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General Observations on the Growth and Development of the Young Pouch Opossum, *Didelphis virginiana*

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Abstract. A 3-year study of general growth and development revealed a uniform increase in body length of young pouch opossums during the first 10 weeks of life. Throughout this period, growth was linear and constant for all animals regardless of sex, litter size, or whether animals were obtained from first, second or third litters. Body weights were somewhat more variable, but there were no significant sex differences. Various aspects of external gross morphology are presented and discussed as they relate to growth of the young opossum.

Introduction

The young pouch opossum, *Didelphis virginiana,* is an excellent model for studying various aspects of postnatal growth and development. Born $12^1/_2$ days after conception, the newborn opossum equates with the 12-day rat or the 2-month human fetus (1). The young continue to develop in the maternal pouch where they are readily accessible. For colony-bred animals, ages of the young can be established by initiating timed pregnancies (5) but for those born in the wild, it is necessary to refer to published growth curves such as those presented by *Hartman* (8). However, the data provided by *Hartman* are somewhat limited in scope, contain interpolations of data provided by other observers, and the weights for the newborn are based on measurements of preserved specimens. More recently *Block* (2) has provided additional postnatal measurements and *Hulsey et al.* (9) have recorded a number of growth parameters for older specimens. The latter observations were made on a single litter of 6 animals whose initial age was estimated from the growth curves determined by *Hartman* (8). In this communication we present the results of a 3-year study of the growth patterns of young pouch opossums.

Methods

During 1975–1977 inclusive, 268 pouch young from 31 litters were studied for general growth and development. 11 litters were present in pouches of females captured from the wild and 20 litters were

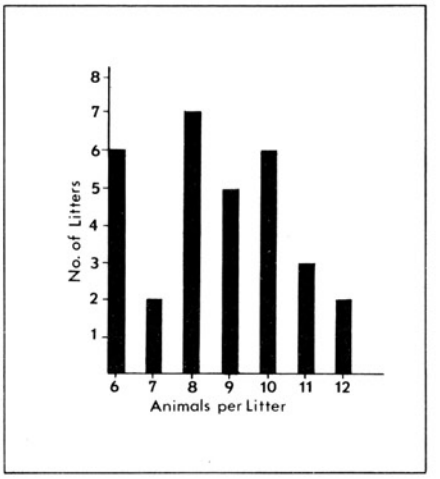


Fig. 1. Frequencies of litter sizes for 31 litters.

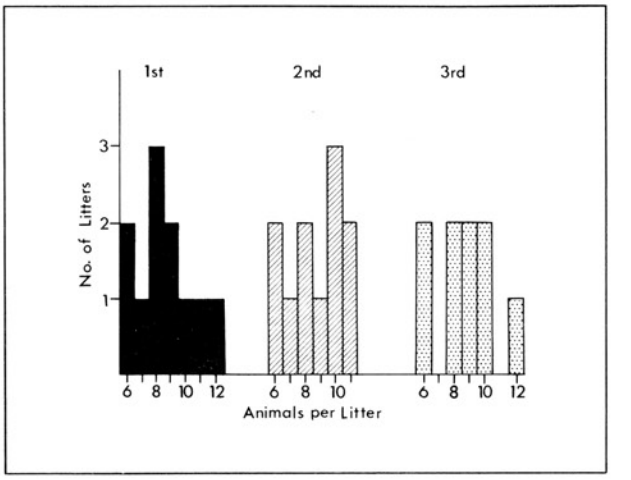


Fig. 2. Comparison of litter sizes for 1st, 2nd and 3rd pregnancies. First pregnancies are those born in the wild and present in the pouch at the time of capture of the female.

obtained by re-breeding these females after removal of the young. The latter provided litters whose ages were known from direct observation. The first measurements of body weights and lengths were made at 12 and 24 h after birth: thereafter the observations were made at regular intervals. Data from additional litters were incorporated into the growth curves by taking the first measurements at times that overlapped those acquired from previous litters. In this manner a growth curve extending from 12 h to 106 days was established each point representing combined data acquired from different litters at different times in the 3 years of study. Additional data were obtained from those young captured in the wild. These also were examined at regular intervals, their initial ages being estimated from the data already obtained.

Measurements of the pouch young were taken usually at weekly intervals, but some litters were examined at 10-, 14- or 21-day intervals. No attempt was made to use intact litters throughout the entire developmental period: animals removed from the pouch were sacrificed for other studies. Reattachment of the youngest animals to a nipple is rarely successful and it was felt that continued, periodic handling of the older animals might introduce variables resulting from stress.

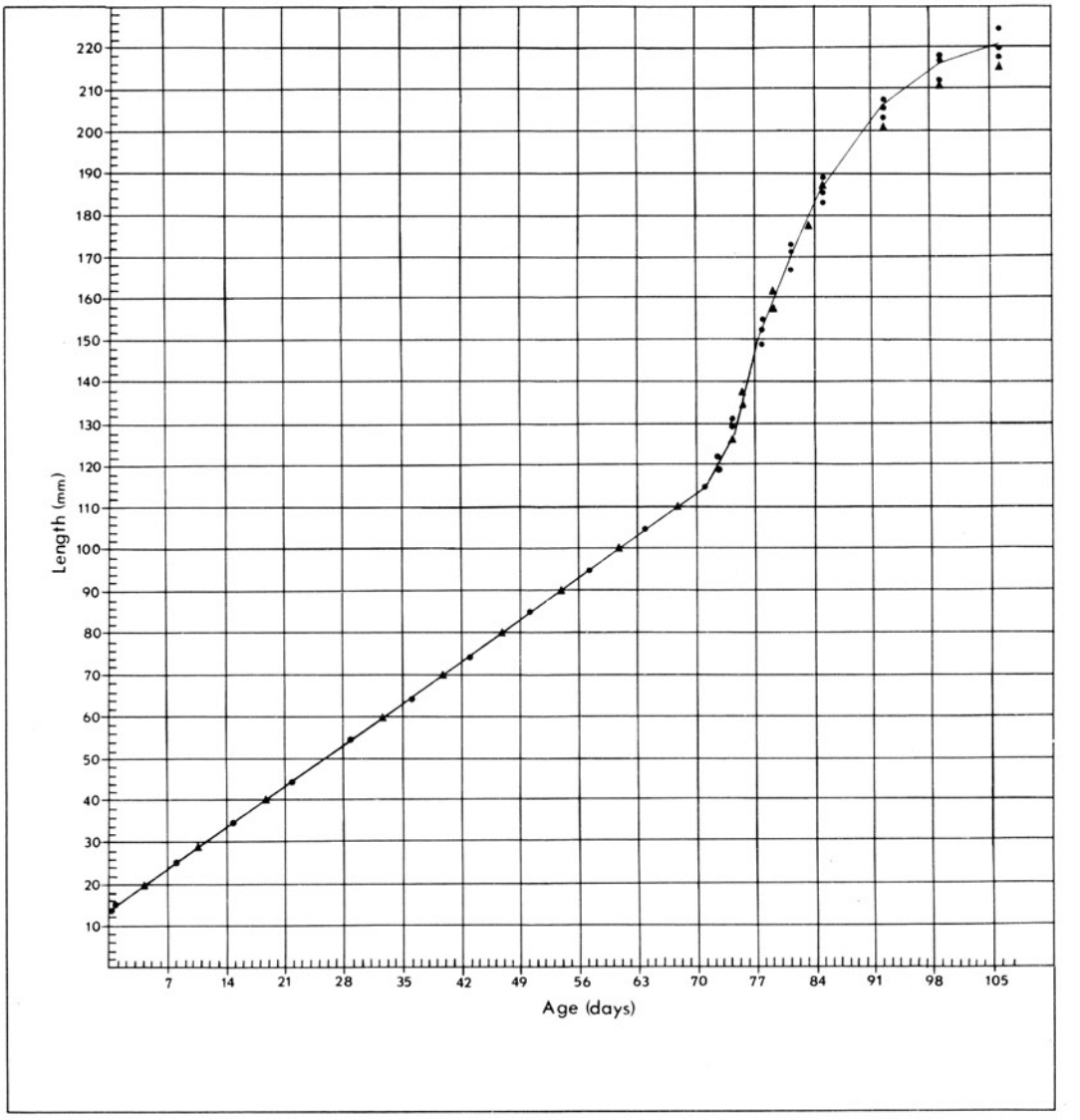
Body lengths were determined as snout-rump lengths and all measurements were made on living animals. The distance from the tip of the snout to the junction of the tail with the trunk was recorded, with the animal on its back and firmly pressed against a scale with slight traction to straighten the spine as much as possible.

Results

Frequency of litter sizes for the 31 litters is shown in figure 1. Litters averaged 8.65 ± 1.83 animals per litter, ranging from 6–12. Litters of 8–10 animals were the most frequent and accounted for 58% of all litters. The 11 wild-born litters constituted first pregnancies. Second pregnancies provided 11, and third pregnancies provided 9 litters and were obtained by re-breeding. As shown in figure 2, there were no significant differences in the litters from first, second or third pregnancies. The mean litter size for first pregnancies was

8.55 ± 1.91: second and third pregnancies contained 8.73 ± 1.85 and 8.66 ± 1.74 animals per litter, respectively. Litters of 8–10 animals made up 54.5% of first and second pregnancies and 66.6% of third pregnancies.

Figure 3 relates body length to age through the first 106 days of postnatal life. For the first 10 weeks the increase in length was remarkably uniform and constant for all animals regardless of sex, litter size, or whether the animals were from first, second or third litters. During this period, growth was linear and the animals increased in length by 1.429 mm/day, a value obtained whether measurements were made at



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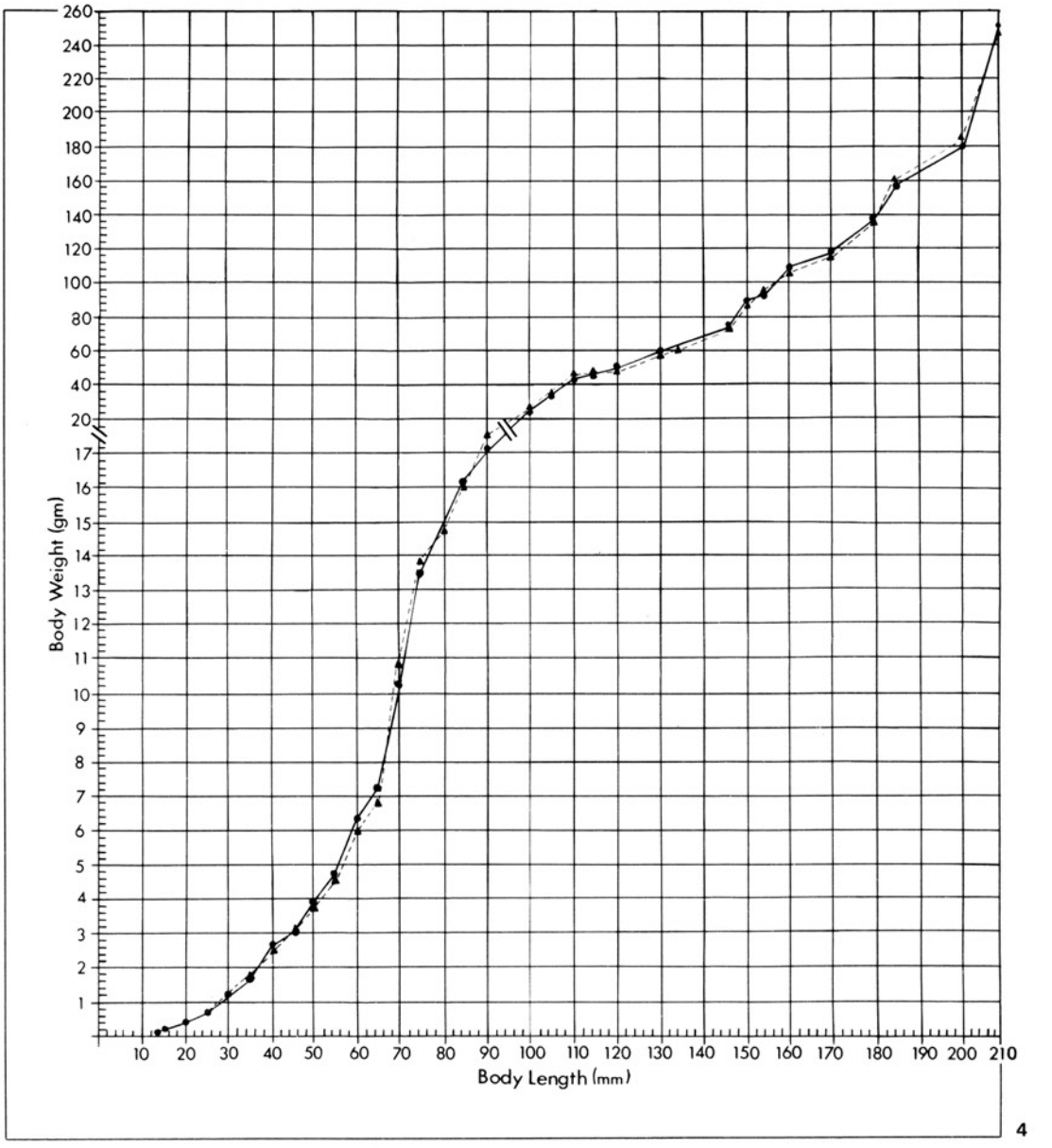

Fig. 3. Length-age relationships of postnatal opossums. ● = Data obtained from litters born in captivity; ▲ = data from litters born in the wild. Each point on the curve is the mean for 3–9 animals.

Fig. 4. Body weights plotted against body lengths. ● = Females; ▲ = males.

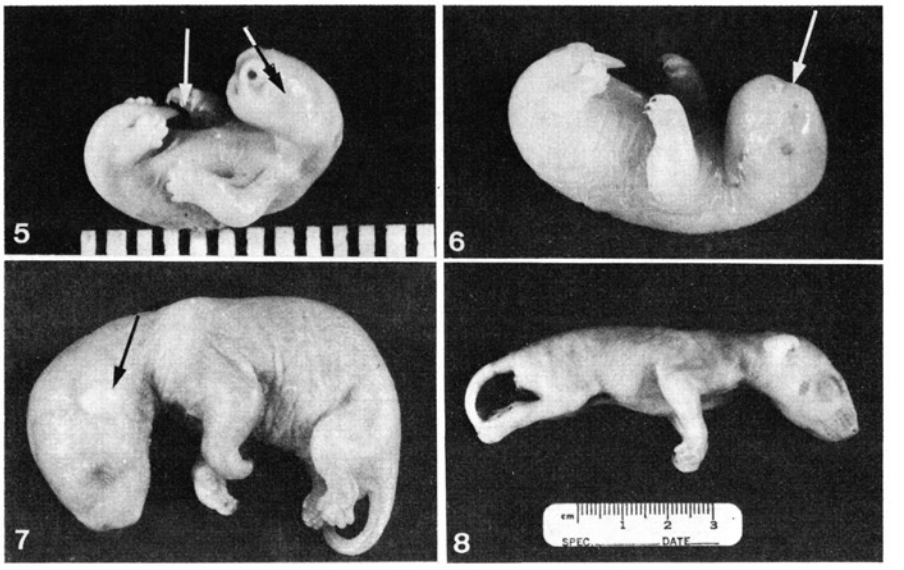

Fig. 5. At 24 hours of age, the young pouch opossum is at a primitive stage of development. Facial features are poorly developed, the eyelids are fused and the eyes (double-headed arrow) are barely visible, the mouth is open only anteriorly, the ears are not formed and the nostrils are widely flared. Forelimb development is much in advance of that of the hindlimb. Deciduous claws (single-headed arrow) are present on the forepaws. Length 15 mm.

Fig. 6. Even at 8 days, the young opossum is markedly immature. The lips are closed except for a small anterior opening (arrow), eyes remain closed but their position is more obvious. Hindlimbs show little additional development. Length 25 mm.

Fig. 7. In the 15-day-old opossum, development of the ears is indicated by a swelling (arrow). Development of the hindlimbs, though advanced over previous stages, lags behind that of the forelimbs, Deciduous claws have been shed but new claws are beginning to emerge from the forepaws. Length 35 mm.

Fig. 8. By the 46th day considerable advance in development is apparent. Facial development includes the appearance of vibrissae about the mouth and in a patch inferior and posterior to the eye, and development of the ears. Eyes and mouth remain closed but the lips are much more in evidence. The body is lightly covered with fur which is most prominent along the back. Forelimbs still are considerably more advanced than are the hindlimbs. Length 80 mm.

7-, 14- or 21-day intervals. The only exception was in one litter measured at 10-day intervals where the daily growth was 1.50 mm. A period of accelerated growth began at the 71st day and continued for about 3 weeks, after which there was a gradual decrease in the growth rate. Subsequent to day 71, growth became more variable, especially from litter to litter, but within a given litter remained fairly uniform. The variability of growth was not related to first, second or third litter animals.

Body weights plotted against lengths are shown in figure 4. There were no significant differences in the weights of males and females and, as might be expected, the young gained weight much more rapidly than they gained in body length. By the 71st day, an 8-fold increase in length had been achieved, but weight had increased nearly 300-fold. One peculiarity of the weight curve was the repression of weight gain that occurred between 110–120 mm.

Various aspects of external morphology

Fig. 9. The eyes of this 71-day-old opossum are not fully opened and the mouth still is closed at the corners. Hindlimb development is now similar to that of the forelimb and, except for some thinning over the ventral surface, the animal is well furred. Length 115 mm.

Fig. 10. By 76 days the animal appears mature. The eyes and mouth are fully open and a luxuriant coat of fur with prominent guard hairs covers the animal and extends onto the ventral surface. Although still dependent on the mother for its nutrition, both at this and the previous stage, the animal freely leaves and re-enters the pouch. Length 140 mm.

during development are shown in figures 5–10. At 24 h (fig. 5) the young opossum obviously is at a primitive stage of development. The well-formed shoulder girdle and forelimbs (which bear deciduous claws) contrast markedly with the clawless hindlimbs that virtually are at the limb-bud (paddle) stage. The ears are unformed, the eyelids are fused and the eyes are barely visible. The lateral margins of the mouth are tightly closed and only anteriorly are the lips separated sufficiently to permit attachment to a nipple. The most prominent facial feature is the widely flared nostrils. Although appreciably larger by 8 days (25 mm), the young opossum in figure 6 still is remarkably immature in appearance: the eyelids remain fused, the ears undeveloped, the lips closed and forelimb development remains much in advance of that of the hindlimb. By 15 days (35 mm), greater development is apparent (fig. 7). The ears are marked as a swelling, the hind limb is more advanced, and the deciduous claws have been shed from the forelimb and are being replaced. The eyes and mouth remain tightly closed.

A pouch young of about 46 days (80 mm) is shown in figure 8. The lips, though still closed, are more clearly defined and vibrissae are present about the mouth and in a patch posterior and inferior to the eye, which remains closed. The ears have formed and the animals is

covered by light, downy hair that is more prominent along the spine. The initial emergence of hair occurs earlier than this however: at the 55-mm (29-day) stage (10). Development of the forelimbs still is in advance of the hindlimbs and even at 61 days (100 mm) locomotion is by a dragging action of the forelimbs, the hindlimbs being relatively immobile.

By 71 days (115 mm) the young opossum is well developed (fig. 9). At the stage shown here, the pouch young are detached from the nipple, freely mobile, and able to leave and return to the pouch at will. Except for some sparseness along the undersurface, the animal is fully furred. Forelimbs and hindlimbs show a similar degree of development. In this animal, the eyes are not yet fully opened and the mouth still is closed at the corners.

Figure 10 shows the mature appearance of a pouch young at 76 days of age (140 mm). The animal is fully furred, even on the ventral surface, and coarse guard hairs are prominent. The eyes are fully opened and the lips completely separated to assume the 'smiling' appearance characteristic of the opossum. From observations of stomach contents at autopsy, the young at this stage still are dependent upon the mother for nutrition and full weaning does not occur until some time later. The presence of solid food in the stomach was not noted until about 85 days of age (190 mm).

During other studies of postnatal development, involving autopsy of over 700 young opossums, developmental anomalies were encountered in only 2 animals. In 1 animal a toe was missing from a forelimb while a second animal lacked one eye.

Discussion

In agreement with *Feldman and Ross* (5) we have found postlactational breeding to be a convenient means of obtaining a continuous supply of young pouch opossums. In contrast to the low rates of postlactational conceptions (37%) reported by these authors, we consistently have obtained 90% or better successful breedings following removal of nursing young, routinely obtaining second and third litters and even on occasion a four litter by such means. No decline in litter size was noted throughout successive pregnancies. The litter sizes reported in figure 2 refer only to those animals which had attached to a nipple. The conception rates are much higher and as many as 20 newborns have been delivered at second and third pregnancies.

The discrepancies in conception rates may arise from two factors. We do not attempt to maintain year-round colonies but capture new females from the wild each breeding season. Females carrying pouch young when captured appear much more likely to become pregnant when re-bred, and the greatest number of failures occurred with animals that did not carry young when captured. Possibly the females used by us, most of which carried young when taken, represent a selection of more naturally vigorous breeders. Additionally, *Feldman and Ross* (5) reported a delayed onset of estrus when the young are removed early from the mother. Since we remove the young sequentially over a period of weeks, this may be a factor in the higher frequency of subsequent pregnancies that we observed. In one instance a litter of 10 attached young was obtained 20 days after the last members of the previous litter were removed.

Our growth curves differ from those of *Hartman* (8). We obtained a remarkably constant linear rate of growth throughout the first 71 days, with none of the scatter reported by *Hartman*. However, all our measurements were made on living rather than dead animals, and

the lengths were obtained by measuring along the dorsal, rather than the ventral, surface. Our data are obtained from animals taken in different years, from different litters, at different times of the year, and include wild-born as well as captive-born animals and thus should be representative. It is conceivable that the growth of the pouch young could be influenced by the sequential removal of animals from the mother in that, as the size of the litter diminished, the remaining animals may have an increased source of nourishment. However, the young opossum remains firmly attached to a given nipple until it becomes free roving, and it is not known whether removal of a suckling young thereby increases milk production in other glands. It is possible that lactation is not uniform from gland to gland: in two litters from which all of the young were removed at one time, the variation in weights of the littermates was related to their position in the pouch. That those deep in the pouch were the heavier might indicate more abundant milk production by these glands or production of milk of different compositions. Variation in responses and activities of mammary glands do occur in other species. The estrogen-induced mammary tumors of the rat tend to arise more frequently in the glands of the mid-abdomen (3) and extreme variation is seen in the red kangaroo, where the lactating glands secrete independently, simultaneously producing milks of different composition and volume (4, 5).

The flattened portion of the weight curve for animals between 110 and 120 mm length coincides with the initiation of more rapidly increasing body lengths, and is also the time at which the young begin to detach from the nipple and become exploratory. Whether or not this relates to a change in milk production prior to weaning is unknown, but changes in milk composition as the young mature have been noted in the echidna and kangaroo (6, 7).

The times at which eye and mouth opening occur are variable and do not provide reliable guides to age. The eyes may begin to open as early as 50 days (75 mm) or remain closed even at 67 days (100 mm). Partial opening of the eyes has always occurred by 71 days (11.5 cm) and is never delayed beyond this. Separation of the lips shows the same time range and appears to occur independent of eye opening and, within this time span, animals can be found with any combination of eye and mouth opening varying from partial to complete, even within the same litter. In our experience, snout-rump lengths provide a reliable means of estimating the age of the young pouch opossum. It is hoped that the present observations, made over a 3-year period, will supplement earlier studies of normal growth and development of the young opossum, and provide a useful basis for future investigations.

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