OBSERVATIONS ON THE NINE-BANDED ARMADILLO, *DASYPUS NOVEMCINCTUS*, IN SOUTHERN LOUISIANA

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ABSTRACT

From 1970 to 1995, observations were made on the nine-banded armadillo, *Dasypus novemcinctus*, in southern Louisiana at the Riverside Campus of Tulane University. Observations and corresponding data were obtained on natural history in general, with emphasis on home range, as well as development and growth of young, in particular.

INTRODUCTION

Although a considerable amount of information has been amassed on the ecology and life history of *Dasypus novemcinctus* (McBee and Baker, 1982), we present herein some additional data from a long-term study of the species conducted in southern Louisiana.

Lowery (1936) recorded range extensions of *D. novemcinctus* within Louisiana. Most of his records were from west of the Mississippi River. However, he mentioned that in late December 1935, two armadillos were captured south of Baton Rouge east of the Mississippi River. Later, Lowery (1943) stated that armadillos were abundant in southwestern Louisiana and that they were common in most of the western portions of the state, but that these mammals were encountered infrequently east of the Mississippi River in the Florida parishes. Fitch et al. (1952) presented many distributional records for the armadillo in Louisiana, Arkansas, and Mississippi, but they had no records for either the Louisiana coastal marshes or the lower Mississippi River delta area. Lowery (1974) included a distribution map based on museum specimens; his record for the delta region just southeast of New Orleans was based on specimens in the Museum of Natural History of Tulane University. For their distribution map of the armadillo, Choate et al. (1994) included all of coastal Louisiana, except for the extreme lower end of the Mississippi River delta and adjacent marshes on both sides. We postulate that *D. novemcinctus* may have gained early access to the lower Mississippi River delta by moving down along the Mississippi River levees.

It is of interest that the earliest specimen of *D. novemcinctus* deposited in the collection of mammals of Tulane University was obtained on 14 January 1966. However, based on our observations, as well as those of other personnel of the

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University, armadillos were reported as common at the Riverside Campus since 1964.

The purpose of this paper is to present summaries of our observations of *D. novemcinctus* in southern Louisiana. Published literature pertinent to our findings is reviewed. However, for a more extensive list of the literature on this species, see the work by McBee and Baker (1982).

STUDY AREA. The Riverside Campus of Tulane University is a 520-acre tract of land at the northern end of Plaquemines Parish, several miles southeast of New Orleans, Louisiana (Figure 1). The area is west of the Mississippi River at English Turn Bend (river mile 78). The Mississippi River forms the southern boundary of the Riverside Campus. More than 1,000 acres of bottomland hardwoods are adjacent to the eastern and northern boundaries of the property.

During World War II, ammunition storage bunkers were constructed throughout the central part of the current Riverside Campus. Throughout the entire area, inclusive of the adjacent acreage, a system of drainage ditches was excavated, and the soil was piled along the ditches. Many of the ditches date back to the early plantation days typical of the area. In subsequent years, trees (*Celtis laevigata, Acer negundo, A. rubrum, Carya illinoensis, Salix nigra, Ulmus americana, Populus deltoides, Quercus virginiana, Myrica cerifera*, and *Sambucus canadensis*, to name some of the common species) became established along and on these spoil ridges alongside the drainage ditches. In the adjacent wooded areas, there are stands of scattered individuals of *Taxodium distichum, Quercus nuttali, Q. nigra, Morus rubra, Magnolia grandiflora, Liquidambar styraciflua, Platanus occidentalis, Diospyrus virginiana, Gleditsia triacanthos, Salix interior, Cephalanthus occidentalis, Nyssa aquatica*, and *Fraxinus pennsylvanica.*

Some of the excavated dirt was piled on and around the ammunition storage bunkers for camouflage; this resulted in the formation of extensive series of ponds (Figure 1-B). The elevated spoil banks along ditches and the elevated soil slopes around the bunkers have become ideal burrowing sites for armadillos. Moreover, the drainage system that was developed during the plantation days and enhanced further by development of the ammunition storage facility resulted in the lowering of the water table and the eventual collapse of soil around the bases of large trees, thus providing additional sites for burrowing by armadillos.

A detailed description of the ammunition storage bunkers was provided by Jones and Pagels (1968). Warkentin (1968) briefly described the common vegetation around the ponds (borrow pits). Suttkus and Jones (1991) described the Riverside Campus of Tulane University and adjacent wooded areas, and provided a list of the common trees on the area. During about the last five years, two invading plants have become abundant in the area. The wind-blown seeds of the Chinese tallow (*Sapium sebiferum*) have germinated on the bare, moist soils along the edges of the ponds during low water levels. It seems that birds have spread the seeds of the Chinese privet (*Ligustrum sinense*) into the area; now most of the margins of the wooded areas are crowded with privet.

During the early to late 1960s, the railroad tracks along the fronts of the ammunition storage bunkers were removed. The railroad track right-of-ways were converted to shell roadways. In addition, most of the brush and trees from on top

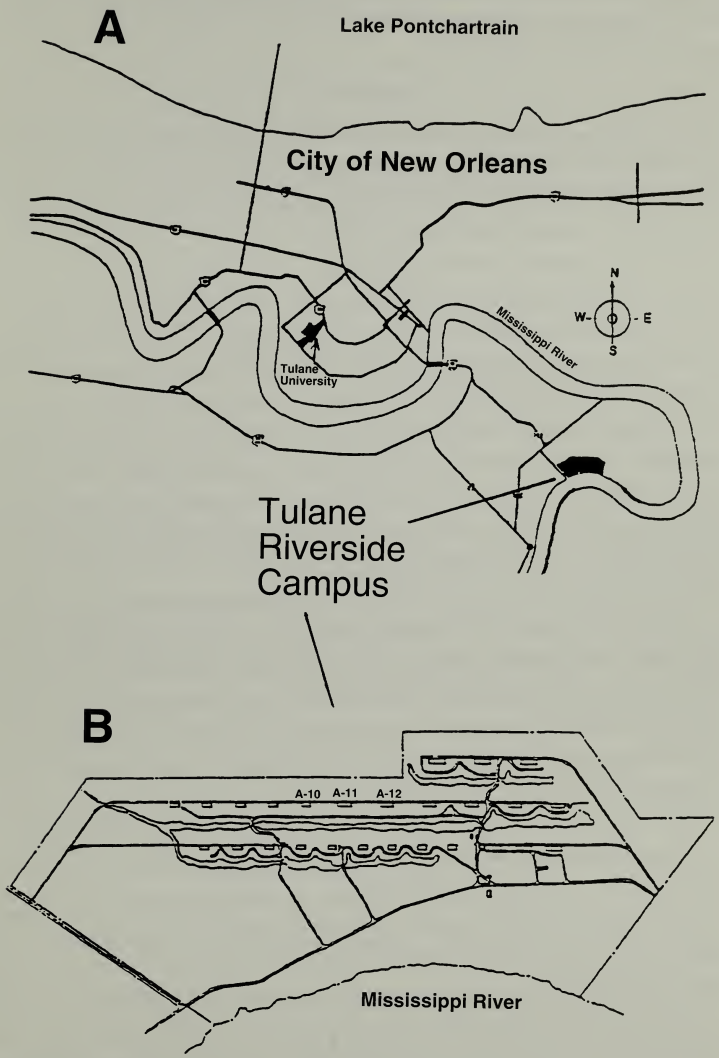

Figure 1. Location of the study area (Riverside Campus of Tulane University) in southern Louisiana. A. General location; B. Enlargement of Riverside tract.

of and around the bunkers were removed. The resultant, open, mowed areas became foraging grounds for armadillos, in addition to the diversity of foraging areas in the adjacent wooded areas.

Methods

Our methods of capture and marking armadillos were similar to those used by Clark (1951), Fitch et al. (1952), and Breece and Dusi (1985), except that instead of numerals, we sprayed a polka-dot pattern on the animals. We captured the animals either by hand or more often with a deep, large-mesh, nylon, long-handled net. We made stencils of cardboard with holes (quarter size) that we used to transfer a polka-dot pattern to the scapular or pelvic shield (or both) with different colors of fluorescent spray paint. The same patterns, numbers, and colors were painted on the right and left side of each animal. During the course of the study, some armadillos were repainted when either one side or the other started to fade. In addition to the spray-paint spots, each animal was tagged on the left ear pinna with a small fisheries opercular strap tag. For nearly all of the armadillos, total length in millimeters (mm), weight in kilograms (kg), and sex were recorded at the time of capture, marking, and tagging.

Armadillos captured initially near the ammunition storage bunkers were marked accordingly. Animals captured near bunker A-9 were marked with yellow; those from the bunker A-10 area were marked with purple; armadillos from around bunker A-11 were marked with green; those from near bunker A-12 were marked with red; animals captured near bunker A-13 were marked with blue; those from around bunker A-14 were marked with gold; and those from the areas adjacent to bunkers A-1, A-2, and A-3 were marked with white.

Animals were marked, tagged, and the corresponding data were recorded at the site of capture; upon completion of the process, the armadillos were released. Most of the *Dasypus* were captured initially and marked on the following dates (numbers of animals in parentheses):14 February 1970 (17); 17 February 1970 (3); 18 February 1970 (8); 22 February 1970 (6). No new armadillos were captured and marked after 22 February 1970. Approximately half of the animals (23) used in the computations of home ranges were recaptured and remarked during the aforementioned period of observations. Identity of each individual remarked was verified by the number of the ear tag.

Some observations of animals were made with the use of field binoculars. However, most of the spray-paint markings could be observed easily with the naked eye. Each observation of a marked armadillo was plotted on a ground chart of known scale. In addition, the time of day, air temperature, and presence and location of other marked, as well as unmarked, animals were recorded. After 14 February 1970, observations were continued periodically throughout March and most of April of 1970.

In this study, minimum home ranges of *D. novemcinctus* were calculated in the manner described by Clark (1951). Each observation of a marked animal was plotted on a known-scale ground chart. The outermost points of the observed ranges of the animals were connected by straight lines; thus, the minimum home range was circumscribed. The minimum home range in acres was determined by placement

of a grid over the known-scale ground chart, counting the number of whole squares within the range diagram, and adding the whole-square equivalent to all of the partial enclosed squares.

Materials for the study of development were obtained by salvage of animals dead on the roads or from females captured in the area. All embryos were deposited in the Tulane University Museum of Natural History as were the salvageable females (mothers). Measurements to the nearest 0.1 mm were taken with a dial caliper.

Additional observations on various aspects of life history and other activities of *D. novemcinctus* in the study area and adjacent regions were carried out sporadically from February 1970 through the fall of 1995.

Results

Home Range and Movements.—A total of 34 armadillos (20 males, 14 females) was captured and marked during this study. After the initial capture, three males and two females were not seen again. One male and one female were observed only one time after being marked. One male and three females were observed two times after the initial capture. Information from these 11 individuals was not used in the determinations of home ranges. Throughout most of the study, especially in the 1970s and 1980s, some armadillos were found dead from apparent gunshot wounds. For example, three animals were found dead after 12, 14, and 12 days of observations, respectively. Minimum home ranges were determined for 14 males and nine females (Table 1). Home range overlap was common; overlaps of ranges of marked animals are presented in Table 2. There were fifteen periods of observations during 17–28 February 1970. Beginning times of observation periods ranged from 1010 to 1722 hours, air temperatures during these observation periods ranged from 14°C to 23°C, with a mean of 17.9°C. There were 22 periods of observations during 1–28 March 1970. Beginning times of observation periods ranged from 1015 to 1800 hours, with air temperatures that ranged from 12°C to 23.5°C with a mean of 17.9°C. Whether the mean temperature of 17.9°C for the 15 observation periods in February and the 22 observation periods in March was coincidental or whether the animals were highly sensitive to air temperatures and regulated their above ground activities accordingly we are not prepared to say. There were two observation periods in April (12 April 1970; 1445 hrs.; 17 April 1970; 1735 hrs.). Air temperature was 25°C during both observation periods.

Development.—Data on seven litters of armadillos from five different years were obtained from the study area. Three of the females carrying fetuses were found dead on roads; four pregnant females were caught by hand. The aforementioned female armadillos were obtained on 15 April 1970, 10 March 1982, 11 February 1983, 14 February 1986, 7 March 1986, 28 February 1987, and 15 March 1987. As expected, all litters included four fetuses. For convenience of presentation, the data presented in Table 3 are arranged by average sizes of fetuses rather than chronology of capture.

Discussion

Home Range and Movements.—Some early work on home range of *D. novemcinctus* was conducted in southern Texas by Clark (1951). Between 18 October 1947 and 15

Table 1. Minimum home ranges and related data for 23 armadillos in southern Louisiana.

Tag Number	Sex	Weight (kg)	Total Length (mm)	Number of Observations	Days of Observations	Minimum Home Range	
						Acres	Hectares
428	Male	4.2	730	8	35	0.89	0.36
460	Male	2.75	710	5	35	0.59	0.24
461	Male	2.75	710	4	12	0.39	0.16
432	Male	4.5	775	14	22	1.67	0.68
434	Male	4.5	735	25	39	2.86	1.16
435	Male	—	—	7	23	0.74	0.30
459	Male	5.0	840	12	55	1.15	0.46
464	Male	3.4	712	6	15	1.08	0.44
441	Male	4.25	720	10	14	1.33	0.54
442	Male	—	—	10	16	2.31	0.93
447	Male	—	725	14	12	1.47	0.59
448	Male	—	660	15	18	2.15	0.87
449	Male	4.0	740	19	21	3.58	1.45
465	Male	3.25	760	6	8	0.39	0.16
457	Female	3.25	635	9	17	1.74	0.70
429	Female	5.5	835	9	12	0.64	0.26
431	Female	4.5	750	11	43	1.92	0.78
433	Female	5.0	790	23	63	2.32	0.94
454	Female	3.5	727	8	19	0.57	0.23
436	Female	3.5	705	7	9	0.54	0.22
439	Female	2.0	—	12	25	1.94	0.78
450	Female	4.5	750	11	21	1.99	0.80
451	Female	3.5	735	4	25	3.32	1.34

February 1948, surveys to observe armadillos were made 30 times. Four animals (one juvenile, three adults) were observed on more than four occasions. The longest period of observation was 28 days. It was estimated that the juvenile armadillo had a home range of 0.69 acres (0.3 hectares, ha); the three adults had an average home range of 8.5 acres (3.5 ha).

From February to June of 1948, Fitch et al. (1952) studied home ranges of armadillos in Natchitoches Parish, Louisiana. Based on 32 observations of 13 different animals, they concluded that the usual home range of an individual was approximately 50 acres (20.3 ha).

Layne and Glover (1977) marked and released 47 armadillos in Highlands County, Florida. They presented estimates of minimum home ranges for eight of 12 animals that were observed four or more times between July 1968 and September 1974. Their estimates of home ranges of *D. novemcinctus* varied from 2.72 acres (1.1 ha) to 34.10 acres (13.8 ha), with an average of 14.08 acres (5.7 ha). In addition, Layne

Table 2. Tag numbers and sexes of free-ranging armadillos with overlapping home ranges in southern Louisiana.

Number, Sex	Number, Sex of Armadillos with which Home Ranges Overlapped
428, male	457, female; 460, male; 461, male
429, female	457, female; 434, male; 461, male
431, female	432, male; 434, male; 433, female; 435, male; 454, female; 459, male
432, male	431, female; 434, male; 433, female; 435, male; 454, female; 459, male
433, female	431, female; 432, male; 434, male; 435, male; 454, female; 459, male
434, male	429, female; 431, female; 432, male; 433, female; 435, male; 454, female; 459, male
435, male	431, female; 432, male; 434, male; 454, female; 459, male; 441, male
436, female	459, male; 464, male; 441, male; 442, male
439, female	441, male; 442, male
441, male	459, male; 436, female; 439, female; 442, male
442, male	439, female; 441, male
447, male	449, male, 451, female
448, male	449, male; 450, female
449, male	447, male; 448, male; 450, female
450, female	448, male; 449, male
451, female	447, male
454, female	431, female; 432, male; 434, male; 433, female; 435, male; 459, male
457, female	428, male; 460, male; 461, male; 429, female
459, male	433, female; 435, male; 454, female; 464, male; 436, female; 441, male
460, male	457, female; 428, male; 461, male
461, male	457, female; 428, male; 460, male
464, male	435, male; 454, female; 459, male
465, male	No overlapping home ranges with any marked armadillos

and Glover (1977) provided information on sizes of animals. The mean weight for 12 armadillos was 2.7 kg; the largest male weighed 3.4 kg and the largest female weighed 3.8 kg.

Thomas (1980) fitted a transmitter to an adult male *D. novemcinctus* in Bosque County, Texas. The animal weighed 5.0 kg when captured; the weight was 4.7 kg at the time of release five days later. The animal was released on 4 June 1978 and located 43 times during a period of 55 days. Based on the minimum polygon method, the home range was estimated at 20.01 acres (8.1 ha).

Galbreath (1982) reported information on home ranges of two adult armadillos (one male, one female) at the Archibold Biological Station, Highlands County, Florida. The size of the home range of the male was estimated at 26.69 acres (10.8 ha); that of the female was 18.78 acres (7.6 ha). Galbreath (1982) also included some information on estimated sizes of home ranges of 8.15 acres (3.3 ha) for males and 8.40 acres (3.4 ha) for female armadillos at an unspecified site in Mississippi.

Table 3. Morphometrics (mm) of seven sets of fetuses of armadillos from southern Louisiana. Means are in parentheses. See text for dates of collections and descriptions of fetuses.

Total Length	Tail Length	Hind Foot	Ear	Head Width	Scapular Shield Width	Scapular Shield Length	Pelvic Shield Width	Pelvic Shield Length	Head Length	Trunk Length
Set 1										
21.0	11.7	3.2	2.0	6.7	8.2	7.4	7.8	6.1	11.5	15.5
21.0	12.2	3.5	2.3	6.6	8.3	7.5	7.6	6.9	11.5	15.5
20.8	12.4	3.4	2.1	6.3	8.3	7.1	7.5	6.3	11.5	15.6
21.0	12.0	3.3	2.0	6.5	8.7	7.0	6.7	6.5	11.2	16.7
(21.0)	(12.1)	(3.4)	(2.1)	(6.5)	(8.4)	(7.3)	(7.4)	(6.5)	(11.4)	(15.8)
Set 2										
34.8	16.5	6.8	3.2	9.0	13.7	10.1	12.0	9.1	15.8	27.2
34.8	16.4	7.0	3.5	9.4	14.5	10.7	12.5	9.2	15.5	27.5
33.6	16.2	6.9	3.2	9.1	14.1	10.4	13.5	8.8	15.0	26.8
34.3	16.5	7.2	3.6	9.5	14.5	10.8	13.4	8.3	15.5	27.4
(34.4)	(16.4)	(7.0)	(3.4)	(9.3)	(14.2)	(10.5)	(12.8)	(8.9)	(15.5)	(27.2)
Set 3										
84.0	29.0	9.0	4.0	12.5	14.3	13.4	13.6	11.8	23.2	36.2
88.0	28.0	9.0	4.0	12.4	14.0	16.8	16.3	11.8	22.6	36.1
86.0	28.0	9.0	4.0	12.1	13.7	14.9	14.8	11.6	23.4	36.5
87.0	30.0	9.5	4.0	12.2	14.3	15.5	16.5	12.0	23.5	37.0
(86.0)	(29.0)	(9.1)	(4.0)	(12.3)	(14.1)	(15.2)	(15.3)	(11.8)	(23.2)	(36.5)

7 March 1986										
87.5	27.5	10.1	3.7	13.3	—	13.9	—	12.6	22.8	39.3
88.6	29.1	10.7	3.8	12.8	—	13.9	—	13.1	23.7	39.5
85.6	27.5	10.8	3.8	13.9	—	14.9	—	13.5	24.4	41.3
85.6	28.0	10.3	3.8	12.7	—	14.2	—	13.3	23.7	39.5
(86.4)	(28.0)	(10.5)	(3.8)	(13.2)	—	(14.2)	—	(13.1)	(23.7)	(39.9)
Set 4										
120.0	44.0	17.0	8.0	17.0	26.7	15.2	27.5	18.8	32.6	50.6
119.0	44.0	16.0	8.0	16.2	24.8	15.2	27.0	18.6	33.3	51.5
120.0	44.0	17.0	8.0	17.6	26.0	15.2	26.5	18.5	32.9	50.8
115.0	44.0	17.0	8.0	17.4	26.0	15.2	26.8	18.8	33.2	50.3
(119.0)	(44.0)	(17.0)	(8.0)	(17.1)	(25.9)	(15.2)	(27.0)	(18.7)	(33.0)	(50.8)
Set 5										
153.0	53.0	22.0	11.0	20.0	27.3	19.0	28.4	24.5	37.1	61.4
152.0	54.0	20.0	10.0	18.2	28.0	18.0	30.7	25.2	37.1	63.2
152.0	52.0	20.0	11.0	19.8	28.0	18.0	29.2	24.4	36.3	63.0
153.0	54.0	21.0	12.0	19.2	27.3	18.1	27.8	24.5	37.2	60.3
(153.0)	(53.0)	(21.0)	(11.0)	(19.3)	(27.7)	(18.3)	(29.0)	(24.7)	(36.9)	(62.0)
Set 6										
241.0	105.0	35.0	19.0	24.8	33.2	25.1	36.5	34.3	51.1	90.7
242.0	100.0	39.0	19.0	25.5	34.6	23.0	37.0	32.5	51.5	96.5
240.0	101.0	34.0	19.0	24.8	32.2	26.2	33.5	32.0	52.0	92.5
242.0	101.0	35.0	19.0	24.5	32.2	25.6	34.2	32.2	52.5	93.5
(241.0)	(102.0)	(36.0)	(19.0)	(24.9)	(33.1)	(25.0)	(35.3)	(32.8)	(51.8)	(93.3)

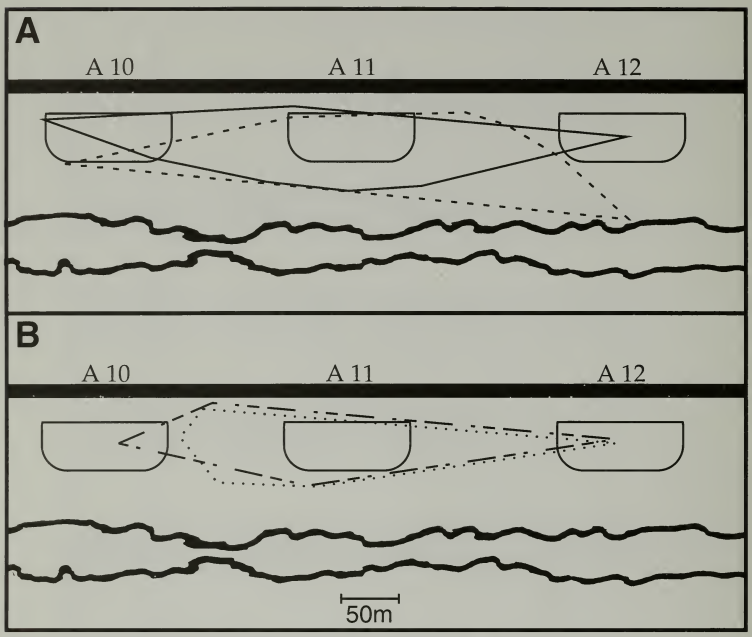

Figure 2. Enlargement of area around bunkers A-10, A-11, A-12 showing bunkers in relation to shell road (heavy black line) and long pond. A. Home ranges of female, number 433 (———) and male, number 434 (- - -); B. Home ranges of female, number 431 (— — —) and male, number 432 ( ).

Breece and Duci (1985) observed 26 adult and 26 juvenile, marked armadillos at the Fred T. Stimpson Sanctuary in Clarke County, Alabama, from July 1972 through August 1973. Average minimum sizes of home ranges for 21 adults seen three or more times each were estimated at 8.67 acres (3.5 ha), whereas those of 15 juveniles were 3.63 acres (1.5 ha).

Based on our observations of *D. novemcinctus* in southern Louisiana, estimates of sizes of home ranges were smaller than those presented in the aforementioned studies. Our estimates were derived by using the minimum polygon method for data obtained on 23 of the original 34 armadillos that were marked and released during the study. Number of observations per individual ranged from four to 25; duration of observations per individual ranged from eight to 63 days (Table 1). Estimated minimum home ranges for 14 males varied from 0.39 acres (0.2 ha) to 3.58 acres (1.4 ha), with a mean of 1.47 acres (0.6 ha). Similar estimates for nine females varied from 0.57 acres (0.2 ha) to 3.32 acres (1.3 ha), with a mean of 1.66 acres (0.7 ha). Analyses of combined data for 14 males and nine females resulted in average,

estimated, minimum home ranges of 1.55 acres (0.6 ha).

There were no apparent correlations between sizes of armadillos and estimated sizes of home ranges. For example, the smallest, marked animal in our study was a female (tag no. 439; 2.0 kg) that was observed on 12 occasions over a period of 25 days; she had an estimated home range of 1.94 acres (0.8 ha). A large, marked female (tag no. 431; 4.5 kg) that was observed 11 times during a period of 43 days had an estimated home range of 1.92 acres (0.8 ha). Figure 2-A depicts the home range of a female, tag no. 433; 5.0 kg; 790 mm total length (TL), based on 23 observations during a period of 63 days and a male, tag no. 434; 4.5 kg; 735 mm TL, based on 25 observations during a 39 day period.

Figure 2-B depicts the home range of a female, tag no. 431; 4.5 kg; 750 mm TL, based on 11 observations during a period of 43 days and a male, tag no. 432; 4.5 kg; 775 mm TL, based on 14 observations during a period of 22 days (Tables 1 and 2).

Obviously the home ranges of the four armadillos cited above overlapped considerably and so it was impractical to place all four on the same diagram. Moreover, there were two additional females and two additional males that had overlapping home ranges with one or more of the four foregoing listed animals (Table 2). These latter four animals also had elongate home range patterns similar to those shown in Figure 2-A and 2-B.

The small sizes of our estimated home ranges of armadillos may be correlated with the topography of the study area, as described previously (Figure 1). The abundance of relatively well-drained burrowing sites seemingly was important to the animals in the area. Hard-packed roads may have served as partial deterrents to movements of animals, especially when foraging. However, it was not uncommon to see armadillos crossing roads. During this study, marked animals frequently were observed foraging in open areas on several occasions (one to four times) during a span of time (one to five hours) daily at relatively short distances between the points of observations. Therefore, it seems logical to assume that there was a plentiful supply of food in the areas frequented by the armadillos.

Layne and Glover (1977) indicated that there were no overlaps in home ranges of adult females. However, several other authors (Clark, 1951; Fitch et al., 1952; Galbreath, 1982; Breece and Dusi, 1985) reported that overlaps of home ranges of armadillos frequently were conspicuous. We observed numerous instances of overlaps of home ranges between juveniles and adults of both sexes (Table 2). Only one individual (adult male) was determined to not overlap with home ranges of other animals. Overlaps of home ranges and closeness of armadillos frequently observed by us may have been related to pairing behavior of *D. novemcinctus* as discussed by McDonough (1997).

There are relatively few published reports of densities of armadillos. Galbreath (1982) provided an estimated density of these mammals as less than one animal per hectare. Kalmbach (1943) attempted to estimate densities of armadillos based on questionnaire surveys; he reported a high density of 0.82 animals per acre and a low density of 0.21 armadillos per acre. Taylor (1946) gave some estimates of densities of *D. novemcinctus* based on strip counts of active dens. However, he expressed uncertainty with regard to the direct correlation between the numbers of active dens and the numbers of animals occupying the burrows; as many as five armadillos were

found in one den. Taber (1945) attempted to correlate numbers of animals with numbers of dens; he found one armadillo per 4.5 dens as a result of one study and one animal per 8.5 dens in another observation.

Random strip surveys were conducted to estimate the number of armadillos in the study area. A road 1.9 kilometers long, with an adjacent observable, open, grassy area estimated to be 20 acres (8.1 ha), was selected for these surveys. The road was traveled in 10 to 15 minutes and the numbers of armadillos observed were recorded. The results of the strip surveys are depicted in Table 4.

Some seasonal changes were noted in connection with patterns of activities of *D. novemcinctus* in the study area. During the winter and early spring, most of the foraging by armadillos was diurnal. However, as the nights became warmer, the animals began to emerge and forage increasingly later in the afternoons. During the summer, most of the foraging activities of armadillos were nocturnal. Other than periods of inclement weather, such as hurricanes, September and October were the driest periods in the study area. The days were warm and the nights were cool; frequently there were ground fogs and heavy dews in the early evening. Although the ground frequently was dry and cracked, the open, grassy areas were frequented by armadillos during this season. McDonough and Loughry (1997a) reported on

Table 4. Observations of armadillos during strip surveys along 1.9 kilometers of road and adjacent areas of an estimated 20 acres (8.09 ha) in southern Louisiana.

Dates	Times of Observations	Numbers of Armadillos
24 October 1987	1630–1640	14
25 October 1987	1500–1510	10
25 October 1987	1755–1805	8
26 October 1987	1535–1545	4
30 September 1990		42
1 October 1990		41
2 October 1990	1720–1730	29
15 October 1990	1805–1815	51
17 October 1990	1705–1720	60
20 October 1990	1755–1810	54
22 October 1990		18
23 October 1990		16
28 October 1990	1120–1130	18
28 October 1990	1620–1630	31
29 October 1990	1117–1127	7
30 October 1990	1120–1130	17
30 October 1990	1620–1630	29
11 September 1995	1845–1856	6
26 September 1995	1900–1905	5
29 September 1995	1819–1833	8
1 November 1995	1657–1703	10

activity periods of armadillos in northern Florida. They observed considerable flexibility in the timing of activity of these mammals. However, activity was correlated positively with cloud cover during the day and with warm and dry conditions at night.

A summary of patterns of mortality in *D. novemcinctus* was presented by McDonough and Loughry (1997b). They found significantly higher incidences of mortality caused by predators in juveniles as compared to adult armadillos. However, mortality during a prolonged period of drought was greater for adults than for juvenile animals. Armadillos frequently are killed on roads (Loughry and McDonough, 1996). However, reliable estimates of the impacts of road kills on populations are difficult to determine (Case, 1978). As implied previously, mortality of armadillos in the study area was attributed mostly to interactions with humans; a few animals were found dead on roads and some armadillos apparently were shot. Newman (1913) provided information on the slaughter of armadillos for the use of the armor in making baskets. For example, he stated that one dealer claimed to have shipped about 40,000 baskets made from armadillos in a period of six years. Incidentally, ornamental items, such as baskets and purses, as well as stuffed animals, still are available in many markets.

Development.—There have been some conflicting reports in the literature with regard to positions of *D. novemcinctus* during copulation. For example, Newman (1913) and other authors reported that copulation occurred with the female turned on her back. However, Galbreath (1982) observed copulation by the male mounting the female from the back. This position of animals during copulation was correlated with studies of the shape of the penis of the male with the structure of the female urogenital sinus (Newfang, 1947; Galbreath, 1982).

One of us (RDS) observed mounting behavior by armadillos in or near the study area. On 6 September 1984, two armadillos were observed for a considerable period of time. One animal was foraging, and was followed by the other which attempted periodically to mount the foraging animal. Each time the rear animal would try to mount, the foraging armadillo would take a few rapid steps forward, disengage, and begin foraging again. The process was repeated numerous times over a distance of several hundred feet. Although copulation was not observed, the actions of this pair of animals could not be described as aggressive behavior as discussed by Denson (1979) and McDonough (1994). On 25 November 1984, an armadillo was observed mounted on the back of another animal at 2200 hours. Based on the movements of the animals, it was assumed that copulation occurred. Some detailed descriptions of pairing behavior of armadillos were presented by McDonough (1997).

Information on the reproductive cycle of *D. novemcinctus* has been provided by numerous authors. Patterson (1913) reported that old females bred first, mating in most cases before 15 October, while the second-year females continued to breed for some time after this period. He indicated a period of quiescence of about three weeks, with a gestation period of about an additional 140 days, with the majority of young born in March and April. Hamlett (1933) suggested a quiescence period of about 14 weeks in duration. Based on examination of over 2,000 female armadillos killed at intervals throughout the year, Hamlett (1935) reported a total length of gestation of nearly eight months, made up of a "free-vesicle stage" of three and a half

months and an actual development period of about four months. A gestation period of eight to nine months, with an embryonic diapause of three to four months, was suggested by Enders (1966). A comprehensive summary of reproductive strategy in *D. novemcinctus* was presented by Storrs et al. (1989). Although the gestation period of armadillos has been regarded generally as eight to nine months, including a three to four month period of embryonic diapause, captive females not exposed to males gave birth to young 13 to 24 months after capture (Storrs et al., 1989).

Talmage and Buchanan (1954) noted that female armadillos produced new litters as early as February. Lowery (1974) reported that February was typical for time of parturi-tion of armadillos in Louisiana. Enders (1966) found fetuses approaching full-term size usually in late March and early April. During this study, we found the largest fetuses in mid April. However, length of gestation and time of parturition may be influenced by various stresses to which female armadillos are subjected (Storrs et al., 1989).

According to Enders (1966), the time of parturition of armadillos in late March and early April coincided with the presence of large numbers of lactating females. In this study, a non-pregnant female captured on 28 February 1987 weighed 4.0 kg, had nipples 9 mm in length, and a vestibular cleft 10 mm in length. A pregnant female captured on the same day weighed 4.6 kg, had nipples 13 mm in length, and a vestibular cleft 20.5 mm in length. A lactating female captured on 30 April 1986 weighed 4.6 kg and had nipples 20.5 mm in length. Another lactating female captured on the same date weighed 4.5 kg and had similar nipple measurements.

On 21 April 1983, a female, dead-on-road, was examined and prepared as a museum specimen. She weighed 5.0 kg, was not lactating and had not given birth recently. There were unusual amounts of fat everywhere, around the legs, at base of tail and in neck and belly regions.

Illustrations of sets of fetuses of *D. novemcinctus* were provided by Newman and Patterson (1910), Newman (1913), Patterson (1913), and Kalmbach (1943); however, dates when fetuses were obtained and measurements of individuals were not included. Newfang (1947) gave crown-rump measurements of 29 fetuses and the dates that they were preserved. In addition to internal structures, she described and illustrated the external genitalia of armadillos.

The following descriptions of external morphology of fetuses of *D. novemcinctus* are based on sets of fetuses (Table 3). The sets of fetuses are listed in order of average fetus size. Following the date of capture of female are the standard measurements (total length, tail length, hind foot length, and ear length) and weight, when known, of the female (mother). If the individual female had a stub tail, then the total length and tail length measurements are enclosed by parentheses. The seven sets of fetuses, with date of capture and measurements of female are as follows: Set 1, 14 February 1986, (668)-(265)-100-37, unknown weight; Set 2, 28 February 1987, 768-337-96-38, 4.6 kg; Set 3, 11 February 1983, 760-320-70-44, 3.8 kg; Set 4, 15 March 1987, (718)-(302)-96-39, 4.2 kg; Set 5, 10 March 1982, 788-353-91-41, 6.3 kg; Set 6, 15 April 1970, 700-323-95-30, 4.9 kg. Data are reported for an additional set of fetuses obtained on 7 March 1986 (Table 3) from a road-killed female. Measurements for the female were 758-313-100-40, unknown weight. The fetuses were blood-stained and damaged such that accurate measurements could not be obtained for width of the scapular and pelvic

shields. Thus, this set of fetuses was not used in the descriptions of development of external morphology and pigmentation.

Rates of growth of armadillos are depicted in Figure 3. The head, trunk, hind foot, and ear pinnae have a similar pattern of change in relative size during development (Figure 3). The relative proportions of these structures are comparatively stable during the course of early development of the fetuses. However, the tail increases in length at a faster rate than the trunk after a total body length of about 80 mm (Figure 3).

Examples of fetuses from Sets l–6 are shown in Figures 4–6. In the early sets of fetuses (Sets 1–4), there was little color (Figure 4). In some cases, the internal organs could be seen through the translucent skin of the belly and the band region of the carapace. In fetus Set 5, adult coloration was discernable and the areas between the scutes were pigmented. However, pigmentation was most obvious on the posterior part of the head, the pinnae, the dorsal part of the carapace, and the bases of the hind feet (Figure 5). The fetuses of the Set 6 essentially were of the same coloration as the adults; but the fetuses were lighter brown in color than the adults (Figure 6).

Progression of the development of the heads was obvious in the sets of fetuses that we examined. In the 1st set of fetuses, the eyes were developed, the lenses could be discerned, and the eye lids were open partially. In fetus Set 2, the eye lids were fused together, but the lenses were obvious. However, in fetuses of Set 3, the eye lids were thicker and opaque; the lenses were obscured. In fetus Set 5, there were narrow slits between the eye lids. In fetuses of Set 6, the eyes were half open.

The nostrils appeared as small pits in the first set of fetuses studied. During subsequent development, the pits were increasingly deeper and greater in diameter. In fetus Set 4, fleshy folds were present that divided the holes vertically and made them appear more slit like. These structures were increased in size in the remaining sets of fetuses.

In the fetus Set 1, the tips of the pinnae were folded inward to close the openings in the ears; the bases of the pinnae were not adhered to the head. However, in fetus Set 2, the bases of the pinnae were adhered to the head, but the tips were not folded inward. These positions of the pinnae were present in all of the other sets of fetuses. In fetus Set 4, development of scutes was noted at the bases of the pinnae. Approximately half of the pinnae were covered with scutes in fetus Set 5. In fetus Set 6, the pinnae were equipped fully with scutes. The distances between the right and left pinnae were similar in all of the fetuses examined. It seemed that the head increased in width and the pinnae enlarged, thus creating the perception that the ears became closer together and moved from the sides to the tops of the heads of the developing fetuses.

The tongues were protruding conspicuously from the mouths of all fetuses of Set1 and Set 2. In fetus Set 3, the tongues were enclosed completely within the mouths of the animals. Perhaps the rates of growth of the jaws exceed those of the tongues. In the smallest fetuses (Sets l–3), the tongues were round in cross section; in Sets 4–6, the tongues were flattened in cross section.

In the smallest fetuses, the jaws were flattened and without well-defined edges. However, the edges of jaws were outlined in the fetuses of Set 2, and well developed in Set 5 and Set 6. All fetuses examined lacked teeth. In fetus Sets 1 and 2, the lower

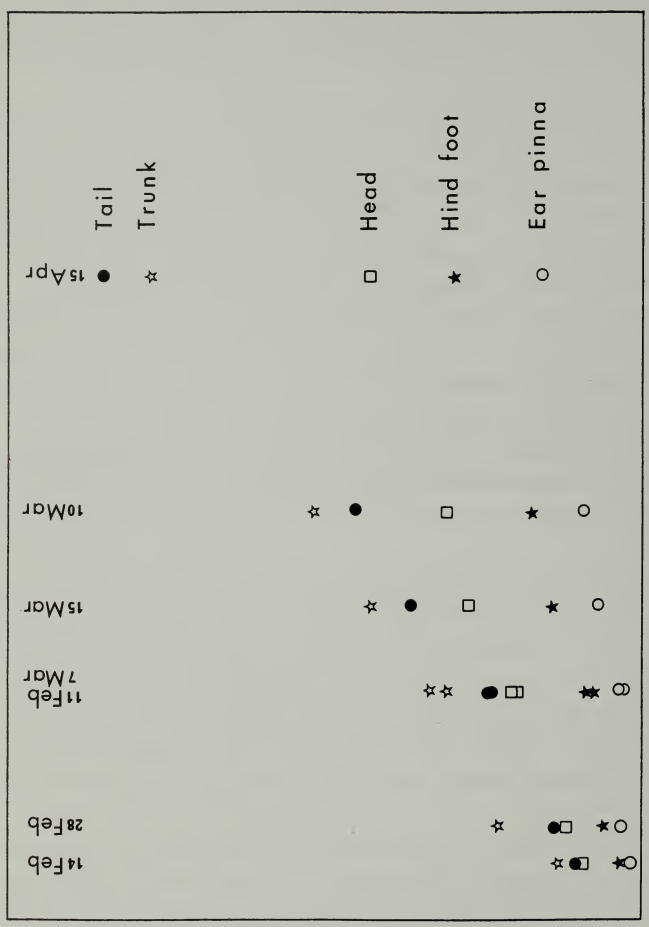

Figure 3. Relative growth of tail, trunk, head, hind foot, and ear pinnae of six sets of fetuses of armadillos from southern Louisiana. Symbols represent the mean value of the respective embryos.

Figure 4. Photographs of representatives from fetus Set 1, Set 2 and Set 3 of armadillos from southern Louisiana.

Figure 5. Photographs of representatives from fetus Set 4 and Set 5 of armadillos from southern Louisiana.

and upper jaws were of the same length. In subsequent sets of fetuses, the upper jaws were more and more protruding; most of the increases in the lengths of the heads were due to the growth of the upper jaws. In fetus Set 6, the upper jaws were 8 mm longer than the lower jaws. Incidentally, this was when fleshy lips were first detected on the fetuses studied.

In fetus Set 1, sutures of the underlying bones of the cranium were visible. In fetuses of Set 2, primordials of scutes were noticeable on the posterior ends and the

Figure 6. Photograph of representative from fetus Set 6 of armadillos from southern Louisiana.

central parts of the tops of the heads. In the remaining fetuses, the individual scutes were distinguishable; the head shields were well defined on the posterior parts of the head (by a skin fold) and also on the snouts of the fetuses. On the snout of each fetus, the shields were interrupted by a single line extending from the edges of the eyes anteriorly to the tip of the snout.

There was noticeable progression of the development of the trunks in each of the sets of fetuses studied. The trunks became changed from arched shapes to extended ones; this trend was conspicuous as demonstrated by examination of the six sets of fetuses (Figures 4–6). The areas that would be eventually covered by the carapaces were already well defined in the smallest fetuses. All nine bands already were present in the dorsal regions, and the anlages of the first five rows of scutes could be discerned. The edges of the carapaces already slightly overlapped the venters and upper extremities of the limbs. In fetus Set 2, the anlages of all scutes were distinguishable from each other. The anlages of the scutes started as small, white spots, but soon became enlarged until the different scutes almost were touching each other. In subsequent sets of fetuses, the individual bands were increasingly longer. The different shapes of the scutes (elongate-triangular in the bands, octagonal on the pelvic shields) were established first in fetus Set 4.

In fetus Set 1, genital papillae were present. The umbilical cords were situated short distances anterior to the papillae. In fetus Set 2, whitish blotches were arranged in rows on the venters of the animals. However, by fetus Set 5, the whitish blotches were in irregular patterns. These white spots may be the anlages for the dermal nuclei that become the sites for hair tufts in adult armadillos. The spots

initially were located on the bellies of the animals, but later (fetus Set 4) were noticeable on the chins, throats, and the upper parts of the legs. No hairs were noticed on the fetuses examined. The anal aperatures were apparent first in fetus Set 5. In fetuses of Set 6, the anal aperatures were slit-like at the crests of slight elevations. In fetus Set 6, nipples were visible.

In the smallest fetuses (Set 1), the tails were curled anteriorly between the hind legs. In fetus Set 2, the tails were uncurled partially; development of bony rings on the tails was detected. The anlages of seven different rings were distinguished; the tails became separated from the carapaces by folds of skin. In fetus Sets 3 and 4, anlages for eight rings were present, and different scutes became distinguishable in the 4th set of fetuses. In fetuses of Set 5, 13 different rows could be counted; in the anterior ten rows, each of the rings consisted of two rows of scales which is the pattern present in adult armadillos.

Initially, the development of the forefeet seemed more rapid than that of the hind feet. In fetuses of Set 1, the four digits of the forefeet were well separated, with some webbing at the bases of the digits. The middle digits were the largest, and the anlages for the claws were present. In fetus Set 2, the webbing was absent and the anlages for the claws had ventral grooves. In fetuses of Set 3, toe-pad like enlargements of the claws were apparent, and the anlages for the scutes (in rows) became obvious. The two middle toes were considerably larger than the first digits. In fetuses of Set 5, the individual scutes were distinguishable; the scutes were partially overlapping. The pad-like structures at the tips of the digits were diminished in relative size; the bases of the claws showed some pigmentation. In fetus Set 6, the claws almost were completely pigmented. The development of the hind feet followed about the same patterns as that of the forefeet. However, in the first four sets of fetuses, the development of the hind feet was less rapid than that of the forefeet. In addition, five digits were present on the hind feet; the third toe was decidedly the largest. In fetus Set 4, anlages of scutes were present on the undersides of the hind feet; fetuses of Set 5 had fewer scute anlages.

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