Live-capture Techniques for Colonizing Nine-banded Armadillos

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Abstract - *Dasypus novemcinctus* (Nine-banded Armadillo) has recently expanded its range northward into Illinois. With this range expansion comes concern from both wildlife managers and the public regarding potential incoming pathogens and unknown impacts on native wildlife. However, to conduct field studies of armadillos in newly colonized areas, information is needed regarding capture methods and efficiency. We attempted several methods to capture colonizing armadillos in southern Illinois during 2019–2020, including spotlighting on roads, staking out burrows, unbaited single-door cage traps, and unbaited double-door cage traps. Based on the ratios of trap nights per capture and person-hours per capture, double-door cage traps were the most efficient method to capture armadillos, and we suggest other researchers use this method in low-density populations.

Introduction

Climate change and conversion of natural landscapes have facilitated the range expansion of several wildlife species in North America, such as *Procyon lotor* (L.) (Raccoon), *Canis latrans* Say (Coyote), and *Didelphis virginiana* (Kerr) (Virginia Opossum) (Hody and Kays 2018, Laliberte and Ripple 2004, Parmesan et al. 2005, Walsh and Tucker 2018). Furthermore, several mammalian species are recolonizing areas with suitable habitat following prior extirpation in the midwestern United States (LaRue et al. 2012, 2019; Smith et al. 2016). The consequences of range alterations have made the study of species expansions increasingly valuable to wildlife biologists. The movement of wildlife into new habitat can have profound ecological effects, including the spread of foreign diseases and parasites, changes in biodiversity, and the alteration of predator–prey dynamics (Gompper 2002, Schmidt 2003, Selechnik et al. 2017). Range expansion and recolonization events also bring the potential for an increase in human–wildlife conflict (Smith et al. 2014).

Dasypus novemcinctus L. (Nine-banded Armadillo, hereafter Armadillo; Mammalia, Cingulata, Dasypodidae) has expanded its range into the Midwest in recent years (Hofmann 2009, Van Deelen et al. 2002), and its range is predicted to expand even further northeast (Feng and Papes 2015). The Armadillo is a habitat generalist with a high tolerance for human disturbance, and conversion of natural cover types to cropland, expansion of roadways, and climate change have likely accelerated its range expansion (Gammons et al. 2009, Loughry et al. 2013, Taulman and Robbins 1996). Its range has been steadily expanding northward since the mid-1850s, following 2 paths of dispersion from Texas and Florida which united in the late

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1970s (Loughry and McDonough 2013, Talmage and Buchanan 1954). Armadillos are expanding northward at a mean rate of 4–10 km per year, with recent records of Armadillo presence as far north as Nebraska and Indiana (Genoways and Freeman 1998; Humphrey 1974; Taulman and Robbins 1996, 2014). The Armadillo has also expanded into southern Illinois; sightings there were sporadic after the 1970s but rapidly increased in the 2000s (Hofmann 2009, Van Deelen et al. 2002).

Given Armadillo expansion, it is imperative that biologists gain a better understanding of their ecology in recently occupied habitats (Loughry et al. 2015, Superina et al. 2014). Wildlife managers are concerned with the introduction of pathogens and potentially negative impacts on native wildlife, such as *Colinus virginianus* (L.) (Northern Bobwhite; Rollins and Carroll 2001, Truman 2005, Vandermark et al. 2018), and the *Gopherus polyphemus* (Daudin) (Gopher Tortoise; Guyer and Hermann 1997, Smith et al. 2013). However, to conduct field studies of Armadillos in newly colonized areas, information is needed regarding capture methods and efficiency. Armadillos are difficult to capture, as studies have found attractants to be ineffective in live capture of the species (Gammons et al. 2005, Ober et al. 2011), though there is evidence that the use of conspecific scent can improve capture rates (Martin et al. 2014). Indeed, few studies (Bergman et al. 1995, Gammons et al. 2005, Silva and Henriques 2009) have provided estimates of capture efficiency for Armadillos. Studies in the southern United States report spotlighting for Armadillos and capturing them via a long-handled dipnet is the best strategy due to capture efficiency and the lack of bycatch (Loughry and McDonough 2013). However, these studies were conducted in areas with established Armadillo populations, likely at higher densities than colonizing populations (Hengeveld and Haek 1982, Phillips et al. 2010), which may necessitate the use of capture methods other than those used by Loughry and McDonough (2013). In addition, dipnets are only useful in certain habitat types and difficult to use in brushy areas, which are typical of southern Illinois (Bergman et al. 1995).

As part of a larger effort to assess movements and home ranges of Armadillos, we attempted to use spotlighting, stake-outs, single-door cage traps, and double-door cage traps to capture Armadillos in southern Illinois. We calculated capture efficiency for each method based on the ratios of trap nights per capture and person-hours per capture. Our goal was to provide insight into alternative field techniques for use in future studies of colonizing Armadillo populations that require capture.

Study Area

Our capture efforts occurred in Trail of Tears State Forest (37°30′55″N, 89°20′25″W), Giant City State Park (37°36′18″N, 89°11′18″W), Touch of Nature Environmental Center (TON) (37°37'39"N, 89°09'30"W), and the Southern Illinois University campus (SIUC) and farms (37°42'38"N, 89°13'22"W), and occasionally in residential areas following layperson reports in Jackson and Union counties in southern Illinois (2853 km^2; US Census Bureau 2019). Climate of the area is temperate, with cold winters, wet springs, and hot, humid summers (Changnon et al. 2004). Monthly average temperature varied from 0.5 °C in January to 25.5 °C in

July. Average monthly precipitation varied from 8.1 cm in January to 14.0 cm in May (ISWS 2018). Elevation was 103–310 m (ISGS 2020) and mean human density was 28 persons per km^2. Landcover was dominated by forest cover (42%) and agricultural crops and pasture (40%); the remainder consisted of open water (3%), human development (7%), and wetlands (7%) (Yang et al. 2018).

Materials and Methods

We used 4 methods to attempt to capture Armadillos: spotlighting, stake-outs, and 2 different cage-trap methods. All areas were known to have Armadillos, with presence confirmed using camera traps placed near potential burrows, sightings of live animals, or roadkilled specimens. As Armadillos are most likely to burrow in hardwood hammocks and riparian areas (McDonough et al. 2000), we located potential burrows by scouting in wooded areas near bodies of water such as ponds, lakes, and creeks. Burrows are often found under fallen trees, at the bases of intact trees, in brushy areas, or along embankments (Loughry and McDonough 2013). Once burrows were located, we aimed camera traps at burrow openings to confirm Armadillo activity.

We used spotlighting and stake-outs as active methods for capturing Armadillos. We performed spotlighting during September–October 2018 and May–August 2019, in 1–4.5-h sessions during 1900–0600 h. Teams of 2 or 3 people drove slowly (16–24 km/h) in a pickup, while a passenger scouted for Armadillos using a spotlight with a 678-m beam distance. The maximum distance scouted was about 300 m before trees or brush obstructed view. We spotlighted along roads rather than searching in forested areas due to the open, mowed patches of land typically found along roads. Armadillos were easily spotted foraging in these areas without view obstruction, and the open areas reduced the chance of the crunching of leaves or snapping of a twig underfoot startling an Armadillo before we could capture it (Loughry and McDonough 2013). Once an Armadillo was located, 2 people used double-lined dipnets (71 cm in diameter) to attempt to capture the animal. We spotlighted on the SIUC campus and university farms, Giant City State Park, TON, and Trail of Tears State Forest. Distance of road traveled for each spotlighting session varied from 16 to 108 km, which included resampling the same areas, such as driving in loops or driving in one direction and then back again.

We conducted stake-outs during October 2018 and July–August 2019, in 1–4-h sessions during 1900–0600 h. Two or three people were present for every search session for stakeouts, which consisted of quietly waiting outside of burrows. We had confirmed Armadillo activity at the burrow using camera traps to check that an Armadillo had entered the burrow, but not exited. Once an Armadillo was sighted, we attempted to capture it using a double-lined dipnet. We measured spotlighting and stake-out effort in the total amount of hours spent searching for and capturing Armadillos (i.e., 2 people searching for 4 h = 8 h of effort). We calculated the efficiency of these 2 active capture methods as the ratio of person-hours spent per Armadillo capture. Stake-outs occurred both on the SIUC campus and at a resident's home in Carbondale, IL.

We used 2 different types of cage traps as passive methods for capturing Armadillos. One cage-trap method consisted of using unbaited single-door Tomahawk® traps (66 cm x 26 cm x 26 cm; Tomahawk Live Traps, Hazelhurst, WI) directly outside of burrows (Fig. 1). We used camera traps to confirm that Armadillos

Figure 1. Single-door trap set-up near a burrow under a fallen tree. Temporary fencing does not cut off the burrow entrance but is used to lead the armadillo to the trap.

frequented burrows, but we opened traps nightly regardless of whether an Armadillo was presently inside the burrow. We set traps during May–June 2019, with up to 14 traps set per night. We placed traps at TON, the SIUC campus and university farms, as well as 1 trap near a resident's home in Carbondale due to reported sightings. We used temporary plastic fencing to create "wings" jutting out from the trap entrance, cut to the same height as the trap, with bamboo stakes holding the fencing in place. The purpose of the fencing wings was to corral Armadillos into the trap, similar to the wooden wing design used by Gammons et al. (2005). The reasoning behind opting for construction fencing rather than wooden wings was for ease of transport to burrows and greater flexibility in wing placement. We assumed this material would not compromise our ability to capture Armadillos, as wildlife-removal agencies often use this material to catch Armadillos (Wildlife Removal 2020). Because these traps had single doors, we did not use fencing to cut off the entrance of the burrow, to avoid deterring Armadillos from the burrow area. Traps were camouflaged with leaf litter and handled with gloves and rubbed with mud to minimize human scent. We set traps in the evening (1600–1900 h) and closed them during the day.

The second cage-trap method we used during June–August 2019 employed unbaited double-door Tomahawk® traps (91 cm x 30 cm x 30 cm; Fig. 2). We set up to 14 traps per night, placing them at TON, the SIUC campus and university farms, and 2 traps at a resident's home in Carbondale due to reported sightings. We placed these traps directly outside of the burrow, with 2 tines in the center of

Figure 2. Double-door trap set-up near a burrow under a fallen tree. Temporary fencing is used to block the path leading out of the burrow entrance and corral the armadillo into the trap.

the trap, which closed both doors when the animal passed through. We also used construction fencing and bamboo stakes in this method, but we left fencing at its original 1.2 m height. Because these traps had 2 doors, we blocked off all other routes of entrance to the burrow with fencing to ensure passage through the double-door trap. When well-used animal trails were evident, we used fencing to intercept the trail and lead the animal to the trap. Traps were camouflaged and handled as with the single-door traps. We set traps in the evening (1600–1900 h) and left them triggered during the day but held open using hooks or zip-ties; this procedure allowed wildlife access to or from the burrow without being captured. In the evening, we reset the traps.

We set traps outside of burrows rather than directly in the mouth of the burrow to minimize the invasiveness of the trap method, as placing traps in the mouth of the burrow would require significant excavation. Placing the traps outside of the burrow also allowed Armadillos to be caught regardless of whether they were entering or exiting the burrow, and thus traps could be opened without the need to confirm that an Armadillo was presently inside the burrow.

We measured capture effort for both cage-trap methods in trap-nights, with 1 trap-night defined as 1 trap open for 1 night. We also calculated total person-hours for time spent setting and checking traps, and calculated efficiency of these methods as (1) the number of trap-nights per Armadillo capture and (2) the number of total person-hours per capture. The latter calculation allowed for direct comparison among all 4 capture methods employed.

Upon capture, Armadillos were weighed, measured, sexed, and aged. We classified Armadillos as juveniles (young-of-the-year) if they weighed <2.5 kg. We ear-tagged captured Armadillos and surgically inserted radiotransmitters in the abdominal cavity following the instructions of Hernandez at al. (2010) for a movement study before release.

Results

Double-door traps had the highest efficiency for any capture method (Table 1). Eight adult Armadillos were captured with double-door Tomahawk traps, which

Table 1. Efficiency of 4 different capture methods for Nine-banded Armadillos in southern Illinois in 2018–2019.

	Spotlighting	Stake-outs	Single-door traps	Double-door traps
Total person-hours	335	73.3	93.3	109
Trap-nights	N/A	N/A	218	201
Captures	1	1	0	8
Sightings	1 sighting/ 41.9 hrs	1 sighting/ 24.4 hrs	N/A	N/A
Efficiency	1 capture/ 335 h	1 capture/ 73.3 h	0 captures/ 217 trap-nights or 93.3 h	1 capture/ 25 trap-nights or 13.6 h

were set for 201 trap-nights. We spent 109 person-hours setting and checking double-door traps. One adult male Armadillo was captured using spotlighting. One female juvenile Armadillo was captured using stake-outs. No Armadillos were captured using single-door Tomahawk traps.

Discussion

The double-door Tomahawk trap was the most efficient method for capturing colonizing Armadillos in southern Illinois. It could be argued that Armadillos may have been more active in June–August rather than May–June when single-door Tomahawks were used (Robertson et al. 2000). However, our records of Armadillo activity in Illinois (C. Haywood, unpubl. data) fluctuated very little between the 2 trapping periods. Resident reports of Armadillos in Illinois were similar throughout 2019, with slightly more reports in May–June (n = 78 reports) than July–August (n = 68 reports). However, the single-door capture method was highly ineffective. Camera-trap data showed 10 separate events at 4 burrows where Armadillos either approached the trap but ultimately went into the burrow without capture or avoided the trap completely. We believe the double-door method was effective because Armadillos were not given the option of avoidance, as they had to enter the trap to enter or exit the burrow. Whereas no Armadillos were caught with the single-door trap, Gammons et al. (2005) captured 1 Armadillo per 82 trap-nights with a similar method. However, comparisons between these studies are tenuous because we placed traps immediately outside of burrows; whereas Gammons et al. (2005) placed in areas with Armadillo sign but avoided areas outside of burrows.

Spotlighting efforts were unproductive, as Armadillo sightings occurred at a low rate, and dipnets were only useful in open areas where they would not become entangled in brush, as noted by Bergman et al. (1995). Using spotlighting to capture Armadillos in more established populations has been far more successful. Robertson et al. (2000) captured an annual mean of 122.6 Armadillos during May–August, observing 0–8 Armadillos per hour each night. It should also be noted that Armadillos are less active in the fall and winter months, which may have contributed to the lack of success of spotlighting and stake outs in September and October (Loughry and McDonough 2013). We believe the stake-out method was deceivingly efficient compared to spotlighting. The only Armadillo captured was a juvenile, which seemed to be easier to capture when using this method than adults likely due to the burrowing habits of Armadillos. Whereas adults tend to frequently change burrows within their home range, juveniles usually remain faithful to the same burrow (Loughry and McDonough 2013). In addition, the burrow of the individual captured was in the backyard of a local resident. This Armadillo regularly foraged close to humans, which may have resulted in a reduced fear of humans, and thereby increased capture success. Using a stake-out method for adult Armadillos in less-urbanized areas is likely less efficient, as no sightings or captures were made when staking out confirmed burrows of adult Armadillos in forested areas during our study.

We recommend double-door traps as an effective and efficient method of capture. Other means of capture, such as the use of trained dogs, can be useful (Bergman et al. 1995). However, trained dogs may not be readily available, and may have a greater cost in comparison to traps (Martin et al. 2014). While studies have shown that a variety of attractants are ineffective in capturing Armadillos (Gammons et al. 2005, Ober et al. 2011), 1 study suggests the use of conspecific scent (Martin et al. 2014), and there is anecdotal evidence that baits such as broken, raw eggs and sardines work well for capture (Loughry and McDonough 2013). It's possible that these baits could improve trapping efficiency in combination with double-door traps. While we suggest the use of double-door traps, we note that our findings were observations made as part of a larger study on the movement and home ranges of Armadillos. Further in-depth studies are needed to confirm the effectiveness of double-door traps.

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