Capture Techniques

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INTRODUCTION

Many raptor studies, including those involving migration, dispersal, home range use, anatomy, and toxicant ingestion, require that birds be captured for examination, marking, or both. This chapter describes a variety of field-tested techniques for capturing birds of prey. Since the first edition of the Raptor Management Techniques Manual in 1987 (Giron Pendleton et al. 1987) almost no new, radically different raptor trap designs have been invented, but several have undergone design improvements and, importantly, several papers dealing with capture success and raptor trapping outside North America have been published.

As Joseph J. Hickey remarked in the foreword to *Birding with a Purpose* (Hamerstrom 1984:vii), raptor trappers are generally different from the rest of the populace: *"You've heard of wolf trappers, fox trappers, muskrat trappers, and the like. Raptor trappers are different. Officially, they want to band birds to learn about their weight and moult, their later movements, their longevity, and all that. Underneath, they are unabashed admirers of the wildness, magnificent strength, and awesome flight of creatures at the top of the animal pyramid. I wouldn't call them childlike; but they do have a youthful zest, and they will endure any hardship and go to any length to catch their birds."*

While passion and enthusiasm for raptor trapping are contributing factors, trapping success depends upon a number of other factors too. Some species such as Common Kestrel (*Falco tinnunculus*), Black-shouldered Kite (*Elanus caeruleus*), chanting-goshawks (*Melierax* spp.), and Red-shouldered Hawk (*Buteo lineatus*) are easy to capture, whereas others, including many eagles, kites, and condors, require more sophisticated techniques. Some raptors are more easily trapped on migration, whereas others are more easily trapped when nesting. The age of the bird also can be a factor. In general, juvenile raptors are easier to trap than adults, and hungry raptors always are more responsive to traps. Consistently successful trapping comes with experience. Successful trappers not only can trap birds on migration, but also can trap specific individuals during the nesting season, and almost always without injuring them in any way or causing nest failures.

Sometimes easy-to-catch raptors can be difficult to capture. WC noted that winged ants, emerging in droves after rains in Israel, were readily eaten by Steppe Buzzards (*B. buteo vulpinus*), which then completely ignored traps baited with mice and sparrows that had worked well at other times. On the other hand, hard-to-catch raptors often can be trapped when they are especially hungry.

Trapping success often shifts seasonally. For example, Swainson's Hawks (*B. swainsoni*) are relatively easy to trap when breeding in North America, but are difficult to trap during migration, when they are nomadic. On the other hand, Sharp-shinned Hawks (*Accipiter striatus*) are readily captured along well-established migration corridors while migrating but are more difficult to catch during the breeding season.

Knowing what trap to use, when to use it, and what kind of lure to place in it requires familiarity with the target species' ecology and behavior. For example, Merlins (*F. columbarius*) are easily captured with House Sparrows (*Passer domesticus*) as lures in a small dho-gaza trap, but Red-tailed Hawks (*B. jamaicensis*) are more often caught using the same lure in a bal-chatri. This is because Merlins are adapted to aerial pursuit of avian prey, whereas the Red-tailed Hawk is adapted to capturing mammalian prey on the ground. Fuller and Christenson (1976) and Hertog (1987) evaluated several different trap types and quantified the effectiveness of different trapping techniques.

Trapping success may be limited if raptors become "trap-shy." Trap-shyness may be a serious problem if one needs to recapture specific individuals to replace transmitters or to study seasonal weight change or molt, etc. We believe that raptors become trap-shy as a result of negative or unrewarding experiences. Things that affect trap shyness, including trap shape, location, lure used, and proximity to people, should be considered prior to any attempt to recapture a trap-shy bird.

In some situations where capturing many individuals of several species is required, a combination of several strategically placed mist nets, bal-chatris and verbails, etc., with motion detector transmitters, can be extremely productive. Such set-ups typically require two to five people.

Although being caught in a trap can stress a raptor, trapped birds rarely are injured physically. The most frequent causes of trap-related injury or death are predation and weather. Raptors may succumb to temperature extremes or predation if allowed to struggle in traps for long periods. Used properly, the traps discussed in this chapter should rarely result in severe injury or death.

While being handled, raptors may struggle, bite, grab, or vocalize depending upon the species and "personalities" of the birds involved. Buteos and many owls, for example, struggle very little while being handled, and rarely vocalize, whereas accipiters, particularly Northern Goshawks (*A. gentilis*), struggle and vocalize most of the time, and readily attack. Most raptors are capable of inflicting painful wounds with their beaks and talons, and large hawks and owls, eagles, and condors, can cause serious injury. In most species, particularly eagles, the talons are most dangerous. In general most species do not bite. Exceptions include vultures, California Condors (*Gymnogyps californianus*), fish eagles (*Haliaeetus* spp.), White-tailed Hawks (*B. albicaudatus*), and falcons.

Researchers capturing and handling raptors must have the proper permits, which vary among countries. In the U.S., these permits may include U.S. Geological Service bird-marking and salvage permits and endangered-species permits, as well as state permits. See Chapter 25 for details.

CAPTURE TECHNIQUES AND THEIR APPLICATION

The first bible for avian trapping techniques was a small booklet titled *Manual for Bird Banders* by Lincoln and Baldwin (1929). Of about 35 traps and capture techniques described therein, only one, the Number 1 leghold trap, was used for the capture of birds of prey. Stewart et al. (1945) provided one of the earliest comparisons of different raptor traps. Beebe (1964) focused on raptors trapped for use in falconry. McClure (1984) and Bub (1995) have written comprehensive overviews of most avian trapping techniques known worldwide. Today, raptor biologists have the option of using 20 different basic trap designs and numerous variations, as well as trap monitors, which allow many traps to be monitored from a distance.

Some countries prohibit the use of live lures in scientific research, and some researchers avoid live lures for personal reasons. Raptor researchers should ensure that the use of live lures is legal in the country they are trapping and should treat lures humanely and not subject them to undue harm and stress. In the U.S. many, if not all, universities have Animal Care and Use Committees that must approve research using live lures and in Canada at least, approval from an ethics sub-committee is now required (D. Bird, pers. obs.). *Guidelines to the Use of Wild Birds in Research*, a special publication of The Ornithological Council (Gaunt and Oring 1999), includes recommendations on wild-bird care in research.

Trap Monitors

The use of motion-detector transmitters and scanning receivers in raptor trapping has greatly advanced raptor trapping success and the ease with which traps are monitored. Any trap with moving parts, as well as traps that are moved when raptors strike them, can be monitored with these devices. This includes line trapping where as many as 20 bal-chatris, verbails, or Swedish goshawk traps, etc. are deployed over large areas (Bloom 1987). Trap monitors are available at Communications Specialists, Inc. (www.com-spec.com).

Prior to the use of trap monitors, each and every trap had to be under continuous visual surveillance or checked at least hourly. This often meant that some birds were caught and escaped in the interim between checks, and that traps sprung by birds that were not caught were rendered non-functional for the remainder of that hour. Trap monitors also can reduce mortality as the sprung trap is visited immediately after having being triggered.

Trap monitors work when a magnet attached to the transmitter is moved when the trap is sprung, initiating a signal that is detected by the receiver. Depending upon the terrain, traps can be monitored continually from a distance of 2–3 km or more. Two of us (PHB, JFK) that have used trap monitors since 1988 have found them useful in oak woodlands and grasslands of California when trapping resident Red-shouldered Hawks, Cooper's Hawks (*A. cooperii*), Barn Owls (*Tyto alba*); in agricultural areas in Argentina when trapping wintering flocks of Swainson's Hawks; and in tropical forests in India when trapping Crested Serpent Eagles (*Spilornis cheela*) and Crested Goshawks (*A. trivirgatus*). In India, despite not having seen Crested Goshawks for almost a month, we caught six birds in two days after line trapping with trap monitors.

Audio Lures

The use of tape-recorded playbacks of vocalizations can be used to bring raptors closer to field workers for identification and surveying. Playbacks also can be used to attract owls to mist nets. This approach is now used to capture migrating Northern Saw-whet Owls (*Aegolius acadicus*) and Flammulated Owls (*Otus flammeolus*) at most migration banding stations where owls are trapped (e.g., Erdman and Brinker 1997, Evans 1997, Whalen and Watts 1999, Delong 2003).

Playbacks also have been used with excellent success during the breeding season to trap Barn Owls, Western Screech Owls (*Megascops kennicottii*), Long-eared Owls (*Asio otus*), Spotted Owls (*Strix occidentalis*), Great Horned Owls (*Bubo virginianus*), Red-shouldered Hawks, Northern Goshawks, Cooper's Hawks (PHB, JWK) and other species by drawing the birds into mist nets or other traps in the playback area. It is important to limit playback use during the breeding season as adult behavior and nest success may be influenced by excessive use of this technique.

The Bal-chatri

Because this trap is one of the most successful devices used to date to catch raptors, considerable attention will be paid to it. The bal-chatri, which roughly translates to "noosed umbrella" (Clark 1992), is a wire cage with monofilament nooses tied to the top, sides, or both, with a lure animal placed inside (Fig. 1; Berger and Mueller 1959). The size and shape of the trap depend upon the species being trapped. Typical lures include the house mouse (*Mus musculus*), black rat (*Rattus rattus*), gerbil (*Gerbillus* spp.), House Sparrow, Common Starling (*Sturnus vulgaris*), and Common Pigeon (*Columba livia*). In countries or remote areas where standard such lures are not available, Red Junglefowl (domestic chickens, *Gallus gallus*) or ducks (*Anas* spp.) can be used. Several designs are in widespread use, including (1) quonset (Berger and Hamerstrom 1962, Ward and Martin 1968, Mersereau 1975), (2) cone (Kirsher 1958, Mersereau 1975), (3) octagonal (Erickson and Hoppe 1979), and (4) box with apron (Clark 1967). One modification involves the use of a Plexiglass top for trapping screech owls (Smith and Walsh 1981).

As with many traps involving live lures, trappers should consider the placement of the trap carefully, as traps may be stepped on by farm animals, run over by cars, or moved by people. In some instances ants can kill the lure.

Construction. Mesh and cage size are determined by the species to be captured, and size of the bait animal. The cage must be large enough for the bait animals to move (run or fly) within it, so that the raptor can detect them. The more space the bait animal has to move about, the more likely the raptor is to notice it quickly.

For American Kestrels (*F. sparverius*) we recommend 0.6-cm hardware cloth rather than 1.3-cm cloth, as small- to moderately-sized house mice can escape through or become caught in the large mesh. For most other species up to the size of eagles 1.3-cm hardware

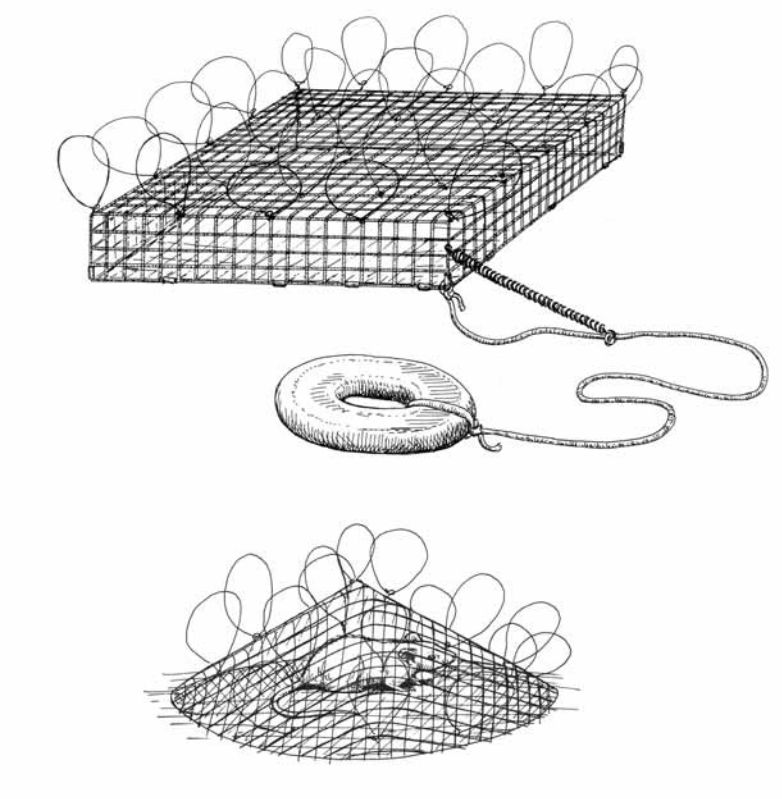

Figure 1. Bal-chatris can be made in a variety of shapes. The box-shaped bal-chatri works well on accipiters, buteos, and owls, whereas the cone-shaped trap works best on kestrels and Burrowing Owls (*Athene cunicularia*).

cloth is best. When using quonset-shaped bal-chatris on large accipiters, buteos, large owls, and Harris's Hawks (*Parabuteo unicinctus*), either 1.3-cm aviary cloth or 2.5-cm chicken wire can be used, especially if the intent is to use a relatively large lure animal (e.g., Common Pigeon). Larger mesh makes the lure animal more visible, particularly at great distances. In addition, the aviary cloth and chicken wire mesh are more flexible and more easily manipulated than hardware cloth, and are easier to work with. On the other hand, aviary- and chicken-wire traps are more easily dented or crushed than are hardware-cloth traps, and nooses cannot be attached as firmly to aviary cloth and chicken mesh as to hardware cloth. Plastic (modeling) cement applied to the area of attachment can alleviate much of this problem.

A single section of hardware cloth or several sections in which the sides, bottom, and top are fastened together can be used to construct the cage. The different flaps or sections of the cage are most efficiently fastened with ring clips (Wiseman 1979) or with wire. The door for the lure animal should be on the bottom of the trap where it will not interfere with nooses.

Camouflaging traps is important. Traps should be spray-painted before the nooses are attached. Good background colors are light green (live vegetation), tan (dead vegetation) and white (snow). Flat colors are preferable to glossy.

A 15- to 25-cm apron of hardware cloth with nooses extending out from the cage increases the potential of capturing individuals that are shy of standing on the cage. This is particularly important for the capture of Burrowing Owls (*Athene cunicularia*).

Some house mice used as lures will pull the nooses inside the bal-chatri, and will gnaw on them or, sometimes, hang themselves. A mouse with a taste for monofilament can ruin hours of work and should be replaced. Placing short lengths of monofilament in the cage sometimes reduces chewing on nooses.

Several knot-tying techniques have been described. Jenkins (1979) found that a running slipknot, which remains closed on the bird's foot or toe once it has tightened, increased trapping success. Unfortunately, the use of such "one-time" knots as part of the noose (the knot also can be used to anchor the noose to the cage) means that all nooses that are closed accidentally must be replaced or retied. We use the traditional technique of an overhand knot for the noose (Collister 1967) and a square knot for the anchor point. This employs simpler knots that can be tied quickly. Unfortunately it may allow more birds to escape than use of the running slipknot. *The North American Bird Banding Manual* illustrates another variation in which an overhand knot is used for the noose but a clinch knot is used at the anchor point (Environment Canada and U.S. Fish and Wildlife Service 1977).

We agree with Jenkins (1979) that the best way to attach nooses to the wire mesh is diagonally across the junction of two wires. Vertical nooses are critical to trapping success. Most nooses can be made to stand vertically by several firm upward tugs on a thick pen tightened in the noose. The knot at the junction of the two wires should be rotated until the noose is in the most vertical position. Plastic cement also may be used to help maintain the erect posture of the noose. When using cement, be certain that it does not weaken the monofilament. See Figure 1 in Berger and Mueller (1959) for tips on attaching nooses so that they stand erect.

The height and spacing of nooses also is important. For small raptors, we make nooses 4-cm tall, spaced at 3 cm. For medium to large raptors we make nooses 5–6.5-cm tall, spaced at 5 cm. Adjacent rows of nooses

are staggered. When the trap is complete, we examine it for spaces and add more nooses as needed. Nooses become brittle with age, particularly when traps are rolled in dust or mud or are exposed to long hours in the sun. Depending upon the amount of use that a trap sustains, we replace all nooses one to five times annually.

Bal-chatris are relatively light traps that must be weighted to prevent birds from taking off with them. For traps under constant surveillance we recommend either a 0.7- or 1-kg barbell weight attached to the trap via a 1-m length of nylon cord. Many researchers attach the weight directly to the floor or sides of the bal-chatri, rather than by a nylon cord with a "shock-absorbing" spring. A problem with the first approach is that there is no opportunity to place a spring between the trap and weight and, as a result, both the weight and noose attachments break more readily. Also, we believe that weights attached to the trap make the trap more conspicuous than a weight on a 1-m line, and that this reduces the likelihood of birds striking the trap. Lighter weights can be dragged short distances by the bird, but are less stressful on the nooses and on the bird's toes than are heavier, stationary weights. The only drawback with having the weight separately rather than directly attached to the trap is that the vehicle must be going slower for the drop. When traps are checked hourly, we recommend either tying the trap to a stationary object or using a heavy weight so that the trap is less likely to be dragged off. A spring or other "shock absorber" must be used in situations where the trap is tied to a stationary object. The shock absorber has two functions. First, it reduces the stress on the nooses, which may snap if tugged sufficiently, and second, it reduces the risk to raptors, which may hemorrhage and die if allowed to struggle against a stationary object for more than 10 minutes (pers. obs.). Barn Owls in particular are prone to the latter. The spring should be securely attached on a nylon cord between the trap and the weight to prevent the bird from escaping with a bal-chatri.

Application. The bal-chatri is an extremely effective, versatile, and portable trap. It can be used during all seasons, and has a success rate of up to 85% for most species that are attracted to it. Most North American raptor species have been captured on bal-chatris. In Guatemala, Thorstrom (1996) captured 12 species, including hawks, hawk-eagles, falcons, and owls, with this technique, some of them in trees. In India, Kenya, South Africa, and Israel, PHB, WSC, or both, have used bal-chatris to catch a wide variety of species of kites, accipiters, buzzards, harriers, small to large eagles, falcons and owls. One of the more difficult species to catch with bal-chatris is the Black Kite (*Milvus migrans*).

There are two principal applications. The first is road trapping, in which traps are placed on the roadside from a vehicle in the immediate vicinity of perched raptors. The second is line trapping, in which 10–15 bal-chatris are placed out before the target bird(s) arrive in known use areas. Line trapping is particularly effective on owls and woodland raptors. In both procedures, traps usually are placed to capture perched raptors. Flying accipiters are the occasional exceptions. Road trapping is best attempted from roads with minimal vehicle use, as cars and trucks tend to frighten the birds. That said, it is indeed possible to catch birds along busy highways. Trapping involves driving on country roads while scanning for raptors perched near roads, often on power poles or utility lines. Once a raptor is identified, a weighted bal-chatri is placed on the shoulder of the road. Time spent dropping the trap from the vehicle should be minimal; on the other hand, merely throwing the bal-chatri from a moving vehicle is construed by some as cruel to the lure prey inside. To improve trapping success and avoid injury to the bird and the lure prey: (1) the vehicle should not be stopped when dropping the trap, as this frequently frightens the bird, (2) the door of the vehicle should be closed quietly, (3) the weight and trap should be placed as far from the edge of the road as possible to ensure that the captured hawk or owl does not drag the trap onto the road, and (4) the trap should be placed from the side of the vehicle away from the perched bird, and on roadside opposite to it such that the bird cannot see the trap being set. If it is necessary to stop, do not step out of the vehicle. In all trapping it is best to disassociate yourself from the trap as much as possible. In most instances this can be achieved by not letting the bird see you with the trap. Many birds appear initially suspicious of the "gift-wrapped" food and will not come down to the trap, and will hesitate for a long time and, eventually, leave the area, even when these procedures are followed. Sometimes, birds repeatedly fly down to traps but do not touch it or do not become entangled, and eventually lose interest. Placing a second trap in a new site frequently results in renewed interest and success.

Line trapping differs from road trapping in that 10–15 bal-chatris are placed (1) in a specific territory in an effort to catch a targeted bird or pair of birds or (2) in appropriate habitat across several square kilometers to trap as many birds as possible. As with road trapping,

traps should not be placed directly in sight of a bird, but instead near known or suspected hunting and resting perches (e.g., perches near nests where the male or female may spend time while not on the nest). The entire trap line is checked hourly or is monitored via trap monitors. As traps are checked and birds removed, they are reset (i.e., closed nooses are reopened), and captured birds are retained until the entire series of traps is checked.

Line trapping has three advantages over road trapping, including (1) high trapping rates, (2) more appropriate habitat selection for trap placement, and (3) more effective trapping of troublesome or trap-shy individuals through placement of several camouflaged traps. Three disadvantages are that (1) predators occasionally kill birds caught on the trap, (2) birds have more time to free themselves compared with road trapping, and (3) trapping is not as selective in that individuals of nontarget species may be caught. The first two disadvantages above can be reduced by using trap monitors that signal the trapper immediately when the trap has been moved or sprung.

When line trapping, there is time to conceal the bal-chatris and tack them to the ground to prevent flipping. Trappers should push surrounding leaves or grass around the trap and place leaves or grass between the nooses on the top, making sure that nothing becomes entangled in the nooses. If you use enough grass or leaves to make the traps difficult to re-locate, the hawk or owl will find them for you. If a bird is trap-shy of bal-chatris, use two to three traps at each perch.

Proper lure animals are important. Pigeons, starlings, and House Sparrows are best for attracting accipiters. Occasionally a house mouse or gerbil can be used. Most falcons do not respond to lures in bal-chatris. One exception is the American Kestrel, which is easily caught on bal-chatris baited with either house mice or House Sparrows. Prairie Falcons (*F. mexicanus*) and Aplomado Falcons (*F. femoralis*) are easily caught on bal-chatris baited with house mice, gerbils, and House Sparrows or combinations thereof. Peregrine Falcons (*F. peregrinus*) and Gyrfalcons (*F. rusticolus*) (B. Anderson, pers. comm.) are rarely if ever caught on bal-chatris.

In our opinion, the best bait animals for capturing buteos are paired combinations of domestic house mice and gerbils, house mice and House Sparrows, or wild and domestic mice. B. Millsap (pers. comm.) has had excellent success trapping Cooper's Hawks using a gerbil-House Sparrow combination. Common Pigeons can be used to lure Cooper's Hawks, Northern Goshawks, Harris's Hawks, and large buteos. Most wild rodents, including *Microtus*, *Peromyscus*, and *Neotoma* spp., are poor attractants because they tend to remain motionless. Northern Harriers (*Circus cyaneus*) and White-tailed Kites (*E. leucurus*) have been caught on bal-chatris with house mice, gerbils and House Sparrows. Medium to large owls are most easily caught on house mice and gerbils. Great Horned Owls can be lured with Common Pigeons. Although Strigidae, which seem to hunt much more by sight than by sound to Tytonidae, readily attack animals in bal-chatris with or without dry leaves in the trap, the latter rarely strike a bal-chatri unless they can hear the sound of the lure animal rustling the leaves.

Although pigeons, starlings, House Sparrows, gerbils, and house mice are the "standard" lures, other species can be used in emergencies (e.g., chipmunks, squirrels, and rabbits). Most native vertebrates are protected by various state and federal laws however, and must not be used without appropriate permits.

The Bartos Trap

A relatively new kind of raptor trap, which blends the concepts of the bow net and the box trap, is the Bartos trap (Bartos et al. 1989). Although this trap has not been used widely to date, it has been used to capture Collared Sparrowhawks (*A. cirrhocephalus*) and Moreporks (*Ninox novaeseelandiae*) in Australia. The trap, which shows considerable potential for capturing small to medium-sized forest raptors lured with small birds, can be suspended at almost any height, in a building, or in a tree near a nest, and does not require attendance, is collapsible for easy transport.

Bow Nets

Several variations of this trap have been used to trap many species, including owls, eagles, falcons, harriers, buteos, and accipiters. The trap consists of two semicircular bows of light metal with gill netting strung loosely between them (Fig. 2). Hinges and springs connect the two semicircles at their bases, the lower one of which is fixed to the ground. When setting the trap, the upper bow is pulled over the lower stationary bow and latched into position. A lure animal, usually a bird, is placed in the center of radius of the trap. When a raptor grabs and holds the lure bird, the trap is triggered, either by a person in a blind pulling a trigger line (Meredith 1943, Mattox and Graham 1968, Clark 1970, Field

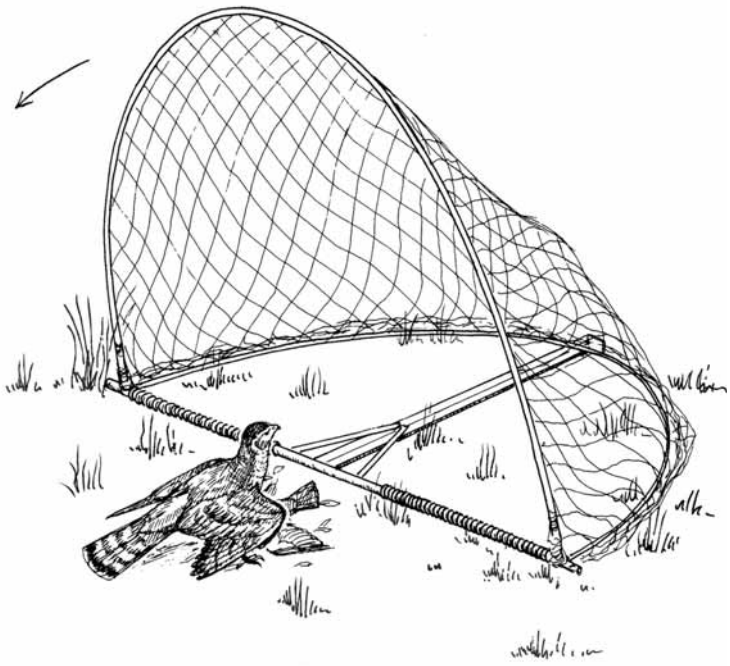

Figure 2. Bow nets may be triggered automatically by the raptor itself, or manually from a blind. The above design is triggered manually and uses garage-door springs to power the bow.

1970), by remote control (Meng 1963, Jackman et al. 1994), or by the action of the attacking raptor itself (Tordoff 1954). Bow nets are sometimes superior to bal-chatris because a tethered lure mouse walking about with only a single trigger wire above it appears less intimidating to a raptor than an animal in a cage.

Application. One of the better automatic bow nets is that of Tordoff (1954). The trap, originally designed for small raptors, can be modified for larger species as well. It is easily concealed and has been used successfully on American Kestrels, screech owls, Great Horned Owls, and Long-eared Owls. Kenward and Marcstrom (1983) describe an automatic bow net for use on Northern Goshawks that uses the partially eaten carcass of a raptor kill or a stuffed bird as bait. This trap is usually quite useful unless disturbed by corvids or rendered immobile by ice.

Clark (1970, 1976) describes a typical manually operated bow net that has seen considerable use at a banding station in Cape May, New Jersey, U.S.A., where three bow nets are managed simultaneously. One attribute of the manually operated bow net is its selectivity. In North America, manual bow nets have been used to capture a variety of eagles, accipiters, buteos, and falcons, as well as Burrowing Owls.

According to Clark (1970), the trapper is stationed in a blind. A pigeon is harnessed in a leather jacket with two lines attached, one of which comes to the blind after going through a bow trap and the other returns to the blind after passing through two guides located at the top and bottom of the lure pole. The two lines are joined at the blind, which allows the trapper to "fly" the pigeon when a hawk is seen in the air, simply by pulling on the first lure line. The fluttering pigeon thus appears to be "injured" and easy prey to the hawk.

If the hawk decides to attack or "stoop" on the pigeon, it is brought back to the center of the bow trap by pulling on the second lure line. Should the hawk continue his stoop and bind to the pigeon, it is captured by triggering the bow trap from the blind.

Another type of bow net useful for capturing large raptors, including eagles (Clark 1970, Field 1970), is a radio-controlled device powered by garage-door springs (Jackman et al. 1994). This type of spring is easily obtained, extremely powerful, and can be adjusted to control speed. Strong springs that will move the bow rapidly are particularly important when trapping eagles because the bow is necessarily large, is concealed by earth and vegetation, and, as a result, is relatively heavy. Proper training in the use of bow nets is mandatory since a bow set off prematurely can strike the bird and cause serious injury or death. Nevertheless, 16 of 19 Bald Eagles (*Haliaeetus leucocephalus*) and 26 of 30 Golden Eagles (*Aquila chrysaetos*) were successfully captured without injury using remote-controlled bownets (Jackman et al. 1994) (Fig. 2). A more recent improved collapsible version of this design has been used to capture hundreds of Bald Eagles and Golden Eagles in California and Arizona (Jackman et al., pers. comm.).

Finally, Q-nets, which are large bow nets that are powered by large bungee cords, have been used to capture carrion-feeding raptors including Southern Crested Caracaras (*Caracara plancus*) (Morrison and McGhee 1996).

Box Traps

Box traps are compartment traps that contain a lower bait cage and an upper section that captures and holds the raptor (Fig. 3). The Swedish goshawk trap originally described by Meredith (1953) has since been improved and made more portable (Meng 1971). The trap's effectiveness in trapping Northern Goshawks is described and compared with similar compartment traps by Karblom (1981) and Kenward and Marcstrom (1983). The Chardoneret trap, which uses a live owl to

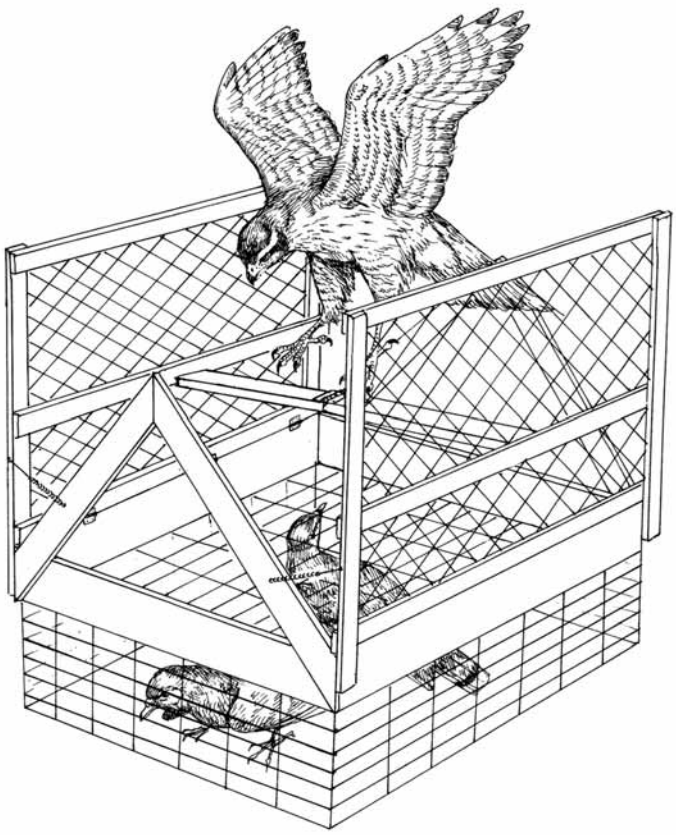

Figure 3. A Northern Goshawk (*Accipiter gentilis*) lands on the trigger stick of a Swedish goshawk trap containing Common Pigeons (*Columba livia*) as bait.

lure raptors during the breeding season (Redpath and Wyllie 1994), is another successful box trap, and Kenward and Marcstrom (1983) provide detailed descriptions of similar compartment traps that may be more useful than the Swedish goshawk in trapping in certain situations.

Application. Meng (1971) provides an excellent description of the materials used in the construction of the Swedish goshawk trap. The Swedish goshawk trap has been used to capture most large hawks (and Great Horned Owls) in North America, as well as Great Black Hawks (*Buteogallus urubitinga*) and Ornate Hawk-Eagles (*Spizaetus ornatus*) in Guatemala (Thorstrom 1996). This trap is particularly useful for falcons because they tend to walk around the trap and do not enter the compartment from above (Meredith 1943). Lure animals typically include Common Pigeons or Common Starlings. Two or more lures should be placed in each trap to increase their movement and visibility, and the trap should be placed in a highly visible location. Although trapping with this method is relatively slow, most birds that enter the trap are caught and do not escape. The best attribute of the trap is that it only needs to be checked every three hours or so and can be monitored using trap monitors.

Trapping during the nesting season involves the placement of two or three traps between 50 and 200 m from the nest. Trapping during migration entails the placement of 5 to 10 traps spaced 0.5 to 1.0 km apart along pole or fence lines in valleys where birds perch to hunt or, less desirably, on ridges where many birds are moving.

One of us (WC) used from 5 to 10 box traps to capture migrating raptors on return migration in Eilat, Israel. In one season, 45 of 653 captured raptors were caught in them, including 41 Steppe Buzzards, 2 Eurasian Sparrowhawks (*A. nisus*), a Levant Sparrowhawk (*A. brevipes*), and a Black Kite. The next season, using fewer traps, 10 of 445 raptors were caught, including 7 Steppe Buzzards, 2 Levant Sparrowhawks, and a Eurasian Sparrowhawk. The traps were baited with domestic house mice, House Sparrows, or both.

Cannon and Rocket Nets

Cannon and rocket nets are used to capture vultures, eagles, and condors. They are similar, relatively expensive traps, but are very effective and can be used to capture many individuals at a single firing. The technique consists of three to four cannons or rockets that propel a large net over the birds (Mundy and Choate 1973). Animal carcasses are used as bait.

Application. Because they involve explosives, cannon and rocket nets are more dangerous than other traps. The cannon net is less dangerous than the rocket net, and we limit our discussion to it, although much of what follows also applies to rocket nets. Because of the difficulties involved in building this trap, we recommend purchasing it from a manufacturer (e.g., Wildlife Materials Inc., www.wild lifematerials.com). One of the safest and simplest designs is described in Mundy and Choate (1973) (J. Ogden and N. Snyder, pers. comm.). Other designs are in Dill and Thornsberry (1950), Grieb and Sheldon (1956), Marquardt (1960a,b), Thompson and DeLong (1967), and Arnold and Coon (1972). Nets and mesh vary in size depending upon the target species. A 15.2 × 15.2-m net of 10.2 × 20.3-cm mesh is good for trapping eagles. Smaller mesh causes the net to remain airborne too long, allowing birds to escape. Because 10.2 × 20.3-cm mesh is not standard, it must be created by cutting the 10.2 × 10.2-cm mesh to create larger holes. Permits, which must be acquired before

detonators (blasting caps) can be purchased, should be applied for one year in advance of the proposed trapping effort.

Cannon nets have been used to capture many species including waterfowl, seabirds, shorebirds, passerines, cranes, and grouse (Dill and Thornsberry 1950, Thompson and DeLong 1967, Arnold and Coon 1972). More recently, raptors, including Black Vultures (*Coragyps atratus*) and Turkey Vultures (*Cathartes aura*), Andean Condors (*Vultur gryphus*), California Condors, Bald Eagles, White-bellied Sea Eagles (*H. leucogaster*) (Hertog 1987) and Golden Eagles have been captured using these traps. The cannon net is one of the best traps available for gregarious species where several individuals accumulate simultaneously. Cannon nets also allow the trapper to capture birds selectively. Non-target species pose little problem when trapping with this method because non-target species feeding at them often attract target species.

To achieve maximum success with eagles, vultures, and condors, lure carcasses should be staked down to render them immoveable. Ideally, the site should be baited at least one week prior to capture attempts, and should be baited continually until the project is finished. Where large nocturnal scavengers such as bears or wild dogs are present, the carcass may need to be removed at the end of each day or be replenished more frequently. Observations should be made from a nearby blind or from about 0.8 km away. Typical bait animals include virtually any medium to large carcass. Fresh rather than rotten carcasses seem to be more attractive to raptors. Stillborn calves are frequently available from dairies.

Between 1982 and 1987, 10 California Condors were captured with cannon nets using the carcasses of stillborn calves as bait (PHB, unpubl. data). Most condors were recaptured using the cannon net at both the same and different locations. During the same period, 43 Golden Eagles were captured, four of which were recaptured. The trap was 100% effective in that none of the targeted condors or eagles escaped capture. On several occasions two to four Golden Eagles were captured with one firing, and Golden Eagles and condors were captured together in the same firing. No injuries or mortalities occurred to either species. In Israel, trappers caught 35 Black Kites with one firing of a cannon net. In Israel, an air-powered cannon net captured European Honey Buzzards (*Pernis apivorus*) when they came to drink at a small pond (WC).

Although selective and efficient, cannon nets are labor-intensive. Initial installation and site preparation requires about four hours. Each firing or preparation for firing takes about one hour. Four people are needed to stretch and fold the net after each firing. Test-firings are needed to determine whether cannons are wired and angled correctly, and to be certain that the net deploys properly.

Selecting a good trap site is important as considerable effort goes into its preparation. A well-camouflaged blind of suitable size should be placed in cover 30–60 m from the trap. Clumps of grass, branches, or both should be placed around each cannon, and the net should be covered lightly with grass.

Cannon and rocket nets set fires easily if dry fuel is available. If wildfires are a strong possibility or the habitat consists of dry vegetation, ridge tops rather than valleys should be used. Regardless of where the trap is set, cut all dry grass from within 5 m of the cannons, and strip this area to near bare earth. Grass within the net landing area, but further than 5 m from the cannons, should be cut to 2 cm. Green grass need not be cut.

Once the trap is ready and desirable raptors are coming to the trap, the blind should be entered about an hour before sunrise. Silence in the blind is important, as eagles, vultures, and condors are highly suspicious and frequently watch for hours before finally settling in to feed. The slightest noise or movement can alert them to the presence of the trappers.

The detonator button on the firing box can be pushed when desired raptors are in position, preferably with their heads down feeding on the carcass. Be certain that no birds are standing where the four projectiles will land, and that no birds are airborne. Once the net has landed and birds secured, they can be taken from under the net and processed. Birds under the net must be separated from each other to avoid having them bite and claw each other. When many raptors are captured with a single firing, each bird should be placed in a restraining device or covered with a light blanket while still under the net.

Cast Lures and Hand Nets

This technique has been used effectively on Great Grey Owls (*S. nebulosa*) and Spotted Owls, but should be successful on other approachable *Strix* spp. The cast lure and hand net consists of a stuffed lure or live rodent attached to a nylon line that is pulled across the terrain, or simply a live rodent placed at the foot of the trapper. When the owl comes into the lure, a fish-landing net is quickly flipped over the bird.

Application. Equipment includes a fish landing net (0.6 × 0.8 m, with a 1.5-m handle), a casting rod, reel and 10-lb test line (Nero 1980). The lure animal is a stuffed or live mouse.

The cast lure and hand net technique described by Nero (1980) to capture Great Gray Owls has since been used to catch Spotted Owls. Essentially, a stuffed lure mouse attached to monofilament fishing line is cast toward the owl and reeled in. The owl is captured with the fish landing net when the lure is close and the owl flies to it or pounces on it. The technique works particularly well with snow on the ground.

The Dho-gaza

The dho-gaza is a mist or gill net suspended between two poles. The nearly invisible net falls with the poles (Harting 1898), detaches from the poles (Meredith 1943, Mavrogordato 1960, Hamerstrom 1963), or slides down the poles when struck by the raptor (Clark 1981). Depending upon the season, a Great Horned Owl or small bird or rodent is used as bait (see below). There are two applications: one involves a large net, used primarily during the nesting season to trap territorial adults (Fig. 4). The other involves a small net and a small lure bird, used primarily during raptor migration or on wintering grounds (Fig. 5).

Elevated small dho-gazas described by Rosenfield and Bielefeldt (1993) and Jacobs and Proudfoot (2002) have been used to increase the recapture rates of "trap shy" individuals previously captured on other types of traps. At close range, taxidermy raptors can elicit strong responses from territorial accipiters.

Application. We use aluminum 1.9–3.7-m or 2.6–4.7-m extension poles. Two 1-m sections of 1-cm reinforcement bar are cut for each net. The two sections of reinforcement bar are pounded into the ground and function as anchor-mounts for each extension pole. The net poles should be painted (mottled green and brown) to blend with the surroundings. A rectangular, 2.1 × 5.5 m, 10.2-cm mesh net is used for large raptors, a 0.8 × 1.2–1.5-m, 10.2-cm mesh net for medium-sized raptors, and a 0.8 × 1.2–1.5-m, 6-cm mesh net for small raptors. Nets are available to licensed banders from sources advertising in *North American Bird Bander* and *Journal of Field Ornithology* (www.avinet.com; AFO Mist Net Sales, Manomet Bird Observatory, P.O. Box 936, Manomet, MA 02345, U.S.A; EBBA Mist Nets, EBBA Net Committee c/o Gale Smith, 8861 Kings Highway, Kempton, PA 19529, U.S.A.).

The net is suspended from each pole by wrapping duct tape around three spring-closure clothespins on each pole (Fig. 4); one clothespin each around top, middle, and 0.6-m from the bottom of each pole. Each side of the net has five loops that would normally slide over the poles for use as a mist net. Since only three loops are necessary for the dho-gaza, we cut off the strings creating the second and fourth loops. To the ends of the three remaining loops, we wrap a 2.5-cm tab of duct tape, rounding off the corners with a pair of scissors. The tabs can then be slipped into the corresponding clothespin on each pole. Care should be taken to insert only the tape tab in the clothespin and no portion of the net loop, because if the loop is inserted in the clothespin, the net will not detach when the raptor flies into it. For small dho-gazas (Fig. 5), we use paper clips rather than clothespins. Each clip is tied to the rod with a rubber band. Tape tabs 1.3-cm long are placed at all four corners of the net and are inserted into the paper clips. For a variation of tab attachment, see Knittle and Pavelka (1994).

One of the bottom corners of the net is attached to a 5-m, 20-lb test monofilament line with a shock absorber and approximately 100-g weight or drag at the other end. The size of the drag depends upon the size of the raptor being trapped. A drag on a long line can be relatively light compared with the size of the bird. If the ensnared raptor becomes airborne the drag pulls it and the net to the ground.

Dho-gazas made from mist nets can be mended when torn; however, nets should be discarded after five major (15-cm hole) repairs. Dho-gazas made from mist nets usually can capture as many as 15 medium-sized or large raptors before they need to be replaced. Dho-gazas made from gill nets last longer, but are more visible.

Small dho-gazas often are used together with bow nets at banding stations along migration corridors. In such instances, gill nets often are used in place of mist nets as hundreds of hawks may be caught weekly. The design most frequently used at stations consists of two or three nets with two poles each and a bow net between them (Clark 1981). The nets are on rings that slide down the poles when a raptor strikes the net. See Clark (1981) for a complete description.

During the nesting season, a large dho-gaza with a Great Horned Owl placed near a nest is probably the most effective trap to use on most small to medium-sized raptors. An array of North American raptors have been captured using large dho-gazas during the breeding season. For a review of this trap's effectiveness, see Bloom et al. (1992).

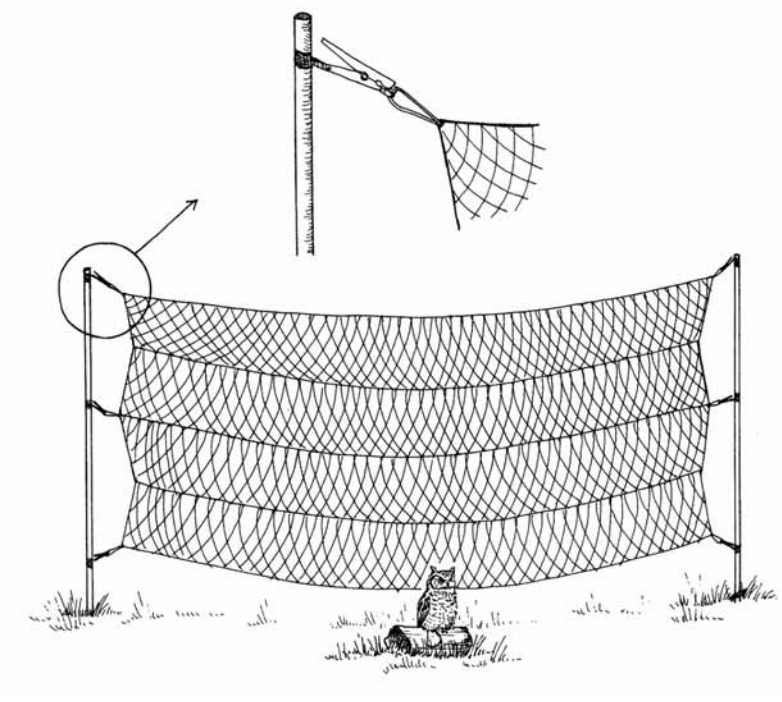

Figure 4. A large dho-gaza with a Great Horned Owl (*Bubo virginianus*) as bait may be used on territorial adult raptors. The inset shows a clothespin attachment to a tape tab on a mist net loop.

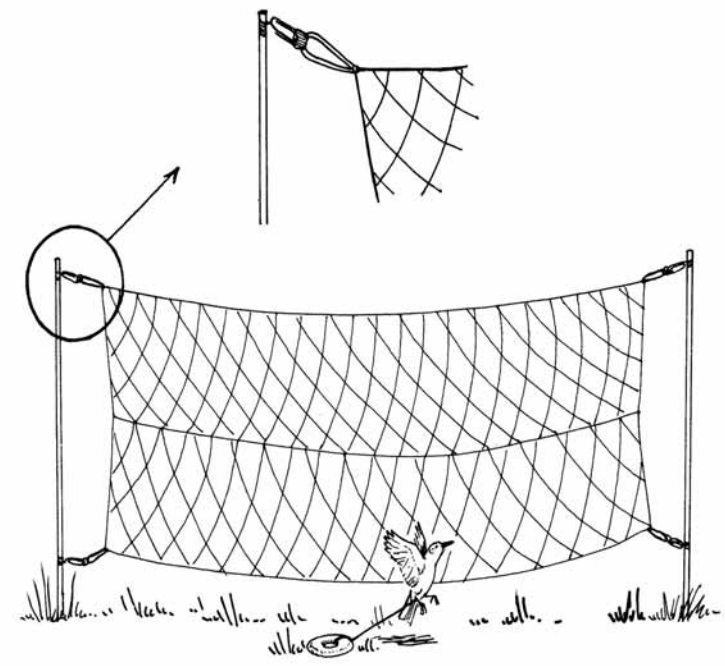

Figure 5. A small dho-gaza with a Common Starling (*Sturnus vulgaris*) as bait may be used for capturing falcons. The inset shows a paper clip attachment on the tape tab.

Great Horned Owls and Eurasian Eagle-Owls (*B. bubo*) make particularly effective lures when used near the nest of raptors because of their predatory potential. A raptor that proves impossible to capture with conventional traps using prey animals as lures may respond readily to a live Great Horned Owl at the nest site. A breeding pair of Greater Spotted Eagles (*A. clanga*) was captured in Poland with a large dho-gaza and live Eurasian Eagle-Owl (Meyburg et al. 2005). Nesting raptors also respond to mounted and mechanical owls, but less vigorously (Gard et al. 1989, Jacobs 1996). Even so, the risk of injury or death either to the lure or to the target is reduced when mechanical or mounted owls are used (McCloskey and Dewey 1999).

Conspecifics are another particularly strong stimulus for many nesting raptors (Elody and Sloan 1984), especially if they are carrying prey within another bird's territory. This relatively rare natural occurrence can be simulated by tethering a conspecific in the nesting territory of the target bird next to a net, and tying a 10-cm line from the bird's leg to a small taxidermy prey. The large dho-gaza has been modified to trap Spanish Imperial Eagles (*A. adalberti*) in Spain, and Golden Eagles in California using a conspecific as the lure (V. Matarranz, pers. comm.). In the latter case, the nets were hand-made using Spiderwire® line (www.spiderwire.com). Three-piece, telescopic, and camouflaged poles were used to elevate the nets. Eighteen of 20 attempts were successful, with the efficiency of the trap highly related to conditions at each site. We recommend using a Great Horned Owl without prey first. If a pair of raptors becomes trap-shy and must be captured again, move the dho-gaza to a new location and use a conspecific with prey. Not all raptors will respond to conspecifics; Red-tailed Hawks, for example, rarely respond.

Another effective variation of this technique, at least for Spotted Owls, is to hand-capture a branching owlet, set it at the middle of the dho-gaza and then handhold a live Great Horned Owl near the chick. The adults usually attack the Great Horned Owl immediately and fly into the net. If the remaining adult is slow to attack, imitations of Great Horned Owl calls and movement by the nestling usually attract the other member of the pair.

For woodland species such as Northern Goshawks, we recommend placing the net and the owl <50 m from the nest tree. The net should be placed so that the lure is between the nest tree or likely perch sites, and the net itself. The owl should be jessed and tied with a 0.6–1-m

tether to a short, portable tree stump or log measuring 0.3 × 0.6 m and weighing about 4.5 kg. The owl is positioned halfway across the span of the net, 1.5 m from it. Whenever possible, place at least one of the supporting poles next to a tree, and stretch the net out in the shade. Place the owl about 1.8 m from the tree (slightly inside from the center of the net). This provides the owl with some structural protection from the attacking raptor and will help force the latter to go through, rather than around the net. If feasible, the second pole also should be placed next to a tree as well. In this way, the poles are somewhat hidden, and, if in the shade, the net is less visible. Try to predict the direction of the attack so the net is pulled away from the owl instead of over it. To protect the hawk, set the dho-gaza so that no large trees, logs, or rocks are within 9 m of the front or back of the net. To reduce the amount of time involved in cleaning the net after a capture, remove as many branches, pine cones, etc. from the ground around the set, or have fresh nets available as replacements. Branches on trees adjacent to the net or "landing area" also should be removed.

Using two nets, rather than one, increases the success rate by about 20%. Once the hawk begins stooping at the owl, a capture is virtually assured if the net is in a good, inconspicuous location. The primary benefit of a second net is to facilitate more rapid capture, particularly in wooded areas. A drawback is that two nets and four poles are more conspicuous and require nearly twice as much time to set and occasionally the hawk becomes entangled in both nets.

Injured Great Horned Owls or Red-tailed Hawks that cannot be rehabilitated and would normally be euthanized make ideal lure birds. For humane reasons, we caution against using blind or partially blind birds, or birds with only one leg. Birds with wing injuries that have healed improperly function well, as do imprints. Taxidermy owls with loose feathers blowing in the wind work better than plastic owls. Taking good care of one's lure birds is not only humane, but also makes good sense because they are not readily available. For example, putting a lure bird out for extended periods in the hot sun can lead to dehydration and death.

Contact between lure owls and stooping raptors is rare. Of 1,400 raptors captured using a dho-gaza with a live Great Horned Owl, Bloom et al. (1992) reported one lure-owl death from a raptor strike, one death from a bobcat (*Lynx rufous*), and two deaths from dehydration. In most cases, hawks are attempting to chase the owl from its territory. Exceptions include Northern Goshawks, Great Horned Owls and Great Gray Owls, which have locked talons with lure owls. When trapping Northern Goshawks, we recommend using a large female Great Horned Owl. We also recommend that the dho-gaza be watched continuously from 5–100 m depending upon the situation.

Trapping during the incubation period may cause nests to fail, and most species are best caught during the nestling and early fledgling stages. One way to reduce or eliminate nest abandonment during incubation is to set the trap >100 m from the nest so that the foraging mate and not the incubating bird is caught. Capturing both members of a pair of accipiters, particularly goshawks, can be difficult and time-consuming. Females usually can be caught within 15 minutes during the nestling period. Males, which are more difficult to trap, are most vulnerable when nestlings are two weeks old.

Using a dho-gaza in open habitats presents its own set of problems, including both increased visibility and wind. In windy situations the net should be placed at right angles to the wind, as the bird will usually stoop into the wind. In some situations it is best to trap at sunrise, when winds are lower and the net is less visible. The hottest part of the day in summer or in arid areas also should be avoided.

As a rule of thumb, we leave the trap out as long as the individual to be captured is still responding (intently looking, stooping, or screaming), or up to three hours. If the bird still shows interest after three hours, we return later and select a different site for trapping. Expending more time at a single set is probably a waste of time, and overly disruptive to the birds.

Small dho-gazas are most effective during migration and on the wintering grounds, particularly on small raptors. Clark (1981) reported that between 1971 and 1979, 6,568 migrants were caught on small dho-gazas in New Jersey. Dho-gazas used at raptor-migration banding stations generally function as back-ups to bow nets (Clark 1981). Lure birds in the bow net attract the raptors, which are subsequently caught in the dho-gaza as they pass the bow net. House Sparrows, starlings, and pigeons are most commonly used as lures.

A wide variety of migrants, including harriers, accipiters, buteos, falcons and small owls have been captured with small dho-gazas in North America (Jacobs and Proudfoot 2002). In Israel, trapped migrants include smaller accipiters and falcons.

Road trapping with small dho-gazas is particularly effective on Prairie Falcons and Merlins. In the case of Prairie Falcons, the trap is placed 60–120 m from the

bird. The activities of the trapper are made less obvious by parking the vehicle and stepping out the side of the vehicle opposite the bird. Placing poles in the ground, attaching the net, and dropping the lure bird or mouse should be completed within three minutes. In the winter when the ground is frozen, 5-cm anchor platforms are useful for keeping the poles upright.

Another method that allows rapid placement of one or two dho-gazas is to have the poles mounted on a 1.2 × 1.2-m plywood base with the net or nets in place between them (B. Millsap, pers. comm.). Spreading soil over the base makes the trap less conspicuous.

Mist Nets

As mentioned earlier, mist nets are large, nearly invisible nets that are secured between poles and placed in appropriate habitat to entangle birds. Although used in Europe for centuries, their use in North America was not recognized until 1925 (Grinnell 1925). MacArthur and MacArthur (1974) later expanded on their use in population studies of birds. Mist nets have been used to trap a number of raptors, principally small to medium-sized owls and migrating hawks (O'Neill and Graves 1977, Weske and Terborgh 1981). Walkimshaw (1965) and Mueller and Berger (1967) have both described work in which mist nets were used to capture migrating Northern Saw-whet Owls. Smith et al. (1983) and Reynolds and Linkhart (1984) have both used them to capture Flammulated Owls and Long-eared Owls, respectively.

Similar in function to large dho-gazas, non-detachable mist nets have been used with live Great Horned Owls lures to catch breeding American Kestrels (Steenhof et al. 1994). While mist nets have been used with success on large buteos, these birds are likely to tear them and may be injured when entangled in them. The use of mist nets in Canada and the U.S. requires government permits.

Application. In North America, relatively inexpensive mist nets are available to licensed banders from several sources (www.avinet.com; AFO Mist Net Sales, Manomet Bird Observatory, P.O. Box 936, Manomet, MA 02345, U.S.A; EBBA Mist Nets, EBBA Net Committee c/o Gale Smith, 8861 Kings Highway, Kempton, PA 19529, U.S.A.). We recommend two types of aluminum extension poles as supports. The first, which is used in painting, is 1.9–3.7 m. The second, which is used to clean swimming pools, is 2.6–4.7 m. Both are lightweight and tall. Poles are placed directly over a 0.6–1-m length of reinforcement bar that has been pounded partway into the ground. Nylon cord tied to trees or to stakes can be used to keep the poles upright. Nets should not be so taut as to prevent their horizontally aligned pockets from forming. If the net is too taut, the birds will bounce off of it.

The most common sizes for nets are 2.1 × 12.8 m and 2.1 × 18.3 m. Mesh sizes of 5.8 cm and 10.2 cm (diagonally stretched) are most useful for raptors (Bleitz 1970).

We use a line of 22 12.8-m long, 5.8-cm mesh nets to catch small owls migrating through forests. Nets are checked at 1–3-hour intervals depending upon the temperature, as cold nights tend to stress small owls. During the nesting season, nets can be placed in corridors between known nest site and hunting areas.

We use 12.8-m long, 10.2-cm mesh nets to catch medium-sized and large owls. Nets placed in marshes are particularly effective for Barn Owls, Long-eared Owls, and Short-eared Owls (*A. flammeus*). Owls can be attracted to the net with lure animals in cages or bal-chatris with dry leaves so that the owls can hear the lures moving within. Taped recordings of mouse squeaks played at low volume below the nets also attract owls.

Portions of mist nets can be used to capture raptors that roost or nest in cavities. Barn Owls are easily captured by quietly approaching the cavity entrance and placing a net over it. The nest tree or nest box is then rapped and the owl becomes entangled in the net as it attempts to leave.

In North America, mist nets have been used to catch migrating accipiters, buteos, and falcons (Clark 1970). The nets are used as back-ups to bow nets. Lure birds in the bow net attract the raptors, which subsequently are caught in the mist nets as they pass over the lure. American Kestrels and Sharp-shinned Hawks are best caught with 5.8-cm mesh nets; whereas as larger species including Cooper's Hawks and Red-tailed Hawks are best caught with 10.2-cm mesh nets.

In India we captured several Montagu's Harriers (*C. pygargus*) in a grassland nocturnal roost by placing six 3 × 18-m, 10-cm mesh mist nets at the roost during the daytime. The nets were spaced about 10 m from each other. The birds were flushed into the nets when we walked through the roost two hours after sunset. In spite of our actions the roost remained active with several hundred occupants for several more weeks before the birds left the area.

Although mist nets are not particularly effective at

capturing raptors in rainforests (e.g., six raptors captured in Guatemala during 15,360 net hours), they are one of the best ways to capture tropical species including Plumbeous Kite (*Ictinia plumbea*) and Great Black Hawk (Thorstrom 1996).

Hand Capture and Spot Lighting

Although Spotted Owls are commonly captured by hand, particularly when provided live mice, in most instances capturing raptors by hand is not a technique that one plans to use. Occasionally however, researchers may find themselves in a position where a raptor can be grabbed. This can occur when the bird is unusually agitated, asleep, distracted, in a nest or roost cavity, sick, or fully gorged. A. Harmata (pers. comm.) has hand-captured several eagles with full gorges during windless conditions.

Capturing raptors by hand in open stick nests as they incubate their eggs or brood their young should be avoided. Doing so often results in nest failure, particularly when the bird is on eggs. The risk of damage to the nest contents by the adult's talons is also high. Capturing cavity-nesting raptors on eggs can usually be accomplished safely if the birds are inside the cavity and the hole is temporarily blocked until the bird calms down. A long pole equipped with a blocking device (e.g. a bunched cloth or paddle) on one end is useful for covering nest holes of American Kestrels (D. Bird, pers. obs.).

Spot lighting, which has been used to capture many types of birds, essentially involves shining a light in the target bird's eyes at night, and either grabbing the bird by hand or with a dip net.

Helicopters and Four-wheel-drive Vehicles

The helicopter-capture technique for Golden Eagles was developed by Ellis (1975) and expanded to include use of a net-gun by O'Hara (1986) (see below). The eagle is pursued with the helicopter until it lands on the ground and crouches with its head down while being intimidated by the helicopter (Ellis 1973). The helicopter then lands 75 m from the bird, drops off the biologist, and returns to hover 10–15 m above the eagle. The eagle is then hand-grabbed from behind by the biologist. This technique, which can be extremely effective (four eagles captured in two hours in Montana) (Ellis 1975), works best and most safely in flat terrain with little if any wind. Perched eagles are easier targets than soaring birds (Ellis 1975). The technique is quite useful when eagles are concentrated in livestock areas, and it is desirable to remove them in a short-time period.

The use of a 4-wheel-drive vehicle to pursue and capture raptors can be effective in certain circumstances. This technique was used in flat to undulating terrain in Saudi Arabia to capture Steppe Eagles (*A. nipalensis*) on 48 of 52 approaches. All successful attempts were completed in <15 minutes, with a mean pursuit time of <9 minutes (Ostrowski et al. 2001).

Ground-burrow Traps

This approach involves the use of several different types of traps including small-mammal live traps to capture Burrowing Owls and, occasionally, Barn Owls. The trap is placed in the entrance to a Burrowing Owl nest burrow (Martin 1971, Ferguson and Jorgensen 1981), along with cages (Winchell 1999) or noose carpets (Bloom 1987) placed outside of burrows (Fig. 6). Ferguson and Jorgensen (1981:149) recommended 23 × 23 × 66-cm live traps with single or double doors (www.havahart.com, www.livetrap.com). Winchell (1999) provides useful illustrations of this technique.

Live traps need to be checked periodically throughout the day; noose carpets every 15–60 minutes unless they are attached to trap monitors. Both techniques can be highly efficient; Ferguson and Jorgensen (1981) reported 49 owls captured with live-traps in 150 man-hours, and noose carpets, which are less cumbersome, have caught 20 owls in 10 man-hours.

Nest Traps

Several variations of nest traps exist for natural cavities including a wire hoop trap that has been used to catch Barred Forest Falcons (*Micrastur ruficollis*) and Collared Forest Falcons (*M. semitorquatus*) in natural nest cavities (Thorstrom 1996) and American Kestrels in nest boxes (Plice and Balgooyen 1999). As mentioned earlier, small sections of mist nets placed over the openings of nest cavities work well on Barn Owls nesting in trees and on bluffs.

We have used long kitchen tongs and short barbeque tongs to extend our reach into cavities to "capture" young, and, sometimes, adults. Thorstrom (1996) has used a noose pole trap (i.e., a wire rod with nooses attached to leather on the end that the raptor grabs onto), to extract raptors from cavities.

Net Guns

The net gun is a relatively expensive but effective device consisting of a hand-held, 3-barrel gun that uses explosives to propel a net. A number of barrel subsystems and net and mesh sizes are available from Coda Enterprises (www.codaenterprises.com). The net gun can project a variety of triangular or square nets, ranging from lightweight, mist nets to heavy-tensile nets. Depending upon the size and mesh, the net can be projected 15–22 m. The gun, which usually is hand-held when fired, can be fired by remote control.

Although net guns have been used to capture a number of large mammals and birds, eagles are the only raptors that have been captured using this technique (O'Hara 1986). Net guns may be particularly useful with unusually approachable species, and those that roost communally.

Noose Carpets

A noose carpet (Fig. 6) is a weighted piece of hardware cloth festooned with monofilament nooses that is strategically placed on a high-use perch or other surface (Anderson and Hamerstrom 1967, Collister 1967, Kahn and Millsap 1978). A shock-absorbing spring (e.g., a 10–15 cm metal spring or rubber surgical tubing) is placed on the line near the weight to reduce stress on the bird's toes, or on the monofilament.

Application. As for bal-chatris, after which they are modeled, materials for noose carpets include either 0.6- or 1.3-cm hardware cloth or aviary wire, 10- to 40-lb test monofilament, nylon cord, and a metal spring or elastic tubing. Nooses 2.5–5-cm tall should be used for small raptors such as American Kestrels or screech-owls; 5–7.5-cm nooses should be used for medium-sized raptors such as Barn Owls or Red-tailed Hawks; and 10-cm or taller nooses should be used for larger raptors. Ten-, 20-, and 40-lb test monofilament should be used on small, medium-sized, and large raptors, respectively. The size of the perch site to which the noose carpet is to be attached dictates the size of the carpet. Careful positioning is critical.

Noose carpets, which can be used during nesting and migration, have been used to trap vultures, kites, harriers, accipiters, buteos, eagles, falcons, and owls in North America. Thorstrom (1996) used noose carpets in Guatemala to capture several species including kites, hawks, hawk-eagles, falcons, and owls.

Like the Verbail trap (see below), noose carpets do not require bait, although a lure animal can be used.

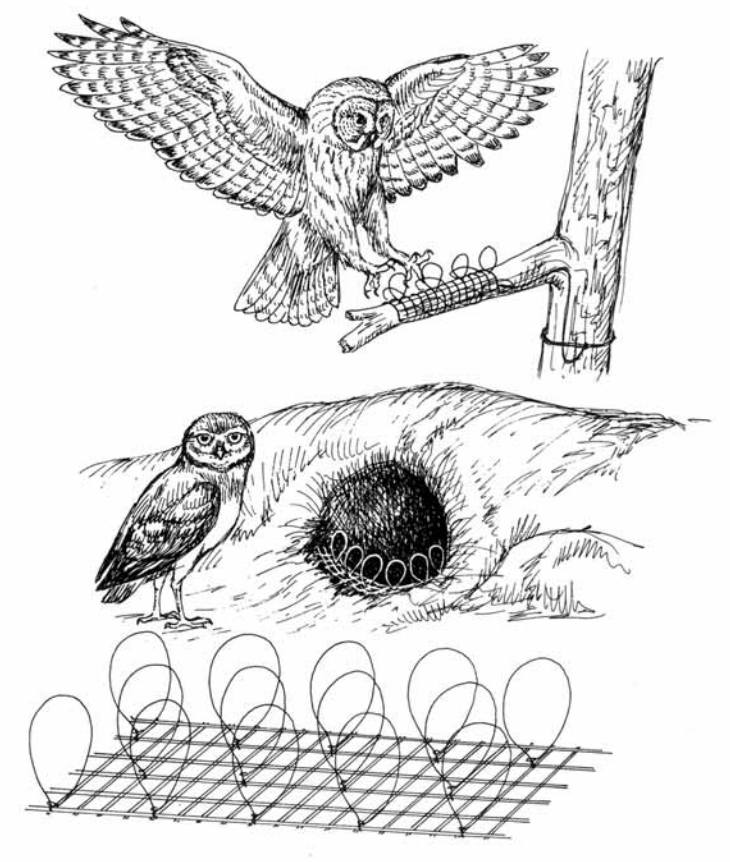

Figure 6. Noose carpets may be applied to branches and around Burrowing Owl (*Athene cunincularia*) nests.

One simply needs to know the location of the target bird's most frequently used hunting perches. Erecting artificial perch sites in strategic locations, such as a meadow, also works. A 10 × 10-cm by 2.5-m fence post with a 0.6-m, 2.5–5-cm diameter branch or dowel attached perpendicularly on top is ideal for trapping many perch-hunting raptors.

For vultures we use four sections of 1.3-cm hardware cloth cut into 10-cm by 0.6-m lengths. The nooses are attached to the hardware cloth using square knots and are either twisted or glued into a vertical position. Each section of hardware cloth is attached to a 1-m nylon cord with a 1-kg weight and a shock absorber. The four carpets are then placed 0.5-1 m out from the carcass. All four sections of hardware cloth, along with the weight, shock absorber, and nylon cord are lightly but completely covered with soil or grass. Only the nooses remain erect and exposed.

Noose carpets are effective for Turkey Vultures, Bateleurs (*Terathopius ecaudatus*) (Watson and Watson 1985) and, presumably, other carrion feeders. Even

American Kestrels have been captured on noose-carpets baited with carrion (Wegner 1981). A noose carpet wrapped around a dead rabbit has been used to capture Roughlegs (*B. lagopus*) (Watson 1985). A. R. Harmata (pers. comm.) found that pushing meat partially through the mesh makes a carrion set more attractive to buteos and Golden Eagles. For kestrels, a rodent carcass is used as bait, and the nooses are attached to two single strands of wire that are nailed in position over the rodent. Wegner (1981) captured two adult Red-tailed Hawks using this technique. Karblom (1981:140) used leather straps with attached nooses wrapped around a fresh kill or a carcass set out like a fresh kill to capture goshawks at regular plucking sites. Noose carpets also can be used when the target bird has killed and partially eaten a harnessed pigeon without being caught. At such times the raptor is flushed from the pigeon, and the carcass is then covered with a noose carpet (Mavrogordato 1960, Webster 1976, pers. obs.).

Burrowing Owls are most easily captured using a 5–15-cm noose carpet made from 0.6-cm mesh hardware cloth. Approximately 10 4-cm nooses (10-pound test) are tied in a staggered arrangement on each strip of hardware cloth. The carpet is then attached to a weight or stationary object by a 0.6-m length of nylon cord, surgical tubing, or inner tube, and placed 3–30 cm inside the entrance of a burrow. The trap functions best during the nesting season, when young begin to venture from the burrow, but are not capable of sustained flight. When attempting to capture nestlings, the burrow should be checked at 15–30-minute intervals, unless a trap monitor is in place. The process can be repeated until all owls are captured. It is best not to release any of the nestlings until all of them have been caught, but in no case should they be held for more than three hours. Larger carpets can be placed on the apron of the burrow with a dead mouse as an attractant. We have captured more than 500 Burrowing Owls using these procedures and found that they work well on both adults and fledglings.

When using elevated noose carpets, the same safety measures apply as for the Verbail trap (see below) (i.e., the anchor line should reach the ground, and a shock absorber is needed).

Noosed Fish

Noosed fish were first successfully employed by Robards (1967) for Bald Eagles in Alaska, and subsequently modified by Cain and Hodges (1989) and Jackman et al. (1993). Bald Eagles, other fish eagles, Greater Spotted Eagles (*A. clanga*), Western Marsh Harriers (*C. aeruginosus*), and Ospreys have been trapped on noosed fish.

Application. The fish should be the size and species normally taken by the targeted raptor. The entrails are removed and replaced with a block of shaped Styrofoam, placed so the fish will float belly up (see Frenzel and Anthony 1982 and Jackman et al. 1993). Two monofilament lines approximately 1-m long enter the fish through the mouth, pass through a segment of the Styrofoam plug for friction, and exit through the anus. A slipknot is tied at the end of each line to create a noose. The nooses should be 12 cm in diameter with the knots lying at the anus of the fish. The nooses are held to the pectoral region of the fish with a breakaway attachment, one on each side of the fish, with the nooses lying flat on the surface of the water. The ends of the lines that exit the mouth are tied to a 30-lb test monofilament line on a fishing rod and reel or to a 4.5 kg anchor.

Tolerance levels of perched Bald Eagles approached by boats vary. Many will flush if approached closer than 0.4 km, whereas some will allow a boat to pass directly underneath them. Once a target bird is found, the noosed fish is dropped from a slow-moving boat, preferably on the side of the boat opposite to the bird. When the raptor attacks the baitfish and attempts to carry it, one or both nooses close around the bird's toes and the bird falls into the water. The bird is then approached by boat as the line is reeled in.

A variation of this technique is to attach the line from the floating fish to a 4.5-kg anchor, which is then lowered to the river or lake bottom. Anchors lighter than 4.5 kg should not be used in deep water since the eagle's forward momentum may pull the anchor into deeper water, causing the bird to drown. A shock absorber must be placed between the weight and the bait or the noose will snap when the eagle grabs the fish. The shock absorber can be attached to a floating log (drift set).

This trap has been used with success on both Ospreys and Bald Eagles. Frenzel and Anthony (1982) reported near 100% effectiveness on Bald Eagles striking the bait. Having nooses and lines placed correctly is critical as others have experienced lower success using slightly different versions of this trap (Harmata 1985, Jackman et al. 1993). Misses result when either the birds fail to put a toe through a noose, or escape after being temporarily snagged. A variation of this technique

used on White-bellied Sea Eagles is provided by Wiersma et al. (2001).

Harnessed Pigeons

The pigeon harness (Webster 1976) is a modified noose trap. Originally designed to capture large falcons, it also is effective in capturing medium-sized to large accipiters, buteos, eagles, and owls. Nylon monofilament nooses are tied or cemented to a leather harness that is attached to a pigeon. Openings in the harness for the legs and wings allow the pigeon to walk or fly about. A 1.5- to 10-m line with a weight or drag at the opposite end is attached to the harness. Modifications include harnessed House Sparrows and starlings used to catch small falcons (Toland 1985), and harnessed ducks, pheasants, and rabbits used to catch eagles.

Application. A pattern is used to outline the harness on 0.3-cm thick leather. The diameter of leg- and wingholes are modified to fit the individual bird being harnessed so that it can walk and fly. Webster (1976) suggested constructing and using several harnesses of different sizes to overcome this problem. A small shock-absorbing spring attached to the harness behind the legs reduces the number of raptors that escape as a result of broken nooses.

Nooses, similar to those described for the bal-chatri, are attached to the harness after first making the noose itself, and then threading the loose end of it through pinholes in the harness. Several overhand knots are tied together into one large knot that cannot slip back through the hole. The knot is glued to the leather on the inner side of the harness with the noose in the desired position. An alternative technique is to punch two holes in the leather 0.5 cm apart and tie the noose as is done on bal-chatris. Harnesses usually are festooned with 25 4-cm nooses made from 20-lb test monofilament. A 0.2 kg, movable drag weight, such as a stick on a 6-m line, works well in plowed fields. An immovable weight should be used in situations near water.

In our experience, the harnessed pigeons have a success rate of 75–85%. Harnessed pigeons have been used worldwide to capture a variety of raptors, including harriers, accipiters, buteos, falcons, eagles, and owls.

The most common application of this technique involves driving on secondary roads or beaches looking for raptors, and tossing the harnessed pigeon out of the window when a target bird is found. A long, 15-m dragline permits the pigeon to fly some distance. A short, 1.5-m line with an immovable weight can be used in areas with heavy shrub cover. Because buteos and Great Horned Owls usually capture their prey on the ground, a 1.5-meter line is best for capturing these species. Alternatively, because falcons prefer to strike their prey in the air, the trap is more attractive when the pigeon flies. That said, if cover is available and a long line is used, the lure bird will hide in cover once it is aware of the raptor. Long lines also tend to become tangled in shrubs. The more vulnerable the pigeon appears, the higher the probability of successfully trapping.

Another effective use is to place 10–15 harnessed pigeons under buteos and falcons migrating through small, upper-elevation valleys. In such situations the pigeons, which are set 0.5 to 2 km apart on short lines with 1-kg weights with shock absorbers, should be checked hourly or monitored with electronic trap monitors.

As discussed by Webster (1976), the success or failure of a trapping operation depends upon the action of the harnessed pigeon. Wild-caught feral pigeons make the best lures, as they tend to be stronger and attempt to fly more frequently than those raised in captivity and rarely flown.

Noose Poles

A noose pole can be a fishing rod (Zwickel and Bendell 1967, Catling 1972), telescoping pole (Reynolds and Linkhart 1984), or sections of rod or pipe that mount on top of each other to extend high enough to reach the targeted owl (Environment Canada and U.S. Fish and Wildlife Service 1977, Nero 1980). A large nylon monofilament or wire noose at the top of the pole is closed by pulling the line or wire that runs up the side or center of the pole.

Noose poles work best on unusually tame species of raptors including Galapagos Hawks (*B. galapagoensis*) (Faaborg et al. 1980), and several species of owls. Noose poles also have been used to retrieve nestling Barn Owls and Burrowing Owls from deep nest cavities (B. Millsap, pers. comm.).

The Phai trap

The phai, or padam (Mavrogordato 1966, Carnie 1969, Webster 1976), is another infrequently used trap with considerable potential. The phai consists of a live lure surrounded by a small ring of relatively tall nooses con-

nected to a rope or hose (Fig. 7). Large falcons have been trapped with this technique, but other raptors also can be caught. A more portable version designed by C.H. Channing consists of a cage containing a lure bird with large nooses suspended along the top (Fig. 8). This trap is most effective for trapping accipiters.

Application. The ring version of the phai consists of about 25 25-lb test, 15–20-cm diameter monofilament nooses. The ring, which is about 1-m in diameter, is formed by a nylon or rubber hose or a piece of rope. The nooses, tied through perforations, are spaced along the hose so that each overlaps the adjacent noose by about 1.3 cm. Because the nooses are tall and flexible, small 15-cm lengths of wire or twigs are sometimes used to support them.

The portable cage version (Fig. 8) differs from the ring of nooses described above, and shares characteristics of the bal-chatri and noose carpet. The cage consists of 1.3-cm mesh or larger hardware cloth measuring 20 × 20 × 10 cm mounted on a 25 × 25-cm piece of 1.9-cm plywood. Four 20-lb test monofilament nooses are used. Four flexible, but relatively stiff 20-cm rubber rods are attached vertically in each corner of the cage. Ten centimeters of each rod stand above the top of the cage. Two 2-cm lengths of solder (metal alloy used for patching) are wrapped around the top and bottom of each rod. A large monofilament noose is tied to the base of each rod and opened so that the noose is supported by folding the solder once at both the top and bottom of each of the four rods. The solder keeps the nooses open and erect, yet releases from them when a hawk pulls on the noose.

The phai has been used to capture Peregrine Falcons and Saker Falcons (*F. cherrug*) (Carnie 1969) using feral pigeons and starlings as lures. We suspect that this method could be used much like a noose carpet for vultures and eagles with carcasses used as bait. Once a perched falcon has been found, the trap is placed at a safe distance using a vehicle to conceal activity. A small quantity of standing grass helps to hide the nooses, and soil can be used to cover the hose.

Recently, the phai was tested while road-trapping Golden Eagles with a rabbit as a lure. Eagles responded within 15 to 90 minutes. The eagles were caught on two of three attempts (Latta et al., pers. comm.).

The cage version of the phai, which can be placed from a vehicle that has stopped momentarily, has been used to trap Cooper's Hawks and should be effective on Northern Goshawks, large buteos, harriers, and Harris's Hawks as well.

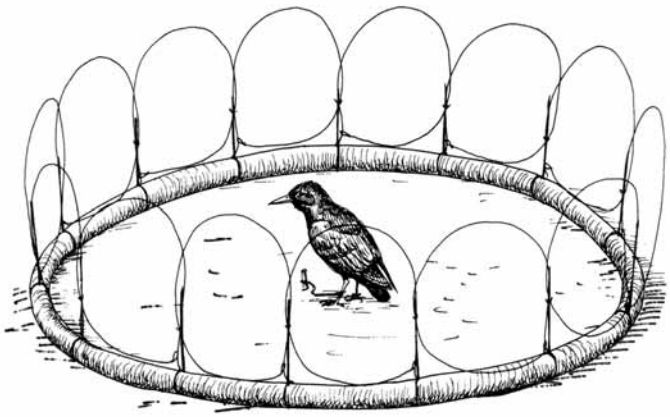

Figure 7. A ring version of the phai trap with a Common Starling (*Sturnus vulgaris*) as bait and a garden hose as the base for the noose attachment.

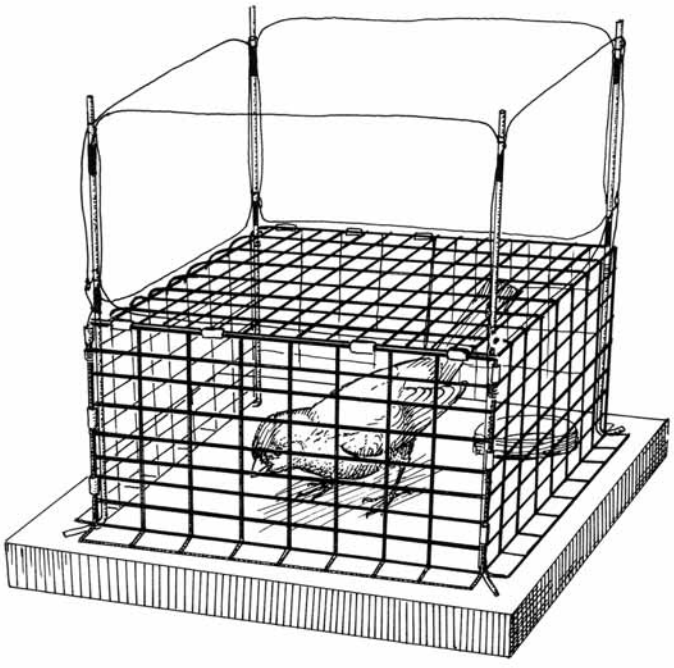

Figure 8. A cage phai trap, with four large nooses, commonly is used to trap accipiters.

Padded Leg-hold Traps

This trapping technique consists of placing several leg-hold traps with weakened springs and padded jaws in the immediate vicinity of an animal carcass (Fig. 9) to catch scavenging raptors. Today this technique is used almost exclusively to capture vultures and eagles. Initially however, it also was used to capture smaller raptors, including Northern Harriers and buteos (Lincoln and Baldwin 1929, Imler 1937).

Application. The most frequently used trap is a Number 3 double long spring leg-hold (Harmata 1985). Because the springs on new traps are powerful enough to break the toes of eagles, the jaws must be weakened or padded, or, preferably, both. Weakening is accomplished by striking both springs near the bend twice with a heavy hammer. When using traps with two coil springs, one of the springs can be removed to weaken the closure. Each jaw of the trap is wrapped with neoprene or leather and again with friction tape until a thickness of about 0.6 cm is obtained (Imler 1937, Stewart et al. 1945). A. Harmata (pers. comm.) has used this technique extensively and emphasizes the need to provide adequate padding. With adequate padding it may not be necessary to weaken the springs as the latter tends to slow closure.

Leg-hold traps have been used successfully to capture both Bald Eagles and Golden Eagles (Niemeyer 1975, Adkins 1977, Harmata and Stahlecker 1977, Harmata 1985, M. Lockhart, pers. comm.). In India, we used padded leg-hold traps to catch Greater Spotted Eagles and Asian Imperial Eagles (*A. heliaca*) in marshes using dead goats and fish, and Egyptian Vultures (*Neophron percnopterus*) and White-rumped Vultures (*G. bengalensis*) using sheep. Number 3 traps are not recommended for smaller species because of leg bone breakage, but modified smaller traps (e.g., Number 1 and Number 2) may be used on medium-sized to large hawks without causing injury. Imler (1937) trapped Red-tailed Hawks, Roughlegs, Prairie Falcons, and Great Horned Owls using a Number 1 trap placed on poles or around rabbit carcasses, but found that Northern Harriers, Swainson's Hawks, and American Kestrels sustained severe injuries during the process. Stewart et al. (1945) also tried padded leg-hold traps placed on the tops of poles for raptors, but also found them unsatisfactory because several trapped individuals received leg injuries, possibly because the traps being used did not have weakened springs. Padded leg-hold traps should be monitored continually or with electronic trap monitors.

Figure 9. Padded leg-hold traps arranged around a desert cottontail (*Sylvilagus audubonii*) carcass function well in capturing eagles. *(Photo by J. Kidd)*

Entire animal carcasses are used to attract eagles, but parts of animals, including the legs of rabbits and deer, also work. Fish can be used when attempting to trap Bald Eagles. Lures should be staked in sites frequented by eagles, and can be sliced open to make them appear previously fed upon and more attractive. Plucked fur or feathers spread around the carcass also enhance the effectiveness of the lure.

Depending upon the size of the lure, two to six traps are placed around it. A depression is dug for each trap, and the traps are set 2.5–50 cm from the lure. It is important that the trigger is not "haired" but is set for maximum pressure (A. Harmata, pers. comm.).

Before covering the traps, the trigger pan is covered with a 12 × 12-cm piece of cloth that extends under the jaws to prevent soil used to camouflage the trap from filling in under the trigger pan. All parts of the trap are then covered with loose soil or grass. Do not use snow as it may freeze. Each trap is attached to a 1-kg weight via a 1.5-m line with a shock absorber, which also is covered. Some researchers (e.g., Harmata 1985) connect two traps together by their stake-down chains in place of a weight. The technique should not be used during high winds or in hilly or mountainous terrain, and should be used with caution near water.

One major drawback with this technique is that smaller, non-target species also may be attracted to carrion, and if caught, may sustain serious injuries to their legs. The number of non-target individuals captured in leg-hold traps can be reduced by placing 7.6-cm fiberglass building insulation under the pan. Doing so allows for heavier trigger pressure (Harmata 1985).

Pit Traps

There are two basic types of pit traps. Both essentially involve placing a person in a hole with bait nearby. The pit traps, or "dig-ins" (Webster 1976), used to capture Peregrine Falcons on beaches during migration, are usually shallow and temporary while those used to capture eagles are deep and used repeatedly. A feral pigeon is used to lure falcons, whereas a large carcass is used to lure eagles, vultures, and condors. The leg or legs of the target raptors are grabbed by hand by the person inside the pit.

Application. A shallow pit deep enough to hide a person lying down is dug on a beach. A person then lies on their stomach or back in the hole and is buried except for his head and shoulders, which are covered and hidden by an approximately 35 × 50-cm basket (M.A. Jenkins, pers. comm.).

Trapping eagles and vultures with a pit trap requires more material and effort (Fig. 10). A 0.9 × 1.8-m, 1-m deep hole is dug in firm soil. A 2 × 2.4 m sheet of 1.9-cm marine varnished, outdoor plywood is used to cover the pit. The walls of the pit are supported by 1-cm outdoor plywood, and braced with 5.1 × 10.2-cm by 0.9-m wooden beams nailed vertically in the corners to prevent dirt slippage. One beam is jammed and nailed between the vertical beams at the front and back of the pit and a pair of 10.2 × 10.2-cm cross beams should be used to strengthen the roof when used in cattle country or where vehicles might be driven over it. A door the width of the pit is cut at one end of the plywood cover. A rim of beams is then nailed around the edge of the door to prevent debris from falling in when the door is opened. The door is hinged at the rear and a 25-cm diameter hole is cut in the middle of the door. A 30-cm high, 35-cm in diameter basket is secured with wire upside down over the hole. A 15–20-cm by 0.8-m opening between the door and the top of the forward wall of plywood serves as the capture space through which the birds are grabbed. The lure carcass lies in a shallow depression about 0.3 m in front of the capture space. This construction allows a person to kneel or sit in the pit with their head in the basket and peer through the capture space with their hands positioned inside of the opening ready to grab a bird. When left unattended, the door can be protected by screwing a piece of plywood about 12 cm wider and longer than the door onto the framing beams.

When construction is complete, a 10-cm layer of earth is applied to the roof. Great care should be taken in camouflaging the door, basket, and capture space with a thick layer of vegetation, preferably grass. A perch log also can be placed on the roof. Eagles frequently land on the log, thereby alerting the trapper inside of their presence. With the addition of some bushes and more grass on the roof, the trap should virtually "disappear" into the landscape. The vegetation resulting from spring rains will add the finishing touches to the camouflage work. Unlike many other traps, when constructed correctly, the pit trap is completely inconspicuous.

Pit traps are commonly used to capture falcons during coastal migration, and can also be used to trap adults or fledglings on the breeding grounds as well. A pigeon is tied on a 1–5-m line held by the trapper. As the pigeon wanders about on the sand, it is occasionally jerked to attract passing, or preferably, perched falcons. The pigeon also can be tossed from the basket if a falcon is observed flying by. When the falcon begins stooping on the pigeon it is pulled toward the trapper concealed in the basket. When the falcon grasps the pigeon, the trapper grabs the falcon with his hands.

Pit traps are not as effective as other methods of capturing falcons (e.g., harnessed pigeons, dho-gazas), but they do have the advantage of being selective.

Pit-trapping Bald Eagles and Golden Eagles is an ancient and well-tested technique that was used by at least 16 tribes of Native Americans (Wilson 1928). Prebaiting ensures faster results. Rabbits, deer, calf, and waterfowl carcasses can be used as lures. Each carcass should be sliced open and partially plucked or skinned to expose the meat and make it appear as though it has already been fed upon. Large carcasses such as adult deer should be frozen and then cut in half to ensure that the eagle stands on the carcass in a location where it can be reached. The carcass should be placed about 15–30 cm from the basket for eagles, 170 cm for vultures. It typically requires between 12 hours and 4 days for eagles to find and begin feeding on a carcass.

The trap should be entered one hour before sunrise so that no human activity is visible to eagles that might be roosting nearby. At no time during the day should the person inside the trap leave unless a bird has been captured, or the trapping attempt has ended. If possible, the observer should not leave the trap while eagles are present. Rather than waiting in position with arms outstretched and head in the basket, it is easier to wait below the basket in a more comfortable position. Eagles make enough noise with their wings when landing to warn the trapper of their approach. Special precautions should be taken to eliminate any possible sound inside the pit that might frighten target birds.

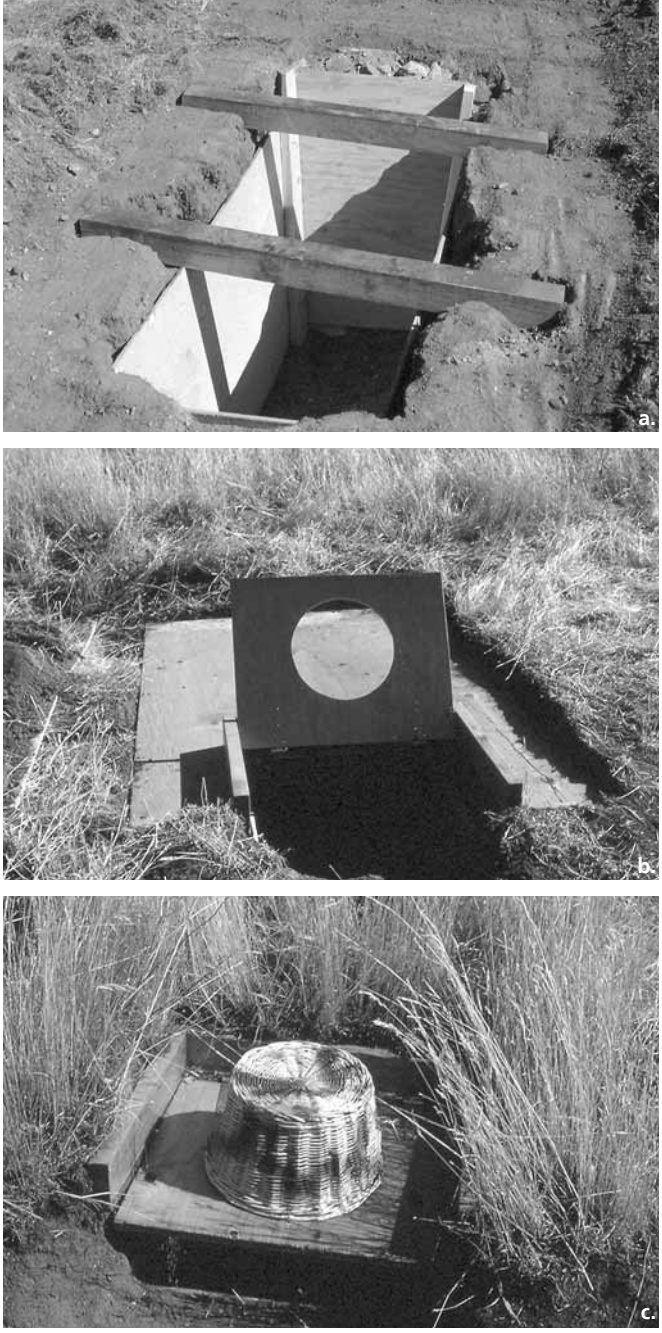

Figure 10. Construction of pit trap for use on eagles. When finished, cut grass is added to the basket, door, grabbing slot, and foreground. A large animal carcass is used as bait. *(Photos by P. Bloom)*

When an eagle or vulture approaches the carcass, the trapper should get into capture position on his knees at the forward end of the pit, with their head in the basket and hands placed on the edge of the space through which the bird's legs will be grabbed. All movements within the pit must be made very slowly. It may take several minutes for the eagle to rotate into the correct position. The trapper can peer through small holes in the basket or through the capture space in order to properly size up the situation. When the eagle or vulture begins feeding and is in range, the trapper should grab one or both tarsi. When the bird attempts to move forward to fly, it will fall on its breast. At this stage the trapper has two options: to stand up and step out of the pit in order to process the bird or, if several eagles are standing in the vicinity and more birds are needed, to slowly and carefully pull the eagle into the pit. This must be done without frightening the remaining eagles, and can be accomplished by placing both of the bird's legs in one hand, pulling its wings together and holding them with the other hand, and lifting the door slightly with your elbows while pulling the bird inside. Immediately replace the vegetation in front of the capture space. The bird's talons and feet should be wrapped with duct tape and the wings folded together. The bird is then placed in a restraining device (Evans and Kear 1972, Passmore 1979). We have caught two Golden Eagles in five minutes using this technique, which works well when the trap has been pre-baited and several eagles have been feeding there for several days.

The pit trap is rarely used today, probably because of the ease and effectiveness of trapping with leg-hold traps or radio-controlled bow-nets. We believe that the pit trap is probably the safest and most effective method for trapping eagles, vultures, and condors. If the trapper is competent, the success rate is virtually 100%. In many respects pit-trapping eagles is better than using cannon or rocket nets. Although it is possible to capture more than one eagle with each firing of a cannon or rocket net, these traps may start fires or cause fatalities. Once made, a pit trap is operational when a carcass is positioned in front of the opening and the pit is manned.

From 1985 to 1987, 125 Golden Eagles and a Bald Eagle were captured at five pit traps in southern California. Eighteen were recaptured two to three times. Five California Condors were captured in pit traps from 1984 to 1986 (PHB). Whereas some eagles and condors occasionally were missed due to noise in the pit, or impatience and noticeable hand movements of the trapper, 31 consecutive Golden Eagles that made contact with the carcass were captured without a miss. Generally speaking, the principal reason for missing eagles at a pit trap is the inexperience of the trapper or impatience. More often than not, time is on the side of the trapper if the bird is important enough.

Greater Spotted Eagles came regularly and naively to pit traps baited with goats in India, and White-rumped Vultures and Red-headed Vultures (*Sarcogyps calvus*) also fed at the carcasses with a person inside the trap centimeters away (PHB).

Some dangers do exist when using pit traps. Considerable care should be taken, particularly on beaches, to be certain that no vehicles are being driven in the area. Positioning the person so that he can see up and down the beach reduces this potential danger. Likewise, in the case of a deep pit trap, vehicles, horses, or other large ungulates wandering into the area can break through the roof. Trappers also should be aware of any poisonous snakes and invertebrates in the area. In India, large wild dogs attempted to remove the carcass several times and would have succeeded if one of the authors did not hold on to it.

The Verbail and Other Pole Traps

Vernon Bailey invented this trap (Stewart et al. 1945), one of several that are sometimes called pole traps. The Verbail trap consists of two sections: a stand mounted on a perch site or fence post, and a carefully bent length of spring steel shaped into a spring (Fig. 11). When a raptor lands on the trigger, the steel spring is released, which closes a 10-cm diameter loop of nylon cord around the bird's leg or legs. The spring is tied to the perch with a nylon line that is usually 1–2.5 m long, depending on perch height, which allows the bird to rest on the ground.

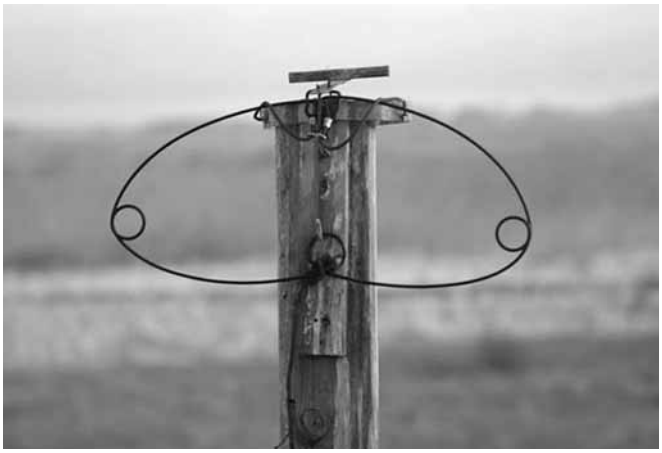

Figure 11. The Verbail trap is used most effectively on owls in places where perches are limited, such as marshes, estuaries and prairies. *(Photo by J. Kidd)*

The Verbail is one of the few traps that we recommend be purchased rather than built. We know of no current manufacturer; however, used Verbails sometimes are available on the Internet.

The Verbail can be used effectively on many raptors both during the nesting season and migration. One of its advantages is that no lure is required, although one can be used if needed. Verbails are most effective in areas where perch sites are limited. If natural perch sites are not available, 10.2 × 10.2-cm by 2.5-m posts, erected in strategic locations about 0.4 km apart, work well. Habitats with limited perch availability such as marshes, deserts and grasslands are excellent locations for erecting posts, but a fence post on a prominent hill also can be effective. Most studies during the nesting season require only one or two traps, but during migration or on wintering grounds it is best to have 10 to 20 traps operating simultaneously. Traps should be monitored continuously in extreme cold, and checked hourly in more moderate temperatures, or equipped with trap monitors.

During the nesting season or when attempting to trap specific individuals, a lure animal such as a pigeon or small rodent can be effective, particularly when a Verbail is used in conjunction with another trapping technique, such as a harnessed pigeon or a bal-chatri.

When a hawk or owl flies toward the lure, it often will land first on a nearby perch for a closer inspection. A Verbail on a perch close to other traps works well in such situations. It also is common for a raptor to attack a trap such as a bal-chatri, but veer away just before making contact. A Verbail on a nearby perch provides an opportunity for a second chance at capture.

Verbail traps have been used to capture harriers, accipiters, buteos, and falcons, and are most effective on medium-sized to large owls (JWK, PHB).

Misses tend to increase with larger raptors because the spread of the bird's legs are wide enough, such that when they land, a part of one or both feet cover the loop and cause it to misfire. Increasing the size of all of the parts on the Verbail trap proportionately should increase its effectiveness on Red-tailed Hawks and larger species. Small passerines occasionally set off the trap without being caught due to their small size.

Trapped raptors seldom are killed as a result of being captured by Verbails, but trapped birds can be preyed upon. Four American Kestrels were killed by Red-tailed Hawks, and a Barn Owl and Great Horned Owl were killed by coyotes (*Canis latrans*) (PHB). One way to limit this is to check each trap at 30-minute intervals or, preferably, to use electronic trap monitors. In areas with heavy dew, birds can become soaked in wet grass beneath Verbails. The same can happen in a sudden rain shower with any trap. Wet birds should be dried before release as they are likely to be deeply chilled and hypothermic. Finally, the spring on a Verbail has considerable tension in a closed position. Individuals setting this trap should be aware of this danger to their eyes from a misfire, and should avoid putting their face close to the spring. When traps are set, no one but the person setting them should be as close as 1 m to them.

Another manually operated pole trap described by Dunk (1991) caught 39 White-tailed Kites during 48 attempts, but failed to catch a number of other raptor species that landed on it.

Perch snares, which are powered by rubber strips, are similar to the Verbail trap in terms of how they operate (Prevost and Baker 1984). Although rarely used, this trap would seem to have great potential for trapping a variety of diurnal and nocturnal raptors. No less than 120 Ospreys were captured in West Africa using this device, 17 of which were caught twice; one bird was captured five times (Prevost and Baker 1984).

Power Snares

Power snares, which were first described by Hertog (1987) for use in trapping territorial White-bellied Sea Eagles, are either triggered by the bird itself, or are set off manually or triggered remotely. Remote-controlled power snares have been described by Jackman et al. (1994) and McGrady and Grant (1996).

A remote-controlled trap used at bait sites captured five of seven Bald Eagles (Jackman et al. 1994). Seventy-five percent of attempts were successful at capturing adult Golden Eagles on the nest (McGrady and Grant 1996). Power snares that have been modified for use on the top of wooden fence posts have been used to capture Golden Eagles (Jackman et al., pers. comm.). Potentially this trap could be used on a number of diurnal raptors, particularly scavengers such as eagles, vultures, and, perhaps, caracaras.

Walk-in Traps

Walk-in traps are large cage traps designed for the simultaneous capture of several vultures (McIlhenny 1937, Parmalee 1954; Fig. 12). Such traps are easy to construct and can be very effective when baited with carrion.

Application. Cage size varies and depends upon the number of birds living in the area and the number of birds to be captured. Cages are usually circular, but can be square or rectangular. Cage diameter can vary from 3–12 m with a height of 1.2–1.8 m (Parmalee 1954). Henckel (1982) built a successful trap 3 × 3 m, 1.8-m high that captured as many as 12 vultures daily. Ten-cm

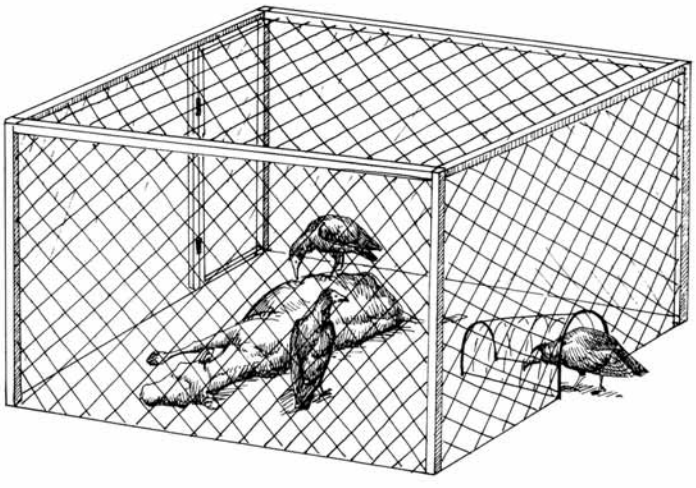

Figure 12. Walk-in trap for capturing Black Vultures (*Coragyps atratus*) and Turkey Vultures (*Cathartes aura*).

braided nylon netting is used to cover the top and sides of the trap. The bottom is left floorless. A door at one end of the cage allows the birds to enter the trap. Vultures enter through a single narrowing funnel that is difficult to exit.

This trap has been used to capture both Black Vultures and Turkey Vultures, with the former being more vulnerable (Parmalee 1954). The trap should be predator-proof, and checked every one to two days depending upon the quantity of food and water remaining. The number of birds caught in some instances is proportional to the size of the trap. In one case, approximately 210 vultures were caught simultaneously in one trap (Parmalee 1954).

We set a walk-in trap for Turkey Vultures in California three times for more than one week each and received only close fly-bys. Success was not obtained until we placed a live, non-releasable Turkey Vulture in the trap, upon which several vultures were captured the next day.

Scaled-down and baited with a tethered lure bird that cannot be killed through the side, this trap also can catch migrating Peregrine Falcons and Merlins (Meredith 1943), as well as accipiters (M. A. Jenkins, pers. comm.) and Northern Harriers. With live lures, ground predators can be a problem.

SUMMARY

Selecting the proper trap and lure for any given situation can be challenging, particularly for the novice. Quantitative studies of trap effectiveness are rare and considerable work remains to be done on this subject (Fuller and Christenson 1976, Bloom 1987, Bloom et al. 1992). The adults of many species that have never been live-trapped await experimentation with different trapping techniques.

Although we have attempted to bring together the important literature sources on trapping raptors, those who delve into the field-studies literature of specific raptors are likely to find descriptions of additional trapping techniques. Those interested in additional details should consult the references cited herein and, most importantly, seek out and gain experience with knowledgeable trappers.

ACKNOWLEDGMENTS

For 35 years a small army of raptor enthusiasts and good friends have spent considerable time assisting us with the capture of over 60,000 raptors representing 107 species of diurnal and nocturnal birds of prey. These people were tremendous in their dedication and passion to studying and conserving raptors and we thank all of you; unfortunately space does not allow proper individual recognition, but we know and you know who you are. R. Thorstrom is thanked for his insights as a trapper of tropical raptor species and for his careful review of the latest edition. J. Nagata provided the superb artwork of traps and birds.

PHB thanks Rebecca Morales for sharing in things natural and for her long-term support and encouragement of his research and conservation efforts.

PHB and WSC thank David Ferguson and the Division of International Conservation of the U.S. Fish and Wildlife Service for sponsoring our expeditions in India and Vibhu and Nikita Prakash and the Bombay Natural History Society for hosting us during our trips. WSC thanks the National Aviary in Pittsburgh, Pennsylvania for travel grants for African field work. S. Porter of Communications Specialists, Inc. is gratefully acknowledged for his support of our research and for the development of the trap transmitter and receivers we use in our studies.

Finally, we thank the many falconers, banders, and raptor biologists who, over the years, have given generously of their ideas. We dedicate this chapter to the memory of Richard R. "Butch" Olendorff who had such a strong influence on so many of us in the raptor world.

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