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Welfare Performance of Three Foothold Traps for Capturing North American River Otters *Lontra canadensis*

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Notes

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Abstract

Foothold traps are effective tools for the live capture and restraint of wildlife for management and research. Successful river otter *Lontra canadensis* restoration programs throughout North America used them extensively. Restoration programs used a variety of methods and models of foothold traps, but comprehensive efforts to describe and quantify injuries associated with river otter captures have been limited. We evaluated injuries of river otters caught in three commercially available models of foothold traps including the number 11 double long-spring with standard jaws, the number 11 double long-spring with double jaws, and the number 2 coil-spring trap. Based on examinations of 70 captured river otters, we classified 78% of the total inj uries detected as “mild” ($n = 174$ injuries) and 17% were classified as “moderate” ($n = 37$ injuries). We classified less than 3% of the injuries observed as “moderately severe” or “severe.” We focused only on the animal welfare performance of traps; the three trap types we tested met the animal welfare criteria required for inclusion in the best management practices for trapping river otter. The criteria based on International Standards Organization guidelines used in this assessment of trap performance provides a scientific basis for future evaluations of river otter welfare when foothold traps are used for restoration, research, and population management.

Keywords: river otters; animal welfare; foothold traps; injury assessment; *Lontra canadensis*

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Introduction

Foothold traps are effective tools for the live capture and restraint of wildlife for management and research programs worldwide (Schemnitz et al. 2009; White et al. 2015). During the past 50 y, 23 state wildlife management agencies implemented river otter *Lontra canadensis* reintroduction efforts (Erb et al. 2018; Raesly 2001; Roberts et al. 2020). Agencies used variety of methods and models of foothold traps and several designs of cage-type traps during these successful restoration programs but comprehensive efforts to describe and quantify injuries associated with river otter captures have been limited (Serfass et al. 1996; Blundell et al. 1999; Belfore 2008; Rutter et al. 2020).

Research addressing the efficiency and animal welfare performance of foothold trap designs commonly used to capture and restrain wildlife intensified throughout North America during the 1990s, due largely to multinational interests to improve animal welfare performance. These interests resulted in a nonbinding agreement between the European Community and the United States of America on humane trapping standards (Agreed Minute; European Commission 1998) and development of best management practices (BMPs) for trapping in the United States (White et al. 2021). The BMPs program is a field-based trap-testing program coordinated by the Association of Fish and Wildlife Agencies and cooperating state wildlife agencies. Extensive testing of foothold traps in this program has resulted in trapping BMPs for 23 species of furbearers. As part of the broader effort to develop trapping BMPs for river otters, we evaluated animal welfare performance of three foothold trap types by quantifying the types, frequencies, and relative severities of injuries sustained, and then compared capture-related injuries to other published reports.

Study Sites

Field personnel trapped river otters in the southeastern United States (Arkansas, North Carolina, South Carolina, and Tennessee) and Missouri, where river otter populations were known to be abundant and where we were able to find experienced and skilled trappers to capture them. This allowed for trapping to occur in diverse conditions (e.g., weather, soil conditions, habitats) and in areas with varying abiotic and biotic conditions that may affect trap performance. Traps captured river otters in riparian corridors, swamps, marshes, reservoirs, and artificial impoundments that were flooded for wintering waterfowl. Climate in the Southeastern United States is predominated by mild temperatures with fully humid, hot summers (Chen and Chen 2013). Major land use and land cover types include deciduous forest (23.0%), evergreen forest (13.8%), pasture-hay (12.7%), and woody wetlands (11.2%; Homer et al. 2015). Missouri has a humid continental type of climate (Köppen climate classification Dfa) in its northern portion and humid subtropical (Köppen climate classification Cfa) type of climate in its southern part. Summers are hot and long, while winters are cold and snowy. The annual rainfall in Missouri ranges from an average 40 inches (1,016 mm) in the north to 45 inches in the south. Snowfall is moderate to heavy, with an average of 15 snowy days in the year that gathers 15 to 20 inches of snowfall. Missouri receives ample sunshine of at least 2,500 to 2,800 h annually across the state. The average relative humidity lies between 65 and 70% and is at the highest during spring and summer (Yu Media Group 2021). Relative to land use and coverage, Missouri consists of farmland (63%; the majority of which is cropland and pastureland), forested land (31.9%; USDA 2017), and various types of wetlands including swamps, shrub swamps, forested wetlands, marshes, wet meadows, fens and seeps, pond and lake borders, and stream banks, which make up about 1.4% of the state's surface area (US Geological Survey 1997).

Methods

We evaluated three commercially available models of foothold traps, specifically the number 11 double long-spring with standard jaws (11S), the number 11 double long-spring with double jaws (11DJ), and the number 2 coil-spring trap (2C). Sleepy Creek Manufacturing (Berkeley Springs, WV) manufactured both models of number 11 double long-spring traps whereas Oneida-Victor Inc. (Cleveland, OH) manufactured the number 2 coil-spring trap. Chaining systems used to anchor traps included four swivels and a shock spring and were consistent across the three trap types tested. The chain construction included one swivel at the anchor point followed by two links of size 2/0 chain, one swivel attached to each end of a shock-spring (PIT no. 17; 14.5-kg pull) followed by three links of size 2/0 chain, and one swivel followed by one link of size 2/0 chain attached to the center of the trap base-plate (Figure 1).

River otter captures

We used two-person teams that consisted of one experienced private trapper responsible for deploying traps and one field technician responsible for local project management and data collection. We selected trappers in areas with relatively abundant populations of river otters and from different geographic locations within a state or region to encompass a broad range of trapping conditions. Trappers followed manufacturer's instructions for restraining traps and used their own knowledge and experience to capture river otters on their established traplines. Trappers conducted capture activities during regulated trapping seasons and adhered to all state trapping regulations. We instructed trappers to set two traps of the same design at each site, which we refer to as a trap station. To avoid bias, each trapper selected a location for a trap station and then the technician randomly assigned a specific model of restraining trap to test at the station. Traps were set within each trap station from 3 to 10 m apart at the

Figure 1. Three models of foothold traps: number 11 double long-spring trap with double jaws (bottom), number 11 double long-spring trap with standard jaws (center), and number 2 coil-spring trap (top) used to capture 70 river otters *Lontra canadensis* to assess trap-related injuries in Arkansas, Missouri, North Carolina, and South Carolina during 1999 to 2007. Chaining systems were consistent among trap types. All three trap types met animal welfare criteria established within the Best Management Practices for Trapping program.

discretion of the trapper. Trap stations were a minimum distance of 100 m apart to increase spatial independence. Technicians recorded set-related data as well as daily trap check information. Trappers deployed the traps for up to 21 d or until each trap type captured a combined total of at least 20 river otters.

Our objective was to quantify injuries associated with the use of foothold traps for live restraint of river otters. Hence, trappers did not deploy traps in sets that would potentially result in drowning or mortality due to other factors. Notwithstanding that restriction, trappers deployed traps using their preferred set locations or methods (e.g., on land or near the water's edge). We required trappers to check each trap daily and remove captured animals before 1200 hours. At each trap station, technicians recorded the species responsible, if possible, for activity at the set including captured and restrained, temporarily captured but not restrained upon inspection, traps activated with no evidence of a capture, and trap sites disturbed but the trap not activated. For each captured river otter, technicians recorded which foot was secured in the trap, the capture position of that foot (e.g., toe, metatarsal or metacarpal pad, wrist, or leg proximal to wrist), and the physical condition (i.e., alive, dead, unconscious) when the trap was checked. Trappers used a .22 caliber rimfire firearm to dispatch captured river otters. Consistent with the American Veterinary Medical Association guidance for euthanizing captured animals, trappers placed shots to the head to ensure rapid and humane death and avoid damage to teeth, legs, or other body parts that could influence postmortem examination results (Sikes et al. 2011; American Veterinary Medical Association 2020). Technicians marked each dispatched river otter with a unique identification number, secured the river otter in a sealed plastic bag, and then froze each specimen following completion of daily trap checks. Trappers released any non-furbearing species (domestic or wild) and any furbearers with closed seasons or that were otherwise not legal to trap in the state where testing occurred.

Injury assessments

Wildlife veterinary pathologists experienced with evaluating trap-related injuries used established procedures to conduct comprehensive whole-body postmortem examinations. To avoid bias, pathologists did not have knowledge of the trap model or any capture-related information, including the foot that each river otter was held by, prior to examination. In cases where physical injuries were difficult to detect by visual observation, pathologists used radiograph examinations of river otter limbs to verify trap-related trauma. Pathologists reported results using the International Organization for Standardization (ISO) methods for scoring specific injuries from restraining traps (ISO 1999). Pathologists determined the sex and age of each river otter; age was determined based on body weights, condition and wear on the teeth, size of the penis and testicles for males, and evidence of pregnancy or placental scars for females.

We used two methods described by ISO (1999; much of which was also described in the Agreed Minute [European Commission 1998]) to evaluate welfare of animals captured in restraining traps (White et al. 2021). The ISO protocols did not include thresholds for acceptable levels of physical trauma, but rather established standardized and comprehensive approaches to evaluate physical trauma using postmortem examination of injuries. The first method assigned points to each specific injury, which ranged from 0 points (no injury) to 100 points for more severe types of injuries (e.g., severance of major tendon, trap-related mortality). The sum of all injuries sustained by a single river otter constituted the cumulative injury score. The second system assigned each observed injury to predetermined ISO trauma categories, specifically "mild," "moderate," "moderate-severe," or "severe." We quantified the animal welfare performance of each trap using two metrics: mean cumulative injury score, and the percentage of individuals in the sample exhibiting either no injuries or injuries categorized only as mild or moderate. We intended this two-pronged approach to account for animal welfare concerns associated with multiple lesser injuries as well as single greater injuries. We used χ^2 tests to compare age and sex rations of captured river otters across trap types and analysis of variance to compare cumulative injury scores associated with the three trap types.

Table 1. Numbers of river otters *Lontra canadensis* captured in three foothold trap types: number 11 double long-spring traps with double jaws (11DJ), number 11 double long-spring traps with standard jaws (11S), and number 2 coil-spring traps (2C), by jurisdiction, sex, and age, during the development of best management practices for trapping river otters 1999-2007.

		Trap type		
State and sex	**Age**	**11DJ (n = 22)**	**11S (n = 21)**	**2C (n = 27)**
Arkansas				
Female	Adult	1	1	6
	Yearling	0	0	0
Male	Adult	1	7	0
	Yearling	0	0	0
Missouri				
Female	Adult	2	4	2
	Yearling	1	1	1
Male	Adult	6	5	2
	Yearling	1	1	0
North Carolina				
Female	Adult	1	0	3
	Yearling	1	0	0
Male	Adult	8	2	7
	Yearling	0	0	1
South Carolina				
Female	Adult	0	0	1
	Yearling	0	0	0
Male	Adult	0	0	3
	Yearling	0	0	1
States pooled				
Female	Adult	4	5	12
	Yearling	2	1	1
Male	Adult	15	14	12
	Yearling	1	1	2

Results

A total of 70 river otters were captured during 1999 (n = 2), 2004 (n = 4), 2005 (n = 4), 2006 (n = 42), and 2007 (n = 18) in Arkansas (n = 16), Missouri (n = 26), North Carolina (n = 23), and South Carolina (n = 5; Table 1). Trappers restrained 22 river otters in the 11DJ trap, 21 in the 11S trap, and 27 in the 2C trap. Eighty percent of river otters were captured by a front foot; the proportion of front foot to hind foot captures was similar across all trap types (χ^2 = 1.193, df = 2, P = 0.551). Thirty-eight percent of the river otters trapped were females; the sex ratio of captured river otters was similar across all trap types (χ^2 = 2.97, df = 2, P = 0.227). Eighty-nine percent of the river otters captured were adults; the age ratio of captured river otters was similar across all trap types (χ^2 = 0.184, df = 2, P = 0.912; Table 1). Mean body weights were 7.0 kg (SD = 1.3 kg) for adult females, 5.2 kg (SD = 1.3 kg) for yearling females, 8.8 kg (SD = 1.7 kg) for adult males, and 5.4 kg (SD = 0.5 kg) for yearling males.

All river otters were alive and active prior to dispatch by trappers. One river otter captured in an 11S trap had no injuries based on postmortem examinations. Pathologists conducted radiograph examinations to further investigate potential injuries on two river otters. The mean number of unique injury types observed per individual river otter was three and ranged from zero to six (Table 2).

Edematous swelling or hemorrhage was the most common injury; observer noted it on 67 of the 70 (96%) river otters examined (Table 2). Other common injuries, all classified as mild, included minor subcutaneous soft-tissue maceration or erosion (n = 43; 61%), minor cutaneous lacerations (n = 35; 49%), and minor periosteal abrasions (n = 22; 31%). Joint luxation at or below the carpus or tarsus was the most common (26–33% of animals observed) moderate injury observed on river otters captured with 11S and 11DJ traps; this injury was uncommon (n = 1; 4%) with the 2C trap (Table 2). Conversely, dental injuries were the most common (n = 5; 19%) moderate injury in the 2C trap but were rare (0–5%) in both models of number 11 traps.

Mean cumulative injury scores were 39.4 for the 11DJ, 48.3 for the 11S, and 45.3 for the 2C trap (Table 3). Mean cumulative injury scores were similar across trap types (F = 0.37, df =2, P = 0.694). There was no difference in mean cumulative injury scores between sexes (t = 1.42, P = 0.162) or age classes (t = –0.37, P = 0.721) of the river otters we examined. Heavier river otters generally exhibited lower cumulative injury scores, but the correlation was not strong (r = –0.207, P = 0.085).

Based on examinations of 69 river otters exhibiting injuries, we classified 174 (78%) of the total injuries detected as mild and 37 (17%) were classified as moderate. We classified 11 ($<$ 3%) of the observed injuries as moderately severe or severe (Table 2). Mild injuries were the most frequently observed classification for all three trap types evaluated (Table 3). Observers noted moderate injuries on six (27%) of river otters captured in the 11DJ traps, 10 (48%) of river otters captured in the 11S traps, and 14 (52%) of river otters captured in 2C traps. Twenty (91%) of the river otters captured in the 11DJ traps exhibited only mild or moderate injuries. Seventeen (81%) of the river otters captured in 11S traps exhibited either no injuries or only mild or moderate injuries. Twenty-two (82%) river otters captured in the 2C traps exhibited only mild or moderate injuries (Table 4).

Discussion

For traps to meet BMP animal welfare criteria for a given species, the mean cumulative injury score must be $\leq$ 55 points, and $\geq$ 70% of individuals in the sample must have either no injuries or injuries categorized only as mild or moderate. The three trap types we tested for river otters met these animal welfare criteria. The ISO criteria used in this assessment of trap performance provides a scientific basis for future evaluations of river otter welfare when researchers or population managers use foothold traps (ISO 1999).

Previous researchers have used variety of approaches to assess the welfare performance of traps used to capture river otters and, less frequently, to comprehensively identify and quantify all injuries sustained by captured river otters. Belfiore (2008) evaluated five models of foothold traps, including the 11S trap evaluated in our

Table 2. Organization for Standardization (ISO) injury type, class, score, and distribution for all injuries sustained by 70 river otters *Lontra canadensis* captured in three foothold trap types: number 11 double long-spring trap with double jaws (11DJ), number 11 double long-spring trap with standard jaws (11S), and number 2 coil-spring trap (2C) tested in live-restraining sets in Arkansas, Missouri, North Carolina, and South Carolina during 1999 to 2007.

Injury category	ISO code	Trauma type	Trauma score	Trap types: 11DJ ($n = 22$) n	%	11S ($n = 21$) n	%	2C ($n = 27$) n	%
None	0	No trauma	0	0	0	1	5	0	0
Mild	1	Claw loss	2	1	4	2	10	4	15
Mild	2	Edematous swelling or hemorrhage	5	22	100	19	90	26	96
Mild	3	Minor cutaneous laceration	5	11	48	10	48	14	52
Mild	4	Minor subcutaneous soft-tissue maceration or erosion (contusion)	10	15	68	17	81	11	41
Mild	5	Major cutaneous laceration, except on foot pads or tongue	10	0	0	0	0	0	0
Mild	6	Minor periosteal abrasion	10	8	35	7	33	7	26
Moderate	7	Severance of minor tendon or ligament (each occurrence)	25	0	0	2	10	3	11
Moderate	8	Amputation of one digit	25	0	0	0	0	3	11
Moderate	9	Permanent tooth fracture exposing pulp cavity	30	0	0	1	5	5	19
Moderate	10	Major subcutaneous soft-tissue maceration or erosion	30	2	9	0	0	2	7
Moderate	11	Major laceration on foot pads or tongue	30	0	0	0	0	2	7
Moderate	12	Severe joint hemorrhage	30	0	0	0	0	0	0
Moderate	13	Joint luxation at or below carpus or tarsus	30	6	26	7	33	1	4
Moderate	14	Major periosteal abrasion	30	1	4	0	0	1	4
Moderate	15	Simple rib fracture	30	0	0	0	0	0	0
Moderate	16	Eye lacerations	30	0	0	0	0	0	0
Moderate	17	Minor skeletal muscle degeneration	30	0	0	1	5	0	0
Moderate-severe	18	Simple fracture at or below carpus or tarsus	50	0	0	1	5	1	4
Moderate-severe	19	Compression fracture	50	0	0	0	0	0	0
Moderate-severe	20	Comminuted rib fracture	50	0	0	0	0	0	0
Moderate-severe	21	Amputation of two digits	50	0	0	0	0	1	4
Moderate-severe	22	Major skeletal muscle degeneration	55	0	0	0	0	0	0
Moderate-severe	23	Limb ischemia	55	0	0	1	5	1	4
Severe	24	Amputation of $\geq$ 3 digits	100	0	0	1	5	1	4
Severe	25	Any fracture or joint luxation on limb above carpus or tarsus	100	2	9	0	0	0	0
Severe	26	Any amputation above digits	100	0	0	0	0	0	0
Severe	27	Spinal cord injury	100	0	0	0	0	0	0
Severe	28	Severe internal organ damage (internal bleeding)	100	0	0	1	5	0	0
Severe	29	Compound or comminuted fracture at/below carpus or tarsus	100	0	0	0	0	1	4
Severe	30	Severance of major tendon or ligament	100	0	0	0	0	0	0
Severe	31	Compound rib fractures	100	0	0	0	0	0	0
Severe	32	Ocular injury resulting in blindness of an eye	100	0	0	0	0	0	0
Severe	33	Myocardial degeneration	100	0	0	0	0	0	0
Severe	34	Mortality	100	0	0	0	0	0	0

study, to capture river otters in California and developed an injury rating scaled from "class I," for relatively minor injuries, to "class IV," for severe injuries. Although Belfiore did not describe specific injuries by trap type, 79% of the river otters captured exhibited class I injuries. Fernandez-Moran et al. (2002) used a similar injury scoring system to quantify injuries sustained by Eurasian otters *Lutra lutra* captured in 1.5 Soft Catch© traps (Woodstream Corp., Lititz, PA) and reported that 79% of the 43 Eurasian otters captured exhibited class I injuries. Many of the injuries described as class I (e.g., minor swelling, claw loss, and small abrasions) during these investigations were consistent with the mild injury category in our evaluations (Table 2). Similar to these studies, 78% of the injuries we detected using three trap types were classified as mild, suggesting that researchers can expect similar frequencies of mild injuries when using traps of similar size and design. Blundell et al. (1999) used the ISO scoring system to compare injuries associated with river otter captures in 11S and Hancock cage traps (Hancock Trap Co, Custer, SD; Olsen et. al 1986). They reported that cumulative injury scores for 30 river otters captured in 11S traps ranged from 0 to 100, with a median score of 5. Median cumulative injury scores for river otters captured in 11DJ and 11S during our study were 28.5 and 45, respectively. The lower cumulative injury scores reported by Blundell et al. (1999) may be attributed to their ability to check traps several times each day and their use of trap transmitters to detect and quickly respond to river otter captures.

Dental injuries are classified as moderate based on ISO scoring and are of particular concern as they could affect an individual's ability to capture and consume prey (Van Valkenberg 1988). Dental injuries associated with river otters captured in Hancock cage traps have been substantial (e.g., > 45% of river otters captured in Alaska) and dental injuries are permanent whereas foothold trap–related injuries usually heal with no apparent debilitation (Shirley et al. 1983; Blundell et al. 1999). Rutter et al. (2020)

Table 3. Cumulative injury score statistics based on evaluations of 70 river otters *Lontra canadensis* captured in Arkansas, Missouri, North Carolina, and South Carolina during 1999 to 2007 in three trap types: number 11 double long-spring traps with double jaws (11DJ), number 11 double long-spring traps with standard jaws (11S), and number 2 coils-spring traps (2C).

Trap type	*n*	Mean	SE	95% CI	Median	Range
11DJ	22	39.4	6.2	25.3–54.0	28.5	10–105
11S	21	48.3	9.2	33.3–63.3	45.0	0–155
2C	27	45.3	6.2	32.1–58.6	40.0	5–135

documented a 25% tooth fracture rate for river otters captured in Comstock Custom Cage traps (Comstock Custom Cage LLC, Gansevoort, NY) in southern Illinois. Tooth damage has been a major consideration in river otter trap selection for research and restoration and Shirley et al. (1983) and Blundell et al. (1999) have recommended foothold traps over cage-type traps. We observed no dental injuries from river otters captured in 11DJ traps; one (5%) river otter captured in 11S traps had a dental injury, which was consistent with Blundell et al. (1999) who found that 6% of the 30 river otters captured in 11S traps had injured teeth. Dental injuries were more common ($n = 5$; 19%) in the larger 2C traps that we tested; Fernandez-Moran et al. (2002) indicated that 19% of the Eurasian otters captured in 1.5 Soft Catch traps exhibited oral cavity or dental injuries. Serfass et al. (1996) reported that 42% of the 38 river otters captured in 1.5 Soft Catch traps equipped with rubber padded jaws, for reintroduction in Pennsylvania, exhibited canine-tooth injuries and 26% exhibited injuries to incisors. Of the 17 river otters captured in 11S double long-spring traps for reintroductions in Pennsylvania, 11 (65%) exhibited canine-tooth injuries and 4 (24%) exhibited incisor injuries. Serfass et al. (1996) used a chaining system that ranged from 0.5 to 1.5 m in length and was anchored to steel plates. Other studies have recommended shorter chaining systems and have suggested that longer chaining systems may result in higher injury rates (Belfiore 2008; Blundell et al. 1999).

We acknowledge that the issue of animal welfare is complex and involves not only physical injury, but other considerations as well (e.g., pain, distress). However, we selected injury as the primary criterion to evaluate animal welfare based on the recommendations of the ISO. Other potential methods or components of welfare could include criteria related to behavior, physiology (stress), immunology, and molecular biology, but the ISO process concluded that there was insufficient knowledge or technology to incorporate those potential metrics (ISO 1999). Likewise, we remain unaware of any cumulative metric that addresses these considerations, can be reliably measured in typical field situations, is science-based, and has a broadly accepted threshold for acceptance. For these reasons, we focused on quantifying injury levels across trap models using standardized ISO scoring protocols, with a goal of improving animal welfare when live-trapping river otters.

Although the development of the ISO testing standards resulted in internationally agreed-upon trap testing and injury measurement protocols, it did not provide an international agreement that included acceptable injury thresholds. Criteria and thresholds developed for BMPs were based on the level of injury that was deemed unlikely to directly or indirectly (i.e., through behavioral changes) have a meaningful effect on subsequent survival or reproduction for > 70% of the animals. Because ISO injury assessments required whole-body necropsies, it was not possible to relate observed injury scores with subsequent release, monitoring, behavior, or survival of captured river otters. Instead, BMP threshold development relied on expert opinion from individuals who had been involved in the ISO process, along with that from other experienced biologists and wildlife veterinary pathologists in the United States.

Table 4. Distribution of Organization for Standardization (ISO) injury-class data from 70 river otters *Lontra canadensis* captured in three foothold trap models: number 11 double long-spring traps with double jaws (11DJ), number 11 double long-spring traps with standard jaws (11S), and number 2 coils-spring traps (2C) tested in live-restraining sets in Arkansas, Missouri, North Carolina, and South Carolina during 1999 to 2007.

	Trap types		
ISO injury categories	11DJ ($n = 22$)	11S ($n = 21$)	2C ($n = 27$)
No injuries (ISO 0)	0	1	0
Mild injuries (ISO 1–6)	22	20	27
Moderate injuries (ISO 7–17)	6	10	14
Moderately severe injuries (ISO 18–23)	0	2	3
Severe injuries (ISO 24–34)	2	2	2

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References

American Veterinary Medical Association. 2020. AVMA guidelines for the euthanasia of animals: 2020 edition. Schamburg, Illinois: American Veterinary Medical Association.

Belfiore NM. 2008. Trapping and handling of North American river otters (*Lontra canadensis*) in a managed marsh. Journal of Zoo and Wildlife Medicine 39:13–20.

Blundell G, Kern TJ, Bowyer R, Duffy L. 1999. Capturing river otters: a comparison of Hancock and leg-hold traps. Wildlife Society Bulletin 27:184–192.

Chen D, Chen HW. 2013. Using the Köppen classification to quantify climate variation and change: an example for 1901–2010. Environmental Development 6:69–79.

Erb J, Roberts NM, Dwyer C. 2018. An otterly successful restoration. Wildlife Professional 12:45–49.

European Commission. 1998. Agreed minute and annex: standards for the humane trapping of specified terrestrial and semiaquatic mammals. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A21998A0807%2801%29 (July 2021).

Fernandez-Moran J, Saavedra D, Manteca-Vilanova X. 2002. Reintroduction of the Eurasian otter (*Lutra lutra)* in northeastern Spain: trapping, handling, and medical management. Journal of Zoo and Wildlife Medicine 33:222–227.

Homer L, Dewitz C, Yang L, Jin S, Danielson P, Xian G, Coulston J, Herold N, Wickam J, Megown K. 2015. Completion of the 2011 National Land Cover Database for the Conterminous United States—representing a decade of land cover change information. Photogrammetric Engineering & Remote Sensing 88:345–354.

[ISO] International Organization for Standardization. 1999. Animal (mammal) traps-part 5: methods for testing restraining traps (ISO-10990-5:1999E). Geneva, Switzerland: ISO.

Olsen GS, Linhart R, Holmes G, Dasch, Male C. 1986. Injuries to coyotes caught in padded and unpadded steel foothold traps. Wildlife Society Bulletin 14:219–223.

Raesly EJ. 2001. Status of river otter reintroduction projects in the United States. Wildlife Society Bulletin 29:856–862.

Roberts NM, Lovallo MJ, Crimmins SM. 2020. River otter status, management, and distribution in the United States: evidence of large-scale population increase and range expansion. Journal of Fish and Wildlife Management 11:279–286.

Rutter A, Hanrahan A, Nielsen C, Schauber E. 2020. Functionality of a new live-capture device for river otters. Journal of Fish and Wildlife Management 11:238–244.

Schemnitz SD, Batcheller GR, Lovallo MJ, White HB, Fall MW. 2009. Capturing and handling wild animals. Pages 232–269 in Silvy NJ, editor. The wildlife techniques manual. Baltimore, Maryland: Johns Hopkins University Press.

Serfass T, Brooks R, Swimley T, Rymon L, Hayden A. 1996. Considerations for capturing, handling, and translocating river otters. Wildlife Society Bulletin. 24:25–31.

Shirley MG, Lincomb RG, Sevin LR. 1983. A live trapping and handling technique for river otters. Proceedings of the Annual Conference for the Southeast Association of Fish and Wildlife Agencies 37:182–189.

Sikes RS, Gannon WL, Animal Care and Use Committee of the American Society of Mammalogists. 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 92:235–253.

U.S. Geological Survey. 1997. National Water Summary on Wetland Resources: United States Geological Survey Water Supply Paper 2425. Available: https://water.usgs.gov/nwsum/WSP2425/state_highlights_summary.html#:~:text=Missouri's%20wetlands%20fjoccupy%20643%2C000%20acres,percent%20of%20the%20State's%20area (July 2021).

[USDA] U.S. Department of Agriculture. 2017. 2017 Missouri census of agriculture: show me the numbers. Available: https://www.usda.gov/media/blog/2019/08/13/2017-missouri-census-agriculture-show-me-numbers (June 2021).

Van Valkenberg B. 1988. Incidence of tooth breakage among large predatory mammals. American Naturalist 131:291–302.

White BH, Batcheller GR, Bogess EK, Brown CL, Butfiloski JW, Decker TA, Erb JD, Fall MW, Hamilton DA, Hiller TL, Hubert GF, Lovallo MJ, Olson JF, Roberts NM. 2021. Best management practices for trapping furbearers in the United States. Wildlife Monographs 207:3–59.

White BH, Decker T, O'Brien MJ, Organ JF, Roberts NM. 2015. Trapping and furbearer management in North American wildlife conservation. International Journal of Environmental Studies: 72:756–769.

Yu Media Group. 2002-2021. Weather atlas: Missouri, USA—climate data and average monthly weather. Available: https://www.weather-us.com/en/missouri-usa-climate (June 2021).