THE COMMON LONG-NOSED ARMADILLO
(DASYPUS NOVEMCINCTUS) IN
NORTHCENTRAL OKLAHOMA

By

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PREFACE

The purpose of this study was to establish activity patterns and food habits of the common long-nosed armadillo, Dasypus novemcinctus, in northcentral Oklahoma. Information on burrow characteristics, activity patterns, and home ranges was collected on a study site southwest of Stillwater, Oklahoma. Measurements and food habits were secured through roadkilled armadillos. The research combined existing published data and original field observations.

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CHAPTER I

INTRODUCTION

This thesis is composed of six chapters. Chapter I serves as the introduction. Chapter II is a review of literature. The remaining four chapters are written as individual manuscripts suitable for submission to scientific journals. These chapters are each complete without additional supporting materials. The manuscripts, written in the Journal of Mammalogy format, are: "Burrow Characteristics of the Common Long-nosed Armadillo, *Dasypus novemcinctus*" (Chapter III), "Armadillo Home Range and Activity in Northcentral Oklahoma" (Chapter IV), "Morphological Characteristics of the Common Long-nosed Armadillo from Oklahoma" (Chapter V), and "Foods of the Common Long-nosed Armadillo in Northcentral Oklahoma" (Chapter VI). Previous approval for format changes was granted by the Graduate College.

CHAPTER II

LITERATURE REVIEW

The mammalian order Xenarthra, also called Edentata, is distinguished by extra articulations between the lumbar vertebrae, xenarthra, hence the order name. These extra articulations give extra support to the pelvic region (Grzimek, 1975). Edentata means "toothless", a condition which does not apply throughout the order. This order is of New World origin with three extant families: Myrmecophagidae (anteaters), Bradypodidae (sloths), and Dasypodidae (armadillos) (Gunderson, 1976). Dasypodidae is the most primitive xenarthran family and ranges from southern Patagonia (Moore, 1968) to northern Oklahoma with occasional sightings as far north as Nebraska (Gunderson, 1976; Oklahoma Mammals). North American armadillos include the extinct Dasypus bellus, which is considered to have been similar to, but three times larger than Dasypus novemcinctus (Auffenburg, 1957; Slaughter, 1959; Guilday et al., 1978). The only other extant edentates to invade Central American tropics are two species of anteaters, Cyclopes didactylus and Tamanda tetradactyla, and one other species of armadillo, Cabassous centralis (Hall and Kelson, 1959). Simpson (1932) has shown that dental enamel has been lost independently at least three times in the evolution of Xenarthra. Distribution (Bushnell, 1952; Buchanan and Talmage, 1954; Rood, 1970) and taxonomy (Newman, 1913; Hamlett, 1939; Russell, 1953; Talmage and Buchanan, 1954) of extant Dasypodidae have been studied but some areas need clarification.

Distribution of *Dasypus novemcinctus*

The name, common long-nosed armadillo, was suggested by Wetzel and Mondolfi (1979) as a better common name than nine-banded armadillo for *D. novemcinctus*. The recent expansion of the North American range of *D. novemcinctus* has attracted much attention (Strecker, 1926; Hibbard, 1943; Cleveland, 1970; Humphrey, 1974). Limits to its range expansion have been predicted, with the present range exceeding earlier predictions. Newman (1913) predicted *D. novemcinctus* expansion would halt at the 33°N latitude, which was quickly crossed. Strecker (1926) stated that the ability of *D. novemcinctus* to adapt to various physical environments was most remarkable. After the Florida population was established through introductions (Sherman, 1943; Bushnell, 1952), Buchanan and Talmage (1954), and later Moore (1968), stated that the two groups of Texas and Florida would merge. Galbreath (1980) reported that the two groups have merged. The southern limit of *D. novemcinctus* was suggested by Hamlett (1939) as the Rio Negro in

Argentina. McNab (1980) noted that *D. novemcinctus* was more successful in penetrating the northern temperate zone than the southern temperate zone where it competes with other armadillo species. Several subspecies have been described based on cranial characteristics (Newman, 1913; Russell, 1953). Expansion from Texas to the north and east, expansion from Florida in every possible direction, and range contraction on the western boundary are trends in their expansion since 1954 (Humphrey, 1974). Slaughter (1959) found *D. novemcinctus* stopping its range along the 18 - 20 inch (451 - 500 mm) per annum rainfall belt in the United States and Mexico. The rainfall belt was close to Humphrey's (1974) limit of 380 mm of precipitation. Humphrey (1974) also gave a maximum limit of nine freeze days annually which correlates with McNab's (1980) predictions. *D. novemcinctus* should be limited in its northwest movement by food availability in cold periods and its inability to reduce energy requirements (McNab, 1980). Food availability is also tied to precipitation in limiting soil invertebrates (Buchanan and Talmage, 1954).

Fitch et al. (1952) surmised that the reason for the recent expansion was due to human reduction of carnivores. Since that publication there has been little evidence that predation by wild carnivores is sufficient to have prevented earlier expansion. Bushnell (1952) reported three occurrences of predation, two by black bears and one by an alligator. Gipson (1974) listed *D. novemcinctus* as a food item for coyotes in Arkansas with only one occurrence, which was the lowest for any wild or domestic animal. Litvaitis and Shaw (1980) reported coyote scats in southwest Oklahoma had remains of armadillos in 9% of 361 scats. It is also listed as a food item for cougars, but no figures are given (Russell, 1978). A recent necropsy of a Florida puma, Felis concolor coryi, an endangered subspecies, found remains of an armadillo (Belden and Forrester, 1980).

The main defense of D. novemcinctus is its shape and speed, not its carapace (Kalmbach, 1944; Talmage and Buchanan, 1954). Kalmbach (1944) believed man and dog were the worst predators. Kalmbach was supported by McDaniel (1929) who reported 4,000 armadillos killed in a single summer around a small Texas town. Man seems to have significantly more influence than any wild predator. Siegler and Newman (1944) found armadillos to be the most abundant roadkill in Texas, with an increase in roadkills during the breeding season. This abundance of roadkills is apparently aided by a reaction that Talmage and Buchanan (1954) and others have labeled a "nervous reflex". The armadillo huddles down when danger approaches and then springs upward when the danger is imminent. This places the armadillo about bumper height just milliseconds before the automobile strikes it. This same mechanism has been described as an effective defense against dogs by Finley and Finley (1925) and J. Watson (pers. comm.). In both accounts, the armadillo huddled to the ground motionless until the dog touched the carapace, then it sprang upward hitting the dog in the muzzle. Before the armadillo touched the ground, it was running. The startled dog ran after the armadillo, but the armadillo disappeared into a den or dense brush nearby.

History in Oklahoma

Blair (1936) was the first to record finding armadillos in Oklahoma. The first was taken in 1932 in the Verdigris River valley in Rogers County, and another was taken in 1935 in the Arkansas River valley of Creek County. Gardner (1948) reported a 1939 Wichita Mountain Wildlife Refuge capture, a 1941 capture 12.8 km northwest of Freedom, Oklahoma, and a seemingly constant increase in numbers. Buchanan and Talmage (1954) reported the range as south of Oklahoma City with occasional sightings further north. Glass and Halloran (1961) updated the Oklahoma distribution. Humphrey (1974) in a 1972 update to the distribution of D. novemcinctus mapped the edge of distribution approximately 32 km north of Oklahoma City, which is close to a line of mean annual freeze-days of nine. Blair (1939) listed D. novemcinctus in two biotic districts, Cherokee prairie and Osage savanna. Currently, it is found in four additional districts of Blair and Hubbel (1938): Ouachita, Mississippi, Ozark, and mixed grass prairie. The northern boundary in its western range is presently fluctuating around the Oklahoma-Kansas border.

Anatomy and Physiology

Dasypus novemcinctus has a normal focusing distance that is a few inches in front of its nose (Walls, 1942). The eye is devoid of cones (Grzimek, 1975), therefore the animal is color blind. A reduced sense of taste is indicated by the few tastebuds in the tongue (Maller and Hare, 1967). The common long-nosed armadillo possesses acute hearing and sense of smell (Fitch et al., 1952; Kalmbach, 1944). *D. novemcinctus* is reportedly capable of detecting insects 20 cm deep in the soil (Grzimek, 1975). Wislocki and Enders (1935) found members of the Xenarthra have permanent intra-abdominal testes. The odor of an armadillo comes from two glands that are lateral to the anus (Bushnell, 1952). As expected in an animal that consistently bears four young, *D. novemcinctus* has four mammae. Miles (1941) gave a description of the shoulder anatomy of *D. novemcinctus*. Greegor (1974) studied the kidney structure of two species, *D. novemcinctus* and *Chaetophractus vellerosus*, concluding the *C. vellerosus* has a kidney for xeric conditions while *D. novemcinctus* has a kidney for conditions between xeric and mesic. Johansen (1961) found peripheral vasoconstriction and retia mirabilia in the limbs linked to heat conservation.

Most of the physiological studies on armadillos have been related to their sensitivity to cold. Armadillos are characterized by low body temperatures, low metabolic rates, and high minimal thermal conductances (Scholander et al., 1950*a*, 1950*b*; Johansen, 1961; McNab, 1980). Physiological responses to environmental factors in *D. novemcinctus* were studied by Gause (1980). Scholander et al. (1943) observed the ability of *D. novemcinctus* to dig rapidly without breathing for as long as 6 mins. Baseline blood data and changes in blood components due to captivity were studied by D'addamio et al. (1978).

Reproduction of *D. novemcinctus* has been studied for several reasons. First, it has an obligate delayed implantation of 3 1/4 to 4 1/2 months (Vaughan, 1972). Second, it has polyembryonic development of four genetically identical young from a single fertilized egg (Newman, 1913). *D. septemcinctus* may have as many as 12 identical young (Grzimek, 1975). D'addamio et al. (1977) reported the cell changes in urogenital smears during the estrous cycle.

In 1971, *D. novemcinctus* was found to have the ability to contract *Mycobacterium leprae* (Kirchheimer and Storrs, 1971), thus becoming a useful experimental animal in leprosy research. Storrs et al. (1978) reported that 40% or more of wild armadillos in Louisiana can contract leprosy through inoculation. Walsh et al. (1977) reported a naturally acquired disease in *D. novemcinctus* that is indistinguishable from *M. leprae* from Louisiana, but Filice et al. (1977) found no observed association between man and *D. novemcinctus* to indicate armadillos as a link in the spread of leprosy. The study of leprosy using armadillos has produced a leprosy vaccine to be used by the World Health Organization (Maugh, 1982).

Two other infectious diseases found in D. novemcinctus are Adiaspirosis, a fungal lung infection (Jellison, 1970), and Leptospirosis. Eight serotypes of Leptospira were isolated from 200 armadillos from Louisiana. Two of these, L. canicola and L. pomona, are associated with disease in man and domestic animals. Dogs are the major source from which man acquires L. canicola (Roth, 1970). Weiss and Wislocki (1956) remarked that armadillos would make good laboratory animals in studying hematopoiesis due to their hundreds of marrow-bearing dermal plates.

For insectivores, the list of internal parasites is extremely small with one helminth, Aspidodera fasciata, specific to armadillos, and few helminths found as immatures that require an arthropod as an intermediate host (Chandler, 1946). The only known parasitic disease to which Dasypus spp. is associated is Chagas' disease, Trypanosoma cruzi. Other important wild hosts of Chagas' includes Didelphis spp. and Neotoma spp. This parasite notably cycles through members of the insect family Reduviidae. Dogs and cats are the significant sources for man's infections, usually attributed to conditions associated with poor sanitary conditions. The southern United States is reported as the northern limit of Chagas' disease (Wells and Lumsden, 1971). Talmage and Buchanan (1954) give lists of ticks and fleas found on D. novemcinctus.

Diet Studies

Diet studies are very numerous for D. novemcinctus with limited work on Chaetophractus vellerosus (Greegor, 1974) and a current study being conducted by Encarnacao and Carter (pers. comms.) on species found in Serra da Canastra National Park in Brazil. Kalmbach (1944), supplemented by Fitch et al. (1952), reported the most extensive studies from stomach analysis of D. novemcinctus. Other studies from different habitats (Baker, 1948; Clark, 1951; Bushnell, 1952) demonstrate the importance of insects in all habitats and an ability to adapt to different food sources.

Ecology of Dasypus novemcinctus

Home ranges of D. novemcinctus have varied from 3.4 ha in Texas (Clark, 1951) to 20 ha in Louisiana (Fitch et al., 1952). Taber (1954) reported 8.5 dens per animal in the coastal prairies of Texas. Greegor (1974) described two types of burrows. The first was a food probe which was less than 30 cm long and the second the den which was greater than 30 cm long. Burrow depths down to 3.5 m are reported (Bushnell, 1952; Walker, 1975). Site selection has been described for several habitats (Taber, 1945; Taylor, 1946; Bushnell, 1952; Fitch et al., 1952). A common factor in all habitats was a preference for brushy, covered sites on a slope, such as a stream bank. Plants associated with the burrow were related to a need for cover and roots to support the tunnel and were not species specific (Taber, 1945).

Nest building is stimulated by cold in most armadillos with _D_. _novemcinctus_ showing a quicker response than other species (Eisenberg, 1961). The nest materials consist of plant matter brought into the burrow in an interesting fashion. Plant debris is gathered under the body with the forelimbs, held between hindlimbs and forelimbs, and then the animal hops backward to the entrance using the tail as a probe (Talmage and Buchanan, 1954). Eisenberg (1961) details several variations observed in captivity. This type of nest is insulating and encourages invertebrates, which may act as a food source. In captivity, _D_. _novemcinctus_ is gregarious with one sex per den (Johansen, 1961). If this same behavior occurs in free-ranging armadillos in the winter, it may be a method of heat conservation as seen in the naked more-rat, _Heterocephalus glaber_ (Jarvis, 1979).

As in most wild species, foraging is the armadillo's single most common activity (Greegor, 1974). While foraging, armadillos are noisy, grunting almost constantly. Armadillos are mostly nocturnal, with _D_. _novemcinctus_ showing a seasonal change to diurnal in the winter (Fitch et al., 1952; Burns and Waldrip, 1971), probably to minimize heat losses (Moore, 1968). Pregnant and lactating females forage earlier and longer (McNab, 1980), with a preponderance of males late in the forage period (Bushnell, 1952).

Most researchers have concluded that the beneficial effects of D. *novemcinctus* outweigh any adverse effects. Chandler (1946) concluded that armadillos in hog pastures may provide the hogs with some protection against helminths by ingesting the infective larval stage found in arthropods, thus breaking the normal life cycles. Of greatest benefit is the destruction of insect pests by armadillos (Kalmbach, 1944; Baker, 1948; Walker, 1975). In fact, Henderson and Craig (1932) felt all insectivorous Xenarthrans deserve to rank with insectivorous birds as insect destructors. Most sugar cane farmers in southern states are delighted by the presence of armadillos due to the reduction of cane beetle problems (Fitch et al., 1952). Other beneficial effects listed by Fitch et al. (1952) include providing burrows for other wildlife, notably fur-bearers; incorporation of organic matter into soil by foraging and burrowing activities; a curio trade of shell products; and for human consumption in the southwestern United States, including Louisiana. Texas is the focal point of the curio trade in the U.S. Comfort, Texas, has an armadillo basket factory that used dogs to hunt armadillos (McDaniel, 1929). A 4-H Girls' Club canned 2,000 number 3 cans of armadillo meat in one season in World War I (Finley and Finley, 1925). The meat, a delicacy in South America, tastes like young pork (Hernandez, pers. comm.), hence the nickname "Poor man's pig" or "Hoover hog" in Louisiana. The Portuguese name for D. novemcinctus is "tatu galinha" or "Chicken armadillo", an allusion to its palatability.

The armadillo has been persecuted because it burrows in the wrong places according to man, i.e., under building foundations, dikes and levees, resulting in erosion damage (Fitch et al., 1952; Walker, 1975; Chamberlain, 1980). Probably the major reason several early studies were funded was the accusation that armadillos were affecting game bird populations by eating eggs. All studies (Graham, 1924; Kalmbach, 1944; Fitch et al., 1952) concluded that egg-eating seemed to be learned and the effect on bird populations is negligible. Beasom (1974), using strychnine chicken egg baits in Texas in testing predator control techniques, killed only six armadillos and calculated it took 667 eggs per armadillo. Stieglitz and Wilson (1968) in studying the Florida duck, reported all nests on dikes were destroyed by mammalian predators, listing only raccoon (Procyon lotor) and armadillos as present. Without evidence pointing to any nest definitely destroyed by an armadillo, the blame was still placed on both mammals. The only instance of the armadillo being proven to prey on eggs is in Florida where it feeds on eggs of the endangered gopher tortoise, Gopherus polyphemus (Douglass and Winegarner, 1977).

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CHAPTER III

BURROW CHARACTERISTICS OF THE COMMON LONG-NOSED ARMADILLO, *DASYPUS NOVEMCINCTUS*[1]

The common long-nosed armadillo, *Dasypus novemcinctus*, is a recent invader into the United States. Oklahoma is the northernmost state in its current contiguous range (Humphrey, 1974). Burrow placement may play a role in this tropical species' ability to withstand the cold. South-facing burrows would be protected from the cold north winds and would receive more direct solar radiation for warming. This south-facing tendency was found by Clark (1951) in Texas armadillos. Geiger (1965) reported rabbits on a North Sea island used south-facing entrances for wind protection and solar warmth.

Burrow diameter of about 20 cm for *D. novemcinctus* has been reported by Kalmbach (1944), Bushnell (1952), Talmage and Buchanan (1954), Layne (1976), and Greegor (1974). Clark (1951) and Galbreath (1980) also reported

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[1] Research conducted by the Oklahoma Cooperative Wildlife Research Unit in cooperation with Oklahoma State University.

a tunnel diameter of 18 cm. A preference for sloped ground for burrow placement was reported by Taber (1945) and Clark (1951).

This paper presents burrow data collected in northcentral Oklahoma. Burrow characteristics include habitat type, slopes, orientation, and measurements at the burrow entrance and 10 cm inside the tunnel.

STUDY AREA

Central Oklahoma is in the Cross Timbers region (Dyksterhuis, 1948). Areas of grassland and bottomland forest are dispersed among forests of post oak (Quercus stellata) and blackjack oak (Q. marilandica). The oak forests are situated on rolling to hilly sandstone upland (Dwyer and Santelman, 1964).

The intensive study site was located 4 km west southwest of Stillwater, Oklahoma. Legal description of the 65 ha site is the E 1/2 of the SW 1/2 of T19N, R2E, Sec. 30, and the E 1/2 of the NW 1/2 of T19N, R2E, Sec. 31. Five major vegetative types on the site were bottomland riparian (13.0%), ephemeral riparian (4.9%), upland (32.3%), brushland (4.0%), and glassland (43.3%) (Fig. 1). The remaining 2.5% was man-controlled and ponds.

METHODS

Burrows were located by sight on ground surveys and through radio-tracked armadillos. Only burrows of 30 cm or greater were analyzed. Burrow locations were recorded using a cartesian coordinate system overlaid on a 1:330' aerial photograph. Vegetation type (Table 1) was determined from an aerial photograph and then confirmed by ground survey. An electronic digitizer was used to calculate the percent area of vegetation type. Dimensions were taken at the entrance and 10 cm inside using a caliper to record the width and height. Orientation of a burrow was taken by sighting a compass along the main axis of the tunnel. This was read as an angular measurement, with 90°, 180°, 270°, and 360° being the principal directions, East, South, West, and North, respectively. Since the important factor being considered was the direction to which the tunnel opening faced, the orientation was recorded as the reciprocal of the measurement of the tunnel axis (e.g., a tunnel whose main axis was read as 360° (N) would be interpreted as an orientation of 180° (S)). A clinometer measured the slope of the tunnel (10 cm inside the entrance) and of the ground the burrow was dug into. A total angle was computed by summing the tunnel slope and the ground slope. Each burrow was marked with a numbered orange flag.

RESULTS AND DISCUSSION

A total of 113 armadillo burrows was located and measured. However, each burrow was not necessarily confirmed by the observed presence of an armadillo. For the following reasons all burrows were included in the analysis. First, D. novemcinctus was the major burrow/den digger present on the site. Second, the entrance of an armadillo burrow was uniquely characterized by a mound composed of layers. The bottom layer was the initial dirt excavated. The remaining layers were composed of a mixture of small leaf fragments, sticks, and dirt. Third, active armadillo burrows were cleaned after a rain as well as every spring. The spring cleaning is to rid the tunnel of the tightly packed leaves used in the fall and winter for insulation indicative of an armadillo burrow.

Burrow density on the total study site was 1.74 per ha. In habitat utilized, the density is 3.17 per ha, close to Taylor's (1946) report of 3.04 dens per ha in Texas.

Burrow locations.--Burrows were found only in bottomland riparian, ephemeral riparian, brushland, and upland habitat types. This meant 45.8% of the study site (grassland and man-controlled) was without burrows. Burrow locations were concentrated in bottomland riparian and ephemeral riparian areas. Only three burrows were found in brushland (Table 2). In Florida, Galbreath (1980) felt forest habitat was suboptimal and grassland optimal. This is opposite to the findings of this study and of Fitch et al. (1952) in Mississippi where grasslands were avoided. Burrows were all located in Vernon and Yahola very sand loam (Cobb and Hawker, 1918). No burrows were found in Vernon loam, which coincided with the large grassy areas.

Burrow measurements.--Measurements taken at the entrance indicate the previously reported diameters were heights. The mean width and height at the entrance were 21.9 cm and 19.8 cm, respectively. This was a significant difference ($\underline{P} < 0.001$). The tunnel measurements were significantly ($\underline{P} < 0.001$) smaller than the entrance (Table 3). The shape of the burrow is horizontally oval.

Slopes associated.--As previously mentioned, _D. novemcinctus_ has demonstrated a preference for sloped terrain. My data also supported this tendency, with 58% of the burrows being located in terrain of greater than 10° slope. Table 3 gives the mean tunnel slope as 28.7°. A maximum tunnel slope of 52° was in a burrow located on flat terrain. The total angle (ground slope + tunnel slope) (Fig. 2) was analyzed and a minimum of 22° was found. This angle is probably the angle which minimizes collapse in sandy soil. The mean total angle was 46.3° and had a coefficient of variation 1/3 that of the ground slope (Table 4).

Orientation of burrow.--The expectation of south-facing burrows was unfounded. Table 5 groups the data into north, east, south, and west-facing burrows. The combined mean orientation of all burrows measured was 30°. The orientations could not be proven to be non-random using a Rayliegh's test (Mardia, 1972). Why Clark (1951) found a south-facing tendency in Texas, when this study could not in Oklahoma cannot be fully explained. The winters should be more severe for the armadillos in Oklahoma, with winter winds from the north. A possible factor may be vegetation. Most burrows on the study site were protected by perennial vegetation, also reported by Taber (1945) and Calbreath (1980). Clark (1951) described vegetation on the Edwards Plateau in Texas as oak-elm woodlands, riparian, and dense juniper undergrowth, very similar to the current study site. The slope of the terrain chosen for a burrow may be another factor. The armadillos may have chosen more sharply sloped sites with protection from direct winds.

In summary, a typical armadillo burrow in northcentral Oklahoma has a tunnel 20.5 cm by 17.5 cm, sloping downward at 29.7°, burrowed into ground sloping upward at about 16°, and is located in wooded areas close to perennial vegetation.

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Table 1. Vegetation types monitored for armadillo use.

Vegetation type	Vegetation Community Structure
Bottomland Riparian	Bottomland hardwood forest including species of cottonwood (*Populus deltoides*), pecan (*Carya illinoensis*), walnut (*Juglans nigra*), willow (*Salix* spp.), mulberry (*Morus* spp.), and oak (*Quercus* spp.).
Ephemeral Riparian	Vegetation along ephemeral creek beds; species composition similar to bottomland but lacking cottonwoods, walnuts, and willows. Flood plains were absent.
Upland	Predominantly post oak (*Q. stellata*) and blackjack oak (*Q. marilandica*) > 5 m in height.
Brushland	Composed of clumped woody vegetation > 3 m and < 5 m in height.
Grassland	Grassland with < 10% woody vegetation.
Man-controlled and ponds	Human maintained areas, i.e., yard and roads, permanent ponds.

Table 2. Armadillo burrow locations by habitat type.

Habitat		Burrow	
Type	% Available	N	% Occurrence
Bottomland Riparian	13.0	65	54.2
Ephemeral Riparian	4.9	13	10.8
Upland	32.3	39	32.5
Brushland	4.0	3	2.5
Grassland	43.3	0	0
Man-controlled	2.5	0	0

Table 3. Armadillo burrow measurements (cm).

Variable		$\overline{X}$ ± SD	Range
Entrance	Width	21.9 ± 3.64	15 - 30
	Height	19.8 ± 4.24	14 - 35
Tunnel	Width	20.5 ± 3.43	13 - 30
	Height	17.5 ± 3.41	13 - 29

Table 4. Slopes associated with armadillo burrows (in degrees).

Variable	$\bar{X}$ ± SD	Range	CV
Ground Slope	16.2 ± 16.1	0 - 85	99
Tunnel Slope	29.7 ± 10.7	0 - 52	36
Total Slope	46.3 ± 14.7	22 - 110	32

Table 5. Orientation of armadillo burrow entrances.

Orientation	Grouped Degrees	Burrows	
		N	% Occurrence
North	316 - 045	32	27.8
East	046 - 135	32	27.8
South	136 - 225	23	20.0
West	226 - 315	28	24.3

Figure Legend

Fig. 1.--Delineation of vegetation types on the northcentral Oklahoma study site.

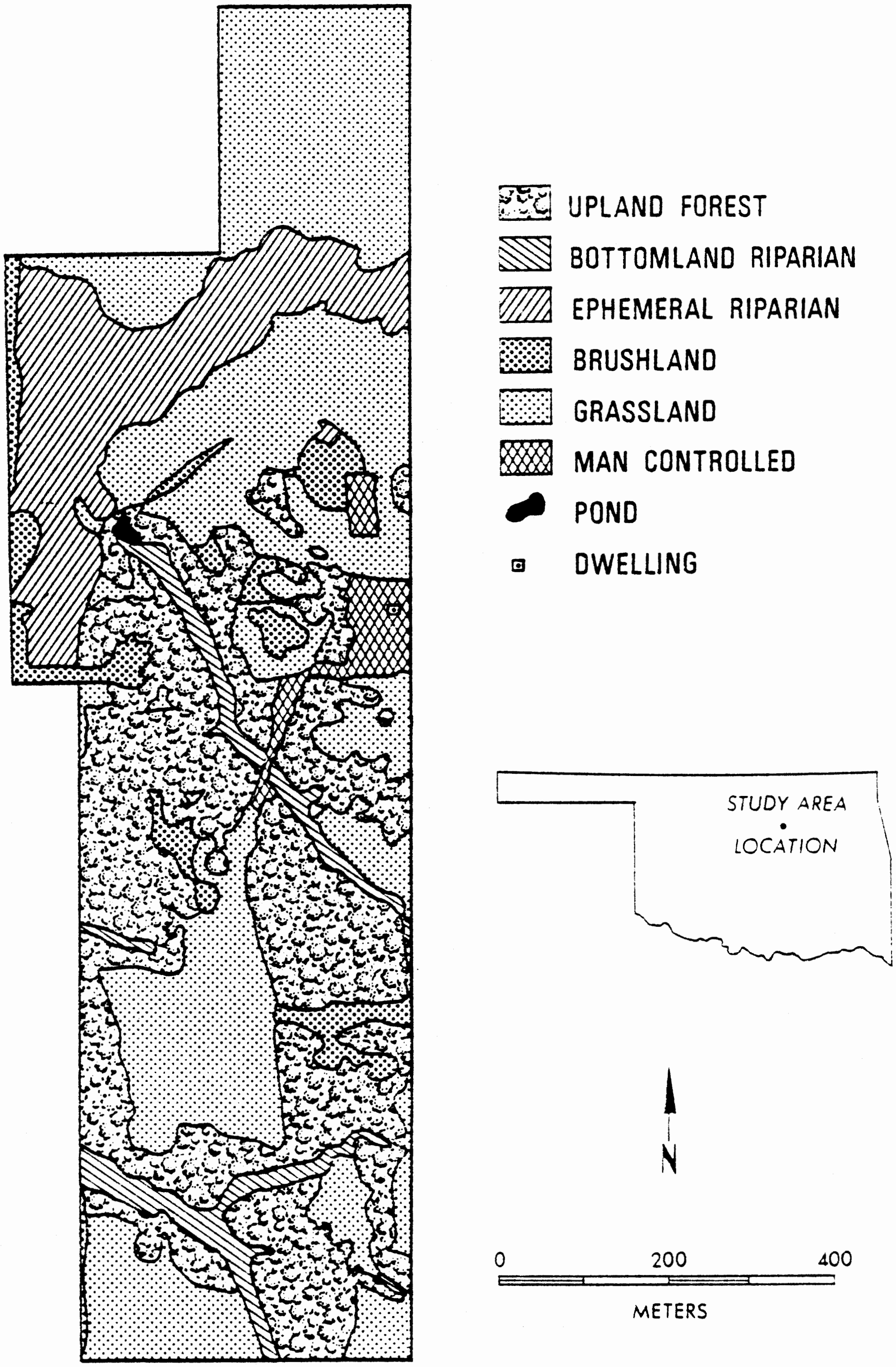
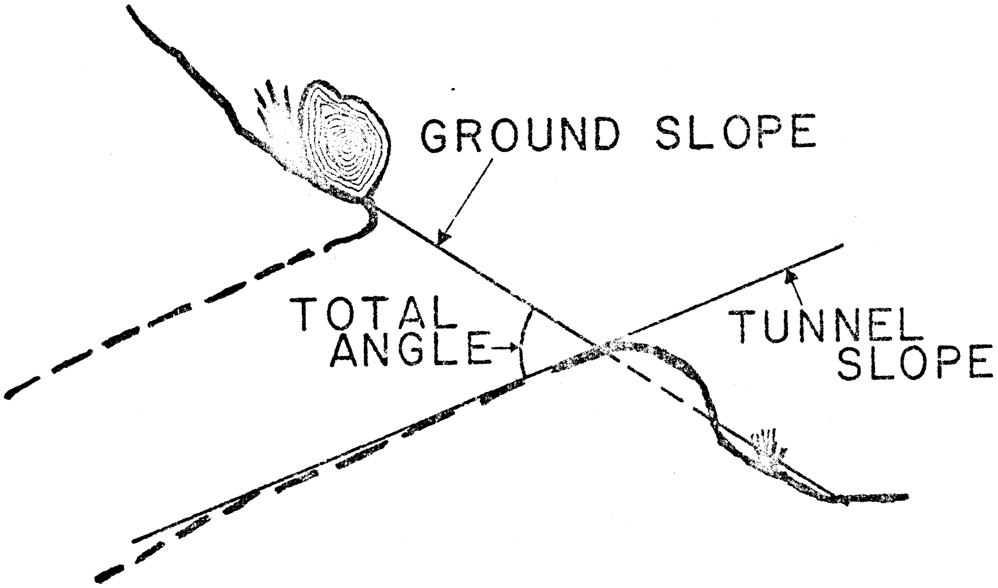

UPLAND FOREST
BOTTOMLAND RIPARIAN
EPHEMERAL RIPARIAN
BRUSHLAND
GRASSLAND
MAN CONTROLLED
POND
DWELLING
STUDY AREA
LOCATION
N
0
200
400
METERS

Figure Legend

Fig. 2.--Slopes associated with armadillo burrows.


GROUND SLOPE
TOTAL ANGLE
TUNNEL SLOPE

CHAPTER IV

ARMADILLO HOME RANGE AND ACTIVITY IN NORTHCENTRAL OKLAHOMA[1]

The common long-nosed armadillo, Dasypus novemcinctus, is a tropical species which has invaded the United States. The extension of its range into temperate regions of the U.S. stimulated numerous studies (Kalmbach, 1944; Fitch et al., 1952; Talmage and Buchanan, 1954). Armadillo adaptations to cooler climates have been studied by McNab (1980) in the laboratory and Gause (1980) in the field. Both of these studies dealt mainly with individuals from Florida although Gause (1980) did include a site in Georgia. Armadillos have been common in northcentral Oklahoma for around 20 years (Glass, pers. comm.), allowing between 10 to 20 generations for acclimatization to more severe winters.

STUDY AREA

A study site 4 km west southwest of Stillwater (northcentral Oklahoma) was selected for its accessibility

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[1] Research conducted by the Oklahoma Cooperative Wildlife Research Unit in cooperation with Oklahoma State University.

and relatively high armadillo density. The 65 ha site was comprised of five major vegetative types. Figure 1 delineates bottomland riparian (13.0%), ephemeral riparian (4.9%), upland (32.3%), brushland (4.0%), and grassland (43.3%). The remaining 2.5% was man-controlled and ponds. Table 1 gives the definition of the vegetative types. At a latitude of 36°00° it is the northernmost area in which D. novemcinctus has been studied. The field season began 1 July 1980 and ended 31 March 1982.

METHODS AND MATERIALS

Radio telemetry and signs were used to track armadillo movements. The success of the radio telemetry portion of this study depended upon capture of animals and reasonable duration of transmitter attachment. Signs, i.e., tracks and probes, were used to follow activity patterns in the vegetation types. Tracks could supplement telemetry when individual recognition was possible.

Armadillos were captured using two basic methods. The first was hand capture, the more successful of the two methods. The second capture method involved live traps. All traps were in the field several days before being set. Live traps tried included Havaharts (30.5 cm by 30.5 cm by 91.5 cm) with and without funnel boards (Marsh and Howard, 1978), handwoven 10 cm mesh net for burrow entrances, and a model of a South American trap used by Carter et al. (1981). The third trap was used during the last six months of the study.

The success of the South American style trap was solely dependent upon placement in an active burrow. The trap was constructed of 0.40 cm steel rods 75 cm long. The circular door (D = 20 cm) was hinged at the top to swing inward and was propped open with a small stick. The steel rods were welded on the outside to three circular metal bands (OD = 20.5 cm). The rods behind the last band (ca 55 cm) were bent inward forming a funnel, then welded together (Fig. 2). The distance between rods was 7 cm.

Upon capture the animal was taken to a field laboratory for measurements and marking. The animal was sedated with an intramuscular injection of 50 mg Rompum and 100 mg Ketaset, given in the hindquarters. Once the armadillo was sedated, standard measurements were taken and all unusual scars were noted. Claws broken in capture proved useful in individual recognition of tracks. Yellow enamel paint was used to paint a large number on the pelvic shield and the right shoulder shield. A small hole was hand-drilled through the left edge of the shoulder carapace to allow a plastic numbered roto-tag to be attached. Radio transmitters (Wildlife Materials Inc., Models HLP 2120LD and HLP 2124LD)[2] were then attached. Attachments were made to the tail. Some transmitters were pop-riveted into the fourth bony

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[2] Use of a product does not imply endorsement by agencies involved.

ring, then reinforced with 2.5 cm waterproof adhesive tape. The transmitters remained attached for an average of 3 days and a maximum of 75 days. Dental acrylic, epoxy, and pop-rivets into the pelvic shield were tried by Carter et al. (1981) for attaching transmitters.

The animals were held until the effects of the drugs wore off and were then released at the capture site. Radio-marked armadillos were located daily for at least 4 days after release, then once weekly.

Tracks, if imperfect, were recorded and sketched. All foraging and probing actions were noted on ground surveys. Sticks were placed in the entrance of burrows to note activity.

RESULTS AND DISCUSSION

Only two hand captures occurred without a chase. Many chases ended unsuccessfully, as armadillos always seemed to be well orientated to burrow locations, as previously reported by Clark (1951) and Galbreath (1980). The path a startled armadillo took was directly to the nearest thicket of greenbriar (*Smilax* spp.) or dogwood (*Cornus drummondii*), or a specific burrow. A burrow may be passed by in preference for another burrow. Clark (1951) referred to the escape burrow as a 'home' burrow.

Eight of the 15 armadillos captured on the study site were observed, tracked, radio-located or recaptured from 3 to 39 times ($\overline{X} = 15.2$). The other seven animals were captured once and never seen again. Intervals between successive locations ranged from 1 to 302 days ($\overline{X} = 9.2$). Observations were more difficult than Taber (1945) reported. Once captured, the armadillos became very wary of slight noises due to human activity.

The Havaharts traps depended greatly upon placement and bait selection. Placement in known armadillo paths had the best results, baited or non-baited. Trap shyness was indicated by armadillo tracks that lead to an open trap then turned 90° about 3 cm before the trap. The tracks then lead to the outside edge of the trap, turned another 90° and ran parallel to the end of the cage where the armadillo returned to the original projected straight path. Armadillos captured by a Havahart trap once were never recaptured in a Havahart. The handwoven net was lightweight and compact, but had a zero capture rate. The South American style trap proved excellent. The distance between the rods (7 cm) allowed capture of animals incapable of squeezing through the 7 cm, hence no rats were captured. Skunks were not captured using this trap, however a skunk was not put into the trap to test possible excape.

<u>Home ranges</u>.--Location data were sufficient for four adults (1♂:3♀) to allow home ranges to be calculated. Home ranges (Table 1) were calculated using the convex hull and minimum polygon methods (Hatfield, 1978). The principal advantage of the minimum polygon method is its ability to delete unused areas. Areas of vegetation types not used by

armadillos were not within the home range boundaries using the convex hull method (Fig. 3). However, using the minimum polygon method, the home ranges computed were less variable (Table 2). Layne and Glover (1977) reported the maximum range length (MRL) correlated ($\underline{r} = 0.78$) well with minimum home range, therefore MRL's are included in Table 1. Both methods resulted in a home range estimate lower than previously reported from other states (Table 3). Home ranges for adult females appear to be smaller in more mesic habitat. Home ranges of adult females did not overlap. Males were caught in female home ranges, but seemed to be transient on the study site. Two adult males were captured once and never seen again; relocations indicated that they travelled linearly until the transmitter detached. Seasonal reduction in home range reported by Burns and Waldrip (1971) could not be demonstrated because most data were taken in winter and spring months.

Activity.--Activity of armadillos in northcentral Oklahoma seems to deviate from that reported from other states. Galbreath (1980) indicated competition for open grassy areas in Florida and Mississippi. Table 4 shows a distinct lack of activity in grassland. Within Table 4, differences in percent signs and percent observations were caused by differential ability to observe the animals between vegetation types and for the animal to leave sign. The only armadillo activity in grassland observed in this study was tracks leading across grassy areas. Soil foraging was observed in small grassy clearings (less than 314 m^2) within upland forests. The large grassy areas on the study site were on Vernon loam, all other habitat types were on Vernon or Yahola very sandy loam. Ockenfels (1980), using a track plot system to analyze habitat preferences in white-tailed deer, collected and analyzed data on other animals, including armadillo. On Ockenfels' two sites that closely resembled this study site, three effects of habitat were found (unpubl. data). First, armadillos selected for riparian and brushy habitats, while avoiding grassland ($\underline{P} < 0.001$). Second, distance to agricultural fields had a significant effect on activity, as distance increased use by armadillos increased ($\underline{P} < 0.02$). Also significant was as distance to cover (for deer) increased, armadillo use decreased ($\underline{P} < 0.01$). Fitch et al. (1952) also reported a preference for bottomland and streamside habitat. The present study also had a concentration of armadillo activity in more mesic habitats.

Three confirmed occurrences of armadillos digging in rural lawns were investigated. All three lawns were adjacent to upland/ephemeral habitats and were being kept moist.

There were not sufficient data to permit comparison of seasonal movements of individuals. Activity patterns observed agreed with Taber's (1945) report of armadillos moving towards mesic areas in times of drought. During a 56 day period of no rainfall in the summer of 1980, activity in upland and ephemeral habitats virtually ceased (ca. 95%). Activity returned within a week of the first rain. One lawn was damaged by an armadillo during this drought when the landowner was watering the lawn daily; damage ceased after rains began.

The activity period has been demonstrated by most studies to shift from nocturnal to diurnal in response to colder temperatures (Taber, 1945; Fitch et al., 1952; Moore, 1968; Burns and Waldrip, 1971; Galbreath, 1980). In fact, Layne and Glover (1977) collected all their winter data between 1300 h and 1800 h.

The shift to daylight hours in the winter was not as marked on the Oklahoma study site. Only two daylight sightings were recorded in two winters, while night sightings continued throughout the year. Daylight activity in northcentral Oklahoma was reported by fellow graduate students on numerous occasions. Many of these daylight reports were on the same day and at the same time as when observers on the study site reported no sighting. Continuous foraging activity throughout rains and thunderstorms, regardless of time of day, was seen. This activity has also been reported previously (Taber, 1945; Moore, 1968).

Reaction to snow was observed during the winter of 1981-82. Nine days of continuous snow cover occurred. During those 9 days activity ceased for 8, after which only limited activity (within 2 m of burrows) was noted until the snow melted. One pregnant female recaptured in riparian habitat prior to the snowfall provided the best example of activity. On the morning of the first snow, the female appeared at the entrance of the burrow but emerged only far enough to turn around and re-enter the same burrow. The next day she checked the entrance again, but refused to venture outside. On the third day, she walked and probed along bare patches created by fallen logs, never leaving a 4 m diameter circle from the burrow entrance. She left this burrow after 10 days when enough bare areas emerged to allow her to find another burrow. Unfortunately the transmitter remained in this burrow and this animal was never relocated.

In northcentral Oklahoma, the common long-nosed armadillo is dependent upon forested areas and concentrates in moist forested areas, such as bottomlands and intermittent stream beds. Home ranges from winter-spring data encompass less area in Oklahoma than in other states.

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Table 1. Vegetation types monitored for armadillo use.

Vegetation type	Vegetation Community Structure
Bottomland Riparian	Bottomland hardwood forest including species of cottonwood (*Populus deltoides*), pecan (*Carya illinoensis*), walnut (*Juglans nigra*), willow (*Salix* spp.), mulberry (*Morus* spp.), and oak (*Quercus* spp.).
Ephemeral Riparian	Vegetation along ephemeral creek beds; species composition similar to bottomland but lacking cottonwoods, walnuts, and willows. Flood plains were absent.
Upland	Predominantly post oak (*Q. stellata*) and blackjack oak (*Q. marilandica*) > 5 m in height.
Brushland	Composed of clumped woody vegetation > 3 m and < 5 m in height.
Grassland	Grassland with < 10% woody vegetation.
Man-controlled and ponds	Human maintained areas, i.e., yard and roads, permanent ponds.

Table 2. Armadillo home ranges from northcentral Oklahoma.

Individual	No. of locations	Hull Convex (ha)	Minimum Polygon (ha)	Maximum Range Length (m)
Female 1	30	3.5	1.6	477.5
Female 2	35	1.8	1.5	304.2
Female 3	25	0.6	0.5	150.7
Male 1	8	1.7	1.7	285.9
Male 2	5	N/A	N/A	286.9
Male 3	4	N/A	N/A	214.1
Male 4	4	N/A	N/A	442.5
	$\overline{X}$	1.9	1.3	

Table 3. Comparisons of armadillo home ranges in different states.

Study	State	Average Home Range (ha) ♀ (N)	♂ (N)	Adult Home Range Overlap
Zimmerman 1982	OK	2.0(3)	1.7(1)	No ♀ overlap
Galbreath 1980	FL	7.6(1)	10.8(1)	No ♀ overlap
Jacobs 1980 (from Galbreath)	MS	3.4	3.3	Overlap present
Layne and Glover 1977	FL	5.7(12)		No ♀ overlap
Clark 1951	TX	3.4(3)		Overlap present
Fitch et al. 1952	LA	4.3(7)[1]		

[1] Used maximum range length equal to diameter of circular home range.

Table 4. Armadillo activity in six vegetation types.

Habitat				
Types	% Available	% Signs[1]	% Observations	% Activity[2]
Bottomland Riparian	13.0	34.0	61.0	40.2
Ephemeral Riparian	4.9	51.1	19.8	44.0
Upland	32.3	12.3	17.4	13.5
Brushland	4.0	1.0	0	0.8
Grassland	43.3	1.0	1.1	1.0
Man-controlled and ponds	2.5	0.5	0.6	0.5

[1] Signs included tracks, probes, leaf foraging, and active burrows.

[2] Activity was computed by summing signs and observations, then percent of total.

Figure Legend

Fig. 1.--Delineation of vegetation types
on the northcentral Oklahoma
study site.

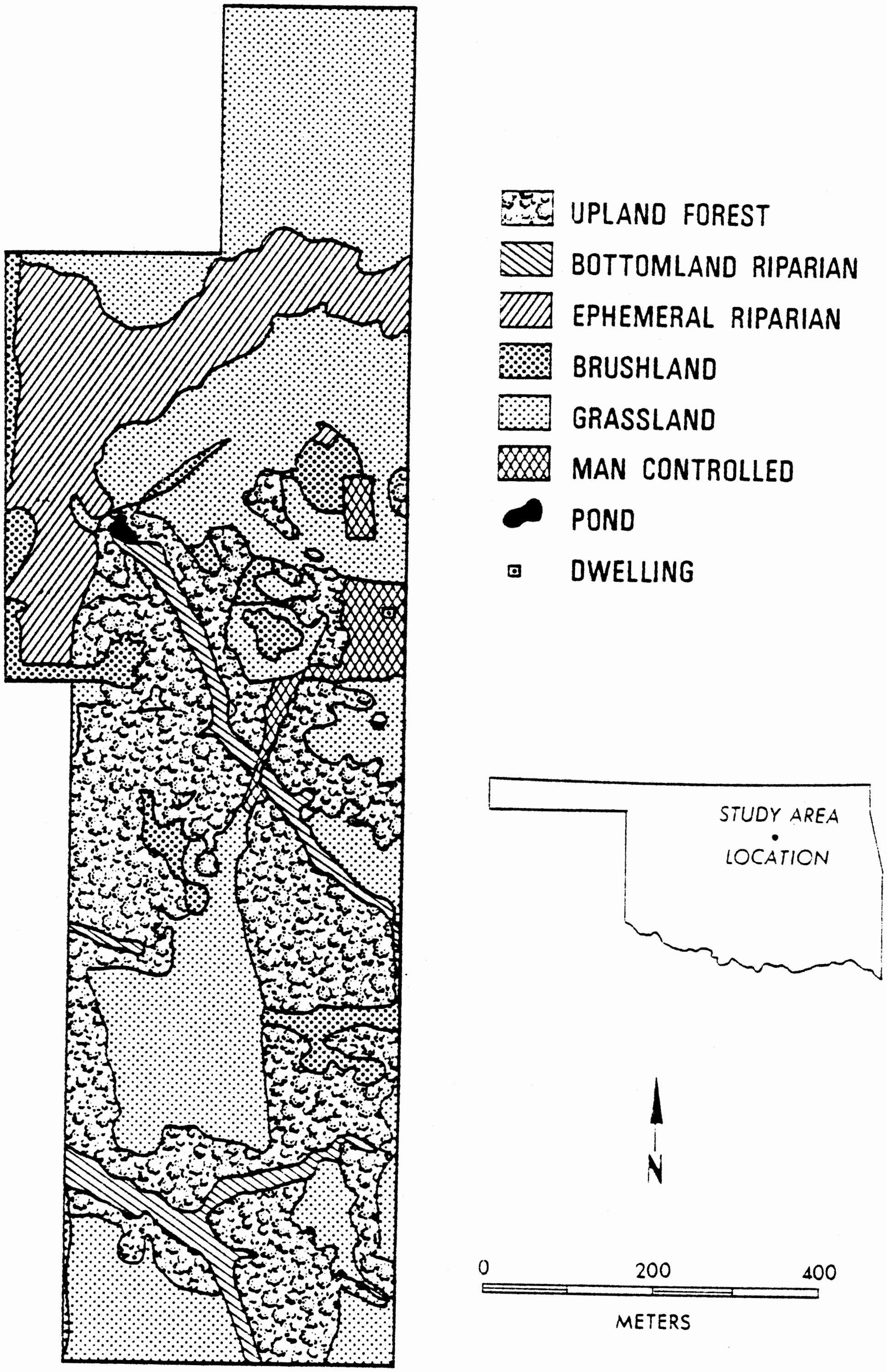
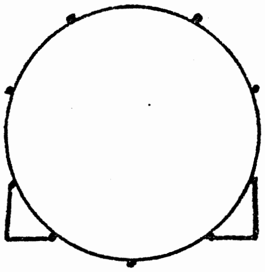

UPLAND FOREST
BOTTOMLAND RIPARIAN
EPHEMERAL RIPARIAN
BRUSHLAND
GRASSLAND
MAN CONTROLLED
POND
DWELLING
STUDY AREA
LOCATION
N
0
200
400
METERS

Figure Legend

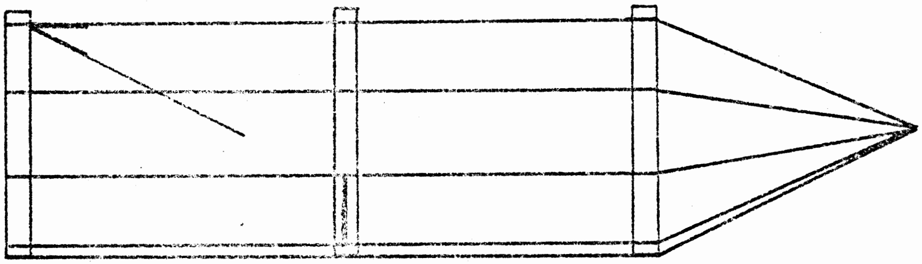
Fig. 2.--South American style armadillo trap.

LIST OF MATERIALS

9 - 0.4 cm metal rods 80 cm long
3 - circular metal bands
    3 cm thick (d = 20.5 cm)
2 - strap hinges
1 - circular metal door
    (d = 20 cm)



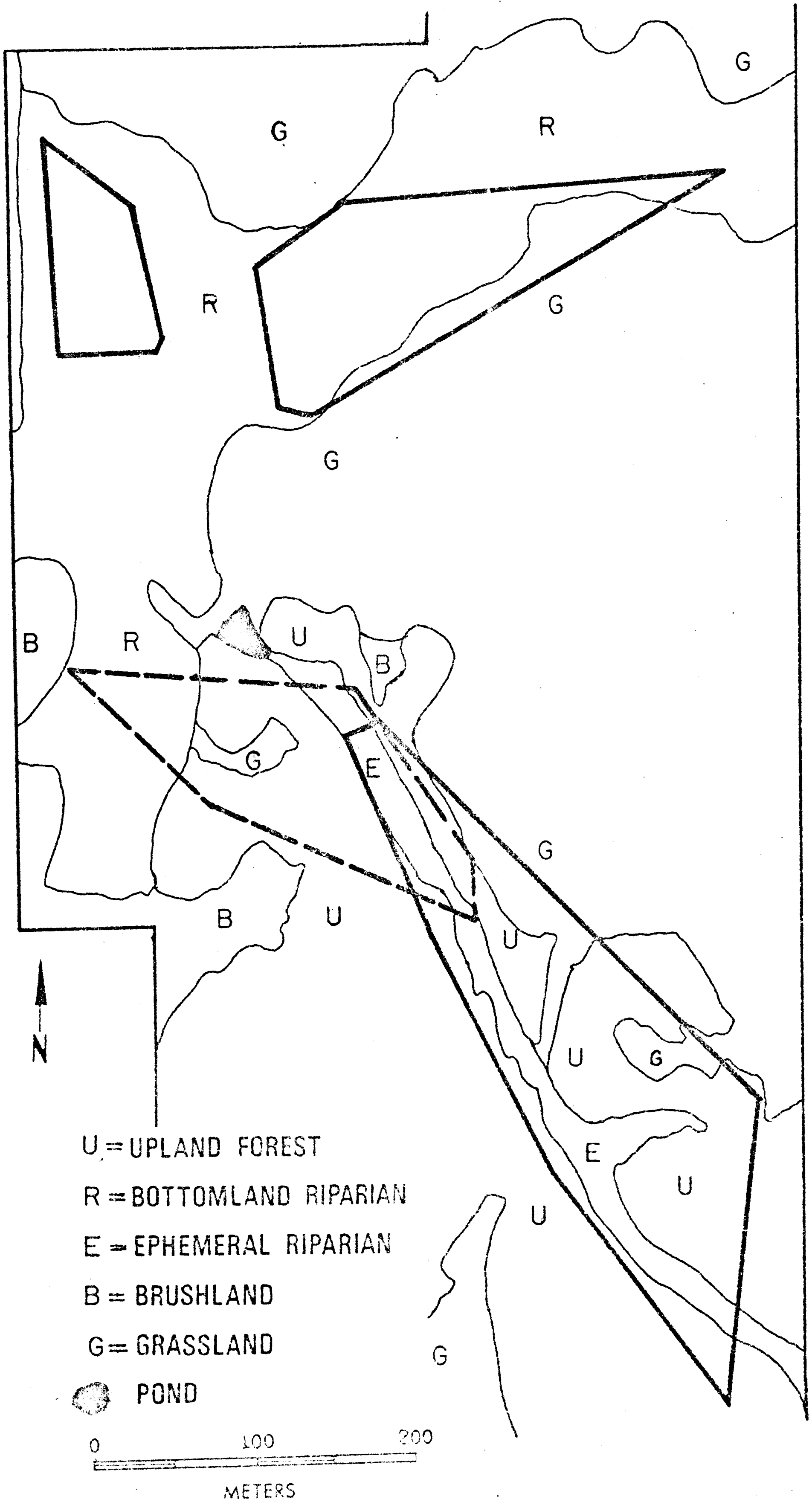
FRONT VIEW



SIDE VIEW
(DOOR OPEN)

Figure Legend

Fig. 3.---Home ranges of four armadillos in northcentral Oklahoma plotted over major vegetative types adjoining ranges. Solid lines are female home ranges. Dashed lines are male home ranges.


G
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U
U
G
N
U = UPLAND FOREST
R = BOTTOMLAND RIPARIAN
E = EPHEMERAL RIPARIAN
B = BRUSHLAND
G = GRASSLAND
POND
0
100
200
METERS

CHAPTER V

MORPHOLOGICAL CHARACTERISTICS OF THE COMMON LONG-NOSED ARMADILLO FROM OKLAHOMA[1]

Recognition of mammalian species and subspecies depends upon differences in external measurements. Data in this paper are to serve only as baseline information on armadillos in Oklahoma for comparisons with other locations. Standard mammalian measurements are given. Some additional characteristics peculiar to armadillos such as headplate length, number of bands, and number of scutes are included.

METHODS

The major source of data was roadkilled individuals. Roadkilled animals have been used in numerous studies (Siegler and Newman, 1944; Case, 1978; Wilkins and Schmidly, 1980). Armadillo data collected from roadkills include first recorded occurrences (Choate and Fleharty, 1975; Henning, 1980), histological facts (Gause, 1980), and stomach content analysis (Kalmbach, 1944; Fitch et al., 1952).

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[1] Research conducted by the Oklahoma Cooperative Wildlife Unit in cooperation with Oklahoma State University.

To increase my sample size at minimum cost, "Wanted Posters" (Fig. 1) were circulated throughout the Department of Zoology and the College of Agriculture at Oklahoma State University. This method was used by V. Flyger (1974) to secure roadkilled squirrels. Every specimen could not supply all data needed. Total lengths were often impossible because of broken tails or bodily dismemberment. All information possible was salvaged from each individual.

<u>Characteristics</u> <u>measured</u>.--The American standard measurements of Total length, Tail length, Left hind foot and Left ear were taken (DeBlase and Martin, 1974). Additional characteristics and definitions follow:

Head + Body length = Total length minus Tail length (to delete bias of broken tails).

Headplate = measurement from tip of the nose to the caudal tip of the bony plate covering the skull.

Complete Bands = number of movable bands that are complete from the left to the right edge of the carapace.

Incomplete Bands = number of movable bands that are not complete across the dorsal surface of the carapace, but overlap at the caudal edge.

Flexible Bands = number of bands that are non-overlapping at the caudal edge, but have skin separating them from the caudal third of the carapace (a solid piece).

Fat Index = the subcutaneous fat was measured at two points on each individual and then averaged. Both points were along a midventral incision. The first measurement was taken 3 cm anterior to a line between the thoracic teats. The second measurement was taken 3 cm caudal to a line between the abdominal teats.

The skulls were saved and cleaned for aging of each individual. Dr. Ralph Wetzel supplied his personal notes on aging D. novemcinctus into 7 age classes based on ossification of suture lines. Appendix A lists the criteria for each age class, which are not confirmed year classes.

RESULTS AND DISCUSSION

A total of 95 roadkilled animals was collected over a 12 month period. Additional data from 13 captured individuals was included in the analysis. The observed male to female sex ratio of 1.00:0.58 is significantly different ($X^2 = 6.40$, $P < 0.05$) from the reported 1:1 (Newman, 1913). The age class and sex distribution (Fig. 2) shows a fairly normal pyramid in age, but females greater than age class 2 are not well represented.

This reduction in females greater than age class 2 has two possible explanations. McNab (1980) predicted that young of the year and pregnant females would be the first to succumb to extended periods of cold. Two successive winters (1977-78 and 1978-79) preceeding this study were severe winters with extended cold periods. The winter preceeding roadkill collections was a milder winter.

The other possibility deals with dispersal and movements. The armadillos with home ranges that included a road are more likely to be killed in the first year. Dispersal would also increase the number of one-year-olds killed crossing roads. Thus, a large sample of age class 1 resulted, while females whose home range did not include a road survived. The males, though, are moving more in search of mates. They have larger home ranges (Galbreath, 1980) which increases their chances of being sampled (roadkilled).

Six armadillos examined had healed wounds in the carapace and 66 had healed broken tails. The high number of healed wounds did not indicate a weak immune system, previously reported in armadillos. Gause (1980), after reporting scarred individuals, suggested some aspect of captivity may cause the lower immune system. The accounts of scarred free-ranging armadillos suggest wounds occurring in the wild are not a major mortality factor.

Carapace bands.--*Dasypus novemcinctus*, as the species name states, often has nine movable bands. Wetzel and Mondolfi (1979) noted the number of bands varied between 7 and 10. Ninety-six percent of the armadillos examined had only eight complete bands (Table 1). One additional incomplete band was present on 87%. Only 26 individuals had an additional flexible band. The total of all bands present was 9 or 10.

Standard mammalian measurements.--In analyzing total lengths and tail lengths, only individuals with complete tails were used. Table 2 gives the mean head + body length as 444.0 mm for all individuals. There were significant differences associated with sex, not previously reported. The females were smaller (Table 3). Only total and tail lengths were not significantly different ($P < 0.05$).

Measurements were also grouped into age classes. Several interesting factors can be seen in Table 4. First, only one individual over age class 2 had a complete tail. Most broken tails were healed from previous injury and not broken on impact. Tail breaks could be the result of an encounter with a predator (Galbreath, 1980) or from a case of extreme frostbite during cold periods. Second, the increase in size from age class 0 to 1 was interesting. Age classes 3-4-5 could not be separated using a Duncan's multiple range test. This correlates with Galbreath's (1980) statement that armadillos attain full physical size between 3 and 4 years of age. Galbreath did not fully describe his method of aging to a year class, so direct comparison between his age and my age classes cannot be made. Gause (1980) and Galbreath (1980) both felt ovulation rarely occurred before 2 years of age. Several females still in age class 1 were pregnant. This difference may be an adaptation to the consistently colder winters in Oklahoma.

Regressions were computed using the Stepwise Procedure in the Statistical Analysis System, using a 0.15 significance level for entry. The equations developed for age class, weight, and sex are given in Table 5. All regressions started with all independent variables possible. Regressions were first developed to find an aging technique from external measurements. The $\underline{r}^2$ values were highest for age class models, but the month of kill proved important for females. It is interesting that the models for age class by sex do not include the same variables. The fat index entered into all weight models. Females' fat index accounted for 52% of the variation in weight. Although the highest $\underline{r}^2$ was only 0.67, I am reporting the best models.

All measurements were within the range of D. novemcinctus reported by Wetzel and Mondolfi (1979) and McBee and Baker (1982). Galbreath (1980) reported that an adult male armadillo from Florida in peak condition weighed 4 kg, although armadillos can reach 6.3 kg. The adult (over age class 2) averages 5.4 kg in Oklahoma with a maximum of 6.3 kg observed. This increase in body mass occurred without a noticeable change in food particle size or competitors, suggesting the armadillo is following Bergmann's rule (McNab, 1971). Only in age class 0 was the mean weight less than 4 kg.

The age class 0 was only observed between 29 June and 27 August 1981, suggesting this age class applies to animals from birth to around 5 months of age. The other age classes were found throughout the year.

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Table 1. Carapace bands on roadkilled armadillos.

Band type	Number of bands	Observations N	%
Complete	7	1	0.9
	8	102	96.2
	9	3	2.8
Incomplete	0	1	0.9
	1	93	87.7
	2	12	11.3
Flexible	0	78	75.0
	1	26	25.0
TOTAL OF ALL BANDS	9	65	63.7
	10	37	36.3

Table 2. Summary statistics of armadillo measurements.

Variable	N	$\overline{X} \pm SD$	Range Min. - Max.
Total length (mm)	28	765.0 ± 45.91	622 - 838
Tail length (mm)	33	345.7 ± 18.78	302 - 380
Head + Body length (mm)	88	444.0 ± 34.32	320 - 515
Left hind foot (mm)	102	67.1 ± 3.92	60 - 75
Left ear (mm)	94	40.4 ± 2.96	32 - 58
Headplate (mm)	94	116.9 ± 5.65	96 - 128
Weight (kg)	105	4.52 ± 0.84	1.7 - 6.3
Scutes on 4th Band	26	60 ± 2.10	56 - 64

Table 3. Differences between female and male armadillo measurements with t statistics. Measurements in mm; weight in kg.

	FEMALES		MALES		
Variable	N	X̄ ± SD	N	X̄ ± SD	P > t
Total length	13	752.0 ± 54.99	15	778.0 ± 33.74	0.16
Tail length	13	340.9 ± 21.77	20	348.8 ± 16.39	0.27
Head + Body	37	432.5 ± 38.58	51	452.4 ± 28.4	0.01
Left foot	41	65.3 ± 3.42	61	68.4 ± 3.77	0.001
Left ear	38	39.4 ± 2.32	56	41.1 ± 3.16	0.004
Headplate	36	115.5 ± 5.49	58	117.7 ± 5.65	0.08
Weight	44	4.32 ± 0.87	51	4.66 ± 0.80	0.05
Scutes on 4th Band	8	61.0 ± 2.07	18	60.0 ± 2.15	

Table 4. Differences in measurements by age classes. Measurements commonly underlined could not be statistically separated. ANOVA and Duncan's multiple range test used as statistical procedure (α = 0.05). Measurements in mm; weight in kg.

	AGE CLASS											
	0		1		2		3		4		5	
Variables	N	$\bar{X}$ ± SD	N	$\bar{X}$ ± SD	N	$\bar{X}$ ± SD	N	$\bar{X}$ ± SD	N	$\bar{X}$ ± SD	N	$\bar{X}$ ± SD
Total length	5	714.4 ± 8.20	12	777.6 ± 40.21	2	797.5 ± 17.68	1	803	0		0	
Tail length	6	336.2 ± 24.77	15	348.7 ± 16.8	2	340.5 ± 7.78	1	327	0		0	
Head + Body	5	383.0 ± 37.38	36	442.8 ± 31.07	9	441.0 ± 40.44	8	466.1 ± 21.36	7	466.4 ± 17.16	2	472.0 ± 12.73
Left hind foot	6	63.0 ± 3.46	44	66.9 ± 3.82	11	67.9 ± 2.88	9	70.2 ± 2.59	9	70.4 ± 3.78	2	69.0 ± 8.49
Left ear	6	38.0 ± 2.83	41	40.2 ± 1.97	11	40.5 ± 2.33	9	42.0 ± 1.85	7	40.6 ± 1.81	2	41.0 ± 1.41
Headplate	6	107.0 ± 7.21	39	115.5 ± 4.07	11	119.6 ± 3.20	9	112.1 ± 4.26	8	120.4 ± 4.57	2	124.5 ± 3.54
Weight	5	2.94 ± 0.96	43	4.32 ± 0.64	11	4.78 ± 0.58	9	5.44 ± 0.73	9	5.27 ± 0.60	2	5.70 ± 0.70

Table 5. Regression equations developed for armadillos in northcentral Oklahoma. Month used was numeric. Weights were recorded in kg. Females equalled sex 1, males were sex 2.

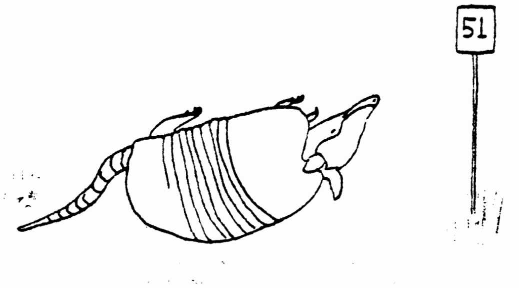
Group Modeled	Model Developed	df	r
All	Age = -8.36 + 0.10 Month + 0.58 Kg + 0.06 Headplate	56	.7229
	Kg = 3.01 + 0.28 Age + 0.31 Sex + 0.01 Fat Index	54	.6705
	Sex = -3.61 - 0.16Kg + 0.01 Body + 0.05 Left Foot	56	.5359
Females	Age = -10.87 + 0.19 Month + 0.01 Body + 0.13 Left Foot	16	.8219
	Kg = 3.36 + 0.2 Fat Index	15	.7316
Males	Age = -5.99 + 0.87 Kg - 0.21 Left Ear + 0.10 Headplate	36	.7698
	Kg = 3.69 + 0.29 Age + 0.01 Fat Index	38	.5968

Figure Legend

Fig. 1.--A 'wanted' poster for roadkilled armadillos.

WANTED

for Research



ROADKILLED ARMADILLOS

ALIAS: HOOVER HOG, POOR MAN'S PIG,
ARMORED OPPOSSUM

REWARD--- A pat on the back in appreciation of every specimen I get, no matter how squashed or putrid.

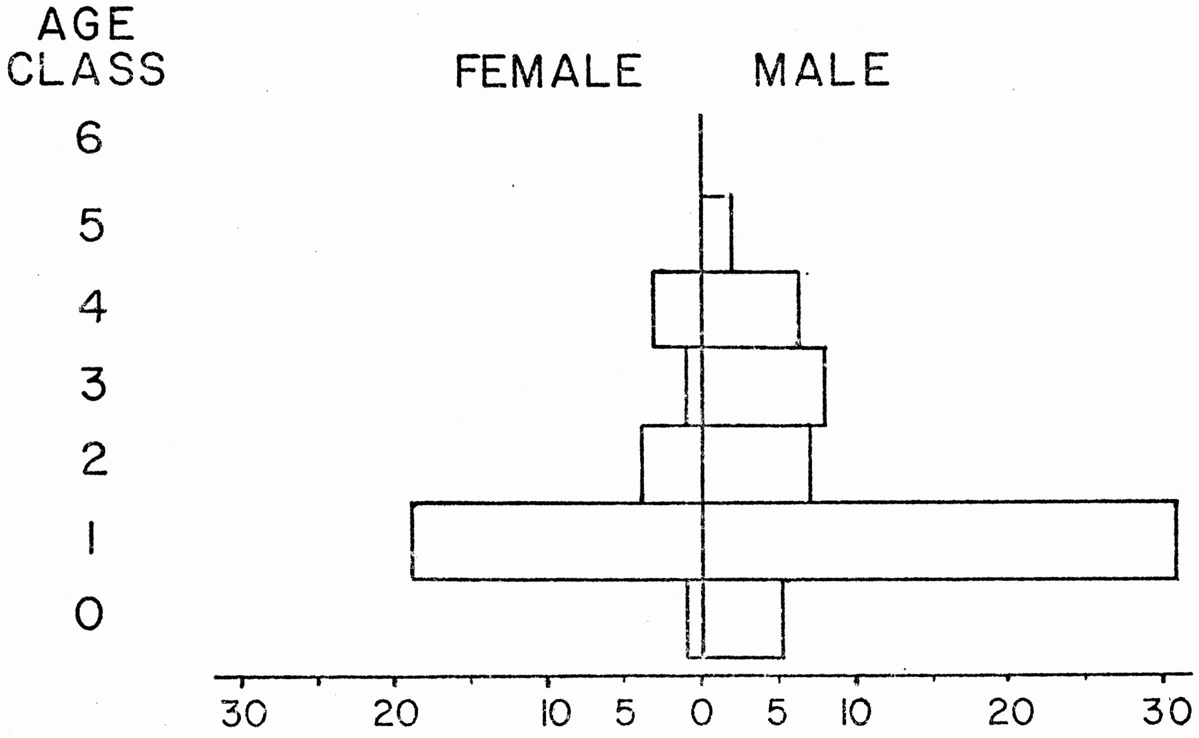
WARNING- Stopping on some highways is DANGEROUS, so collect only those which can be picked up safely and conveniently.

NOTE : Please place armadillos in plastic bags (I can supply) with the DATE and LOCATION the specimen was found and drop them off at my office. If you can't pick it up, phone exact location and time seen to my home or office and I will pick up within 20 miles of Stillwater.

JOHN W. ZIMMERMAN
OKLAHOMA STATE UNIVERSITY
L.S.W. 414
OFFICE: 624-5555 EXT. 41
HOME: 624-0477

Figure Legend

Fig. 2.--Roadkilled armadillo age/sex pyramid.


AGE
CLASS
FEMALE
MALE
6
5
4
3
2
1
0
30
20
10
5
0
5
10
20
30

CHAPTER VI

FOODS OF THE COMMON LONG-NOSED ARMADILLO IN NORTHCENTRAL OKLAHOMA[1]

The common long-nosed armadillo, Dasypus novemcinctus, has invaded northcentral Oklahoma in the last 20 years. This species originated in South America and expanded its range northward through Central America. In the 1870's, this armadillo was first reported in the lower Rio Grande Valley (Strecker, 1926). Since the 1870's, several studies on the food habits of D. novemcinctus have been conducted. Kalmbach (1943) listed four studies in the files of the Fish and Wildlife Service, and produced the baseline data for all other studies. Kalmbach (1943), Baker (1943), and Moore (1968) reported foods eaten in Texas. Fitch et al. (1952) supplemented Kalmbach's study with data from Louisiana. Bushnell (1952) and later Nesbitt et al. (1978) analyzed armadillo stomach contents taken in Florida. Greegor (1980) compared the reported (U.S.) diets of D. novemcinctus to that of Chaetophractus vellerosus found in Argentina. The present study provides the only data on food habits of armadillos in Oklahoma.

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[1] Research conducted by the Oklahoma Cooperative Wildlife Research Unit in cooperation with Oklahoma State University.

METHODS

Stomach contents were collected from roadkilled armadillos in Oklahoma (Fig. 1). Collection began April 1981 and ended March 1982. Armadillos were frozen until necropsying (1 to 90 days). The stomachs were removed whenever intact, weighed, emptied and reweighed. The contents were washed through two sieves, the first 2 mm diameter and the second 1 mm diameter. The soil and debris less than 1 mm were not identified. Filtrates were preserved in 40% isopropyl alcohol until sorting under a dissecting scope. This study was not an entomological project, therefore identification was to order, unless otherwise noted. Volume was measured by water displacement in a graduated cylinder. Weight calculations were based on damp weight. Volume and weight calculations were figured for comparison with previous investigations. Analyses were performed using the Statistical Analysis System (SAS).

RESULTS

Fifty stomachs were analyzed from northcentral Oklahoma. The volumes, weights, and frequency of occurrence of the food items are listed in Table 1 in decreasing volume order. Percentages by volume and by weight were all within 1.0 percentage point in each category.

Coleoptera larvae accounted for 30% of all identified contents, the single most prevalent group. Coleoptera, Hymenoptera, Homoptera, Lepidoptera, and Diptera are predominant food items. These five orders comprised 82% of the stomach contents in this study, but only represented 65% in Texas (Kalmbach, 1943), 58% in Louisiana (Fitch et al., 1952), and 68% in Florida (Nesbitt et al., 1978). Adult, pupae, larvae, and eggs of Formicidae (ants) were the main Hymenoptera ingested. Vespid pupae cases made up most of the 'other' Hymenoptera. Homoptera was represented by nymph Cicadidae, most swallowed whole. Larvae of Noctuidae and Sphingidae were the most common Lepidoptera. Larval Tipulidae was the predominant Diptera family. Myriapods, chiefly millipedes and centipedes, were present in 76% of the stomachs, but comprised only 2.7% by volume. Arachnida consisted of spiders and one mite and amounted to 0.8% by volume. Vertebrates (1.5%) were only represented by lizards and snakes in this study. Plant and gravel matter were grouped together as large debris. Only two items of vegetable material could be considered food. Mulberries, <u>Morus ruba</u>, in early May amounted to 29% and 46% of two individual stomach contents. Wild grapes, <u>Vitis spp</u>., were present in one stomach in late August.

Variation between months was analyzed using the SAS procedure for analysis of variance with Duncan's multiple range test performed on the monthly volume means. Only food items significantly different between months are given in Table 2. The mean volume of Coleoptera was highest in October. Although the Duncan's test on Diptera larvae could not separate December through April, only March was significantly higher than the remaining months. Formicidae had a high mean of 17.4 ml in June. Myriapods also peaked in June. March produced a significantly higher mean volume for earthworms than the rest of the year. The category plant and gravel had highs in May-June and August-September, when mulberries and grapes were available, respectively. A breakdown of food volume by month is given in Appendix B.

Seasonal variation was also analyzed. An analysis of variance proved two food categories, Coleoptera and Formicidae, significantly different ($\underline{P} < 0.06$) between seasons (Table 3). Coleoptera were consumed in higher volume in the fall season than any other. High mean volumes for Formicidae occurred in summer and fall.

Variation in seasonal consumption was calculated by a second method. This method added the percent volume to the percent frequency to secure a percent consumption. Figure 2 represents percent consumption grouped into three trends. The first trend was to have low consumption in winter, increase to a peak in the summer, and then decrease (Fig. 2A). Only Coleoptera larvae consumption in Fig. 2A continued to increase in the fall season. A second trend was a peak consumption in winter or spring, than a decrease (Fig. 2B). The last general tendency occurred about equally year round (Fig. 2C). Orthoptera was placed in this last group because percent frequency included trace amounts.

The greatest influence of trace items was in Orthoptera which accounted for 33% consumption in the winter, 15% in the spring, 9% in the summer, and 0% in the fall. The actual data by season are included in Appendix B.

DISCUSSION

Armadillos in Oklahoma have diets resembling those described from other states. Table 4 summarizes the five diet studies, including this one. There are two basic differences. The first is the importance of Homoptera. A high of 0.3% Homoptera in other studies was substantially lower than the 6.2% found in this study. The second deviation is in the occurrence of Orthoptera in the diet. The volume of Orthoptera had a reported range of 6.2% to 10.5%, while this study showed 0.6%. The apparent switching that occurred may be explained by timing. This study coincided with local emergence of 17-year cicada according to Oklahoma State University entomology surveyor, Dr. D. C. Arnold. Homoptera were more abundant than in other study areas, and slower than Orthoptera, therefore presumably easier to capture. This supports the view that _D. novemcinctus_ is a true 'opportunist'.

Seasonal trends in Coleoptera, Diptera, Formicidae, and Arachnids reported from Louisiana (Fitch et al., 1952) and from Florida (Nesbitt et al., 1978) match the trends seen in Oklahoma. The changes seen apparently track the seasonal abundance of these orders. Coleoptera and Formicidae are less abundant in winter and would be expected to peak in the late summer. The Diptera larvae consumed are in families characteristically found in moist humus habitat in the spring. Arachnids are present throughout the year in about equal numbers. Differences in food habits are seen in Lepidoptera and Myriapoda. Lepidoptera consumption in Florida peaked in the fall. A probable reason for this fall peak was that one armadillo consumes 245 fall army worms (*Laphygma frugiperda*) (Nesbitt et al., 1978). Fitch et al. (1952) reported Lepidoptera peaking in the spring in Louisiana, while in Oklahoma consumption of Lepidoptera was about equal seasonally. Myriapoda consumption in Florida and Oklahoma was generally increased throughout the year from a winter low, while in Louisiana it peaked in winter. Earthworm concumption peaked in the wetter seasons, when soil moisture forced the earthworms to the surface.

Most vegetable matter consumed by armadillos is considered debris (Kalmbach, 1944; Bushnell, 1952; Nesbitt et al., 1978). The vegetable matter considered as food are seasonal fleshy fruits and berries. Baker (1946) reported one armadillo stomach from Texas contained 80% black persimmons (*Diospyros texana*) in August. Other fruits consumed include white bay (*Magnolia virginia*), grapes (*Muscadinia* spp. and *Vitis* spp.), blueberries (*Vaccinium* spp.), dewberries (*Rubus trivialis*), and mulberries (*Morus* ruba) (Fitch et al., 1952; this study.)

All diet studies lead to the same conclusion. Dasypus novemcinctus is an opportunist consuming mostly invertebrate material regardless of habitat or distribution within the United States.

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Table 1. Stomach analysis of 50 armadillos in Oklahoma. Percentages based on pooled total of all food items.

Item	Volume ml - % identified	Weight gm - % identified	Frequency % occurrence
Coleoptera			
Adult	183.9 - 16.76	181.2 - 16.43	80
Larvae	331.9 - 30.25	341.1 - 30.93	76
TOTAL	515.8 - 47.01	522.3 - 47.36	80
Hymenoptera			
Formicidae	190.85 - 17.40	186.3 - 16.90	76
Other	16.5 - 1.54	17.6 - 1.60	12
TOTAL	207.7 - 18.93	203.9 - 18.49	76
Homoptera			
Immature	67.4 - 6.14	59.1 - 5.36	41
Lepidoptera			
Adult	5.1 - 0.46	3.3 - 0.30	6
Larvae	58.0 - 5.29	58.1 - 5.27	66
TOTAL	63.1 - 5.75	61.4 - 5.57	66

Table 1.---(cont., p.2)

Item	Volume		Weight		Frequency
	ml	- % identified	gm	- % identified	% occurrence
Diptera					
Larvae	47.2	- 4.30	42.9	- 3.89	54
Orthoptera	6.8	- 0.62	7.8	- 0.71	48
Isoptera	1.4	- 0.13	1.3	- 0.12	18[3]
Hemiptera	0.5	- 0.05	0.8	- 0.07	26
Total Insect	909.9	- 82.93	899.5	- 81.58	82
Annelida	81.2	- 7.40	87.8	- 7.96	42
Myriapods	29.3	- 2.67	34.6	- 3.14	76
Arachnida	8.9	- 0.81	9.3	- 0.84	40[3]
Vertebrates	15.9	- 1.45	17.4	- 1.58	14
Plant and Gravel	51.95	- 4.73	54.0	- 4.90	82
Total Identified	1097.15 ml		1102.6 gm		
Unidentified > 1 mm	147.9	- 11.88[1]	147.7	- 11.81[2]	80

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[1] Percent of total volume collected.

[2] Percent of total weight collected.

[3] Includes 14% trace data points.

Table 2. Food items with mean volumes significantly different between months. Measurements commonly underlined could not be statistically separated using the Duncan's multiple range test (∝ = 0.05). P-values were derived from an ANOVA.

	MONTHLY MEAN VOLUMES (ml)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	P > F
Coleoptera	3.5	0.6	2.4	11.7	11.0	5.0	6.1	10.3	38.0	28.6	2.0	0.5	0.44
Diptera larvae	6.3	4.0	8.7	3.0	0.3	0.2	N/S	0.2	N/S	N/S	N/S	2.5	0.10
Formicidae	0.2	0.1	0.7	1.5	3.9	17.4	2.5	9.5	9.4	5.5	5.5	N/S	0.08
Myriapod	0.7	0.6	0.5	1.2	0.5	2.3	0.6	0.4	0.7	0.2	N/S	0.1	0.22
Annelida	0.6	0.1	30.2	6.4	6.8	N/S	0.2	0.7	0.8	0.4	N/S	0.1	0.09
Plants	0.3	0.5	0.9	0.7	5.4	1.6	0.2	1.2	1.2	0.4	0.1	0.2	0.63

N/S = not seen in any stomach that month.

Table 3. Food items with mean volumes significantly different between seasons. Measurements commonly underlined could not be statistically separated using the Duncan's multiple range test ($\alpha = 0.05$). *P*-values were derived from an ANOVA.

Item	SEASON MEAN VOLUMES (ml)					
	Spring[1]	Summer[2]	Fall[3]	Winter[4]	*P*	F
Coleoptera	11.2	7.2	27.9	1.3	0.03	
Formicidae	2.4	9.1	7.2	0.1	0.06	

[1] March, April, May

[2] June, July, August

[3] September, October, November

[4] December, January, February

Table 4. Comparison of armadillo food studies by percent volume, except where noted.

	Kalmbach (1943) TX	Baker (1943) TX	Fitch et al.[2] (1952) LA	Bushnell (1952) FL	Nesbitt et al. (1978) FL	Zimmerman (1982) OK
Coleoptera	41.6		44.6	34.5	29.7	47.0
Hymenoptera	14.0		3.9	12.2	15.1	18.9
Formicidae	NA		3.9			17.4
Other	NA		T			1.5
Homoptera	9.5[1]		0.1		0.3	6.1
Lepidoptera	7.8		4.7	5.1	9.2	5.8
Diptera	1.5		4.2	17.8	13.3	4.3
Orthoptera	6.2		8.5		10.5	0.6
Isoptera	4.5		1.2		0.1	0.1
Hemiptera	2.0		1.6		0.1	0.5
TOTAL INSECT	77.6	77.4	68.8	69.9	78.5	82.9
Annelida and Miscellaneous Invertebrates	6.2	13.8	6.4	15.6	6.0	7.4
Myriapoda	6.2	1.2	8.5	2.2	8.1	2.7
Arachnida	1.7	T	2.1		5.1	0.8
Vertebrates	1.6	0.8	4.5	2.4	1.5	1.5
Plant matter	2.1	2.1	9.8	1.1	0.5	4.73
Debris	4.6	4.3	N/A	8.8	0.3	

Table 4.--(cont., p. 2).

	Kalmbach (1943) TX	Baker (1943) TX	Fitch et al.[2] (1952) LA	Bushnell (1952) FL	Nesbitt et al. (1958) FL	Zimmerman (1982) OK
TOTAL IDENTIFIED		1604.4 ml	5130.0 ml		3913.4 ml	1097.2 ml
n	169	25	104	139	172	50

[1] Percent occurrence - Volume figured into Hemiptera

[2] Percent Weight

Figure Legend

Fig. 1.--Location of roadkill armadillos used for stomach content analysis.

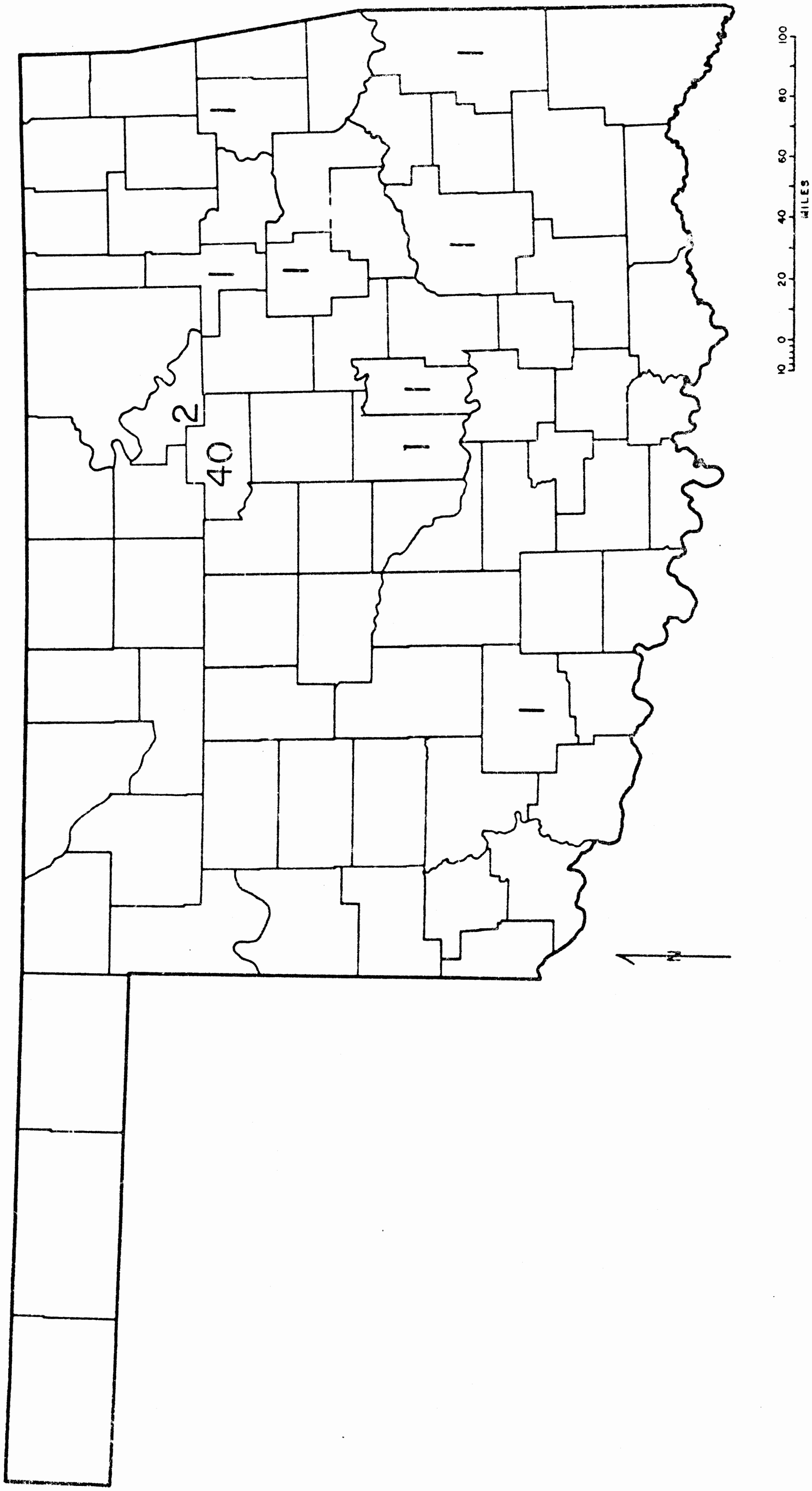
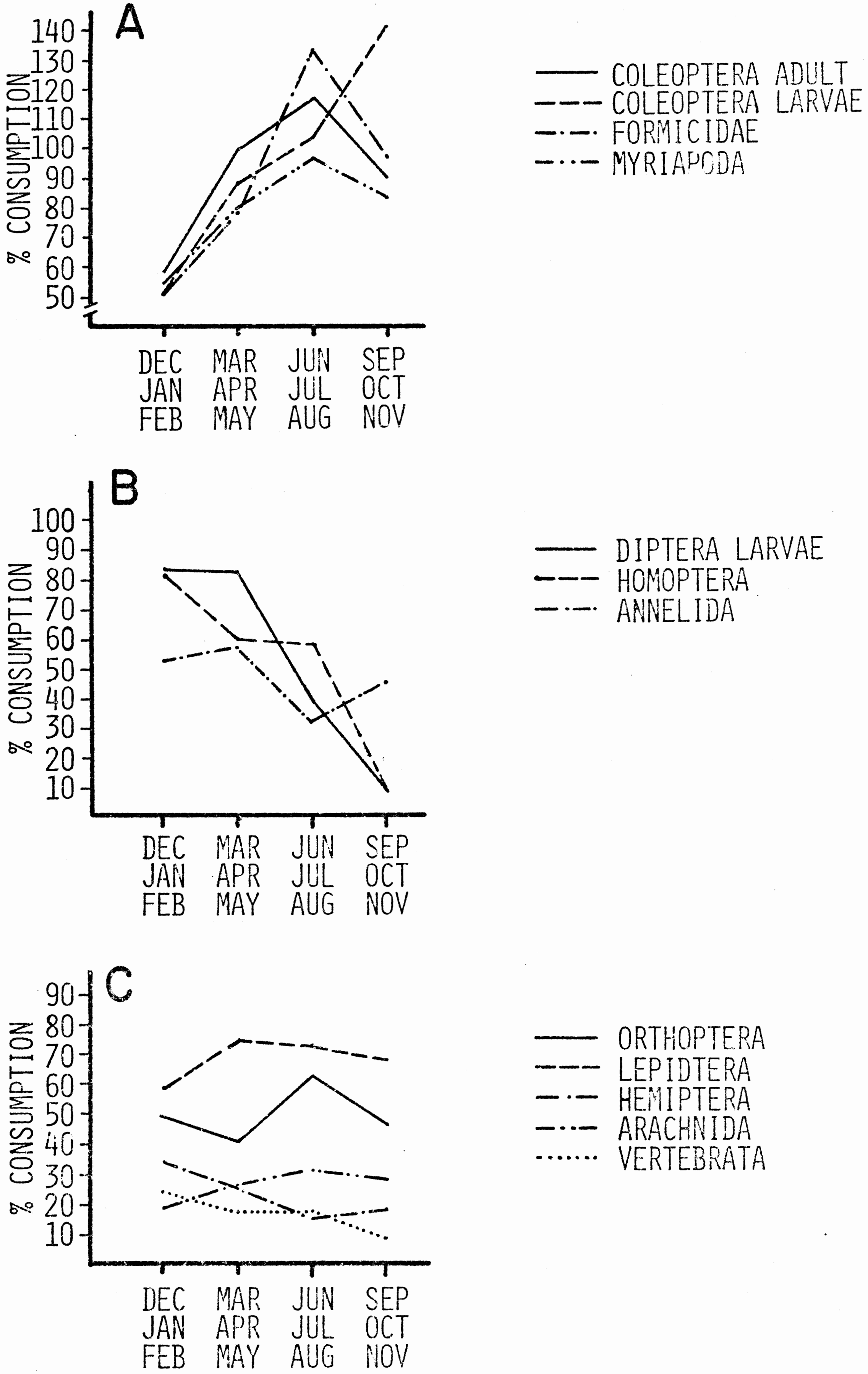

2
40
1
1
1
1
1
1
1
1
100
80
60
40
20
0
10
MILES
N

Figure Legend

Fig. 2.--Percent consumption of armadillo food items.


A
% CONSUMPTION
140
130
120
110
100
90
80
70
60
50
DEC JAN FEB
MAR APR MAY
JUN JUL AUG
SEP OCT NOV
COLEOPTERA ADULT
COLEOPTERA LARVAE
FORMICIDAE
MYRIAPODA
B
% CONSUMPTION
100
90
80
70
60
50
40
30
20
10
DEC JAN FEB
MAR APR MAY
JUN JUL AUG
SEP OCT NOV
DIPTERA LARVAE
HOMOPTERA
ANNELIDA
C
% CONSUMPTION
90
80
70
60
50
40
30
20
10
DEC JAN FEB
MAR APR MAY
JUN JUL AUG
SEP OCT NOV
ORTHOPTERA
LEPIDTERA
HEMIPTERA
ARACHNIDA
VERTEBRATA

APPENDIX A

AGE CLASS CRITERIA FOR

<u>DASYPUS</u> <u>NOVEMCINCTUS</u>

Table 1. Age class criteria for <u>Dasypus novemcinctus</u> using skull ossification. Derived by Dr. R. M. Wetzel upon examination of skulls at Midwestern University, Texas.

Age Class	Characteristics
0	Perotic separate; occipitals not fused; midlines of parietals and frontals not fused.
1	Midlines of parietals and frontals mostly fused.
2	Midlines of parietals and frontals completely fused; occipital-basisphenoid partially fused.
3	Perotic-occipital fused; occipital-basisphenoid completely fused.
4	Presphenoid-basisphenoid fused.
5	Lacrimal-maxilla fused.
6	Parietals-frontals completely fused.

APPENDIX B

SEASONAL DIETS OF THE ARMADILLO

Table 1. The spring diet of the armadillo by month.

	MAR(N=6)	APR(N=9)	MAY(N=5)	SPRING(N=20)
	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.
Coleoptera				
Adult	33.3 - 7.4	88.9 - 22.2	100.0 - 32.0	75.0 - 23.8
Larvae	33.3 - 1.2	88.9 - 19.6	100.0 - 6.5	75.0 - 12.6
Total	33.3 - 8.6	88.9 - 41.8	100.0 - 38.5	75.0 - 36.3
Hymenoptera				
Formicidae	33.3 - 1.2	77.8 - 4.6	100.0 - 11.8	70.0 - 6.7
Other	0	0	20.0 - 1.3	5.0 - 0.5
Total	33.3 - 1.2	77.8 - 4.6	100.0 - 13.1	70.0 - 7.2
Homoptera Immature	16.7 - 0.2	77.8 - 14.8	40.0 - 5.2	50.0 - 9.5
Lepidoptera				
Adult	0	11.1 - TR	0	5.0 - TR
Larvae	33.3 - 11.8	77.8 - 4.8	80.0 - 13.7	65.0 - 8.9
Total	33.3 - 11.8	77.8 - 4.8	80.0 - 13.7	65.0 - 8.9
Diptera larvae	16.7 - 14.7	100.0 - 10.1	100.0 - 0.7	75.0 - 7.4

Table 1.--(cont., p. 2).

	MAR(N=6)	APR(N=9)	MAY(N=5)	SPRING(N=20)
	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.
Orthoptera	33.3 - 0.3	33.3 - 0.3	60.0 - 1.3	40.0 - 0.6
Isoptera	0	55.6 - 0.6	40.0 - TR	35.0 - 0.3
Hemiptera	0	22.2 - 0.1	60.0 - TR	25.0 - TR
TOTAL INSECT	100.0 - 36.8	100.0 - 77.0	100.0 - 72.4	85.0 - 70.2
Annelida	33.3 - 51.0	55.6 - 13.5	40.0 - 8.2	40.0 - 16.4
Myriapoda	16.7 - 0.8	100.0 - 4.7	100.0 - 1.5	75.0 - 3.1
Arachnida	0	44.4 - 1.6	20.0 - 0.1	25.0 - 0.8
Vertebrata	33.3 - 8.4	11.1 - 0.7	20.0 - 1.2	15.0 - 1.9
Plant and Gravel	50.0 - 2.9	88.9 - 2.5	100.0 - 16.5	75.0 - 7.5
TOTAL IDENTIFIED	59.2 ml	236.9 ml	164.3 ml	460.4 ml
Unidentified > 1 mm	33.3 - 13.2*	88.9 - 16.8*	100.0 - 14.9*	75.0 - 14.6*
Empty stomachs	0	0	0	0

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*Percent of total volume collected.

Table 2. The summer diet of the armadillo by month.

	JUN(N=3)	JUL(N=5)	AUG(N=5)	SUMMER(N=13)
	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.
Coleoptera				
Adult	100.0 - 9.6	100.0 - 27.2	100.0 - 15.9	100.0 - 16.4
Larvae	66.7 - 6.3	80.0 - 31.4	100.0 - 20.3	84.6 - 18.3
Total	100.0 - 15.9	100.0 - 58.8	100.0 - 36.2	100.0 - 34.7
Hymenoptera				
Formicidae	100.0 - 62.9	80.0 - 17.6	100.0 - 35.9	92.3 - 40.4
Other	33.3 - 3.6	20.0 - TR	40.0 - 8.8	30.8 - 5.4
Total	100.0 - 66.5	80.0 - 17.6	100.0 - 44.7	92.3 - 45.8
Homoptera Immature	33.3 - 1.9	100.0 - 11.6	60.0 - 2.4	53.8 - 4.2
Lepidoptera				
Adult	0	0	20.0 - 0.1	7.7 - 0.1
Larvae	66.7 - 0.5	100.0 - 4.3	80.0 - 5.2	69.2 - 3.6
Total	66.7 - 0.6	100.0 - 4.3	80.0 - 5.3	69.2 - 3.7
Diptera larvae	33.3 - 0.2	20.0 - TR	60.0 - 0.2	38.7 - 0.2

Table 2.--(cont., p. 2).

	JUN(N=3)	JUL(N=5)	AUG(N=5)	SUMMER(N=13)
	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.
Orthoptera	66.7 - 1.0	40.0 - 1.6	80.0 - 0.3	61.5 - 0.8
Isoptera	33.3 - TR	0	0	7.7 - TR
Hemiptera	0	20.0 - TR	80.0 - 0.1	38.5 - TR
TOTAL INSECT	100.0 - 86.2	100.0 - 93.9	100.0 - 89.2	100.0 - 89.3
Annelida	0	40.0 - 0.7	40.0 - 1.1	30.8 - 0.7
Myriapoda	100.0 - 8.2	80.0 - 3.9	100.0 - 1.4	92.3 - 4.0
Arachnida	0	0	80.0 - 1.1	38.0 - 0.6
Vertebrata	0	20.0 - 0.2	20.0 - 2.5	15.4 - 1.3
Plant and Gravel	100.0 - 5.7	80.0 - 1.2	100.0 - 4.7	92.3 - 4.3
TOTAL IDENTIFIED	83.1 ml	56.1 ml	131.7 ml	270.9 ml
Unidentified > 1 mm	100.0 - 6.4*	100.0 - 14.2*	100.0 - 9.2*	100.0 - 9.5*
Empty stomachs	0	0	0	0

*Percent of total volume collected.

Table 3. The fall diet of the armadillo by month.

	SEP(N=4)	OCT(N=5)	NOV(N=2)	FALL(N=11)
	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.
Coleoptera				
Adult	100.0 - 10.2	80.0 - 3.5	50.0 - 34.1	81.8 - 8.2
Larvae	100.0 - 64.1	80.0 - 79.7	0	72.7 - 68.6
Total	100.0 - 74.3	80.0 - 83.2	50.0 - 34.1	81.8 - 76.8
Hymenoptera				
Formicidae	100.0 - 14.9	80.0 - 12.7	50.0 - 64.7	81.8 - 15.4
Other	0	0	0	0
Total	100.0 - 14.9	80.0 - 12.7	50.0 - 64.7	81.8 - 15.4
Homoptera Immature	0	20.0 - 0.3	0	9.1 - 0.1
Lepidoptera				
Adult	25.0 - 2.6	0	0	9.1 - 1.5
Larvae	75.0 - 1.3	80.0 - 1.2	0	63.6 - 1.3
Total	75.0 - 3.9	80.0 - 1.2	0	63.6 - 2.8
Diptera larvae	75.0 - TR	20.0 - TR	0	9.1 - TR

Table 3.--(cont., p. 2).

	SEP(N=4) % Occ. - % Vol.	OCT(N=5) % Occ. - % Vol.	NOV(N=2) % Occ. - % Vol.	FALL(N=11) % Occ. - % Vol.
Orthoptera	50.0 - 0.6	60.0 - 0.4	0	45.5 - 0.5
Isoptera	25.0 - TR	0	0	9.1 - TR
Hemiptera	25.0 - 0.1	20.0 - TR	0	18.2 - TR
TOTAL INSECT	100.0 - 93.9	80.0 - 97.8	50.0 - 98.8	90.1 - 95.6
Annelida	50.0 - 0.8	60.0 - 1.0	0	45.5 - 0.9
Myriapoda	75.0 - 1.1	100.0 - 0.6	0	81.8 - 0.9
Arachnida	75.0 - 1.8	0	0	27.3 - 1.0
Vertebrata	25.0 - 0.5	0	0	9.1 - 0.3
Plant and Gravel	100.0 - 1.9	60.0 - 0.5	50.0 - 1.2	54.5 - 1.3
TOTAL IDENTIFIED	189.5 ml	128.8 ml	8.5 ml	326.8 ml
Unidentified > 1 mm	100.0 - 10.7*	80.0 - 4.9*	50.0 - 37.0*	81.8 - 9.4*
Empty stomachs	0	0	50%	9%

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*Percent of total volume collected.

Table 4. The winter diet of the armadillo by month.

	DEC(N=1)	JAN(N=3)	FEB(N=2)	WINTER(N=6)
	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.	% Occ. - % Vol.
Coleoptera				
Adult	100.0 - 2.1	33.3 - 21.4	40.0 - 1.8	50.0 - 8.4
Larvae	100.0 - 2.1	33.3 - 1.5	50.0 - 0.6	50.0 - 1.3
Total	100.0 - 4.2	33.3 - 22.9	50.0 - 2.4	50.0 - 9.7
Hymenoptera				
Formicidae	100.0 - TR	33.3 - 1.1	50.0 - 0.6	50.0 - 0.6
Other	0	33.3 - 0.4	0	16.7 - 0.1
Total	100.0 - TR	33.3 - 1.5	50.0 - 0.6	50.0 - 0.7
Homoptera Immature	100.0 - 52.1	33.3 - 9.9	50.0 - 35.4	50.0 - 30.9
Lepidoptera				
Adult	0	0	0	0
Larvae	100.0 - 10.4	33.3 - 3.1	50.0 - 11.6	50.0 - 8.4
Total	100.0 - 10.4	33.3 - 3.1	50.0 - 11.6	50.0 - 8.4
Diptera larvae	100.0 - 26.0	33.3 - 48.1	50.0 - 11.6	50.0 - 32.7

Table 4.--(cont., p. 2).

	DEC(N=1) % Occ. - % Vol.	JAN(N=3) % Occ. - % Vol.	FEB(N=2) % Occ. - % Vol.	WINTER(N=6) % Occ. - % Vol.
Orthoptera	100.0 - 1.0	33.3 - TR	50.0 - TR	50.0 - 0.3
Isoptera	0	0	0	0
Hemiptera	100.0 - 1.0	0	50.0 - TR	33.3 - 0.3
TOTAL INSECT	100.0 - 94.8	33.3 - 85.5	50.0 - 74.4	50.0 - 81.3
Annelida	100.0 - 1.0	33.3 - 4.6	50.0 - 0.6	50.0 - 2.0
Myriapoda	100.0 - 1.0	33.3 - 5.3	50.0 - 3.7	50.0 - 3.6
Arachnida	100.0 - 1.0	0	0	16.7 - 0.3
Vertebrata	0	0	50.0 - 18.3	16.7 - 7.7
Plant and Gravel	100.0 - 2.1	66.7 - 4.6	50.0 - 3.0	66.7 - 3.3
TOTAL IDENTIFIED	9.6 ml	13.1 ml	16.4 ml	39.1 ml
Unidentified > 1mm	100.0 - 5.9*	33.3 - 13.2*	50.0 - 19.2*	50.0 - 14.3*
Empty stomachs	0	33%	50%	33%

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*Percent of total volume collected.

VITA

John Wayne Zimmerman

Candidate for the Degree of

Master of Science

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