A survey for the nine-banded armadillo (*Dasypus novemcinctus*) in Illinois

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The nine-banded armadillo (*Dasypus novemcinctus*) is the only member of the Neotropical family Dasypodidae that occurs in the United States (Nowak 1999). Formerly placed in the order Xenarthra with sloths and anteaters, Dasypodidae is now the single family in the order Cingulata (Wilson and Reeder in press). The nine-banded armadillo was first documented in the United States in southern Texas in the mid-1800s (Audubon and Bachman 1854). Since then its range has expanded greatly, through natural dispersal and human intervention (Buchanan and Talmage 1954, Humphrey 1974, McBee and Baker 1982, Taulman and Robbins 1996, Freeman and Genoways 1998). Its northern expansion will be limited by the severity of winter temperatures because this insectivorous species cannot hibernate (Humphrey 1974, Jones et al. 1983, Taulman and Robbins 1996). The nine-banded armadillo's potential range could include the southern part of Illinois (Taulman and Robbins 1996) and there have been occasional reports of armadillos being found in the state (e.g. Schwegman 1992). To assess the occurrence of nine-banded armadillos in Illinois I conducted a mail survey of people knowledgeable about the fauna of southern Illinois. I also collected roadkilled armadillos and looked for live animals in areas of southern Illinois from which I had received multiple reports of armadillo sightings.

Natural history of the nine-banded armadillo

The ecology, reproductive biology, and behavior of the nine-banded armadillo has been studied by Newman (1913), Kalmbach (1944), Taber (1945), and Clark (1951) (among others) and has been reviewed by Talmage and Buchanan (1954), McBee and Baker (1982), and Layne (2003). Information in this section is based on these sources. The armadillo occupies a variety of terrestrial habitats, including forests, shrubland, prairies, agricultural land (e.g. cropland and pastures), and developed areas (e.g. cemeteries, golf courses, and residential yards). Nine-banded armadillos have smaller home ranges than carnivores of comparable size (Layne 2003). An individual excavates several burrows, each typically having a single entrance about 20-22 cm in diameter. Burrows are located under stumps, brush piles, shrubs, logs, or buildings and in stream banks. Some burrows contain an enlarged chamber with a nest of leaves and grass. Armadillos also nest in rock crevices in Texas (Taber 1945) and nests on the surface of the ground have been found in Texas (Clark 1951) and Florida (Layne and Waggener 1984).

Insects and other invertebrates form the bulk of the nine-banded armadillo's diet. Beetles, beetle larvae, caterpillars, and ants are common foods. Armadillos also eat millipedes, centipedes, fly larvae, snails, earthworms, amphibians, reptiles, birds, reptile and bird eggs, fruits, mushrooms, and carrion. A foraging armadillo digs up invertebrates with its sharp front claws and also tears apart logs and stumps in search of prey. Armadillos sometimes damage gardens, lawns, or golf courses with their digging.

Nine-banded armadillos breed once a year and most mating occurs during summer. The species experiences delayed implantation; embryos don't implant in the uterine wall until November or December. Development then proceeds for approximately 120 days so the young are born during spring. A few cases of a much longer delay in implantation

et al. 1952). An isolated population that had become established in southern Alabama (Baldwin County) by 1949 presumably represented descendents of introduced animals (Fitch et al. 1952, Buchanan and Talmage 1954). An armadillo was known to have been released in the area in 1937 (Fitch et al. 1952).

The armadillo's range in 1954 (Figure 1) included southern and eastern Texas (i.e. not the Panhandle or Trans Pecos regions), parts of southern Oklahoma, southernmost Arkansas, almost all of Louisiana, the tip of Alabama, and parts of peninsular Florida (Buchanan and Talmage 1954). Fitch et al. (1952) thought the species also was established in southwestern Mississippi and this was confirmed by Buchanan (1958). By 1950 there were extralimital records (pioneers or introduced individuals) in Kansas (Hibbard 1943), Missouri (Anonymous 1947), and Georgia (Fitch et al. 1952).

Humphrey (1974) mapped the permanent range of the nine-banded armadillo as of 1972 (Figure 2). It covered southern and eastern Texas, southern Oklahoma, much of southern Arkansas, all of Louisiana, southern and western Mississippi, southwestern Alabama, all of peninsular Florida except the Everglades, the western part of the Florida Panhandle, and southeastern Georgia. At that time there also were extralimital records for Tennessee (Humphrey 1974), Colorado (Hahn 1966), and South Carolina (Humphrey 1974) as well as an increased number of records in Kansas (e.g. Getz 1961, Smith and Lawlor 1964).

By 1995 (Figure 3) the armadillo was established in southern and eastern Texas (now including the eastern portion of the Panhandle), most of Oklahoma (except the Panhandle), parts of southern Kansas, southern Missouri (except the Bootheel), all of Arkansas and Louisiana, southwestern Tennessee, Mississippi, much of Alabama and Georgia, southern South Carolina, and Florida except the southern part of the Everglades (Taulman and Robbins 1996). There were extralimital records as far north as Nebraska (Taulman and Robbins 1996, Freeman and Genoways 1998).

Thus, the nine-banded armadillo's expansion northward and eastward from Texas (and the expansion of introduced populations in Florida and Alabama in all possible directions) has been dramatic and well documented. Humphrey (1974) determined that average invasion rates for the species were 4-10 km/year; these rates are considered rapid for mammals (Taulman and Robbins 1996). Over the period 1972-1995, expansion of the Texas population to the northeast occurred at a rate of 11.2 km/yr, expansion through Oklahoma into Kansas at about 11 km/yr, and expansion north from the Gulf Coast at 17.2 km/yr (Taulman and Robbins 1996).

In contrast, the nine-banded armadillo's range has contracted somewhat in the west. Bailey (1931) called it a rare resident in the southeastern corner of New Mexico, but it has disappeared from that state (Buchanan and Talmage 1954). The armadillo also disappeared from western Texas between 1905 (Bailey 1905) and 1954 (Buchanan and Talmage 1954). By 1995, however, armadillos were established in the eastern part of the Texas Panhandle and individuals were recorded in the western Panhandle (Jones et al. 1993, Taulman and Robbins 1996). The rate of expansion to the northwest for 1972-1995 was only 1.7 km/yr (Taulman and Robbins 1996).

Taulman and Robbins (1996) hypothesized that the northward spread of the nine-banded armadillo into the United States was limited by hunting pressure from indigenous people in northeastern Mexico until the decline of those populations that followed European settlement. Postulated reasons for the armadillo's rapid range expansion in the United States are habitat changes due to human land-use practices, including fire suppression and irrigation (Taber 1939, Fitch et al. 1952, Taulman and Robbins 1996, Freeman and Genoways 1998); elimination of large predators (Taber 1939, Fitch et al. 1952); climatic change (Humphrey 1974); and the development of transportation networks that facilitate the movement of armadillos by humans (Taulman and Robbins 1996). Buchanan and Talmage (1954) and Taulman and Robbins (1996), however, found no evidence that predators had been a limiting factor for armadillos.

Natural range expansion involves the movement of individuals outward from the edge of a species' range and riparian systems have been considered important dispersal corridors for the armadillo. For example, armadillos are thought to have advanced along the Sabine and Red rivers in Louisiana (Strecker 1928), along the Red and Arkansas rivers in Oklahoma (Blair 1936), and along the Republican River into Nebraska (Freeman and Genoways 1998). There is no doubt, however, that human translocation has played a major role in the armadillo's spread (e.g. Fitch et al. 1952, Buchanan and Talmage 1954, Jones et al. 1983, Taulman and Robbins 1996). Armadillos captured as pets or curiosities can subsequently be intentionally released or escape long distances from their original locations. As mentioned previously, the release or escape of individuals led to the establishment of armadillo populations in Florida and Alabama (Fitch et al. 1952, Buchanan and Talmage 1954). In addition, there can be unintentional translocation of armadillos into new areas. "Hitchhikers" can be transported on trucks, railroad cars, and barges. Fitch et al. (1952), for example, had been informed that when cattle trains from Texas arrived in Rankin County, Mississippi during the 1930s live armadillos frequently escaped from the boxcars.

There also is consensus that climate will limit the nine-banded armadillo's distribution (e.g. Taber 1939, Humphrey 1974, Jones et al. 1983, Taulman and Robbins 1996). Humphrey (1974) proposed a lower limit of 380 mm annual precipitation for the species. Contraction of the armadillo's range in the Southwest may have been the result of increased aridity in the region (Humphrey 1974). Because armadillos have high thermal conductance (McNab 1980) and cannot hibernate, their northward expansion will be limited by the severity of winter temperatures. Bailey (1905) considered the nine-banded armadillo an inhabitant of the Lower Sonoran Zone (south of 33°N latitude). Taber (1939) noted that the northern boundary of the armadillo's primary range was still about 33°N and thought that cold weather would prevent its establishment north of that latitude. By 1954, however, the species was established close to 35°N (Buchanan and Talmage 1954).

According to Humphrey (1974) the northern boundary of the armadillo's distribution in 1972 corresponded approximately to a maximum of 9 freeze-days per year. He also thought that the species might not have reached its temperature limit and that the "winter

barrier" was moving northward. Taulman and Robbins (1996) concluded that the armadillo's established range in 1995 reached about 38°N latitude in Kansas. The species occupied areas on the Great Plains where mean temperatures for January (typically the coldest month) were greater than -2°C (28.4°F; Taulman and Robbins 1996). They found that areas with January mean temperatures of -2°C tend to experience less than 24 freeze-days annually. The isopleth for mean January temperatures of -2°C, as mapped by Taulman and Robbins (1996), crossed southern Illinois at about 39°N latitude, just north of Alton and south of Effingham. Taulman and Robbins (1996) pointed out that there will be short-term fluctuations in the location of this isopleth and that the number of consecutive freeze-days may be more limiting than the total number. Thus, the northern boundary of the nine-banded armadillo's range will be fluid, but Taulman and Robbins' (1996) map of the potential range of the species includes the southern portion of Illinois.

Previous nine-banded armadillo records for Illinois

Prior to 2002 there were two nine-banded armadillo specimens from Illinois in scientific collections. The Illinois State University mammal collection includes a roadkilled armadillo that was found in Empire Township, McLean County in September 1999 (ISU 1215). Dr. Angelo Capparella provided data on this specimen. It was a female, had a total length of 800 mm, and its stomach contained beetles and ants. The other specimen, in the Illinois Natural History Survey mammal collection (INHS 818), is part of the carapace of a roadkilled armadillo found on IL 48 near Boody, Macon County in June 2000 (Van Deelen et al. 2002). Because of the poor condition of the carcass, measurements were not taken and the age and sex of this specimen were not determined.

On 26 June 2002 Terry Esker, Illinois Department of Natural Resources' Natural Heritage Biologist for Districts 21 and 22, collected a roadkilled armadillo on the southbound lane of I-57, approximately 1.5 miles south of the Benton exit in Franklin County. He brought the animal to the INHS and part of its carapace will be added to the INHS mammal collection as a voucher.

Dr. Alan Woolf, Cooperative Wildlife Research Laboratory at Southern Illinois University-Carbondale, provided details of a necropsy performed on a nine-banded armadillo (CW84-7) that had been found alive, but moribund, in Alexander County in December 1983 (e-mail communication, 20 October 2003). The individual was an adult male weighing 3.3 kg. Its stomach was empty. Dr. Woolf reported that two or three more necropsies on armadillos had been performed later, but those records were lost.

During an armadillo survey (Taulman and Robbins 1996), Dr. James Taulman talked to Dennis Thornburg of the Illinois Department of Natural Resources' Division of Wildlife Resources by telephone on 6 February 1995 (e-mail communication, 27 May 2005). Mr. Thornburg stated that he had recorded two roadkilled armadillos in Union County within the past year.

John Schwegman discussed armadillo sightings in Illinois in a 1992 Illinois Department of Conservation news release (Schwegman 1992). During autumn 1991 he was shown a

roadkilled nine-banded armadillo in Golconda, Pope County. He learned that this animal had been released near Golconda by crewmembers of a barge that had come up the Mississippi and Ohio rivers. Mr. Schwegman was told that another roadkilled armadillo had been found in Hardin County a few years earlier. He also remembered a newspaper account of a live armadillo seen near Anna, Union County in the late 1970s.

Dr. Russell Graham, then at the Illinois State Museum, wrote an article about armadillos for the museum's magazine in 1993 (Graham 1993). In the article Dr. Graham asked residents of Illinois and Missouri to report any armadillo sightings to him. He received no reports from Illinois (e-mail communication, 26 July 2004). In his e-mail message Dr. Graham reported that he had talked to a Conservation Police Officer who found a dead armadillo along a road in southern Illinois around 1990.

Finally, Talmage and Buchanan (1954) mentioned that there had been an unpublished report of an armadillo killed by an automobile in Illinois, but they did not provide a date or specific location.

Illinois armadillo survey: mail questionnaire and other information sources

In 2003, I mailed a questionnaire (and cover letter) to 136 individuals who were considered knowledgeable about the fauna of southern Illinois. The recipients were Illinois Department of Natural Resources (IDNR) District Wildlife Biologists (14), District Foresters (9), and Natural Heritage Biologists (8); Illinois Nature Preserves Commission field staff (4); IDNR biologists at Prairie Ridge and Cache River state natural areas (2); conservation police officers in IDNR Regions IV and V (48); superintendents of state parks, fish and wildlife areas, conservation areas, and other state properties (37); Shawnee National Forest biologists (2); National Wildlife Refuge managers (3); The Nature Conservancy's biologist at Cypress Creek National Wildlife Refuge (1); U.S. Army Corps of Engineers superintendent at Carlyle Lake (1); and academics (7). I was unable to find a list of animal control officers, but mailed questionnaires addressed to the person responsible for animal control in 22 southern Illinois counties and municipalities.

The questionnaire (Appendix 1) asked if the recipient had personally observed armadillos in Illinois since 1990 and, if so, when and where the animals had been seen and whether they were dead or alive. It also asked for details of other recent sightings that the recipient considered reliable. In the cover letter I requested that information on future sightings be sent to me.

In addition to mailing questionnaires, I posted a request for armadillo sightings on IBET, an Internet listserve for Illinois birders in 2003. Birders spend many hours outdoors and can be very observant about wildlife in general.

I also checked whether the mammal collections of the Field Museum of Natural History, Illinois State Museum, Chicago Academy of Sciences, University of Illinois Museum of Natural History, Western Illinois University, Eastern Illinois University, Southern Illinois

University, Cooperative Wildlife Research Laboratory (Southern Illinois University), and Southern Illinois University-Edwardsville included any nine-banded armadillo specimens from Illinois.

Newspaper articles about the armadillo survey appeared in the Chicago *Sun-Times* (10 August 2003), Peoria *Journal Star* (11 January 2004), and Chicago *Tribune* (18 March 2005) (Appendix 2). An article describing the survey also appeared in the winter 2005 issue of Illinois Natural History Survey Reports (Hofmann and Esker 2005). These stories elicited telephone calls and e-mail messages about additional armadillo sightings from a variety of people. I also learned about a sighting from a student who attended a presentation that I gave at the Illinois State Academy of Science's annual meeting in April 2004.

Each report received from the mail survey or other sources was entered in a FileMaker Pro database (sample entry in Appendix 3). If the location provided was sufficiently precise, a colored pin marking the site was placed in an Illinois highway map and it later was marked on an outline map of the state for this report. These locations also will be entered in a GIS file.

Armadillo survey results

I received 101 responses from the 158 questionnaires that were mailed (63.9%). Twenty-three of the respondents (22.8%) knew of at least one armadillo sighting since 1990. Two of these individuals did not describe specific sightings, but referred me to other IDNR personnel who had already received questionnaires. Ten respondents (9.9%) had observed armadillos personally. Seven of these individuals reported a single armadillo, two had seen two animals, and one (Lloyd Nelson, animal control officer for Jackson County) reported multiple records for 2000, 2001, and 2002.

As of 15 June 2005 I had received 37 telephone calls, e-mail messages, or direct communications from both biologists and members of the general public about armadillo sightings in Illinois. Some people provided documentation of a sighting (a photograph or carcass) and I found and photographed two of the roadkills that had been reported. I accepted essentially all reports as valid because the uniqueness of the armadillo makes it unlikely to be confused with any other mammal. Most people reported a single animal, but the total number of armadillo observations was 46. One person also stated in 2003 that armadillos had been reported in Pope County "3 or 4 years ago" and a graduate student at Illinois State University mentioned the armadillo specimen in the ISU mammal collection.

After Terry Esker brought the roadkilled armadillo from Franklin County to the INHS in 2002 he solicited information on armadillo sightings from several other IDNR biologists in southern Illinois. Most of the observations they sent to Terry were subsequently reported during the mail survey, but some additional information was obtained from their original messages. On the other hand, I learned of no additional nine-banded armadillo specimens from Illinois in museum or university collections.

There was sufficient detail in some communications to make it obvious that more than one person had reported the same armadillo. In a few cases it was not possible to ascertain whether reports could have referred to the same animal. From all sources (and including the 2002 roadkill brought to the INHS by Terry Esker), I collected records for 102-106 individual armadillos in Illinois for 1990 through 15 June 2005. Most of these animals were roadkills (Figure 4). Unspecified numbers of armadillos reportedly were observed in Pope and Alexander counties as well. During this period the specimens from McLean (ISU 1215) and Macon (INHS 818) counties were collected and two or three additional sightings had been recorded previously (Schwegman 1992, Taulman and Robbins 1996).

Some people were uncertain about the year of an armadillo sighting, but very few sightings prior to 1999 were reported. A roadkilled armadillo was observed in Union County in 1995 (this may have been one of the armadillos reported to Taulman and Robbins [1996] during their survey) and one was found dead on railroad tracks in Scott County in 1998. A live armadillo was seen in Cook County (Park Forest) sometime during the 1990s. The Illinois Department of Transportation (IDOT) brought a dead armadillo to the IDNR office in Randolph County prior to 1999 (the animal was discarded later following a freezer malfunction). Only two to four reports were collected for 1999. Therefore, the vast majority (92%) of the nine-banded armadillo sightings in Illinois collected during this survey have occurred since 2000.

I collected specific armadillo reports for 29 counties for the period 1990 through 15 June 2005 (Figure 5). Eleven of these counties had only one reported sighting (Tazewell, Fulton, Pike, Scott, Christian, Montgomery, Madison, Wayne, Perry, Saline, and Hardin). The largest number of armadillos (at least 24) was observed in Jackson County. This was followed by Randolph County, for which there were 13 reports. There were clusters of armadillos found in Bond and Clinton counties (nine) and in Jersey, Greene, and Calhoun counties (ten). In addition, a former Conservation Police Officer told Brian Mahan, IDNR Wildlife Biologist, in 1999 that armadillos had been in Pope and Alexander counties for three or four years (a highway crew also informed Greg Smothers of IDOT that some had been reported in Pope County). During the period single specimens were collected in McLean and Macon counties (see section on previous armadillo records). Thus, there are nine-banded armadillo reports for 33 Illinois counties since 1990.

Some reports did not include information that was specific enough to map the location of the armadillo. Sixty-two locations from this survey are mapped in Figure 6. Among the animals not shown were many that had been reported by Jackson County Animal Control. Also included in Figure 6 are the localities for the specimens from McLean and Macon counties since they were collected during the same time period. Although a few armadillos have been observed in northeastern and central Illinois, most were recorded in the southern half of the state. Approximately 89% of the armadillos whose locations are shown in Figure 6 (as well as many animals that could not be mapped) occurred south of central Calhoun and southern Greene counties. The Calhoun County locations were clustered near Hardin, which is at 39°09'N latitude. Hardin also is near the isopleth for

mean January temperatures of -2°C, as mapped by Taulman and Robbins (1996). Most of the southern Illinois armadillos were found west of I-24 and I-57.

Necropsies

As of 15 June 2005 I had obtained four dead nine-banded armadillos from Illinois (two more animals are in freezers at IDNR offices in southern Illinois). They were collected south of Benton (Franklin County) in June 2002, in DuQuoin (Perry County) in August 2003, in Percy (Randolph County) in May 2004, and in Breese (Clinton County) in April 2005. At least part of the carapace of these animals will be deposited in the INHS mammal collection as vouchers. The armadillo from Franklin County mummified and could not be necropsied. The others were necropsied at the University of Illinois School of Veterinary Medicine Diagnostic Laboratory on 21 April 2005 by Dr. Marie Pinkerton and veterinary students.

The specimen from Perry County was a female that weighed 4 kg and had a total length of 82 cm. The animal had sustained massive physical trauma (probably having been hit by a vehicle); the carcass was greatly autolyzed. Reproductive organs were not evident. It was in fair nutritional condition ("adequate skeletal muscle stores and adequate to slightly decreased subcutaneous and visceral adipose stores"). The stomach contained numerous insect larvae.

The armadillo from Randolph County was a male that weighed 5.9 kg and also had a total length of 82 cm. It was the victim of physical trauma (presumably a roadkill) and the carcass was in poor condition. The animal was in good nutritional condition ("adequate skeletal muscling and good subcutaneous and visceral adipose stores"). The stomach contained many insect larvae as well as a large amount of soil.

The specimen from Clinton County was only 71 cm long, but weighed 5.4 kg. It was a gravid female and contained four fetuses that had a crown-to-rump length of 65 mm (Figure 7). The left ovary had a corpus luteum approximately 6 mm in diameter. There was a large hole in the animal's head (the result of a vehicle collision or gunshot). The animal was in good nutritional condition, with abundant body fat. The stomach was markedly distended with plant material, insects, insect larvae, and worms (including earthworms).

Field searches

Because nine-banded armadillos are frequently found as roadkills, I decided to search for live animals by driving at dusk and after dark in areas from which multiple armadillo reports had been received. Steven Amundsen (INHS) and I drove slowly along state and county highways and local roads. When it was safe to do so, we scanned the roadsides with a hand-held spotlight; otherwise we relied on the vehicle's headlights to illuminate the roadsides. On the night of 1 October 2003 we drove roads in western Greene and Jersey counties and Calhoun County (traveling between Hardin and Red's Landing). On 27 and 28 September 2004 we drove through parts of Jackson County as well as Crab

Orchard National Wildlife Refuge in Williamson County and Pine Hills in Union County. In addition, we looked for fresh armadillo roadkills in Jackson County during the daytime. On the night of 16 May 2005 we explored the area around Carlyle Lake. The following morning we looked for fresh roadkills in Clinton County. Finally, on the night of 17 May 2005 we drove roads in southern and western Jackson County. No armadillos were seen on any of these trips.

Discussion

Only sporadic occurrences of nine-banded armadillos in Illinois had been reported prior to 1990 (Talmage and Buchanan 1954; Schwegman 1992; A. Woolf, personal communication). However, more than 100 armadillos have been reported in the state since 1990 (this survey, Van Deelen et al. 2002, ISU specimen 1215, Taulman and Robbins 1996, Schwegman 1992). These recent findings raise two fundamental questions. First, how did these animals get to Illinois? Second, is the species becoming established in the state?

The nine-banded armadillo has become common in the southern part of Missouri since about 1980 (Robbins et al. 1994) and there have been sightings north of the St. Louis area (Robbins et al. 1994, updated map of county records from the Missouri Department of Conservation). The species is not known to occur in Kentucky (Layne 2003). Therefore, if natural dispersal is occurring, it is most likely individuals from Missouri that are entering Illinois. Armadillos can swim, but the Mississippi River would seem to be a formidable barrier for dispersers. It is possible that armadillos cross the river on bridges; there are several highway bridges between Pike County and Cairo. Numerous islands are present in the Mississippi between Quincy and Alton and "island hopping" may enable armadillos to cross the river in stages.

Armadillos also could enter Illinois as "hitchhikers" on trucks, trains, or the barges that travel up the Mississippi, Ohio, and Illinois Rivers. For example, Dan Kassebaum from Columbia mentioned that his (late) father who had worked in the railroad yards in East St. Louis spoke of seeing armadillos in rail cars coming up from Texas. Similarly, Bruce Miers of Germantown Hills found a dead armadillo at the entrance to the Caterpillar Proving Grounds in Tazewell County after some equipment had been brought from Texas by truck. Finally, people could intentionally transport armadillos into Illinois from other states. Some animals may well have been released as pranks. In other cases people who acquire an armadillo elsewhere as a curiosity or pet might release it after they return home or the animal might escape.

It was not possible to ascertain how individual armadillos got to Illinois, but translocation of this species by humans has been common (Fitch et al. 1952, Buchanan and Talmage 1954, Jones et al. 1983). Jones et al. (1983) stated that "so many individuals have been released in places where the species previously did not occur that the precise natural distribution cannot be defined." Because anthropogenic changes in land cover and, perhaps, climate as well as the development of transportation networks have facilitated the dispersal of animals, species may no longer have "natural" ranges (Taulman and

Robbins 1996). If the nine-banded armadillo were to become established as part of Illinois' mammalian fauna, how it originally reached the state might be of academic interest only.

Despite the large number of records collected during this survey it cannot be determined definitively if the nine-banded armadillo has become established in southern Illinois, i.e. that there is a permanent, breeding population. Rather, there could be a continual influx of individuals into the state through dispersal and translocation. A pregnant female was found dead in Clinton County in April 2005, but this is not necessarily evidence of breeding in Illinois. Because delayed implantation occurs in the nine-banded armadillo the female mated during the summer of 2004, possibly in another state.

Humphrey (1974) felt that range maps that do not make a distinction between "permanent armadillo populations and areas containing only pioneering individuals are misleadingly simple." Genoways et al. (2000) defined the pioneering zone as "the area where, under favorable conditions, the species is capable of reproducing and conducting its normal activities." It could take as long as 30 years following the arrival of pioneers for a species to become established in an area (Humphrey 1974). Freeman and Genoways (1998) concluded that the pioneering zone for the nine-banded armadillo had expanded into Nebraska, which is farther north than most armadillo reports in Illinois.

The factor limiting the northward expansion of the nine-banded armadillo is winter temperatures (e.g. Humphrey 1974, Jones et al. 1983, Taulman and Robbins 1996). Since these temperatures vary from year to year, the northern edge of the armadillo's distribution will be fluid. For example, there were fewer armadillo sightings in northern Kansas in 2001, following the very cold winter of 2000-2001 (Merriam 2002). Taulman and Robbins (1996) concluded that armadillos may be able to persist in areas where mean January temperatures are greater than -2°C. Their isopleth for -2°C, based on climate data through 1990, crossed Illinois at about 39°N latitude.

Mean January temperatures at Carbondale (Jackson County; 37°43'N latitude) for the period 1997 through 2005 averaged 0.6°C (all climate data were obtained from the Illinois State Water Survey at www.sws.uiuc.edu/climate/climatedb/). The lowest mean January temperatures in Carbondale for the period were -1.9°C in 1997 and -2.5°C in 2003. In Sparta (Randolph County; 38°07'N) the mean January temperatures for the same nine-year period averaged -0.5°C. The January mean in Sparta was less than -2°C only in 1997 and 2004. In Belleville (St. Clair County; 38°31'N) mean January temperatures during this period averaged 1.0°C and never were less than -2°C. Mean January temperatures for Alton (Madison County; 38°53'N) were available for only seven years between 1997 and 2005; they averaged -1.1°C. At Jerseyville (Jersey County; 39°07'N) the average of mean January temperatures for seven years between 1997 and 2005 was only -2.1°C. The January mean at Jerseyville was below -2°C during four of those seven winters.

Most of the armadillos reported during this survey were roadkills. If enough individuals were to survive and breed, winter temperatures in Illinois south of the East St. Louis

region should be favorable for the species to become established. This would be especially true if the recent warming trend for winters in Illinois (Angel 2004) were to continue. Even in far southern Illinois mortality could increase, of course, during harsher winters. Although there was a cluster of armadillo reports in Jersey, Greene, and Calhoun counties (Figure 6), temperature records for Jerseyville suggest that the species would do well that far north only during mild winters.

Summary

Reports of more than 100 armadillos observed in Illinois since 1990 were collected during this survey. The vast majority of these animals were seen since 2000. It is likely that most of the armadillos were intentionally or unintentionally transported into the state by people. Given its relatively mild winters, the southern third of Illinois can be considered part of the pioneering zone for the nine-banded armadillo. Establishment of the species in Illinois has not been demonstrated and could take many years.

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Acknowledgements

This survey was supported by grant 04-037W from the Illinois Wildlife Preservation Fund (IDNR). Conversations with Terry Esker (IDNR) prompted me to undertake the project. Individuals too numerous to name contributed to the survey by responding to the mail questionnaire or reporting armadillo observations. Steven Amundsen (INHS) drove many miles with me, searching for armadillos in southern Illinois. Paul Thole of Breese kept a dead armadillo refrigerated overnight so I could collect it. Dr. Nohra Mateus-Pinilla (INHS) arranged the necropsies of armadillo specimens at the University of Illinois School of Veterinary Medicine; the necropsies were conducted under the supervision of Dr. Marie Pinkerton (UI). Carolyn Nixon and Liane Cordle (INHS) provided assistance with maps for this report and Drs. Edward Heske and Christoper Phillips (INHS) reviewed the report.

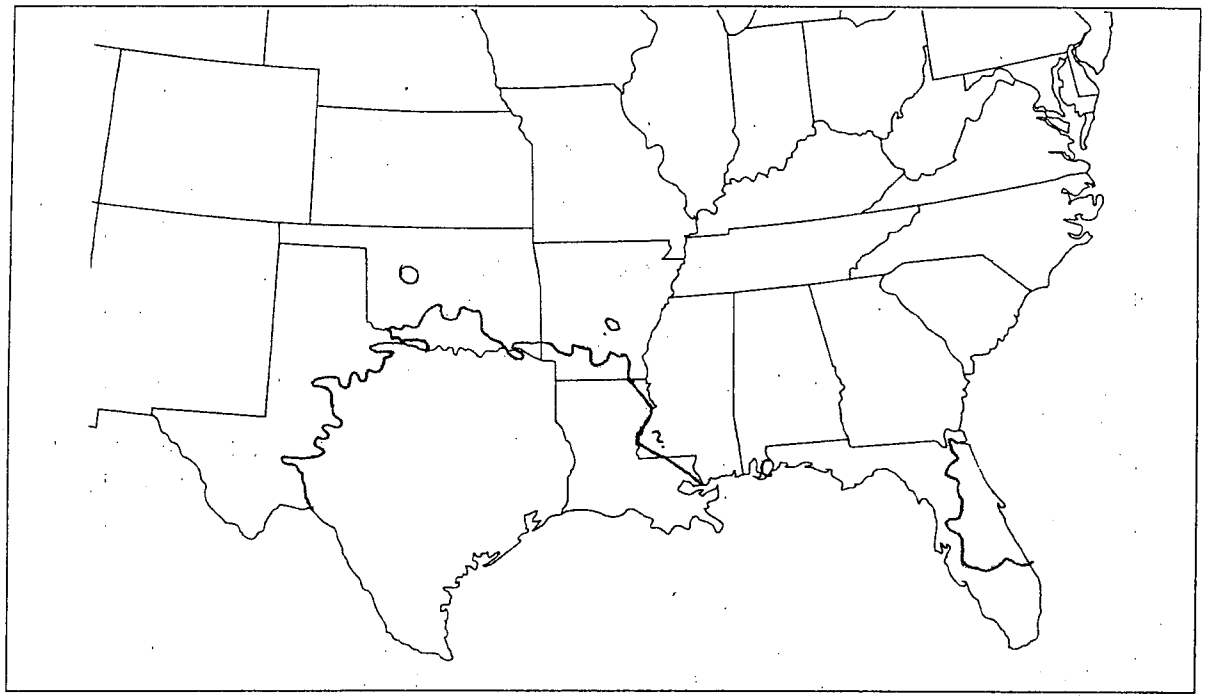


Figure 1. Range of the nine-banded armadillo in the United States in 1954 (after Buchanan and Talmage 1954).

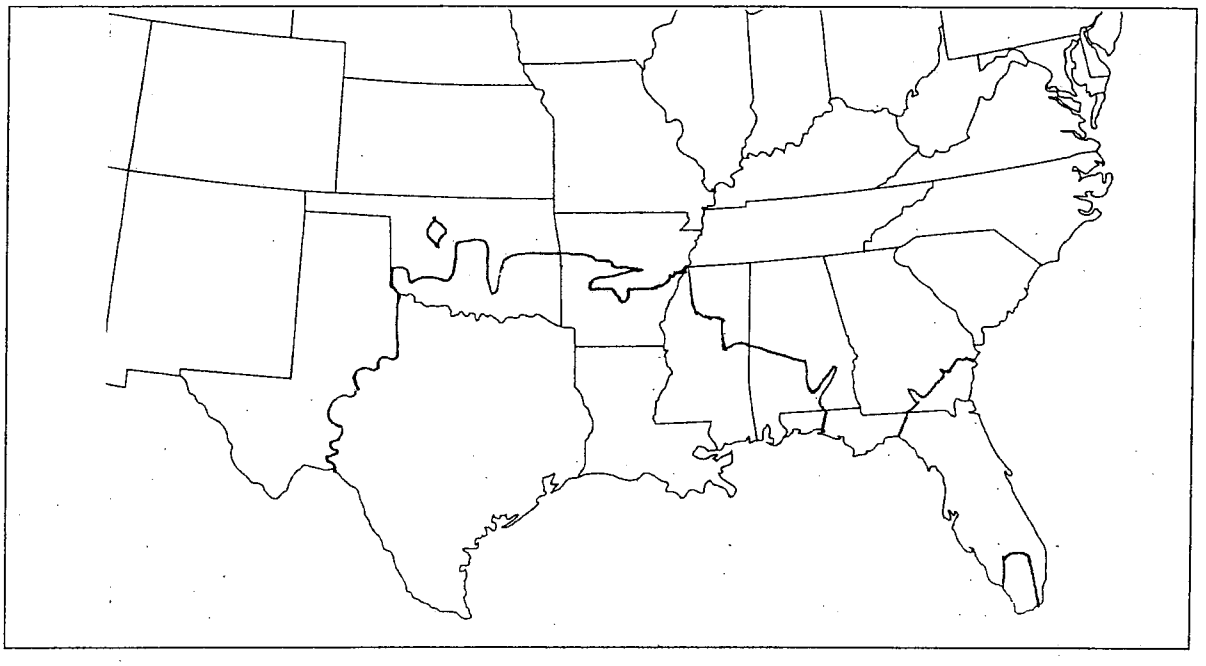


Figure 2. Range of the nine-banded armadillo in the United States in 1972 (after Humphrey 1974).

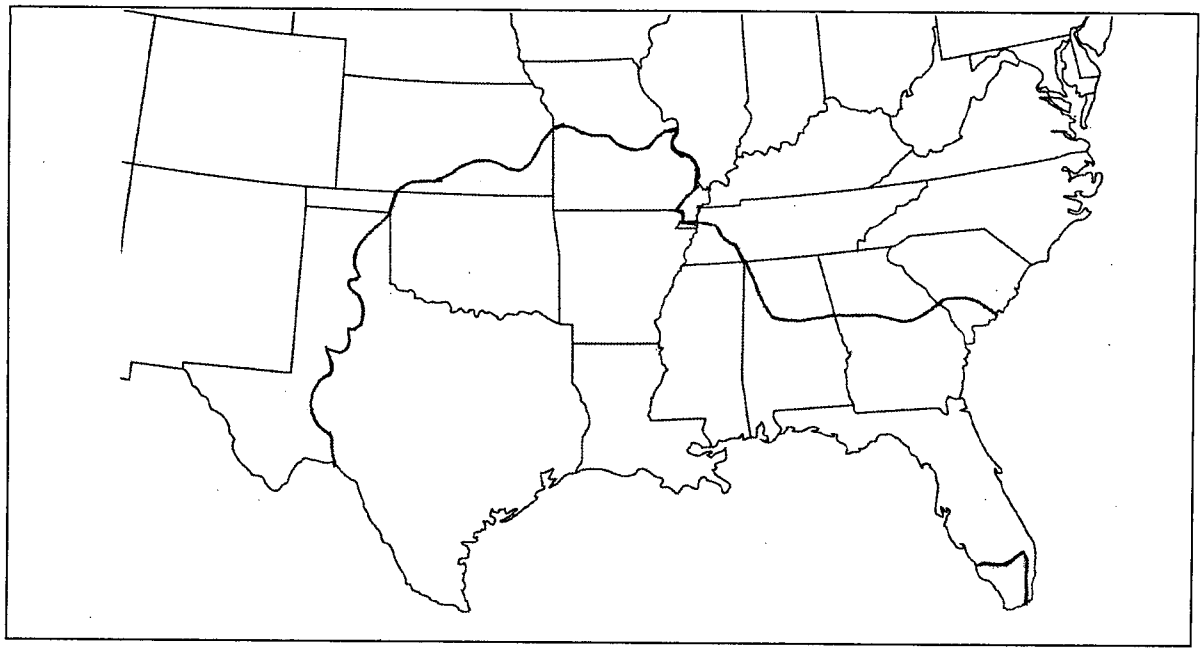


Figure 3. Range of the nine-banded armadillo in the United States in 1995 (after Taulman and Robbins 1996).

Figure 4. Roadkilled nine-banded armadillo, Bond County, Illinois, 2003. Photo by Joyce Hofmann, INHS

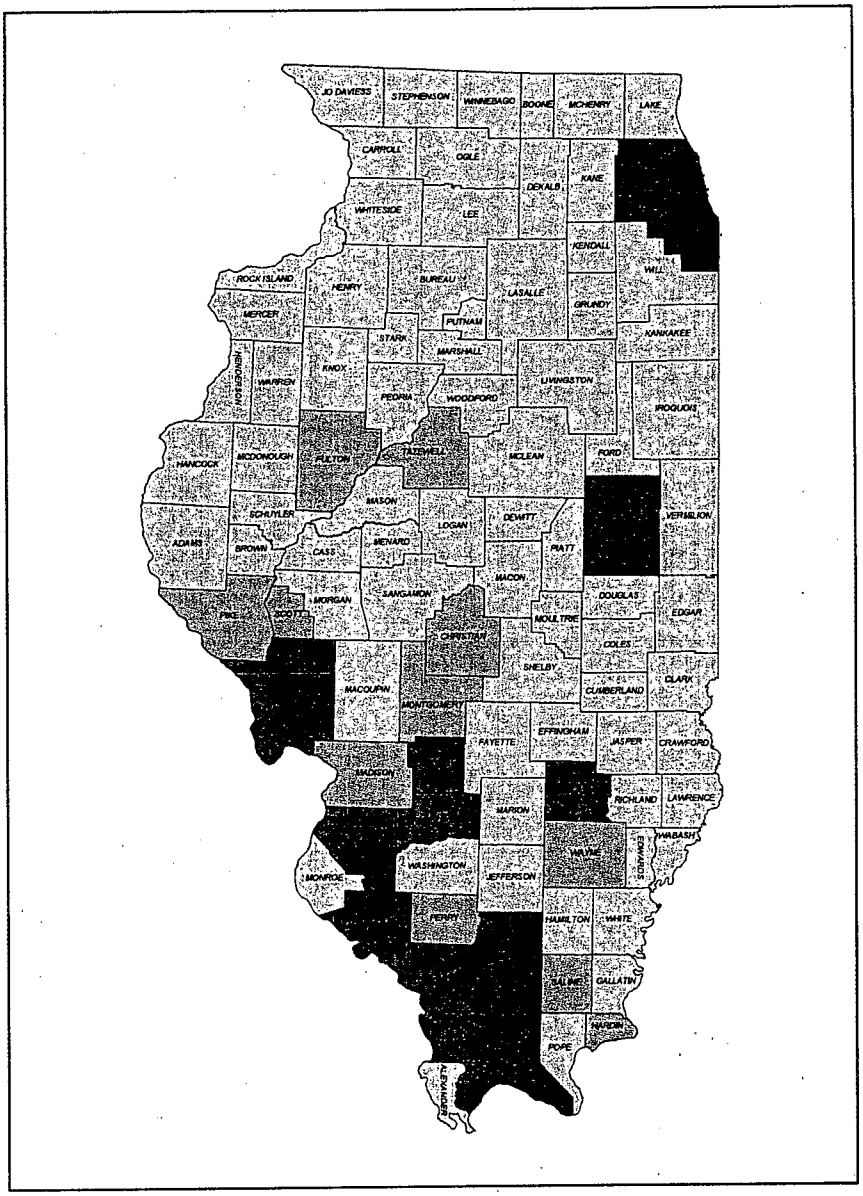


Figure 5. Illinois counties for which specific armadillo reports were collected during this survey for the period 1990 through 15 June 2005. Counties with one report are light blue, those with more than one report are darker blue. In addition, specimens were collected in McLean (ISU 1215) and Macon (INHS 818) counties during this period.

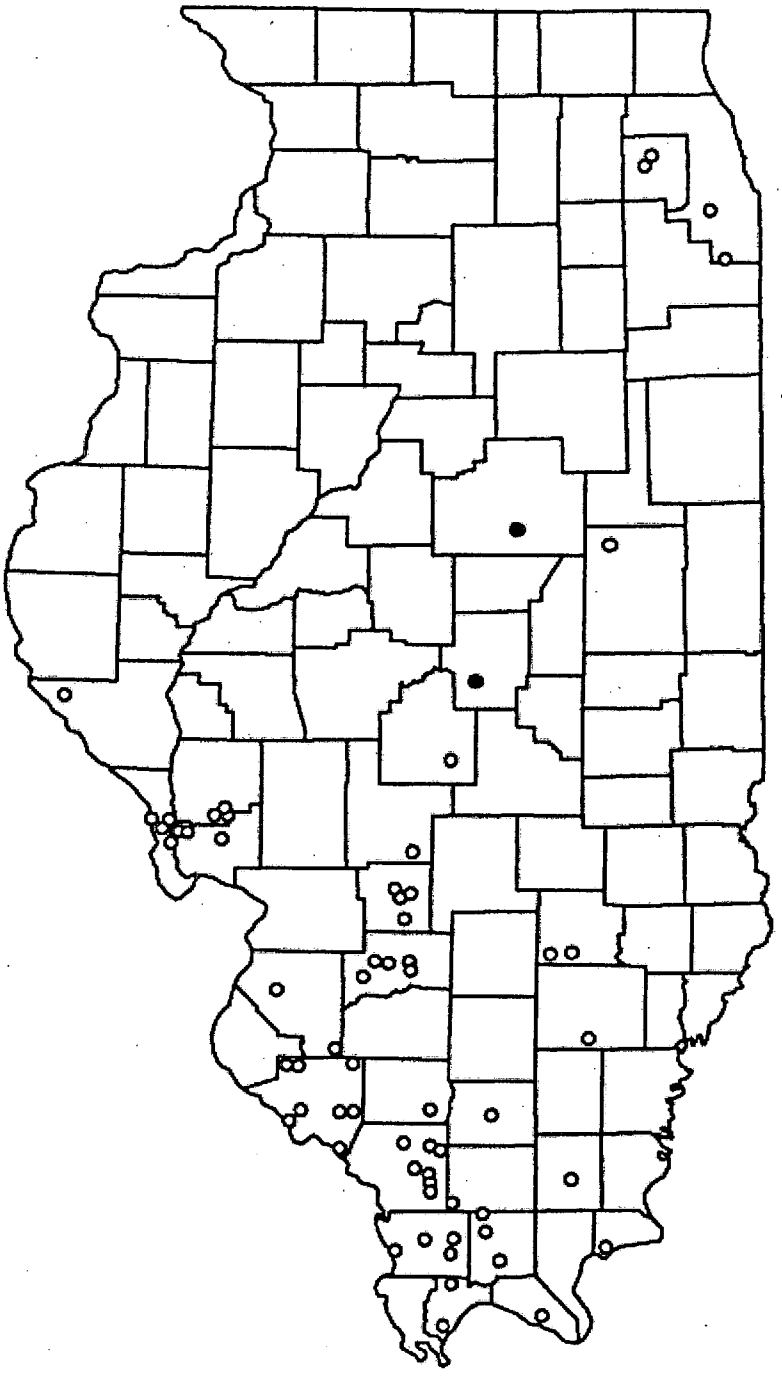


Figure 6. Locations of nine-banded armadillos reported in Illinois during this survey for the period 1990 through 15 June 2005 (open circles). Also shown are the locations for specimens ISU 1215 and INHS 818, collected in 1999 and 2000, respectively (solid circles).

Figure 7. Fetuses from female nine-banded armadillo found dead in Clinton County, Illinois in April 2005. Photo by Dr. Marie Pinkerton, University of Illinois School of Veterinary Medicine.

Appendix 1

Survey questionnaire about nine-banded armadillo sightings mailed to people knowledgeable about the fauna of southern Illinois in 2003

Name _____

Position _____

Phone number or e-mail (optional) _____

Have you observed armadillos in Illinois recently (since 1990)? Yes ____ No ____

If so, please provide as much information as possible about these sightings.

County	Specific Location	Date	Live/roadkill

Do you know of other recent sightings in Illinois that you consider reliable? Yes ____ No ____

If so, please provide as much information as possible, including a general description of the source (e.g., co-worker, neighbor, news article).

County	Specific Location	Date	Live/roadkill	Source

Were any of these animals deposited in a museum or university collection? Yes ____ No ____

If yes, which collection(s)?

Appendix 2

Newspaper articles about the Illinois Natural History Survey nine-banded armadillo survey

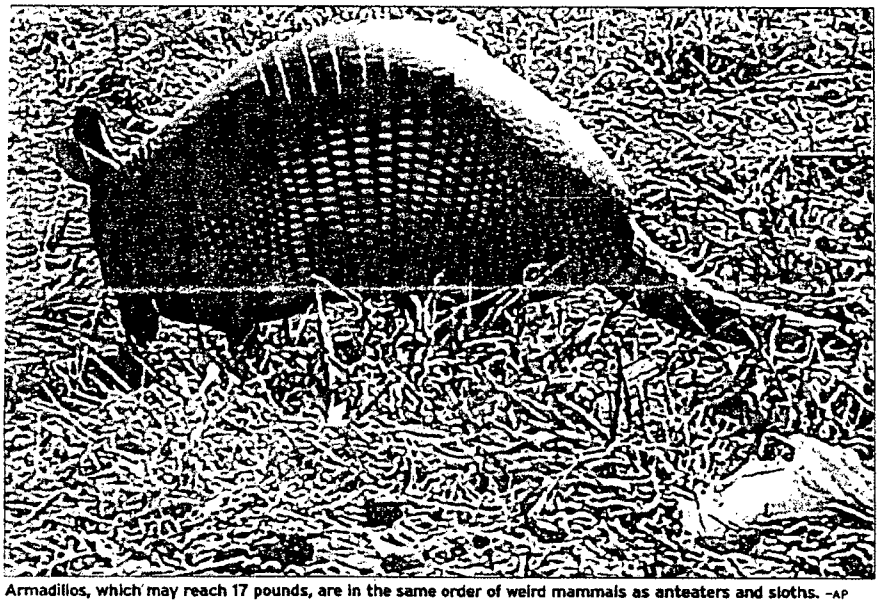
Article 1: Chicago Sun-Times, 10 August 2003

Article 2: Peoria Journal Star, 11 January 2004

Article 3: Chicago Tribune, 18 March 2005

OUTDOORS

NEWS AND NOTES BY DALE BOWMAN



Armadillos, which may reach 17 pounds, are in the same order of weird mammals as anteaters and sloths. -AP

Trek and field stars: Armadillos making their way around Illinois

I envision driving across the bridge into St. Louis someday and seeing an armadillo waddling against traffic toward Illinois.

Hey, the nine-banded armadillo arrived here some way. There are pins all over the map in Joyce Hofmann's office to prove it.

"I would love to see them walk across a bridge," said Hofmann, a research scientist for the Illinois Natural History Survey. "There is that big river. They can swim, but I don't know that they can cross something as large and fast-moving as the Mississippi. That's part of the mystery. Did some hop off a barge or ride freight trains?"

The first reports of the nine-banded armadillos (Dasypus novemcinctus) in Illinois came about a quarter-century ago in far southern areas. Then there was a lull. Since the mid-1990s, reports in Illinois have increased again.

Armadillos reached southern Texas in the 1850s. Since then they have moved steadily north. In the 1990s, they established in Missouri, the likely origin of Illinois' armadillos.

In real life, Hofmann is an expert on bats. As a sideline project, she began tracking armadillos in Illinois with the encouragement of Terry Esker, a biologist in southern Illinois for the Illinois Department of Natural Resources.

With a small grant, Hofmann began systematically collecting reports of armadillos in Illinois earlier this summer.

She has documented, mostly road kills, armadillos as far north as Jersey and Greene counties, a cluster in Bond and Clinton counties and others as far east as Saline and Pope counties in southern Illinois.

There are reasons why so many armadillo reports are road kills.

One, they tend to be nocturnal animals. Two, in the modern world, one of the armadillo's defense mechanisms is defective. When startled, they jump straight into the air. That's very effective in scaring a coyote, dog or bobcat. But it's a lousy defense against a vehicle going 60 mph.

Ergo, there's another road-killed armadillo pancake, a distinctive feature of Texas highways. But still a startling sight in much of Illinois and Missouri.

Against all odds, armadillos keep lumbering around Illinois. Hofmann points out that the distinctive "waddling" of armadillos is feeding speed. When they are so inclined, armadillos can move at "a good clip," she said.

"The thing that limits how far north they will come is the severity of winters," Hofmann said.

The northern line for armadillos will probably establish through central Illinois and Missouri. Hofmann doubts they will ever establish even as far north as Kankakee, Grundy or Will counties. Our winters are too harsh. However, armadillos apparently survived the very harsh weather last winter in southern Illinois.

"There is no question they are fairly common in the southern part of [Missouri]," said Bill Heatherly, wildlife program manager for the Missouri Department of Conservation. "A real severe winter pushes them back. We don't believe it is the cold weather that gets them, but we believe they can't find food."

Armadillos are burrowing mammals that feed primarily on insects and other invertebrates. It's their digging for grubs and insects that will occasionally bring them into conflict with humans who value their neat lawns.

The tank-like appearance of armadillos makes them so distinctive. Flexible bands of "bony plates covered with leathery epidermis" connect the shields on the head and pelvic area, Hofmann said. Armadillos, which may reach 17 pounds, are in the same order (xenarthra) of weird mammals as anteaters and sloths.

"They are such odd creatures," Hofmann said. "It is kind of neat to see."

Dale Bowman may be reached at outdoordb@aol.com. *"Bowman's Outdoor Line" is heard on "Outdoors With Mike Norris" (3-4 p.m. Thursdays).*

Outdoors

Journal Star
Peoria, Ill

State can count on armadillos

Illinois encounters with bony-shelled mammals have increased recently

Somewhere in Illinois an armadillo is shivering.

The Arctic blasts we experienced last week are hard on all critters in the Prairie State. But they're doubly hard on nine-banded armadillos, a relative newcomer to Illinois.

What's that? You didn't know armadillos lived in Illinois?

Truth be told, neither did many other folks until Joyce Hofmann started compiling armadillo information as part of a project funded by the Department of Natural Resources. The findings surprised even Hofmann and other biologists.

Jeff Lampe

Instead of a few scattered sightings, Hofmann found a widespread distribution of armadillos across southern Illinois. To gather data, Hofmann sent surveys to biologists, state park managers and scientists across southern Illinois last summer.

"For each report I put a pin on a map in my office," said Hofmann, a research scientist with the Illinois Natural History Survey. "I've got a lot of pins on my map."

Some pins are as far north as Calhoun and Pike counties in west-central Illinois. That prompts a natural question. Could armadillos play in Peoria?

"We won't know for sure until more time passes," Hofmann said. "The northern boundary (of the armadillo's range) will probably move back and forth depending on the winters."

Mild winters allow armadillos to move farther north. Protracted cold spells probably make the natives of South America wish they'd never left their home continent.

But since 1850 armadillos have made a steady migration through Texas and the southern United States. After becoming established in the south, armadillos continued waddling north. Illinois' first documented sightings were in the 1970s, according to Hofmann.

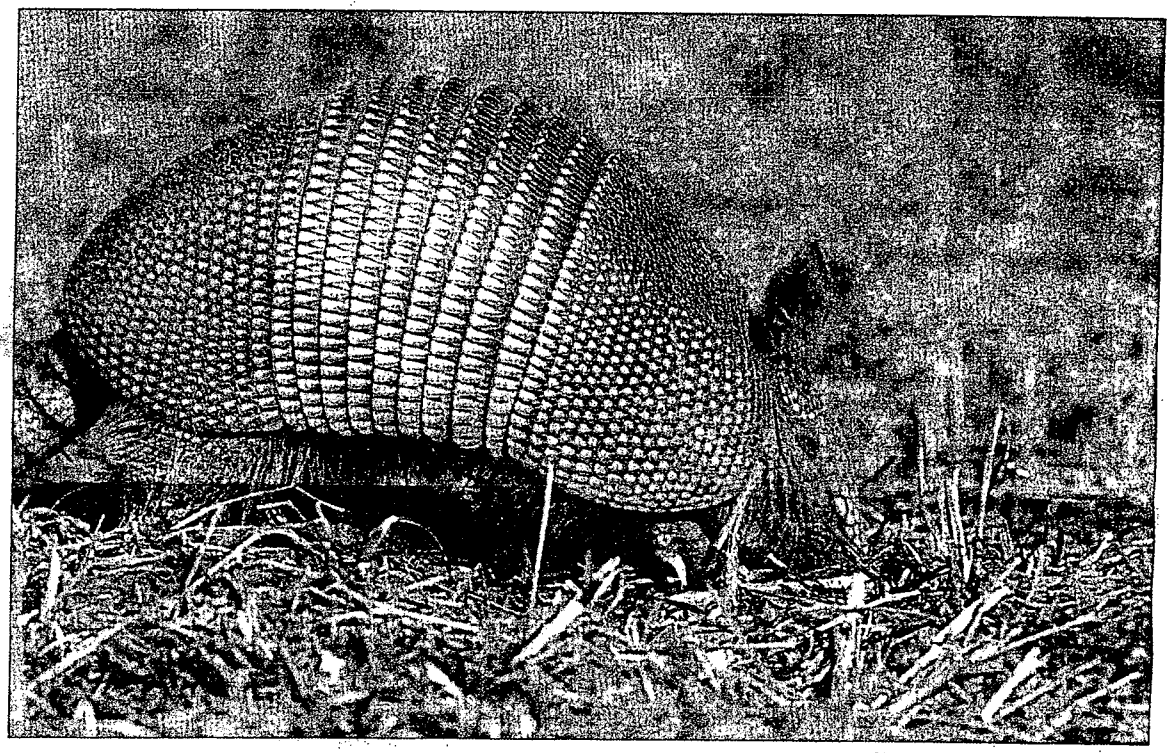


Photo courtesy of U.S. Fish and Wildlife Service

Research reveals nine-banded armadillos, natives of South America, are more widespread in Illinois than previously believed.

Armadillo encounters became more regular in the mid-1990s and appear to have increased in the past five years. Last year Hofmann documented sightings in 11 southern Illinois counties, including one road-kill on a Carbondale city street.

"We used to have reports where somebody said they had seen an armadillo run across the road. Some of that was attributed to too much holiday cheer or not knowing the difference between an armadillo and an opossum," said Lloyd Nelson, an animal control officer in Jackson County. "Initially, my reaction was that we possibly had some animals that stowed away in semis or train cars and made it up here.

"But after we found seven (armadillos in 2000), it became apparent it wasn't random and accidental transport."

Biologists assume most migrant armadillos hail from Missouri, where the population has been established for nearly two decades. Exactly how armadillos navigate the Mississippi River remains unknown.

"They can swim, but supposedly not for real long distances," Hofmann said. "Who knows. They could walk across a bridge or wander onto a barge and jump off. It's hard to say exactly how they are getting here."

The significant thing is they are getting here.

Once here, they appear to be finding enough of the brushy, forested habitats they prefer to survive. Nine-banded armadillos typically reach lengths of 16 inches, with another 14 inches of tail. Top weight is about 18 pounds for these bony-shelled mammals whose name in Spanish means "small armored one."

Nocturnal animals, armadillos feed mostly on insects and other invertebrates that they encounter while digging through soil. Freezing conditions make it difficult for them to find food, a requirement since they do not hibernate.

Beyond that, little is known about the armadillo's existence in Illinois. That's why Hofmann hopes to expand her research this spring to live animals. Nearly all her other data deals with road kills — the way most people typically see armadillos.

Wandering roadsides at night in search of carrion is often a fatal habit for armadillos, whose main defense mechanism doesn't help any. When threatened, armadillosjump straight in the air. Obvously, that's not real effectiv against a truck or car.

Aside from a few damaged bumpers and grills, the most obvious impact of armadillos moving into Illinois will be felt by homeowners, gardeners and golf-course operators.

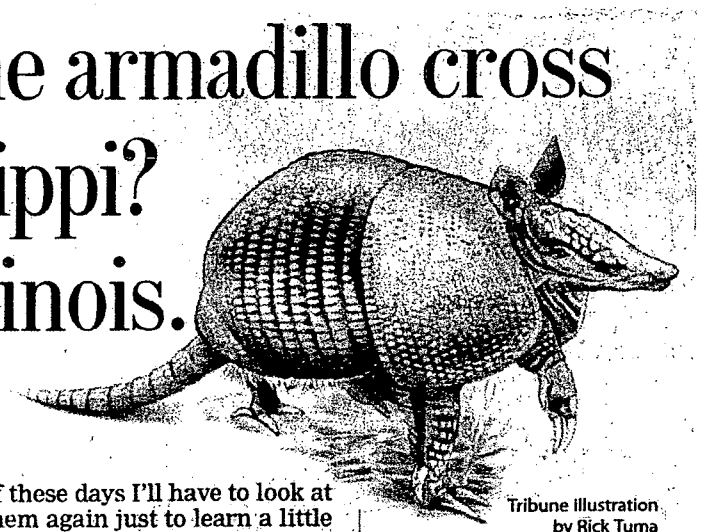
"Apparently they dig after grubs similar to skunks. But the holes they make are considerably larger," said Nelson, who has already trapped one armadillo busily burrowing through a flower bed.

Despite the possible inconvenience, Hofmann sees the arrival of a new species as "interesting."

"It's kind of fun to have something different to think about," Hofmann said. "And I think we can officially count them as being part of the Illinois fauna."

Jeff Lampe is Journal Star outdoors columnist. Write him at 1 News Plaza, Peoria, IL 616-43, call (309) 686-3212 or e-mail jlampe@pjstar.com

Why did the armadillo cross the Mississippi? To get to Illinois.



Tribune Illustration by Rick Tuma

By Ted Gregory
Tribune staff reporter

In their 55 million years, armadillos have rooted their way into peculiar nooks and crannies of culture.

Their notoriety as roadkill has spawned dozens of jokes: Why did the chicken cross the road? To show the armadillo it could be done.

But now armadillos—a.k.a. Texas speed bumps—are occupying a new place: Illinois.

A survey recently published in the winter edition of Illinois Natural History Survey Reports recorded 80 sightings of armadillos in recent years, primarily in 22 counties in the southwestern corner of the state.

"I've got three in the freezer right now," said Joyce Hofmann, a research scientist and mammologist with the Illinois Natural History Survey who conducted the count, "and one of these days I'll have to look at them again just to learn a little bit more about them. They can get pretty squished up sometimes. You'd think with all that armor, they'd hold up pretty well. But, oh, no, they don't."

Armadillos have managed to hold up well enough to make their way across the Mississippi River from southeast Missouri, where they have been residing for a decade or two.

They may have waddled along the bike lane on the Mississippi River bridge at Alton or island-hopped across the river. They may have stowed away on barges, railroad cars and trucks.

They've also been reported as far north as Terry and Cindy Bronke's back yard in Bloo-

PLEASE SEE **ARMADILLOS,** PAGE 8

'Dillo data

This armored mammal, a 'possum on the half shell' in Louisiana, is quite unique:

SOME PIPES
It can hold its breath for six minutes and walk along river bottoms

NOT TOO BRIGHT
Nor can it see well, but it can smell food nearly 8 inches below ground.

COOK WELL
It can transmit leprosy to people if eaten raw.

ARMADILLOS: Most sightings in Illinois are roadkill

CONTINUED FROM PAGE 1

mingdale.

"My wife was laughing at me," Terry Bronke recalled of the summer morning last year when he sat sipping coffee on his deck and saw an armadillo toddle across his back yard.

"She thought it was a possum. She said I was nuts and I said, 'Dear, I've seen armadillos. I know what they look like. That wasn't a possum. That was an armadillo."

The fact that armadillos, a native South American mammal that migrated into Central America across the Panamanian land bridge 3 million years ago, have ventured this far north may seem inconceivable or, at least, astonishing.

But the Illinois arrival of the nine-banded armadillo (Dasypus novemcinctus), a nocturnal mammal about the size of a large housecat, makes sense. Their needs are simple.

Armadillos can survive where they find an abundant source of water and where the average January temperature is above 28 degrees. Rivers, creeks, ponds and lakes are abundant in southern Illinois, where the average winter temperature ranges from 32 to 36 degrees.

And, armadillos have been marching north and east on their clawed feet since first being documented in the Rio Grande Valley of southern Texas in 1849. That migration has been aided in large part by the transformation of forests to farm fields and yards, which drove out armadillo predators and created near ideal foraging conditions for the hard-shelled mammals.

About a hundred years after it was recorded in Texas, the armadillo was inhabiting all of Louisiana, where they are known as "possums on the half shell," and the southern sections of Oklahoma and Arkansas. Less than two decades later—helped in part by a pair that escaped from a private zoo in Brevard County, Fla., in 1922 and another escape that reportedly occurred in 1936 when a circus truck overturned near Titusville, Fla.—two waves of armadillos met in Alabama and continued to move.

By the 1970s, armadillos were digging up and munching on beetles, termites and caterpillars and nibbling on carrion in Mississippi, Georgia, Alabama, Colorado, Kansas and Tennessee. The mammals' territory expanded in those states and moved into South Carolina by 1995, when some had been spotted as far north as Nebraska.

Most important for Illinois, armadillos also began establishing themselves in southern Missouri about that time. Once there, it was only a matter of time before they crossed the Mississippi and set up dens in southern Illinois.

The first of them made their way, posthumously, to Hofmann in September 2002, when her colleague, DNR restoration ecologist Terry Esker, brought an armadillo that had met its fate, as have countless of its relatives, on a road. This road was in Franklin County, in deep southern Illinois.

To determine whether the Franklin County armadillo was an aberration, she obtained a $1,000 grant from the Illinois Wildlife Preservation Fund and, in July 2003, surveyed 135 people, including DNR wildlife biologists, foresters, conservation police, nature preserve field staff, and county and municipal animal control officers.

Sixty-five percent of those surveyed responded, and 21 percent of the respondents said they knew of armadillo sightings. And the sightings have continued to trickle in.

At last count, Hofmann said she has received 80 sightings from about 60 people. About 76 sightings occurred in the southwestern quarter of the state, and virtually all of the animals have been seen since 1999, Hofmann said. Most have been roadkills.

There's a reasonable explanation. Armadillos find carrion along or on roads. Not the brightest mammal and hampered by terrible eyesight, armadillos do not rattle easily.

But, when they are surprised, they jump, sometimes as high as 3 feet in the air—a reaction meant to scare or startle predators. It often yields fatal results when the animal encounters a car or truck on the road.

"That sort of response works well if the armadillo is looking at a cougar," said Joshua Nixon, a PhD biology student at Michigan State University who has run an exhaustive armadillo Web site for a decade. "It doesn't work so well if it's looking at a Dodge Ram."

The armadillo is vulnerable in other areas, as well. They are used in medical research, particularly in leprosy, because their body temperature is low and their immune system is weak.

In fact, experts say they can be carriers of leprosy, although about the only way for a human to get the sickness from an armadillo is by consuming the animal raw.

Still, the critters have survived and surfaced in some unexpected places that are not geographical.

In the Depression, when economically distressed people cooked and ate armadillos—they reportedly taste like pork—armadillos got the nickname Hoover Hogs, a jab at then-President Herbert Hoover's promise to put a chicken in every pot.

More recently, armadillos were on display at the Texas State Society's "Black Tie and Boots Ball," on Jan. 20 in Washington to celebrate President Bush's second inauguration.

Northwestern University has its Armadillo Day, an all-day Saturday party in May, started by students from Texas in 1972.

And, in Bolivia, armadillo shells are used to make the *charango*, a 10-string guitar-like instrument.

Beyond that, armadillos possess some rather curious physiological abilities. Armadillos can smell food 20 centimeters below the surface. Females give birth to identical quadruplets.

They can hold their breath for up to six minutes, which allows them to walk along river and lake bottoms. If an armadillo needs to swim, it can swallow air deep into its intestines for buoyancy. Those aquatic skills may explain in part how they found their way to Illinois.

That is just one of the questions Hofmann is trying to answer. First she needs to find an armadillo that doesn't look like a flattened football sprouting a tail. She has made two trips to southern Illinois in attempts to find an armadillo, dead or alive. Both expeditions have been fruitless.

Undaunted, Hoffman is planning another armadillo reconnaissance mission in April. She is hopeful, but realistic.

"It'd be nice to find a live one," she said.

Appendix 3

Sample entry in FileMaker Pro database of nine-banded armadillo reports in Illinois

location	I-57 at mile marker 7
county	Pulaski
year	2003
time	22 February
status	roadkill
reported by	Jeremy Tiemann, INHS
remarks	southbound lanes

fips 153