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ARMADILLOS: PROBLEMS AND CONTROL

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ABSTRACT: The nine-banded armadillo (*Dasypus novemcinctus*) has been successful in extending its range throughout the southeastern states. It occupies such a diverse range of habitats that its effects on its surroundings depend largely on where it is located. It offers benefits from its burrowing and eating patterns by creating dens for furbearers and destroying large quantities of injurious insects and their larva. Those same activities in urban and suburban areas are now being recognized as a source of considerable nuisance and moderate damage. Damage is most severe from July through early November. They have been recognized in connection with several diseases of public health importance. Control is possible in urban areas by use of live traps of various types. Rural control is possible through a wider variety of methods. The armadillo's position in American culture and social life offers a challenge for future management which should not be ignored.

One of the most interesting and novel of mammals is the nine-banded armadillo (*Dasypus novemcinctus*). Only one species of the Order Edentata inhabits the United States although other species exist in Central and South America such as the true anteaters, Infraorder Vermilingua. The armadillo has a horny carapace covering most of the dorsal body and head. The cephalic plate covers the flattened face but not the ears. The body carapace is divided into three portions, the middle of which is divided again into nine flattened narrow bands over the rib section (Savage 1977, Marsh and Howard 1978). The tail covering consists of 14 rings of decreasing diameter. The shell is composed of a thin horny material covering a calcareous base. Chemical analysis shows the composition to be similar to bone but does not correspond to exoskeletons (Kalmbach 1943). Body coloration varies from light grey or yellowish to a darker brownish. The ears, abdomen and insides of the legs have no heavy scales and the animal is nearly without hair except for coarse studded hairs on the abdomen.

The head is small, elongated and has large, naked ears. The neck is flexible and allows withdrawal of the head to the protection of the anterior carapace. The legs are extremely strong and the feet have toes with sharp claws, four on the front foot and five on the hind (Audubon and Bachman 1854, Davis 1978). The average length of the adult male is 31.4 inches (798 mm.) and the average weight is about 13 pounds (5.9 kg.). Females are slightly smaller. They possess only 7 or 8 simple, rootless and peg-like molars in each jaw totalling 28 to 32 teeth (Kalmbach 1943, Savage 1977). The tongue is cylindrical, viscous and capable of projecting several inches beyond the snout (Curtin 1977).

The armadillo has poor eye sight and only a little more effective hearing. Smell is the predominant sense whether foraging for food or searching for signals of danger (Carlisi and Cooper 1975; Taber 1940). They have the ability to nose out insects as deep as six inches while rooting in soil for food (Pearsall 1965, Taber 1945). While feeding they occasionally emit a low grunting sound. Body temperature is about 9°F (5°C) lower than usual for mammals and fluctuates with the armadillo's environment. To keep its temperature at an optimum level, it modifies its rhythm of activity so that it appears outside its den only in the warm afternoon of cold winter days and in the twilight or night of summer (Carlisi and Cooper 1975, Kalmbach 1943).

The armadillo is extremely agile and can jump vertically and run rapidly with ease (Carlisi and Cooper 1975). Its remarkable climbing ability caused Taber (1940) to construct observation pens with 5 foot high walls with 2 feet of buried fencing in an "L" shape. A strip of wire fencing a foot wide and projecting inward and downward at the top was necessary to prevent them from climbing over. Once having reached the barrier they could not climb down and would generally fall with no apparent harm. Lampe (1977) reported they are no longer used in zoos because of the tail being often broken from falls. The armadillo is likewise not deterred by water obstacles. If shallow, short distances are involved, it may simply walk across the bottom. If larger distances are encountered or greater depth, they gulp air which inflates the intestinal tract giving them the ability to dog paddle as they float across. This action changes their specific gravity from 1.06 to 0.92 (Audubon and Bachman 1854, Davis 1978, Pearsall 1965, Kalmbach 1943, Taber 1940).

The most noticeable sign left by armadillos are the shallow feeding burrows shaped like inverted cones approximately two inches deep and two inches in diameter at the surface. More positive identification is a series of three-toed tracks and the drag mark of the tail. Armadillo scat is typically marble shaped and contains hundreds of insect parts embedded in a heavy matrix of earthy matter which looks like mud (Bailey 1905). Feces are usually found along trails with two or three pellets dropped at once (Taber 1945). While most food excavations are shallow, the animal can dig shoulder deep in an ant hill or termite colony. The stomach of a well fed animal may contain as much as 60cc. of food. From 281 stomachs checked, 169 of which were examined critically, Kalmbach (1943) determined that the diet consisted of at least 488 specifically different food items. Insects and other invertebrates comprised nearly 92% of the total contents. Large quantities of pests such as white grubs, caterpillars and termites were included. Birds eggs appeared in only 5 stomachs. Rare evidence was also found of turtle eggs, reptiles, amphibians, berries and fungi.

The armadillo depends largely on the ability to smell to locate sexually attractive mates as well. The anal glands produce a pungent odor which appears to initiate sexual excitation (Carlisi and Cooper 1975). The breeding season begins in July and over one-half of the females are pregnant by the end

of that month. Implantation occurs in November, 14 weeks after fertilization. Most births are in March but April births are not rare. Gestation is 120 days (Kalmbach 1943). Polyembryony is natural in armadillos with the young appearing as four genetically identical siblings. Litter mates are always of the same sex (Curtin 1977, Carlisi and Cooper 1975). However, Williams and Storrs found that the quadruplets, contrary to previous data, were not totally identical. They studied 16 sets of quads killed at birth to avoid environmental influences. They found that the hearts, spleens or adrenal glands in individual sets of quads sometimes varied in size to as much as twice that of their siblings. Acids and other chemicals analyzed showed a greater disparity (Anon. 1968). The pinkish shell plates of the newborn are soft, their eyes are open and within a very short time are following their mother. Taber (1940) found that the family unit remained together for several months.

Sweepston's 1974 survey indicated that armadillos take advantage of a wide variety of habitats. Sandy and loamy soils are preferred and densities of the animal were reported highest adjacent to creek or river beds. Areas not preferred included marshy areas and those with shrub and grassland. According to Pearsall (1965) they tend to prefer dense shady cover of brush and woodland or cactus and chaparral. They thrive in limestone outcroppings where crevices, caves and ledges offer natural shelter. In constructing a burrow, the nose and forefeet loosen the soil which is pushed halfway back under the abdomen. Then balanced on forefeet and tail, the animal kicks the pile backward with the hind feet. Taber (1945) observed one animal completely bury itself in packed soil in two minutes. He also noted that the root system of the youpon bushes were preferred for burrows but roots of haws, shrubby oaks, osage orange, and other brushy plants were acceptable. They live in a system of several burrows with one serving as the primary home or nest. As a rule only one entrance exists; however, there may be several passages. Most burrows average 7 or 8 inches in diameter and vary in length from 4 to 24 feet. The nest cavity may be 18 inches or more in diameter and up to 4 feet beneath the ground (Carlisi and Cooper 1975, Kalmbach 1943). Armadillos average 5 dens each but the number of dens varies with soil texture. One den excavated by Kalmbach (1943) held 12 young indicating 3 females shared the nest. Taber (1940) was never able to verify claims that rattlesnakes and armadillos shared burrows at the same time. However, when he dug out 51 armadillo dens in Chambers County, he did find 15 occupied by a variety of animals including: 6 armadillos, 5 opossums, 5 cottontail rabbits, 1 striped skunk, 4 cotton rats and 2 burrowing owls. He found a cotton rat, a cottontail rabbit and an armadillo all sharing one nest and in another, an armadillo and an opossum.

Questions on the range of the species are of great interest because this is one of the few species which is undoubtedly expanding. In a questionnaire, Humphrey (1974) requested information in eight south-central and southeastern states on distribution, mortality and topography or vegetation type. He recognized that frontier specimens for 20 to 30 years have appeared in Kansas, Missouri, northern Alabama and Georgia as well as Colorado. This survey noted three major changes: continued northerly and eastwardly expansion by the Texas group; all directional expansion by the Florida group; and contraction of the west Texas range. The west Texas armadillo population contraction appeared to be related to the long term aridity noted in the southwest by several prominent authors. The animal was noted in almost all other terrestrial habitats including swamps and mountains. If current climatic trends continue, Humphrey (1974) feels the western range contraction and decelerated northward immigration will continue. Sweepston's survey (1974) showed the extension northward and presence in all parts of Texas except the Trans-Pecos and the High Plains. Decreases were noted in the lower Rio Grande Valley and near major cities. Estimates of densities for 12 counties in which human population centers exist were all 6-10/100 ac. except for Abilene (no estimate), San Antonio (.5-.9/100 ac), and Austin (.16-20/100 ac).

Layne and Glover (1977) observed armadillos feeding near each other and home ranges overlapping with no sign of competition or aggression. Some indication exists from the Florida study that adult female home ranges are more likely to be adjacent than overlapping. They felt under certain conditions adult females may exhibit antagonism toward each other not displayed with males or young. They found the maximum range length was 382 ± 51 m., average distance between successive captures or sightings was 170 ± 18 m., and minimum home range area of 5.7 ± 1.7 ha. Movements in Florida were greater than those reported in Texas or Louisiana. Data on three armadillos in the Florida study that escaped after capture gave mixed results on efforts to determine homing tendencies. One male and one female failed to return to their capture sites but remained in the area of escape. In contrast, another animal that escaped one week after capture was retaken three weeks later at the original site 930 m. from the escape area. One case of long range homing tendency was reported by Ramsey (1979). A single armadillo returned three times to the same capture site after being removed to areas 2, 7 and 23 miles away.

Weather may be the most effective barrier to migration. Armadillos do not hibernate. Cold weather may cause them to stay in their dens for as many as 3 days but hunger eventually forces them to seek food. Extreme cold leads generally to starvation because frozen ground makes food inaccessible and exposure causes them to freeze. Heat is less hazardous because they simply revert to being nocturnal during summer. Drought presents a hardship by baking the ground so that it is difficult to dig or it drives food too deep (Pearsall 1965, Taber 1945). Even though armadillos have been found in areas miles from water, free drinking water is a necessity (Taber 1940). Humphrey's data (1974) indicated the lower limit of about 380 mm. annual precipitation and an upper limit of 9 freeze days a year represented the moisture and winter barrier to migration.

The armadillo has been accused of committing suicide on Texas highways. It is victim to a reflex action which it biologically cannot control. When startled it leaps several feet in the air placing it in perfect position for a direct motor vehicle hit (Lampe 1977). This was the highest mortality factor reported in both surveys cited. Dogs, humans, coyotes, blackbear, bobcats, foxes and raccoons were also listed as causes of mortality. Cold and drought were also decimating factors with cold being deemed as the factor most affecting range expansion.

In considering damage done by armadillos, one must take disease or potential disease as a factor. In a wildlife survey for the prevalence of leptospires, 34 out of 50 (68%) of the randomly selected armadillos of all ages exhibited renal lesions. Nine different leptospira serotypes were demonstrated. The disease was not clinically apparent until 66 to 75% nephron destruction occurred (Stuart, et al. 1977). In addition, Curtin (1977) noted that the armadillo is of public health importance as a reservoir host for *Trypanosoma cruzi*, the causative organism of Chagas' Disease. Leprosy is still one of the major world health problems affecting 15 million people, 3,000 in the United States (Anon. 1971). Dr. Eleanor E. Storrs was first able to successfully inoculate armadillos in 1971 with the disease to use as a research model (Storrs 1978). Since then studies of naturally occurring diseases in armadillos captured from the wild in southern Louisiana have found 7 to be afflicted with a leprosy-like disease affecting several vital organs and nerves. Data indicated a 10% prevalence of the disease in armadillos (Walsh, et al. 1975). Weiser (1975) stated the leprosy-like disease is characterized by nerve invasion by the mycobacterial bacilli, which in human mycobacterial diseases is held to be pathologic positive for leprosy. Mycobacterial diseases in nature are common and afflict a wide variety of animals including rats, Bolivian frogs, and Indonesian water buffalo. The somewhat ineffective temperature regulatory system of the armadillo may be the factor allowing them to be susceptible. Storrs and Walsh confirmed at least one animal positive for *Mycobacterium leprae*, the human leprosy agent. The significance of human contact now looms with a proven reservoir existing in nature. The connection to possible transmission leads to rice growing areas (Anon. 1976).

In addition to the potential damage which may result from its connection with several diseases, the animal is accused of uprooting seedlings, plundering wild turkey and quail eggs from nests and crippling livestock with their burrows (Lampe 1977). Kalmbach (1943) noted only 5 of 281 stomachs contained bird's eggs. Since the armadillo always leaves sign through tracks and digging, he felt it was being blamed in field observations for damage to nests for which other predators, which leave less sign, were primarily responsible. In two Texas dummy nest studies with 120 nests, armadillos were deemed responsible for destruction of only 6 (Brownlee 1973, Jurries 1974). It would appear it is not a menace to ground nesting birds.

Danger does exist for livestock where land clearing exposes burrows. In addition, erosion may be intensified along stream banks where dens caved in by cattle after clearing are washed out by flooding. In one case a gully 3 feet deep and 20 feet long was formed. No such erosion occurred along a stream where equal numbers of burrows existed but where woody vegetation was allowed to stand. In Louisiana, dens also led to collapse of levees, dikes and dams (Taber 1945). Armadillos may also dig under fruit and nut trees causing root damage. In rural areas they burrow under farmhouses and barns. Some persons have complained of the odor especially when the animal has become excited. In urban areas they are generally considered a nuisance (Marsh and Howard 1978). In their foraging activities they are attracted to probe more frequently in damp soil with grass cover or deep litter (Layne and Glover 1977). Vegetable and flower gardens, golf courses, parks, football and baseball fields, and cemeteries are most attractive to the animals because they are more moist than the surrounding areas and may have more insects.

The types of damage reported by the public and verified by wildlife damage control specialists of the Rodent & Predatory Animal Control Service located in 12 metropolitan areas of Texas were reviewed. I used data from the monthly wildlife damage complaint logs for the period of July, 1975 to November, 1979 inclusive (Table 1). Few complaints of damage were recorded during any period other than between the months of July and November of each year. The most frequent type of damage reported was uprooted lawn, plants and shrubs. Only 4 instances out of 362 damage complaints involved undermining structures {2 patios, 1 house foundation, and 1 driveway}.

Table 1. Armadillo complaints received over the five month period (July - November) and estimated losses calculated for each of five years.

YEAR	NUMBER OF DAMAGE COMPLAINTS	ESTIMATED LOSS
1975	16	\$ 190.00
1976	12	780.00
1977	147	10,275.00
1978	142	7,601.50
1979	45	1,470.00
Totals	362	\$20,316.50

The largest single loss was sustained to a nursery Azalea garden (\$2,000). To further check on the pattern which appeared in the wildlife complaint logs, I reviewed three years of the control methods instruction monthly reports which record all calls received and office visits made to obtain information on or assistance with control of all species for which we have responsibility. This report combines all nuisance, damage and damage prevention requests by species. The monthly analysis for the period from September, 1976 through August, 1979 (Figure 1) again demonstrated the peak at the same time in each of the 3 years although some complaints were recorded in every month except December, 1976. In Texas Fiscal Year 1977, 309 complaints were received; in FY 1978, 434; and in FY 1979, 237 for a total of 980. The total number of armadillo complaints received by 12 urban offices in Texas from September 1976 through August 1979 are given in Table 2. The cities recording the highest number of complaints were Austin with 294 and Houston with 199. The two lowest were Port Arthur with 8 and Corpus Christi with 9. There appears to be a strong correlation between breeding season onset and the sudden rise in

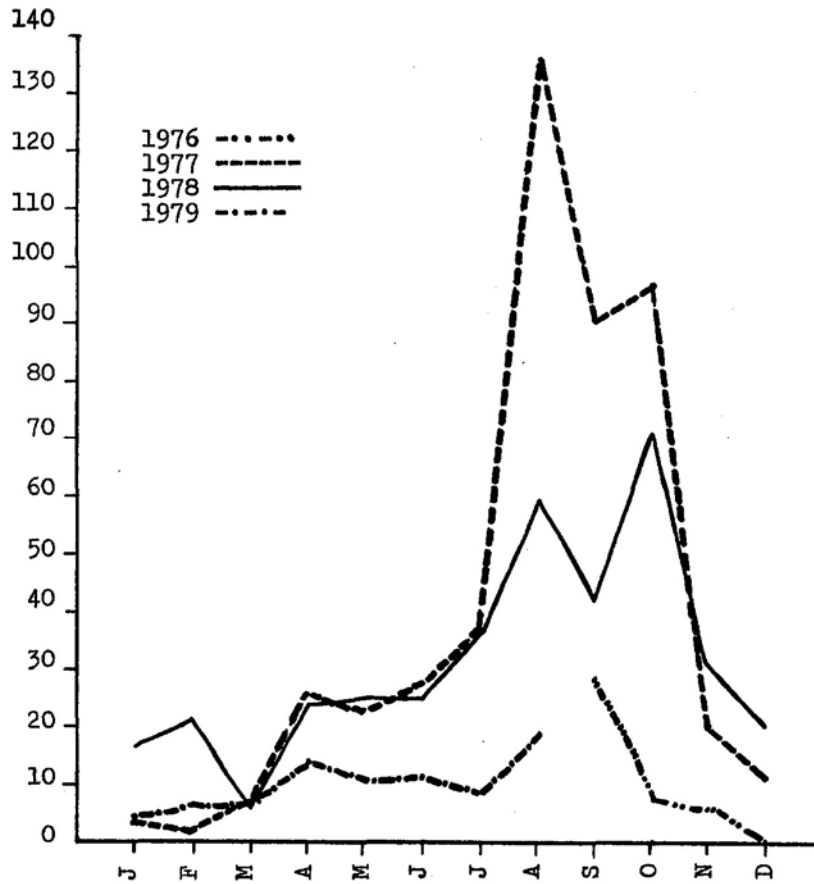


Fig. 1. Complaints on armadillos received in urban offices in Texas plotted by the month from September 1976 through August 1979.

Table 2. Armadillo complaints received in 12 urban offices in Texas from September 1976 through August 19-79.

CITY	FY 77	FY 78	FY 79	TOTAL
Austin	101	131	62	294
Houston	62	67	70	199
Tyler	23	92	17	132
Ft. Worth	31	37	19	87
Dallas	27	30	21	78
San Antonio	10	18	18	46
Abilene	14	22	3	39
Mid-cities (D-FW)	19	15	4	38
Waco	18	11	7	36
Wichita Falls	2	5	7	14
Corpus Christi	1	5	3	9
Port Arthur	1	1	6	8
	309	434	237	980

complaints. The rise starts in July and drops again in November which also coincides with the date of implantation. Although the data presented strongly indicate some behavioral relationships exist, further study is needed over a longer period of time to answer all of the questions raised in connection with: mating density, male-female complaint ratios, fall food-energy requirements, and erratic rainfall pattern effects.

In addition to negative factors such as disease and damage, positive factors must be mentioned. Taber (1941) valued the animals for several reasons. They destroy large quantities of noxious insects, destroy fire ants which attack bobwhite quail just at hatching, and provide excellent dens and safety retreats for furbearers. He noted that farmers and ranchers got enough money from furs to pay taxes and urged protection of the armadillo as an "involuntary but valuable aid to the fur animals." He also felt they made excellent pets because they served as a biological control on cockroaches when allowed to roam free in a house. The Apelt Armadillo Company made one piece baskets by connecting the empty shell by the nose and tail. The baskets were then lined with bright colored silk and were used for fruit or flowers, photoholders, and needlework (Anon. n.d.). In a six year period prior to 1913, one dealer in hide products shipped 40,000 baskets for sale. The novelties were popular until shortly after 1920 and decreased thereafter (Kalmbach 1943). Some are still made in Mexico. The armadillo has also served as food with a taste described as flavoring turtle, young pork or chicken (Kalmbach 1943, Taber 1940). The "poor man's hog" was a life-saving staple during times of economic stress and was used in one 4-H Club project to make 2,000 No. 3 cans of preserved meat (Kalmbach 1943). In Mexico, the oil of the animal was reported to serve several medicinal purposes including use as a treatment for rheumatism. Armadillo oil also may be used for softening and preserving leather.

During the last regular session of the Texas Legislature, two bills were introduced affecting in some way the status of the armadillo. The first was a bill requesting that the armadillo, among other animals, be declared a public health hazard and therefore prohibited from sale as a pet. The bill passed. The second bill (Henderson, et al. 1979) which would have proclaimed the armadillo as the official mammal of Texas failed. This points out the varied thoughts on the animal and the extremes of opinion. On the one hand it is declared a public health threat and on the other was almost given total protection and honor. The armadillo holds a special place in the hearts of Texans. It has been raised to the position of unofficial mascot by the students of the University of Texas at Austin. Its picture has been emblazoned on T-shirts, plates, cups and car windows. It has appeared on television as symbol for a favorite beer and armadillo races are held in several cities annually. Those which don't escape appear unwillingly but tastily at chili cookoffs. In 1969, the Armadillo World Headquarters organization was established largely because some youths felt they had similarities in life style with the armadillos that were "misunderstood, abused and mistreated." (Pearsall 1965). If the love for the armadillo continues unabated, we may find more of our traps flattened in the street by vans full of teenagers, as one group decided to do. However, objections to control or use of the animal dates to the late 1800's. South Texas outdoorsmen opposed the killing of them because if lost and forced to live off the land, the men felt they could kill an armadillo with a rock or club and survive (Davis 1978, Bailey 1905).

Control may be approached from several aspects: environmental, mechanical and chemical. In rural areas Taber (1945) found that brush clearing had a detrimental effect on those armadillos living in the area prior to clearing. However, in urban and suburban areas, alteration of the vegetation is most often unacceptable or impossible (i.e., golf courses or cemeteries). Limited numbers of animals may be captured by hand. Patience and perseverance is required and a hand hold must be taken on the tail close to the carapace and under the back with the animal upside down. If the tail is not held close enough to the base, a violent swinging action in a circular motion will generally rasp the animal free. If the animal escapes and lodges itself inside a burrow, a hunter will not generally be able to pull it free. Charles Apelt (Anon, n.d.) recommended tickling the animal with a stick on its unprotected soft underparts which causes it to loosen its hold and allows capture.

In areas where prudence, common sense and laws permit, shooting is a good control measure. Daytime shooting is easiest and most productive during the colder winter months when the animal reverts to diurnal behavior. Night shooting with a spotlight is also feasible but more time consuming. A rifle of larger than .22 caliber equipped with a scope permits selective shooting at a distance and a cleaner kill. If not instantly killed, the animal will generally jump repeatedly and try to reach a burrow. Clubbing will also result in a quick kill if the head is squarely hit with a swift and strong blow. Armadillos may be deterred in their travels by any solid wall. However, if they desire to escape and find no easy means of egress, they will tunnel under the obstruction. Ordinary mesh wire fences are no hindrance because if they cannot find their way through, they will climb over or dig under. The only effective fencing is that described earlier by Taber (.1940). Holes dug under netting wire in rural areas are used by a variety of animals. Most may use the holes without modification; however, larger animals such as coyotes, can easily widen the hole to accommodate their bodies. Armadillos are sometimes caught accidentally in steel traps or snares set in holes under fences for foxes, raccoons, or coyotes. Number 1 or 1 1/2 leg-hold traps will work when setting in fence slides or burrow entrances. However, steel traps are not recommended for use in urban lawns and gardens where a major part of reported damage occurs. We are presently working on a specially modified box trap incorporating a Conibear 110 to determine its efficacy. It has been designed to limit materially the non-target effect.

Any of a variety of commercially available live traps or home made box traps will work so long as the minimum size is 1x1x3 feet. In areas of dense human habitation, this is the preferred method of control. The traps should be set near buildings in areas where digging sign appears or near fences, burrow entrances or trails. The trap is opened at both ends and made more effective by the use of

long planks (1x4 or 1x6) placed at a 20-45 degree angle from the entrances. This drift fence approach is very important in directing movement of the animal. Live traps do not necessarily need bait. However, to, serve as an added attractant, baits ranging from broken eggs, fetid meats, meal worms, hamburger, over-ripe fruits and meat filled with maggots have been recommended by various sources. The most novel bait is that described by Barbe (1976) who related that the scent from armadillo sex glands was effective in capturing 7 armadillos in a trap placed in the open without the use of drift planks.

Chemical control is very limited since there are no pesticides registered in the United States at this time naming armadillos on the label. Elimination of the food supply attracting the animals to yards and lawns may be an effective indirect chemical control. Fumigation of burrows known to be inhabited by the target animal has been used in the past quite effectively. Although calcium cyanide, carbon bisulfide, methyl bromide and gas cartridges all are effective, the latter is preferred largely because of the ease of handling. The Pocatello or commercial gas cartridges are registered for burrowing rodents and when ignited and sealed inside a burrow, they kill the animal by releasing toxic gases. A former District Agent of the US Fish & Wildlife Service (Whitehead 1963) wrote that eggs could be used as an attractant during control operations. He used pigeon or pullet sized eggs containing one or two grains of strychnine. This required breaking the eggs on the top or side and mixing the toxicant well inside. This process permitted the odor of the egg to escape and entice any nearby foraging armadillo. Whitehead also recommended the use of meat baits of marble size with strychnine alkaloid and bicarbonate of soda mixed 50:50 at the rate of one grain of strychnine to the bait. Because of the ease of trapping and the hazard of poisons in urban areas, the use of toxicants is not recommended. Despite the problems it occasionally creates, it is an animal with many redeeming qualities and should be left alone if not in a damage or nuisance situation.

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