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Abstract: Wildlife managers, researchers, and nuisance-control operators often require a nonlethal means of capturing beavers (*Castor canadensis*). Historically, live-capture has relied on enclosure-type traps such as Bailey or Hancock traps. We describe the live-capture of 231 beavers using snares in southern Illinois from 2002 to 2005. Capture success averaged 5.4 beavers/100 trap-nights. Capture success did not differ between sexes ($P = 0.57$) or age-classes ($P = 0.68$). We captured most beavers in haul-out slide sets, surface run sets, or channel sets. Recaptures accounted for 28% ($n = 65$) of all captures. Mortality rate using snares was 10% and decreased annually during the study period. Snares are advantageous over enclosure-type traps because they have a high capture:cost ratio and are less heavy and cumbersome than traps. However, mortality rates are relatively high, limiting the utility of this technique for some research.

Key words: beavers, *Castor canadensis*, human–wildlife conflicts, live-capture, snare, trapping

Research on beavers (*Castor canadensis*) often requires the live-capture and handling of individuals. Furthermore, removal of nuisance beavers may necessitate live-capturing animals in areas where lethal removal is illegal or unacceptable. Historically, this has required enclosure-type traps, such as Hancock, Bailey, or box traps (Smith et al. 1994, Van Deelen and Pletscher 1996, Koenen et al. 2005). However, there are several disadvantages to using these traps. Enclosure-type traps are heavy, cumbersome, and expensive. Therefore, the number of trap-nights is often limited by practical constraints. The number of traps set at a location is usually limited to how many traps a person has and can transport. Thus, not all the suitable trap locations are set. In addition, much time is needed to create a good set. Finally, in more southern latitudes, beavers are less likely to be attracted to bait in these traps because ample natural food is available year round (Novak 1987).

Trappers have long known the value of snares to capture beavers. Snares are light, inexpensive, and easy to set with little disturbance to beavers' natural environment. Wildlife researchers probably first realized the value of snares in the early 1980s. Mason et al. (1983), Weaver et al. (1985), and Frey et al. (2007) describe the use of snares for research and suggested that snaring might be useful in studies necessitating live capture.

Only 1 study has described snare use to live-capture beavers. McKinstry and Anderson (1998) reported capture success, capture rates of males and females, and mortality rates. Additional research regarding the use of snares for live-capturing beavers, including analyses of monthly capture success and recapture rates, is necessary to better understand the utility of this technique. Herein, we describe our experience snaring and handling beavers in southern Illinois and offer recommendations for efficient, humane use of snares.

Study area

This work was conducted on 2 sites in southern Illinois: a reclaimed surface coal mine in Saline County (Amax Delta [AD]) and a state-owned waterfowl area (Union County Conservation Area [UCCA]) in Union County. The AD site was located in the Southern Till Plain natural division, and the UCCA was located in the Lower Mississippi River Bottomlands natural division (Neely and Heister 1987). The AD site was landlocked, whereas streams and drainage ditches connected the UCCA to the Mississippi River watershed. Dominant vegetation on the AD site included reedgrass (*Phragmites australis*), buttonbush (*Cephalanthus occidentalis*). Maples (*Acer* spp.), oaks (*Quercus* spp.), hickories (*Carya* spp.), and elms (*Ulmus* spp.) were the dominant upland woody vegetation.

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Trapped beaver.

Dominant species on the UCCA were sweetgum (*Liquidambar styraciflua*), pecan (*C. illinoensis*), pin oak (*Q. palustris*), black willow (*Salix nigra*), and cottonwood *(Populus deltoides*). Aquatic vegetation was primarily buttonbush, elodea (*Elodea* spp.), and water lily (*Nymphaea* spp.).

Methods

We constructed all snares using materials obtained via trappers' supply outlets. Snares were constructed of 1-m lengths of 7×7 strand, 2.4-mm diameter stainless steel aircraft cable. Using a bench vise, we crimped a 12-mm nut to 1 end of the cable to act as a stop for the attached swivel. Swivels allow the captured animal to roll over without kinking and weakening the snare. We then crimped a deer stop (another 12-mm nut) approximately 34 cm from the other end of the snare. The stop limited the capture of nontarget animals (*e.g.*, river otters [*Lontra canadensis*]) by keeping the snare from closing smaller than a 12.5-cm circle. The other end of the snare was then doubled over and attached to itself using a washer slide-lock (Burkshire Products, Inc., Sheffield, Massachusetts, USA). We could construct about 10 snares/hour.

We used snares to capture beavers during January to February 2002, August to November 2002, September to December 2004, and September to October 2005 for an ongoing study of beaver ecology in southern Illinois (McNew and Woolf 2005, Nielsen et al. 2005). We set snares at den entrances, dams, haul-out slides, surface runs, and channels. We used scent attractor sets that we constructed to simulate beaver scent mounding stations (Aleksuik 1968) by depositing a mound of substrate and wetland debris on the bank. A small amount of beaver castoreum was applied to the mounds. A snare was set between the mound and the water in a manner that would allow capture of a visiting beaver. For terrestrial snares, a piece of 12-gauge wire was fashioned into a support, either by sticking it in the ground or attaching it to a nearby tree. An N bent into the end of the support wire held the snare in place over the run or haul-out spot. Snare loops were set to about 25 cm in diameter to minimize capture of nontarget animals and set about 8 cm from the ground. We anchored snares with either a ≥ 0.75-m stake or with a swivel to a nearby tree with 2 pieces of 12-gauge wire. Water sets required longer (> 1 m) wooden stakes; dive poles and vegetation were used to funnel beavers into snares. We attached cable leads to snares to allow beavers captured in water sets to reach land.

We checked snares every morning. Captured animals were restrained with a body-gripping catch-pole. Often, trapped beavers wrapped the snare lead around adjacent vegetation or the trap stake, thus restraint with the catch-pole was not required. Nontarget animals were released immediately. We recorded set type and location for all captured beavers.

We immobilized target animals with an intra-muscular injection of ketamine hydrochloride (6–12 mg/kg) and xylazine hydrochloride (0–1.25 mg/kg). Ear tags were applied for identification. We weighed beavers by placing them in a plastic crate and hanging it on a spring scale (accurate to 0.3 kg), and we sexed beavers by palpation for bacula (Osborn 1955). Beavers were assigned to 4 age classes based on weight (McTaggart 2002): kits (<11.0 kg), yearlings (11.0–16.0 kg), subadults (16.0–19.0 kg), and adults (>19 kg). Probable cause of mortality was based on field- or laboratory-based necropsies using procedures described by Woolf (1978) and classified as capture-related heart failure, predation, intra-specific attack, drowning, or unknown. Capture and handling procedures were approved by Southern Illinois University Carbondale's Institutional Animal Care and Use Committee (Southern Illinois University Carbondale Animal Assurance # 01–020).

We calculated overall and monthly capture success by dividing the number of captures by the number of trap-nights. We used Chi-square tests in program CONTRAST to determine differences in capture success among months, sexes, and age-classes (Hines and Sauer 1989). Similar tests were used to determine whether recapture rates differed by sex and age. We considered $P < 0.05$ to be significant.

Results

Capture success

We captured 231 beavers (166 different individuals) in 4,316 trap-nights, a success rate of 5% (5.4 beavers/100 trap-nights); 1.5 beavers

Table 1. Comparison of capture success (capture/trap-nights) and capture-related mortality rates of beavers among studies using snares and enclosure-type traps.

Study	Location	Trap Type	Capture Success (%)	Capture Mortality Rate (%)
This study	Ill.	Snares	5.4	10.0
Weaver (1986)	Miss.	Snares	7.0	12.2
Mason et al. (1983)	N/A	Snares	5.2	——
Van Deelen (1991)	Mont.	Hancocks	12.2	0.0
Koenen et al. (2005)	Mass.	Box Traps	12.0	0.0
Collins (1976)	Wyo.	Baileys	——	0.0
Jackson (1990)	Mont.	Hancocks	10.0	3.1
Smith et al. (1994)	Wis.	Hancocks & Baileys	17.8	4.2
McKinstry and Anderson(1998)	Wyo.	Snares	8.4	7.5

were captured/night of effort. Sixty-five of the 231 (28%) captures were adults, 51 (22%) were subadults, 65 (28%) were yearlings, and 40 (17%) were kits (Table 1). The ages of 10 (4%) beavers were unknown. Overall, there was no difference in the proportion of females (0.52) or males (0.48) captured (χ^2_1 = 0.3, P = 0.57). Monthly capture success tended to increase throughout the study period. On average, we observed 14% increase in capture success from 1 capture month to the next. This trend was common for all age classes except that of kits, which showed no monthly increase in capture success.

We captured most beavers in haul-out slide sets, surface run sets, or channel sets, which accounted for 64 (28%), 47 (20%), and 43 (19%) captures, respectively. Scent attractor, dam, and den/lodge entrance sets accounted for 9%, 7%, and 7% of all captures, respectively. Relative set-type success was undeterminable because set type-specific trap-nights were not recorded during the study period. We did not specifically document where on the body each beaver was captured, but >80% of beavers were captured around the torso.

Recaptures accounted for 28% (n = 65) of all captures, and most recaptures were recaptured only once, although 1 beaver was captured 8 times (Figure 1). The recapture rates of yearlings, subadults, and adults were generally similar at 28%. The recapture rate of kits was 12%, but there were no differences in recapture rates among age-classes ($\chi^2_{3,\ 217}$ = 4.5, P = 0.20). When age-classes were combined, 30% of males and 28% of females were recaptured at least once. Moreover, capture to recapture ratios did not differ among specific sex/age-classes ($\chi^2_{7,\ 192}$ = 7.2, P = 0.41).

Twenty-two nontarget animals were captured; 16 raccoons (*Procyon lotor*), 3 river otters (*Lontra canadensis*), 2 snapping turtles (*Chelydra serpentina*), and 1 muskrat (*Ondatra zibethicus*). Two raccoons were found dead in snares; no other nontarget captures were physically impaired as a result of being snared and were released without incident.

Capture-related mortality

Twenty-three beavers (10% of total captures, 11 adults, 8 juveniles, 4 kits; 9 males, 14 females) died as a result of being trapped or handled. Twelve beavers died in the snare; 5 from heart failure, 2 from suffocation due to being snared by the neck, 2 from bites inflicted by another beaver, 2 from drowning, and 1 was killed by a predator. Seven beavers died in the recovery crate of stress-related heart failure. One beaver drowned after forcing its way out of the recovery crate and into the water before it completely recovered from immobilization,

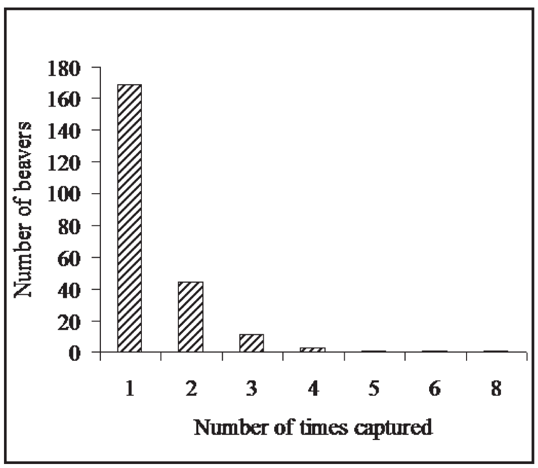

Figure 1. Number of times individual beavers were captured using snares in southern Illinois, 2002 to 2005.

and 1 beaver suffered the same fate after being released before fully recovering. One beaver pulled the trap stake out of the ground, leaving the snare around its torso; when recaptured 2 weeks later, it was euthanized. One beaver died of unknown causes 5 days after being captured and handled. Because it survived <7 days after capture, its death was assumed to be capture-related. Mortality rates among males (8%) and females (13%) did not differ ($\chi^2_{1,206}$ = 1.4, P = 0.25). We found no differences in mortality rates among kits (10%), yearlings (11%), subadults (3%), or adults (17%) ($\chi^2_{3,\ 217}$ = 6.9, P = 0.08). Furthermore, mortality rates decreased over the course of the study; the average monthly decline in the capture mortality rate was 6%.

Discussion

Capture success

Our overall capture success (5/100 trap-nights) using snares was similar to that of other snaring studies (Table 1). Capture success increased over the course of the study. This was likely due to increased trapper experience over time. As the study proceeded, we began to focus on sets that produced the most captures (haul-out slide sets, surface run sets, and channel sets) and to avoid sets that had produced fewer captures (scent attractor sets, dam sets, and den/lodge entrance sets). Others have noted that trapper experience leads to increased success over time (Weaver 1986, Koenen et al. 2005).

We observed that capture success in autumn increased as the season progressed. We attribute this to changes in beaver foraging behavior due to differing availability of food. Beavers have been reported to prefer aquatic vegetation over woody species during spring and summer (Brenner 1962, Novak 1987), and they likely limit their movements to the water when these species are prevalent. In September, there was still abundant aquatic vegetation on our study areas, and beavers had less cause to leave the safety of water to find food. Beavers were likely more vulnerable to trapping in late autumn due to increased terrestrial foraging and lodge maintenance activities.

Success could have been greater had we limited sets to those that produced the most captures. However, we were attempting to capture as many beavers as possible in the shortest amount of time. Our age-structure information for beavers obtained via snaring may be biased, but sex ratios probably are not. This conclusion is based on comparisons with those of a recent study in central Illinois (McTaggart and Nelson 2003) that reported the age-structure to be 34% adult, 34% juvenile, and 32% kits. These results were based on trapping out all beavers from colonies using conibear traps. Because we were using snares and needed to limit trap sets to those in shallow water and on land to keep animals alive, our method likely biased trap success toward older beavers because kits do not travel far from the lodge and rarely leave the safety of water (Hodgdon and Lancia 1983). Capture rates were similar for males and females in our study and for McTaggart and Nelson (2003). Given that beaver sex-ratios are generally 1:1 (Novak 1987), it appears that the use of snares does not result in sex-related trapping bias. This is because the sexes move and behave similarly outside of the lodge (Novak 1987), and therefore are equally susceptible to trapping (McTaggart and Nelson 2003).

Recaptures using snares were common (28%), suggesting that the ability of beavers to recognize sets is limited. Snares are inconspicuous, small, and appear as a vine or other vegetation. The recapture rates of beavers in other studies using snares and enclosure traps have generally not been reported with the exception of Jackson (1990) and VanDeelen (1991), who recaptured approximately 6% and 23% of beavers, respectively, using Hancock traps.

Reducing capture-related mortality

Most of our beavers that died did so while struggling in the snare. To reduce these mortalities, researchers should avoid sets on steep haul-out slides, which in our study were always more severely destroyed than others, indicating beavers struggled more in sets on steeper slopes. Any objects (e.g., logs, stumps) upon which a snared beaver might crawl and hang itself over should be removed. Two beavers in this study and one in Weaver's (1986) study suffocated as a result of this behavior. Two of our beavers drowned because they had entangled their snares in submerged vegetation and could not get to the surface. We resolved this problem by removing underwater vegetation and debris at sets. Beavers should be held for $\geq$2 hours from time of injection of immobilizing drugs to allow them to recover. Two beavers drowned before fully recovering from the anesthetic. Securing the lids of plastic recovery crates with bungee cords and staking the crates in place eliminated this problem. Two beavers died from intra-specific attacks in snares set close to their lodge. We believe the abnormal behavior of a beaver in a snare may trigger a defensive reaction in the other members of their colony. It seems unlikely that a transient beaver would attack a resident individual close to its own lodge, and researchers generally agree that transients are at far greater risk of intra-species attacks than residents (Novak 1987). Weaver (1986) also observed fresh bite marks in the backs of beavers captured in snares but was unable to account for the cause. Therefore, we recommend excluding sets from within 20 m of

Beaver tagged and swimming.

established lodges or bank dens.

Snares versus enclosure-type traps

All capture techniques have advantages and disadvantages to their use, and our analysis lends itself to a comparison between snares and enclosure-type traps. Snares are easier to set and much less cumbersome than enclosure-type traps. However, we also assessed snares versus enclosure-type traps based on capture success, capture:cost ratio, and potential for mortality. Capture success (captures/trap-night) is generally lower for snares than for enclosure-type traps (Table 1). We believe this is due to the fact that study areas are saturated with snares, substantially increasing the total number of trap-nights. Although our capture success was only 5%, we were able to capture 1.5 beavers/day, which is probably greater than studies using enclosure-type traps. However, we are unable to substantiate this claim because capture success is typically reported as beavers captured/trap-night, not beavers captured/night of effort.

In addition, snares provide a higher capture:cost ratio because they cost ~$1.25 each to purchase or ~$0.70 each to build, whereas Bailey and Hancock traps retail at ≥$350 each. Therefore, for the price of 1 trap, researchers could purchase 280 snares or the components to build 500 snares. We used ~500 snares to capture 231 beavers in 153 nights at a total cost of <$350. At the highest reported trap success rate (12%; Weaver 1986), we would have been able to catch 19 beavers in the same amount of time for the same cost. At that rate, it would have taken ~12 traps to capture 231 beavers at a cost of >$4,000.

Conclusions

Although relatively effective, enclosure-type traps suffer from the constraints of expense, size, and transport. Our evaluation suggests that snares offer a cost-effective alternative for live-capturing beavers. Where snares are legal to use, they can be advantageous because they have a higher capture:cost ratio and are less difficult to handle than traps. Furthermore, accidental snare-related mortality can be limited using proper care and placement of sets. Notwithstanding, snares can cause occasional mortality, which may limit utility of this technique for research projects that require live animals.

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Craig K. Bloomquist (photo below) is currently pursuing an M.S. at the Cooperative Wildlife Research Lab at Southern Illinois University–Carbondale. His research includes beaver behavior, space use, and survival in southern Illinois. He received a B.S. degree in fisheries and wildlife from Michigan State University.