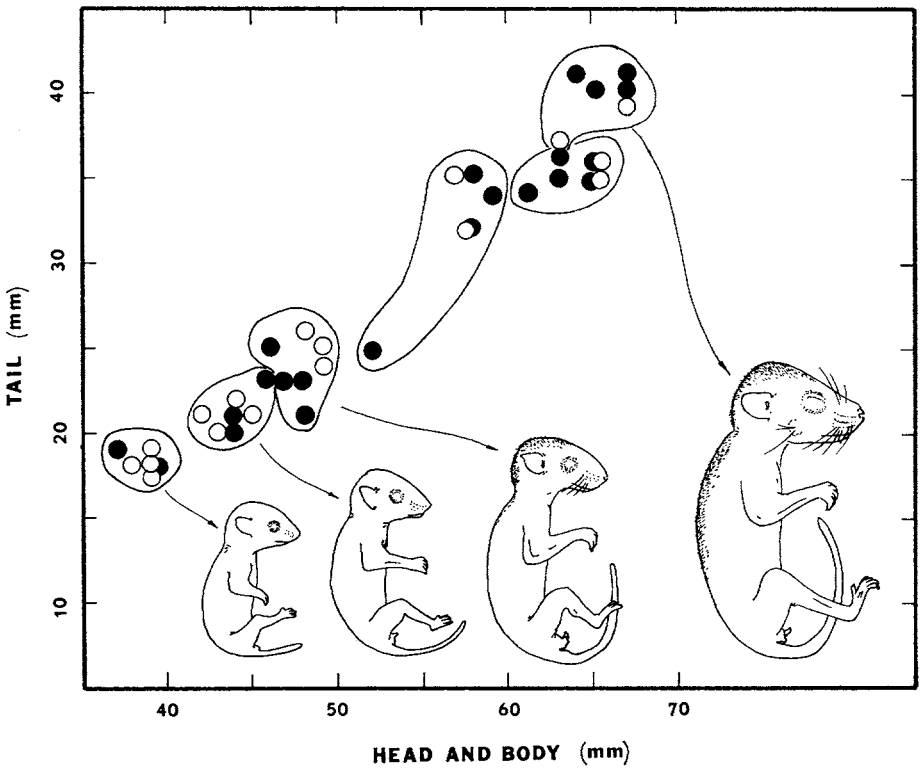


FIG. 1.—Scatter diagram comparing development in six litters of *Philander opossum*. Solid circles represent males and open circles represent females; litters are grouped within encircling lines. Line drawings to scale compare development of external features with increase in size in four litters.

m, Matagalpa; (3) 4 km W Teustepe, 140 m, Boaco; (4) 1–5 km N Sabana Grande, 45 m, Managua; (5) Cara de Mono, 50 m, Zelaya; (6) 1 km NE Esquipulas, 420 m, Matagalpa; (7) 3 km N and 4 km W Diriamba, 600 m, Carazo.

In our material (Table 1), females of *Philander opossum* in Nicaragua carried pouch young at least from March through July, but Biggers (1966: 265) reported pouch young from as early as February and as late as October in Nicaragua. It is not known if the four-eyed opossum is reproductively active throughout the year. Biggers (*loc. cit.*) has presented evidence that females undergo anestrus for about 2 months, beginning in early November and coinciding with the last half of the rainy season. Males, according to Biggers (*op. cit.*: 251), have spermatozoa in their testes and epididymides throughout the year and therefore are "non-seasonal." Enders (1966: 198) suggested that reproductive activity in the four-eyed opossum in Panamá begins with the onset of the dry season in February; previously he (1935: 411) had reported capturing nonbreeding females of *P. opossum* in the period January to April. In Veracruz, México, the four-eyed opossum was thought by Hall and Dalquest (1963: 199) to be reproductively active "at all times of the year."

The number of young per litter in *P. opossum* evidently varies from one to seven. Enders (1966: 198) stated that *P. opossum* has ". . . smaller [litters] than *Didelphis* . . . the largest encountered was five." Enders (1935: 411) studied four-eyed opossums on Barro

Colorado Island, Panamá, and found litters of two, four, and five, which led him to state (*loc. cit.*) that "five is the largest number possible in a litter that can survive, as there are but five mammae." Goldman (1920: 52) also reported a litter of five from Panamá, and Goodwin (1946: 284) noted that females carrying five young had been taken in Costa Rica. From Nicaragua northward, the published records indicate that litters of five, six, and seven are most common. Litters of five and seven have been reported from Guatemala (Handley, 1950: 143; Murie, 1935: 17); two females from there in our collection, both taken in February, carried four and five young. Litters of three, four, and five have been taken in El Salvador (Felten, 1958: 217). In México, litters of five and seven have been recorded from Veracruz by Davis (1944: 375) and pouch young numbering four and six have been reported from the same state by Hall and Dalquest (1963: 199). As indicated by live young in the pouch, the average number in 21 litters from Nicaragua (Table 1) was 6.05, with a range of three to seven and a mode of seven.

In 13 litters for which we have sex ratios, 41 (53 per cent) of 78 pouch young were males, whereas 37 (47 per cent) were females. None of the litters had an equal number of males and females (Table 1). The great variation in size of pouch young obtained in March is of interest. Young examined from that month ranged from tiny, "embryonic" neonates measuring about 35 mm (head and body) to large, active young averaging 107 mm in length; the latter still were nursing but were willing also to feed on ripe bananas. Great variation in size (and age) of young at a given time in the breeding season also is characteristic of the woolly opossum (*Caluromys derbianus*) in Nicaragua (Phillips and Jones, 1968: 320–321).

Degree of external development of pouch young has been compared with size in Fig. 1. The difference between young four-eyed opossums measuring about 45 mm in head and body length and those measuring about 49 mm is noteworthy. The larger young have short vibrissae and dark, downy fur on the crown and nape, and, furthermore, the external ear opening is visible; these features are not characteristic of the slightly smaller individuals. One of the six litters plotted in Fig. 1 is of special interest because it was the only litter of 13 examined in the laboratory in which we found a "runt." In this particular litter five of the young (three males and two females) have a head and body length approximating 58 mm, whereas the one "runt" measures only 52 mm (although it is essentially the same as its larger littermates in external development). In the period of development illustrated in Fig. 1, males and females appear to grow at the same rate.

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## CELLULOLYTIC BACTERIA AND REINGESTION IN THE PLAINS POCKET GOPHER, *GEOMYS BURSARIUS*

Although the presence of symbiont, cellulose-decomposing microorganisms in the digestive tract of certain herbivorous mammals is well known, microbial digestion in only a few nonruminant mammals has been studied (Hall, 1952; Keys *et al.*, 1967). Information on rodents is particularly scarce. Keys *et al.* (*loc. cit.*) implied cellulolytic activity in *Rattus*, and Riggs and Studier (1966) identified cellulase-secreting microorganisms in *Thomomys bottae*. We report here the occurrence of cellulose-digesting bateria in the cecum and large intestine of the plains pocket gopher, *Geomys bursarius*.

The animals used were live-trapped during the spring of 1968 in the vicinity of Arlington, Tarrant Co., Texas. Immediately after capture, the animals were brought to the laboratory, sacrificed, and the contents of the small intestine, cecum, and large intestine were diluted with sterile saline in separate containers. Standard bacteriological procedures were followed for the enrichment, isolation, and characterization of aerobic bacteria capable of utilizing cellulose (Harrigan and McCance, 1966; Pramer and Schmidt, 1965). Early enrichment cultures yielded some morphological types resembling members of the genus *Sporocytophaga* but failed to respond positively to our enrichment techniques.

We obtained 11 isolates in pure culture. All cells (0.8–1.0 × 5–7 $\mu$) were gram negative and arranged singly. We did not observe microcysts or fruiting bodies. Two cultures produced flat, spreading colonies on trypticase soy agar (BBL) at 22–24°C. The remainder produced slightly raised, moist colonies, some exhibiting "slime trails" at their edges. All isolates utilized cellulose fiber and cellulose gum (carboxymethylcellulose), and six strains demonstrated some degree of pectinolytic activity. These and other data obtained agreed with the characteristics of the bacteria *Cytophaga* sp. (Breed *et al.*, 1957; Skerman, 1967). Samples from the small intestine did not produce cellulolytic organisms on culture.

Pocket gophers are strictly herbivorous, and food is least available in winter. *G. bursarius* in Texas stores food and practices subterranean "grazing" on rhizomes (Kennerly, 1964). Cellulolytic activity is probably most contributive to the energy budget in winter.

Wilks (1962) reported reingestion in *G. bursarius*. This behavior probably augments the nutritional harvest by re-exposure of food to digestive processes that include microbial activity. Persistent reingestion of all fecal material, however, would be disadvantageous, because net assimilation would decline with successive circuits through the gut.

*G. bursarius* assembles fecal pellets in special subterranean chambers (subsequently filled with soil); therefore, some but not other pellets are reingested. Domestic rabbits produce soft, mucous pellets at night and hardened, round pellets by day, but only the former are reingested (Madsen, 1939). This intestinal pattern, which prohibits excessive cycling of digesta, may indicate rhythmic reingestion in the pocket gopher.

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