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POSTNATAL GROWTH AND DEVELOPMENT OF THE SPINY RAT, *NIVIVENTER COXINGI* (SWINHOE, 1864)

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Yao-Sung Lin and Hon-Tsen Yu (1987) Postnatal growth and development of the spiny rat, *Niviventer coxingi* (Swinhoe, 1864). *Bull. Inst. Zool., Academia Sinica* **26**(1): 1-7. Growth and development of a wild-born, laboratory-raised litter of the spiny rat, *Niviventer coxingi*, were studied from after birth through the 77th day in captivity. The altricial young were naked and blind at birth and a juvenile pelage was completed on day 25. On the 12th day upper incisors first erupted, and lower incisors protruded in the next day. Opening of the eyes and the auditory meatus occurred on day 19 and 20, respectively. The young showed the nipple-clinging behaviour at the pre-weaning stage. They were weaned on day 25 and could walk and climb well on day 40. Instantaneous growth rates of weight and linear measurements were highest in the first 10 days and then decreased. Relative to the adult size, the hind foot and the ear showed a more rapid growth than the other parameters measured in this study. It may indicate the vital role of hind foot and ears in early survival for the animal. The maternal behaviours were well developed in the nursing female and could last for more than 2 months.

The spiny rat, *Niviventer coxingi* (Swinhoe, 1864) has long been recognized as *Rattus coxingi* endemic to Taiwan (Aoki and Tanaka, 1941; Musser and Chiu, 1979). However, recently Musser (1981) treated it under a newly installed genus *Niviventer* and reported its occurrence in Northern Burma as well. Lin (1982) briefly reviewed general accounts of *N. coxingi* in Taiwan, but still relatively little information is available on the biology of this species. Aoki and Tanaka (1941) reported its distribution from the foot of mountains up to 2500 m, but the rat was not seen in level land or in mountains around 3000 m. Yu (1983) found it associated with wooded areas. Although it is basic to the understanding of the life history, nothing appeared to have been published previously on the ontogeny of this rat. This report presents results on the growth and development of a litter of *N. coxingi* after birth through the 77th day in captivity, supplemented with fragmented field observations.

Details of growth and development were obtained from a wild-born, laboratory-raised litter. In September 1982, in the Experimental Forest of the National Taiwan University (NTU) at Chitou, central Taiwan, a female spiny rat captured in a meshwired rodent cage (24×15×11 cm) gave birth to 3 neonates, 1 male and 2 females. The cage together with the rats were then transferred to the Zoology Department, NTU at Taipei. The animals were subjected to natural temperature and light cycles. Pieces of newspaper and cloth were provided as nesting material. Sweat potatoes, carrots, corn, beans, and

spinach were fed to the animals and water was provided ad lib. Without anesthetizing the rats, weights and linear measurements were taken daily from day 4 to day 17 and thereafter on days when it was convenient to do so through day 77. Linear measurements were made with a caliper and estimated to the nearest 0.1 mm. Weights was read to the nearest 0.1 gm. Developmental data were recorded when measurements were made. Percentage of adult size attained for the young was based on measurements of a series of adults from Chitou. The average measurements for 20 males and 20 females were: head and body, 185.2 mm; tail, 223.4 mm; hind foot, 36.9 mm; ear, 27.2 mm; weight, 158.3 gm. Instantanous growth rates (IGR) are calculated according to the formula: $IGR=(\ln m_1-\ln m_2)/(t_1-t_2)$, where ln is the natural logarithm, m is the measurements taken, and t is time (Simpson *et al.*, 1960). Owing to this small sample size, the data presented are the result of the combined measurements of both sexes.

DEVELOPMENT

The parturition was not witnessed. The mother rat and her young were found in the cage at 9:30 A. M. No afterbirth was seen and it could have been consumed by the mother rat. The noticeable events in postnatal development were summarized in Fig. 1.

Day 0 (day of birth)—The young were born hairless and the skin wrinkled. Viscera were visible through the pink, translucent skin. The umbilical scar, though inconspicuous, was present; teats were absent; digits were fused and the nails were visible; pinnae were folded and sealed; eyes were not open and were seen as dark bulges below the skin surface; no teeth were visible and mystacial vibrissae were not noticed. The young always lay on backs or on sides; when disturbed, wriggled their bodies. Within one day after birth, the young could utter faint squeaks which were almost inaudible. The sexes were distinguishable by the greater ano-genital distance in the male. Day 1—Outer appearance was similar to that of day 0. Mites from the mother rat began to crawl about on the young. Day 4—The skin wrinkled more deeply. The dorsal region except for the digits, showed dark pigmentation particularly on the tips of pinnae and regions around the eyes. Mystacial vibrissae were apparent. Body fur emerged as a sparse fuzz on the dorsal region. Nails were more prominent and digits were still fused. Day 5—Pinnae were erect, but the external auditory

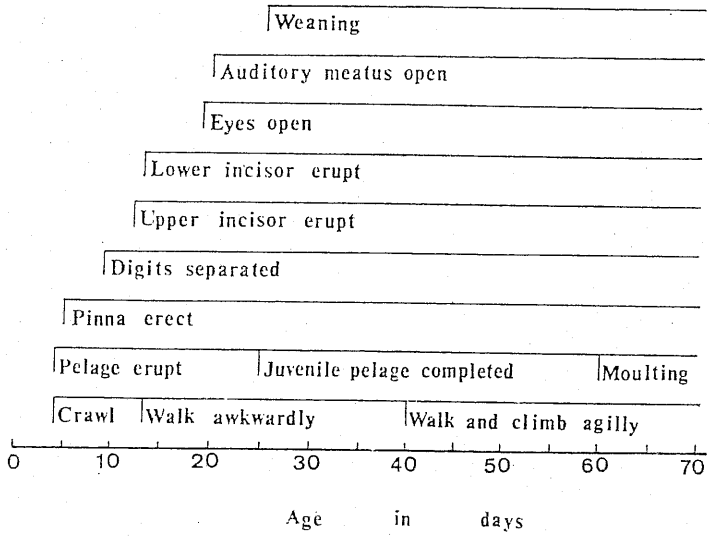

Fig. 1. Summary of postnatal developmental events of *Niviventer coxingi*.

meatus remained sealed. The muzzle was swoolen because of the growth of mystacial vibrissae. Scales on the tail were visible. Dark pigments accumulated on the scrotum of the male. The ano-genital distance of the male was 7.70 mm, while that of the females were 4.50 mm and 3.45 mm, respectively. When the mother rat moved, the baby rats, clinging to the nipples, were dragged along. Day 6—Pigmentation on the dorsal region became darker. The young were able to right themselves easily when turned on their back. Day 7—The fur on the dorsal region was thicker, and that on the venter erupted. Day 8—Incisors could be seen beneath the gums. Day 9—The fur on the dorsal region became yellowish brown, and the long white guard hairs (spines), although still soft, were visible. The dorsal part of the tail was black and thus made their tails bicolored. The dorsal regions of the four limbs were black but that of the digits remained white. The digits were separated and the young were able to grasp. Day 12—The upper incisors erupted. Day 13—The lower incisors erupted. The limbs were splayed out and movement was awkward. Day 17—The guard hairs (spines) appeared on the venter. The walking ability was improved. Day 19—The eyes were open. Day 20—The external auditory meatus were open. Day 25—The testes bulged under the abdominal fur but did not became scrotal. Judging from the feces, the young began to take solid food and thus weaning was assumed to have occurred. The general coloration of the pelage was very similar to that of adults, but the texture was finer and fluffier. Day 40—The walking ability was excellent. The young could climb a vertical stick with agility. Day 60—Moulting was observed. Hair replacement began on the rump region and proceeded forwards dorsally. The adult pelage was coarser and scattered heavily with long black guard hairs (spines) which characterized the species. Day 70—The male died without any obvious cause. The testes still remained in the abdomen. Day 66—The females also died of uncertain cause. The vagina was yet not open.

GROWTH

Growth in weight and linear measurements of young spiny rats from birth through 66 days of age were depicted in Figs. 2 and 3, respectively. Table 1 presents the instantaneous growth rate (IGR) up through 66 days of age. The intervals by which the IGR calculated were kept to 10 days or as close to 10 days as possible.

Weight—At birth, total weight of the 3 neonates was 14.4 gm or 10% that of the mother rat. The average weight for each rat was 4.8 gm or 3.0% of the adult size at birth, it reached 11.9 gm (7.5% of adult size) when weaning occurred, and was 33.8 gm (21.4% of adult size) at 66 days of age. The IGR was highest (6.4%) in the first 10 days after birth, but it declined sharply (1.1%) in the second 10 days. The rats resumed a high IGR from 20 through 50 days of age, and then it dropped again. Head and body length—Average head and body length at birth was 41.3 mm or 22.3% of adult size. Though the initial IGR of the head and body length was high (4.6%), the rate dropped rapidly, and the attainment of adult size was only 57.4% (106.3 mm) on day 66. Tail length—Average tail length at birth was 19.4 mm or 8.7% of adult size. Relative to adult size, the initial tail length was shortest among linear dimension studied. The IGR of the tail was highest (7.4%) before 10 days of age, it remained relatively high from 10 through 42 days of age. The tail length exceeded the head and body length after 30 days, and remained thus through day 66. After 42 days, the growth of the tail slowed down, and the tail length attained 52.8% (117.9 mm) of adult size at 66 days of age. Hind foot length—Average hind foot length on day 4 was 11.3 mm or 30.6% of adult size. The hind foot grew rapidly in the first 20 days, and relatively slowly thereafter up

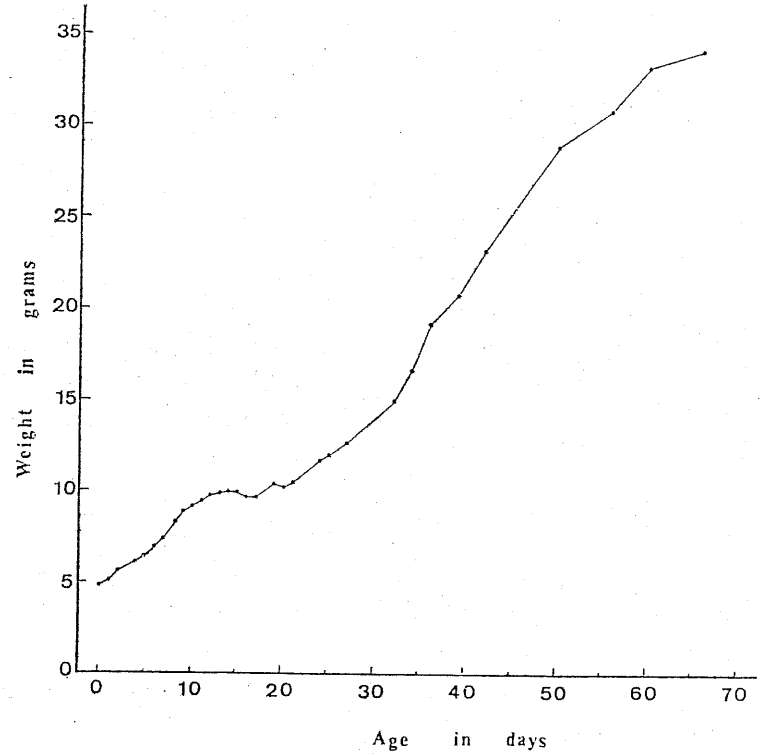

Fig. 2. Growth in weight of a wild-born, laboratory-raised litter of *Niviventer coxingi* from birth through 66 days of age.

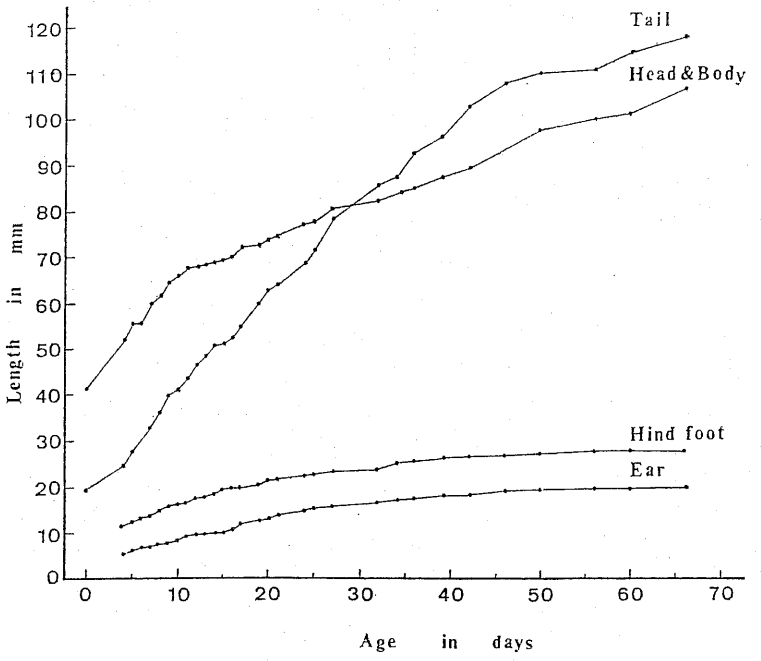

Fig. 3. Linear growth data for a wild-born, laboratory-raised litter of *Niviventer coxingi* from birth through 66 days of age.

TABLE 1
Instantaneous growth rates (IGR; per cent per day) of weight and linear measurements of a wild-born, laboratory raised litter of *Niviventer coxingi*

Age interval in days	Head and body		Tail length	Hind foot length	Ear length
	Weight	Length			
0-10	6.4	4.6	7.4	6.3*	8.0*
10-20	1.1	1.1	4.3	2.6	4.4
20-32	3.2	1.0	3.5	0.9	2.0
32-42	4.4	0.8	1.8	0.8	1.0
42-50	2.7	1.1	0.8	0.6	0.7
50-60	1.5	0.3	0.3	0.2	0.1
60-66	0.3	0.9	0.5	0.1	0.4

* Denote the rate from day 4 to day 10.

through 66 days of age. The hind foot length reached 75.3% (27.8 mm) of adult size on the 66th day which was the highest adult size attained among the linear measurements taken at the end of the observations. Ear length—Average length of the ear on day 4 was 5.2 mm or 19.1% of adult size. The ear grew rapidly up to 60.7% of adult size at 32 days and then the IGR of the ear length decreased. The ear length attained 73.5% of anult size at 66 days of age.

MATERNAL BEHAVIOURS

Provided with fallen twigs and leaves, the mother rat built a cup-shaped nest, but when replaced by pieces of paper and cloth, she shredded the material to make a crude ball-shaped nest with a central cavity which the rats occupied. The mother rat carried her young by holding their loose nape skin in her incisors. Whe nest was disturbed, the mother rat pushed the young under her belly and would bite the forceps or fingers that was trying to get the young. When we held the young, the mother rat would move up to drug them backwards by their napes or legs. When we returned the young to the cage, the mother rat would retrieve them to the nest and groom them extensively. This grooming behaviour made our attempt to mark the young with ink unsuccessful. The maternal defence behaviour diminished after the 40th day when the young acquired their own moving ability, but still the young would flee to the mother's belly when frightened. In the field, a marked 63-day-old rat and its mother rat were caught in a cage. We released the mother rat first, but it lingered around until we released the young, and then left with her baby rat. This indicates the maternal behaviour may last for more than 2 months.

The female had 4 pairs of teats, 2 pectoral and 2 inguinal. Not all teats were used in nursing, and if so, the teat would become red and swollen because of the sucking by the young. On day 6, we observed the mother rat consuming the feces of the young, and since we were unable to find the feces of the young before weaning occurred, this behaviour might be quite common before the young were weaned.

Like the *Rattus* species (Taylor, 1961; Wirtz, 1973; Fox, 1979), *N. coxingi* gives birth to altricial young. Fox (1979) summarized the developmental features in 5 species and subspecies of Australian *Rattus*. Compared with his result and that of Wirtz's (1973) for *Rattus exulans* in Hawaii, we observed a remarkable similarity between *N. coxingi* and *Rattus* species except for the longer vaginal perforation period in *N. coxingi*. In this

study, the young female *N. coxingi* at 77 days of age still had a closed vagina whereas perforation of the vagina in *Rattus* species occurred before 57 days of age, or even happened as early as on day 22. However, this similarity in ontogeny implies a close relationship between *N. coxingi* and *Rattus* species.

The nipple-clinging behaviour in young *N. coxingi*, though to a somewhat varied extent, is quite common in several other genera in murids such as *Aethomys* (Meester and Hallett, 1970; Cheeseman, 1981), *Apodemus* (Imaizumi and Tsujimura, 1971), *Hydromys* (Olsen, 1982), *Mesembriomys* (Crichton, 1969), *Notomys* (Crichton, 1974), *Praomys* (Meester and Hallett, 1970; Happold, 1979), *Pseudomys* (Kemper, 1976), *Rattus* (Fox, 1979), and *Thallomys* (Meester and Hallett, 1970), and in some cricetid genera, *Mystromys* (Meester and Hallett, 1970), *Onychomys* Horner and Taylor, 1968), and *Otomys* (Davis and Meester, 1981). The continuous milk supply is the major adaptive significance of nipple-clinging (Horner and Taylor, 1968). It is much further developed in marsupials (Russell, 1984) which bear the extremely altricial young, and thus is important for acquiring of milk from the mother. The other possible adaptive significance is when there is danger and the mother move to escape, the young cling to the nipples and are dragged from danger (Meester and Hallett, 1970).

To determine the weaning age, we judged it from solid traces in the feces. King *et al.* (1963) suggested that weaning should be a gradual process resulting from the ability of the young to subsist on food other than the mother's milk and from the mother's resistance to nurse the young. We observed that after day 25, young *N. coxingi* tried to nurse but were unsuccessful due to uncooperation of the mother rat. Thus it seemed to be a reasonable estimate if we consider day 25 as the weaning age.

Sexual dimorphism is observed in adult *N. coxingi*, with males being significantly larger in weight and head and body length (unpublished data). Though our sample was too small to make a definite comparison, the young male was larger in the above 2 measurements, but the differences were trivial. Perhaps the trend would become more significant in the stage of growth later than our observation period.

There seemed to be a common trend in linear growth, with the IGR being highest in the first 10 days, dropping quite sharply at the interval of 10–20 days, and then leveling off in following intervals. Though the IGR of weight grossly followed this trend, it showed a increase from the interval of 20–32 days to that of 32–42 days and then tapered off. The somewhat slow increase in weight at interval 10–20 days is particular, but we were unable to find its cause since the food and water supply were normal and there was no apparent abnormality in the young.

As concerns to the adult size attained in each measurement at the end of the observations, the hind foot and the ear reached over 70% of adult size, the figures for head and body and the tail were less than 60%, and that for weight was barely over 20%. The rapid growth for the hind foot and the ear may indicate their vital roles in early survival for the animal.

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刺鼠 *Niviventer coxingi* (Swinhoe, 1864) 幼鼠之生長與發育

林 曜 松　　于 宏 燦

本文記錄實驗室內飼育的一胎野生刺鼠，*Niviventer coxingi* (Swinhoe, 1864)，自出生至第77天之生長與發育。幼鼠係晚熟性，出生時全身裸露無毛且尚未睜眼。幼鼠皮毛在第 25 天長成。上門齒在第12天長出，下門齒則於次日長出。眼睛及外耳道分別在第19及20天張開。幼鼠在第25天斷奶。斷奶前，幼鼠有銜咬乳頭之行爲，而在第40天時已能熟練地行走與攀爬。體重及線性測量之生長速率在最初 10 天內最高，而後隨卽下降。本研究內幼鼠各項測量對成鼠該項測量之比率，以後脚及耳朵生長較爲迅速，顯示其可能對早期之生存甚爲重要。母鼠之育幼行爲相當仔細且可維持 2 個月以上之久。