# Capturing and Handling Wild Animals

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## INTRODUCTION

THE ART OF CAPTURING wild animals for food and clothing is as old as human existence on earth. However, in today's world, reasons for catching wild species are more diverse. Millions of wild animals are captured each year as part of damage and disease control programs, population regulation activities, wildlife management efforts, and research studies. Many aspects of animal capture, especially those associated with protected wildlife species, are highly regulated by both state and federal governmental agencies. Animal welfare concerns are important regardless of the reason for capture. In addition, efficiency (the rate at which a device or system catches the intended species) is a critical aspect of wild animal capture systems.

Successful capture programs result from the efforts of experienced wildlife biologists and technicians who have planned, studied, and tested methods prior to starting any new program. State regulations related to animal capture vary widely, and licenses or permits, as well as specialized training, may be required by state wildlife agencies for scientists, managers, and others engaging in animal capture for research, damage management, or fur harvest. Institutional Animal Care and Use Committees, required at universities and research institutions by the Animal Welfare Act (U.S. Department of Agriculture 2002), often question whether scientists capturing animals for research have ensured that pain and distress are minimized by the techniques used. The information in this chapter will assist wildlife management practitioners to identify appropriate equipment and obtain the necessary approvals for its use. Researchers are encouraged to consult Littell (1993) and Gaunt et al. (1997) concerning guidelines and procedures relating to capture and handling **permits.**

Major reviews of bird capture techniques include Canadian Wildlife Service and U.S. Fish and Wildlife Service (1977), Day et al. (1980), Davis (1981), Keyes and Grue (1982), Bloom (1987), Bub (1991), Schemnitz (1994), and Gaunt et al. (1997). Detailed coverage of mammal capture methods include Day et al. (1980), Novak et al. (1987), Schemnitz (1994), Wilson et al. (1996), American Society of Mammalogists (1998), and Proulx (1999*a*). Mammal capture usually becomes more difficult as animal size increases. Thus, observational techniques and mammalian sign are often more efficient for obtaining both inventory and density information (Jones et al. 1996). Several new techniques to capture mammals ranging in size from small rodents to large carnivores have been developed in recent years. Some of these represent either improved or modified versions of traditional capture methods. Most animals are captured by hand, mechanical devices, remote injection of drugs, or drugs administered orally in baits. The emphasis in this chapter is on methods and equipment other than remotely injected drugs used for capture. Scott (1982), Heyer et al. (1994), Olson et al. (1997), and Simmons (2002) have compiled comprehensive capture references for amphibians.

This chapter is a revision of Schemnitz (2005) and includes additional citations and new methods for the capture and handling of wild animals. Users of this chapter are encouraged to refer to the series on wildlife techniques by Mosby (1960, 1963), Giles (1969), Schemnitz (1980), Bookhout (1994) and Braun (2005). Mammal researchers are encouraged to consult Gannon et al. (2007). They stress the need when live-trapping to provide adequate food, insulation, and avoidance of temperature extremes.

## CAPTURING BIRDS

### Use of Nets

#### Dip and Throw Nets

The common **fish dip net** has been used for capture or recapture of radiotagged birds for many years (Table 3.1). Unlike commercial nets, dip nets used to capture wildlife are usually constructed by the investigator. Constructed nets usually have a larger diameter hoop (≥1.5 m) and a longer handle (3–4 m), with mesh size being dependent on the type of animal being captured. Radiotagged birds are first located at night using a "walk in" technique. The bird is located by gradually circling it and then using a flashlight to temporarily blind the bird. A long-handled, large-diameter dip net is then placed over the bird. If several birds roost together (especially a hen with brood), a radiotagged bird can be used to locate a flock, and several other birds also can be trapped. Dark nights with light rain worked best when night lighting birds. This technique can be used on nonradiotagged birds, such as those roosting on roadsides, located on nests, nonflying young on nests or flushed from nests, and birds roosting on water (collected by using boats and long-handled dip nets). The use of dip nets for capturing wildlife is limited only by the investigator's imagination.

Drewien and Clegg (1991) had great success capturing sandhill and whooping cranes (**scientific names** for birds, mammals, reptiles, and amphibians can be found in Appendix 3.1) using a portable generator mounted on an aluminum backpack frame and a 28-volt spotlight mounted on a helmet to locate them (Table 3.2). Cranes were then captured using long-handled (3.0–3.6 m in length) nets, with best success on dark overcast nights when they were roosting in small flocks during summer. Well-trained pointing dogs and 2–3-m-long handled nets have been used to capture nesting and broods of American woodcock (Ammann 1981). Drewien et al. (1999) captured trumpeter swans using night lighting to locate them from a lightweight (180 kg) airboat during severe winter weather. King et al. (1994) successfully captured roosting double-crested cormorants using night lighting from a boat at winter roosts in cypress trees (*Taxodium distichum;* Fig. 3.1). Cormorants were captured with a long-handled net in shallow water. Whitworth et al. (1997) combined the use of dip nets from small boats at sea to capture Xantus murrelets. Mitro et al. (2008) used night lighting to capture adult common loons with chicks. Gill et al. (1970) and Bugoni et al. (2008) described the use of a cast net thrown by hand from a fishing boat to capture scavenging pelagic sea birds attracted by bait thrown into the water.

*Table 3.1.* Dip and throw nets used to capture wildlife

| Group/species[a] | Reference |
|---|---|
| Birds | |
| American white pelican | Bowman et al. 1994 |
| California gull | Bowman et al. 1994 |
| Common loons | Mitro et al. 2008 |
| Cormorants | Bowman et al. 1994, King et al. 1994 |
| Cranes | Drewien and Clegg 1991 |
| Doves | Morrow et al. 1987, Swanson and Rappole 1994 |
| Eiders | Snow et al. 1990 |
| Greater prairie-chicken | Robel et al. 1970 |
| Greater sage-grouse | Wakkinen et al. 1992 |
| Murrelets | Whitworth et al. 1997 |
| Nightjars | Earlé 1988 |
| Pelagic sea birds | Gill et al. 1970, Bugoni et al. 2008 |
| Swans | Drewien et al. 1999 |
| Mammals | |
| American beaver | Rosell and Hovde 2001 |
| Jackrabbit | Griffith and Evans 1970 |
| Nutria | Meyer 2006 |
| Amphibians and reptiles | |
| Aquatic amphibians | Wilson and Maret 2002, Welsh and Lind 2002 |

[a] Scientific names are given in Appendix 3.1.

Bowman et al. (1994) successfully used night lighting to survey, capture, and band island-nesting American white pelicans, double-crested cormorants, and California gulls. Disturbances to birds while night lighting was minimal, and there was no predation by gulls on eggs or chicks. Night lighting was more effective for capturing young than for capturing adults. Snow et al. (1990) night-lighted common eiders during the summer in shoal waters using deep hoop nets 46–61 cm in diameter attached to 3.7–4.3-m-long handles.

Wakkinen et al. (1992) modified night spotlighting techniques by using binoculars in conjunction with a spotlight to locate greater sage-grouse. Binoculars allowed greater detection in 55 of 58 (95%) instances. Capture success increased by >40%.

**Throw nets** have been used to capture wildlife, but more skill is involved with this technique. These cast-nets are usually used with night lighting to capture birds. **Cast-nets** also

*Table 3.2.* Night-lighting methods and equipment used to capture wildlife

| Group/species[a] | Reference |
|---|---|
| Birds | |
| Greater rhea | Martella and Navarro 1992 |
| American white pelican | Bowman et al. 1994 |
| Double-crested cormorant | Bowman et al. 1994, King et al. 1994, 2000 |
| Waterfowl | Glasgow 1957, Lindmeier and Jessen 1961, Cummings and Hewitt 1964, Drewien et al. 1967, Bishop and Barratt 1969, Merendino and Lobpries 1998 |
| Trumpeter swan | Drewien et al. 1999 |
| Common eider | Snow et al. 1990 |
| Ruffed grouse | Huempfener et al. 1975 |
| Greater sage-grouse | Giesen et al. 1982, Wakkinen et al. 1992 |
| Greater prairie-chicken | Labisky 1968 |
| Northern bobwhite | Labisky 1968 |
| Ring-necked pheasant | Drewien et al. 1967, Labisky 1968 |
| Shorebirds | Potts and Sordahl 1979 |
| Sandhill crane | Drewien and Clegg 1991 |
| Whooping crane | Drewien and Clegg 1991 |
| Yellow rail | Robert and Laporte 1997 |
| American woodcock | Rieffenberger and Ferrigno 1970, Shuler et al. 1986 |
| California gull | Bowman et al. 1994 |
| Common nighthawk | Swenson and Swenson 1977 |
| Mammals | |
| Cottontail rabbit | Drewien et al. 1967, Labisky 1968 |
| Jackrabbit | Griffith and Evans 1970 |
| Muskrat | McCabe and Elison 1986 |
| Mule deer | Steger and Neal 1981 |

[a] Scientific names are given in Appendix 3.1.

can be used to capture birds on water by using night lighting techniques. Earlé (1988) combined night lighting and a cast-net to capture nightjars (Caprimulgidae) along gravel roads. The 85-cm diameter, circular cast-net had handles to facilitate throwing it

## Mist Nets

The number of papers describing the use of mist nets to capture birds or bats are too numerous to include in this chapter. Here we provide the reader with examples of various methods to deploy mist nets and papers that caution the reader on how to use data obtained from this method.

Mist nets continue to be an effective method for sampling bird populations. Ralph and Dunn (2004) summarized and recommended commonly used protocols for monitoring bird populations using mist nets. They discussed a variety of key factors, including annual photography and vegetation assessment at each net site to document vegetation height and density, exact net placement and locations, and type of net used (e.g., net material, mesh size, dimensions, methods used to measure birds, fat scores, and frequency of

*Fig. 3.1.* Jon-boat showing positioning of night-lighting equipment (bow rails, lights, converter box, and generator) and personnel. *From King et al. (1994).*

net checks), thereby allowing comparison of results among independent studies. Length of netting seasons should follow **standardized procedures.** Mist-netting studies should be carefully planned to ensure that sampling design and estimated sample size will allow clearly defined study objectives to be met. Remsen and Good (1996) urged caution in the direct use of mist-net data to estimate relative bird abundance. Corrections should be based on detailed knowledge of the ecology and behavior of the birds involved. Ralph et al. (1993) emphasized the importance of setting nets in locations of similar vegetation density and terrain. Jenni et al. (1996) reported the proportion of birds avoiding mist nets without entering a net shelf depended on the extent of shading and net-shelf height, but not on species, wind speed, or habitat. Dunn et al. (1997) reported that annual capture indices of 13 songbird species based on standardized autumn mist netting were significantly and positively correlated with breeding bird survey data from Michigan and Ontario, Canada. Their results suggested that mist netting could be a useful population monitoring tool. Wang and Finch (2002) noted consistency between the results of mist netting and point counts in assessing land-bird species richness and relative abundance during migration in central New Mexico.

Meyers and Pardieck (1993) developed a lightweight, **low canopy** (1.8–7.3 m) mist-net system using adjustable aluminum telescoping poles. Sims (2004) and Burton (2004) described improvements in net poles and a tool for raising and lowering mist nets. Stokes et al. (2000) perfected a method to deploy mist nests horizontally from a canopy platform in 30-m-tall forests. A connecting wooden bridge can be built between platforms. The nets and net poles were suspended from a support cable and pulled along the cable by a control cord and pulley. This system allowed comparisons of mist net capture rates between forest canopy and understory levels.

Albanese and Piaskowski (1999) perfected an inexpensive ($35.00) **elevated** mist-net apparatus that sampled birds in vegetation strata from ground level to a height of 8.5 m. The equipment consisted of metallic tubs, clothesline cord, and single and double pulleys, and it required only 1 person to operate the system. Bonter et al. (2008) evaluated bird capture success with paired mist nets set at ground level and at elevated heights. They found significantly higher capture rates in nets set at ground level. Meyers (1994*a*) captured orange-winged parrots by using mist nets in a circular configuration around roost trees. Live parrot decoys were placed within the circle of mist nets and supplemented with playback vocalizations. Catch rate was increased by flushing parrots as the observer rushed toward the nets. Sykes (2006) clustered 3 short mist nets in a triangular array around a heavily baited bird feeder. Observers rushed the feeder, flushing ground-feeding painted bunting into the surrounding mist nets. Wilson and Allan (1996) captured prothonotary warblers and Acadian flycatchers in a forested wetland by placing a mist net in a V-shaped configuration, mounted on a boat. A decoy study mount was placed close to a mist net pole. Barred owls were successfully captured by Elody and Sloan (1984) using 3 mist nets set in an A-shaped configuration with a live barred owl placed in the center as a decoy, along with an outdoor megaphone speaker and cassette tape player broadcasting a recorded call of a barred owl.

Lesage et al. (1997) modified mist net techniques to capture breeding adult and young surf scoters. They placed 2 nets at scoter feeding sites, extending perpendicular from the shore and using copper poles painted black and pushed firmly into the lake bottom. A boat was used to herd the scoters into the net. Capture was successful when nets were placed both above and below the water surface. Breault and Cheng (1990) used **submerged** mist nets to capture eared grebes. They set the nets in waist-deep (1.5 m) water and used 7-g fishing weights attached to the net bottom at 1.5-m intervals to sink the net. Nets were attached to wooden poles. Grebes were driven into the nets by personnel walking or canoeing from behind the birds toward the submerged nets. Avoidance of drowning was achieved by immediate removal of any captured birds from the nets. Bacon and Evrard (1990) successfully captured upland nesting ducks by holding a mist net in a horizontal position over the nest. When the hen flushed, she became entangled in the net mesh. The net was attached between 3-m sections of conduit. Kaiser et al. (1995) placed an array of 3 mist nets floating on rafts to catch marbled murrelets as the birds flew through narrow coastal channels. They used aluminum tubing to support the nets. Nets were set against a forested background to reduce their visibility to approaching murrelets. Pollock and Paxton (2006) devised a technique for capturing birds over deep water by using mist nets suspended between poles kept afloat on compact buoys. Paton et al. (1991) used a large mist net consisting of 5 nets sewn together, elevated by pulleys 45 m into the forest **canopy** (Fig. 3.2) to capture marbled murrelets. Netting sessions were conducted during the main activity periods, 60 minutes before to 60 minutes after sunrise. When not in use, the net was wrapped with a plastic tarp to avoid entanglement with woody debris.

Hilton (1989) used taped fledgling alarm calls along with mist nets near active blue jay nests to successfully capture blue jays. The taped calls were broadcast from a portable tape recorder placed beneath the center of the net. Airola et al. (2006) had more capture success of purple martin with fixed mist nets than with hand-held hoop nets at nest cavity sites. They suggested that a combination of both types of nets might be ideal. They also used purple martin distress calls of captured birds to enhance capture rates. Jones and Cox (2007) efficiently mist netted male Bachman's sparrows during the breeding season by using playback recordings.

Silvy and Robel (1968) placed mist nets at a 45° angle on the **ground** (Fig. 3.3) to intercept greater prairie-chickens walking to booming grounds and found these nets caused fewer behavioral problems with displaying males than did cannon nets. This method also was more efficient for capturing female prairie-chickens. Skinner et al. (1998) combined pointing dogs and mist nets attached to galvanized pipe poles to capture juvenile willow ptarmigan. After the dogs located and pointed the birds, the mist nets were arranged in a V-shaped pattern ahead of the covey. The ptarmigan were then flushed into the nets and captured. Geering (1998) used playback tapes during the breeding season to attract birds to be captured in mist nets. Bull and Cooper (1996) presented 4 new techniques for capturing pileated woodpeckers and Vaux's swifts in roost trees. They camouflaged traps with tree bark or lichens set above the entrance hole. A person on the ground released the trap by pulling a taut line as soon as the bird entered the hole. The lichen-covered trap closed to the side of the hole. Both the bark and the lichen-covered plastic netting were taped to a frame. They also used 2 designs, a mist net on a frame and a mist net suspended between 2 trees (Fig. 3.4) and positioned 3–5 m in front of a nest cavity to capture swifts. Hernandez et al. (2006) tested several capture techniques for Montezuma quail and found a modified (portable) mist net method to be the most successful.

Steenhof et al. (1994) successfully used a tethered great horned owl 1 m behind 2 mist nets to capture American kestrels. Nets were placed 20 m from nest boxes occupied by American kestrels with >5-day-old young. They recommended placement of the nets and a live owl near trees when possible to provide shade and so reduce heat stress on the lure owl. Gard et al. (1989) reported that breeding American kestrels responded less aggressively to taxidermy mounts of great horned owls than to live owls. Rosenfield and Bielefeldt (1993) suggested modifications to Bloom et al. (1992) methods for trap-shy breeding Cooper's hawks. They advised using an elevated great horned owl set, 10–13 m above ground, rather than at or within 0.5 m of the ground, to en-

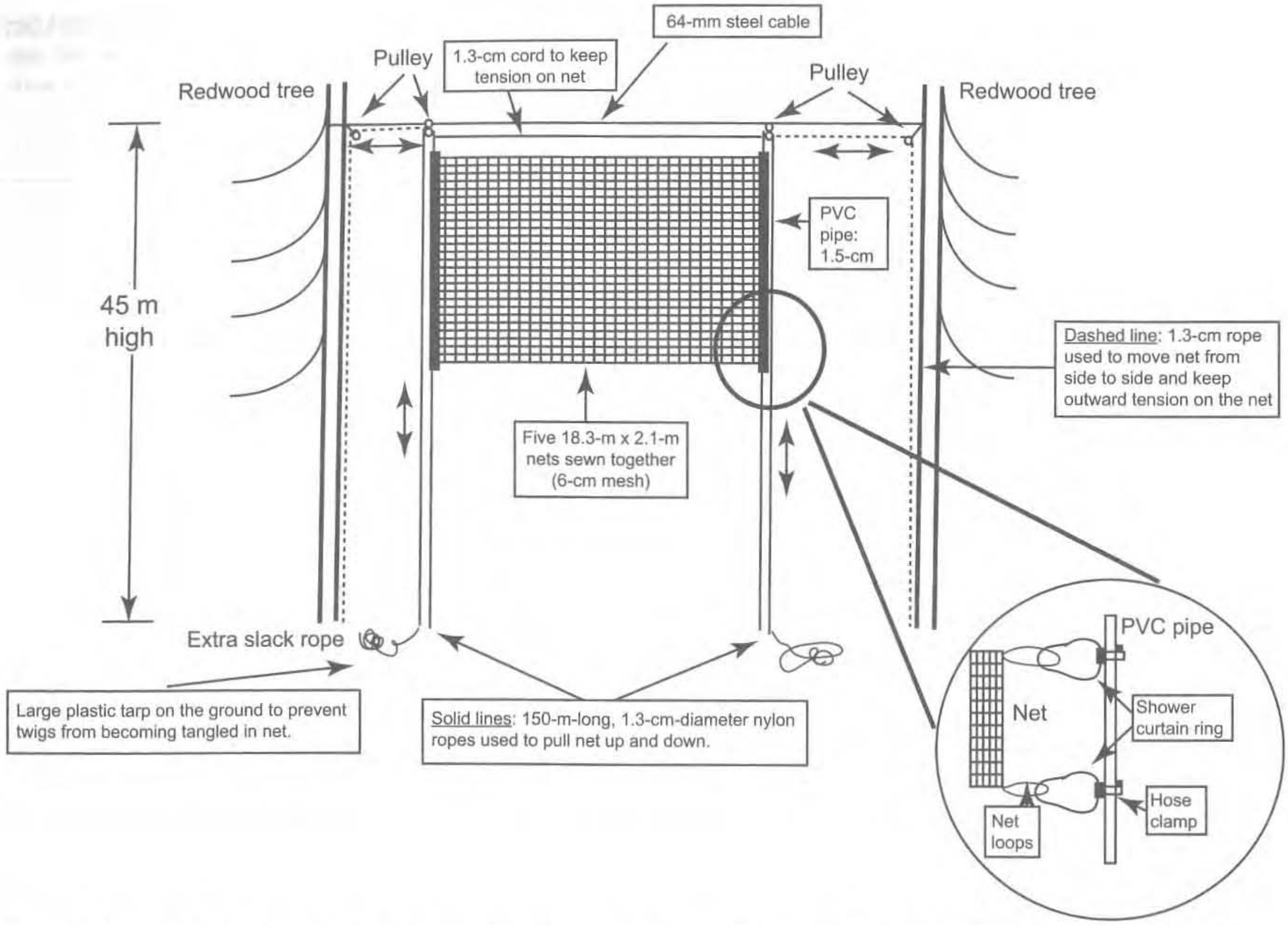


*Fig. 3.2.* Schematic of mist net used to capture marbled murrelets in the forests of northern California. Branches were on all sides of both trees and were not removed. Diagram not drawn to scale. *From Paton et al. (1991).*

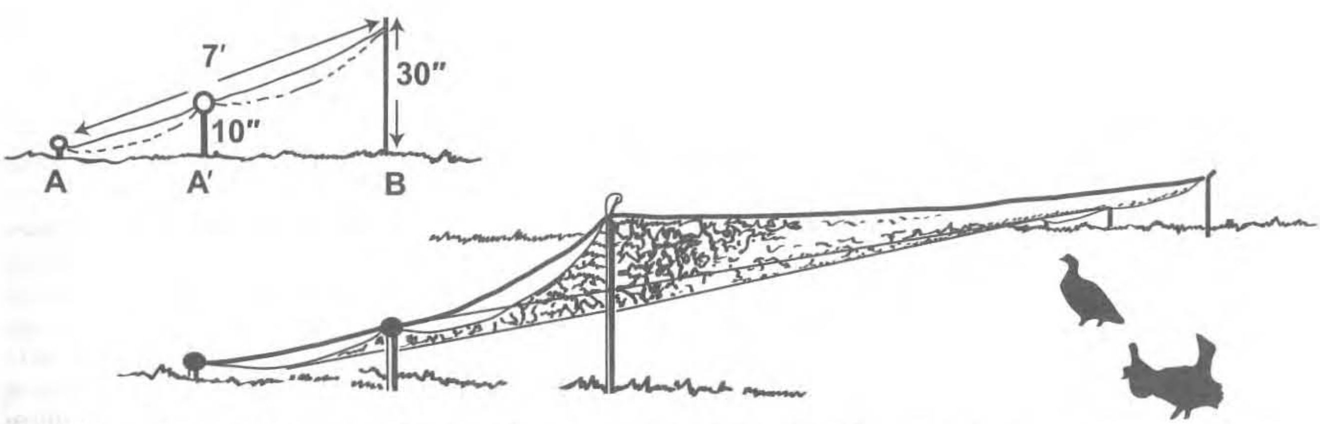


*Fig. 3.3.* Diagram of erected mist net set at a 45° angle to the ground. The elevated edge of the net should face the path of approaching birds. *From Silvy and Robel (1968).*

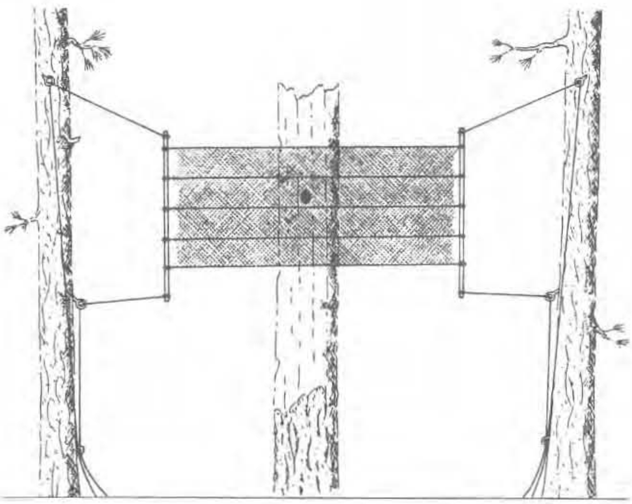

*Fig. 3.4.* Mist net erected between 2 live trees and positioned in front of a nest cavity. *From Bull and Cooper (1996).*

hance trapping success. They also advised pre-incubation trapping at or near dawn. Hawks were trapped in mist nets, bow nets, or bal chatris baited with European starlings or ringed turtle doves. Jacobs (1996) reported high trapping success (69% overall) with mist nets set next to a mechanical, mounted great horned owl decoy used to attract red-shouldered, Cooper's, and sharp-shinned hawks (Table 3.3).

Blackshaw (1994) devised a method to secure closed and rolled mist nets that prevented unrolling, tangling, and sagging. She used a 61-cm length of sisal or braided nonslick twine attached to the net and to a long stick placed vertically in the ground near the center of the net. Sykes (1989) used strips of asphalt-saturated, 13.6-kg roofing felt under each tightly furled mist net to prevent accidental capture of birds, small mammals, and large insects, such as beetles, in unattended nets. A chainsaw was used to cut rolls of roofing felt at 22.9-cm intervals.

## Dho Gaza Nets

A **dho gaza net** is a large mist net between 2 poles; the net detaches as a bird hits the net and falls to the ground with the bird caught in it. A **fixed dho gaza** has a similar mechanism, but the net does not disconnect from poles; instead it falls in as the whole set. Bierregaard et al. (2008) combined a unique training response that attracted barred owls to a squeaking mouse and then captured them with a dho gaza net. Zuberogoitia et al. (2008) used a combination of a dho gaza and mist net plus an owl lure to capture 13 species of European raptors.

Bloom et al. (1992) evaluated the effectiveness of the dho gaza net baited with a live, tethered great horned owl (Fig. 3.5) as a lure for 11 species of diurnal raptors and 3 species of owls. The technique was most successful when targeting a territorial pair during the reproductive cycle. Playback of audiotaped recordings of great horned owls reduced the time necessary for capture. Net poles should be concealed and the owl lure placed in the shade.

Knittle and Pavelka (1994) simplified attaching a dho gaza net to poles by using fabric hooks and self-adhesive Velcro® as loop fasteners. McCloskey and Dewey (1999) improved success trapping northern goshawks by using a mounted great horned owl decoy that was moved manually while held upright within 1 m of a dho gaza net. The trapper, covered with camouflage netting and holding the

*Table 3.3.* Decoys and enticement lures used to capture birds

| Group/species[a] | Reference |
|---|---|
| Waterfowl | |
| Mallard | Sharp and Lokemoen 1987 |
| Gadwall | Blohm and Ward 1979 |
| Northern pintail | Grand and Fondell 1994, Guyn and Clark 1999 |
| Northern shoveler | Seymour 1974 |
| Blue-winged teal | Garrettson 1998 |
| Canvasback | Anderson et al. 1980 |
| Lesser scaup | Rogers 1964 |
| Barrow's goldeneye | Savard 1985 |
| Galliformes | |
| Ruffed grouse | Chambers and English 1958, Naidoo 2000 |
| Greater prairie-chicken | Anderson and Hamerstrom 1967, Silvy and Robel 1967 |
| Sharp-tailed grouse | Artmann 1971 |
| Northern bobwhite | Smith et al. 2003c |
| Ring-necked pheasant | Smith et al. 2003c |
| Raptors | Berger and Hamerstrom 1962, Bloom 1987, Bloom et al. 1992, Plumpton et al. 1995, Jacobs 1996 |
| Northern goshawk | Meng 1971, McCloskey and Dewey 1999 |
| Cooper's hawk | Rosenfield and Bielefeldt 1993 |
| Red-tailed hawk | Buck and Craft 1995 |
| Northern harrier | Hamerstrom 1963 |
| Crested caracara | Morrison and McGehee 1996 |
| American kestrel | Bryan 1988, Gard et al. 1989, Steenhof et al. 1994 |
| Merlin | Clark 1981 |
| Other birds | |
| Yellow rail | Robert and Laporte 1997 |
| Virginia rail | Kearns et al. 1998 |
| Sora | Kearns et al. 1998 |
| American woodcock | Norris et al. 1940 |
| Band-tailed pigeon | Drewien et al. 1966 |
| Northern saw-whet owl | Whalen and Watts 1999 |
| Tawny owl | Redpath and Wyllie 1994 |
| Spotted owl | Bull 1987, Johnson and Reynolds 1998 |
| Pileated woodpecker | York et al. 1998 |
| Brown-headed cowbird | Burtt and Giltz 1976 |
| American robin | Dykstra 1968 |
| Loggerhead shrike | Kridelbaugh 1982 |
| Red-winged blackbird | Burtt and Giltz 1970, 1976; Picman 1979 |
| American magpie | Wang and Trost 2000 |
| Regent honeyeater | Geering 1998 |

[a] Scientific names are given in Appendix 3.1.

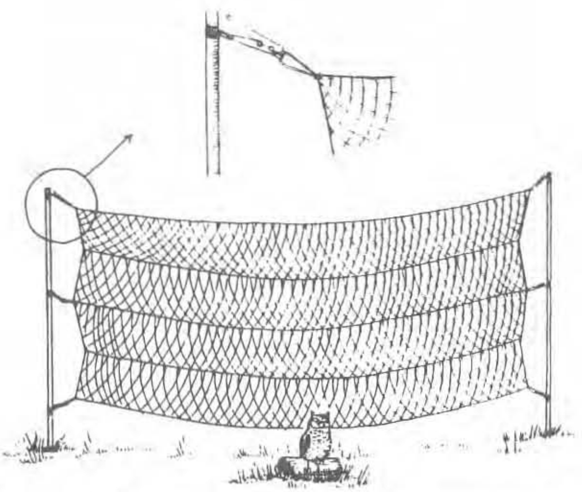

*Fig. 3.5.* Large dho gaza trap with a tethered great horned owl as an attractant may be used to catch territorial adult raptors. The inset shows a clothespin attachment to a tape tab on a mist net loop. *From Bloom (1987).*

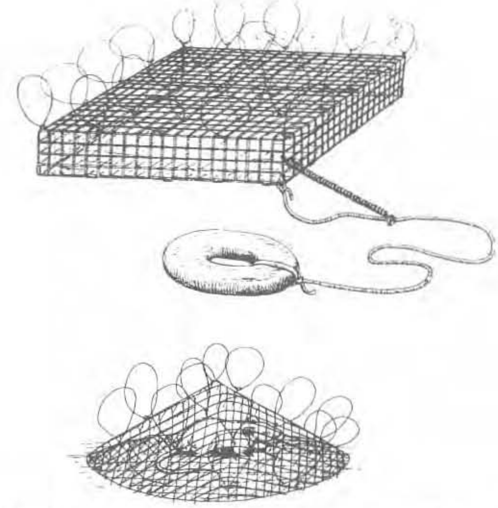

*Fig. 3.6.* Bal chatri traps can be made in a variety of shapes. The box-shaped bal chatri functions well for accipiters, buteos, and owls, whereas the cone-shaped trap functions best on kestrels and burrowing owls. *From Bloom (1987).*

mounted owl, uttered the 5-note territorial hoot of the great horned owl.

## Bal Chatri, Noose Mats, and Halo Traps

A **bal chatri trap** is small wire cage with a rock dove or mouse inside. The cage is covered with monofilament nooses, which twine and trap the raptor's feet. Wang and Trost (2000) caught American magpies with a bal chatri trap baited with a female American magpie and placed under a nest tree. Bierregaard et al. (2008) used a bal chatri noose trap to capture barred owls. Thorstrom (1996) reviewed the methodology used for capturing birds of prey in tropical forests. Baited bal chatri traps (Fig. 3.6) were the most effective and versatile and the simplest to set. He described a modified bal chatri, called an envelope trap, which used as bait the food left behind by a flushed raptor. The bait was enclosed on a semi-flat wire cage with nooses that were tied to the ground. Miranda and Ibanez (2006) successfully used a modified bal chatri trap with horizontal nooses attached to a cage containing a live rabbit to capture Philippine eagles. Crozier and Gawlick (2003) had success using plastic flamingo decoys to attract wading birds. Jacobs and Proudfoot (2002) designed an elevated dho gaza net assembly they used in combination with a great horned owl decoy to capture 5 species of nesting raptors. The owl decoy had a moveable head as described by Jacobs (1996). The net trap was attached to a 2–8-m telescoping pole to allow adjustment to the nest site height and was set within 50 m of the nest tree. Great horned owl vocalizations also were used to attract nesting raptors to the net system.

Smith and Walsh (1981) modified a bal chatri trap for eastern screech owls by placing a 3-mm Plexiglas™ top on a rectangular hardware cloth base. Taped calls were used to

*Fig. 3.7.* Noose mats may be applied to branches and around burrowing owl nests. *From Bloom (1987).*

attract owls to the mouse-baited trap. Small holes were drilled in the Plexiglas, in which nooses were tied. Blakeman (1990) increased the capture success rate of bal chatri traps by spraying them with flat dark paint. Nylon monofilament used for nooses was soaked for a day in black fabric dye. Both treatments helped camouflage the traps.

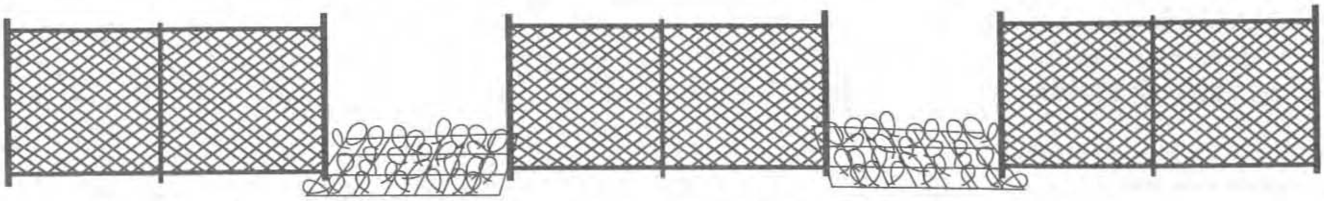

*Fig. 3.8.* Positioning of lead fences and noose mats to capture wintering shorebirds. *From Mehl et al. (2003).*

Toland (1985) designed a **leather harness** with 15 monofilament slip nooses that he attached to house sparrows to capture trap-wary American kestrels. One end of a monofilament line was attached to a wooden dowel or stick and the other end to the edge of the harness. The wooden weight functioned as a drag when the kestrel attempted to fly away with the harnessed sparrow. Bloom (1987) provided details on the use of a harnessed rock dove for the capture of raptors. Nylon monofilament nooses were tied or cemented to a leather harness that was attached to a rock dove tied on a line to a weight or a nearby shrub.

**Noose mat traps** are much like bal chatri traps except that monofilament loops are attached to a mat or carpet (Fig. 3.7). McGowan and Simons (2005) used a remote-controlled mechanical decoy to lure territorial adult American oystercatchers for capture in a leg-hold noose mat trap. Paredes et al. (2008) placed a noose carpet attached to a wooden pole on cliff ledges to capture breeding razorbills on the Labrador, Canada, coast. Lightweight noose mats were combined with alternating lead fences by Mehl et al. (2003) to capture wintering shorebirds (Fig. 3.8). Caffrey (2001) was unsuccessful in capturing American crows using a noose carpet. African fish eagles were captured on water by using a floating fish snare vest (Hollamby et al. 2004).

Hilton (1989) described a unique **double halo** nest trap to capture blue jays. The trap consisted of a black metal hanger bent into a "dog-bone shape." Halos at each end had a diameter of 12.5 cm and were connected by a 15-cm wire. Clear nylon, 4–5-kg test monofilament fishing line was tied into nooses similar to those used on bal chatri and other noose traps. Elliptical nooses, 7 × 5 cm, were most successful. The bottom halo was anchored to the branch supporting the nest with 7–8-kg test monofilament tied to a metal washer. The double halo trap was designed to catch a bird by its neck as it arrives or leaves the nest. It was necessary for the bird trapper to remain nearby to prevent strangulation of the bird. The trap was deployed several days after incubation had begun to avoid provoking nest desertion.

## Drop Nets

Drop nets (Table 3.4) using **explosive charges** to drop the nets have been deployed to capture wild turkey (Baldwin 1947 and Glazener et al. 1964), band-tailed pigeon (Wooten 1955, Drewien et al. 1966), greater prairie-chicken (Jacobs 1958), shorebirds (Peyton and Shields 1979), and flightless Canada goose (Nastase 1982). Silvy et al. (1990) developed a tension-operated (**nonexplosive**) drop net to capture Attwater's prairie-chicken and king rail (Fig. 3.9). White nets blended into early morning fog and were more efficient at capturing prairie chickens than were dark nets. Bush (2008) developed a similar tension-operated drop net to capture greater sage-grouse. More grouse were captured with gray

*Table 3.4.* Drop nets used to capture wildlife

| Group/species[a] | Reference |
|---|---|
| Birds | |
| Attwater's prairie-chicken | Silvy et al. 1990 |
| Canada goose | Nastase 1982 |
| Greater prairie-chicken | Jacobs 1958 |
| Greater sage-grouse | Bush 2008 |
| Wild turkey | Baldwin 1947, Glazener et al. 1964 |
| King rail | Silvy et al. 1990 |
| Band-tailed pigeon | Wooten 1955, Drewien et al. 1966 |
| Shorebirds | Peyton and Shields 1979 |
| Mammals | |
| White-tailed deer | Ramsey 1968, Conner et al. 1987, DeNicola and Swihart 1997, Lopez et al. 1998 |
| Mule deer | White and Bartmann 1994, D'Eon et al. 2003 |
| Mountain sheep | Fuller 1984, Kock et al. 1987 |

[a] Scientific names are given in Appendix 3.1.

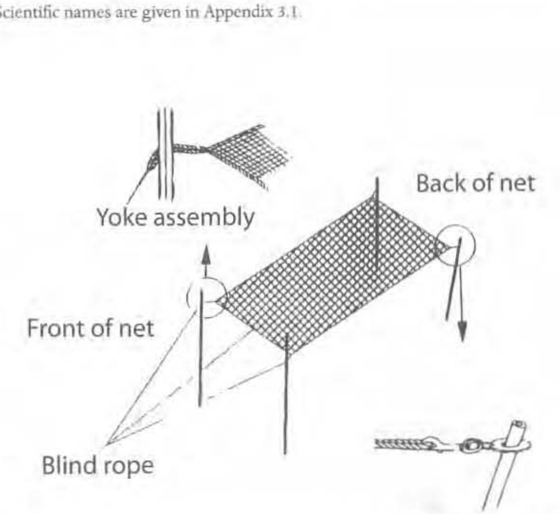


*Fig. 3.9.* Nonexplosive drop net showing the yoke assembly at the front of the net and the swivel snap-washer assembly for attaching net to back poles. *From Silvy et al. (1990).*

than with black nets. Lockowandt (1993) designed an electromagnetic trigger for drop nets that worked well in cold weather with high winds and ice.

## Cannon and Rocket Nets

Cannon and rocket nets (Fig. 3.10) have relative **advantages and disadvantages** with respect to each other. Rocket nets cost more per firing; rocket propellant (charges) cannot be shipped and must be delivered to their place of use, which adds to their cost; and rockets are prone to start fires. Rocket propellant is now solely available through Winn-Star (Marion, IL). Purchasers of rocket propellant should be aware of the type of rockets they are using, as charges used in the old Wildlife Materials (Carbondale, IL) rockets require different changes than do Winn-Star rockets; using the wrong charges can cause the rockets to blow apart. Rockets have the advantage they can be mounted to more readily fire over larger animals (i.e., deer) and the rockets need not be cleaned after firing. Cannons must be cleaned after firing and cannot be mounted above the ground to accommodate larger animals; however, they do not start fires, they are less expensive to fire, no federal permit is required for their use, and charges can be shipped by overnight express companies. Both cannon and rocket net charges must be stored away from buildings and in explosive resistant containers. Also, rocket net charges are prone to explode with age. In recent years, air cannons (i.e., Net Blaster™; Martin Engineering, Neponset, IL) have become available. These cannons are more expensive, but they offer the advantage of not having to use explosives to propel the net. As a result they also cause fewer animal behavioral problems when fired over a given area for several days in succession. Caffrey (2001) captured American crows with camouflaged rocket and cannon nets and a net launcher.

A portable platform for setting rocket nets in **open water** habitats was perfected by Cox and Afton (1994). King et al. (1998) developed a rocket net system consisting of an aluminum box (containing the net) set in 2–4-cm-deep water. Mahan et al. (2002) modified nets and net boxes to enhance the capture of wild turkey. They rotated a 12-m × 12-m net 45° so that it resembled a baseball diamond and attached 3 rockets. One set of drag weights rather than 3 were used.

*Table 3.5.* Cannon and rocket nets used to capture wildlife

| Group/species[a] | Reference |
|---|---|
| Birds | |
| American white pelican | King et al. 1998 |
| Waterfowl | Dill and Thornsberry 1950, Turner 1956, Marquardt 1960, Funk and Grieb 1965, Raveling 1966, Moses 1968, Wunz 1984, Zahm et al. 1987, Cox and Afton 1994, Grand and Fondell 1994, Merendino and Lobpries 1998 |
| Great blue heron | King et al. 1998 |
| White ibis | Heath and Frederick 2003 |
| Blue grouse | Lacher and Lacher 1964 |
| Greater sage-grouse | Lacher and Lacher 1964, Giesen et al. 1982 |
| Sharp-tailed grouse | Peterle 1956 |
| Greater prairie-chicken | Silvy and Robel 1968 |
| Ring-necked pheasant | Flock and Applegate 2002 |
| Wild turkey | Austin 1965; Bailey 1976; Wunz 1984, 1987; Davis 1994; Eriksen et al. 1995; Pack et al. 1996; Mahan et al. 2002 |
| Bald eagle | Grubb 1988, 1991 |
| Ruddy turnstone | Thompson and DeLong 1967 |
| Ring-billed gull | Southern 1972 |
| Band-tailed pigeon | Smith 1968, Pederson and Nish 1975, Braun 1976 |
| American crow | Caffrey 2001 |
| Brown-headed cowbird | Arnold and Coon 1972 |
| Mammals | |
| White-tailed deer | Hawkins et al. 1968, Palmer et al. 1980, Beringer et al. 1996, Cromwell et al. 1999, Haulton et al. 2001 |
| Fallow deer | Nall et al. 1970 |
| Mountain sheep | Jessup et al. 1984 |
| Dall sheep | Heimer et al. 1980 |

[a] Scientific names are given in Appendix 3.1.

Rocket and cannon nets have been used to trap both birds and mammals (Table 3.5).

## Net Guns

Net guns are usually used to capture mammals; however, they also have been employed to capture birds (Table 3.6). Mechlin and Shaiffer (1980) used net guns to capture waterfowl, and O'Gara and Getz (1986) captured golden eagle

*Fig 3.10.* Photograph of cannon (left) and rocket nets (right) shortly after being fired. Note how the front end of the rocket net comes off the ground, allowing taller animals to be trapped than could be accomplished with a cannon net. *Photo by N. J. Silvy.*

*Table 3.6.* Net guns used to capture wildlife

| Group/species[a] | Reference |
|---|---|
| Birds | |
| Waterfowl | Mechlin and Shaiffer 1980 |
| Golden eagle | O'Gara and Getz 1986 |
| Mammals | |
| Coyote | Barrett et al. 1982, Gese et al. 1987 |
| Moose | Carpenter and Innes 1995 |
| White-tailed deer | Barrett et al. 1982, DeYoung 1988, Potvin and Breton 1988, Ballard et al. 1998, DelGiudice et al. 2001*a*, Haulton et al. 2001 |
| Mule deer | Barrett et al. 1982, Krausman et al. 1985, White and Bartmann 1994 |
| Caribou | Valkenburg et al. 1983 |
| Pronghorn | Barrett et al. 1982, Firchow et al. 1986 |
| Mountain sheep | Andryk et al. 1983, Krausman et al. 1985, Kock et al. 1987, Jessup et al. 1988 |
| Dall sheep | Barrett et al. 1982 |

[a] Scientific names are given in Appendix 3.1.

with a net gun. Herring et al. (2008) used a **net gun** to capture nearby (maximum distance, 15 m) wetland birds, whereas Caffrey (2001) was unsuccessful in capturing American crow with one.

### Bow Nets

Barclay (2008) developed a technique for nighttime trapping of burrowing owls combining a bow net activated by a solenoid and a live tethered mouse decoy. Jackman et al. (1994) devised a successful radiocontrolled bow net and power snare (Fig. 3.11) to selectively capture bald and golden eagles. The net was completely concealed in loose soil and operated from distances up to 400 m. A recognizable marker was placed just outside the perimeter of the net trap to verify the eagle was in the center of the trap and was feeding with its head down before triggering the trap. Shor (1990*a*, *b*) described an easily constructed, simple-to-set bow net that safely caught hawks.

Proudfoot and Jacobs (2001) combined 2-way radios with a conventional home security switch to develop an inexpensive alarm-equipped bow net. The radio alarm eliminated the need to periodically inspect automatic bow nets. The bow net was used to signal the capture of owls, hawks, and loggerhead shrike. Collister and Fisher (1995) tested 4 trap types for capturing loggerhead shrike. They had a higher percentage of trapping successes with a modified Tordoff bow trap. Larkin et al. (2003) perfected an electronic signaling system for prompt removal of an animal from a trap. Herring et al. (2008) developed a solenoid activated **flip trap** for capturing large wetland birds.

Morrison and McGehee (1996) set a **Q-net** (Fuhrman Diversified, Seabrook, TX) similar to a bow net next to a live crested caracara tethered within 100 m of an active nest. The territorial and aggressive resident caracara moved toward the lure bird and was caught in the Q-net when the observer pulled the trigger wire. Modern Q-nets come with a digital radio release that can activate the net from ≤75 m away.

### Helinet

Brown (1981) developed the helinet (Fig. 3.12) to capture prairie-chicks and ring-necked pheasant. Lawrence and Silvy (1987) used the helinet to capture and translocate 44 Attwater's prairie-chickens from runways and small areas of prairie habitat adjoining runways of a small airport in Texas. Prairie-chickens were captured by flying over display grounds and flushing an individual bird and then flowing the bird's flight (not pushing the bird) until it landed. After 1 or a few flushes, the bird's primary feathers would become wet, and it could no longer fly and would try to hide in tall grass. The helicopter with a net attached to the struts would then place the net over the hiding bird, and a person riding shotgun in the helicopter would catch the bird by hand from under the net. The passenger door was removed from the helicopter to facilitate capture. Permission had to be obtained from the Federal Aviation Administration prior to attaching anything to a helicopter. This method was the most efficient and cost effective for capturing female prairie-chickens.

## SNARES AND NOOSE POLES

Benson and Suryan (1999) described a circular noose (Table 3.7) that allowed safe capture of specific individual black-legged kittiwakes. The leg noose was fitted to the rim of the nest and was remotely triggered. Launay et al. (1999) attached **snares** at 10-cm intervals to a 50-m-long main line at male houbara bustard display areas. They also placed female bustard decoys surrounded by snares at display sites. Nesting females were attracted to dummy eggs made of wood painted to resemble houbara bustard eggs; they were caught with adjacent snares.

Cooper et al. (1995) described a noose trap arrangement used to capture pileated woodpeckers at nest and roost cavities. **Foot nooses** of clear monofilament line were spaced at 1-cm intervals along a main support line, and fence staples were used to secure the line to the tree.

Thorstrom (1996) devised a **noose pole** trap for removing incubating and nestling birds from tree cavities. Young that were out of view in 2-m deep nest cavities were safely extracted. Kramer (1988) designed a noosing apparatus made of wire, plastic straws, and monofilament fishing line that he used to remove nestling bank swallows from their burrows for banding. Thiel (1985) built a similar noosing device to capture adult belted kingfishers as they entered their nesting burrows. Kautz and Seamans (1992) used noose poles to successfully capture rock dove in silos, but not in barns.

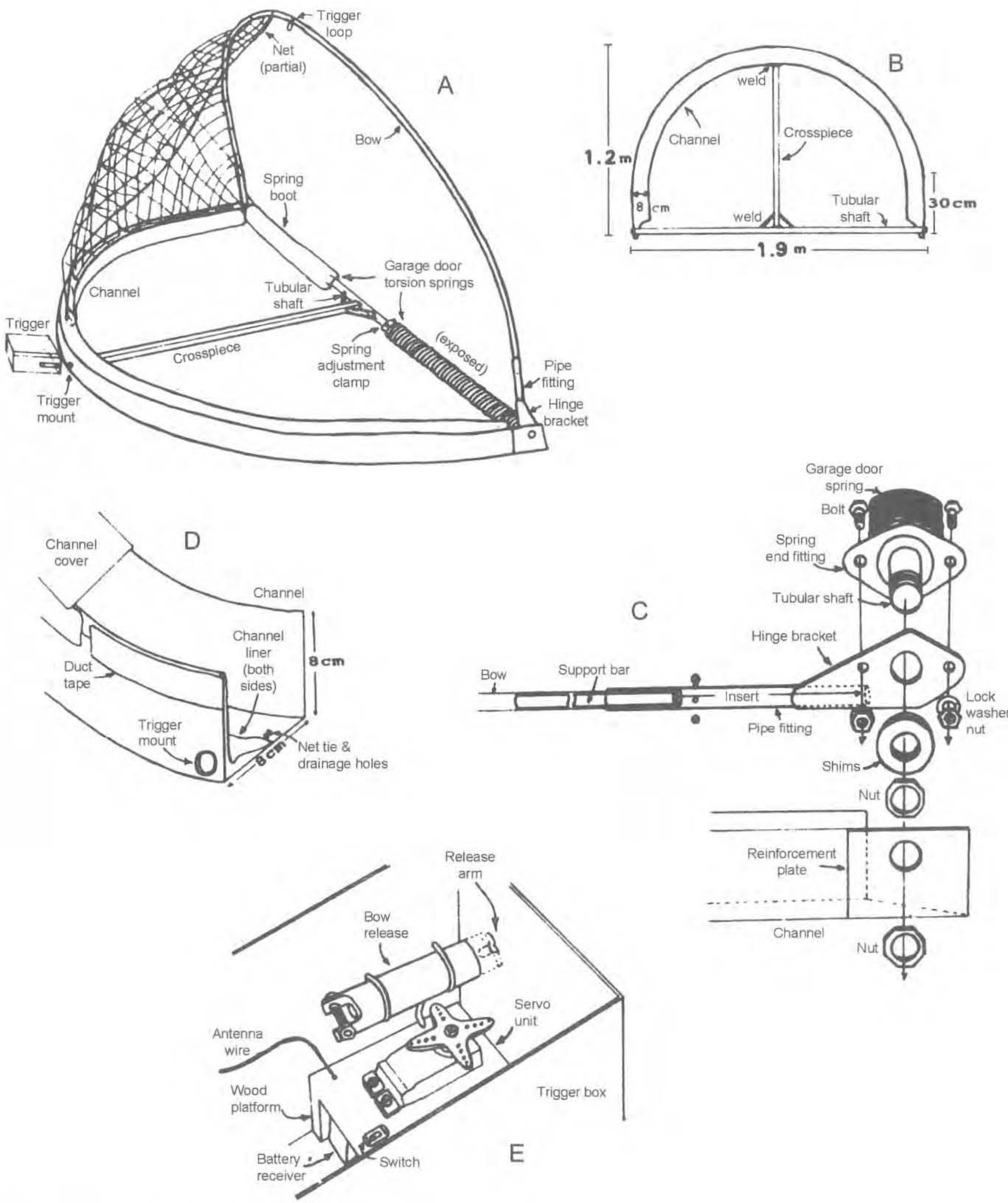


*Fig. 3.11.* Radiocontrolled eagle bow net. (A) Bow net opening, showing position of principal components; (B) top view, no springs; (C) detail of spring–hinge–bow–channel attachment; (D) cross-section detail of channel at trigger mount; (E) interior detail of trigger box. *From Jackman et al. (1994).*

*Fig. 3.12.* Helicopter with helinet attached to the front of its struts. *Photo by N. J. Silvy.*

Frenzel and Anthony (1982) and Cain and Hodges (1989) described **floating fish snares** with 2 and 4 nooses for capturing bald eagles. Jackman et al. (1993) described a modified floating-fish snare that achieved 40% capture success. They inserted a Styrofoam™ plug in the anterior portion of the fish bait, allowing the tail of the fish to dip more deeply below the water surface. Nooses consisted of 18-kg-test light-green monofilament tied with a slip knot. Two (10–20 cm) nooses were placed in an alternate or lateral position. Sucker (*Catostomus* sp.) or catfish (*Ictalurus* sp.) approximately 40 cm long were used for bait. Fish were anchored and placed in shaded areas during early morning, when the monofilament was less visible to eagles.

McGrady and Grant (1996) designed a radiocontrolled **power snare** similar to that described by Jackman et al. (1994) to capture nesting golden eagles. A nest anchor was used to keep the captured eagle on the nest to avoid injury. Nestlings were isolated in a small chicken-wire cage to avoid fouling the trap snare before firing. A video camera facilitated a clear view of the trap. Territorial golden eagles were caught on the nest efficiently and safely using this design.

Monofilament nooses of 15-kg test line, 5 cm in diameter, were attached to a 1-m-diameter chicken-wire dome and placed over the nest by Ewins and Miller (1993) to capture nesting ospreys. They secured the dome with cords around the base of the nest. Thiel (1985) placed a 20–25-cm monofilament fish-line snare into nest burrows of belted kingfisher. The snare was anchored to a tent stake inserted into the sand bank near the nest burrow entrance.

Winchell and Turman (1992) used a combination of monofilament nooses and wooden dowel rods to capture burrowing owls during the fledging season, when the owls were extremely wary of any change near their burrows or roosts. Several noose rods were placed outside the burrow, and a dowel and weight were inserted beneath the soil surface.

Reynolds and Linkhart (1984) used a telescoping noose pole with an attached 12.5-cm-diameter loop of coated stain-

*Table 3.7.* Snares and noose poles used to capture birds

| Group[a] | Reference |
|---|---|
| Galliformes | |
| Greater prairie-chicken | Berger and Hamerstrom 1962 |
| Spruce grouse | Schroeder 1986 |
| Blue grouse | Zwickel and Bendell 1967 |
| Willow ptarmigan | Hoglund 1968 |
| Raptors | Berger and Mueller 1959, Berger and Hamerstrom 1962, Ward and Martin 1968, Jenkins 1979, Dunk 1991 |
| White-tailed kite | Dunk 1991 |
| Rough-legged hawk | Watson 1985 |
| Bald eagle | Frenzel and Anthony 1982; Cain and Hodges 1989; Jackman et al. 1993, 1994 |
| Golden eagle | Jackman et al. 1994, McGrady and Grant 1994, 1996 |
| Osprey | Frenzel and Anthony 1982, Prevost and Baker 1984, Ewins and Miller 1993 |
| Crested caracara | Morrison and McGehee 1996 |
| American kestrel | Wegner 1981, Toland 1985 |
| Prairie falcon | Beauvais et al. 1992 |
| Barn owl | Colvin and Hegdal 1986 |
| Short-eared owl | Kahn and Millsap 1978 |
| Eastern screech-owl | Smith and Walsh 1981 |
| Tropical screech-owl | Thorstrom 1996 |
| Burrowing owl | Barrentine and Ewing 1988, Winchell and Turman 1992 |
| Flammulated owl | Reynolds and Linkhart 1984 |
| Spotted owl | Bull 1987 |
| Other | |
| Colonial seabirds | Edgar 1968 |
| Double-crested cormorant | Foster and Fitzgerald 1982, Hogan 1985 |
| Black-legged kittiwake | Benson and Suryan 1999 |
| Houbara bustard | Launay et al. 1999 |
| Passerines | |
| Common nighthawk | McNicholl 1983 |
| Belted kingfisher | Thiel 1985 |
| Pileated woodpecker | Cooper et al. 1995 |
| Loggerhead shrike | Yosef and Lohrer 1992, Collister and Fisher 1995, Doerr et al. 1998 |
| American magpie | Scharf 1985 |
| Bank swallow | Barrentine and Ewing 1988, Kramer 1988 |
| Chipping sparrow | Gartshore 1978 |

[a] Scientific names are given in Appendix 3.1.

less steel line (Zwickel and Bendell 1967) to capture flammulated owl from trees. Scharf (1985) used noose-covered wickets placed around a live male American magpie decoy to capture territorial magpies.

Robertson et al. (2006) used a **pole with a noose** attached to the end to capture common murres in Newfoundland, Canada. Hipfner and Greenwood (2008) used a similar 3-m-long fishing-rod noose pole with an attached monofilament noose to capture common murres in British Columbia, Canada.

Proudfoot (2002) perfected the use of a flexible fiberscope and noose to successfully remove ferruginous pygmy-owl nestlings from oak (*Quercus* spp.) nest cavities without injury. He also suggested using a miniature camera system to assist with nestling removal from cavities.

A live tethered mouse attached to a board surrounded by a monofilament noose lured spotted owls for capture (Johnson and Reynolds 1998). The noose was manually tightened when the owl landed on the mouse. Redpath and Wyllie (1994) captured territorial tawny owls by using a live tethered tawny owl as an attractant in a large modified Chardoneret trap (Fig. 3.13). The territorial owl entered an open lid and lit on a perch that released the trigger, closing the entrance lid.

## Drive Nets and Drift Fences

Tomlinson (1963) developed a method for drive-trapping dusky grouse. Clarkson and Gouldie (2003) used a drive net trap to capture moulting harlequin duck. Costanzo et al. (1995) successfully herded large flocks of flightless Canada geese into a moveable catch pen comprised of 6 attached panels (Table 3.8). Each panel was 3.4 m × 1.5 m, made of nylon netting attached to a conduit frame. This trap was inexpensive, portable, and simple to assemble.

Flores and Eddleman (1993) placed **drop-door traps** along 1-m-tall drift fences of 1.8-cm mesh black-plastic bird netting to capture black rail. The netting was stapled to wooden surveyor's stakes. Kearns et al. (1998) combined

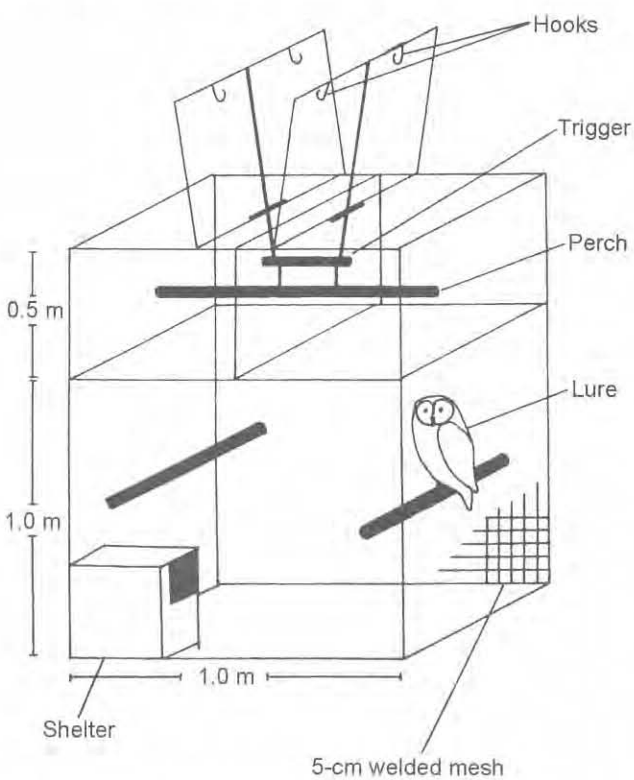


*Fig. 3.13.* Modified Chardoneret using a captive owl as a lure. Owls flew from an external perch into one of the top compartments, landing on the internal perch and releasing the trigger, which allowed the lid to close. *From Redpath and Wyllie (1994).*

*Table 3.8.* Drive and drift traps used to capture wildlife

| Group/species[a] | Reference |
|---|---|
| Birds | |
| Canada goose | Robards 1960, Heyland 1970, Timm and Bromley 1976, Costanzo et al. 1995 |
| Snow goose | Cooch 1953 |
| Wood duck | Tolle and Bookhout 1974 |
| Harlequin duck | Clarkson and Gouldie 2003 |
| Diving ducks | Cowan and Hatter 1952 |
| Blue grouse | Pelren and Crawford 1995 |
| Dusky grouse | Tomlinson 1963 |
| Ruffed grouse | Liscinsky and Bailey 1955, Tomlinson 1963 |
| Greater sage-grouse | Giesen et al. 1982 |
| Greater prairie-chicken | Toepfer et al. 1988, Schroeder and Braun 1991 |
| Lesser prairie-chicken | Haukos et al. 1990 |
| Scaled quail | Schemnitz 1961 |
| Sandhill crane | Logan and Chandler 1987 |
| Clapper rail | Stewart 1951 |
| Black rail | Flores and Eddleman 1993 |
| Virginia rail | Kearns et al. 1998 |
| Sora | Kearns et al. 1998 |
| American coot | Glasgow 1957, Crawford 1977 |
| Shorebirds | Low 1935 |
| American woodcock | Liscinsky and Bailey 1955, Martin and Clark 1964 |
| Mammals | |
| Snowshoe hare | Keith et al. 1968 |
| White-tailed deer | Stafford et al. 1966, Silvy et al. 1975, DeYoung 1988, Sullivan et al. 1991, Locke et al. 2004 |
| Mule deer | Beasom et al. 1980, Thomas and Novak 1991 |
| Himalayan musk deer | Kattell and Alldredge 1991 |
| Mountain sheep | Kock et al. 1987 |

[a] Scientific names are given in Appendix 3.1.

2.5-cm-mesh welded-wire cloverleaf traps with ramped funnel entrances and an attached catch box to catch sora and Virginia rails. Drift fences deflected the rails into the traps. Capture rate was increased by using playback of rail vocalizations. The sound system was powered by solar panels. Fuertes et al. (2002) used a modified fish-net trap in the shape of a funnel in pairs with a deflecting drift net in between to capture small rails. They added fruits, vegetables, and cat food as bait. Their traps were easy to transport and place and had a low injury rate. Caudell and Conover (2007) deployed a floating gill net to capture eared grebe in conjunction with a motorboat and a new method (**drive-by netting**).

Haukos et al. (1990) recommended walk-in drift traps (Fig. 3.14) over rocket nets and baited **walk-in traps** for the capture of lesser prairie-chicken in leks in spring. Advantages of the walk-in drift traps included minimal capture stress, no need for observer presence, and the ability to trap the entire lek. Pelren and Crawford (1995) successfully captured blue grouse with walk-in traps that intercepted mov-

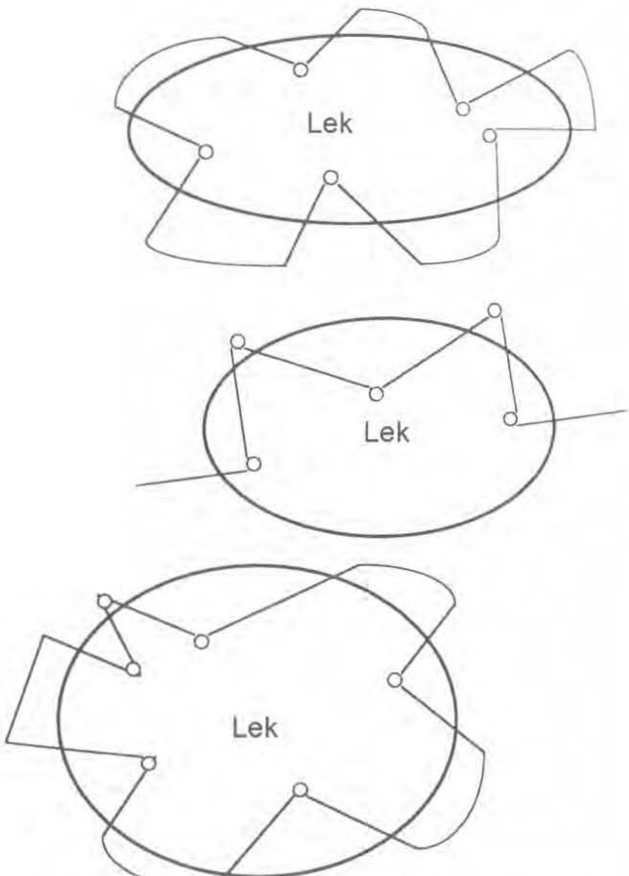


*Fig. 3.14.* Overhead view of 3 lek walk-in designs used to capture lesser prairie-chickens. *From Haukos et al. (1990).*

ing birds with 60-cm-tall mesh-wire fences. The fences guided the grouse into funnels connected to trap boxes, which were made of plastic netting with fish netting tops to minimize injury to trapped birds.

## Nest Traps

Blums et al. (2000) perfected a **multicapture nest box** for cavity-nesting ducks (Table 3.9). This trap featured a swinging false floor, entrance baffle, and counter balance. A scaled down version of this trap can be used to capture smaller cavity-nesting birds. Plice and Balgooyen (1999) designed a remotely operated trap to capture American kestrel by using nest boxes. Kestrels were trapped during prey delivery to nestlings. Cohen and Hayes (1984) perfected a simple device to block the entrance to nest boxes. They used a wooden clothespin or a similarly shaped Plexiglas clothespin attached to a monofilament line. After the bird entered the nest box, the line was pulled, and the entrance was closed. Cohen (1985) used feathers to lure male tree swallows into nest boxes, where they were subsequently captured.

Pribil (1997) developed a clever nest trap for house wrens. The trap consisted of a nest box containing a grass nest with 1 egg (Fig. 3.15). The egg was glued to a lever connected to a spring that closed a door over the entrance hole. The pecking action of the bird pushed the egg down releasing the lever. The lever, attached to a rubber band, pulled a string, which closed the door over the entry hole, thereby

*Table 3.9.* Nest traps used to capture birds

| Trap type/species[a] | Reference |
|---|---|
| Cavity | |
| Hooded merganser | Blums et al. 2000 |
| Wood duck | Blums et al. 2000 |
| Acorn woodpecker | Stanback and Koenig 1994 |
| Red-cockaded woodpecker | Jackson and Parris 1991 |
| Pileated woodpecker | Bull and Pedersen 1978 |
| Red-bellied woodpecker | Bull and Pedersen 1978 |
| Tree swallow | Rendell et al. 1989 |
| Bank swallow | Rendell et al. 1989 |
| Nest box | |
| American kestrel | Plice and Balgooyen 1999 |
| Tree swallow | Lombardo and Kemly 1983, Cohen and Hayes 1984, Cohen 1985, Stutchbury and Robertson 1986 |
| Bluebird | Kibler 1969, Pinkowski 1978 |
| House sparrow | Mock et al. 1999 |
| House wren | Pribil 1997 |
| European starling | DeHaven and Guarino 1969, Lombardo and Kemly 1983 |
| Other passerine birds | Dhondt and van Outryve 1971, Stewart 1971, Yunick 1990 |
| Waterfowl | Harris 1952, Sowls 1955, Addy 1956, Weller 1957, Coulter 1958, Miller 1962, Salyer 1962, Doty and Lee 1974, Zicus 1975, Shaiffer and Krapu 1978, Blums et al. 1983, Zicus 1989, Bacon and Evrard 1990, Dietz et al 1994, Yerkes 1997, Loos and Rohwer 2002 |
| Natural nests | |
| Pied-billed grebe | Otto 1983 |
| Egrets and herons | Jewell and Bancroft 1991, Mock et al. 1999 |
| White ibis | Frederick 1986 |
| American coot | Crawford 1977 |
| American avocet | Sordahl 1980 |
| Black-necked stilt | Sordahl 1980 |
| Mountain plover | Graul 1979 |
| Snowy plover | Conway and Smith 2000 |
| Wilson's phalarope | Kagarise 1978 |
| Mourning dove | Swank 1952, Stewart 1954, Harris and Morse 1958, Blockstein 1985 |
| White-winged dove | Swanson and Rappole 1994 |
| Raptors | Jacobs and Proudfoot 2002 |
| Osprey | Ewins and Miller 1993 |
| Short-eared owl | Leasure and Holt 1991 |
| Belted kingfisher | Thiel 1985 |
| Passerines | Gartshore 1978 |
| Cliff swallow | Wolinski and Pike 1985 |
| Barn swallow | Wolinski and Pike 1985 |
| Blue jay | Hilton 1989 |

[a] Scientific names are given in Appendix 3.1.

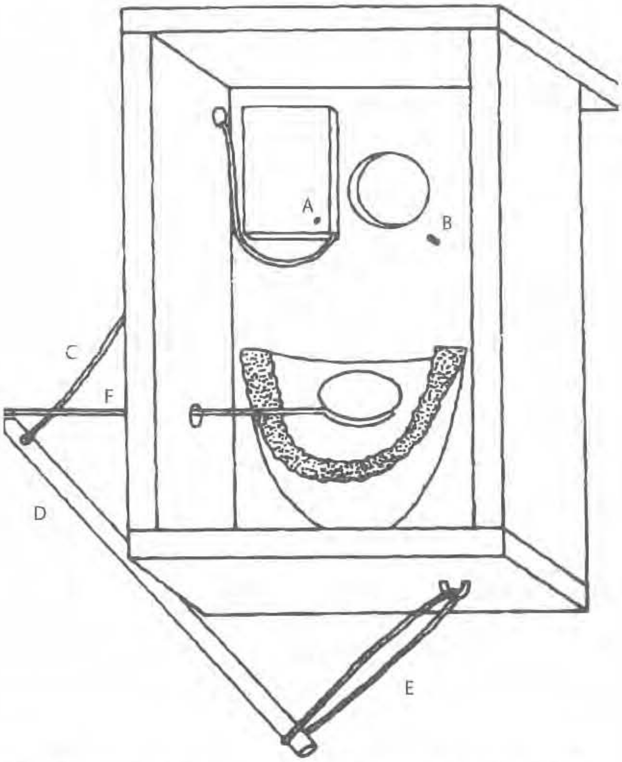


*Fig. 3.15.* Trapping box viewed from the rear with the back wall removed. A portion of the nest is removed to illustrate the position of the metal lever and the placement of the egg. A = pin around which the wooden door revolves; B = nail protruding from the wall, which keeps the door aligned over the entrance; C = string; D = wooden lever; E = rubber band; F = metal lever. *From Pribil (1997).*

capturing the wren. The wren trapping box should be placed 15–25 m from an active house wren nest. The author had her best trapping success early in the spring breeding season. Stanback and Koenig (1994) developed techniques for capturing acorn woodpecker inside natural cavities. They reached the tree hole with the aid of basic rock-climbing gear and extension ladders. They then cut a triangular door below the cavity entrance, using a folding pruning saw for the main cuts, and held the door in place with nails. The cavity entrance was blocked with a plastic bobber after the bird entered the nest, and the captured bird was then removed.

Dietz et al. (1994) designed an inexpensive **walk-in duck nest trap** with a funnel entrance and lily-pad shape. It was made of welded wire with a top of garden netting. The trap worked most effectively in dense vegetation, where researchers could make a concealed approach to block the entrance. Yerkes (1997) described a portable inexpensive trap for capturing incubating female mallard and redhead ducks that used cylindrical artificial nesting structures. The wire-covered trapdoors at each end of the nesting cylinder were manually triggered with ropes. Loos and Rohwer (2002) found long-handled nets to be more efficient than nest traps for capturing upland nesting ducks. Trapping injuries were far less frequent when long-handled nets were used in comparison to nest traps. Netted females returned to their nest more rapidly than those captured with nest traps. Netting ducks required only 1 trip to the nest, disturbing females less often than with nest traps.

A **self-tripping nest trap** was designed by Frederick (1986) to capture white ibis and other colonial nesting birds. His trap design had the advantage of being suitable for capturing large numbers of birds in a dense nesting site with minimum disturbance where traps were left unattended. A similar automatic trap was developed by Otto (1983) to catch pied-billed grebe. Mock et al. (1999) developed a nest trap that featured a wire door that prevented escape. An electronic-release triggering mechanism allowed the researcher to control the capture at distances ≤200 m. The remote control system was battery operated and inexpensive.

Yunick (1990) suggested blocking the entrance to nest boxes with a broom or rake handle upon approach to prevent escape of an incubating bird. He also described a simple, effective nest box trap of semi-rigid plastic film that hung inside the box entrance. The trap worked on the principle of a hinged flap that could be pushed like a swinging door. The U-shaped film was pinned in place.

Rendell et al. (1989) perfected a manually operated **basket trap,** consisting of a wire skeleton covered with mist netting attached by tape or line. The basket was attached to the end of a lightweight extendable pole and raised to enclose the entrance of a cavity containing a hole-nesting bird, such as a tree or bank swallow. Their trap was simple for 1 person to use, flexible, portable, lightweight, easy to construct, and required few materials.

Robinson et al. (2004) and Friedman et al. (2008) described a simple, inexpensive, and successful nest box trap. Newbrey and Reed (2008) developed an effective nest trap for female yellow-headed blackbirds. Hill and Talent (1990) used a T-shaped spring trap to capture nesting least tern and snowy plover (Fig. 3.16).

Swanson and Rappole (1994) modified a **hoop net trap,** described by Nolan (1961), by attaching mist netting to an aluminum frame from a fishing dip net to capture nesting white-winged doves) in subtropical thorn forest habitat. Conway and Smith (2000) designed a nest trap for snowy plovers. The trap consisted of 1.83-m lengths (2) of 1.25-cm electrical conduit, 16-cm pieces (4) of 1-cm-diameter wooden dowels, and 2 medium-weight strap hinges. The 2 pieces of conduit were bent into equal U shapes and attached to hinges to form the trap frame. Mesh netting was attached to the frame with twine, and black paint was sprayed on the aluminum conduit frame. The trap was anchored and activated with a 50-m-long pull cord by an observer when the incubating bird returned to the nest. The pull cord was at-

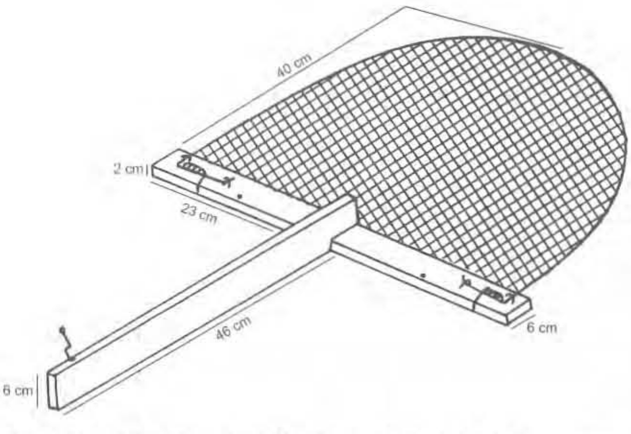


*Fig. 3.16.* Spring-loaded trap for capturing incubating least terns and snowy plovers. *From Hill and Talent (1990).*

tached to the top piece of conduit. After the bird was caught, the trap was removed to facilitate rapid return of the incubating plover to the nest.

Hines and Custer (1995) collected great blue heron eggs from nests in tall trees by using an extendable net-pole. The device consisted of 4 collapsible 2-m sections with an 11-cm wire loop and an attached 9-cm-deep basket made from nylon stocking material.

### Box and Cage Traps

Box and cage traps have been used for years to capture a variety of bird species (Table 3.10). Caffrey (2001) captured American crows and emphasized that crows are extremely wary and difficult to catch. She modified the **Australian crow trap** (Aldous 1936) by adding a drop-door at one end. Bait on trapping days should not be large food items that can be picked up and carried away easily. In all cases, prebaiting and habituating crows to trapping methods were required. Recaptures were infrequent. The Modified Australian crow trap was useful for capturing many species of crop-depredating birds, depending on the size of the entrance (Gadd 1996). Aruch et al. (2003) used a peanut-shaped baited open-door trap with 2 entrances to capture Kalij pheasants in dense Hawaiian forests. Ashley and North (2004) perfected inexpensive automated doors for waterfowl traps, thereby curtailing depredation and escapes. Clark and Plumpton (2005) perfected a simple one-way door design in combination with an artificial burrow to facilitate relocation of western burrowing owls.

Winchell (1999) designed a simplified and efficient push-door wire-mesh trap that readily captured complete broods of burrowing owls. Botelho and Arrowood (1995) constructed a trap for burrowing owls consisting of a 61-cm-long and 10-cm-diameter polyvinyl chloride (PVC) pipe. A hinged one-way Plexiglas door was inserted midway in the PVC pipe, which was placed in the owl burrows. Trapped owls were removed through a hinged door that opened on

*Table 3.10.* Box and cage traps used to capture birds

| Group/species[a] | Reference |
|---|---|
| Waterfowl | Kutz 1945, Hunt and Dahlka 1953, McCall 1954, Schierbaum and Talmage 1954, Addy 1956, Schierbaum et al. 1959, Mauser and Mensik 1992, Evrard and Bacon 1998, Harrison et al. 2000 |
| Raptors | Ward and Martin 1968, Buck and Craft 1995 |
| Ruffed grouse | Tanner and Bowers 1948, Chambers and English 1958 |
| Sharp-tailed grouse | Hamerstrom and Truax 1938 |
| Greater prairie-chicken | Hamerstrom and Truax 1938 |
| Ring-necked pheasant | Hicks and Leedy 1939, Kutz 1945, Flock and Applegate 2002 |
| Northern bobwhite | Schultz 1950, Smith et al. 1981 |
| Scaled quail | Schemnitz 1961, Smith et al. 1981 |
| Wild turkey | Baldwin 1947, Bailey 1976, Davis 1994 |
| Puffin | Nettleship 1969 |
| Burrowing owl | Martin 1971, Ferguson and Jorgensen 1981, Plumpton and Lutz 1992 |
| Mourning dove | Reeves et al. 1968 |
| Band-tailed pigeon | Drewien et al. 1966, Smith 1968, Braun 1976 |
| Chihuahua raven | Aldous 1936 |
| American magpie | Alsager et al. 1972 |
| House finch | Larsen 1970 |
| House sparrow | Therrien 1996 |

[a] Scientific names are given in Appendix 3.1.

top of the PVC pipe. Plumpton and Lutz (1992) made multiple captures of burrowing owls by modifying large **Sherman traps** placed in burrow entrances by replacing one end with 2.5-cm wire mesh. They also captured young nestlings by quietly approaching the burrow and grabbing the birds by hand before they retreated completely into the tunnel. Banuelos (1997) advocated using a one-way Plexiglas door trap for burrowing owls. The ease of constructing and setting the trap, potentially high capture rate, and lack of trapping injuries made this simple trap ideal. The one-way door trap captured owls twice as fast as did bal chatri and noose carpet traps.

Harrison et al. (2000) described a trap designed to accommodate tidal water level fluctuations by providing a 1,500-$cm^2$ floating platform in the trap to curtail mortality from drowning. Mauser and Mensik (1992) constructed a portable **swim-in bait trap** to capture ducks. The trap panels were covered with plastic netting to minimize injuries. A floating catch box allowed trap operation in a variety of water depths. They suggested a loafing platform for birds in the trap.

Wang and Trost (2000) used baited traps with a 50-cm-long funnel entrance with a chicken wire open hoop 20 cm high at the end to catch American magpie. This hoop required the magpie to jump over the hoop to reach the bait.

Buck and Craft (1955) had success catching great horned owl and red-tailed hawk with 2 designs of **walk-in traps.**

One type had a welded-wire funnel entrance. The other was activated with a monofilament tripwire that released a trapdoor. Rock doves, domestic chickens, or captive-bred northern bobwhites were enclosed in wire cages and served as live bait. Dieter et al. (2009) evaluated the duck capture success rates of various trap design types. They recommended oval traps.

### Decoy Traps and Enticement Lures

Similarly, a **Swedish Goshawk Trap** is a large cage with a trigger mechanism that uses a rock dove in a separate section as bait to trap raptors. Plumpton et al. (1995) successfully used padded and weakened **foothold traps** to capture red-tailed, ferruginous, and Swainson's hawks along roads. Trap springs were weakened by repeatedly hitting them with a hammer. Jaws of size 3 and 3N double-spring foothold traps were padded with 5-mm-thick adhesive-backed foam rubber and then wrapped with cloth friction tape. Traps were baited with a live mouse held in a harness in the form of a 24-gauge steel wire loop. The loop was placed over the head and behind the ears of the mouse. Traps were hidden with a thin covering of sifted soil or snow.

Whalen and Watts (1999) assessed the influence of **audio lures** on capture patterns of northern saw-whet owls. They found a general pattern of decreasing capture frequency with increasing distance from the audio lure. They suggested that capture rates may be maximized by using more lures, each with a small number of nets. Gratto-Trevor (2004) compiled detailed information on procedures to capture shorebirds (Charadriiformes, suborder Charadrii). Play-back distress calls increased shorebird capture rates (Haase 2002).

Various species of upland game birds have been attracted and captured with the use of **recorded calls** (Table 3.11). Breeding male ruffed grouse readily responded to playbacks of recordings of drumming display sounds by approaching to ≤2–9 m of the observer (Naidoo 2000). Playback of recordings of male display sounds near a stuffed decoy could be used to lure ruffed grouse into noosing range for capture. Taped calls and drums of pileated woodpeckers were combined with a mist net by York et al. (1998) to rapidly capture this species with minimum stress to the birds.

*Table 3.11.* Use of tape recordings of calls to attract and expedite capture of game birds

| Species[a] | Reference |
|---|---|
| Ruffed grouse | Healy et al. 1980, Lyons 1981, Naidoo 2000 |
| Blue grouse | Stirling and Bendell 1966 |
| Spruce grouse | MacDonald 1968 |
| Sharp-tailed grouse | Artmann 1971 |
| Greater prairie-chicken | Silvy and Robel 1967 |
| White-tailed ptarmigan | Braun et al. 1973 |
| Chukar partridge | Bohl 1956 |
| Scaled quail | Levy et al. 1966 |
| Gambel's quail | Levy et al. 1966 |
| Montezuma quail | Levy et al. 1966 |

[a] Scientific names are given in Appendix 3.1.

Evrard and Bacon (1998) tested 4 duck trap designs. In spring, traps with a live female mallard decoy and traps with a similar decoy and bait were more successful than bait traps without a decoy. Spring trapping was more successful than autumn trapping. Floating bait traps were largely unsuccessful in capturing waterfowl. Conover and Dolbeer (2007) successfully used decoy traps to capture juvenile European starling.

### Use of Oral Drugs

O'Hare et al. (2007) provided details on the use of **alpha-chloralose** (A-C) by the U.S. Wildlife Services, Department of Agriculture, to immobilize birds. Bucknall et al. (2006) successfully employed A-C to capture flighted birds affected by an oil spill on the Delaware River. Bergman et al. (2005) described the historical and current use of A-C as an anesthetic to capture or sedate wild turkey.

Stouffer and Caccamise (1991) successfully captured American crow with A-C inserted in fresh chicken eggs. However, McGowan and Caffrey (1994) expressed concern about high mortality of crows captured with A-C. Caccamise and Stouffer (1994) explained the possible cause of mortality and justified the continued use of A-C.

Woronecki et al. (1992) conducted safety, efficacy, and clinical trials required by the U.S. Food and Drug Administration (FDA) to register A-C. They reported the most effective dose to be 30 mg and 60 mg of A-C/kg of body weight for capturing waterfowl and rock dove, respectively. They concluded that A-C was a safe capture drug for these birds. In 1992, the U.S. Wildlife Services was granted approval by the FDA to use A-C nationwide for capturing nuisance waterfowl, American coot, and rock dove (Woronecki and Thomas 1995). Wildlife Services personnel must complete a 12-hour training course and pass a written examination to be certified to use A-C (Belant et al. 1999). The use of A-C 30 days prior to and during the legal waterfowl season for populations that are hunted is prohibited.

Initial use of 60 mg/kg of A-C in field operations yielded a low (6%) capture rate of rock dove. Belant and Seamans (1999) reevaluated doses of A-C used for rock doves and recommended treating corn with 3 mg A-C/corn kernel and 180 mg/kg as an effective dose. Mean time of first effects and mean time to capture at the 180 mg/kg dose rate were significantly less than with lower dosages. Belant and Seamans (1997) also assessed the effectiveness of A-C formulations for immobilizing Canada geese. A-C in tablet form was as effective as A-C in margarine and corn oil in bread baits. Male and female geese responded similarly to A-C immobilization. Seamans and Belant (1999) recommended A-C over DRC-1339 (3-chloro-4-methylbenzenamine hydrochloride) as a gull population-management chemical, because it was fast acting, humane, and could be used as a nonlethal capture agent.

Scientists at the National Wildlife Research Center (Wildlife Services), Fort Collins, Colorado, have recently developed and tested a tablet form of A-C. These new tablets will be available in 3 sizes, so that combinations of pellets can be used to achieve accurate dose levels for a variety of birds. Tablets should be placed inside bread cube bits for administration to birds. The tablet formulation provides a safer and simpler alternative to the current formulation, which requires mixing a powder prior to use and a syringe for injection of the solution into the bread bait.

Janovsky et al. (2002) tested **tiletamine (zolazepam),** another oral drug for bird immobilization, at a dosage of 80 mg/kg (applied in powdered form to the surface of fresh meat) on common buzzards in Austria. The deepest anesthesia was produced by fresh-drugged bait administered immediately after preparation. This drug combination had a wide safety margin with little lethal risk of overdosing nontarget birds that might accidentally feed on the bait.

### Miscellaneous Capture Methods

Smith et al. (2003*c*) located radiomarked adult northern bobwhite quail with a brood of young chicks (1–2 days old). They then erected a corral of screen covered panels that surrounded the adult and brood. After flushing the adult, they **hand captured** the chicks in the corral. Thil and Groscolas (2002) caught king penguin by hand and safely immobilized them with tiletamine zolazepam. Kautz and Seamans (1992) described several methods to expedite capture of rock doves. They caught rock doves mainly at night by hand at roost sites in barns and silos by closing the roosting sites with burlap drop window covers to prevent the birds from escaping. They also designed a catch window, consisting of a net bag of 2.5-cm × 2.5-cm mesh nylon gill netting. They developed a stuff sack that allowed placing birds into a burlap bag with 1 hand, a necessity while holding on to a supporting structure. Headlamps with an on-off switch and a rheostat were used to help hand-capture rock doves. Folk et al. (1999) devised a safe and efficient daylight capture technique for whooping cranes. They used a unique capture blind made from a cattle feed trough baited with corn. They grabbed the crane's leg through armholes in the side of the trough while the cranes were feeding on the corn in the trough.

Martella and Navarro (1992) devised a novel method for capturing greater rhea. They blinded the birds using a spotlight at night and captured them using a **boleadoras,** a device consisting of 2 or 3 balls of round stone covered with leather and attached to a long strap of braided leather, 7 mm in diameter and 1-m long. When the bird began to run, the boleadoras was thrown toward the bird's legs. The straps wound around the rhea's legs, causing it to fall and allowing hand capture.

Ostrowski et al. (2001) captured steppe eagle in Saudi Arabia by **vehicle pursuit.** Their method was limited to open habitat, but it was effective on trap-shy individuals. Eagle chases were restricted to a maximum of 15 minutes. Similarly, Ellis et al. (1998) used a **helicopter** to pursue and capture sandhill crane in open habitat.

King et al. (1998) captured American white pelican and great blue heron with modified No. 3 **padded-jaw foothold traps** by replacing both factory coil springs with weaker No. 1.5 coil springs. They also substituted the factory chain with a 20-cm length of aircraft cable and a 30-cm electric shock cord to minimize injury to captured birds. Cormorants also have been captured with padded foothold traps placed in trees with the aid of an 18-m extension ladder. The trap was camouflaged with a flour-water mixture to simulate cormorant guano (King et al. 2000).

## CAPTURING MAMMALS

Readers of this chapter are encouraged to review previous major detailed coverage of mammal capture and handling methods. These include Day et al. (1980), Novak et al. (1987), Schemnitz (1994, 2005), Wilson et al. (1996), American Society of Mammalogists (1998), Proulx (1999*a*), and Feldhamer et al. (2003). Gannon et al. (2007) stressed the need when live trapping to provide adequate food, insulation, and protection from temperature extremes. The newly developed web-based material should be investigated, especially *Best Management Practices for Trapping in the United States,* produced by the Association of Fish and Wildlife Agencies (AFWA 2006*a;* http://www.fishwildlife.org).

Mammal capture usually becomes more difficult as animal size increases. Thus, observational techniques and mammalian sign are more efficient for obtaining both inventory and density information (Jones et al. 1996). Several new techniques to capture mammals ranging in size from small rodents to large carnivores have been developed in recent years, often for specific research purposes. Some of these represent either improved or modified versions of traditional capture methods. Well-designed commercial traps are available for a variety of species. Biologists and wildlife managers now often use such traps, both for convenience and reliability. Nuisance wildlife control operators and fur trappers use commercial traps almost exclusively. An overwhelming variety of trap types and variations is available from commercial vendors (see Appendix 3.2).

Most animals are captured by hand, mechanical devices, remote injection of drugs, or drugs administered orally in baits. The emphasis in this chapter is on methods and equipment other than remotely injected drugs used for capture (see Chapter 4, This Volume). Powell and Proulx (2003) summarized the importance of mammal trapping ethics, proper handling, and the humane use of various traps for various species.

## Use of Nets

### Dip Nets

Such mammals as jackrabbits (Griffith and Evans 1970) and skunks are first located with spotlights and then pursued on foot using a flashlight and **dip net.** Dip nets also are used to pull down drugged mammals. Rosell and Hovde (2001) combined a spotlight and the use of nylon mesh landing nets from boats on rivers and on foot on land to catch American beaver. The net, when used in the water, was closed with a drawstring to prevent escape. The netting method resulted in no mortalities, in contrast to 5.3% mortality with snares (McKinstry and Anderson 1998).

### Mist and Harp Nets

Kuenzi and Morrison (1998) suggested combining mist net capture with **ultrasonic detection** to identify the presence of bat species. Francis (1989) compared mist nets and 2 designs of **harp traps** for capturing bats (Chiroptera). Large bats (megachiropterans) were captured at similar rates in harp traps and mist nets, but microchiropterans were captured nearly 60 times more frequently in traps. He noted that small bats have teeth with sharp cutting edges and often chewed part of the net around them and escaped. He recommended use of 4-bank harp traps over 2-bank harp traps for capture efficiency. Tidemann and Loughland (1993) devised a trap for capturing large bats. It featured wire cables stretched between rigid uprights. Vertical strings were strung between the cables. Waldien and Hayes (1999) designed a hand-held portable H-net used to capture bats that roosted at night under bridges. The H-net consisted of a mist net attached to PVC pipe and T-couplers. Palmeirim and Rodrigues (1993) described an improved harp trap for bats that was inexpensive and lightweight (4.5 kg) and could be assembled by 1 person in 2 minutes.

Cotterill and Fergusson (1993) described a new trapping device (Fig. 3.17) to capture African free-tailed bats as they left their daylight roosts. They used polythene **plastic sheeting** attached to a rectangular frame of aluminum tubing. Bicycle wheels were attached to each corner of the frame to carry the assembled trap into position below the roost exit. Two people elevated the trap with ropes and pulleys. Bats were caught in a plastic bag and easily removed with a minimum of stress, in contrast to mist nets. Kunz et al. (1996) provided an in-depth review of bat capture methods.

### Drop Nets

Drop nets using **explosive charges** have been used to capture white-tailed deer (Ramsey 1968, Conner et al. 1987, and DeNicola and Swihart 1997), mule deer (White and Bartmann 1994, D'Eon et al. 2003), and mountain sheep (Fuller 1984, Kock et al. 1987). Silvy et al. (1990) developed a **non-explosive** drop net to capture Key deer. Lopez et al. (1998) develop a drop net triggered by a **pull rope** to capture urban deer. Jedrzejewski and Kamler (2004) perfected a modified drop net for capturing ungulates.

### Drive Nets and Drift Fences

Silvy et al. (1975) developed a **portable drive net** to capture free-ranging deer. Peterson et al. (2003*b*) and Locke et al. (2004) described several advantages of a portable drive net for capturing urban white-tailed deer. Okarma and Jedrzejewski (1997) and Musiani and Visalberghi (2001) used fladry to help capture gray wolves. Fladry consists of red flags attached to nylon ropes 60 cm above ground, placed along roads or trails in forested areas. **Beaters,** spaced at 250-m intervals, drove the wolves into nets, where they became entangled and were captured. Drive nets have been widely used to capture large mammals, but they also are useful for trapping small ones. Vernes (1993) devised a drive fence with attached wire-cage traps set parallel to forest edges. Sullivan et al. (1991) compiled data on captures of 430 white-tailed deer using the drive-net technique. The observed capture-related mortality and overall mortality rates were 1.1% and 0.9%, respectively. These rates were lower than those re-

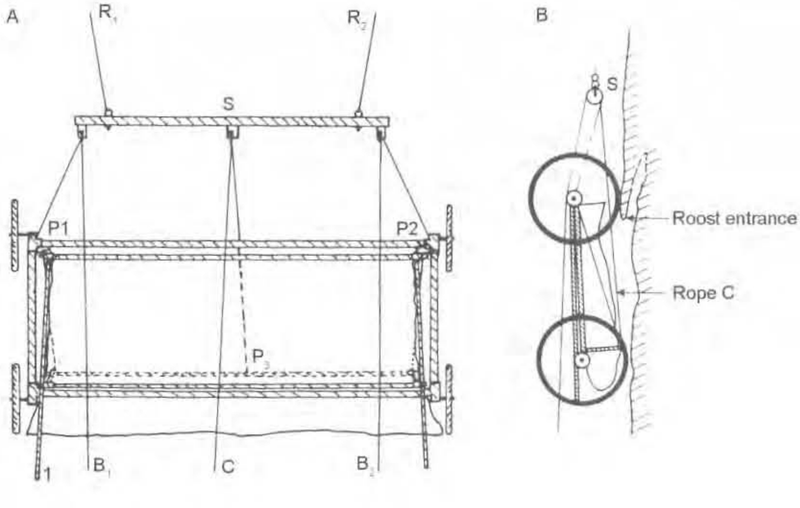


*Fig. 3.17.* Trap arrangement for catching bats. (A) Assembled trap with ropes and their points of attachment, (B) lateral view of the assembled trap. Aluminum frames are cross-hatched. *From Cotterill and Fergusson (1993).*

ported for other common capture methods. Kattell and Alldredge (1991) used 3–6-m-long, 1.8–2.0-m-high nets to capture Himalayan musk deer in Nepal. After the nets were set, 2 people slowly drove the deer toward the nets, where the animals became entangled. Faulhaber et al. (2005) used **drift fences** to capture Lower Keys marsh rabbits.

Thomas and Novak (1991) described procedures contributing to successful **helicopter** drive-net captures of mule deer. Netting was dyed a dull green or brown color to reduce its visibility. When possible, nets should be placed in or near a drainage bottom, where deer could be herded downhill into the net, which should be concealed by terrain. Net sites providing close hiding cover for observers, which allowed quick access to entangled animals, were essential. Ideal weather conditions consisted of high overcast that reduced glare and net visibility. A steady breeze of 9–18 km/hr blowing downwind from the helicopter toward the deer and net reduced the possibility of animals scenting and avoiding the capture site.

Kelly (1996) captured ringed seals with nets set at breathing holes in the ice. He designed a net that lined a breathing hole and closed below the surface with a weighted triggering device. Three wire hoops were attached to the net to hold it open. He increased seal visitation by cutting holes in the ice.

### Cannon and Rocket Nets

Rocket and cannon nets have been used to trap mammals (Table 3.5) for many years. Beringer et al. (1996) noted that if rocket nets are used to capture deer, capture should be limited to ≤3 deer per capture. They advised that handling time be minimized to reduce stress to captured deer. If deer are to be radiotagged, there should be at least 1 person per deer and an extra person to apply the radio collar. Deer should be blindfolded immediately after capture to prevent stress.

### Net Guns

Carpenter and Innes (1995) used net guns from helicopters to capture moose with a mortality rate of less than 1%. White and Bartmann (1994) reported that net gunning (Table 3.6) was a more economical, efficient, and safe capture method than drop nets for mule deer fawns. The use of net guns from a helicopter was the most effective method for winter capture of yearling and adult white-tailed deer in non-yarding populations (Ballard et al. 1998). Webb et al. (2008) found the **helicopter** and net gun capture technique for white-tailed deer to be safe compared to other capture techniques.

## Snares and Noose Poles

Gray wolves were pursued in Finland with snowmobiles over soft snow 80-cm deep and were captured with a neck hold noose attached to a pole (Kojola et al. 2006). Davis et al. (1996) designed a lightweight noose device attached to ski poles to safely remove mountain lions and bears from trees and cliffs. Grizzly and black bears captured in leg snares exhibited more muscle injury and capture myopathy than did bears captured by helicopter darting or bear drop door traps (Cattet et al. 2008).

## Box and Cage Traps

Various box and cage traps are used to capture a large variety of mammals (Table 3.12). Haulton et al. (2001) evaluated 4 methods (Stephenson box traps, Clover traps, rocket nets, and dart guns) to capture deer. They found that smaller deer captured with Clover traps were more susceptible to capture mortality. Anderson and Nielsen (2002) described a modified Stephenson trap to capture deer. It featured lightweight panels that were easily set up and readily movable. They recommended their trap for capturing deer in urban areas. Ballard et al. (1998) used Clover traps and darting from tree stands to capture white-tailed deer. They bolted U-clamps to keep the drop doors on the Clover traps closed to avoid deer escapes and substituted nuts and bolts for welds that broke at sub-zero temperatures.

*Table 3.12.* Box and cage traps used to capture mammals

| Species[a] | Reference |
|---|---|
| Kangaroo rat | Brock and Kelt 2004, Cooper and Randall 2007 |
| Bushy-tailed woodrat | Lehmkuhl et al. 2006 |
| Dusky-footed woodrat | Innes et al. 2008 |
| Key Largo woodrat | McCleery et al. 2005, 2006 |
| Cotton rat | Sulok et al. 2004, Cameron and Spencer 2008 |
| Deer mouse | Whittaker et al. 1998, Rehmeier et al. 2004, Jung and O'Donovan 2005, Reed et al. 2007 |
| Nine-banded armadillo | Bergman et al. 1999 |
| Snowshoe hare | Aldous 1946, Libby 1957, Cushwa and Burnham 1974, Litvaitis et al. 1985a |
| Lower Keys marsh rabbit | Faulhaber et al. 2005 |
| Pygmy rabbit | Larrucea and Brussard 2007 |
| Flying squirrel | Carey et al. 1991, Flaherty et al. 2008, Wilson et al. 2008 |
| Red squirrel | Haughland and Larsen 2004, Herbers and Klenner 2007 |
| Gray squirrel | Huggins and Gee 1995, Linders et al. 2004 |
| Fox squirrel | Huggins and Gee 1995; McCleery et al. 2007*a*, *b* |
| Abert's squirrel | Patton et al. 1976, Dodd et al. 2003 |
| Townsend's chipmunk | Carey et al. 1991 |
| Eastern chipmunk | Waldien et al. 2006, Ford and Fahrig 2008 |
| Woodchuck | Trump and Hendrickson 1943, Ludwig and Davis 1975, Maher 2004 |
| California ground squirrel | Horn and Fitch 1946 |
| Pocket gopher | Howard 1952, Sargeant 1966, Baker and Williams 1972, Witmer et al. 1999, Connior and Risch 2009 |

*continued*

*Table 3.12.* continued

| Species[a] | Reference |
|---|---|
| Prairie dog | Dullum et al. 2005, Facka et al. 2008 |
| American beaver | Couch 1942, Hodgdon and Hunt 1953, Collins 1976, Koenen et al. 2005 |
| Mountain beaver | Arjo et al. 2007 |
| Muskrat | Takos 1943, Snead 1950, Stevens 1953, Robicheaux and Linscombe 1978, McCabe and Elison 1986, Lacki et al. 1990 |
| Nutria | Norris 1967, Evans et al. 1971, Palmisano and Dupuie 1975, Linscombe 1976, Robicheaux and Linscombe 1978, Baker and Clarke 1988 |
| Porcupine | Brander 1973, Craig and Keller 1986, Griesemer et al. 1999, Zimmerling 2005 |
| Coyote | Foreyt and Rubenser 1980, Way et al. 2002 |
| Gray fox | AFWA 2006*e* |
| Kit fox | Zoellick and Smith 1986 |
| Swift fox | Kamler et al. 2002 |
| Mountain lion | Shuler 1992 |
| Canada Lynx | Mowat et al. 1994 |
| Bobcat | Woolf and Nielson 2002, AFWA 2006*b* |
| Black bear | Erickson 1957, Black 1958, Cattet et al. 2008 |
| Brown and grizzly bear | Craighead et al. 1960, Troyer et al. 1962 |
| Raccoon | Robicheaux and Linscombe 1978, Moore and Kennedy 1985, Proulx 1991, Gehrt and Fritzell 1996, AFWA 2006*h* |
| American marten | Naylor and Novak 1994, Bull et al. 1996 |
| Virginia opossum | AFWA 2006*g* |
| Fisher | Arthur 1988, Frost and Krohn 1994, AFWA 2007*b* |
| Striped skunk | Allen and Shapton 1942, AFWA 2009*a* |
| Northern river otter | Northcott and Slade 1976; Melquist and Hornocker 1979, 1983; Shirley et al. 1983; Route and Peterson 1988; Serfass et al. 1996; Blundell et al. 1999 |
| Long-tailed weasel | Belant 1992 |
| Short-tailed weasel | Belant 1992 |
| Feral hog | Matschke 1962, Williamson and Pelton 1971, Saunders et al. 1993, Jamison 2002, Mersinger and Silvy 2006 |
| Collared peccary | Neal 1959 |
| Elk | Thompson et al. 1989 |
| White-tailed deer | Bartlett 1938; Ruff 1938; McBeath 1941; Webb 1943; Glazener 1949; Clover 1954, 1956; Hawkins et al. 1967; Sparrowe and Springer 1970; Runge 1972; McCullough 1975; Foreyt and Glazener 1979; Palmer et al. 1980; Rongstad and McCabe 1984; Morgan and Dusek 1992; Naugle et al. 1995; Beringer et al. 1996; Ballard et al. 1998; VerCauteren et al. 1999; DelGiudice et al. 2001*a*; Haulton et al. 2001; Anderson and Nielsen 2002 |
| Mule deer | Lightfoot and Maw 1963, Roper et al. 1971, D'Eon et al. 2003 |

[a] Scientific names are given in Appendix 3.1.

*Fig. 3.18.* Culvert trap for capturing bears. *Photo by the New Mexico Department of Game and Fish.*

Bull et al. (1996) covered wire cage traps with black plastic to protect American marten from rain and snow to reduce the risk of mortality from **hypothermia.** They also placed clumps of wool for insulation in wood boxes to provide warm, dry shelter during winter trapping. Baited culvert traps (Fig. 3.18) have been widely used to capture and transplant nuisance bears (Erickson 1957).

Carey et al. (1991) placed a single-door collapsible wire-box trap 1.5 m above ground in large trees to capture arboreal mammals, such as northern flying squirrels and Townsend's chipmunks. A nest box was inserted behind the trap treadle to minimize stress and hypothermia. Hayes et al. (1994) described a simple and inexpensive modification (Fig. 3.19) of the technique of Carey et al. (1991) to attach live traps to small-diameter trees, 8.5–30.0-cm diameter at breast height, by means of a triangular plywood bracket. The bracket was set tangential to the tree trunk, and 2 aluminum nails were driven through the plywood and into the tree. Nylon twine was tied around the trap and secured to 2 additional nails. Malcolm (1991), Vieira (1998), and Kays (1999) described an **arboreal** mammal box-trap system that could be hoisted to sample arboreal mammal communities. Huggins and Gee (1995) tested 4 cage trap sets for gray and fox squirrels; they found traps set at eye level on a platform attached to tree trunks resulted in the highest rate of capture.

Szaro et al. (1988) assessed the effectiveness of pitfalls and Sherman live traps in measuring small mammal community structure. They found that live traps and pitfalls provided different estimates of species composition and relative abundance. However, live-trapping was significantly more successful than pitfalls in terms of number of new captures per trap night. They recommended the use of both pitfalls and live traps, particularly when shrews (Soricidae), which are not readily caught in live traps, need to be sampled. Slade et al. (1993) advised using a combination of trap types for sampling diverse small mammal faunas.

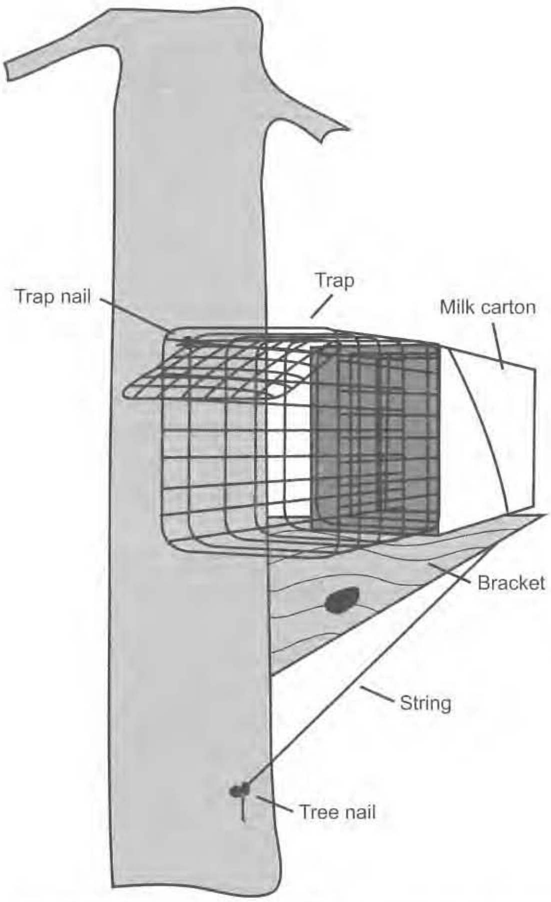


*Fig. 3.19.* Tomahawk live trap attached to a small-diameter tree by a bracket. *From Hayes et al. (1994).*

Fitzgerald et al. (1999) tested the capture rate of buried and unburied folding Sherman live traps in desert grasslands and desert shrub communities. Traps were set in pairs for 3 consecutive nights. The unburied trap capture rate was significantly greater than that for buried traps. Burying traps may be a cost-effective method of reducing trap fatalities related to temperature fluctuations in desert environments.

**Standardization** of traps and trapping procedures are needed to adequately sample small-mammal populations. Kirkland and Sheppard (1994) proposed a standard protocol for sampling small-mammal populations with emphasis on shrews. They suggested using Y-shaped arrays of 10 **pitfall traps** (large cans or buckets recessed into the ground) and drift fences. Each arm, which was anchored on a central pitfall, consisted of 3 pitfalls separated by 5-m sections of drift fence. Pitfalls ≥14 cm in diameter and 19-cm deep should be half-filled with water to quickly drown captured animals. They recommended that arrays be operated for 10 consecutive days. This interval totaled 100 trap nights of sampling effort per array per sampling period and allowed easy calculation of relative abundance as the percentage capture success. Handley and Varn (1994) suggested using a small, easily set pitfall array in the form of a triangle with 2.5-cm sides and set in a transect for capturing shrews. Two people set 2 arrays per hour. They used 2-liter, heavy-gauge plastic soft drink bottles with the tops cut off as pitfalls. The plastic bottles were 20-cm deep and 11 cm in diameter. At the center of the array they used a 4-L plastic bottle 18-cm deep and 15 cm in diameter. Pitfalls were arranged with 120° between arms and joined with 1.2-m-long and 30-cm-high drift fence. Tew et al. (1994) tested 2 trap spacings, 24 m and 48 m, using 184 Longworth live traps set in a rectangular grid covering an area of 10 ha. They found the 2 spacings were equally effective in capturing wood mice. They suggested that projects with limited numbers of traps should consider wider trap spacing with an increased trapping period.

A study by Mitchell et al. (1993) in saturated forested wetlands showed that pitfalls in conjunction with drift fences captured significantly greater numbers of small mammals than did isolated pitfall can traps in the same general area. They recommended that different researchers should use the same technique and sampling effort for the same taxa. Moseby and Read (2001) recommended 8 nights of pitfall trapping as the most efficient duration for mammals. Pitfalls should be ≥40 cm deep for small mammals and ≥60 cm for agile species, such as hopping mice.

Hays (1998) devised a new method for live-trapping shrews by inserting small 10-cm Sherman live traps into holes cut in Nalgene plastic jars (25-cm high × 15-cm diameter). The trap entrance was covered with 12-mm wire mesh to exclude mice. Traps were baited with mealworms and cotton batting. Traps were checked daily, and trap mortality was only 1%. Yunger et al. (1992) greatly decreased the mortality of masked shrews (77.5% survival) caught in pitfall traps by providing 7 g of whitefish (*Coregonus* spp.) per pitfall.

Whittaker et al. (1998) evaluated captures of mice in 2 sizes of Sherman live traps. Small Sherman traps captured significantly more white-footed and cotton mice. More rice rats were caught in large Sherman traps. Jorgensen et al. (1994) set paired Sherman and wire-mesh box traps. More rodents were consistently caught in the Sherman traps made of sheet metal. They attributed the capture rate difference to less frequent entry by rodents into wire-mesh traps and a more sensitive treadle in the Sherman traps. In contrast, O'Farrell et al. (1994) experimented with similar sized Sherman and wire-mesh live traps. Captures were significantly greater in mesh traps than in Sherman traps. They surmised that an open trap that can be seen through was preferred to an enclosed box. Their estimates of small mammal density at different sites using wire mesh traps were 15–37% higher than estimates with Sherman traps. They concluded the composition of communities of small mammals might be inaccurately represented based on the type of trap used. McComb et al. (1991) compared capture rates of small mammals and amphibians between pitfall and Museum Special snap traps in mature forests in Oregon.

Fewer small mammal and amphibian species were caught with Museum Special traps than with pitfalls. However, 2 species of salamander were captured only in pitfall traps. Museum Specials baited with peanut butter were more effective than traps baited with meat paste. Pearson and Ruggiero (2003) examined **trap arrangement** in forested areas by comparing transect and grid trapping of small mammals. Transects yielded more total and individual captures and more species than did grid arrangements.

Dizney et al. (2008) evaluated 3 small mammal trap types in the Pacific Northwest. Pitfalls were the most effective trap. Sherman traps significantly outperformed mesh traps. Anthony et al. (2005) compared the effectiveness of Longworth and Sherman live traps. They suggest that using a combination of both traps would ideally sample small mammals with a minimum of bias. Jung and O'Donovan (2005) cautioned the use of Ugglan wire-mesh live traps caused mortality of deer mice, because their upper incisors became entangled in the wire mesh. Kaufman and Kaufman (1989) place wood shelters over Sherman traps at ground squirrel burrows and increased capture success. Waldien et al. (2006) covered Sherman traps with a milk carton sleeve for insulation and used polyfiber batting to provide additional **thermal protection** for captured animals. Umetsu et al. (2006) found pitfalls to be more efficient than Sherman traps for sampling small mammals in the Neotropics. A simplified, easily constructed Tuttle-type collapsible bat trap using PVC tubing was designed by Alvarez (2004). Fuchs et al. (1996) described a technique widely used for catching European rabbits in Scotland that consisted of a buried tip-top galvanized steel box. The earth floor of the trap was covered with wire mesh to prevent escape.

Lambert et al. (2005) detailed an arboreal trapping method for small mammals in tropical forests (Fig. 3.20). Winning and King (2008) perfected a baited pipe trap mounted vertically to a tree to successfully capture squirrel glider in Australia (Fig. 3.21). Waldien et al. (2004) cautioned mammal trappers on the potential mortality of birds captured in Tomahawk™ and Sherman live traps.

Mitchell et al. (1996) reported that use of an **ant insecticide** (Dursban®) did not affect overall capture yield or probability of capture of 12 species of small mammals and that mutilation rates by ants were lower. Gettinger (1990) reported that use of chemical insect repellents increased capture rates.

Yunger and Randa (1999) immersed Sherman live traps for 5 minutes in a 10% bleach solution (sodium hypochlorite) to **decontaminate** them from sin nombre hantavirus. No effect on small mammal capture rate was observed. Cross et al. (1999) tested bleach treatment and found no effect on trap success. Van Horn and Douglass (2000) used a Lysol® disinfectant followed by a fresh water rinse to clean traps. This treatment did not influence subsequent deer mouse capture rates.

Heske (1987) recommended the use of clean live traps to obtain an unbiased demographic sample of small mammals.

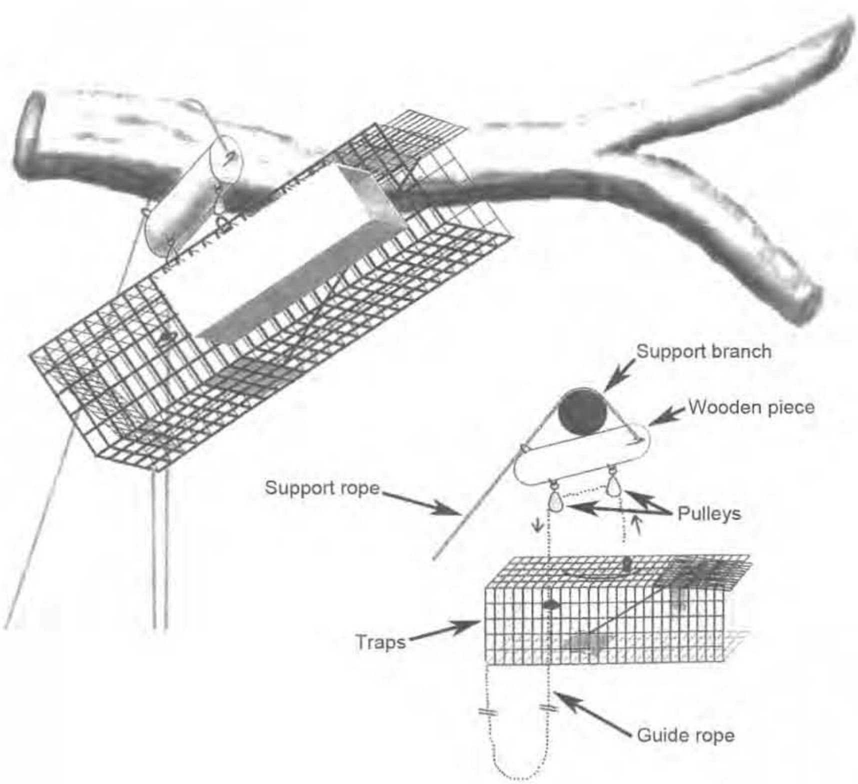


*Fig. 3.20.* Diagram of the arboreal trapping method used in the southeastern Amazon. *From Lambert et al. (2005).*

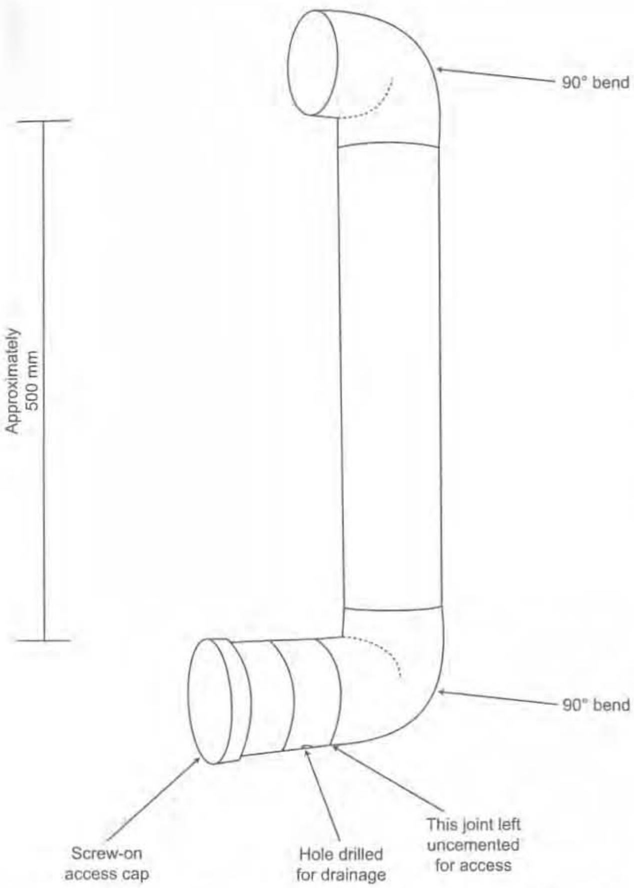


*Fig. 3.21.* Design of pipe trap. The design uses 90-mm polyvinyl chloride (PVC) pipe and fittings throughout. *From Winning and King (2008).*

He observed that using soiled traps might cause possible violations of the assumptions of equal catch success of all individuals. He documented that *Microtus* samples were more accurate demographically if all traps were kept clean. Jones et al. (1996) advised cleaning all traps with soap and water after each trapping session to increase consistency in trapping success.

Live trapping **bias** of small mammals varies with gender, age, and species. Results of capture rates to previous trap occupancy depended on gender and age (Gurnell and Little 1992). Wolf and Batzli (2002) reported that white-footed mice were less likely to be captured in live traps that previously held short-tailed shrews. Adult white-footed mice were more likely to be captured in traps previously occupied by conspecific individuals of the opposite gender than in traps previously occupied by the same gender. In contrast, Gurnell and Little (1992) reported no evidence of breeding males or females being attracted to traps containing the odor of the opposite gender. Their studies involved various wood rodents (wood mice, bank voles, and yellow-necked mice).

### Corral Traps

Sweitzer et al. (1997) designed a modified **steel mesh panel trap** for capturing multiple feral hogs with a minimum (5%) of injury. Their traps included a gate entrance with a runway leading to an enlarged corral with a trip line activating a side-hinged squeeze gate. Saunders et al. (1993) suggested attaching fine mesh wire on the inside of trap drop gates to prevent hogs caught inside the trap from gripping the gate with their teeth and lifting it, allowing others to escape. They set traps using a trip wire placed in a back corner of the trap 20 cm above its floor. Jamison (2002) described effective traps for feral hog capture. He emphasized the need for a strong, portable trap the width and length of an average pickup truck bed to facilitate transporting live hogs. Choquenot et al. (1993) used estrous sows as a lure, but no hogs were attracted or captured. West et al. (2009) describe several traps used to capture feral hogs.

Cancino et al. (2002) designed a modified corral trap (Table 3.13) consisting of a 70-ha **enclosure** and an adjacent observation tower. A 4-ha area in the enclosure was irrigated to attract pronghorn. A gate at one end was closed to confine the animals that gradually moved toward the end of the exclosure, attracted by captive pronghorn, mobile feeders, and water, where another gate was closed to confine them. Lee et al. (1998) summarized other pronghorn capture methods. Pérez et al. (1997) perfected a corral trap for capturing Spanish ibex. The trap consisted of a 3-m-high metallic net fence with a 3-m-high net inside. The 2 nets were 1 m apart; salt blocks were used as bait.

### Foot Traps and Snares

Since 1997 the Association of Fish and Wildlife Agencies (AFWA), in cooperation with state wildlife agencies and the U.S. Department of Agriculture's Animal and Plant Health Inspection Service, has engaged in a congressionally mandated project evaluating commercial traps for 23 species of North American furbearers in 5 U.S. regions to develop **Best Management Practices (BMP)** for traps and trapping (AFWA

*Table 3.13.* Corral traps used to capture wildlife

| Group/species[a] | Reference |
|---|---|
| Canvasback | Haramis et al. 1987 |
| Jackrabbit | Henke and Demarais 1990 |
| Collared peccary | Neal 1959 |
| Feral hog | Sweitzer et al. 1997 |
| Deer | Lightfoot and Maw 1963, Hawkins et al. 1967, Rempel and Bertram 1975 |
| Elk | Couey 1949, Mace 1971 |
| Moose | Pimlott and Carberry 1958, LeResche and Lynch 1973 |
| Pronghorn | Spillett and ZoBell 1967, Cancino et al. 2002 |
| Spanish ibex | Pérez et al. 1997 |

[a] Scientific names are given in Appendix 3.1.

2006*a*). Evaluations include performance profiles for commercial traps that include efficiency, selectivity, safety, practicality, and animal welfare, using international standards for humaneness (International Organization for Standardization [ISO] 1999*a*, *b*). Numerous documents (cited elsewhere in this chapter) provide data and background information on the AFWA project and are available at the AFWA website, which is continuously updated as new data become available. The technical information and animal welfare information are useful in selecting the most appropriate equipment for particular uses, often help researchers answer the concerns of Institutional Animal Care and Use Committees, help manufacturers design and improve state-of-the-art capture equipment, and help state wildlife agencies maintain healthy wildlife populations using regulated trapping.

Fur trappers, nuisance-wildlife control agents, and researchers have used commercial (see Appendix 3.2 for a list of suppliers) and hand-made traps to capture a variety of mammals, including carnivores, rodents, lagomorphs, and marsupials. These mechanical devices can be divided into 2 broad categories: restraining (live) and killing traps. However, certain trap designs can be included in either category, depending on how they are deployed in the field.

The AFWA documented the performance of foot traps, snares, and other forms of restraining traps in support of the development of BMP (AFWA 2006*a*). Test traps were selected based on knowledge of commonly used traps, previous research, and input from expert trappers. Data collection, including safety evaluations, was undertaken using procedures specified in ISO Documents 10990-4 and 10990-5 (ISO 1999*a*, *b*). Trauma scales used to assess animal welfare performance for restraining traps are presented in ISO Document 10990-5, and BMP research adapted those scales for evaluating injury in captured animals (injury scales ranged from 0 for uninjured animals to 100 for animals found dead in traps). BMP traps are required to consistently yield little to no injury to captured animals (AFWA 2006*a*), and therefore they are acceptable in many wildlife research applications.

## Trap Types

**Restraining traps** are those designed to capture an animal alive. Three basic types are used to capture mammals. Cage or box traps are manufactured in an array of sizes for small insectivores, rodents, lagomorphs, carnivores, and ungulates. They are constructed of wire or nylon mesh, wood, plastic, or metal. The functional components include the cage box, 1 or 2 self-closing doors, a door lock mechanism, a trigger, and a treadle or trip pan. Foothold traps are commonly used to capture medium-sized mammals, such as wild canids and felids (Fig.3.22). A typical foothold trap has 2 jaws open at 180° when in the set position and closing 90° upon each other when released. Another foothold design includes foot-encapsulating devices, such as the EGG™ trap (Proulx et al. 1993*c*, Hubert et al. 1996) and Duffer's trap (IAFWA 2000), which have a pull trigger that releases a small striking bar to block an animal's paw as well as a plastic or metal housing that protects the captured limb from torsion or self-inflicted injuries (Fig. 3.23). These traps are species-specific, are considered relatively "dog proof," and are used to capture raccoons and opossums.

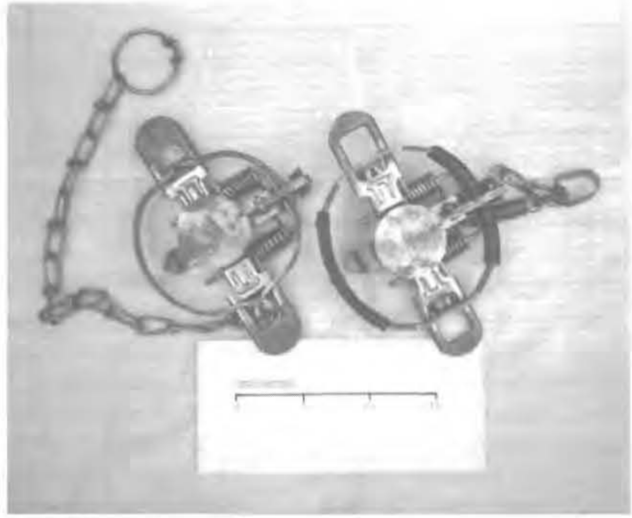

*Fig. 3.22.* Foothold restraining traps used to capture mammals: Victor No. 1.5 coil spring foothold trap (left) and Victor No. 1.5 Soft-Catch foothold trap with padded jaws (right). *Photo by G. F. Hubert, Jr.*

**Foot snares,** such as the Aldrich (Poelker and Hartwell 1973), Åberg™ (Englund 1982), Fremont™ (Skinner and Todd 1990), and Belisle™ (Shivik et al. 2000), are spring-powered cables used to capture and hold medium and large animals by a limb (Fig. 3.24). Modified manual neck snares (McKinstry and Anderson 1998, Pruss et al. 2002) and specialized cable restraints, such as the Collarum™ (Shivik et al. 2000), also can function as restraining traps. The performance of snares as live restraint tools versus killing systems is determined by numerous variables, including set location, snare and lock types, and experience of the trapper (AFWA 2009*b*).

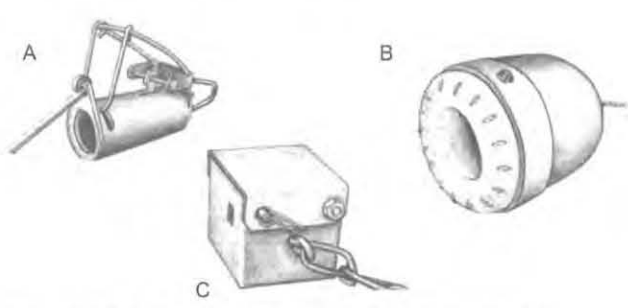


*Fig. 3.23.* Foot encapsulating traps specifically designed for capturing raccoons (they prevent self-mutilation) and reducing the capture of domestic pets: (A) Lil' Grizz Get'rz, (B) EGG, (C) Duffer's. *Photo courtesy of the Association of Fish and Wildlife Agencies.*

*Fig. 3.24.* Novak foot snare. *Photo by G. F. Hubert, Jr.*

**Killing traps** have one or more striking jaws (or a snare noose) activated by one or many springs upon firing by a trigger mechanism. Killing traps come in a variety of sizes, and their method of action varies. Mousetrap-type devices, where one jaw closes 180° on a flat surface, are commonly used to capture commensal and other small rodents. Killing boxes, pincer- and spear-type traps, and certain body-gripping devices are used to capture fossorial rodents and moles. The cage/box and foothold restraining traps also can be used as killing devices by placing them in or near water, so the captured animal is submerged and drowns. This technique is commonly used by fur trappers when harvesting aquatic and semi-aquatic mammals, such as American beaver, mink, muskrat, and northern river otter. Planar traps, in which a spring functions as a killing bar, are used to catch rat-sized rodents and small carnivores (e.g., Mustelidae). Rotating-jaw or body gripping traps have a scissor-like closing action and are used for a variety of mammals ranging in size from tree squirrels to beaver. Finally, manual locking neck and power snares are used to catch and kill medium-sized carnivores, such as foxes, coyotes, and bobcats (Table 3.14).

*Table 3.14.* Snares and neck collars used to capture mammals

| Group/species[a] | Reference |
|---|---|
| Snowshoe hare | Keith 1965, Brocke 1972, Proulx et al. 1994*a* |
| Ground squirrel | Lishak 1976 |
| American beaver | Collins 1976, Mason et al. 1983, Weaver et al. 1985, McKinstry and Anderson 1998, Riedel 1988 |
| Nutria | Evans et al. 1971 |
| Gray wolf | Van Ballenberghe 1984, Schultz et al. 1996 |
| Coyote | Nellis 1968, Guthery and Beasom 1978, Onderka et al. 1990, Phillips et al. 1990*b*, Skinner and Todd 1990, Phillips 1996, Sacks et al. 1999, Shivik et al. 2000, Pruss et al. 2002 |
| Red fox | Berchielli and Tullar 1980, Novak 1981*b*, Rowsell et al. 1981, Englund 1982, Proulx and Barrett 1990, Bubela et al. 1998 |
| Gray fox | Berchielli and Tullar 1980 |
| African lion | Frank et al. 2003 |
| Amur (Siberian) tiger | Goodrich et al. 2001 |
| Snow leopard | Jackson et al. 1990 |
| Mountain lion | Pittman et al. 1995, Logan et al. 1999 |
| Canada lynx | Mowat et al. 1994 |
| Black bear | Poelker and Hartwell 1973, Johnson and Pelton 1980*b* |
| Raccoon | Berchielli and Tullar 1980 |
| Skunk (Mustelidae) | Novak 1981*b* |
| Feral hog | Anderson and Stone 1993 |
| White-tailed deer | Verme 1962, DelGiudice et al. 1990 |
| Mule deer | Ashcraft and Reese 1956 |
| South American Guanaco | Jefferson and Franklin 1986 |
| Pronghorn | Beale 1966 |

[a] Scientific names are given in Appendix 3.1.

## Trap Research, Performance Standards, and Evaluation

Traps have been and continue to be important and traditional tools for wildlife management and research (Boggess et al. 1990). Nevertheless, the use of these capture devices is not without controversy (Gentile 1987, Andelt et al. 1999). Most concerns are related to **animal welfare.** Consequently, professional wildlife biologists have expressed the need to reduce injury and pain inflicted on animals by trapping (Schmidt and Brunner 1981, Proulx and Barrett 1989). Novak (1987) reviewed traps and trap research related to furbearers. Recent efforts to improve the welfare of animals captured in traps by developing humane trapping standards have met with mixed success. Activities in the United States have primarily focused on the development of BMP for trapping furbearers by using restraining traps under the auspices of the AFWA (AFWA 2006*a*).

Endeavors through the ISO led to the adoption of 2 international standards—one for methods for testing killing trap systems used on land or underwater (ISO 1999*a*) and another for methods for testing restraining traps (ISO 1999*b*). The Canadian General Standards Board first published a national **killing trap standard** in 1984, based on a 180-second time-to-unconsciousness interval (Canadian General Standards Board 1984). Twelve years later this interval was relaxed to 300 seconds for some species (Canadian General Standards Board 1996). However, there are several killing traps currently available that have been shown to kill certain species quicker than the Conibear™ body-gripping series listed as state-of-the-art in 1996. Examples include the C120 Magnum with pitchfork trigger for American marten (Proulx et al. 1989*a*), the C120 Magnum with pan trigger and the Bionic™ for mink (Proulx et al. 1990, Proulx and Barrett 1991), and the Sauvageau™ 2001-8 for arctic fox (Proulx et al. 1993*a*).

**Numerical scores** have often been used to quantify the extent of injury incurred by a trapped animal (e.g., Olsen et al. 1986, 1988; Linhart et al. 1988; Onderka et al. 1990; Phillips et al. 1992; Hubert et al. 1996). Although Linhart and

Linscombe (1987) recommended establishment of a standardized numerical system to rank trap-caused injuries, the issue is complicated by the existence of a variety of scoring systems (Proulx 1999*b*). Engeman et al. (1997) criticized the use of injury scores for judging acceptability of restraining traps. In contrast, Onderka (1999) indicated that numerical scoring reflecting the severity of injuries tended to be consistent and appropriate to assess live-holding devices. The current **international standard** that describes methods for testing restraining traps contains 2 trauma scales (ISO 1999*b*). One assigns point scores to 34 injury types; the other places these 34 injury types into 4 trauma classes that may be combined to provide an overall measure of animal welfare.

Most recently 2 international agreements, designed to further improve the welfare of trapped animals, have been developed. The United States and the European Union adopted a nonbinding understanding in 1997; the other was signed by Canada, Russia, and the European Union in 1997 and 1998 (Andelt et al. 1999). Since that time, activities in the United States have focused on the development of BMP for trapping furbearers under the auspices of the International Association of Fish and Wildlife Agencies (IAFWA 1997). As part of this project, the best-performing killing traps consider time to death, effectiveness, selectivity, safety, and practicality of field use. Similarly, the best restraining traps will be those based on reduced physical damage to the animal, effectiveness, selectivity, safety, and practicality. The first BMP was completed in 2003 and addresses the use of restraining traps for coyotes in the eastern United States (IAFWA 2003). BMP for all other major furbearer species are under development (IAFWA 1997).

Currently, both the AFWA and the Fur Institute of Canada provide **updated and comprehensive reviews** of traps for use in mammal capture programs (Tables 3.15, 3.16, and 3.17) that comply with BMP standards (AFWA 2009*a*) or the Agreement on International Humane Trapping Standards (Fur Institute of Canada 2009).

### Evaluation and Status of Tranquilizer Trap Devices

Balser (1965) used **tranquilizer trap devices** (TTDs) containing diazepam, a controlled substance not registered for such use by the U.S. Drug Enforcement Administration (Savarie et al. 1993) to reduce injuries to coyotes. Another drug, propiopromazine hydrochloride (PPZH), which acts as a tranquilizer and depresses the central nervous system, was tested on captive coyotes by Savarie and Roberts (1979). Foot injuries to coyotes and other animals caught in foothold traps were reduced substantially when they ingested tranquilizers from tabs attached to trap jaws (Balser 1965).

Linhart et al. (1981) used TTDs containing PPZH to reduce foot and leg injuries to wild coyotes captured in foothold traps. Preliminary data reported by Zemlicka et al. (1997) suggested **significant reduction** in trap related injuries to the feet and legs of 37 gray wolves captured in traps using TTDs containing PPZH. None of 33 nontarget animals captured in traps with TTDs loaded with PPZH succumbed from ingestion of the tranquilizer, and injuries tended to be less severe than among nontarget captures in traps without PPZH TTDs. Sahr and Knowlton (2000) demonstrated that TTDs containing PPZH effectively reduced injuries to limbs of wolves captured in foothold traps, but failed to reduce the severity of tooth injuries. Pruss et al. (2002) evaluated a modified locking neck snare equipped with a diazepam tab for coyotes in an effort to decrease stress, injuries, and unwanted animal captures. This device successfully reduced the incidence of lacerations experienced by captured coyotes without compromising capture efficiency or increasing the capture of nontarget species. Savarie et al. (2004) successfully tested PPZH in a plastic polyethylene pipette reservoir attached to a trap jaw.

The 2 drugs (diazepam and PPZH), used in conjunction with TTDs, are not available for widespread use. Pruss et al. (2002) reported that future use of diazepam in Canada would require a researcher to submit a special request to the Drug Strategy and Controlled Substances Programme, Office of Controlled Substances, Ottawa, Ontario, Canada, and nonresearch use would require the cooperation of a veterinarian. In the United States, diazepam (Valium®) is a Class IV controlled substance (Seal and Kreeger 1987) and has not been authorized as a tranquilizer for traps. Currently, only the U.S. Wildlife Services is authorized to use PPZH in TTDs as part of its wildlife damage-control operations under a special permit issued by the U.S. Food and Drug Administration (T. J. Deliberto, U.S. National Wildlife Research Center, Department of Agriculture, Fort Collins, Colorado, personal communication).

### Miscellaneous Capture Methods

Bergman et al. (1999) captured nine-banded armadillo by following a trained **tracking dog** to a burrow. They then placed a 30-cm-high wire fence around the burrow and a cage live trap at the burrow entrance. Godfrey et al. (2000) described a detailed protocol for safe entry into black bear tree dens for capture purposes that minimized risks to biologists and bear mortality.

Karraker (2001) attached a string to hang from the cover board over pitfall traps, allowing small mammals to escape. Perkins and Hunter (2002) reduced small mammal capture by placing wooden sticks in pitfall traps. The rate of amphibian capture was not reduced. Padgett-Flohr and Jennings (2001) perfected a simple and inexpensive small-mammal **safe-house** that is placed in the bottom of pitfall traps (Fig. 3.25). The safe house was constructed of 5-cm-diameter PVC pipe in 12.5-cm lengths and capped at one end. The center of the safe house was one-third filled with 100% cotton batting, and the house was glued to a base of PVC pipe cut in half to a length of 12 cm.

*Table 3.15.* Live capture devices that meet state-of-the-art animal welfare performance criteria by individual species[a]

| Species[b] | Capture method | Trap type |
|---|---|---|
| American beaver | Suitcase | Breath Easy™ Live Trap; Hancock™ Live Trap |
| | Body snare | 7×7 weave 0.24 cm (0.94 inch) cable diameter with bent washer lock; 7×7 weave 0.24 cm cable diameter with BMI™ "Slide Free" Lock; 7×7 weave 0.32 cm (0.13 inch) cable diameter with cam lock; 7×7 weave 0.24 cm cable diameter with cam lock; 0.13 cm (1/19 inch) weave 0.24 cm cable diameter with Raymond Thompson™ lock |
| Bobcat | Foothold | 1.5 coiled-spring; 1.5 coiled-spring with padded jaws, 4- coiled 2 coiled-spring; 1.75 coiled-spring; 1.75 coiled-spring with offset, laminated jaws 2 coiled-spring with offset, laminated jaws, 4-coiled; 3 coiled-spring; 3 coiled-spring with laminated jaws; 3 coiled-spring with offset jaws; 3 coiled-spring with offset, laminated jaws; 3 coiled-spring with padded jaws, 4 coiled; 3 double long spring; MJ 600; MB 650-OS with 0.64 cm (0.25 inch) offset jaws |
| | Foot snare | Bélisle™ Foot Snare No. 6 |
| | Cage | Tomahawk™ 109.5 |
| Coyote | Foothold | 1.75 coiled-spring wih offset flat jaws; 1.5 coiled-spring with padded jaws, 4 coiled; 1.75 coiled-spring; 1.75 coiled-spring with forged, offset jaws; 1.75 coiled-spring with offset, laminated jaws; 22 Coyote Cuff™; 2 coiled-spring; 2 coiled-spring with forged, offset jaws; 2 coiled-spring with offset, laminated jaws, 4-coiled; 3 coiled-spring with padded jaws, 4-coiled; 3 Montana Special™ Modified, 2-coiled; MB 650-OS with 0.64 cm (0.25 inch) offset jaws; MJ 600 |
| | Foot snare | Bélisle™ Foot Snare #6 |
| | Neck snare | 7×7 weave 0.24 cm cable diameter with Reichart™ washer lock; 7×7 weave 0.24 cm cable diameter with #4 Gregerson™ lock; 7×7 weave 0.24 cm cable diameter with BMI Slide Free lock; 7×19 weave 0.24 cm cable diameter with Reichart washer lock; 7×19 weave 0.24 cm cable diameter with #4 Gregerson lock; 7×19 weave 0.24 cm cable diameter with BMI Slide Free lock; 7×7 weave 0.32 cm cable diameter with Reichart washer lock; 7×7 weave 0.32 cm cable diameter with #4 Gregerson lock; 7×7 weave 0.32 cm cable diameter with BMI Slide Free lock; 7×19 weave 0.32 cm cable diameter with Reichart washer lock; 7×19 weave 0.32 cm cable diameter 7×19 weave 0.32 cm cable diameter with BMI Slide Free lock |
| Fisher | Foothold | 1.5 coiled-spring with padded jaws, 4 coiled |
| | Cage | Tomahawk 108 |
| Gray fox | Foothold | 1.5 coiled-spring with Humane Hold™ pads on jaws; 1.5 coiled-spring with padded and double jaws; 1.5 coiled-spring with padded jaws, 4 coiled; 1.5 coiled-spring with padded jaws and 0.135 spring; 1.75 coiled-spring with offset, laminated jaws; 2 coiled-spring with padded jaws |
| | Foot snare | Bélisle Foot Snare |
| | Cage | Tomahawk 108 |
| Nutria | Foothold | 1 coiled-spring with padded jaws; 1.5 coiled-spring with padded jaws |
| Raccoon | Foot-encapsulating | Duffer's™; EGG™; Lil' Grizz Get'rz™ |
| | Foothold | 11 double long spring with offset and double jaws; 1.5 coiled-spring with double jaws; 1 coiled-spring; 1.5 coiled-spring with double-jaws and lamination; 1.5 coiled-spring with double-jaws and flat offset; 1.5 coilspring with double-jaws and flat offset, 4-coiled |
| | Cage | Tomahawk 108 |
| Red Fox | Foothold | 1.5 coiled-spring; 1.5 coiled-spring with laminated jaws; 1.5 coiled-spring with padded jaws; 1.5 coiled-spring with padded jaws, 4 coiled; 5 coiled-spring with Humane Hold™ pads; 1.75 coiled-spring; 1.75 coiled-spring with offset laminated jaws; 1.75 coiled-spring with offset wide jaws; 2 coiled-spring with padded jaws; 2 coiled-spring with offset laminated jaws, 4 coiled; 3 coiled-spring with padded jaws, 4 coiled |
| | Neck snare | 7×7 weave 0.24 cm cable diameter with Reichart washer lock; 7×7 weave 0.24 cm cable diameter with #4 Gregerson lock; 7×7 weave 0.24 cm cable diameter with BMI Slide Free lock; 7×19 weave 0.24 cm cable diameter with Reichart washer lock; 7×19 weave 0.24 cm cable diameter with #4 Gregerson lock; 7×19 weave 0.24 cm cable diameter with BMI Slide Free lock; 7×7 weave 0.32 cm cable diameter with Reichart washer lock; 7×7 weave 0.32 cm cable diameter with #4 Gregerson lock; 7×7 weave 0.32 cm cable diameter with BMI Slide Free lock; 7×19 weave 0.32 cm cable diameter with Reichart washer lock; 7×19 weave 0.32 cm cable diameter with #4 Gregerson lock; 7×19 weave 0.32 cm cable diameter with BMI Slide Free lock |
| | Foot snare | Bélisle Foot Snare No. 6 |
| Northern river otter | Foothold | 11 double long spring; 11 double long spring with offset and double jaws; 2 coiled-spring |
| Striped skunk | Cage | Tomahawk 105.5; Tomahawk 108 |
| Virginia opossum | Foot-encapsulating | EGG |
| | Foothold | 1.5 coiled-spring with double jaws; 1.5 coiled-spring with padded jaws; 1.5 coiled-spring with padded and double jaws; 1.5 coiled-spring with padded jaws, 4-coiled; 1.65 coiled-spring with offset laminated jaws; 1 coiled-spring with padded jaws |
| | Cage | Tomahawk 108 |

[a] As listed in *Best Management Practices for Trapping in the United States* species documents (Association of Fish and Wildlife Agencies 2009*a*,*b*; http://www.fishwildlife.org/furbearer_resources.html).

[b] Scientific names are given in Appendix 3.1.

*Table 3.16.* Live capture devices that meet state-of-the-art animal welfare performance criteria by individual species[a]

| Species[b] | Capture method | Trap type |
|---|---|---|
| Bobcat | Footsnare | Bélisle Footsnare #6 |
| Coyote | Foothold | Bridger #3 equipped with 0.79 cm (0.31-inch) offset, doubled rounded steel jaw laminations 0.48 cm (0.19-inch) on topside of jaw and 0.64 cm (0.25-inch) on underside of jaws), with 4 coiled springs and an anchoring swivel center mounted on a base plate; Oneida Victor #3 Soft Catch equipped with 2 coiled springs |
| | Footsnare | Bélisle Footsnare #6 |
| Canada lynx | Foothold | Oneida Victor #3 Soft Catch equipped with 2 coiled springs; Oneida Victor #3 ft Soft Catch equipped with 4 coiled springs; Victor #3 equipped with a minimum of 8mm thick, non-offset steel jaws, 4 coiled springs and an anchoring swivel c enter mounted on a base plate |
| | Footsnare | Bélisle Footsnare #6 |
| Gray wolf | Footsnare | Bélisle Footsnare #8 |

[a] As certified through Canada's process for implementing the Agreement on International Humane Trapping Standards (Fur Institute of Canada 2009; http://www.fur.ca/index-e/trap_research/index.asp?action=trap_research&page=traps_certified_traps).

[b] Scientific names are given in Appendix 3.1.

*Table 3.17.* Killing traps that meet state-of-the-art animal welfare performance criteria by individual species[a]

| Species[b] | Capture method | Trap type |
|---|---|---|
| American | Bodygrip | Bélisle Classic 330; LDL C280; Sauvageau 2001-8; Bélisle Super X 280; LDL C280 beaver Magnum; Sauvageau 2001-11; Bélisle Super X 330; LDL C330; Sauvageau 2001-12; BMI 280 Body Gripper; LDL C330 Magnum; Species-Specific 330 Magnum; BMI 330 Body Gripper; Rudy 280; Species-Specific 440 Dislocator Half Magnum; Bridger 330; Rudy 330; Woodstream Oneida; Victor Conibear 280; Duke 330; Sauvageau 1000-11F; Woodstream Oneida; Victor Conibear 330 |
| Fisher | Bodygrip | Bélisle Super X 120; LDL C220 Magnum; Sauvageau 2001-5; Bélisle Super X 160; Rudy 120 Magnum; Sauvageau 2001-6; Bélisle Super X 220; Rudy 160 Plus; Sauvageau 2001-7; Koro #2 Rudy 220 Plus; Sauvageau 2001-8; LDL C160 Magnum |
| Canada lynx | Bodygrip | Woodstream Oneida; Victor Conifear 330 |
| American marten | Bodygrip | Bélisle Super X 120; Koro #1; Sauvageau C120 Magnum; Bélisle Super X 160; Northwoods 155; Sauvageau 2001-5; BMI 126 Magnum; Rudy 120 Magnum; Sauvageau 2001-6 Body Gripper; LDL B120 Magnum; Rudy 160 Plus |
| Muskrat | Bodygrip | Bélisle Super X 120; Duke 120; Sauvageau C120 Magnum; BMI 120; Koro Muskrat; Sauvageau C120; "Reerse Bend"; BMI 120 Magnum; LDL B120 Magnum; Triple M; BMI 126 Magnum; Rudy 120 Magnum; Woodstream Oneida; Victor Conibear 110; Bridger 120; Sauvageau 2001-5; Woodstream Oneida; Victor Conibear 120; Any jaw type trap (body gripping or leghold) set as a submersion set that exerts clamping force on a muskrat and that maintains a muskrat underwater. |
| Raccoon | Bodygrip | Bélisle Classic 220; Bridger 220; Rudy 160 Plus; Bélisle Super X 160; Duke 160; Rudy 220; Bélisle Super X 220; Duke 220; Rudy 220 Plus; Bélisle Super X 280; LDL C 160; Sauvageau 2001-6; BMI 160 Body Gripper; LDL C 220; Sauvageau 2001-7; BMI 220 Body Gripper; LDL C 220 Magnum; Sauvageau 2001-8; BMI 280' LDL C 280 Magnum; Species-Specific 220; Dislocator Half Magnum; BMI 280 Magnum; Northwoods 155; Woodstream Oneida Body Gripper; Victor Conibear 160; Bridger 160; Rudy 160; Woodstream Oneida; Victor Conibear 220 |
| Northern river otter | Bodygrip | Bélisle Super X 280; Rudy 280; Woodstream Oneida; Victor Conibear 220; LDL C280 Magnum; Rudy 330; Woodstream Oneida; Victor Conibear 330; Sauvageau 2001-8 |
| Weasel | Snap Trap | Victor Rat Trap |

[a] As certified through Canada's process for implementing the Agreement on International Humane Trapping Standards (Fur Institute of Canada 2009; http://www.fur.ca/index- e/trap_research/index.asp?action=trap_research&page=traps_certified_traps).

[b] Scientific names are given in Appendix 3.1.

Scotton and Pletscher (1998) jumped from a hovering **helicopter** to hand capture neonatal Dall sheep. They advocated using smaller, less noisy helicopters to minimize disturbance of ewes and their lambs.

An efficient technique for capturing **swimming deer** (Fig. 3.26) was developed by Boroski and McGlaughlin (1994) for use in lakes and reservoirs. They made a "head bag" from the upper half of a pants leg with a hole for insertion of pipe insulation for flotation. Other materials included a canvas pack cinch, a leather latigo strap, a nylon "piggin" string, and a 1.4-kg weight. A 3-person crew included a boat handler and 2 deer handlers. The piggin string was placed around

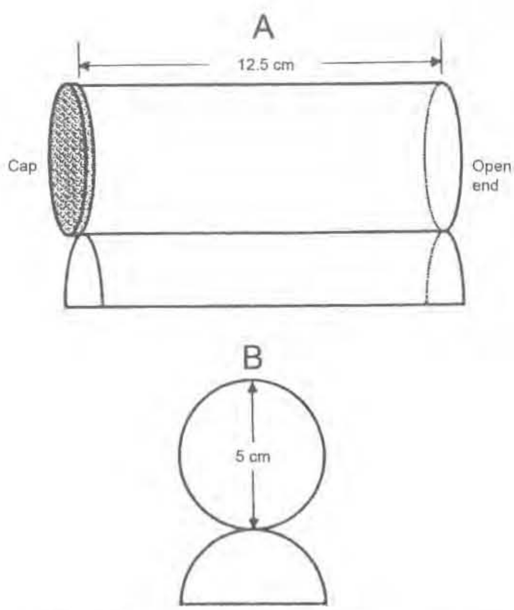


Fig. 3.25. Side (A) and front (B) view of the assembled small-mammal safe-house constructed from 5-cm-diameter polyvinyl chloride (PVC) pipe. *From Padgett-Flohr and Jennings (2001).*

the deer's neck and the head bag was placed over the animal's head to calm the it. The latigo strap was positioned in front of the rear legs. After attachment of a radiocollar to the deer, the restraints and head bag were removed, and the deer previously kept in the water was released and allowed to swim freely. Handling time of captured deer averaged 5.5 minutes.

Ballard et al. (1998) decided that intensive grid ground searching was the most effective method for locating and **hand capturing** neonate white-tailed deer fawns. Franklin and Johnson (1994) hand captured South American guanacos 30–60 minutes after birth, before the neonates could escape by running. Care was taken to avoid separation of the mother from her offspring. Only 5 of 435 captured young guanacos (1.2%) failed to unite or were abandoned by their mothers. They suggested that hand capture and tagging of precocial newborns had potential application to a variety of African, Asian, and North American ungulates that live in open habitats.

Fig. 3.26. Restraint and radiocollar attachment for deer captured while swimming. *From Boroski and McGlaughlin (1994).*

Lanyon et al. (2006) developed a method for live-capturing dugongs in open water using the **rodeo method,** which involves pursuit of a dugong by boat until it is fatigued, followed by a human catcher jumping off the boat to restrain the dugong. McBride and McBride (2007) successfully, safely, and selectively captured jaguars using trained cat hounds. Omsjoe et al. (2009) used a similar paired-snowmobile pursuit method, entangling a Svalbard reindeer in a net. Capybaras were captured in Venezuela by **lassoing** from horseback (Salas et al. 2004). Corrigan (1998) tested various types of **glue traps** and found them to be largely ineffective for capturing house mice.

Bishop et al. (2007) described the successful use of **vaginal implant transmitters** to aid in the capture of mule deer neonates. Vaginal-implant transmitter modification, including larger holding wings and antennas protruding 1 cm past the vulva, resulted in more successful drops of deer fawns at birth sites (Haskell et al. 2007; Table 3.18).

Benevides et al. (2008) designed a **trap signaling device** with long distance reception (18 km), durability in adverse weather, and light weight, which allowed reduction in the effort required to check traps and quick release of endangered and nontarget species. Nolan et al. (1984) used transmitters for monitoring leg snares set for grizzly bears. Neill et al. (2007) reviewed a Global System for Mobile communication trap alarms attached to padded leg-hold traps that shortened the retention time of capture of Eurasian otters to 22 minutes and reduces trap injuries (Table 3.19).

## Use of Attractants

The success of most animal trapping operations depends on a suitable bait or lure to attract animals to traps. Numerous native and commercial foods, artificial and visual lures, agricultural products, and naturally occurring and artificial scents have been used as attractants. Because of the diversity of habitats and species, no universal attractant successfully works for all animals. Consequently, wildlife biologists may need to evaluate several baits or lures before finding

*Table 3.18.* Use of vaginal implant transmitters for capture of neonates

| Species[a] | Reference |
|---|---|
| Mule deer | Garrott and Bartmann 1984, Johnstone-Yellin et al. 2006, Bishop et al. 2007 |
| White-tailed deer | Bowman and Jacobson 1998, Carstensen et al. 2003, Haskell et al. 2007, Swanson et al. 2008 |
| Elk | Seward et al. 2005, Johnson et al. 2006, Barbknecht et al. 2009 |

[a] Scientific names are given in Appendix 3.1.

*Table 3.19.* Systems for signaling successful trap capture

| Species[a] | Capture method | Type of signal | Reference |
|---|---|---|---|
| Small Hawaiian carnivores | Tomahawk live trap | Radio transmitter | Benevides et al. 2008 |
| Large mammals | Trap and foot snare | Radio transmitter | Halstead et al. 1995 |
| Mule deer | Clover trap | Telemetry | Hayes 1982 |
| Wild canids | Padded jaw foothold | Electronic | Larkin et al. 2003 |
| Wild canids | Treadle snare | Radio transmitter | Marks 1996 |
| Otter | Padded jaw foothold | Mobile phone technology | Neill et al. 2007 |
| Grizzly bear | Aldrich snare | Radio telemetry | Nolan et al. 1984 |
| Raptors | Bow net | Two-way radio | Proudfoot and Jacobs 2001 |

[a] Scientific names are given in Appendix 3.1.

those that attract different species in a specific geographical area.

## Baits

Prebaiting is generally an important prerequisite to, and baiting an essential part of, any successful trapping program. Carnivores may be attracted to traps by bait made from chunks of meat that is fresh or tainted. For example, holes can be punched in a container of sardines to make a long-lasting attractant. (Bluett 2000) reported that selectivity for certain species, such as raccoons, was enhanced by using **sweet baits,** such as fruit or marshmallows. Saunders and Harris (2000) evaluated bait preferences of captive red fox. Whole mice were the most preferred and horsemeat the least preferred of the 6 animal baits tested. Travaini et al. (2001) simultaneously tested a variety of scented meat baits and 3 ways of delivering these baits to culpeo and Argentine gray foxes in Patagonia. All 4 types of baits used were equally attractive to both species of fox. The percentage of the different types of baits consumed by the 2 species did not differ among bait type, and no differences were detected in visitation rates to the 3 types of bait delivery systems. Andrzejewski and Owadowska (1994) successfully captured bank voles at a significantly greater rate by using conspecific odor foam cube baits rather than food as bait.

Morgan and Dusek (1992) had success capturing white-tailed deer in Clover traps on summer range using **salt blocks** as bait. Alfalfa hay was a successful bait in winter. Naugle et al. (1995) had better deer trapping success using corn rather than salt in summer in agriculture–wetland habitats. Bean and Mason (1995) evaluated the attractiveness of **liquid baits** to white-tailed deer. Apple juice was preferred to cyclamate or saccharin solutions. Volatile apple extract also was an effective lure. Hakim et al. (1996) found the most successful use of liquid bait was in May. They suggested that spring was the best season to attract and capture deer in Virginia. Ballard et al. (1998) reported that white cedar (*Thuja occidentalis*) browse was the best bait for trapping white-tailed deer in winter.

Edalgo and Anderson (2007) evaluated the effects of prebaiting on small-mammal trapping success and concluded that prebaiting was not worthwhile. Barrett et al. (2008) tested various supplements to corn baits and found no increase in deer capture success in Clover traps.

## Scents

Fur trappers have used a variety of scents to attract furbearing mammals to traps. These lures can be divided into 3 basic categories: gland, food, and curiosity scents. **Gland scents** are made of different parts of animals, such as the reproductive tract and anal glands. Examples of **food scents** include extracts of honey and anise, and fish oil. **Curiosity scents** are typically blends of essential oils, exotic musk, and American beaver and muskrat scent glands. Mason and Blom (1998) listed the common ingredients in lure formulations as well as their sources, methods of preparation, and common uses (Table 3.20).

A variety of scents, including those composed from rotten eggs, decomposed meat, and fish oil, has been used to increase trapping success rates. Other items, such as seal oil, Siberian musk oil, anal glands from foxes and skunks, and mink musk, also are widely used. Clapperton et al. (1994) tested a variety of attractants for feral cats in New Zealand. Catnip (*Nepeta cataria*) and matatabi (*Actinidia polygama*) were the most promising scent lures tried.

Phillips et al. (1990*a*) evaluated seasonal responses of captive coyotes to 9 chemical attractants and tested 26 additional attractants during summer to examine the efficacy of traps, **M-44s** (a tube-like spring-loaded device designed to deliver a lethal dose of sodium cyanide into the mouth of a coyote), and placed baits. Of the 9 attractants tested throughout the year, fatty acid scent (**FAS**) and **W-U lure** (Trimethylammonium decanoate plus sulfides) ranked highest in overall attractiveness. FAS and W-U lure also ranked highest among the 35 attractants tested only during the summer. Kimball et al. (2000) formulated 7 new synthetic coyote attractants by using representative compounds from commercially available attractants with the intention of developing

*Table 3.20.* Common ingredients in lure formations, methods of preparation, and common applications

| Ingredient | Source | Preparation | Use |
|---|---|---|---|
| Muskrat glands/musk | Small glands on either side of vent of males during spring | Fresh ground, preserved, tinctured | Acids in musk are attractive to coyotes |
| Beaver castor | Large flat glands on each side of vent of both males and females | Fresh ground, preserved, dried, rasped to a powder; tinctured (castorium) | Phenols attractive to coyotes, serve to fix, preserve other ingredients in lures |
| Beaver sac oil | Long oval-shaped, whitish glands next to the castors | Fresh ground, preserved, oil squeezed from glands | Used alone or mixed with castors and used as a fixative |
| Mink glands/musk | Glands on either side of vent of males in breeding season | Ground fresh, preserved, tinctured | Contains sulfides, attractive to coyotes |
| Glands/urine from canids/felids/mustelids | Fox, bobcat, dog, badger, etc. | Ground fresh, preserved, rotted | |
| Asafetida | Plant | Gum or powdered or tinctured | Contains sulfides, attractive to coyotes |
| Garlic, onion | Plant | Powders, salts, oils | Contains sulfides, attractive to coyotes |
| Valerian root | Plant | Powder, oil, extract or salt (i.e., zinc valerate) | Valeric acid, attractive to coyotes |
| Rue oil | Plant | Oil, 3–5 drops per 0.25 L | Methyl ketones impart a cheesy odor |
| Skunk musk | Glands on either side of vent in males | Oil, 3–5 drops per 0.25 L used as component, 6–10 drops per 0.25 L as dominant odor | Powerful sulfide (mercaptan) odor odor attractive to coyotes |
| Orris root | Plant | Powder, oil, tincture, 0.5 tsp of oil/tincture or 0.125 tsp to powder per 0.25 L | Fixative, contains acids attractive to coyotes |
| Oakmoss | Plant | Resin, tincture, 3–5 drops resin, or 0.25 tsp of tincture per 0.25 L | Fixative |
| Phenyl acetic acid | Synthetic chemical | Tincture or crystals | Honey-like odor, also found in urines and scent glands |
| Cilantro oil (coriander leaf oil) | Plant | Oil, 2–4 drops per 0.25 L | Aldehydes attractive to coyotes |
| Anise oil | Plant | Oil, 3–5 drops per 0.25 L | Licorice odor |

Adapted from Mason and Blom (1998).

[a] Scientific names of animals are given in Appendix 3.1.

relatively simple synthetic alternatives. Bioassays with captive coyotes were conducted to compare 9 behavioral responses elicited by the 7 new attractants. Results indicated that each attractant elicited a different behavioral profile. No significant differences among attractants in regard to urinating, sniffing, and licking behaviors were detected, but differences among the attractants existed for rubbing, rolling, scratching, defecating, digging, and pulling behaviors. Saunders and Harris (2000) evaluated 9 chemical attractants for red fox. They reported the strongest preferences were for 2 gustatory additives (sugar and a combination of beef and sugar) and an olfactory attractant (synthetic fermented egg).

Andelt and Woolley (1996) tested the attractiveness of a variety of odors to urban mammals, including cats, dogs, fox squirrels, striped skunks, and raccoons. Deep-fried cornmeal added to bait increased the rate of visitation to scent stations. Harrison (1997) field-tested the attractiveness of 4 scents (Hawbaker's Wildcat 2, synthetic FAS, bobcat urine, and catnip) to wild felids, canids, and Virginia opossum. No differences were noted in visitations to scent stations. McDaniel et al. (2000) tested scent lures to attract Canada lynx and found beaver castoreum and catnip oil to be most effective.

Fur trappers, especially those who focus on foxes and coyotes, often use **urine** at trap sets to enhance their success. Young and Henke (1999) assessed trap response of cottontail rabbits using wooden cage traps baited with food, block salt and minerals, and urine from nonpregnant female domestic European rabbits. They captured significantly more cottontails in traps baited with rabbit urine.

**Plant extractions** also may be added to scents. The root of the Asiatic plant asafetida (*Ferula assafoetida*) imparts a strong, persistent odor to scents. The oils from the herbs anise (*Pimpinella anisum*) and valerian (*Valeriana officinalis*) also have been added to scent mixtures.

Scents are used primarily to attract carnivores, but other mammals also are attracted to them. Large rodents, such as beaver and muskrat, can be attracted with scent mixtures containing castoreum from beaver and oil sacs from muskrats. Mason et al. (1993) evaluated salt blocks and several olfactory lures as potential lures for use in attracting white-tailed deer. Such odor stimuli as acorn, apple, and peanut butter significantly enhanced the effectiveness of salt blocks. Mineral blocks were more attractive to deer than salt, molasses, and mineral–molasses blocks; all were scented with apple extract.

### Visual Attractants

Visual attractants can enhance trapping success for such species as bobcat that rely heavily on their sense of sight when hunting. Bobcats can be attracted to traps by a piece of fur or feathers suspended 90–120 cm above the wire or string. However, in many states, use of visual attractants by trappers is illegal, because they may attract protected raptors. Knight (1994) and Virchow and Hogeland (1994) described the use of visual attractants in trapping mountain lion and bobcats, respectively.

## Species-Specific Traps and Their Performance

### American Badger

Limited research in Wyoming indicated that No. 1.5 coil-spring foothold traps with unpadded, laminated, or padded jaws can be used to capture American badgers with only minor injuries (Kern et al. 1994). Also, 78% of 45 badgers captured for a telemetry study in Illinois using Victor™ No. 3 Soft-Catch™ padded foothold traps had no visible injuries (R. E. Warner, University of Illinois, unpublished data). Injuries recorded for the remaining 10 (22%) were minor (e.g., claw loss, mild edema, and small lacerations). No data on the performance of killing traps for badgers are available.

### American Beaver

Limited data on restraining traps for beaver are available. Clamshell-type traps, such as the Bailey, Hancock, and Scheffer-Couch, have been used successfully to capture beaver alive for research and management (Couch 1942, Hodgdon and Hunt 1953), but are relatively inefficient, bulky, and expensive. Using Hancock and Bailey traps, Collins (1976) caught >100 beaver with no mortalities. McKinstry and Anderson (1998) reported that 2.38-mm locking snares could be used to efficiently live-capture beaver, but they recorded a mortality rate of 5.3%.

Research in Canada performed under controlled conditions has shown that beaver can be killed in ≤6.1 minutes using standard Conibear 330 and modified (jaws bent inward) Conibear 280 and 330 traps in terrestrial sets (Novak 1981*a*). Gilbert (1992) reported that Conibear 330 traps with clamping bars rendered 14 beaver unconscious in ≤3 minutes. However, consistent positioning of juvenile beaver in a proper manner was an apparent problem. When captured underwater in locking snares or in drowning sets using No. 3 and No. 4 Victor foothold traps, beaver died in 5.5–10.5 minutes due to $CO_2$ narcosis or asphyxiation (Novak 1981*a*, Gilbert and Gofton 1982). Novak (1981*a*) reported that beaver trapped underwater in modified Conibear 330 traps were killed in 7.0–9.25 minutes. In addition, tests on anesthetized beaver measured the minimum energy forces required to cause death when delivered via a blow to the head, neck, thorax, or chest (Gilbert 1976, Zelin et al. 1983).

An improved, safe beaver live trap was developed by Müller-Schwarze and Haggert (2005). Vantassel (2006) modified the Bailey beaver trap to curtail misfires and increase capture success. McNew et al. (2007) used neck snares to live-capture beavers. Advantages of snares include light weight, low cost, and ease of setting.

**BMP** for trapping in the United States were based on field studies that captured and evaluated 100 beaver using the Breathe Easy™ Live Trap and the Hancock trap in New Hampshire during 1998–2001 (AFWA 2007*a*). Both traps met all BMP criteria (Table 3.15). Animal welfare performance was similar for the 2 trap types (cumulative injury score of 13 ISO scale) and efficiency was >92%. Of the 100 beavers captured, there were 2 mortalities: 1 in each trap type.

Snares are the most commonly used trapping technique for capturing beaver by fur trappers in the United States (AFWA 2005). BMP for snare trapping in the United States were based on field studies that captured and evaluated 193 beaver using 6 different snares for live restraint in New Hampshire during 2001–2007 (AFWA 2007*a*). Cable diameters used were 2.38 mm or 3.17 mm. Cables used during testing were either 7 × 7 multistrand constructions (Fig. 3.27) or 1 × 19 single strand construction (Fig. 3.28). Various locking systems were used, but all locks were either relaxing or positive locking types, no power assisted locks were used (AFWA 2009*b*). All cable devices tested for live restraint passed BMP criteria for animal welfare (Table 3.15). Efficiency ranged from 58.2% to 91.7%. Of the 193 beaver captured in live restraint cable devices, only 1 mortality occurred.

### Bobcat

Relatively few studies have investigated the performance of restraining traps for bobcat. Research in the western United States (Linscombe and Wright 1988, Olsen et al. 1988) and Michigan (Earle et al. 1996) has shown the Victor No. 3 Soft-Catch foothold trap with padded jaws was effective in cap-

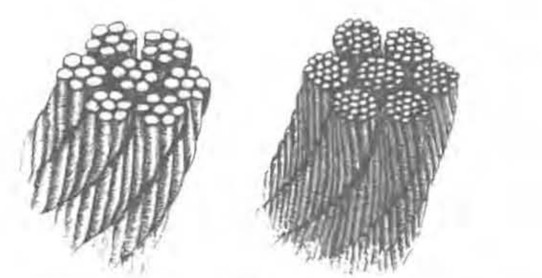

Fig. 3.27. The 7 x 7 multistrand cable has 7 bundles of 7 wires each. The 7 x 19 multistrand cable has 7 bundles of 19 wires each. *Illustration courtesy of the Association of Fish and Wildlife Agencies.*

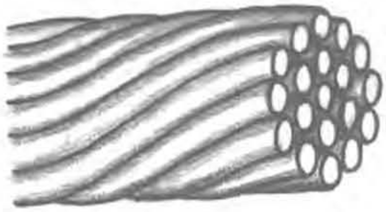

*Fig. 3.28.* The 1 x 19 single-strand cable construction consists of 7 wires (twisted right) wrapped by 12 wires (twisted left). *Illustration courtesy of the Association of Fish and Wildlife Agencies.*

turing bobcat with minimal injuries compared to unpadded foothold traps. Modifications to the No. 3 Soft-Catch, such as heavier springs, improved trapping success (Earle et al. 1996). Woolf and Nielson (2002) reported live capture of 96 bobcats in wire cage traps and No. 3 Soft-Catch traps. Trap related injuries were uncommon with both devices and included only minor cuts and bruises. They captured 1.6 bobcats per 100 trap-nights in the cage trap compared with 0.8 per 100 trap-nights using the Soft-Catch trap. Earle et al. (2003) determined the Victor No. 3 Soft-Catch foothold trap with padded jaws was effective in capturing bobcat with minimal injuries compared to unpadded foothold traps.

**BMP** for trapping bobcats were based on 584 bobcats captured in 16 restraining devices in 16 states during 1998–2006 (AFWA 2006*b*). All 16 trapping devices evaluated for bobcat met BMP criteria for welfare, efficiency, selectivity, safety, and practicality (Table 3.15). The cage trap had the lowest mean cumulative injury score and the highest efficiency rating. However, animal welfare was acceptable in all trap types tested, and 75% of the traps tested had an efficiency rating for bobcats of >90%.

The most commonly used trap type in the United States for capturing bobcat is the No. 3 coil-spring (IAFWA 1992, AFWA 2005). The standard No. 3 coil-spring trap met all BMP criteria as did the same trap size with modifications, including padded, offset, and laminated jaws and jaws with both offset and lamination. The efficiency of all traps meeting BMP criteria for bobcat ranged from 61% to 100% capture per opportunity. The cage trap was the most efficient, followed by the No. 3 long-spring trap, the No. 1.5 standard coil-spring trap, the No. 2 standard coil-spring trap, and the No. 3 padded coil-spring trap. Trap selectivity for bobcat ranged from 10% to 45%. The No. 3 padded coil-spring trap was the most selective for bobcat, followed by the MJ 600 coil-spring trap, the No. 1.75 offset laminated coil-spring trap, and the No. 3 offset laminated coil-spring trap. No consistent pattern relative to trap type or modifications was apparent for selectivity.

### Coyote

More restraining trap research has been conducted on coyotes than on any other North American mammal. Andelt et al. (1999) summarized injury scores and capture rates for 8 coyote traps tested by the Denver Wildlife Research Center. Other investigations of trap performance for coyotes include Linhart et al. (1986, 1988), Linscombe and Wright (1988), Olsen et al. (1988), Onderka et al. (1990), Skinner and Todd (1990), Linhart and Dasch (1992), Phillips et al. (1992, 1996), Gruver et al. (1996), Phillips and Mullis (1996), Hubert et al. (1997), and Shivik et al. (2000). Although Phillips et al. (1996) and Hubert et al. (1997) suggested that laminated traps are likely to be less injurious than standard unpadded foothold traps, the differences in the mean injury scores they observed were not significant. Houben et al. (1993) found no significant difference in mean injury scores assigned to limbs of coyotes captured in modified (heavier springs) No. 3 Soft-Catch padded foothold traps and No. 3 Northwoods™ foothold traps with laminated offset jaws. Padded foothold traps, such as the No. 3 Soft-Catch modified (Gruver et al. 1996) and the No. 3.5 E-Z Grip® (Phillips et al. 1996), have performed best in terms of both animal welfare and efficiency.

Way et al. (2002) tested 4 models of Tomahawk wire cage traps (models 610A, 610B, 610C, and 109) as an alternative capture technique for coyotes in a suburban environment in Massachusetts. These traps proved undesirable for capturing coyotes due to trap expense, time involved in baiting and conditioning coyotes to traps, a high rate of nontarget captures, and difficulty in capturing >1 adult in a social group. On the positive side, those coyotes caught sustained few injuries.

Phillips (1996) tested 3 types of killing neck snares for coyotes. He found that 94% of the coyotes snared by the neck with Kelley locks were dead when snares were checked versus 71% and 68% for the Gregerson and Denver Wildlife Research Center locks, respectively. However, the interval between trap checks was not specified. Phillips et al. (1990*b*) evaluated 7 types of breakaway snares were for use in coyote control. Maximum tension before breakage for individual snares ranged from 64.5 kg to 221 kg. They indicated that differences in tension loads between coyotes and nontarget species should allow for development of snares that will consistently hold coyotes and release most large nontarget animals.

Phillips and Gruver (1996) evaluated performance of the Paws-I-Trip™ pan tension device on 3 types of foothold traps commonly used to capture coyotes. This device reduced capture of nontarget animals without reducing the effectiveness of the traps for catching coyotes. The mean overall exclusion rates for combined nontarget species in the No. 3 Soft-Catch, Victor 3NM, and No. 4 Newhouse™ foothold traps were 99.1%, 98.1%, and 91%, respectively. Kamler et al. (2002) effectively used modified No. 3 Soft-Catch foothold traps equipped with the Paws-I-Trip device set at 2.15 kg to capture coyotes while excluding swift foxes.

Shivik et al. (2005) compared various coyote trapping devices for efficiency, selectivity, and trap related injuries. Tomahawk cage traps were the least selective and efficient (0%

catch). The Collarum neck restraint, soft catch, and power snare devices had 87–100% catch efficiency. None of the devices used caused major injury.

**BMP** for capturing coyotes were based on field studies that captured, dispatched, and evaluated 1,285 coyotes using 20 restraining type devices in 19 states during 1998–2005 (AFWA 2006*d, e*). Sixteen of these devices met or exceeded established BMP criteria for welfare, efficiency, selectivity, safety, and practicality. No coyotes died in any of the trap devices tested, and there were no documented practicability or safety concerns for trappers or nontrappers. Among devices that met BMP established criteria, the nonpowered cable device, Belisle footsnare, offset flat-jaw traps, and offset laminated-jaw traps had lower mean cumulative injury scores than did the standard offset-jaw traps, or offset forged-jaw traps. Also, noteworthy is that 2 regular-jaw traps (No. 1.75 and No. 2 coil-springs) had mean cumulative injury scores lower than standard offset-jaw traps or offset forged-jaw traps (Table 3.15).

The most commonly used trap in the United States for capturing coyotes is the No. 2 coil-spring trap (AFWA 2005). This trap met all established BMP criteria and produced the highest score for the "no injury" category, whereas the 1.75 offset flat-jaw trap had the highest cumulative scores for none, mild, and moderate injuries (99.9%), followed by the No. 3 padded 4-coiled trap (98.1%), the MJ 600 trap (98.0%), and the 1.5 padded, 4-coiled trap (97.9%). All trap devices that meet or exceed BMP standards had ≥83% cumulative injuries in the none, mild, or moderate categories. Trap devices of the No. 3 size typically had the highest efficiency; all had an efficiency of ≥85%. No consistent pattern for selectivity was apparent. However, all traps that meet or exceed BMP criteria had an overall furbearer selectivity of ≥84%.

During BMP studies, nonpowered cable devices and the Belisle No. 6 performed well for restraining coyotes, produced low mean cumulative injury scores (19.3 and 22.7, respectively), and did not result in any mortalities. Of the restraint devices tested, the Belisle No. 6 footsnare and nonpowered cable devices performed well and resulted in either no or mild injuries (AFWA 2006*d, e;* Table 3.15).

### Feral Cat

Wire mesh traps (40 cm × 40 cm × 60 cm) and Victor No. 1.5 Soft-Catch padded jaw foothold traps have been used to trap feral cat in Australia (Molsher 2001). No difference was found in capture efficiency between trap types. Injuries suffered by cats in cage traps were generally minor and usually involved self-inflicted abrasions to the face. Only 1 of 12 cats (8.3%) caught in Soft-Catch traps was more seriously injured. Meek et al. (1995) and Fleming et al. (1998) also used Soft-Catch traps (No. 1.5 and No. 3) to capture feral cat. These researchers reported 100% and 68.6%, respectively, of the cats trapped had no visible trap related injuries or only slight foot or leg edema or both.

### Fisher

Fur trappers commonly use cage traps to capture fisher in Massachusetts, but efficiency and animal welfare data for this and other restraining traps are not available. Researchers in Canada have evaluated a variety of killing traps for capturing fisher. Controlled testing on captive animals has shown the Bionic trap cocked to 8 notches consistently killed fisher in 60 seconds (Proulx and Barrett 1993*b*). The mechanical characteristics of the Sauvageau 2001-8 and modified (stronger springs) Conibear 220 traps surpassed the kill threshold established for fisher, but the standard Conibear 220 and AFK Kania traps did not (Proulx 1990). Double strikes (head and/or neck, and thorax) with a modified Conibear 220 trap equipped with 280-sized springs killed 5 of 6 fisher in an average of 51 seconds (Proulx and Barrett 1993*a*).

**BMP** for trapping in the United States were based on field studies that captured and evaluated 74 fishers using both foothold and cage traps in 5 states during 2004–2009 (AFWA 2007*b*). Two of the devices tested met or exceeded established BMP criteria: the No. 1.5 Soft-Catch foothold trap modified with 4 coil-springs and the Tomahawk 108 cage trap (Table 3.15). Use of the cage trap produced fewer injuries. Efficiency was higher with the cage trap, although efficiency for both traps was >90%. Selectivity was similar among the 2 trap types.

### Arctic Fox

Two studies in Canada focused on the Sauvageau 2001-8 (a rotating-jaw killing trap) and the standard Victor No. 1.5 coil-spring foothold trap. Compound testing revealed that 9 arctic foxes caught in the Savageau 2001-8 set in a wire mesh cubby lost consciousness in an average of 74 seconds (Proulx et al. 1993*a*). During field tests on trap lines in the Northwest Territories, Canada, most arctic foxes captured in the No. 1.5 coil spring trap had only minor injuries when traps were checked daily (Proulx et al. 1994*b*).

### Gray Fox

Berchielli and Tullar (1980) found no difference in trap related injuries of gray fox caught in Victor No. 1.5 coil-spring foothold traps versus those captured with Ezyonem™ leg snares. However, the leg snare was less effective in capturing fox than was the coil-spring foothold trap. Other researchers in the eastern United States have compared the unpadded Victor No. 1.5 coil spring with the padded Victor No. 1.5 Soft-Catch for gray fox. These studies found no difference in capture efficiency between trap types (Tullar 1984, Linscombe and Wright 1988) and a reduction in injuries for foxes captured in padded traps (Tullar 1984, Olsen et al. 1988). Gray fox can be captured in rotating jaw killing traps (e.g., Conibear 220-2) as well as in cage-type restraining traps, but performance data are lacking.

**BMP** for trapping gray fox were based on 925 foxes that were restrained, dispatched, and evaluated in 13 states during 1998–2003 (AFWA 2006*c*). Nine of 17 trapping devices evaluated for gray foxes met BMP criteria for welfare, efficiency, selectivity, safety, and practicality (Table 3.15). The No. 1.5 padded coil-spring trap with strengthened coil springs had the lowest mean cumulative injury score, followed by the cage trap and the No. 1 laminated coil-spring trap. The No. 1.5 laminated coil-spring trap, No. 1.5 padded coil-spring trap, and No. 1.65 offset laminated coil-spring trap all had welfare scores slightly higher (5 points) than the BMP criteria. However, all had ≥74% injuries in the lowest 3 classes. In addition, all 3 traps had efficiency ratings of ≥84%. The No. 1.5 padded coil-spring trap and No. 1.65 offset laminated trap both had gray fox selectivity scores higher than the 7 traps that met all criteria. Although the No. 1.5 laminated was not as selective for gray fox, it was selective for furbearers. The most commonly used trap in the United States for capturing gray fox is the No. 1.5 coil-spring (IAFWA 1992, AFWA 2005). This trap met BMP criteria only when modified with padded jaws, padded double jaws, and padded with strengthened coil-springs or with 4 coil-springs.

**Efficiency** of all traps meeting BMP criteria for gray fox ranged from 41% to 100% capture per opportunity. The cage trap was the most efficient, followed by the No. 1.5 padded 4-coiled coil-spring trap, No. 1.75 offset laminated coil-spring trap, No. 1.5 padded with strengthened coil-springs, and No. 2 padded coil-spring trap. Trap selectivity for gray fox ranged from 16% to 57% for traps meeting BMP criteria. The No. 1.5 with padded and double jaws was the most selective for gray fox, followed by the No. 1.5 padded with strengthened coil-springs, No. 2 padded coil-spring trap, and No. 1.75 offset laminated coil-spring trap.

### Kit Fox

Kozlowski et al. (2003) described an enclosure system to live capture denning kit foxes.

### Red Fox

The Victor No. 1.5 coil spring is the most common restraining trap used to capture red fox in the United States (IAFWA 1992). Several studies have compared the performance of this trap to the No. 1.5 Soft-Catch foothold trap with padded jaws (Tullar 1984, Linscombe and Wright 1988, Olsen et al. 1988, Kreeger et al. 1990, Kern et al. 1994). The No. 1.5 Soft-Catch proved to be as efficient as its unpadded counterparts, and it caused fewer and less serious injuries to trapped foxes. Kern et al. (1994) also reported that No. 1.5 coil spring traps with laminated or offset jaws were less injurious than those with standard jaws. Some foot snares have been found to be effective restraining traps for foxes under certain conditions (Novak 1981*b*, Englund 1982). During field tests in southern Ontario, Canada, and powder snow conditions in northern Sweden, the Novak™ and Åberg (Swedish) foot snares virtually eliminated trap related injuries. However, Berchielli and Tullar (1980) reported the Ezyonem foot snare was less effective than the No. 1.5 coil spring foothold traps for capturing foxes, and both devices produced similar trap related injuries. Researchers in Australia found a particular treadle (i.e., foot) snare difficult to set and inefficient; 3 of 71 red foxes they captured using this device had broken legs (Bubela et al. 1998).

Few published data on the performance of killing traps for red fox exist. Limited testing of neck snares indicated that red fox become unconscious ≤6 minutes in power snares, but manual snares may not be suitable killing devices for this species (Rowsell et al. 1981, Proulx and Barrett 1990). Frey et al. (2007) experienced success using neck snares to capture red foxes with very few fatalities.

The development of **BMP** for red fox was based on 654 red foxes captured in 14 devices in 16 states during 1998–2002 (AFWA 2006*f*). Thirteen of 14 trapping devices evaluated for red fox met BMP criteria for welfare, efficiency, selectivity, safety, and practicality (Table 3.15). The most commonly used trap in the United States is the No. 1.5 coil-spring (IAFWA 1992, AFWA 2005). The Victor No. 1.5 coil-spring was tested and met BMP criteria.

Padded traps with manufacturer-provided integral padding and cable devices had the lowest mean cumulative injury scores. The most efficient devices were the nonpowered cable and Belisle foot snare. Offset laminated and 4-coiled foothold traps followed in efficiency. No consistent pattern was apparent for selectivity, except that none of the 4 most selective devices were padded traps. Efficiency of all traps meeting BMP criteria for red fox ranged from 79% to 100% capture per opportunity. Nonpowered cable devices were the most efficient, followed by the Belisle foot snare, No. 1.75 offset laminated coil-spring trap, No. 3 4-coiled padded coil-spring trap, No. 1.5 4-coiled padded coil-spring trap, and the No. 2 4-coiled offset laminated coil-spring trap. Trap selectivity for red fox ranged from 14% to 34% for traps meeting criteria. The No. 1.75 coil-spring trap with wide offset jaws was the most selective for red foxes, followed by the No. 1.5 coil-spring trap, No. 2 4-coiled offset laminated coil-spring trap, and No. 1.5 laminated coil-spring trap. Selectivity of all furbearers captured in traps tested for red fox ranged from 87% to 94%. The most selective trap was the No. 1.75 coil-spring trap with wide offset jaws, followed by the No. 1.75 coil-spring trap, nonpowered cable device, and No. 1.5 laminated coil-spring trap.

### Swift Fox

Baited single door Havahart™ wire cage traps (25.4 cm × 30.5 cm × 81.3 cm) have been successfully used to capture swift fox in Texas (Kamler et al. 2002). The capture rate of swift fox was 48% higher in reverse double sets (which used 2 traps set in opposite directions) than in single sets. No data on trap related injuries were presented.

## Gray Wolf

A variety of foothold restraining traps, including the Aldrich™ foot snare, has been evaluated for capturing gray wolf (Van Ballenberghe 1984, Kuehn et al. 1986, Schultz et al. 1996). Van Ballenberghe (1984) reported on trap related injuries to wolves caught in 3 types of long-spring foothold traps and the Aldrich foot snare, but small sample sizes precluded comparison of injuries among trap types. However, suggested methods for reducing injury included shortened chains, center mounting of the chain, and use of tranquilizer tabs. Gray wolf captured in Minnesota using a custom-made No. 14 foothold trap with serrated jaws offset by 0.7 cm had fewer injuries than those caught in No. 4 double long-spring traps (with smooth jaws either not offset or offset by 0.2 cm) and another No. 14 trap with a smaller offset (Kuehn et al. 1986). Schultz et al. (1996) equipped all their wolf traps with drags and checked their sets at least once every 24 hours. They found that 15% of the wolves captured in foothold traps with modified No. 14 Newhouse jaws had moderate to severe injuries. They recommended use of the No. 4 Newhouse trap with modified jaws for capturing wolf pups. Schultz et al. (1996) noted that a pan tension system (Paws-I-Trip) was effective in reducing unwanted captures of other species. No data on the performance of killing traps for wolves are available. Frame and Meir (2007) substantiated that rubber-padded traps minimized capture related injuries to wolves.

## Feral Hog

McCann et al. (2004) described various feral pig trap designs (e.g., box and corral) and trapping procedures for island and mainland ecosystems. West et al. (2009) compiled the available data on trapping methods for feral hog.

## Jaguar

A safe, selective, and effective procedure for capturing jaguar using trained cat hounds was described in detail by McBride and McBride (2007). Additional orthodox capture methods for jaguar were discussed in detail by Furtado et al. (2008), including leg-hold snares and large cage traps with metal mesh over trap bars to avoid injury.

## Canada Lynx

Three restraining traps and 2 killing traps have been evaluated for capturing lynx in Canada. When tested in the Yukon at temperatures ranging from –40° to 0° C, modified Fremont foot snares caused less injury than did the Victor No. 3 Soft-Catch foothold trap with padded jaws (Mowat et al. 1994). Proulx et al. (1995) reported a modified 330 Conibear trap could consistently kill lynx in ≤3 minutes. Breitenmoser (1989) developed a footsnare system to capture lynx and other medium-sized carnivores.

## American Marten

The initial research to evaluate performances of killing traps for capturing marten was conducted in Canada using captive animals (Gilbert 1981*a*, *b*). Additional comparative testing revealed that standard Conibear 110 and 120 traps could not consistently kill marten in 5 minutes (Novak 1981*a*, Proulx et al. 1989*b*). Proulx et al. (1989*a*) reported 13 of 14 marten caught in the C120 Magnum trap equipped with a pitchfork trigger had an average time to unconsciousness of ≤68 seconds. Field tests in Alberta, Canada, indicated the C120 Magnum placed in elevated box sets was as efficient as foothold traps for harvesting marten (Barrett et al. 1989). During additional field tests in Ontario, Canada, Naylor and Novak (1994) found that wire box traps and the Conibear 120 had similar selectivity, but box traps were less efficient. Novak (1990) experimented with a variety of sets and traps and reported the most efficient and selective set for marten used a killing trap placed in a "trapper's box" on a horizontal pole. Proulx et al. (1994*a*) designed a snare system that successfully captured snowshoe hare, but allowed snared marten to escape. Their 0.02-gauge stainless steel wire snare was set with a 10.2-cm-diameter loop and equipped with a release device, a 12-gauge high-tensile fence wire shaped into a 5-coil spiral used as a snare anchor.

Fisher et al. (2005) further perfected and tested a snare system to curtail marten mortality and not impact snowshoe hare trapping success. They effectively used 22-gauge brass or 6 strand picture wire.

## Mink

Restraining trap research on mink is lacking. Research in Canada under controlled conditions has shown that mink can be killed in terrestrial sets in ≤180 seconds using the C120 Magnum trap with a pan trigger (Proulx et al. 1990, 1993*d*), the Bionic trap with a 6-cm bait cone (Proulx and Barrett 1991, Proulx et al. 1993*d*), and the C180 trap with a pan trigger (Novak 1981*a*). In contrast, the standard Conibear 110 and 120 failed to consistently kill mink in 300 seconds when used on land (Gilbert 1981*b*, Novak 1981*a*). Mink died in 240 seconds when captured in drowning sets using foothold traps, but most of them "wet" drown (Gilbert and Gofton 1982). During field tests in Canada, the C120 Magnum with a pan trigger was as efficient for capturing mink as standard foothold traps and the Conibear 120 (Proulx and Barrett 1993*a*).

## Mountain Lion

Logan et al. (1999) used modified foot snares (Schimetz-Aldrich) to trap mountain lion in New Mexico. Most captures (93.3%) resulted in minor or undetectable injuries except for swelling of the capture foot, which ranged from none to >0.2 times normal girth. Mountain lions sustained severe, life-threatening injuries in 2.4% of 209 captures; 4

mountain lions (1.9%) subsequently died. Some problems with mortality of nontarget captures, especially mule deer and oryx, also were encountered.

### Muskrat

Lacki et al. (1990) compared the efficiency of 2 cage-type live traps with double doors for capturing muskrat: the Tomahawk was more effective than the Havahart trap. Killing traps for muskrat have been evaluated in Louisiana, New Jersey, and Canada (Palmisano and Dupuie 1975, Linscombe 1976, Penkala 1978, Parker 1983). Tests on anesthetized animals have measured the minimum energy forces required to cause death when delivered via a blow to the head, neck, thorax, and abdomen (Gilbert 1976, Zelin et al. 1983). Novak (1981*a*) reported that muskrats die in ≤4 minutes if caught in Conibear 110 traps set under water, but standard Conibear 110 and 120 traps failed to consistently kill muskrats in ≤5 minutes when used on land. However, muskrats captured in modified (18-kg springs) Conibear 110 traps set on land died in ≤200 seconds. Controlled experiments have shown that muskrats taken in drowning sets using No. 1.5 long-spring foothold traps died in ≤315 seconds (Novak 1981*a*), and about half had no injuries (Gilbert and Gofton 1982). Based on a field study in New Jersey using drowning sets, McConnell et al. (1985) reported the Victor No. 1 VG Stoploss with padded jaws caused significantly less damage to limbs of trapped muskrat compared to the unpadded Victor No. 1 VG Stoploss; both traps captured and held muskrat equally well in drowning sets. Conibear 110 traps (standard and modified) set at den entrances were more efficient for capturing muskrat than were a variety of No. 1 size foothold traps placed in similar locations (Penkala 1978). Parker (1983) found that Conibear 110 traps were more humane (i.e., killed a higher percentage of the muskrats caught) and selective for harvesting muskrat than were Victor No. 1 Stoploss and Victor No. 1.5 long-spring footholds.

### Nutria

Four field studies, 3 in Louisiana and the other in Great Britain, have evaluated the efficiency of nutria traps. In Great Britain, cage traps set on rafts caught significantly more nutria than traps set on land as well as 50% fewer nontarget animals (Baker and Clarke 1988). Victor No. 1.5 and No. 2 long-spring foothold restraining traps proved more efficient for capturing nutria in Louisiana marshes than were either the Conibear 220 (a killing trap) or the Tomahawk 206 (a cage trap; Palmisano and Dupuie 1975, Linscombe 1976, Robicheaux and Linscombe 1978). The Conibear trap failed to kill about 10% of the nutria caught.

Nolfo and Hammond (2006) used an airboat and a long-handled fishing net to capture nutria in marsh vegetation. Meyer (2006) used a dip net baited with oats to capture nutria when sitting and facing away from the animals. Burke et al. (2008) tested 4 odor lure attractants to enhance capture of nutria with leg-hold traps. All lures increased trapping success, with nutria fur extract being the most effective. Witmer et al. (2008) perfected a multiple-capture box trap for nutria consisting of 2.5-cm PVC tubing with attached welded-mesh wire fencing on sides, top, and bottom. Traps were baited with marsh grass and various vegetable baits (e.g., sweet potatoes, feed corn, and carrots).

**BMP** for trapping in the United States were based on field studies that captured and evaluated 430 nutria using foothold traps in Louisiana marshes during 1998–2004 (AFWA 2007*c*). Two devices tested met or exceeded established BMP criteria: the No. 1 Soft-Catch (padded jaw) trap and No. 1.5 Soft-Catch (padded jaw) trap. Animal welfare was similar among traps. Efficiency was >85%, and selectivity >95% for both traps (Table 3.15).

### Virginia Opossum

Restraining traps for Virginia opossum have been evaluated on a limited basis, primarily in the eastern United States. Berchielli and Tullar (1980) failed to observe any injuries in 67% of the opossum caught in standard unpadded No. 1.5 coil spring traps, but 20% had fractures. Other reports containing data on restraining trap performance for this species included Turkowski et al. (1984), Linscombe and Wright (1988), and Phillips and Gruver (1996). Hubert et al. (1999) examined injuries of opossums captured in the EGG trap, a foot-encapsulating device, and found severe injuries, such as bone fractures, were limited to animals weighing ≤1.9 kg. Warburton (1982, 1992) examined the performance of several restraining traps for capturing Australian brush-tailed opossum. Hill (1981) noted that certain killing traps appeared to be more efficient for catching Virginia opossum when placed in boxes on the ground rather than above ground level.

**BMP** for trapping in the United States were based on field studies that captured and evaluated 2,145 Virginia opossums using various restraining trap types. Twenty-two trap types were tested in 20 states during 1998–2001 (AFWA 2006*g*). BMP criteria were met for 8 of the trap types evaluated, including foothold type traps, a foot-encapsulating trap (EGG), and a wire-mesh cage trap (Tomahawk 108; Table 3.15). Of the foothold trap types that met BMP criteria, all had modifications to the jaws, including padding and/or double-jaws (Fig. 3.29), and offset and lamination. These traps included the Oneida-Victor™ No. 1.5 coil-spring with double jaws, Oneida-Victor No. 1.5 Soft-Catch (with 2 coil-springs and modified with 4 coil-springs), No. 1.5 Soft-Catch with double-jaws, No. 1.65 coil-spring with offset and laminated jaws, and the No. 1 Soft-Catch (padded jaws). Of the traps tested, the Tomahawk 108 cage trap had the lowest mean cumulative injury score (12.5) and was the most selective for opossum (51.9%). Animal welfare (ISO scale) was

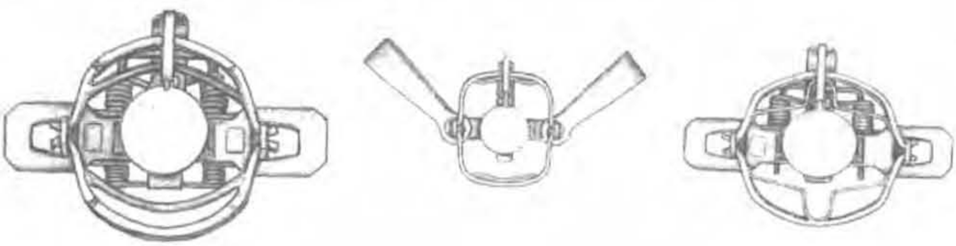

*Fig. 3.29.* Coil-spring and long-spring traps modified with double jaws. *Illustration courtesy of the Association of Fish and Wildlife Agencies.*

similar among all foothold traps; the EGG trap had cumulative injury scores ranging between 41.1 and 55 points. The efficiency of traps meeting BMP criteria were >87%. The Tomahawk 108 cage trap, EGG trap, No. 1 Soft-Catch, and Bridger No.1.65 offset and laminated jaw trap all had efficiency ratings of 100%.

## Porcupine

Single-door cage traps baited with sliced apples and placed at the base of occupied trees have been used successfully to capture porcupine (Griesemer et al. 1999). Traps also have been used to capture porcupines by other researchers (Brander 1973, Craig and Keller 1986). However, injury and efficiency data are lacking for this species. The performance of killing traps for porcupines has not been evaluated.

## Pocket Gopher

Witmer et al. (1999) described a variety of killing and cage or box restraining traps for pocket gopher (Geomyidae). They noted that >100 killing trap designs have been developed and tried over the past 140 years, but only a few types remain in common use in North America. Few cage/box restraining-type live traps are available because of a limited market; rectangular box traps of metal construction have been produced by Sherman Traps (Tallahassee, FL) and Don Sprague Sales (Woodburn, OR; Witmer et al. 1999). Sargeant (1966) and Baker and Williams (1972) described cylindrical cage/box restraining traps made of wire mesh and plastic, respectively.

Proulx (1997) evaluated the efficiency of 4 types of killing traps for gophers during the autumn in alfalfa fields. The ConVerT™ box trap was most successful, and was followed, in decreasing success, by the Black Hole™, Guardian™, and Victor Easyset™. Proulx (1999*b*) tested the experimental pocket-gopher killing trap and found 9 of 9 northern pocket gophers unconscious in ≤78 seconds. He also reported that pocket gophers caught in ConVerT and Sidman killing traps sometimes remained alive if captured in the lower thorax or abdominal regions. Pipas et al. (2000) evaluated the efficiency of 3 types of traps (Cinch [Chinch Trap Company, Hubbard, OR], Macabee [Z. A. Macabee Gopher Trap Company, Los Gatus, CA], and Black Hole Rodent [F. B. N. Plastics, Tulare, CA]) for capturing pocket gophers; they found the Macabee trap to be the most effective.

## Raccoon

Numerous studies of restraining traps for raccoons have been conducted. Most research has focused on comparing the capture rate and injuries associated with different trap types. In some instances, injury data from these investigations are difficult to compare, because scoring systems have varied, and several studies reported only injuries to the trapped limb. However, a significant conclusion has been that most serious injuries observed are due to self-mutilation (e.g., Proulx et al. 1993*c*, Hubert et al. 1996).

Berchielli and Tullar (1980) reported the Blake & Lamb™ No. 1.5 coil spring trap was more efficient for capturing raccoon than the Ezyonem leg snare. They observed self-mutilation in 39% of the raccoons caught in the No. 1.5 coil spring, but were unable to compare injuries between trap types due to the small sample size for the Ezyonem ($n = 2$). However, raccoons caught in the No. 1.5 coil spring had fewer injuries when the traps were covered with sifted soil. Similarly, Novak (1981*b*) reported a raccoon capture rate of 57% ($n = 113$) for the Novak foot snare compared with 76% ($n = 34$) for the No. 2 coil spring and No. 4 double long-spring traps, both with offset jaws. He noted that 82% of the raccoons caught in the foot snare ($n = 49$), and 50% of those taken in the foothold traps ($n = 22$) had no injuries.

Tullar (1984) was the first researcher to report on the performance of padded foothold traps for raccoons. His data indicated injury scores failed to differ between the unpadded Victor No. 1.5 coil spring and a padded prototype No. 1.5 coil spring. However, 89% ($n = 9$) of the raccoons caught in the padded trap had injury scores ≤15 compared with 50% ($n = 14$) for the unpadded trap. Self-mutilation was observed in 24% ($n = 17$) of the raccoons caught in the unpadded trap.

Most reports published since Tullar (1984) indicate that padded traps failed to preclude self-mutilation behavior and did not significantly reduce injury scores compared to unpadded traps (Olsen et al. 1988, Hubert et al. 1991, Kern et al. 1994). However, Saunders et al. (1988) and Heydon et al. (1993) provided data contrary to this generalization. Padded traps also appeared to be less efficient than unpadded versions for capturing raccoon (Linscombe and Wright 1988, Hubert et al. 1991). Smaller foothold traps seemed to reduce injuries without sacrificing efficiency. The only restraining trap tested to date that has significantly reduced the frequency of self-mutilation and the severity of injuries to trapped raccoon compared with padded and unpadded jaw-type foothold traps is the EGG (Proulx et al. 1993*c*, Hubert et al. 1996). Based on a field study in Illinois, Hubert et al. (1996) reported the mean total injury score (based on a modified Olsen scale) for raccoon caught in EGG foothold traps was 68 compared to 116 for those trapped with the No. 1 coil spring trap. They reported the EGG trap had a raccoon capture efficiency exceeding that of the unpadded No. 1 coil spring. Proulx (1991) found the raccoon capture efficiency of the EGG was similar to that of cage traps in British Columbia, Canada, but it was less efficient than the Conibear 220 during the latter part of the fur trapping season in Quebec, Canada.

Cage-type restraining traps are commonly used to capture raccoon. Preliminary data contained in a progress report (IAFWA 2000) indicated that 52% ($n = 112$) of the raccoons caught in Tomahawk 108 wire cage traps sustained no injuries. Moore and Kennedy (1985) used Tomahawk and Havahart wire cage traps during a population study and found that capture success was highest in autumn and winter, increased with increasing temperatures, and was negatively correlated with precipitation. Gehrt and Fritzell (1996) reported a gender biased response of raccoons when using Tomahawk cage traps in Texas. Adult males were consistently captured more frequently than were adult females.

Controlled lab tests have been conducted on anesthetized raccoons to measure the minimum energy forces a killing trap must deliver to cause death via a blow to the head and neck (Gilbert 1976, Zelin et al. 1983). Limited data about the effects of clamping force also have been obtained (Zelin et al. 1983). Other research on killing traps conducted in enclosures indicated that raccoon cannot be consistently killed in 5 minutes using standard Conibear 220, 280 (with pan trigger), and 330 traps (Novak 1981*a*). However, about 60% of the raccoons captured in the Conibear 220 and 280 traps died in 4 minutes. Proulx and Drescher (1994) reported the Savageau 2001-8 and a modified (extra clamping bar) Conibear 280 have the potential to consistently immobilize raccoons and render them irreversibly unconscious in ≤4 minutes, but not in ≤3 minutes. In a separate lab study, the average time to unconsciousness for 4 of 5 immobilized raccoons caught in the BMI 160 (a rotating-jaw trap similar to the Conibear) was 172 ± 16 seconds; the remaining animal was euthanized after 5 minutes (Sabean and Mills 1994). Proulx (1999*a*) recommended future research should focus on killing systems for raccoon that differ from the rotating-jaw trap type.

The raccoon capture efficiency of the Conibear 220 may be comparable to or better than some restraining traps under certain environmental conditions, but in other instances, it may not (Proulx 1991). Linscombe (1976) reported the Victor No. 2 long spring trap was more efficient than the Conibear 200 for capturing raccoons in brackish marshes. In contrast, Hill (1981) caught a similar number of raccoons per trap night with No. 2 coil spring traps placed in dirt-hole sets and with Conibear 220 traps in boxes placed on the ground.

Kerr et al. (2000) improved trapping success for raccoon by modifying Tomahawk cage traps. They added an extended metal floor that acted as a trip device and wrapped hardware cloth around the back of the trap to reduce missing baits. They also added an elevated bait hook to curtail fire ants. Austin et al. (2004) evaluated EGG and wire cage traps for capturing raccoon. They found that EGG traps (Fig. 3.23) were more effective, especially for capturing males.

Research conducted in support of BMP for trapping in the United States found that No. 1.5 coil-spring foothold traps modified with double jaws reduced self-mutilation and improved animal welfare. Various double-jaw configurations (Fig. 3.29) were tested, and all reduced self-mutilation compared to standard jaw traps. Self-mutilation was reduced to 10% ($n = 128$) when the No. 1.5 coil-spring trap was modified with double jaws compared to a self-mutilation rate of 37.9% ($n = 206$) reported for the No. 1.5 coil-spring trap with standard jaws. Similarly, the No. 11 double long-spring trap modified with double jaws reduced self-mutilation compared to the standard jaw No. 11 ($n = 135$; self-mutilation rate = 27.4%), but only when modified with an offset in the jaws ($n = 35$; self-mutilation rate ≤10%). The efficiency of traps modified with double jaws was similar to that of standard jaw traps.

**BMP** for trapping in the United States were based on field studies that evaluated 382 raccoons captured in foot encapsulating traps (AFWA 2006*h*). Three models of foot encapsulating traps were tested during 1998–2004, including the EGG, Duffer's and Lil' Grizz Get'rz (Table 3.15; Fig. 3.23). The foot encapsulating traps passed all BMP criteria. Injury scores ranged from 37.5 to 48.4. Self-mutilation was minimal (2%) due to trap design, which prevents captured animals from accessing the encapsulated foot. Efficiency was higher for these traps types compared to coil-spring and long-spring foothold traps commonly used to capture raccoon. Cage-type restraining traps are frequently used to capture raccoon (AFWA 2005).

### Northern River Otter

A variety of restraining traps for the live capture of river otter has been evaluated in Canada and the United States. Capture success with Hancock traps has varied, depending on the season and setting techniques (Northcott and Slade 1976, Melquist and Hornocker 1979, Route and Peterson 1988). In Newfoundland, Canada, Bailey traps proved ineffective (Northcott and Slade 1976). Shirley et al. (1983) reported that a modified Victor No. 11 double long-spring trap was a practical and efficient live trap for otters in Louisiana marsh habitat, but they failed to catch any otters in Tomahawk 208 cage traps. Serfass et al. (1996) compared unpadded Victor No. 11 double long-spring modified (heavier spring added) traps with Victor No. 1.5 Soft-Catch traps with padded jaws for catching otter for relocation. Fewer severe injuries were noted in animals captured with the Soft-Catch trap, but there was no difference in frequency or severity of dental injuries between trap types. More recently, Blundell et al. (1999) compared Hancock and No. 11 Sleepy Creek™ double-jaw foothold traps with long springs for live-capture of northern river otter using blind sets at latrines. They found Hancock traps had slightly lower efficiency, higher escape rate, lower rate of malfunction, and much lower use than the No. 11 Sleepy Creek foothold trap. Otters captured in Hancock traps had significantly more serious injuries to their teeth than animals captured in foothold traps. Although more serious injuries to appendages were observed for animals caught in foothold traps compared with Hancock traps, the difference was not significant. No published research on killing traps for river otter is available.

**BMP** for trapping in the United States were based on field studies that captured and evaluated 70 river otters using foothold traps. Studies were conducted in 4 states during 2005–2007 (AFWA 2007*d*). Three foothold traps were tested: No. 2 coil-spring, No. 11 double long-spring, and No. 11 double-jaw double long-spring. All 3 traps met or exceeded established BMP criteria (Table 3.15). The No. 2 coil-spring trap is the most commonly used trap for capturing river otter for fur harvest (AFWA 2005). This trap produced an average cumulative injury score of 45.3, with 81.4% of injuries ranking in the 3 lowest trauma classes (none, mild, and moderate). The efficiency for this trap was 69.9%, and the selectivity for river otter was 25.5%. No published research on killing traps for river otter is available.

### Gray and Fox Squirrels

Huggins (1999) presented a detailed review of trapping techniques and equipment for gray and fox squirrels. Based on limited comparative research, cage traps and jaw-type foothold traps were relatively nonselective; rotating-jaw and tunnel-type killing traps were relatively selective for these species. Research needs included welfare and effectiveness testing of killing traps and additional comparative studies of trap types.

### Red Squirrel

The Kania 1000, a mouse-type killing trap with a striking bar powered by a coil spring, can reliably cause unconsciousness in red squirrel in ≤90 seconds (Proulx et al. 1993*b*). When set under conifer branches, it is unlikely the Kania would attract and capture birds (Currie and Robertson 1992). Preliminary field tests showed this trap had the potential to capture red squirrel during the regular harvest season (G. Proulx, Alpha Wildlife Research & Management, unpublished data).

### Striped Skunk

The restraining trap research conducted on striped skunk indicated leg injuries of animals caught in unpadded and padded foothold traps were often severe due to the high incidence of self-mutilation (Berchielli and Tullar 1980, Novak 1981*b*). Novak (1981*b*) reported that skunk can be captured with few injuries in the Novak foot snare, but this device has a low capture rate and an unacceptable level of efficiency. Numerous pan tension devices have been used on a variety of coyote traps; all have been effective in reducing accidental skunk captures (Turkowski et al. 1984, Phillips and Gruver 1996). The performance of killing traps on striped skunk has not been evaluated.

**BMP** for trapping in the United States were based on field studies that captured and evaluated 51 striped skunks using cage traps during 2007–2009 (AFWA 2009*a*). Two models of Tomahawk wire cage traps were tested (models 105.5 and 108), and both met or exceeded established BMP criteria (Table 3.15). These traps were highly effective (capture rate of 100%), and no trap related injuries were reported. Selectivity of traps were 53.8% (model 108) and 67.6% (model 105.5).

### Long-Tailed and Short-Tailed Weasels

Research information on traps commonly used for harvesting weasels in North America is not available. During a field study in New Zealand, King (1981) concluded that correctly set Fenn traps killed weasels more humanely than did Gin traps. Typically, North American trapping technique manuals recommend the use of small foothold or rotating-jaw traps as killing traps for these animals.

Belant (1992) tested the efficiency of double-door Havahart, single-door National™, and single-door wooden cage/box traps for capturing long-tailed and short-tailed weasels in New York. Overall success for all 3 types was similar. Trap-related injuries of long-tailed weasel caught in Havahart traps included skin abrasions and broken canines.

### Wolverine

Copeland et al. (1995) used a specialized log trap to live-capture wolverine in Idaho. No injuries were noted on individuals captured, but 3 wolverines escaped by chewing holes in the traps. No data are available on the performance of killing traps for wolverine. Copeland et al. (1995) and Lofroth et al. (2008) described and evaluated live-capture techniques for wolverine.

## CAPTURING AMPHIBIANS AND REPTILES

### Amphibians

#### Hand Captures

Corn and Bury (1990) described **time-constrained searches** for amphibians and reptiles that were immediately captured by hand. Equal effort was expended in each area searched.

They described another hand collection method for amphibians (surveys of coarse woody debris) and advised searching 30 downed logs per forest stand. Barr and Babbitt (2001) compared 2 techniques for sampling larval stream salamanders. More larvae were captured at high densities using 0.5-$m^2$ quadrats. Time-constrained sampling for 0.5 hours was more successful at low densities. Pearman et al. (1995) evaluated day and night transects, artificial cover, and plastic washbasins with added leaf litter as sampling methods for amphibians. Significantly more species were found during **nocturnal searches** than with other methods. Parris et al. (1999) compared 3 techniques for sampling amphibians in forests. Nocturnal **stream searches** were the most sensitive and pitfall trapping the least sensitive sampling technique. A minimum of 4 nights of stream searching was recommended to determine the number of amphibian species present at a site. Haan and Desmond (2005) concluded that area-constrained searches for salamanders were superior to pitfall traps, especially during dry periods. Mattfeldt and Campbell-Grant (2007) recommended using both area-contained transects and **leaf litter bags** for improved sampling of stream salamanders.

## Dip Nets

Wilson and Maret (2002) reported that **timed dip-net collections** of 5 minutes provided reliable estimates of aquatic amphibian abundance and were superior to **drop box sampling.** Welsh and Lind (2002) sampled amphibians by searching streambed substrates with hardware-cloth catch nets placed downstream and from bank to bank to capture escaping individuals.

## Drift Fences with Pitfall and Funnel Traps

Campbell and Christman (1982) developed and described a **standardized** amphibian trapping system. Their system included pitfalls and double-ended funnel traps placed in conjunction with drift fences that diverted moving animals into traps. Data obtained using their technique allowed estimates of species richness and an index of relative abundance of most common terrestrial amphibians and reptiles. Dodd (1991) warned that drift fences used with pitfalls were **biased** in sampling amphibians. Frogs, in particular, readily cross drift fences by climbing over them. Other species burrow under drift fences. Brown (1997) also found that drift fences allowed frogs to escape. She tested pitfall traps and reported that 1% of the individuals placed in pitfall traps escaped.

Scott (1982), Heyer et al. (1994), Olson et al. (1997), and Simmons (2002) have compiled comprehensive capture references for amphibians. Adams and Freedman (1999) evaluated catch **efficiency** of 4 amphibian-sampling methods: pitfall transects, pitfall arrays, quadrat searches, and time-constrained searches in terrestrial habitats. Pitfall arrays sampled the greatest relative abundance and species richness of amphibians. Nadorozny and Barr (1997) designed a **side-flap pail** to capture amphibians that were not readily captured in conventional pitfall traps due to their climbing and jumping ability. This trap design, when used with funnels and drift fencing, was effective for capturing amphibians in terrestrial habitats. Crawford and Kurta (2000) tested capture success of black and white plastic pitfall traps on anurans and masked shrew. Both were caught significantly more often in pitfalls with a black interior than in those with a white one. Adding rims to pitfall traps increased effectiveness by hindering the escape of certain species of salamanders and frogs (Mazerolle 2003). Stevens and Paszkowski (2005) tested 2 pitfall trap designs for sampling boreal anurans. They found that plastic buckets with a polyethylene funnel design were easier to construct and allowed fewer escapes.

Murphy (1993) captured tree frogs with a **modified drift fence** (Fig.3.30) of clear plastic suspended from PVC pipe joined in a T-shaped configuration. Daoust (1991) suggested placing moistened sponges (10 cm × 5 cm × 7 cm) in funnel traps along drift fences to minimize mortality of wood frog from dehydration. Willson (2004) compared **aquatic drift fences** with traditional funnel trapping as a quantitative method for sampling amphibians. Mushet et al. (1997) connected a 200-cm drift fence that directed free-swimming salamanders to the opening of funnel traps. Malone and Laurenco (2004) suggested the use of polystyrene for drift fence

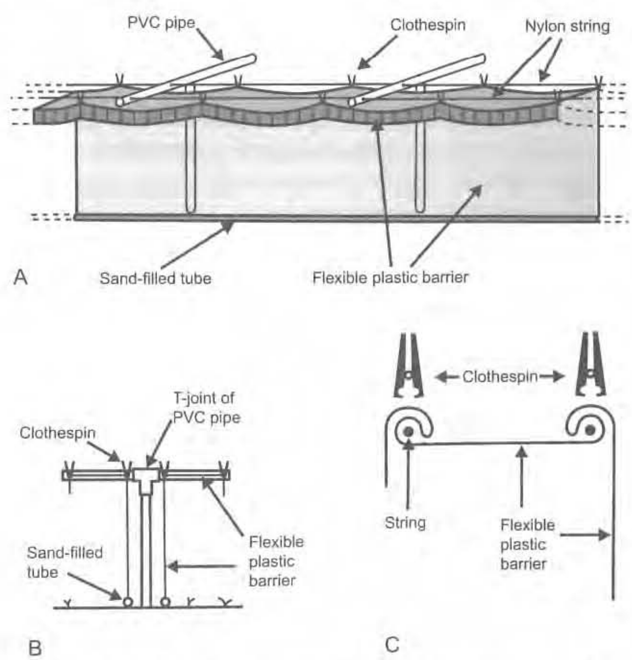


Fig. 3.30. Drift fence for capturing tree frogs as they enter and leave ponds. (A) Front view of the fence. Only a portion of the fence and only one of the plastic barriers are shown. (B) Side view of the fence showing both plastic barriers. (C) Enlarged side view of the fence showing method of attachment of flexible plastic barrier to strings. *From Murphy (1993).*

sampling, because it was economical and easily repaired compared to aluminum or silt fence (silt fence is a woven polypropylene material used to control sediment runoff at construction sites). Rice et al. (2006) combined collapsible minnow traps with PVC pipes attached to a portable drift fence structure to capture various frogs and toads.

Smith and Rettig (1996) sampled amphibian larvae with an **aquatic funnel trap** made of 5-cm-diameter PVC pipe with funnels at each end held in place with a large rubber band. Fronzuto and Verrell (2000) tested the capture efficiency of wire and plastic funnel traps for aquatic salamanders. Plastic funnel traps with a maximum diagonal mesh of 5 mm were superior to 10-mm mesh hardware-cloth wire minnow traps. Mushet et al. (1997) designed a funnel trap for sampling salamanders in wetlands. Casazza et al. (2000) captured aquatic amphibians and reptiles using baited wire-funnel–entrance eel pots with Styrofoam blocks. The blocks allowed the traps to float partly out of the water, avoiding trap mortality from drowning. Richter (1995) used baited aquatic funnel traps made from plastic soda pop bottles attached to a steel rod baited with salmon (Salmonidae) eggs. He captured tadpoles and adult amphibians. Smith and Rettig (1996) increased the catch rate of tadpoles by putting **glow sticks** at night in 3 different funnel trap designs. Jenkins et al. (2002) compared 2 aquatic surveying techniques to sample marbled salamander larvae. Nocturnal visual surveys were less intrusive, less expensive, and more accurate at detecting presence than were the bottle funnel traps described by Richter (1995).

Parris (1999) summarized the **advantages and disadvantages** of various techniques for sampling amphibians in forests and woodlands. Lauck (2004) discussed factors influencing the capture of amphibian larvae in aquatic funnel traps. Willson and Dorcas (2004) verified that funnel traps combined with an aquatic drift fence increased amphibian capture rates. O'Donnell et al. (2007) compared the efficiency of funnel and drift fence trapping, and light touch and destructive sampling of frogs and salamanders in forested seep habitats. Light touch sampling was the most suitable method. Palis et al. (2007) evaluated 2 types of commercially made aquatic funnel traps for capturing ranid frogs and found that both had similar capture rates. They determined that nylon traps were less durable than steel mesh traps. Buech and Egeland (2002) tested 3 types of funnel traps in seasonal forest ponds. Traps with 6-mm mesh captured more wood frog tadpoles than did plastic traps. Traps with 3-mm mesh captured more blue-spotted salamander and spring peepers. Jenkins and McGarigal (2003) tested the catchability of reptiles and amphibians along drift fences using paired funnel and pitfall traps in the northeastern United States. Their results showed funnel traps to be superior to pitfalls in wet or rocky areas. Ghioca and Smith (2007) cautioned against using funnel traps to avoid **biased estimates** of the abundance of larval amphibians. Glow sticks in funnel traps significantly increased capture rates of aquatic amphibians (Grayson and Roe 2007). Willson and Dorcas (2003) found funnel trapping superior to dip-netting for quantitative sampling of stream salamanders.

### Pipes

Boughton and Staiger (2000) caught hylid tree frogs in white 3.81-cm-diameter PVC pipe capped at the bottom and hung vertically in hardwood trees, 2 m and 4 m above the ground. The 60-cm-long pipe caught more frogs than did the 30-cm pipe. Moulton (1996) used PVC pipes to capture hylid tree frogs. Bartareau (2004) found that PVC pipes with varied diameters influenced the species and sizes of tree frogs captured in a Florida coastal oak-scrub community. Myers et al. (2007) tallied more captures (81%) of Pacific tree frogs in tree-based than in ground-based pipe refugia. Johnson (2005) designed a novel arboreal pipe trap to capture gray tree frogs using black plastic acylonitrile-butadiene-styrene (ABS) pipe that allowed a constant water depth. Zacharow et al. (2003) sampled 2 species of hylid tree frogs using ground-placed PVC pipes of 3 diameters and identified potential trap biases. The addition of escape ropes to PVC tree pipes used by tree frogs prevented flying squirrel mortality (Borg et al. 2004).

### Cover Boards

Trapping methods for herpetofauna are time and labor intensive, and they can result in injury to captured individuals due to physical stress, such as overheating, desiccation, drowning, or predation. **Cover boards** ("boards" placed on the ground under which herpetofauna may hide) avoid these problems. Grant et al. (1992) evaluated cover boards in detail. They recommended that both metal and wood cover boards be used and a wait of at least 2 months after placement before beginning the survey program. They suggested that checks of cover boards be made at different times of day and weather conditions to sample all taxa in residence. They advised that if encounter rates are to be compared among sites, time and weather conditions should be identical.

DeGraaf and Yamasaki (1992) used cover boards to simulate fallen timber to attract and evaluate terrestrial salamander abundance during daylight hours. Their procedure avoided laborious installation of pit traps, as they placed a cluster of 3 boards along transects. They lifted boards 8 times during June–August in a variety of different-aged forest stands. Use of the boards avoided degradation of salamander habitat by turning or breaking existing logs or disrupting forest litter. Hyde and Simons (2001) investigated 4 common sampling techniques to examine variability of salamander catches. They found natural cover transects and artificial cover boards to be the most effective sampling techniques for detecting long-term salamander population trends because of lower sampling variability, good capture success, and ease of use. They associated higher capture rates and lower variability with fewer, but larger plots. **An evaluation** of cover boards for sampling terrestrial salamanders by Houze and Chandler (2002) found that most species were sampled in lower numbers (0.8 salamanders/grid search) than under natural cover (2.3 salamanders/grid search). Temperatures were more variable under cover boards than under natural cover. Carlson and Szuch (2007) found no difference in the use of old and nonweathered cover boards by salamanders. Moore (2005) encountered more red-backed salamanders under native dominant-wood cover boards than under artificial wood cover boards. Luhring and Young (2006) combined a halved PVC pipe with screens at each end attached to a cover board to sample stream-inhabiting salamanders.

### Unique Methods

Williams et al. (1981*a*) used **electroshocking** methods in the Allegheny River, Pennsylvania, to capture hellbender and reported that it was superior to search and seizure, potato rake, and seine herding as a capture method. Soule and Lindberg (1994) used a **peavey** to move large rocks to locate and catch hellbender. The peavey was hooked to the bottom of the rock, which was then manually moved. This technique required a 3-person crew to move rocks and capture the animals. The peavey was much less expensive than electroshocking equipment. Nickerson and Krysko (2003) reviewed a wide array of techniques and their variants used in studying a cryptobranchid salamander and discussed their **advantages and disadvantages.** Electroshocking surveys were strongly discouraged because of the great potential for damaging reproductive success and immune systems, and because they were of questionable effectiveness. Because successful hellbender nesting sites appear to be quite limited, the use of Peavy hooks and crowbars to breakup bedrock or dislodge large cover rocks should be restricted. Currently, **skin-diving** surveys coupled with turning objects is the only method shown to obtain all sizes of gilled larvae and multiple age groups of nongilled and adult hellbenders in brief periods. Foster et al. (2008) compared 3 capture methods for eastern hellbender and found that **rock turning** was most efficient in terms of catch per unit effort. Camp and Lovell (1989) caught blackbelly salamander using a **fishing pole** made from metal coat hangers with barbless hooks baited with earthworms.

## Reptiles

To quantify reptile densities, Corn and Bury (1990) used **time-constrained searches** for reptiles that were immediately captured by hand. Equal effort was expended in each area searched. This allowed the calculation of relative densities for each area searched.

### Drift Fences with Pitfall and Funnel Traps

Hobbs et al. (1994) tested a variety of pitfall trap designs. A straight line of pit traps with buckets approximately 7 m apart was most effective for sampling reptiles in arid Australia. The use of shade covers reduced heat related mortality. Hobbs and James (1999) reported that foil covers placed inside and at the bottom of buckets reduced pitfall temperature and had minimal influence on trap success. Foil covers were superior to cardboard and plastic. Aboveground covers reduced capture success for mammals, but increased snake captures.

Vogt and Hine (1982) advocated the use of drift fences combined with traps as a practical way to uniformly census reptiles and amphibians. **Aluminum drift fences** (50-cm high) caught more animals per 15 m of fence than did those made of either screening or galvanized metal. A system of 18.9-L traps, 7.6-L traps with funnel rims, and funnel traps was necessary to capture the entire spectrum of amphibians and reptiles in the communities sampled. Funnel traps were more effective for catching lizards than were pit traps, and they also were effective for catching snakes. They recommended at least 4 trapping periods of 3–5 days during April–mid-June.

Moseby and Read (2001) recommended 5 nights of pitfall trapping as the most efficient duration for capturing reptiles. Greenberg et al. (1994) compared sampling effectiveness of pitfalls and single- and double-ended funnel traps used with drift fences. All 3 trap types yielded similar estimates of lizards and frogs, but not snakes. Estimates of relative abundance of large snakes were higher in double-ended funnel traps than in pitfalls or single-ended funnel traps. Captures of snakes were restricted to funnel traps. More surface-active lizards and frogs were captured in pitfalls. They advised that choice of trap type(s) depended on target species and sampling goals. Enge (2001) presented a detailed assessment of the effectiveness of pitfall versus funnel traps. He concluded that salamanders, anurans, lizards, and snakes were captured significantly more often in funnel traps than in pitfall traps. He added that studies that found funnel traps to be less effective than pitfall traps used smaller or poorly constructed or installed funnels. He also reported herpetofaunal mortality rates were generally higher in funnel traps than in pitfall traps. Enge (2001) recommended that traps be checked at least every 3 days to minimize mortality.

Fair and Henke (1997) evaluated the efficiency of capture methods for a low density population of Texas horned lizard. **Road cruising** yielded the highest capture rates, with systematic searches second. Searching resulted in a higher rate of capture than did using pitfall and funnel traps. Sutton et al. (1999) compared pitfalls and drift fences with cover boards for sampling sand skink. They reported that **cover boards** were most efficient in detecting the presence of skinks and were less costly and labor intensive. Allan et al. (2000) developed a successful **habitat trap.** The trap consisted of an artificial replica of a preferred habitat placed on a large sheet of camouflaged plastic. Two people lifted the plastic sheet at all edges once lizards had begun to occupy the artificial habitat, and the animals were trapped.

The artificial habitat consisted of a rock pile or woodpile placed in an excavated shallow pit 15 cm deep covering an area of 1 $m^2$.

Doan (1997) captured large lizards by using large (88.5 cm × 31.0 cm × 31.0 cm), collapsible aluminum **Sherman live traps.** Traps were camouflaged with green mosquito netting and fallen branches and leaves. Zani and Vitt (1995) attached a wire-mesh minnow trap over holes in trees, whereas Paterson (1998) used a mesh barrier of bridal veil fabric wrapped around a tree trunk to facilitate hand capture of arboreal lizards.

Gluesenkamp (1995) designed a simple **snake rake** consisting of 120-cm-long, 19-mm-diameter aluminum pipe and 2 pieces of 25-cm-long, 6.5-mm-diameter steel. The 2 pieces were bent 90°, welded together at a 25° angle, and then attached with hose clamps to the end of the aluminum pipe.

Lannom (1962) dangled a barbless dry fly from a support over a buried 1-L glass jar to attract and catch desert lizards. Whitaker (1967) increased his rate of capture of small lizards in pitfall traps by using canned fruit as bait. He also suggested using captive lizards in pitfall traps to attract other curious lizards. Serena (1980) used a **fishing pole** with a line attached to edible palm fruit to attract and capture whiptail lizards. Durden et al. (1995) caught skinks by using crickets (family Gryllidae) threaded onto fishing line attached to a fishing rod. They also baited little Sherman small-mammal traps with crickets tied inside the trap. Small smooth-scaled lizards were captured by Durtsche (1996) using a combination of a pole (fishing pole or collapsible car antenna) with a piece of **sticky pad** fastened to the end. The sticky pad was touched to the back of the lizard, allowing capture. Bauer and Sadleir (1992) used mouse **glue traps** to capture lizards. Corn oil was used to release the animals. Whiting (1998) increased lizard capture success by baiting glue traps with insects and figs. Downes and Borges (1998) captured small lizards with commercial packing tape by creating sticky traps. However, Vargas et al. (2000) cautioned that sticky-trapping of lizards had a higher fatality rate than did capture with a noose or rubber band; sticky-trapping also yielded less reliable gender-biased capture information.

Witz (1996) coated the prongs of a bolt retriever (total length 60 cm) with liquid plastic. This **lizard grabber** grabs the pelvic girdle firmly with minimal chance of escape or injury to the lizard. Strong et al. (1993) caught small fast-moving lizards by chasing them into PVC pipes covered at one end (Fig. 3.31). Brattstrom (1996) used a plastic wastebasket or garbage can as a "skink scooper." When he located a skink, he held the plastic container 15–30 cm away and swept the leaf letter and the skink into the scooper for capture. Sievert et al. (1999) made a "herp scoop" (Fig. 3.32) of pliable plastic for safely capturing herpetofauna from roads at night. They used a flashlight combined with a 1–3-liter clear soft-drink bottle with the bottom removed and a V-shaped

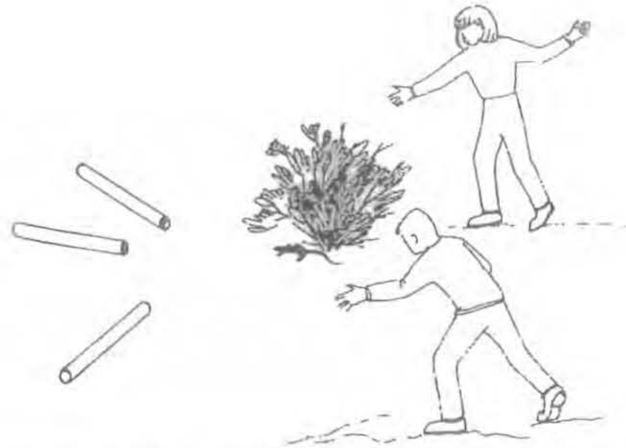

*Fig. 3.31.* Method for catching lizards by chasing them into tubes placed near a bush. The tubes have one end covered with tape. *From Strong et al. (1993).*

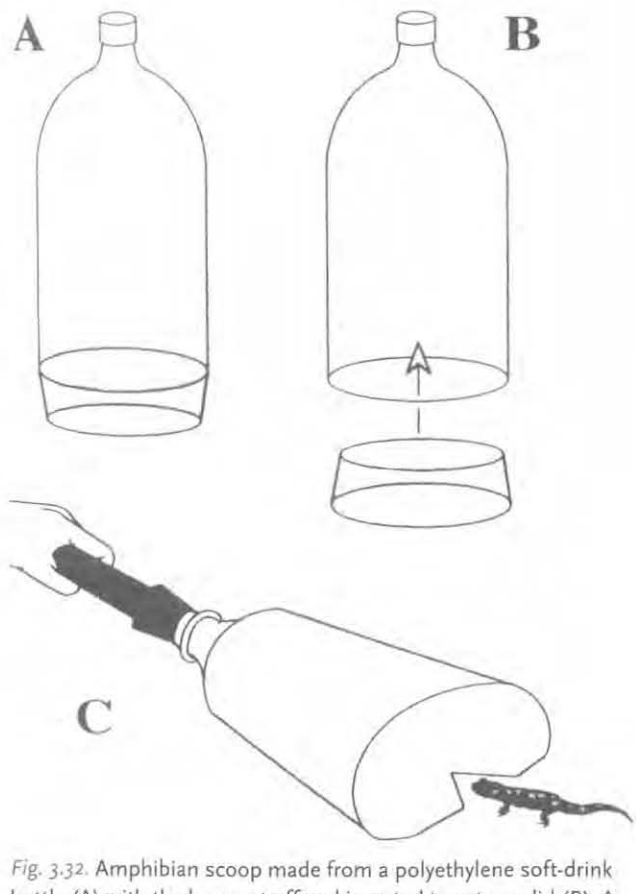


*Fig. 3.32.* Amphibian scoop made from a polyethylene soft-drink bottle (A) with the base cut off and inverted to act as a lid (B). A V-shaped notch and a flashlight (C) were added to make the scoop more useful. *From Sievert et al. (1999).*

notch cut 3–5 cm wide and 2 cm deep into the bottom lip of the bottle.

Recht (1981) modified a rat trap to block the entrance of burrows of desert and Bolson tortoises to facilitate **hand-capture** as they attempted to re-enter their burrows. Bryan et al. (1991) designed a trap with a spring-loaded arm released by a trigger mechanism activated by a gopher tortoise as it exited its burrow. A net was attached to the trigger to restrain the tortoise.

Graham and Georges (1996) modified collapsible turtle funnel traps by adding PVC pipe as struts to keep the funnels open and in place. They also used a piece of foam as a buoy to expedite trap retrieval. Mansfield et al. (1998) had success capturing spotted turtle in funnel traps by using turtle-shaped decoys of cement poured in plaster-of-Paris casts. Decoys were painted to resemble turtle markings and color. Christiansen and Vandewalle (2000) perfected pitfall traps with wooden flip-top lids along drift fences that were effective in capturing terrestrial turtles (Fig. 3.33). Their traps were more effective in capturing adult terrestrial turtles than were wire box traps or open pitfalls. Feuer (1980) modified the chicken-wire turtle trap described by Iverson (1979) by using oval galvanized hoops with nylon netting. He attached lines to hold the throats of hoop nets in place.

Braid (1974) used a **bal chatri trap** with snares similar in design to a bird trap to capture basking turtles. Unlike bal chatri traps used to catch birds, bait was not necessary. Nooses should be kept upright, and the chicken wire base should be tied to a log. Vogt (1980) used **fyke and trammel nets** to catch aquatic turtles.

Fitch (1992) found that artificial shelters were superior to live traps and random encounters for capturing snakes during a 12-year study. Kjoss and Litvaitis (2001) used black plastic sheets to capture snakes. Their cover sheet method was cheap, limited injuries, required less frequent checks, and was effective in open-canopy habitats. Lutterschmidt and Schaefer (1996) used mist netting with enclosed bait to capture semi-aquatic snakes.

Fritts et al. (1989) successfully captured brown tree snake using **bird odors.** Their funnel traps were baited with chicken and quail manure. Shivik and Clark (1997) found that brown tree snake were attracted to carrion and entered traps baited with dead mice as readily as traps baited with live mice. Engeman (1998) devised a simple method for capturing brown tree snake in trees. He used a branch or stick with a fork at one end that was placed in the middle of the snake, and the stick was then twirled to wind the snake on the stick. The snake would coil around the stick, allowing time to retrieve the stick and snake from the tree for hand capture. Lindberg et al. (2000) tested a variety of **lures** for capturing brown tree snake. They found that visual lures lacking movement were ineffective. Lures combining movement and prey odors were most effective (Shivik 1998). Engeman and Linnell (1998) used modified crawfish traps

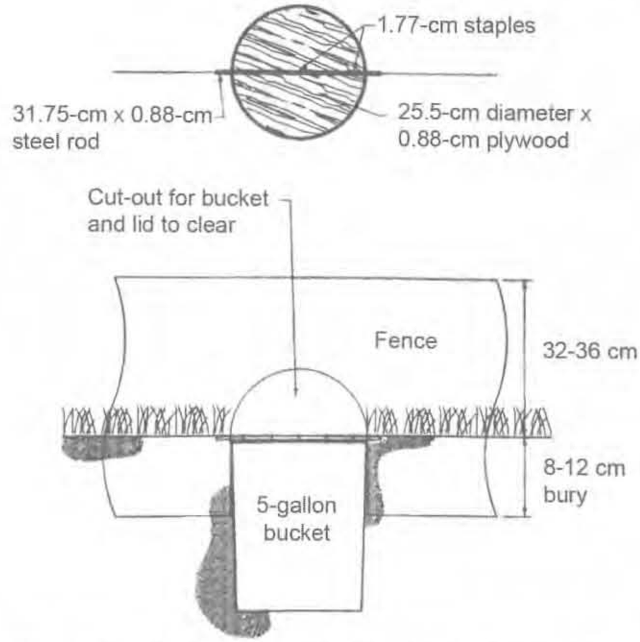


*Fig. 3.33.* Specifications of flip-top lid on 19-L (5 gallon) bucket set in a drift fences. *From Christiansen and Vandewalle (2000).*

of 10-mm wire mesh with one-way flaps installed at the entrance and baited with a live mouse to capture brown tree snake. Engeman et al. (1999) recommended placing a horizontal bar at the top of chain link fences to facilitate capture of brown tree snake. Captures of these snakes by trapping exceeded those using spotlight searches of fences (Engeman and Vice 2001).

## Lizards

Goodman and Peterson (2005) perfected a **pitfall style** trap for lizards consisting of a bucket and a tray of live food (e.g., adult crickets with their hind legs removed or *Tenebrio* larvae). This method was especially effective in rocky habitats. Ferguson and Forstner (2006) perfected a durable and effective predator-exclusion device attached to pitfall traps along a drift fence. An effective, inexpensive tube-trap made of transparent plastic with a one-way door was designed by Khabibullin and Radygina (2005) to sample small terrestrial lizards. Cole (2004) employed a class 1 **laser pointer** to capture arboreal geckos (family Gekkonidae). The geckos chased the laser dot. Estrada-Rodriguez et al. (2004) effectively used a new method, a **water squirting** technique, to hand-capture desert lizards in sand dunes. Horn and Hanula (2006) attached burlap bands on tree trunks to attract and capture various lizards. Lettink (2007) used a double-layered **artificial retreat** made of Onduline™, a lightweight corrugated roofing, in rocky habitat for capturing geckos.

Bennett et al. (2001) described a **noose trap** attached to the side of a tree along with a trigger stick for catching large lizards. Bertram and Cogger (1971) described a noose gun for live lizard captures. The noose gun was made of copper-coated welding wire and used rubber bands to tension the noose and trigger.

Rodda et al. (2005) compared **glueboard** lizard-capture rates with total removal plots on various oceanic islands. Results varied by species, speed, mode of locomotion, and habitat. They concluded that glueboard capture frequencies of arboreal species were less reliable than for terrestrial species. Ribeiro et al. (2006) also indicated that glueboard trapping of lizards provided a useful addition to other sampling methods of neotropical forest lizards. Glor et al. (2000) suggested placing glue traps in shaded areas to avoid heat related mortality in the mainland tropics. Whiting (1998) increased lizard capture success by adding ripe figs and/or live, moving insects as bait to glue traps.

## Turtles

Browne and Hecnar (2005) found that capture success for northern map turtle with floating **basking traps** to be superior to baited hoop traps. McKenna (2001) and Gamble (2006; Fig. 3.34) described similar capture results for painted turtles. Robinson and Murphy (1975) perfected a successful net trap for basking softshell turtles. Petokas and Alexander (1979) designed an effective trap for basking turtles made of wood planking and aluminum flashing as a basking platform in a sloping configuration with a chicken-wire bottom and urethane foam. Fratto et al. (2008) evaluated 5 modified hoop net designs. They found that a chimney design was most effective in curtailing turtle bycatch mortality while not reducing catfish catch rates. Barko et al. (2004) found a high mortality of drowned turtles in fyke nets set to capture fish inside the channels of large rivers. They recommended that nets be set several inches above water to avoid turtle mortality. Glorioso and Niemiller (2006) attached a large cork to inexpensive floating, baited, and deep-water crayfish trap nets to successfully catch turtles of various sizes. Sharath and Hegd (2003) designed 2 new traps for sampling black pond turtle. One was a baited **floating pitfall trap;** the other was a baited see-saw board trap. Both were more efficient than a conventional pitfall trap. Fidenci (2005) evaluated the capture efficiency of various traditional turtle-capture methods (e.g., by hand, and using basking and funnel traps) and found his baited wire method to be more effective.

Thomas et al. (2008) tested 3 different baits in **funnel traps** for capturing pond-dwelling turtles. Both canned fish and frozen fish captured more turtles than did canned creamed corn. Kuchling (2003) described a collapsible baited turtle-trap tied to a tree branch that functions in shallow and changing water levels. Kennett (1992) developed a baited **hoop trap** composed of 2 sections, an entry section with funnel entrance to reach the bait, and a holding section from which turtles cannot escape. Plastic floats were placed inside the traps to keep them afloat, thereby allowing trapped turtles to breathe. Borden and Langford (2008) caught nesting diamondback terrapin in pitfall traps with self-righting lids attached to drift fences.

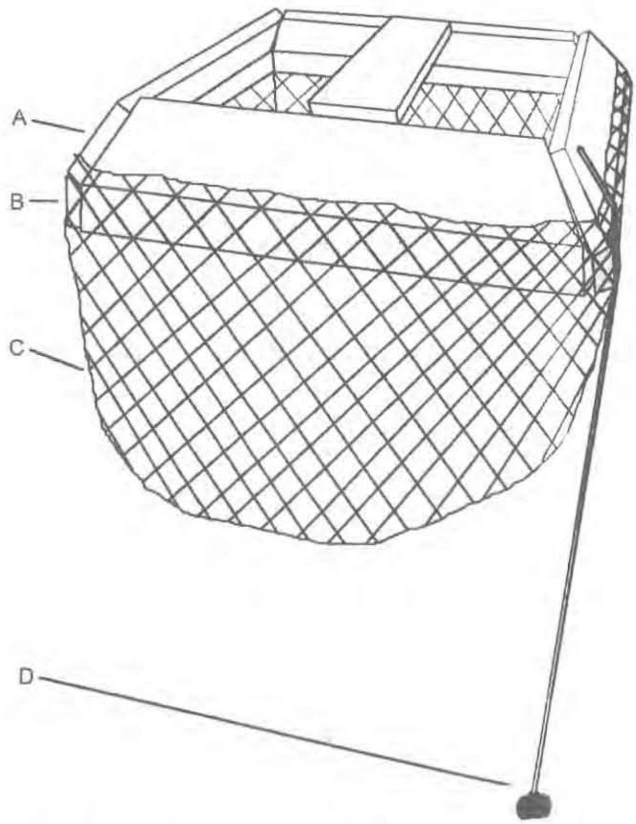


Fig. 3.34. Turtle basking-trap design. A = wood frame, B = foam floats, C = net basket, D = anchor. *From Gamble (2006).*

## Snakes

Dickert (2005) used modified eel **pot traps** with attached Styrofoam floats to capture giant garter snakes. Row and Blouin-Demers (2006*a*) surrounded snake hibernacula with a perimeter fence and funnel traps for successful snake capture. Mao et al. (2003) designed a new PVC funnel trap with an inverted-T shape and 2 entrances to capture semi-aquatic snakes. Use of live mice in snake traps after rodent suppression enhanced brown tree snake capture rates (Gragg et al. 2007). Keck (1994*a*) and Winne (2005) both increased aquatic-snake capture success using baited **funnel traps.** Willson et al. (2005) tested escape rates of aquatic snakes and salamanders from various commercially available minnow funnel traps. Plastic and steel minnow traps had the highest retention rates. They recommended plastic traps for sampling small snake species and steel traps for larger species of water-snakes. Camper (2005) warned about potential mortality problems while sampling semi-aquatic snakes in funnel traps due to imported fire ants. Burgdorf et al. (2005) perfected a successful trap design for capturing large terrestrial snakes that consisted of a 4-entrance funnel trap used with perpendicular drift fences and having hinged doors on top to facilitate retrieval of trapped snakes. They suggested frequent trap visits, ant control, and trap placement in shaded areas to curtail snake mortality.

### Alligators

Franklin and Hartdegen (1997) sprayed large reptiles in the face with a fine **mist of water** to safely capture American crocodile, American alligator, pythons, and iguanas. Elsey and Trosclair (2004) and Ryberg and Cathey (2004) used baited **box traps** effectively to capture alligators. Chabreck (1965) captured alligators using an airboat at night with a spotlight and a wire **snare** mounted on a stout pole.

### Miscellaneous Capture Methods

Lohoefener and Wolfe (1984) designed a **pipe trap** consisting of aluminum window screening, black PVC pipe, and 3 wooden disks. Pipe traps were used with drift fences and were more efficient for capturing salamanders, lizards, and snakes than were pitfall traps. Frogs and toads were more likely to be captured in pitfall traps. A **wire hook** with a blunt end was placed around the tails of lizards by Bedford et al. (1995) to extract the animals from tree and rock crevices. They grasped the lizard by its head with forceps as it emerged from the crevice. Bending the wire at a 90° angle made a handle, and a flashlight was used to help position the wire hook. Enge (1997) recommended silt fencing over aluminum or galvanized drift fencing as inexpensive, easy to install, and durable.

## HANDLING CAPTURED ANIMALS

Clark et al. (1992) and Fowler (1995) are excellent sources of information on the restraint and handling of wild animals. Nonchemical handling and physical restraint of captured animals is inexpensive and usually causes lower mortality rates than does retraint involving chemicals (Peterson et al. 2003*b*).

### Birds

Cox and Afton (1998) advised that holding times of **waterfowl** be minimized when large numbers are captured with rocket nets. To minimize subsequent mortality, ducks should be released immediately after they are processed and their plumage is dry. Maechtle (1998) described the Aba (cloak) made from rectangular cotton cloth for restraining **raptors** and other large birds. Wing pockets were stitched, and a strip of elastic tape was sewn onto the back of the cloth to be wrapped around the bird's tarsi. The Aba allows measurements and blood samples to be taken with a minimum of handling. Blood sampling of birds from the brachial and jugular veins did not influence survival, movement, or reproduction (Colwell et al. 1988, Gratto-Trevor et al. 1991, Lanctot 1994). Lecomte et al. (2006) described a successful method of blood sampling of waterfowl embryos.

A 4-pronged pick-up tool was used by Richardson et al. (1998) to remove **red-cockaded woodpecker** nestlings >8 days old from tree cavities. The 4 prongs must be blunted by bending or covered with liquid rubber to avoid injury to the young woodpeckers. Hess et al. (2001) questioned the feasibility of the Richardson et al. (1998) technique because of a high injury rate to red-cockaded woodpecker nestlings.

Cardoza et al. (1995) suggested delaying attempts to capture **wild turkeys** that appear to be wet on arrival at a bait site if a soaking rain had recently occurred. If turkeys become wet from snow or rain during the capture process, they should be allowed to dry in transport boxes before handling to avoid excessive defeathering. Peterson et al. (2003*a*) developed a modification of the Rio Grande wild-turkey funnel trap to reduce injuries to the birds.

Patterson et al. (1993) facilitated handling of **mourning dove** by designing a modified restraining device similar to one described by DeMaso and Peoples (1993) for **northern bobwhite.** Time of handling and stress and struggling of the captured doves was minimized while leg bands and radio-transmitters were attached.

Ralph (2005) described a body grasp technique that speedily and safely allows removal of birds from **mist nets.** His method allowed an average removal time of 10 seconds per bird. Ponjoan et al. (2008) recommended that handling and restraint of **little bustards** after capture should not exceed 20 minutes to curtail capture myopathy. Abbott et al. (2005) minimized northern bobwhite muscular damage after capture and handling and increased survival by injecting vitamin E and selenium. Rogers et al. (2004) successfully treated cannon-net captured shorebirds in Australia with **capture myopathy** by suspension in a sling.

### Mammals

Swann et al. (1997) reviewed the effects of orbital sinus **sampling of blood** on the survival of small mammals and found the results to be variable. White-throated woodrat and deer mouse survival estimates were not adversely affected, but desert pocket mouse and prairie vole survival rates were lower. Douglass et al. (2000) found no difference in handling mortality of 7 species of nonanesthetized wild rodents that were bled versus similar species of rodents that were not bled. They concluded that bleeding in the absence of anesthesia did not affect immediate mortality or subsequent recapture. Parmenter et al. (1998) verified that handling and bleeding procedures for hantavirus had no adverse effect on survival and trap rates of murid rodents (including deer mouse, woodrats, and prairie vole) and cottontail rabbit.

Mills et al. (1995) provided guidelines for personal safety while trapping, handling, and releasing rodents that might be infected with **hantavirus.** Special consideration is essential to provide respiratory protection from aerosolized virus. The use of protective gloves and clothing and suitable disinfectant also is necessary.

Yahner and Mahan (1992) used a polyvinyl Centrap™ cage as a restraining device for **red squirrel.** They used a mesh bag with a cone to minimize mortality from handling shock. Koprowski (2002) safely handled >3,500 squirrels of 7 species with a mortality of 0.01% using a cloth cone and without using an anesthesia, as suggested by Arenz (1997). McCleery et al. (2007*a*) developed an improved method for handling squirrels and similar-sized mammals.

Frost and Krohn (1994) described the care and handling of **fisher.** Serfass et al. (1996) successfully transported immobilized northern **river otters** in a well-ventilated tube made from 1-m sections of 40-cm-diameter PVC pipe.

Beringer et al. (1996) evaluated the influence of 2 capture methods, rocket nets and Clover traps, on **capture myopathy** in **white-tailed deer.** All deer mortality attributable to capture myopathy was associated with rocket net captures. Mortality attributable to capture myopathy can be reduced by using Clover traps instead of rocket nets when possible. If rocket nets are used, they suggested that capture be limited to ≤3 deer per capture. They advised that handling time be minimized to reduce stress on the animals. Peterson et al. (2003*b*) found that use of drugs after physical capture of white-tailed deer led to greater mortality than if drugs had not been used.

Byers (1997) described proper precautions for handing young **pronghorn,** including avoidance of handling 6 hours after birth or when coyotes or golden eagles were in sight or known to be within 1 km. Handling time should be brief and avoided during crepuscular hours, when coyotes are active. Byers (1997) concluded that methods he described did not increase mortality risk.

Thompson et al. (2001) concluded that direct release of **mountain sheep** from vehicles was advisable rather than transporting them via helicopter to holding pens. Expenses were less, survival was lower for the sheep kept in holding pens, and no difference was evident in dispersal and group cohesion.

DelGiudice et al. (2005) reviewed major factors influencing margins of safe capture and handling of **white-tailed deer** primarily captured in Clover traps. They stressed the need, when live-trapping, to provide adequate food, insulation, and avoidance of temperature extremes. Powell (2005) studied the blood chemistry effects on black bear captured in Aldrich foot snares and handled in dens. Both met the accepted standards for trap injuries. Forman and Williamson (2005) developed a safe handling device for **small carnivores** captured in a metal box live-trap using a plasterers' float and net bag. Freeman and Lemen (2009) tested various types of leather and recommended deerskin gloves to safely handle various **bat species** while maintaining dexterity. Beasley and Rhodes (2007) evaluated the effects of raccoon tooth removal to determine age and failed to detect any difference in recapture rates between the treated and untreated groups. MacNamara and Blue (2007) designed a portable holding corral system and **TAMER** that allowed physical and safe restraint of wild antelope and goats without the use of immobilizing drugs. The TAMER was constructed with a drop floor and attached electronic weight scale.

## Amphibians

Christy (1998) used **elastic straps** and damp gauze attached to a wood base to restrain captured frogs. Rose et al. (2006) restrained captured lizards for measurements in a tray with Velcro strips attached to it. Bourque (2007) used a compression plate and pads to measure frogs without injury. McCallum et al. (2002) made a **frog box** to hold frogs by cutting a round hole in the lid of a Styrofoam ice chest. They then inserted a Styrofoam cup with the bottom removed into the hole, and a second intact cup was inserted inside the first cup to close the hole. The frog box allowed quick collection and secure containment of large numbers of anurans in the field.

## Reptiles

King and Duvall (1984) restrained venomous snakes safely in a clear **noose tube** for field and laboratory examination. Quinn and Jones (1974) first developed a snake squeeze box, consisting of a foam rubber pad and Plexiglas, to measure snakes. Hampton and Haertle (2009) modified the snake **squeeze box** described by Cross (2000) and Bergstrom and Larsen (2004) that uses Plexiglas to allow safe dorsal and ventral views. Birkhead et al. (2004) designed "cottonmouth condo," a unique venomous-snake transport device. Penner et al. (2008) followed monkeys habituated to humans in a West Africa forest to efficiently locate and safely capture highly dangerous, venomous rhinoceros vipers. When the monkeys encountered a snake, they gave loud alarm calls, thereby alerting the herpetologists to capture and insert the snake into a custom-made transparent Plexiglas tube with a lockable end. Rivas et al. (1995) described a safe method for handling large nonvenomous snakes, such as anacondas. They placed a **cotton sock** over the snake's head and then wrapped several layers of plastic electrician's tape around the sock. The tape could be removed to release the snake into cloth bags for transport or release. Gregory et al. (1989) developed a portable device made of aluminum tubing to safely restrain **rattlesnakes** in the field. Walczak (1991) safely handled **venomous snakes** by immersing them in a plastic trash barrel partially filled with water. He then placed a clear plastic tube over the snake's head and gently submerged the snake. After the snake entered the tube, its body and the tube end were then grasped firmly with one hand. This method increased handler safety and decreased trauma. Mauldin and Engeman (1999) restrained snakes by using a wire-mesh cable holder. Cross (2000) described a new design for a lightweight squeeze box to allow safe handling of venomous snakes. His squeeze box was made of Plexiglas with a foam rubber lining, sliding doors, and portholes at each end. The squeeze box allowed measurements with a minimum of direct handling of snakes.

Jones and Hayes-Odum (1994) used white PVC pipe with an inside diameter of 0.31 m cut in 3-m lengths to restrain and transport **crocodilians.** Holes of a diameter sufficient for a rope to move freely were drilled at 15-cm intervals in the PVC pipe. One rope was looped around the head and another in front of the hind legs. Pipe diameter and length were chosen to accommodate a variety of alligator sizes.

Tucker (1994) described an easy method to remove **snapping turtle** from Legler™ hoop traps. He grasped the turtle by the tail and the posterior edge of the carapace. The turtle was then upended with the head down. With the animal in a vertical position, it was pressed down over the substrate, forcing the turtle to retract its head. The turtle's hind limbs were held, and it was then removed from the trap. A PVC pipe (10.16 cm in diameter and approximately 60 cm in length) was placed over the heads of snapping turtles for restraining and safe handling by Quinn and Pappas (1997).

Hoefer et al. (2003) placed **ice-cooled** lizards in a petri dish on top of adhesive tape to take measurements. Kwok and Ivanyi (2008) safely extracted venom from helodermatid lizards by using a rubber squeeze bulb. Poulin and Ivanyi (2003) used a locking adjustable hemostat to safely handle **venomous lizards.**

## SUMMARY

Many new and innovative capture and handling methods, techniques, and equipment have been described in this chapter, with extensive literature citations for the reader interested in learning more. The coverage of amphibian and reptile capture and handling methods in this chapter is more detailed than was provided in previous editions of the *Wildlife Techniques Manual.* Humane capture and handling techniques continue to be of paramount importance. Tranquilizer trap devices show promise for minimizing injuries to nontarget captures, but unfortunately, they are restricted in their use and availability by the U.S. Food and Drug Administration and a similar agency in Canada. Although complex electronic and mechanized devices have recently been developed to expedite successful and efficient capture, simple variations of existing equipment (e.g., nets) and methods (e.g., the use of live and mounted decoys) continue to be widely described in the literature. The use of different net types and configurations (e.g., bow, cannon, drift, drop, mist, and rocket) continue to be the predominant technique for capturing birds. Mammals are captured primarily with snares and foothold, box, and cage traps. Wild animals may be captured for a variety of purposes, including subsistence, animal damage control, population management, disease control, enhancement of other species, economic benefits, and research. Regardless of the reasons for capture, it is imperative the most humane devices and techniques be used. Finally, all untested capture devices should be evaluated using standardized, scientifically sound protocols that include the documentation of capture-related injuries via whole body necropsies.

## APPENDIX 3.1. COMMON NAMES AND SCIENTIFIC NAMES OF ANIMALS MENTIONED IN THE TEXT AND TABLES

The authority for scientific names of North American amphibians, birds, mammals, and reptiles is Banks et al. (1987). The authority for scientific names for non–North American amphibians and reptiles is Sokolov (1988), for non–North American birds is Sibley and Monroe (1990), and for non–North American mammals is Grizimek (1990).

| Common name | Scientific name |
|---|---|
| **Amphibians and reptiles** | |
| Alligator, American | *Alligator mississippiensis* |
| Crocodile, American | *Crocodylus acutus* |
| Frog, gray tree | *Hyla versicolor* |
| Pacific tree | *Pseudacris regilla* |
| spring peepers | *Pseudacris crucifer* |
| tree | *Hyla* spp. |
| wood | *Rana sylvatica* |
| Hellbender | *Cryptobranchus alleganiensis* |
| Iguana | *Iguana* spp. |
| Lizard, Texas horned | *Phrynosoma cornutum* |
| whiptail | *Cnemidophorus* spp. |
| Salamander, blackbelly | *Desmognathus quadramaculatus* |
| blue-spotted | *Ambystoma laterale* |
| marbled | *Ambystoma opacum* |
| red-backed | *Plethodon cinereus* |
| Skink, sand | *Neoseps reynoldsi* |
| Snake, anaconda | *Eumcetes* spp. |
| brown tree | *Boiga irregularis* |
| giant garter | *Thamnophis gigas* |
| rattlesnake | *Crotalis* spp. |
| python | *Python* spp. |
| rhinoceros viper | *Bitis nasicornis* |
| Terrapin, diamondback | *Malaclemys terrapin* |
| Tortoise, Bolson | *Gopherus flavomarginatus* |
| desert | *Gopherus agassizii* |
| gopher | *Gopherus polyphemus* |

*continued*

| Common name | Scientific name |
|---|---|
| Turtle, black pond | *Geoclemys hamiltonii* |
| northern map | *Graptemys geographica* |
| snapping | *Chelydra serpentina* |
| spotted | *Clemmys guttata* |
| **Birds** | |
| Avocet, American | *Recurvirostra americana* |
| Blackbird, red-winged | *Agelaius phoeniceus* |
| yellow-headed | *Xanthocephalus xanthocephalus* |
| Bluebird | *Sialia* spp. |
| Bunting, painted | *Passerina ciris* |
| Bustard, houbara | *Chlamydotis undulate* |
| little | *Tetrax tetrax* |
| Buzzard, common | *Buteo buteo* |
| Caracara, crested | *Caracara cheriway* |
| Chicken, domestic | *Gallus gallus domesticus* |
| Coot, American | *Fulica Americana* |
| Cormorant, double-crested | *Phalacrocorax auritus* |
| Cowbird, brown-headed | *Molothrus ater* |
| Crane, sandhill | *Grus canadensis* |
| whooping | *Grus Americana* |
| Crow, American | *Corvus brachyrhynchos* |
| Dove, mourning | *Zenaida macroura* |
| ringed turtle | *Streptopelia risoria* |
| rock | *Columba livia* |
| white-winged | *Zenaida asiatica* |
| Duck, Barrow's goldeneye | *Bucephala albeola* |
| blue-winged teal | *Anas Discors* |
| canvasback | *Aythya valisineria)* |
| gadwall | *Anas strepera* |
| harlequin | *Histrionicus histrionicus* |
| lesser scaup | *Aythya affinis* |
| mallard | *Anas platyrhynchos* |
| northern pintail | *Anas acuta* |
| northern shoveler | *Anas clypeata)* |
| redhead | *Aythya americana* |
| wood | *Aix sponsa* |
| Eagle, African fish | *Haliaeetus vocifer* |
| bald | *Haliaeetus leucocephalus* |
| golden | *Aquila chrysaetos* |
| Philippine | *Pithecophaga jefferyi* |
| steppe | *Aquila nipalensis* |
| Eider, common | *Somateria mollissima* |
| Falcon, prairie | *Falco mexicanus* |
| Finch, house | *Carpodacus mexicanus* |
| Flycather, Acadian | *Empidonax virescens* |
| Goose, Canada | *Branta canadensis* |
| snow | *Chen caerulescens* |
| Grebe, eared | *Podiceps nigricollis* |
| pied-billed | *Podilymbus podiceps* |
| Grouse, blue | *Dendragapus obscures* |
| dusky | *Dendragapus obscurus* |
| greater sage- | *Centrocercus urophasianus* |
| ruffed | *Bonasa umbellus* |
| sharp-tailed | *Tympanuchus phasianellus* |
| spruce | *Falcipennis canadensis* |
| Gull, California | *Larus californicus* |
| ring-billed gull | *Larus delawarensis* |
| Harrier, northern | *Circus cyaneus* |
| Hawk, Cooper's | *Accipiter cooperii* |
| ferruginous | *Buteo regalis* |
| northern goshawk | *Accipiter gentilis* |
| red-shouldered | *Buteo lineatus* |
| red-tailed | *Buteo jamaicensis* |
| rough-legged | *Buteo lagopus* |
| sharp-shinned | *Accipiter striatus* |
| Swainson's | *Buteo swainsoni* |
| Heron, great blue | *Ardea herodias* |
| Honeyeater, regent | *Xanthomyza phrygia* |
| Ibis, white | *Eudocimus albus* |
| Jay, blue | *Cyanocitta cristata* |
| Kestrel, American | *Falco sparverius* |
| Kingfisher, belted | *Ceryle alcyon* |
| Kite, white-tailed | *Elanus leucurus* |
| Kittiwake, black-legged | *Rissa tridactyla* |
| Loon, common | *Gavia immer* |
| Magpie, American | *Pica hudsonia* |
| Merganser, hooded | *Lophodytes cucullatus* |
| Merlin | *Falco columbarius* |
| Murre, common | *Uria aalge* |
| Murrelet, marbled | *Brachyramphus marmoratus* |
| Xantus | *Synthliboramphus hypoleucus* |
| Nighthawk, common | *Chordeiles minor* |
| Nightjars | Family Caprimulgidae |
| Osprey | *Pandion haliaetus* |
| Owl, barn | *Tyto alba* |
| barred | *Strix varia* |
| burrowing | *Athene cunicularia* |
| eastern screech | *Megascops asio* |
| flammulated | *Otus flammeolus* |
| great horned | *Bubo virginianus* |
| northern saw-whet | *Aegolius acadicus* |
| pygmy | *Glaucidium brasilianum* |
| short-eared | *Asio flammeus* |
| spotted | *Strix occidentalis* |
| tawny | *Strix aluco* |
| tropical screech | *Megascops choliba* |
| western burrowing | *Athene cunicularia hypugea* |
| Oystercatcher, American | *Haematopus palliatus* |
| Parrot, orange-winged | *Amazona amazonica* |
| Partridge, chukar | *Alectoris chukar* |
| Pelican, American white | *Pelecanus erythrorhynchos* |
| Penquin, king | *Aptenodytes patagonicus* |

| Common name | Scientific name | Common name | Scientific name |
|---|---|---|---|
| Phalarope, Wilson's | *Phalaropus tricolor* | Wren, house | *Troglodytes aedon* |
| Pheasant, Kalij | *Lophura leucomelanos* | **Mammals** | |
| ring-necked | *Phasianus colchicus* | Armadillo, nine-banded | *Dasypus novemcinctus* |
| Pigeon, band-tailed | *Patagioenas fasciata* | Badger, American | *Taxidea taxus* |
| Plover, mountain | *Charadrius montanus* | Beaver, American | *Castor canadensis* |
| snowy | *Charadrius alexandrinus* | Bobcat | *Lynx rufus* |
| Prairie-chicken, Attwater's | *Tympanuchus cupido* | Bat, African free-tailed | *Tadarida fulminans* |
| *attwateri* | | Bear, black | *Ursus americanus* |
| greater | *Tympanuchus cupido* | brown | *Ursus arctos* |
| lesser | Tympanuchus *pallidicinctus* | grizzly | *Ursus arctos horribilis* |
| Ptarmigan, white-tailed | *Lagopus leucurus* | Capybara | *Hydrochoerus hydrochaeris* |
| willow | *Lagopus lagopus* | Caribou | *Rangifer tarandus* |
| Puffin | *Fratercula* spp. | Cat, feral | *Felis catus* |
| Purple martin | *Progne subis* | Chipmunk, eastern | *Tamias striatus* |
| Quail, Gambel's | *Callipepla gambelii* | Townsend's | *Tamias townsendii* |
| Montezuma | *Cyrtonyz montezumae* | Coyote | *Canis latrans* |
| northern bobwhite | *Colinus virginianus* | Culpeo | *Pseudalopex culpaeus* |
| scaled | *Callipepla squamata* | Deer, fallow | *Dama dama* |
| Rail, black | *Laterallus jamaicensis* | Himalayan musk | *Moschus moschiferus* |
| clapper | *Rallus longirostris* | Key | *Odocoileus virginianus* |
| king | *Rallus elegans)* | *clavium* | |
| sora | *Porzana carolina* | mule | *Odocoileus hemionus* |
| Virginia | *Rallus limicola* | white-tailed | *Odocoileus virginianus* |
| yellow | *Coturnicops noveboracensis* | Dog, domestic | *Canis familiaris* |
| Raven, Chihuahua | *Corvus cryptoleucus* | prairie | *Cynomys* spp. |
| Razorbill | *Alca torda* | Dugong | *Dugong dugon* |
| Rhea, greater | *Rhea americana* | Elk | *Cervus canadensis* |
| Robin, American | *Turdus migratorius* | Fisher | *Martes pennanti* |
| Scoters, surf | *Melanitta perspicillata* | Fox, Arctic | *Alopex lagopus* |
| Shrike, loggerhead | *Lanius ludovicianus* | Argentine gray | *Pseudalopex griseus* |
| Sparrow, Bachman's | *Aimophila aestivalis* | gray | *Urocyon cinereoargenteus* |
| chipping | *Spizella passerina* | kit | *Vulpes macrotis* |
| house | *Passer domesticus* | red | *Vulpes vulpes* |
| Starling, European | *Sturnus vulgaris* | swift | *Vulpes velox* |
| Stilt, black-necked | *Himantopus mexicanus* | Gopher, northern pocket | *Thomomys talpoides* |
| Swallows, bank | *Riparia riparia* | pocket | *Geomys breviceps* |
| barn | *Hirundo rustica* | Guanaco, South American | *Lama guanicoe* |
| cliff | *Petrochelidon pyrrhonota* | Hare, snowshoe | *Lepus americanus* |
| tree | *Tachycineta bicolor* | Hog, feral | *Sus scrofa* |
| Swan, trumpeter | *Cygnus buccinator* | Ibex, Spanish | *Capra pyrenaica* |
| tundra | *Cygnus columbianus* | Jaguar | *Panthera onca* |
| Swift, Vaux's | *Chaetura vauxi* | Leopard, snow | *Panthera uncia* |
| Tern, least | *Sterna antillarum* | Lion, African | *Panthera leo* |
| Turnstone, ruddy | *Arenaria interpres* | mountain | *Puma concolor* |
| Turkey, wild | *Meleagris gallopavo* | Lynx, Canada | *Lynx canadensis* |
| Warbler, prothonotary | *Prothonotaria citrea* | Marten, American | *Martes americana* |
| Woodcock, American | *Scolopax minor* | Mink | *Mustela vison* |
| Woodpecker, acorn | *Melanerpes erythrocephalus* | Mouse, cotton | *Peromyscus gossypinus* |
| pileated | *Drycopus pileatus* | desert pocket | *Chaetodipus penicillatus* |
| red-bellied | *Melanerpes carolinus* | deer | *Peromyscus maniculatus* |
| red-cockaded | *Picoides borealis* | hopping | *Notomys* spp. |

*continued*

| Common name | Scientific name | Common name | Scientific name |
|---|---|---|---|
| Mouse (*continued*) | | Reindeer, Svalbard | *Rangiver tarandus platyrhynchus* |
| house | *Mus musculus* | Seal, ringed | *Phoca hispida* |
| white-footed | *Peromyscus leucopus* | Sheep, mountain | *Ovis canadensis* |
| wood | *Apodemus sylvaticus* | Dall | *Ovis dalli* |
| yellow-necked | *Apodemus flavicollis* | Shrew, masked | *Sorex cinereus* |
| Moose | *Alces alces* | short-tailed | *Blarina brevicauda* |
| Mountain beaver | *Aplodontia rufa* | Skunk, striped | *Mephitis mephitis* |
| Muskrat | *Ondatra zibethicus* | Squirrel, Abert's | *Sciurus aberti* |
| Nutria | *Myocastor coypus* | California ground | *Spermophilus beecheyi* |
| Opossum, Australian brush-tailed | *Trichosurus vulpecula* | fox | *Sciurus niger* |
| Virginia | *Didelphis virginiana* | gray | *Sciurus carolinensis* |
| Oryx | *Oryx gazella* | ground | *Spermophilus* spp. |
| Otter, Eurasian | *Lontra lutra* | northern flying | *Glaucomys sabrinus* |
| northern river | *Lontra canadensis* | red | *Tamiasciurus hudsonicus* |
| Peccary, collared | *Tayassu tajacu* | Tiger, Amur (Siberian) | *Panthera tigris altaica* |
| Porcupine | *Erethizon dorsatum* | Vole, bank | *Clethrionomys glareolus* |
| Pronghorn | *Antilocapra americana* | prairie | *Microtus ochrogaster* |
| Rabbit, eastern cottontail | *Sylvilagus floridanus* | Weasel, long-tailed | *Mustela frenata* |
| European | *Oryctolagus cuniculus* | short-tailed | *Mustela erminea* |
| Jackrabbit | *Lepus* spp. | Wolf, gray | *Canis lupus* |
| Lower Keys marsh | *Sylvilagus palustris hefneri* | Wolverine | *Gulo gulo* |
| pygmy | *Brachylagus idahoensis* | Woodchuck | *Marmota monax* |
| Raccoon | *Procyon lotor* | Woodrat, bushy-tailed | *Neotoma cinerea* |
| Rat | *Rattus* spp. | dusky-footed | *Neotoma fuscipes* |
| cotton | *Sigmodon hispidus* | Key Largo | *Neotoma floridana smalli* |
| kangaroo | *Dipodomys* spp. | white-throated | *Neotoma albigula* |
| rice | *Oryzomys palustris* | | |

## APPENDIX 3.2. SOME MANUFACTURERS AND SUPPLIERS OF ANIMAL TRAPS, SNARES, AND RELATED EQUIPMENT

This information is provided for the convenience of readers and offers only a small sampling of the many manufacturers and suppliers of animal traps and related equipment. The authors, their agencies, and The Wildlife Society makes no claim to its accuracy or completeness and neither endorses nor recommends any particular style, brand, manufacturer, or supplier of traps and trapping materials.

Alaska Trap Company
380 Peger Rd.
Fairbanks, AK 99709-4869 USA
Telephone: 907-452-6047

Blue Valley Trap Supply
4174 W Dogwood Rd.
Pickrell, NE 68422 USA
Telephone: 402-673-5935

Butera Manufacturing Industries (BMI)
1068 E 134th St.
Cleveland, OH 44110-2248 USA
Telephone: 216-761-8800

CDR Trap Company
240 Muskingham St.
Freeport, OH 43973 USA
Telephone: 740-658- 4469

J. C. Conners
7522 Mt. Zion Cemetery Rd.
Newcomerstown, OH 43832 USA
Telephone: 740-498-6822

CTM Trapping Equipment
7171 S 1st St.
Hillsdale, IN 47854 USA
Telephone: 765-245-2837

Cumberland's Northwest Trappers Supply
P.O. Box 408
Owatonna, MN 55060 USA
Telephone: 507-451-7607

Duffer's Trap Company
P.O. Box 9
Bern, KS 66408 USA
Telephone: 785-336-3901

Duke Company
P.O. Box 555
West Point, MS 39773 USA
Telephone: 662-494-6767

The Egg Trap Company
P.O. Box 334
Butte, ND 58723 USA
Telephone: 701-626-7150

Fleming Outdoors
5480 Highway 94
Ramer, AL 36069 USA
Telephone: 800-624-4493

F&T Fur Harvester's Trading Post
10681 Bushey Rd.
Alpena, MI 49707 USA
Telephone: 989-727-8727

Funke Trap Tags & Supplies
2151 Eastman Ave.
State Center, IA 50247 USA
Telephone: 641-483-2597

Halford Hide & Leather Company
2011 39 Ave. NE
Calgary, AB T2E 6R7 Canada
Telephone: 403-283-9197

Hancock Trap Company
P.O. Box 268
Custer, SD 57730-0268 USA
Telephone: 605-673-4128

Kaatz Bros Lures
9986 Wacker Rd.
Savanna, IL 61074 USA
Telephone: 815-273-2344

Kania Industries
63 Centennial Rd.
Nanaimo, BC V9R 6N6 Canada
Telephone: 250-716-1685

Les Entreprises Bélisle
61, Rue Gaston-Dumoulin, Bureau 300
Blainville, QC J7C 6B4 Canada
Telephone: 450-433-4242

Les Pieges du Quebec (LPQ)
16125 Demers St.
Hyacinthe, QC J2T 3V4 Canada
Telephone: 450-774-4645

Margo Supplies
P.O. Box 5400
High River, AB T1V 1M5 Canada
Telephone: 403-652-1932

Minnesota Trapline Products
6699 156th Ave. NW
Pennock, MN 56279 USA
Telephone: 320-599-4176

Molnar Outdoor
9191 Leavitt Rd.
Elyria, OH 44035 USA
Telephone: 440-986-3366

Montgomery Fur Company
1539 West 3375 South
Ogden, UT 84401 USA
Telephone: 801-394-4686

National Live Trap Corporation
1416 E Mohawk Dr.
Tomahawk, WI 54487 USA
Telephone: 715-453-2249

Oneida Victor
P.O. Box 32398
Euclid, OH 44132 USA
Telephone: 216-761-9010

PDK Snares
8631 Hirst Rd.
Newark, OH 43055 USA
Telephone: 740-323-4541

Quad Performance Products
Rt. 1, Box 114
Bonnots Mill, MO 65016 USA
Telephone: 573-897-2097

Rally Hess Enterprises
13337 US Highway 169
Hill City, MN 55748 USA
Telephone: 218-697-8113

Rancher's Supply—The Livestock Protection Company
P.O. Box 725
Alpine, TX 79831 USA
Telephone: 432-837-3630

R-P Outdoors
505 Polk St., P.O. Box 1170
Mansfield, LA 71052 USA
Telephone: 800-762-2706

Thompson Snares
37637 Nutmeg St.
Anabel, MO 63431 USA
Telephone: 660-699-3782

Rocky Mountain Fur Company
14950 Highway 20/26
Caldwell, ID 83607 USA
Telephone: 208-459-6854

Rudy Traps—LOYS Trapping Supplies
577 Lauzon Ave.
St-Faustin, QC J0T 1J2 Canada
Telephone: 819-688-3387

Sleepy Creek Manufacturing
459 Duckwall Rd.
Berkeley Springs, WV 25411 USA
Telephone: 304-258-9175

The Snare Shop
330 Main, P.O. Box 70
Lidderdale, IA 51452 USA
Telephone: 712-822-5780

Sterling Fur & Tool Company
11268 Frick Rd.
Sterling, OH 44276 USA
Telephone: 330-939-3763

Sullivan's Supply Line
429 Upper Twin
Blue Creek, OH 45616 USA
Telephone: 740-858-4416

Tomahawk Live Trap Company
P.O. Box 323
Tomahawk, WI 54487 USA
Telephone: 800-272-8727

Wildlife Control Products
P.O. Box 115, 107 Packer Dr.
Roberts, WI 54023 USA
Telephone: 715-749-3857

Wildlife Control Supplies
P.O. Box 538
East Granby, CT 06026 USA
Telephone: 877-684-7262

Wildlife-Traps.com (Online) SuperStore
P.O. Box 1181
Geneva, FL 32732 USA
Telephone: 407-349-2525

Woodstream Corporation
69 N. Locust St.
Lititz, PA 17543 USA
Telephone: 800-800-1819