Reprinted from International Zoo Yearbook Vol. 22 1982

The management and reproduction of the Large hairy armadillo

Chaetophractus villosus

at the National Zoological Park

MILES ROBERTS[1], LAWRENCE NEWMAN[2] & GREGORY PETERSON[2]

[1]*Department of Zoological Research and* [2]*Department of Mammalogy, National Zoological Park, Washington, DC 20008, USA*

Armadillos are the most ecologically versatile of the edentates and have undergone a remarkable radiation in South America where they occupy a wide range of habitats. Such diversity makes the armadillo of considerable zoological interest and, when handled with care and attention, several species do well in captivity, achieve excellent longevity and even reproduce with some regularity (Crandall, 1964; Meritt, 1976). Unfortunately, armadillos are rarely seen in zoos and relatively little is known about their habits either in captivity or in the wild.

The Large hairy armadillo *Chaetophractus villosus* is a common inhabitant of the pampas and intermontane regions of Argentina, Uruguay and Chile from approximately 30–40° latitude (Cabrera, 1957; Cabrera & Yepes, 1960; Peña, 1961). Along with the fairy armadillos *Chlamyphorus* spp, the Pichis *Zaedyus pichiy*, and the congeneric *C. nationi* and Small hairy armadillo *C. vellerosus, C. villosus* comprises the temperate subradiation of the primarily tropical and subtropical family Dasypodidae (McNab, 1980). A high altitude,

YEAR	NO. OF ZOOS WHERE BRED (NO. BORN)						
	C. vill.	*E. sexc.*	*T. mat.*	*T. tric.*	*D. novem.*	*C. cen.*	*Z. pich.*
1963	2 (2+)						
1964	1 (?)	1 (?)			1 (3)		
1965		2 (6)			2 (6)		
1966	1 (5)	1 (?)			2 (8)		
1967		2 (14)	1 (1)		1 (2)		
1968	1 (12)						
1969	3 (15)		1 (4)				
1970	4 (15)	2 (10)	1 (1)		3 (10)		
1971	2 (9)	2 (8)			2 (8)		
1972	1 (7)	2 (4)	2 (2)		1 (4)		1 (1)
1973	2 (9)	3 (11)	2 (7)		1 (5)		
1974	3 (10)	1 (2)	2 (12)		1 (3)	1 (1)	
1975	2 (9)	2 (4)	2 (10)	1 (1)	1 (4)		
1976	3 (7)	1 (1)	3 (14)		1 (2)		
1977	3 (9)		2 (10)	1 (2)	2 (8)		
1978	1 (1)		1 (2)				

Table 1. Reproduction in zoos of seven species of armadillo from 1963–1978 as reported in Volumes 5–20 of the *Yearbook*. The species referred to are *Chaetophractus villosus*, *Euphractus sexcinctus*, *Tolypeutes matacus*, *T. tricinctus*, *Dasypus novemcinctus*, *Cabassous centralis* and *Zaedyus pichiy*.

dry temperate plains environment has led to a number of adaptations including a substantial ventral and dorsal pelage (considerably less than that of *Chlamyphorus*, however), a higher degree of omnivory than tropical forms (Greegor, 1974, 1980a), and burrowing habits that presumably permit it to escape high and low temperature extremes (Greegor, 1980b; McNab, 1980). Renal adaptations which allow the animal to survive only on metabolic water for long periods (Greegor, 1975) and the ability to store fat subcutaneously suggest physiological adaptations both to a temperate, dry climate and to the seasonal availability of high energy foods such as insects and other invertebrates.

The hairy armadillo has not been uncommon in captivity. It appears to have been relatively easy to maintain and has reached a longevity of over 15 years (Flower, 1931; Crandall, 1964). A review of the *Yearbook* breeding lists for the years 1963–1978 (Volumes 5–20) indicates that *C. villosus* has been the most frequently bred species of armadillo over this period (Table 1). European zoos seem to have worked most extensively with the species and three Polish zoos, Katowice, Wroclaw and Lodz, have been responsible for the majority of the captive births, with the animals at Katowice breeding regularly every year from 1970–1977. In North America only the Lincoln Park Zoo in Chicago, a zoo with an outstanding record in edentate reproduction, and the Salt Lake City Zoo in Utah have bred the species over the period surveyed; Lincoln Park between 1970–1977 and Salt Lake City between 1975–1976. Melbourne Zoo in Australia bred some successfully between 1970–1977.

There have been few published reports on the management and husbandry of the Large hairy armadillo and finding these was made more difficult by the fact that we included them in the genus *Chaetophractus* while several reports refer to the species as *Euphractus villosus*. The bulk of the available information is contained in short reports by Beck (1972), Encke (1962), Gensch (1966), Kühn (1954) and Meritt (1969).

The National Zoological Park has rarely exhibited the Large hairy armadillo. Four were born there in 1930 (Mann, 1930) and only two ♂♂, both exhibited at different times, are recorded as having been kept subsequently.

No births occurred between 1930 and the one described in this report.

COLONY HISTORY

Four ♀♀ were received from an animal dealer in England in August 1976 where they had been since May, having been wild-caught in Argentina. In July 1979 a wild-caught ♂ was received on loan from Lincoln Park Zoo. The animal had originally been imported from Argentina by the Bronx Zoo, New York, and had bred successfully at Lincoln Park. At the time of writing, the NZP colony consists of two of the four original ♀♀, the Lincoln Park ♂ and two young born 6 May 1981 to ♀ F.

ENCLOSURE HISTORY

The armadillos have been housed in a variety of indoor enclosures ranging from a $6 \times 1{\cdot}2 \times 2{\cdot}5$ m high bar-fronted cage in a noisy exhibit building, to a completely secluded off-exhibit holding room $4{\cdot}6 \times 4{\cdot}6 \times 2{\cdot}5$ m high.

Since August 1980 the animals have been housed in a large glass-fronted exhibit ($4{\cdot}5 \times 11 \times 3{\cdot}4$ m high) in the Lion/Tiger building. They share this exhibit with *c.* 40 Seba's short-tailed bats *Carollia perspicillata*, *c.* 20 Jamaican fruit bats *Artibeus jamaicensis* and three Two-Toed sloths *Choloepus didactylus*. The enclosure is on a reversed-lighting schedule, the animals coming to it from normal ambient lighting conditions. The night phase consists of a combination of blue and red incandescent flood lights with a floor light level of 10 footcandles. This phase lasts from 0900 to 1800 from October to April and 0900 to 2100 from May to September. The daylight phase consists of full-spectrum fluorescent tube lighting with a floor light level of *c.* 125 footcandles.

Heating, cooling and ventilation are provided by a thermostatically controlled forced-air system. A commercial floor model humidifier is used to increase the relative humidity. The temperature ranges from 17–22°C in the winter to *c.* 20–23°C in the summer and the humidity averages 55% at all times of the year, although it increases substantially for a few hours when the cage is hosed down.

The floor of the enclosure is covered with a thick layer of stringbark mulch purchased in bulk from a local supplier. Extra mulch and grass hay are placed on the favourite sleeping spot in a corner of the cage and numerous hollow and rotting logs are provided for sleeping and playing or digging. An L-shaped nest-box, measuring approximately $0{\cdot}6 \times 0{\cdot}6 \times 0{\cdot}3$ m high is also provided. The animals rarely use the logs or box for sleeping, preferring to build a sleeping mound out of hay and mulch. Much time is spent reworking and shaping this mound and it is here that ♀ F chose to give birth. Considerable amounts of other materials are also present in the exhibit, such as plants and branches, but these are primarily for the sloths and bats and the armadillos rarely make use of them.

ENCLOSURE MAINTENANCE

The enclosure is normally spot-cleaned as needed; faecal removal is relatively quick and easy since both the armadillos and sloths have regular toilet areas. Fresh water is provided every day and the animals are fed once a day at about 1500 hours (except for the lactating ♀ which was fed twice a day). More than one food pan is provided in order to reduce competition at feeding time.

Approximately once a month all the bats are caught for census and marking, and at this time all substrate is removed, the walls, floors and perches are disinfected and thoroughly cleaned and fresh substrate is added. The armadillos are removed from the enclosure on these days and placed in a holding room $1{\cdot}8 \times 1{\cdot}7 \times 2{\cdot}5$ m high for approximately 24 hours since previously, given the opportunity, the armadillos would catch and eat any tired or injured bats, or any young which had become separated from their mothers. Unfortunately, on almost all census days we found that some bats were missing 'presumed eaten'. As soon as the bat colony has been restabilised, the armadillos are returned to the exhibit.

DIET

Each animal is fed once a day at about 1500 hours and the standard diet per adult animal is 100 g tinned Zu/Preem Feline Diet, 1 teaspoon wheat germ granules, $\frac{1}{4}$ tsp Mirracoat and enough water to make a pasty mixture.

Live crickets are occasionally thrown into the enclosure and are eaten with apparent enthusiasm. From time to time the fresh substrate contains various unidentified invertebrates which are also eaten. In general, though, these supplements are an insignificant part of the diet and considered to be more an entertainment than a food.

MEDICAL CARE

A number of endoparasites including *Giardia*, *Strongyloides*, *Oxyuris*, *Capillaria*, *Ascaris*, hookworm and amoeba were diagnosed and treated. Routine faecal screening with subsequent treatment has rendered endoparasitic infection a minor medical problem.

The major medical concern has been a persistent and recurring abscessing of dermal plates and the soft tissue between the plates. These abscesses are often difficult to detect as they may become extensively developed subdermally before they appear on the surface. The abscess is normally treated by cleaning with Betadine ointment followed by the administration of oral antibiotics. The ♂ has developed numerous small virogenic papillomas on the dermal plates but these growths have presented no medical problem to date. Armadillos do not require any immunisation vaccinations.

SOCIAL INTERACTION

One of the four original ♀♀ died in quarantine from complications associated with subdermal abscesses. The three remaining animals, which had been separated from one another while in quarantine, were initially rather aggressive towards one another. Two ♀♀, D and F, soon settled down and began to sleep together but the third ♀, H, was aggressive towards both animals and would regularly pursue, mount and scratch at them. Female D died of enteritis in 1978.

The ♂ was introduced to ♀♀ H and F in July 1979. Female H was rather aggressive towards the ♂ while ♀ F accepted his presence almost immediately. The ♂ and compatible ♀ F were removed from the exhibit cage and placed in a secluded holding room. During the ensuing 16 months the ♂ was observed to mount the ♀ many times but no actual copulations were seen. The ♀ usually ran away from or tried to throw the ♂ when he attempted to mount.

In August 1980 all three animals were reunited in the new exhibit enclosure in the Lion/Tiger facility and although ♀ H again pursued and worried ♀ F the behaviour quickly subsided, probably because the greatly increased space and the more complex environment meant that the subordinate ♀ F could escape more easily. Within an hour of the encounter all three animals were seen sleeping peacefully together on a mound of substrate.

REPRODUCTION

Although the ♂ was seen to mount both ♀♀ on a number of occasions, no actual copulations were observed. Mounting usually began with the ♂ following the ♀ closely for several minutes before attempting to mount, then climbing onto the ♀'s back and clasping her about the abdomen with his forelegs. If the ♀ continued to move, the ♂ would remain holding onto her, walking on his hind legs until dislodged either by being shaken off or by the ♀ going through a small log or nestbox opening. Pursuit and mount sequences lasted from a few seconds to more than 15 minutes. They were repeated several times a day and at intervals that did not suggest a regular oestrous cycle.

Mountings occurred in every month of the year from 1979 onwards and, because no young were born over this period, the birth in early May 1981 was totally unexpected. Consequently we had not been examining the ♀ for pregnancy, and so had not prepared the enclosure for birth or separated the expectant mother from her cage-mates. In retrospect, we can note that ♀ F reached her highest weight (4·45 kg) just prior to birth and that her general activity was higher than usual for two days prior to birth (keeper records indicate 'a lot of running around all over the place'). Any of these factors alone may not be enough to diagnose pregnancy but together they are suggestive of imminent birth. Other indicative signs include a full, rounded abdomen and prominent, erect nipples one to three weeks before birth (D. Meritt, pers. comm.).

BIRTH AND REARING

On 6 May 1981 two infants were found on the sleeping mound near ♀ F and close to the other two animals which were also asleep on the mound. Later, ♀ F was seen lying on her back with one infant lying across her venter nursing while the other slept in contact with her.

The mother soon left the sleeping mound and the ♂ approached the young and began sniffing and digging at them. Both he and ♀ H were immediately removed to prevent them from harming the young or disturbing the mother. As a result either of the removal of the other two animals or of our presence in the enclosure so near her young, ♀ F became quite agitated and began to dig and shape the sleeping mound which, at the time, was composed exclusively of mulch. In the process she repeatedly buried the young under several inches of mulch and when our concern that they might suffocate led us to uncover them several times the ♀ appeared to become even more determined to shape and mould the mound. The digging became so intense that several times both young were literally kicked out of the nest, whereupon they would right themselves and laboriously climb up the mound regardless of whether the mother was there or not. It appeared that the ♀ was disturbed mainly by our interference in removing the two other armadillos since she continued to appear stressed and tried to secure the young deep in the nest. Lack of success, primarily because of the dry and non-cohesive nature of the mulch, then resulted in increased agitation. Eventually the ♀ began to carry one or other of the infants around the enclosure by the foreleg, and, since Gucwinska (1971) has reported that such carrying behaviour can result in serious injury or death to newborn Six-banded armadillos *Euphractus sexcinctus*, we began to make preparations to hand-rear the young. It was a step we were reluctant to take, primarily because the animals are reputedly very difficult to hand-rear successfully (Block, 1974) and we felt our chances of success would be small. (We later learned that hairy armadillos have been successfully reared with evaporated milk and water (D. Meritt, pers. comm.).) One last effort was made to induce the ♀ to settle down and resume caring for the young. The mulch from the nest/sleeping mound was removed completely and replaced with grass hay which we hoped would make a more suitable nest material. The ♀ immediately put down the infant she was carrying and within fifteen minutes had excavated a nest in the hay which apparently suited her for she deposited the young in it and kept them there until they ventured out on their own some weeks later.

Female F's food consumption dropped off sharply immediately after giving birth and on some days she did not eat at all. After nearly a month of eating almost nothing her weight had dropped by 30% from 4·45–3·08 kg. A number of unsuccessful modifications to the diet were made during this period in an attempt to stimulate her appetite, and we finally succeeded in getting her to eat a commercial brand of tinned tuna, having first tried mealworms, earthworms, mashed bananas, and assorted fruits and vegetables. She also appeared to like a commercial brand of cat food (advertised as being for 'finicky eaters') and cottage cheese so a combination of these items became her staple. Subsequently, tinned Zu/Preem Feline Diet was substituted for the commercial brand and she was gradually weaned back onto the original diet.

The ♀'s only activity during the first month was nest renovation and maintenance. The nest itself consisted entirely of grass hay and was approximately 75 cm in diameter and 40 cm high. An opening at the top of the mound led straight down to about floor level where it branched horizontally in two directions. At the end of each branch was an enlarged chamber and the young apparently slept together in one or other of them. The ♀ usually lay in the vertical tunnel just below the opening and appeared to act as a plug for the burrow opening since a rush of warm air was emitted from the nest whenever she emerged.

The ♀ formed the nest mound by pulling materials under the body with alternate forefeet and then kicking them backwards onto the mound with the hind feet in a manner similar to that described for *Dasypus* (Eisenberg, 1961) and for *Chlamyphorus* (Rood, 1970). She would then shape the pile by walking on it while gathering material closely under the

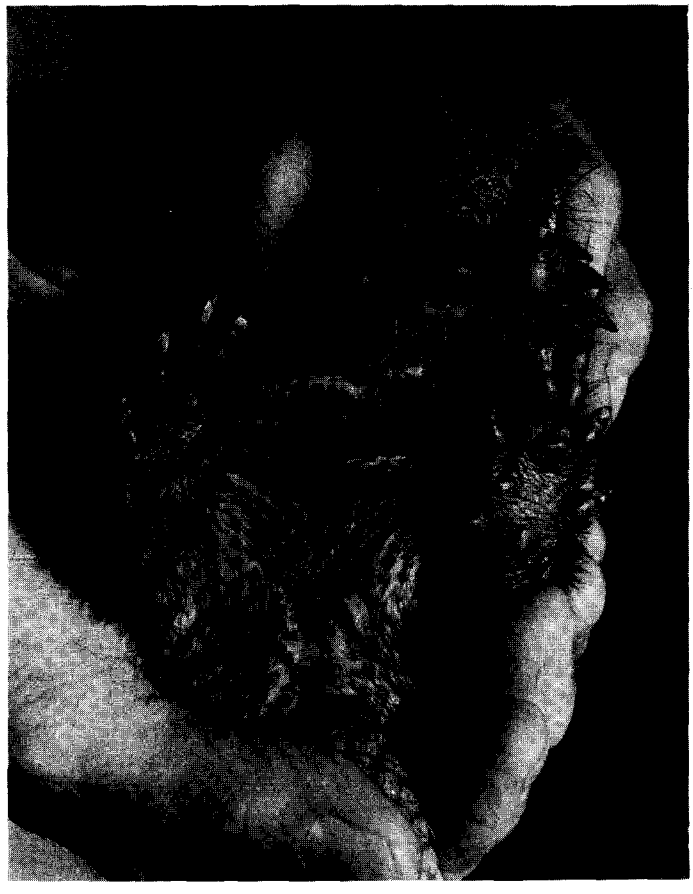
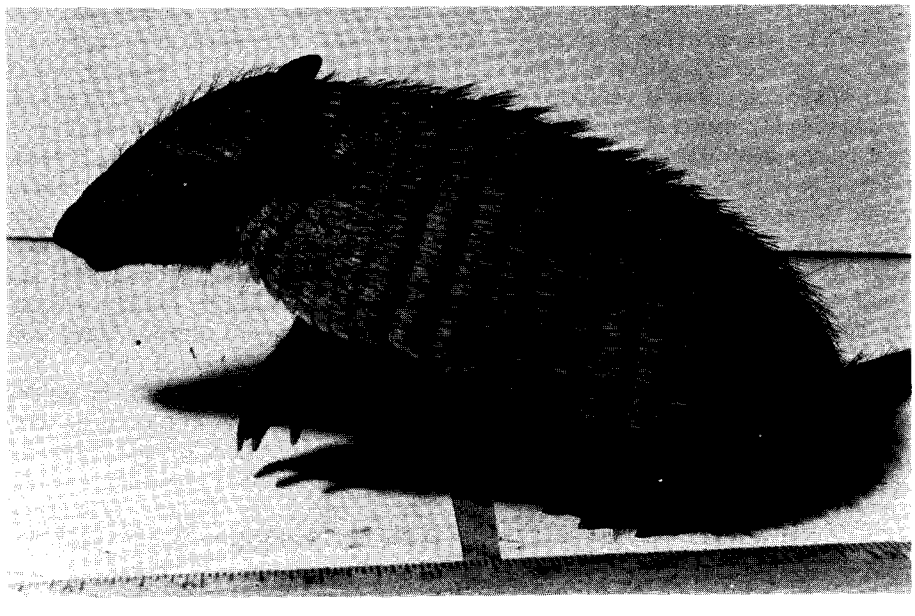


Plate 1. Ventral view of a three-week-old ♀ Large hairy armadillo *Chaetophractus villosus* born at Washington NZP. Note the pattern of hair distribution, well-developed claws and vermiform clitoris which, in the young, resembles a penis. *Jessie Cohen, National Zoological Park.*

Plate 2. Three-week-old ♀ showing pelage pattern, and development of dermal plates. *Jessie Cohen, National Zoological Park.*



body with the forelegs, as if to compact it. Pushing materials with the head shield also helped to shape the nest. Packing by vibrating the hind quarters as described in *Chlamyphorus* (Rood, 1970) and gathering materials with a hopping motion as described in *Dasypus* (Eisenberg, 1961) were not observed.

If the nest was disturbed the ♀ would emerge, growling, and approach the intruder. If the young were removed from the nest out of the ♀'s sight, she would respond not by searching for the young but rather by piling more hay onto the nest and attempting to shape over the disturbed area. It was therefore relatively easy for us to remove the young for weighing and measuring each week without unduly disturbing the mother.

GROWTH AND DEVELOPMENT

At birth, the young were about 13 cm long with soft greyish-pink dermal plates and no evidence of hair on the dorsal surface. Fine hairs were present on the ventrum and face in a pattern similar to that seen at three weeks of age. The eyes and ears were closed, the forelegs and claws were well developed and hard, and the infants could right themselves and walk up a 30° incline. The neonates appeared embryonic but by two weeks of age they were perfect miniatures of the adults. By 12 weeks they were three-quarters of the size of the adults and, except for their dermal plates being fresh and unworn, were virtually indistinguishable from them.

The young were first seen eating solid food on day 55 and shortly thereafter a weaning diet was prepared and offered to the mother and the young twice a day at 0800 and 1500 hours. This diet consisted of 120 g tinned Zu/Preem Feline Diet, 2 tablespoons Gerbers Dry Mix Cereal, 30 g Carnation evaporated milk, 1 tsp wheat germ granules, ¼ tsp Mirracoat and 30 g water.

Data on the general growth and development of the young are combined in Table 2 with data from other studies for this and seven other armadillo species. Growth curves for the two animals are displayed in Fig. 1 along with comparable data from two other studies, one being of a single hand-reared ♂ (Beck, 1972) and the other of a single mother-reared ♂ (Encke, 1962).

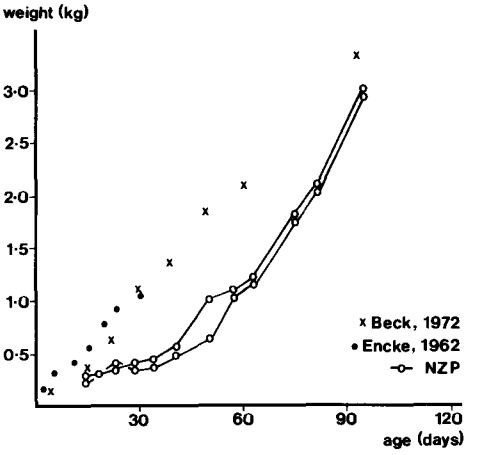


Fig. 1. Growth curves for two Large hairy armadillos *Chaetophractus villosus* born at Washington NZP. Shown for comparison are data points for a single hand-reared ♂ (Beck, 1972) and a single mother-reared animal (Encke, 1962).

DISCUSSION

The two mother-reared Large hairy armadillos born at NZP grew more slowly than did either a single mother-reared animal (Encke, 1962) or a single hand-reared animal (Beck, 1972). Until weaning at *c.* 56 days the combined weight of the twins was roughly equivalent to that of the mother-reared ♂, suggesting relatively equivalent levels of maternal investment in these cases. Growth rates of the young increased rapidly when the mother resumed eating and accelerated after weaning. The fact that young can survive periods of maternal nutritional stress and can compensate when the mother later improves her nutritional condition suggests that these animals are well suited to the harsh and rather unpredictable environment in which they live. Hairy armadillos are found in habitats which vary considerably both seasonally and annually (Greegor, 1980a, 1980b) and infant survival may depend largely on the mother's ability to convert seasonally deposited body fat to milk during lean periods.

Other features of infant growth and development suggest clues to the lifestyle of the species. Their ability to walk independently from birth, and even to orientate towards the

SUBFAMILY AND SPECIES	HABITAT TYPE	BIRTH SEASON	LITTER SIZE	GESTATION (days)	ADULT ♀ WEIGHT (kg)	EYES OPEN (days)	WALK/ RUN	SEXUAL MATURITY (months)	REFERENCES
Euphractinae									
Chaetophractus villosus	scrub desert	Feb–Dec	1–2	60–75	4·5	16–30	birth	9	Beck (1972) Encke (1962) Kühn (1954) Zuckerman (1953)
Euphractus sexcinctus	dry savannah, pampas	throughout year	1–3	60–65 74		20–25	birth	9	Gucwinska (1971) Kuhlhorn (1954) Krumbiegel (1940) Sanborn (1930)
Zaedyus pichiy	high pampas	Jan/Feb	1–3 2						Meritt (1972)
Priodontinae									
Priodontes giganteus	eastern subtropic lowland regions		1–2		55				Krieg (1929)
Cabassous centralis	open upland plateaux		1						Meritt (pers. comm.)
Tolypeutinae									
Tolypeutes matacus	open grasslands	Oct–Jan	1	120	1·2	21–22	birth		Krieg (1929) Meritt (1971, 1972, 1976) Sanborn (1930)
Dasypodinae									
Dasypus novemcinctus	wide variety of tropical and subtropical habitats	Mar–Apr	2–5 usually 4	120 (also has delayed implantation)	3·5	20–26	birth	12	Buchanan (1957) Hamlett (1932) Talmage & Buchman (1954)
Chlamyphorinae									
Chlamyphorus sp	high desert				0·12				Rood (1970) Walker (1968)

Table 2. Data available on selected life history parameters for eight species of armadillo.

nest despite having sealed eyes and ears, suggests that olfactory and tactile stimuli are vitally important to neonates. Hairy armadillos reportedly dig nest burrows in nature (Cabrera & Yepes, 1960; Greegor, 1980b), so it would appear to be adaptive for young to be able to locate and move towards their mother using olfaction, sensitivity to temperature change, or low frequency sound reception in the dark, sound-dampening conditions of a deep burrow.

It was noted that the ♀ had a tendency to bury the young rather than merely to conceal them. The measured temperature inside the burrow was over 38°C and the rate of airflow inside appeared to be quite low. McNab (1980) has noted that the ability of adult *Chaetophractus* to absorb and release heat is quite high and it is reasonable to assume that this ability is even higher in the young. Burying the young in insulatory material would reduce the energy they would require to maintain normal body temperature thereby increasing the energy available for growth. Gucwinska (1971) has noted that the survival rate of captive-born *E. sexcinctus* is significantly increased when ♀♀ are provided with nesting materials which can be used to build tightly-packed nests within which the young can be contained. It may be that the young, by virtue of their increased ability to absorb heat, are sensitive to changes in temperature and can therefore orientate using thermal cues. This may account for our observation of the still blind and deaf young climbing back into the warm nest even in the absence of the mother. The well-developed locomotor and digging ability of the young may be associated with adaptations to maintain the euthermic microclimatic conditions necessary for rapid growth.

The tendency of the mother to plug the burrow entrance with her own body may contribute to the maintenance of high burrow temperatures as well as functioning to block the entrance against predators such as foxes (e.g. *Dusicyon*) or weasels (e.g. *Lyncodon*) that may otherwise find the young easy prey. In either event, constant burrow attendance by the ♀ appears to be of sufficient importance to render the ♀ essentially dormant except for routine burrow maintenance activities. A possible cost of the plugging behaviour is reduced airflow and resultant low levels of oxygen within the burrow. Scholander *et al.* (1943) have shown that adult *Dasypus* can live on a remarkably low level of oxygen and that this may be an adaptation for survival in the occasionally anaerobic conditions of the burrow. In *Chaetophractus* it is possible that the ability to sustain an oxygen debt permits the young to tolerate the necessarily high burrow temperatures produced by plugging behaviour. It may also have been a necessary preadaptation for the evolution of torpor in *Zaedyus* (McNab, 1980).

McNab (1980) has noted that the Euphractini deposit body fat under good foraging conditions and that this stored energy can later be used if environmental conditions become unfavourable. In *C. villosus* the ♀ strategy may be geared towards making use of body fat to produce milk while necessarily remaining inactive while guarding and plugging the nest, so the fact that our ♀ ate so little in the first month may well have been normal. Because of their high heat exchange capabilities and the fact that they are unable to enter torpor (McNab, 1980), ♀♀ are expending energy both for body maintenance and for lactation. The period of lactation is thus bound to be short and the rate of growth of the young quite rapid, as this and other reports show (Encke, 1962; Beck, 1972). Although, to our knowledge, no milk analysis has been conducted on the Dasypodidae it would be expected that, under the conditions outlined above, milk would be concentrated, high in fat and produced for a short period of time. The tractable nature of the ♀ in this study indicates that the milk samples necessary to test this hypothesis would be readily obtainable.

Growth, development and reproduction of *C. villosus* are similar to those described for the other Euphractinae but differ somewhat from those found in the Dasypodinae and Tolypeutinae (Table 2). *Tolypeutes* has a longer gestation, consistently smaller litter size and relatively greater litter weight. *Dasypus* has a longer gestation (sometimes including delayed implantation) and also shows polyembryony which results in a considerably larger litter

size. Unfortunately, too few data are available for *Zaedyus*, *Priodontes*, *Cabassous* or *Chlamyphorus* to make even rudimentary comparisons.

ACKNOWLEDGEMENTS

Our thanks go to Diane DeGraffenreid, Julie McLaughlin, Joe Raspberry and Melba Sheilds for animal care and support provided during the preparation of this report. Jessie Cohen took the photographs for Plates 1 and 2. We also thank Dennis Meritt of the Lincoln Park Zoo for the loan of the ♂ *C. villosus*. Judith Block, Dennis Meritt and Kathy Ralls provided many useful suggestions. Mary Firestone typed and perfected the manuscript.

PRODUCTS MENTIONED IN THE TEXT

Betadine ointment: manufactured by Sherwood Pharmaceutical Company, Mahurah, NJ 07430, USA.

Carnation evaporated milk: manufactured by Carnation Company, Los Angeles, CA 90036, USA.

Chloromycetin palmitate: oral antibiotics (100 mg BID), manufactured by Parke-Davis, Morris Plains, NJ 07950, USA.

General Electric model A130 fluorescent tubes: manufactured by General Electric Company.

Gerbers Dry Mix Cereal: human infant food, manufactured by Gerber Products Company, Fremont, MI 49412, USA.

Mirracoat: vitamin supplement powder, manufactured by The Borden Company, 350 Madison Avenue, New York, USA.

Purina Canned Catfood: manufactured by Ralston Purina Company, Checkerboard Square, St Louis, MO 63188, USA.

Sears model 758.74095 humidifier: manufactured by Sears Roebuck and Co., Chicago, Illinois, USA.

Zu/Preem Feline Diet: manufactured by Hills Pet Products Inc., PO 148, Topeka, KS 66001, USA.

REFERENCES

BECK, U. (1972): Uber die kunstlische Aufzucht von Borstengurteltieren (*Euphractus villosus*). *Zool. Gart., Lpz.* (N.F) 41: 215–222.

BLOCK, J. (1974): Hand-rearing seven-banded armadillos *Dasypus septemcinctus* at the National Zoological Park, Washington. *Int. Zoo Yb.* 14: 210–214.

BUCHANAN, G. D. (1957): Variation in litter size of nine banded armadillo. *J. Mammal.* 38: 529.

CABRERA, A. (1957): Catalogo de los mamiferos de America del Sur. I. *Revta. Mus. argent. Cienc. nat. 'Bernadino Rivadavia'* 4: 1–307.

CABRERA, A. & YEPES, J. (1960): *Mamiferos Sud Americanos.* Buenos Aires: Ediar, S. A.

CRANDALL, L. S. (1964): *Management of wild mammals in captivity.* Chicago: University of Chicago Press.

EISENBERG, J. F. (1961): Observations on the nest building behaviour of armadillos. *Proc. zool. Soc. Lond.* 137: 322–324.

ENCKE, W. (1962): Aufzucht von Borstengurteltieren, *Chaetophractus villosus. Zool. Gart., Lpz.* (N.F.) 31: 88–90.

FLOWER, S. S. (1931): Contributions to our knowledge of the duration of life in vertebrate animals. 5. Mammals. *Proc. zool. Soc. Lond.* 1931: 145–234.

GENSCH, W. (1966): Kurze Mitteilung über die sucht des Borstengurteltieres (*Euphractus villosus villosus*) im Zoologischen Garten Dresden. *Zool. Gart., Lpz.* (N.F.) 32: 216–218.

GREEGOR, D. H. (1974): Comparative ecology and distribution of two species of armadillos, *Chaetophractus vellerosus* and *Dasypus novemcinctus*. Ph.D. dissertation, University of Arizona.

GREEGOR, D. H. (1975): Renal capabilities of an Argentine desert armadillo. *J. Mammal.* 56: 626–632.

GREEGOR, D. H. (1980a): Diet of the little hairy armadillo, *Chaetophractus vellerosus*, of Northwestern Argentina. *J. Mammal.* 61: 331–334.

GREEGOR, D. H. (1980b): Preliminary study of the movements and home range of the armadillo, *Chaetophractus vellerosus. J. Mammal.* 61: 334–335.

GUCWINSKA, M. (1971): Development of six-banded armadillos *Euphractus sexcinctus* at Wroclaw Zoo. *Int. Zoo Yb.* 11: 88–89.

HAMLETT, G. W. (1932): The reproductive cycle of the armadillo. *Z. wiss. Zool.* 141: 143–157.

KRIEG, H. (1929): Biologische Reisestudien in Sudamerika. 9. Gurteltiere. *Z. Morph. Ökol. Tiere* 14: 166–190.

KRUMBIEGEL, I. (1940): Der Säugetiere der Sudamerika–Expedition Prof. Dr. Kriegs. I. Gurteltiere. *Zool. Anz.* 131: 49–73.

KUHLHORN, R. (1954): Termitenfiende. *Natur Volk* 82: 49–53.

KÜHN, E. (1954): Zum Wachtum mannlicher Borstengurteltiere. *Zool. Gart., Lpz.* (N.F.) 20: 82–85.

MANN, W. M. (1930): Wild animals in and out of the zoo. *Smithson. scient. Ser.* 6: 1–362.

McNAB, B. (1980): Energetics and the limits to a temperate distribution in armadillos. *J. Mammal.* 61: 606–627.

MERITT, D. (1969): Edentate diets currently in use at Lincoln Park Zoo, Chicago. *Int. Zoo Yb.* 10: 136–138.

MERITT, D. (1971): The development of the La Plata three-banded armadillo *Tolypeutes matacus* at Lincoln Park Zoo, Chicago. *Int. Zoo Yb.* 11: 195–196.

MERITT, D. (1972): Report No. 1021–Johnson Fund (1971). In nature the behavior of armadillos (sic.) *Am. phil. Soc. Yb.* 1972: 383–384.

MERITT, D. (1976): The nutrition of edentates. *Int. Zoo Yb.* 16: 38–46.

PEÑA, L. E. (1961): El peludo, *Chaetophractus villosus,* un nuevo mamifero para Chile. *Revta. Univ., Catol. Santiago* 46 (An. Acad. Chil. Cienc. nat. No 24): 141–142.

ROOD, J. (1970): Notes on the behavior of the pygmy armadillo. *J. Mammal.* 51: 179.

SANBORN, C. C. (1930): Distribution and habits of the three-banded armadillo *(Tolypeutes). J. Mammal.* 11: 61–69.

SCHOLANDER, P. F., IRVING, L. & GRINNELL, S. W. (1943): Respiration of the armadillo with possible implications as to its burrowing. *J. cell. comp. Physiol.* 21: 53–63.

TALMAGE, R. & BUCHMAN, G. (1954): The armadillo. *Pamph. Rice Inst.* 41(2): 1–135.

WALKER, E. P. (1968): *Mammals of the world.* Baltimore: Johns Hopkins Press.

ZUCKERMAN, S. (1953): The breeding season of mammals in captivity. *Proc. zool. Soc. Lond.* 122: 827–950.

Manuscript submitted 19 August 1981