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Introduction

Capturing animals enables the collection of data that cannot necessarily be collected with other methods. For example, information on morphology, abundance, population status, demographics, health and reproduction can be collected from trapped animals. Additionally, trapping is often required for collection of biological samples, including scats, tissue samples and voucher specimens. This chapter details general operating procedures (GOP) for capturing terrestrial mammals, reptiles and amphibians, and capture of birds and bats with mist nets. Capture methods for aquatic animals are covered elsewhere in this book (see chapters 12–14), as are additional methods for the capture of birds (chapter 15). Capture methods are diverse; this chapter is not intended to provide an exhaustive review of techniques, but focuses on those that are often the subject of research applications to animal ethics committees. The welfare effects of these methods on study and non–target animals can be mitigated through careful planning, proper resourcing, and ensuring that personnel have appropriate training and experience.

Funnel, cage, aluminium box, pitfall and pipe traps

Helen P. Waudby, Scott Thompson, Sophie Petit, James M. Turner, David Taggart, Graham Thompson, David Hamilton, Paul D. Meek, Clare Death, Jocelyn Bentley, Judy Dunlop and Deborah S. Bower

Target taxa
This GOP applies to dasyurids (chapter 18), bandicoots, bilbies, possums, gliders and occasionally wombats (chapter 19), small wallabies and potorids (chapter 21), cats and foxes (chapter 22), rodents, rabbits and hares (chapter 24), snakes and lizards (chapter 26), and amphibians (chapter 27).

Context and scope
This GOP describes the capture of animals with funnel, cage, aluminium box (typically Elliott, Sherman or Longworth traps), dry pitfall (pitfalls), and arboreal and terrestrial pipe traps (Fig. 7.1). A range of context–dependent animal welfare considerations are associated with these trap types, but most are manageable with careful planning by experienced personnel. The effectiveness of the proposed trap design relative to its expected financial and ethical costs should be evaluated prior to undertaking work (Waudby *et al.* 2019). Trapping programs that rely on static traps left *in-situ* for a time must be designed so that sufficient resources are available for all traps to be checked in an appropriate time frame.

Figure 7.1. a) funnel traps with shade covers positioned alongside drift–net fencing (photo by Terrestrial Ecosystems); b) soft–sided cage trap often used for wallaby capture (photo by David Taggart; c) Elliott trap placed near vegetative shelter (photo by Helen P. Waudby; d) pitfall trap for capturing ground-dwelling fauna (photo by Helen P. Waudby); e) arboreal pipe trap (photo by James M. Turner); f) ground–based pipe trap for catching large dasyurids (photo by David Hamilton).

Funnel traps are used for capturing frogs and reptiles. Small mammals are occasionally caught, but often chew their way out of funnel traps. Sizes of animals caught in traps range from tiny juvenile geckoes up to snakes around 2 m in length. Davis *et al.* (2008) reported that tree–mounted funnel traps caught small arboreal geckoes and skinks effectively. Others noted that funnel traps rarely caught small ground–dwelling mammals (e.g. small rodents and dasyurids), but were effective for catching medium– and large–sized terrestrial snakes, widely–foraging, medium–sized skinks and dragon lizards, and arboreal geckos that can climb out of pitfalls (Thompson and Thompson 2007). Funnel traps consist of shade cloth stretched over a foldable sprung frame, which can be single– or double–ended, although most have openings at both ends to increase likelihood of capture. A zippered opening allows removal of captured animals. Funnel traps vary in size, but their dimensions are typically approximately 750 × 180 × 180 mm with an internal funnel entrance diameter of around 40 mm. Funnel traps are usually set alongside drift–net fencing when targeting ground–dwelling animals and may be installed with pitfall traps where they can capture species not targeted by pitfalls (Eyre *et al.* 2018).

Typically, cage traps are used for trapping larger dasyurids and rodents, possums, gliders, bandicoots, bilbies, wombats in some instances (see chapter 20 for specific considerations relating to wombats), small macropods, cats, foxes, and medium– to large–sized reptiles and mammals, including *Tiliqua* spp. Cage traps can be used to capture terrestrial animals or mounted to a tree to target arboreal mammals. Wire cage traps have either an internal treadle mechanism or a hook for attaching the bait. When either is touched, a mechanism is released that closes the door. Trap sizes and construction material (e.g. steel; aluminium; shade cloth) vary depending on the manufacturer and are target specific. Collapsible traps are available in various sizes, and in rigid wire or foldable form. Cage traps can also have soft sides to reduce facial injuries (e.g. soft–sided traps for rock wallabies; Fig. 7.1). Doors can be external or enclosed within the trap. Internal closing sprung–loaded doors are useful if traps are rolled over (cage traps with gravity–triggered doors may open if the trap is tipped upside down). For some species, such as quolls (*Dasyurus* spp.) and cats, the cage trap should be secured so that it cannot roll (i.e. pegged against a log or secured with other materials).

Dimensions of aluminium box traps vary among brands, but typical dimensions (i.e. for Elliott traps) are large (15 × 15 × 46 cm), medium (9 × 10 × 33 cm) and small (8 × 9 × 23 cm). Elliott and Sherman traps consist of aluminium sheets with an internal treadle that closes the door when an animal enters the trap and stands on it. Longworth traps are similar, but comprise a tunnel containing a hair–trigger that closes the trap when touched; a housing and bedding area is attached to the back of the tunnel. Care should be taken to file or bend sharp edges on new traps before use. Like cage traps, box traps are sometimes mounted in a tree to capture arboreal animals. Johnson (1996) described a locking mechanism to minimise the risk of certain small mammal species, such as *Phascogale,* opening the door and escaping. Pitfalls typically consist of poly–vinyl chloride (PVC) piping, rolled plastic sheets, plastic or metal buckets (Petit and Waudby 2012). The typical genera targeted by pitfalls are those of *Rattus* (mammals), *Ctenotus* (skinks), and snakes with body lengths less than the pitfall depth (Fitch 1987). Pitfalls are also used to target frogs (Willson and Gibbons 2009). In general, different pitfall designs are effective for targeting different taxa (e.g. Friend *et al.* 1989; Thompson *et al.* 2005; Waudby *et al.* 2019).

Arboreal pipe traps are mounted on tree trunks or limbs. They typically target small arboreal possums and gliders, but also scansorial species, such as *Antechinus*. The trap comprises a vertical length of PVC pipe (9 cm diameter; around 50 cm in length) fitted with an 90° elbow at either end and a 10 cm piece with a screw cap attached to the lower elbow, which acts as the capture chamber (Winning and King 2007). A small hole is drilled in the floor of the chamber for drainage. A second cap, with a small entrance hole, can be fitted to the upper elbow to target small species, such as pygmy–possums (*Cercartetus* spp.). The animal investigates the open upper elbow, falls inside and cannot climb up the smooth pipe surface.

Large terrestrial pipe traps (N. Mooney and D. Ralph, unpub. data) are designed specifically to capture Tasmanian devils, but can also target smaller dasyurids, including spotted–tailed and eastern quolls. Traps are constructed of lengths of PVC pipe (length 875 mm; depth 315 mm) with a hinged door at one end. The door contains ventilation holes, one of which lines up with a pin mechanism attached to the body of the trap; this mechanism holds the door open. A length of degradable string is tied to a piece of bait (generally lamb or macropod) and threaded through a hole in the rear of the pipe so that the bait is flush against the roof of the trap. The exterior end of the string is tied to the pin holding the door open. When the bait is pulled, the pin is removed from the door, causing it to fall and close the trap. A second pin is triggered when the door falls, which locks the door shut. Ventilation holes are also present in the closed end of the trap, and along the bottom of the body. These holes, combined with the PVC material, make the traps easy to sanitise after use (an important consideration when dealing with Tasmanian devils, which are affected by a rare, highly transmissible form of cancer – see chapter 19). Cage, aluminium box and pipe traps are baited; funnel traps and pitfalls are not. A mixture of honey and water is usually sprayed in the vicinity of arboreal pipe traps and aluminium box traps that are affixed to trees.

Animal welfare considerations

Stress, mortality or injuries from other animals caught in the same trap

One funnel or pitfall trap can catch multiple individuals and species (cage, box and pipe traps occasionally do too), which can increase stress and the risk of fatal interactions between trapped animals. Predatory invertebrates, such as beetles, centipedes and ants may also attack and kill other animals in the trap. The risk can be reduced by frequent trap checking and careful placement during installation. Pitfalls are furnished with a shelter (or several) to provide some protection to animals from one another. Invertebrates are removed from pitfalls each time they are checked and released at a reasonable distance from the trap to reduce the likelihood of recapture.

Ant–related stress or mortality

Attacks on trapped animals by ants can be an issue for all trap types, but particularly with baited traps that may attract them, and in pitfall traps in arid environments. Ant attack can cause rapid death of small vertebrates confined in a trap. Some ant species inflict painful bites and others appear to attract conspecifics when disturbed (Thompson pers. obs.). Large numbers of ants can congregate in and around traps, biting captured animals, inflicting wounds, pain and stress. Before installation, researchers scrutinise the site for the presence of large ant species, such as *Iridomyrmex*, *Camponotus*, and *Myrmecia* species, although smaller species can be problematic if present in high numbers. Traps are located away from ant nests and obvious ant trails. Ideally, an alternative site is chosen if ant nests are nearby. Underground nest sites may not be visible, and *C. terebrans*, for example, is mostly active at night, so it is useful to check for ant activity after dark. Personnel may also ‘stomp’ the ground to check for jumping ants (*Myrmecia* spp.).

It can be difficult to avoid ants altogether through strategic trap placement. Insecticides should be avoided, but are used under certain conditions (DBCA 2018). Odourless pyrethrum–based sprays may be necessary in situations where ants are ubiquitous; the effects of short–term exposure of native animals to pyrethroids are not well understood, while attacks by ants will almost certainly result in painful deaths for small trapped animals. Anecdotally, some researchers report no evidence of impact on trapped frogs and reptiles if used in small amounts (cited in Petit and Waudby 2012). However, pyrethroids may be toxic to reptiles and frogs (DBCA 2018), bioaccumulate in bats, and are considered endocrine disrupters, altering testosterone production in rats (cited in Oliveiraa *et al.* 2020), so they are not without risk. Personnel should consider the implications of off–label use, including (for example) completing a risk assessment that considers the potential exposure dose of different species based on the planned strategy of application, the species' likely sensitivity to that dose and the potential effects on the environment. The chemical's safety data sheet must be read before use.

At any rate, it can be impractical to place pyrethroid powder or spray around each trap if large numbers are affected by ants, and it is possible (although apparently untested) that using chemicals around a trap will deter animals. If used, powders should be applied sparingly and mixed through the soil around the traps. Personnel can also spray (with a weed spraying container or similar) the ground beneath the trap and then lay the trap on top of the soil, or spray the mix around a pit trap (but not in it). Doing so means that animals captured in the trap do not contact the insecticide directly, which is particularly important in a pitfall, where sand–swimming skinks would be exposed if the spray had been applied to soil inside a trap. If a particular trap–line or trap is infested repeatedly by ants, then it should be closed or moved. For pitfalls, placing a thin stem or blade of grass reaching from the base of the pitfall to its lip may allow ants and other non–target invertebrates to escape. For aluminium box traps, avoiding using honey in bait mixtures may reduce ant activity near traps.

Drowning

The risk of drowning in all of these trap types is relatively low as rain and associated surface sheet flow will flow through them, but drowning may occur if traps become inundated completely. Placing traps in ephemeral creek lines should be avoided when heavy rain is a possibility. Pitfalls and pipe traps are designed with appropriate drainage capacity. For some pitfalls (e.g. pipes), the base is fashioned from aluminium mesh or a similar material. For bucket–style pitfalls, holes are drilled into the base that are sufficiently small to prevent trapped animals (e.g. small skinks) from escaping through them. Drilling is done from inside the bucket to ensure that any lip created through drilling will not interfere with drainage. Some soil types (i.e. those rich in clay minerals) may impede drainage. Pitfalls can be furnished with objects or shelters that float and also provide shade or shelter, such as foam meat trays, stubby holders, cork disks, taking into consideration risks caused by ingestion. If rain is forecast, researchers evaluate the risk that access to traps may be prevented, or that they may flood. If doubt exists, traps are closed and reopened when the weather has cleared.

Extreme temperatures

Trap placement should always consider the best site for protection of the species during extreme conditions (e.g. avoid placing traps where they receive afternoon sun). Climatic conditions for the area are monitored regularly. The combination of rain and cool temperature, or low humidity and high temperatures can produce poor welfare outcomes (or increase death rates), so decisions are made based on expected conditions and the physiology of animals likely to be captured. Death from overheating or desiccation may occur in pitfalls when ambient temperatures reach 40°C (or less for some species) and if trapped small mammals are very active in the trap, raising their body temperature (e.g. Read *et al.* 2016). However, trap microclimate can be much higher than ambient, particularly in aluminium box traps that are not completely in the shade. Heat radiating from the ground into traps should also be considered. If forecast temperatures exceed 40°C, researchers consider closing their pitfalls (although capture rates of some species increase during hotter temperatures; Read *et al.* 2016) or increasing the number of daily checks and providing water if it does not attract undesirable species in a particular area.

In some cases, funnel traps can be placed either under or on the southern and western edges of vegetation. If opened during the day in warmer weather, aluminium box traps and wire cage traps require a shade cover unless they are placed under vegetation where they receive constant shade. Moveable traps can be placed in or near vegetation or provided with additional shade. Shades can consist of vegetative material (branches; leaves) or artificial materials (shade cloth; hessian; air–cell glare shield). For funnel traps, using two shade–cloth or jute/hessian bag covers may reduce temperatures and prolong the period before trap temperatures reach potentially lethal levels (Thompson and Thompson 2009). However, wrapping the entire funnel or cage trap might result in limited airflow, increasing the internal ambient temperature instead of allowing it to disperse. Shade should cover one end of the funnel, as animals tend to hide in a corner of the trap rather than in the middle, even if the shade is centred evenly across the trap.

Shades may be added to pitfall traps to reduce internal temperatures, but they may affect capture rates (Thompson and Thompson 2005). A layer of sand or soil in the bottom of pitfalls provides shelter for fossorial reptiles. A wet sponge or other moist substrate may increase survival, particularly of frogs. The sponge should be monitored to ensure that it does not attract ants (Read *et al.* 2016 and references therein) and may dry quickly, becoming ineffective. Pitfalls should always contain a shelter that will reduce solar radiation and buffer cool overnight temperatures (Petit and Waudby 2012). Bedding (e.g. coconut fibre; wool; square of neoprene or polar fleece; sleeping bag filling) should always be placed in aluminium box traps for small mammals, although in some cases investigators may avoid materials with loose fibres because animals may catch their feet on them. Closed cell foam sheets can be placed underneath box traps to insulate them from the ground and traps can be placed inside a plastic bag to protect them from precipitation or dew. If low overnight temperatures are likely to affect animals, researchers consider closing traps earlier in the evening (Tasker and Dickman 2001; Waudby *et al.* 2019). Aluminium box traps heat quickly, and must be always shaded completely in warm weather (either by vegetation or with heavy jute bags);

Exposure to predators

Currawongs, magpies, goannas, snakes, dingoes, foxes, and cats may be attracted to trap sites (Petit and Waudby 2012). Some carnivorous marsupials, such as *Dasycercus* spp., will enter pitfalls to eat trapped animals (Dickman pers. comm. in Petit and Waudby 2012). Deep pitfalls (≥ 60 cm) may offer protection from large predators and reduce escapes, especially when combined with a funnel and jar capture point (see Doughty *et al.* 2011). However, ghost bats can enter 65 cm deep pitfalls to prey on trapped rodents, becoming caught themselves (Diete *et al.* 2016). All trap types may be tampered with by larger predators and some corvids may learn to remove pins from box traps. In these scenarios, traps may need to be secured to the ground in some way or trapping ceased if the problem continues. Shelters in pitfalls may provide some protection to trapped animals. Personnel do not discard food or other waste (including body waste) in proximity to trap sites to avoid attracting predators. Similarly, animals that are being released may become easy targets for watching predators if disorientated or in a panic to escape. In an extreme case, one author observed a released *Melomys* sp. run directly into the mouth of a goanna that was following her down the trap line. Predators may need to be chased away or the animal held until the predators have left, in these situations. Ultimately, researchers monitor and evaluate the situation and consider if a trapping site should be closed because of predation. Wildlife monitoring cameras trained on trap arrays may help to detect trap interference.

Repeated recaptures

Trapping may increase stress in study animals, resulting in reduced body mass, and increased corticosterone levels (e.g. Pearson *et al.* 2003; Bosson *et al.* 2012). Little research has been undertaken on the long–term impacts of repeated recaptures on individual animals' welfare. Researchers mark animals (permanently or temporarily depending on their objectives) to clarify recapture rates, and are alert to signs of stress (e.g. reduced body mass between sessions). Recaptured animals are released immediately. In cases where recapture rates are high, researchers consider if sufficient data have been collected, and close the site. Typically, trapping should be paused temporarily after three to four days and nights if recapture rates are high (Tasker and Dickman 2001; C. Pavey pers. comm. in Petit and Waudby 2012) or ceased if personnel deem that sufficient data have been collected to meet the study objectives. Some researchers release recaptured animals on the opposite side of the pitfall drift fence to their initial release location in the hope that it may reduce the likelihood of recapture because they are not trying to return to a shelter, burrow, or territory on the other side of the fence (Petit and Waudby 2012). Recapturing lactating females may affect dependent young. Avoiding trapping in the seasons where animals have large pouch young, dens or nests helps to minimise impact.

Disruptions to natural activities

Small mammals that are removed from traps with obvious signs of nursing (extended teats sometimes with dried milk visible or an open pouch) or with pouch young present are processed immediately and released undercover 20–40m from the point of capture. Traps that recapture the same lactating female repeatedly within a session may be closed (DBCA 2018) or the animal taken further away in the opposite direction. Where females are caught in traps with young at foot, the individuals should be kept together, and released together. Some small mammal species with high energetic requirements (e.g. honey possums, *Tarsipes rostratus*) may need to be fed a sugar solution prior to release (DBCA 2018).

Capture of non–target species
All trap types often catch non–target species. For pitfalls, choosing the most appropriate pitfall design for the target species reduces the likelihood of non–target capture (Waudby *et al.* 2019). Non–target species are released as soon as possible into habitat that provides some initial protection to give them time to adjust, and typically approximately 20–40 m from the trap.

Injury from falling into pitfalls or moving traps
Injury from falling into a pitfall appears to be rare (or at least difficult to determine), but it may be a greater risk with deep pitfalls (i.e. over 40 cm in depth). Providing a layer of sand or a soft substrate in the bottom of the pitfall trap may assist in reducing the risk. Cage and terrestrial pipe traps should be secured properly. In particular, tubular pipe traps can roll around if not secured, causing considerable stress to trapped animals. Similarly, Tasmanian devils are strong and may attempt to get into a closed trap with an animal in it, dislodging the trap in the process unless it is well secured. These traps can be secured by being placed between trees, or by securing them between rocks on both sides so that they do not roll.

Poor funnel trap clearance
Small reptiles and a range of invertebrates can hide under the funnels, so it is important that the zipper is opened, and the funnel traps properly searched for animals. It is recommended that funnels are picked up and looked through to search corners, to avoid small reptiles going undetected. Occasionally, large snakes will retreat either under the shade cover, between the funnel and the drift fence or under the funnel trap.

General procedures

Planning
Personnel should identify their target species or taxa, an appropriate trap type and design, trapping array, and suitable sites that will deliver study objectives, but also where hazards (such as ants) appear low. Personnel should evaluate the anticipated effectiveness of the proposed design relative to its financial and ethical costs beforehand (Waudby *et al.* 2019). Personnel should design their study in such a way to ensure that they can check all open multi–catch traps (e.g. pitfall traps) with appropriate frequency (ideally twice per day) with the resources they will have available to them. Single–catch traps can be closed during the day following trap checks, and reopened late in the afternoon, although this requirement is context– and species–specific, and researchers may leave traps open if risks to animal welfare are low. For example, pipe and cage traps used for Tasmanian devils and quolls are typically left open for 24 h periods and only checked once, in the morning, because risks from overheating, hypothermia and starving are less than for smaller species (see chapter 19 for further details) and traps are generally not targeted by devils or quolls at these times (D. Hamilton, unpublished data). However, capture myopathy may be a risk for species that are prone to it if they are caught soon after trap checks and not removed until the next check. At any rate, personnel should evaluate the likelihood and degree of welfare impacts for target and non–target species versus the anticipated scientific benefits, if leaving traps open for 24 h periods. If checking traps once per 24–hour period, adequate bedding and food

should be provided. Decisions should not be made based purely on logistical constraints.

Ideally, personnel identify the anticipated location of trapping sites before commencing field work. The specific location of each trap is determined in the field. Selecting an appropriate location based on vegetation cover and shade is important for aluminium box and wire cage traps. In warmer months, personnel should place traps where they will receive the least amount of direct sunlight (if left open at any point during the day).

Installing traps
Traps are usually deployed in a systematic manner so that they can be easily located and checked. Personnel mark and record the location of each individual trap (preferably with a GPS) and the general site location. Reflective tape on trees or long pieces of flagging tape (with trap site details written on them) assist with locating traps and sites at night. However, personnel should ensure that marking sites in this way will not interfere with (for example) land management activities (i.e. different combinations of coloured flagging tape can be used to demarcate logging coupes or similar on some tenures).

Funnel traps are typically placed in pairs on either side of a flywire drift fence and secured to the fence. Various configurations have been tested for drift fences and funnel traps (e.g. even trap spacing along a transect line; a 'T' or 'Y' formation); personnel select one appropriate to their study objectives. Funnel traps are typically spaced along drift fences in pairs and secured to the drift fence with bulldog clips. For funnel traps, a ramp of substrate is placed at the entrance to each funnel to provide a smooth transition from the substrate into the funnel for animals moving along the drift fence. Two shade cloth covers are placed over funnel traps in warm to hot weather and a single shade cloth cover in cooler conditions.

When conducting ground–based trapping, personnel set aluminium box and cage traps on firm flat bases to minimise movement of the trap, which will discourage animals from entering it. For trapping arboreal species, box traps are typically mounted on platforms fixed to trees or branches; pipe traps are attached to platforms with wire or metal brackets with the entrance facing the tree trunk. Once aluminium box and wire cage traps are set, personnel check the mechanism operation to ensure that the door closes properly and is free from obstructions. For wire cage traps, substrate is often placed in the bottom of the cage, to minimise the animal walking on wire mesh and encourage it to enter the cage. Terrestrial pipe traps should be secured on flat ground with trees or rocks lining both sides of the trap. The entrance and rear of these traps must be flush with the ground so that the trap does not tip if an animal puts its weight on either end. Traps should be set along runways, near crevices, logs or tree roots, or under vegetation cover (Tasker and Dickman 2002).

Traps are baited with an attractant appropriate to the target animals. Bait should be fresh and not contain pathogenic organisms (i.e. honey is not used by some agencies because it may contain microorganisms as well as attracting ants). Peanut butter and oats are used for many species, but bait should be biologically suitable for the target species. Bait should not be discarded in the field or moved between sites

(Eyre *et al.* 2018) and ingredients that may germinate should be rendered inert before use to avoid the risk of weed invasion. For some taxa, particularly those with high metabolic demands (e.g. small dasyurids and pygmy–possums), providing sufficient and appropriate bait may reduce impacts on individuals substantially, particularly those that are recaptured repeatedly or in particularly cold weather. Anecdotally, doing so may contribute to reduced mortality, particularly if trapping in years when animals are in poor condition (J. Bentley pers. obs.).

Personnel should dig holes and insert pitfalls so that the edge is level with the ground, and the pitfall lip is not visible. Pitfall lines may be arranged in any manner that fulfils the study objectives, but personnel avoid placing curves or sharp angles in drift–net fencing. Angles may direct animals away from the trap line and change the area that is being sampled, which is an issue if multiple sites are being compared. If used, driftnet fencing is placed over the centre of each pitfall in a continuous line and held in place by steel pegs. Driftnet may consist of fine aluminium mesh ('fly wire'), plastic sheeting (often black), or shade cloth, and should be maintained regularly. Driftnet increases capture rates for many species caught in pitfalls (Petit and Waudby 2012 and references therein). Funnels or cones, inserted into the top of the pitfall, may increase capture success for some mammal species (e.g. hopping mice), or a board or other flat cover placed over the pitfall, but elevated just slightly, may be useful for targeting snakes (Fitch 1987). Numbers are written inside the pitfalls to assist with recording data.

Traps must be provided with sufficient bedding and/or shelters, which may need to be increased during particularly cold conditions. Importantly, aluminium box traps should contain bedding that prevents the animal from coming into contact with the trap's cold metal floor. See additional comments under 'Animal welfare considerations'.

Trapping times and duration

Trapping times depend on the study objectives and ecology of the target species. Similarly, trapping duration varies depending on the selected method, habitat, target species and objectives. Typically, three–five consecutive nights are recommended for threatened mammals (DSEWPAC 2011a), although additional species may be detected if trapping operates for longer in some environments (Moseby and Read 2001), and monitoring of Tasmanian devils is typically conducted over seven–10 nights (the point at which capture rates of new individuals start to diminish).

All trap types can be left open for 24 h periods if required, providing that personnel plan for an appropriate checking regime, which should focus on animal welfare and integrity of data collection rather than logistical constraints. Personnel design their study in such a way to ensure that they can check all traps comfortably and with appropriate frequency with the resources they will have available to them. Typically, traps should be checked at least twice if left open for 24 h (i.e. in the morning and in the late afternoon or early evening), although this requirement is context– and species–specific (see 'Planning'). If researchers propose once per day checks then they have a reasonable level of confidence that welfare of target and non–target species will not be compromised and that any potential risk is outweighed by the scientific benefits. Checking traps regularly allows personnel to replenish bait regularly, which may be eaten by ants and non–target vertebrates, to release non–target species, and to reduce the time of captivity in the traps.

In very hot weather, traps are checked more frequently to minimise heat stress and desiccation, or they are closed if doing so is not possible. Similarly, in cold weather, traps may be checked more frequently or during the night to minimise the time animals are contained in a trap or closed earlier in the night. Checking time will vary depending on the local conditions and study objectives. Personnel may check traps close to dawn (prior to sunrise) to remove and release nocturnal animals while light levels are still relatively low. However, checking traps early in the morning can result in crepuscular animals that are active early in the day being caught early in the morning and then remaining in the traps during the midday heat. Providing internal shelters and bedding material, and external shelters or shades, and increasing checks of traps during warmer weather minimises this risk.

Checking traps and removing animals
Personnel should record trap shut and open times consistently, so that trap effort can be calculated accurately. A designated person should ensure that all traps are accounted for during each check by maintaining a tally or check list (DBCA 2018). Personnel confirm what type of animal is in a trap before they attempt to remove it and confirm if it is a venomous snake. Personnel may be able to see scales or fur through the gaps in the sides of aluminium box traps without picking it up. Animals caught in box or pipe traps can be confirmed by lowering the door of the box trap slightly or tilting the screw cap on a pipe trap and looking through the gap, although care should be taken to ensure the animal does not attempt to leap through the gap. Often the trap's weight (or smell in the case of Tasmanian devils) will provide an indication of what might have been caught. Closed arboreal box traps may need to be detached from the platform or branch for checking. Personnel should check pitfalls carefully before reaching into a pitfall (a head torch may be necessary for deep pitfalls) and use long–handled tongs to examine shelters and under substrate. In general, personnel should check pitfall traps meticulously, including sifting through sand inside the pitfall, to ensure that small species like centipedes, scorpions, and fossorial reptiles (e.g. *Lerista* and *Menetia* species), are not missed. The latter are over–represented in mortalities (Read *et al.* 2016; H. Waudby pers. obs.). Invertebrates are removed (an insect aspirator can be used if necessary).

Gloves may be worn to remove animals from traps and during handling, but some handlers believe that doing so reduces sensation and the ability to handle animals appropriately. Where disease transmission between target animals is a consideration (e.g. when working with Tasmanian devils or amphibians) then sterile gloves must be worn throughout the process. For box, cage and pipe traps, placing an appropriately sized catch bag over the trap entrance and encouraging the animal into the bag can be used to secure medium–sized captured animals. If animals are removed from a trap by hand, they are grasped gently, but firmly, and placed immediately into a clean calico trap bag with the seams turned inside out to avoid claws or teeth snagging on them. Only one animal should be placed in each bag, and bags are preferably not reused for a new animal until they have been washed, to avoid parasite and disease transfer. It is important that animals cannot see through the bag that they are being transferred into for handling, and that this bag is placed securely in a cool, dark or shaded location prior to processing. Animals typically remain very quiet once bagged and placed in a shaded and dark location.

Animals can be processed at the site or transported to a central processing area. If transported, animals should be kept in their tightly closed and labelled (masking tape can be used for labelling) calico bags, but placed inside a hard container, such as a plastic aquarium or large bucket, to avoid accidental squashing. Unless the animal is very small, it is generally easiest to measure, sex and assess an animal in a catch bag and probably less stressful for the animal than to hold it outside of the bag during processing. Keeping animals' eyes covered at all times (or as much as possible) during processing will reduce animal and handler stress significantly. For appropriate handling techniques for each taxon, refer to the appropriate chapters in Section 3.

Animals must be released not far from their point of capture. Exact distances will depend on the species and environment, but small rodents, dasyurids and reptiles generally should be released 20–40 m from the trap site. All trapped animals should be released near shelter and observed until they access it. Personnel should be aware of any potential predators. See recommendations under 'Animal welfare considerations'.

Removing traps
Personnel should always count and record the number of box, cage and pipe traps deployed and retrieved. Each trap location should be recorded with a GPS. It is very easy to miss a trap, so this step should not be skipped. Pitfalls may be left closed *in-situ* if they are to be used again. Pitfalls that are used regularly are furnished with a stick that reaches from the bottom of the pitfall to its lip, but does not prevent the lid from being closed. The stick may help some animals escape if the lid becomes compromised. Lids must fit the trap properly, be fastened on securely, and checked regularly to ensure that they are in good working order. Plastic lids will perish more quickly than PVC screw–on lids and should be checked periodically. A layer of soil placed over lids between sessions extends their integrity. Placing stones or dead branches over the trap may help locate it in the future and deter large animals from walking over it. Traps that are left for extended periods (e.g. more than six months depending on the environment) are filled with sandbags, soil (with care not to introduce animals into the traps), rocks, or another substrate and the lid replaced securely (clicked in or screwed on). Where hard–hoofed ungulates are present, pitfalls may need metal lids. All equipment moved between sites is cleaned and disinfected before reuse, including in areas affected by dieback *Phytophthora cinnamomi* (DBCA 2018). Researchers should articulate their plan for maintenance and/or removal.

Hygiene
Personnel should wash catch bags after every field trip. For species where disease transmission is a major concern (Tasmanian devils and amphibians), catch bags will need to be single use. Ideally, catch bags are used for one animal before being retired for washing, and allowed to dry completely in the sun before reuse. However, where doing so is not feasible, bags that have held animals with obvious external parasites are quarantined and washed after a single use. Ticks and mites will not necessarily die in a warm water wash, so where animals have ticks, catch bags will

need to be checked and ticks removed and killed, although eggs and microscopic life stages will not be visible. Bags can be immersed in methylated spirits or 70% alcohol to kill parasites, but must be washed and dried before use. Aluminium box traps are washed and disinfected after each trapping session. Funnel traps will need to be inspected to remove seeds, vegetation, and dead insects before they are reused. Wire cage traps need to be checked to ensure all remnant bait and vegetation is removed and traps are clean. Terrestrial pipe traps being used to target Tasmanian devils are cleaned thoroughly and sanitised with veterinary disinfectant (F10) after every animal capture, and again at the end of the trip. Personnel should consider the risk of transmission of anthropozoonoses to study animals and prepare accordingly; consulting with Wildlife Health Australia may assist with preparedness.

Animal treatment, withdrawal and euthanasia

Researchers monitor the situation continually. Personnel make a decision to euthanise injured animals based on likelihood of survival, anticipated additional pain and stress if treatment is sought (i.e. a veterinarian), and skill set of personnel. Injured animals that are unlikely to survive if released are euthanised by experienced personnel (or those under the supervision of experienced personnel) in line with accepted published procedures and protocols (see relevant species chapters). If capture numbers are high and traps cannot be checked in a timely manner (context specific), then either all or some traps are closed temporarily. Trapping may cease temporarily in very hot or cold weather, during rain, or if personnel anticipate that trap sites may become inaccessible (i.e. because of predicted flooding or bushfire).

Equipment and maintenance

The equipment required will vary depending on the target species or taxon, local environment, and study objectives. Typical items are listed in Table 7.1. All traps should be scrutinised prior to installation and again as they are packed away to ensure that they are in good working order. Doing so is important to minimise the hazard that traps pose to animals, but also to ensure that they are working properly and collecting useable data. Aluminium box traps are susceptible to being bent out of shape and should be assessed regularly to ensure that the release mechanism remains sufficiently sensitive to trap target animals. Pitfall traps left *in-situ* are assessed during each trapping session or every 12 months to ensure that they are not deteriorating and presenting a hazard to animals between trapping sessions. All traps and equipment used to install traps should be cleaned and disinfected before being used at sites and between each trapping session (in the case of removable traps), to minimise the risk of spreading pathogens such as chytrid fungus (*Batrachochytrium dendrobatidis*), *P. cinnamomi* and diseases such as Tasmanian devil facial tumour disease.

Table 7.1. Suggested equipment and materials required for the installation and operation of funnel, cage, aluminium box, pitfall, and arboreal and ground–based pipe traps.

Installing and opening traps	**Checking traps**	**Processing animals**	**Maintenance and closing**
Traps Covers/shades for traps	Gloves Insect aspirator Long–handled tongs	Calipers Clear plastic ruler Scales	Spare drift–fence and pegs for repairs

Drift fences for attaching to funnel traps Mattock or similar for creating drift–fence trenches Flagging tape Global positioning system Permanent marker or grey lead pencil Drift–net fencing and pegs for pitfall traps Digging implements Crowbar Shelters Bedding material for box and pipe traps Closed cell foam mats and plastic bags for box traps Pitfall shades Floating substrate Moist substrate Flagging or reflective tape Poles or star pickets for marking sites and traps Compass Bait for box and cage traps	Snake hook Head torch Identification books and reference material Soup ladles or scoops	Calico bags (dark / opaque) Clipboards and data sheets Previously collected data Animal identification guides Animal marking implements Solid container for animal transportation Permanent marker / grey led pencil Masking tape String Vials for samples 70–90% alcohol for disinfection of equipment and sample preservation snap lock bags Hand–lens or magnifying glass Face mask Hand wash Disinfectant or sanitiser for hands or gloves	Equipment and ties for rolling up and securing drift fencing Sandbags or similar Shovels Spare pitfall lids Spare traps Sticks that fit inside length of pitfalls Equipment for trap maintenance Cable ties

Specific qualifications, experience and training

The skills required to undertake trapping–based studies vary depending on sensitivity of the study species to the presence of humans and disturbance, and the nature of the study. Ideally, the primary investigator should be competent in the technique proposed, and in procedures for setting and clearing traps. They should be very familiar with the species or similar taxa, having undertaken similar work (including capture and handling). Ideally, at least someone in the team should have experience in removing animals (particularly venomous snakes) from traps and in handling that or a similar species, to teach and supervise others.

Workplace health and safety

Bites, scratches, and stings

Tucking pants into socks and checking clothes and body for ticks and mites is important following field work. A dedicated first–aid kit for bites and stings is kept close by, and personnel carry sufficient snake–bite bandages. When checking pitfalls, the risk of being bitten, scratched, or stung by trapped animals is minimised by checking the base of traps carefully with a tool, such as long–handled tongs, before reaching in to remove animals. Tongs are used to check the soil for animals, including venomous snakes and invertebrates. Shelters are checked by holding them with a set of tongs. Long–handled tongs are useful for checking deep pitfalls. Ladles or scoops are used to remove invertebrates such as spiders and scorpions. Personnel may use a head torch to see into the bottom of deep and narrow pitfalls. Personnel may wear gloves to avoid bites, but doing so may reduce sensation and their capacity to handle animals effectively.

All traps will potentially catch large snakes. For funnel traps, leaving the zipper open for a brief period will often be sufficient for the snake to vacate the trap of its own accord, which is the safest strategy. Snakes that feel threatened will often search the funnel trap rapidly for an exit and may find one of the openings at the end of the funnel. In this case they often leave the funnel quickly and to the surprise of the researcher. Removing the wire pin that holds an Elliott trap together is the safest strategy for releasing snakes from aluminium box traps. Propping the door of a wire cage trap open and allowing the snake to leave of its own accord is the safest strategy. The screw cap of pipe traps can be removed, and the capture chamber left open. Snakes should be removed from pitfalls by experienced personnel. If removal by hand is unnecessary, snakes can be removed with a snake hook or similar.

Manual handling (digging and leaning over)
Personnel follow standard procedures for manual handling. Only personnel who are sufficiently fit and healthy should install and check traps. Installation of pitfalls in particular can require considerable exertion, particularly if being installed manually.

Alternative procedures
The trapping methods described in this GOP are used to answer questions about the presence/absence, abundance, and/or population demographics of small and often cryptic animals. It can be difficult to answer such questions without capturing the species of interest. However, researchers should consider if study questions could be answered with remote monitoring equipment or indirect detection methods (see chapters 4 and 5).

Mist nets, harp traps and triplining for birds and bats

David Watson, Lindy Lumsden and Sophie Petit

Target taxa
This GOP applies to microbats and megabats (chapter 23), and smaller bird species, including a number of passerine groups (chapter 33).

Context and scope
This GOP describes the use of mist nets for the capture of birds and bats, and the use of harp traps and triplining for the capture of bats. Most birds and all bats use active flight for locomotion, with the requisite energetic demands affecting most aspects of their anatomy, ecology and life history. Powered flight affords birds and bats access to locations and resources beyond the reach of other vertebrates, but also adds to the challenge of studying them. While many aspects of bird ecology and behaviour can be gleaned from observational work, bats exhibit far less morphological variation, even between families. This conservatism, coupled with their nocturnal habits, means that research involving bats often relies on their capture (although monitoring increasingly uses acoustic recorders, chapter 6). A variety of nets and traps are used to capture these animals, with mist nets the most widely used method for birds. In Australia, microbats are mostly caught using harp traps, although mist nets and triplining are useful in some environments and for some species. Flying–foxes are caught using both mist nets and mega harp traps. These methods are regulated by federal and state legislation and require considerable training to ensure they are deployed correctly and that trapped animals

are freed, handled, processed and released in ways that minimise ethical and welfare impacts.

Animal welfare considerations

Entanglement and physical damage

Mist nets and harp traps are passive capture devices that intercept actively flying animals and hold them safely until they are removed by experienced handlers. Harp traps have been designed to capture and hold bats for extended periods (often deployed overnight), whereas mist nets require active checking to remove captured animals. A correctly set microbat harp trap should not entangle bats – rather, the 'harp' of taut monofilament fishing line intercepts bats in flight, they then slide down into the canvas bag below and crawl beneath the overhanging plastic sheet (Tidemann and Woodside 1978). For megabat harp traps individuals slide down the wire cables and are caught by hand at the base (Tidemann and Loughland 1993).

Mist nets catch animals in flight. Animals become suspended in the net, their weight supported by the netting and tensioned shelf strings. The longer an animal remains in the net, the more likely it is to struggle, becoming further entangled and attracting the attention of predators. When extracting animals from mist nets, particular care is needed with the wings of bats and the legs of birds, both of which have fine delicate bones and can become snarled in the net. Also, many birds protrude their tongues while calling and panting – for honeyeaters and other birds with arrow–shaped tongues, netting can become caught around the base of the tongue, which is best removed with an awl while the bird's body is supported.

Triplining, which is often used in conjunction with mist netting, involves tautly stretching multiple strands of fine fishing line parallel to the surface of the water, several centimetres above it (Churchill 2008). As bats fly down to drink, they trip on the fishing line and fall into the water. Most species are unable to take off from the water's surface and need to swim to shore, where they can be collected by hand. This technique should only be used where the water's edge is clear from vegetation so that the bats do not become entangled in vegetation and are obvious when the reach the shore. Care needs to be taken to ensure personnel do not stand on bats that are still on the ground. Bats and birds can easily become tangled on loose threads on the inside of catch bags. Before using cloth bags for holding live animals, personnel ensure the seams are on the outside and any loose thread inside has been removed, or use bags with double seams.

Disruption to dependent young

When animals are caught, their behaviours are disrupted, which can affect the trapped individual and dependent young. When using harp traps to capture bats it is good practice to check the trap at least once during the night, so that any bats caught early in the night can be released and resume foraging. During the breeding season when females are lactating, harp traps should be checked multiple times during the night and closed several hours before dawn to allow sufficient time for processing and release before dawn, so that females can return to their young. As roosts may be a considerable distance from the capture point (e.g. up to 12 km for long–eared bats and wattled bats, Lumsden *et al.* 2002), personnel should allow sufficient time for this return flight.

Exposure
Birds caught in mist nets are less able to regulate their temperature, with their feathers disrupted and their position relative to sun and shade, wind and rain constrained. For most applications, mist nets should be set in the shade and not be deployed in inclement or hot (>30°C) weather. Harp traps provide greater protection for microbats from wind and rain, and their ability to enter torpor enables them to tolerate colder temperatures. However, if left in traps during the day they can be exposed to extremely hot temperatures (Ellis 2016), so traps left open all night should be checked early in the morning before temperatures rise. The fur of bats caught using triplining will be wet and must be dried before release. As this technique is typically used on warm nights, drying usually occurs while they are held in cloth bags awaiting processing. Mist nets can be furled temporarily, which is advisable if a large number of animals are caught or if conditions become inclement (Keyes and Grue 1982). Harp traps can accommodate many individuals and the only time that traps would need to be temporarily moved to reduce overcrowding is when set at a roost (e.g. cave entrance). Bats should not be released during the day, so if any traps are checked after first light, trapped individuals must be kept secure until dusk (see chapter 24).

Predators
Predators may be attracted to animals caught in mist nets or harp traps. In addition to harming or killing captured animals, predators can also become caught. When locating mist nets and harp traps, give careful consideration to the local predator community. If predators seem to be attracted to captured animals, increase checking frequency. If the issue remains, relocate the mist net or harp trap. If an owl is observed targeting sites where bats are released, move several hundred metres away, or hold the bat for an hour or so until the owl loses interest. Ensure no potential runways are present, such as logs that lead up to the harp trap hips that would give terrestrial animals (e.g. rats) access to the bag (Lumsden 1989).

Bycatch
While the likelihood of capturing target species can be greatly increased by careful placement, these methods can catch non–target species, including animals like snakes and large insects, which can be difficult to extract from mist nets unharmed. When targeting bats, keep mist nets furled until dusk to avoid catching diurnal birds. Harp traps will occasionally catch birds; however, bycatch is usually very low (e.g. less than 0.1% of captures, L. Lumsden unpublished data). Large animals like kangaroos and cattle can stumble into nets or harp traps, rarely becoming captured for long, but invariably rendering the equipment unusable. By ensuring the lower shelf of the mist net is well clear of the ground or water and staying away from animal track–ways, bycatch can be minimised.

General procedures
Mist nets, triplining and harp traps are used to catch free–flying animals, so the likelihood of the target species being captured is enhanced by observing their habits and noting those areas that are frequently used or consistently avoided. Nectarivorous and frugivorous species focus their foraging activities around food plants in full flower and full fruit (respectively). Many arid–zone species are attracted to standing water for drinking, bathing and foraging. When capturing bats, harp traps are regarded as less stressful (to both personnel and bats), but mist nets are

preferred for some groups (e.g. bats with fluttering flight in the Hipposideridae and Rhinolophidae, and large–bodied bats in the Megadermatidae that chew through harp trap bags), contexts (over water or upper canopy deployment) or situations (remote fieldwork with space and weight restrictions for equipment; Francis 1989). Although these methods are non–selective, the likelihood of capturing particular target species (of both birds and bats) can be enhanced with judicious placement (next to known roosts, near favoured resources or in flight paths) or use of acoustic lures. The use of acoustic lures to increase trap success of microbats in harp traps is an emerging technique in Australia, which is showing promising results (Hill *et al.* 2015).

Mist nets

Personnel spend time in target areas to decide where best to place nets (Fig. 7.2). Animal trails and ant nests are avoided and fallen sticks and low branches cleared within approximately one metre either side of the intended mist net location. Personnel choose the most appropriate mesh size for the target species. For most work on small to medium–sized birds, 32 mm mesh size is ideal, while 24 mm mesh size is recommended if target species are very small birds, and 60 mm mesh size for larger songbirds (Pardieck and Waide 1992). Finer monofilament mist nets are typically used for catching microbats. Personnel erect the net, ensuring that the bottom shelf would remain well clear of the ground, even with a captured bird, unless targeting ground–active bird species. Nets are tensioned so that the shelf strings are tight – the fine nylon mesh will naturally billow to support captured animals. Personnel check that the shelves of the net are spaced correctly by ensuring the cords at either end of the net (perpendicular to the shelf strings) are taut. When mist netting for birds, once nets are set, personnel stay away from the nets to minimise disturbance. For birds, nets are checked every 20–30 min, or more frequently if conditions are damp or windy (Ralph *et al.* 1993). If check times take >20 min, personnel remove and process all trapped animals, and furl some nets immediately to reduce capture rates and removal times. To check nets, it is essential to know on what side of the net the animal was caught. Personnel approach each net and examine the ground beneath it, then grasp the net mesh beneath each shelf string and enclose the body and wings of the animals to minimise risk of injury to animal and handler. A seam ripper or fine scissors should always be available when checking nets. If an animal is visibly stressed and unable to be extracted quickly from the net, personnel should cut a strand or two to expedite removal, being careful to ensure no loose threads are left attached to the animal (Spotswood *et al.* 2012).

Figure 7.2. A mist net deployed for birds, set poorly (a) and properly (b). Rather than position the net across an animal trail in direct sunlight, it should be located in the shade adjacent to a high visitation area – in this case, between two nectar–bearing plants. Instead of leaning into branches with the base touching the ground and catching on sticks, the net should be at least 300 mm clear of vegetation either side of the net and the bottom shelf. Rather than sagging from a flimsy cane and a bright single guy rope, the net should be tensioned from a sturdy pole secured with two dull–coloured guy ropes, shelf strings evenly spaced. Note the personnel wearing dark clothing without external fasteners – buttons readily catch on mist nets and are difficult to remove. Photos by David Watson.

Bats can chew their way out of a monofilament net in less than a minute, or alternatively become very tangled if left longer. When mist netting for microbats, nets are checked every 1–5 min, so an appropriate number of nets and personnel, and the time to check nets are considered during planning. A bat detector can alert personnel to a bat flying near and colliding with the nets and then a light is shone along the length of each net to check for bats. Similarly to birds, individuals should be extracted from the side of the net they entered, freeing the tail and feet first. When mist netting for flying–foxes two people should be present, one to restrain the bat (one hand around neck, another holding the body) and the other to untangle it.

Triplining

Triplining is most effective at small bodies of water in dry or arid areas with little other water nearby, and in hot weather when bats are more likely to come down to drink. The banks of the water body should be free of vegetation and only gently sloping. Fishing line should be stretched across the water in parallel lines approximately 2 m apart and pulled tightly to prevent sagging. The fishing line is held in place by wrapping it around tent pegs or sturdy sticks stuck into the ground at the edge of the water. Triplines need to be monitored continually. A bat detector can alert personnel to a bat in the area and the sound of a bat plopping into the water is the signal to turn the light on to see where it has landed. At least two people are needed for this technique with one person on either side of the water body. One person shines a light at the bat, which results in it swimming in the opposite direction, towards the second person who keeps their light off until the bat reaches the shore, where it is quickly picked up. Having only one light shining on the bat reduces the risk of it swimming in circles, which occurs if a light is shone from both sides. Bats are surprisingly good swimmers; however, it is important to reduce the amount of time the bat is in the water. Personnel need to be prepared to wade into the water to rescue a bat on the rare occasion that one gets into difficulty.

Harp traps

While bats are nocturnal, harp traps are best set up by two people in the late afternoon. When choosing trapping locations, look for positions that act as natural funnels such as along tracks, gaps between trees, creek–lines or gullies (Fig. 7.3). Optimal trapping locations have dense vegetation either side and above the trap (Churchill 2008). As with mist nets, harp traps need to be tensioned correctly—too taut and flying bats will bounce off the fishing line; too loose and the bats will fly straight through. When tying the canvas bag, pull the sides in firmly so that there is only a narrow gap between the plastic sheets through which the bats slide into the bag, to prevent bats subsequently escaping. For deployment over water, ensure the bag is well clear of the surface, allowing for sudden changes in water depth. Use guy ropes to securely stabilise the trap to prevent it blowing over in the wind. If set at the entrances to mines and caves, harp traps should be monitored continually so that traps can be moved out of the flight path or individuals removed promptly to prevent overcrowding if large numbers are caught. Harp traps are positioned well away from ant nests. When checking the harp trap, personnel need to ensure all corners of the bag are checked thoroughly so that no bats are missed. When dismantling the trap, take the bag off and thoroughly check all areas again, then invert the bag and shake out any debris.

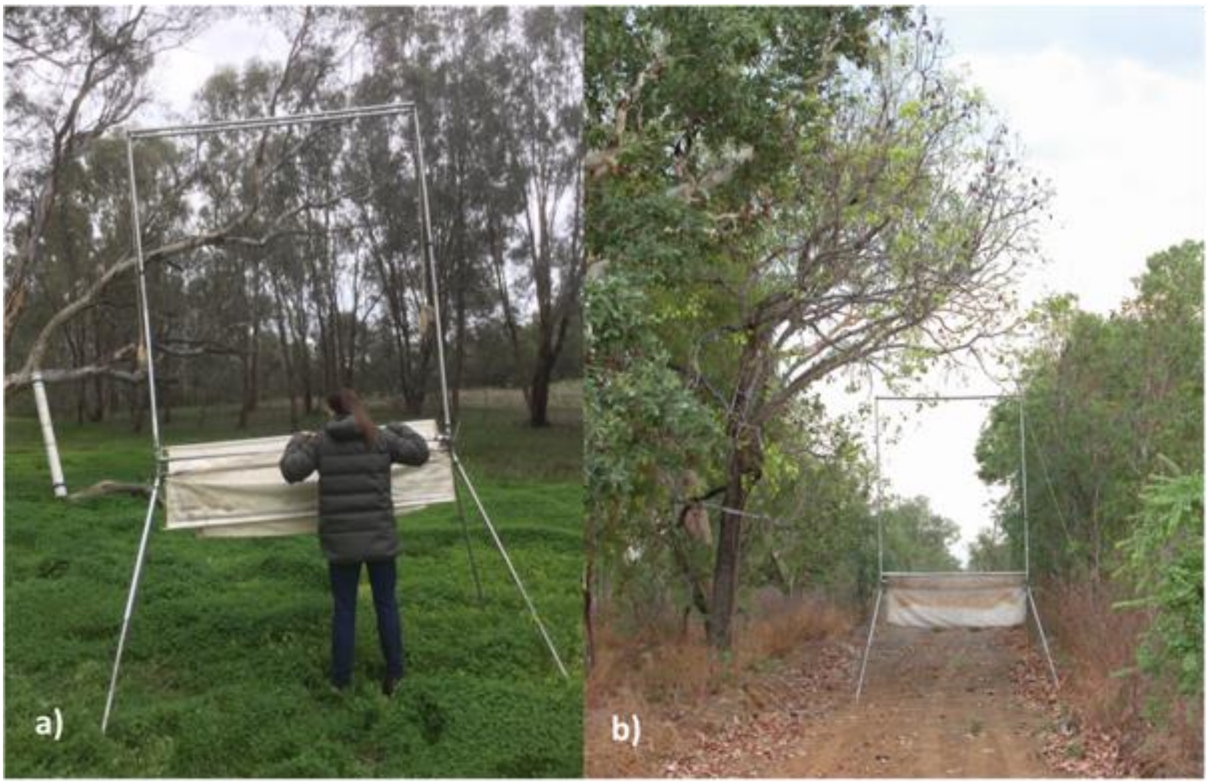

Figure 7.3. A harp trap deployed less than optimally (a) and properly (b). More bats will be captured when the trap is placed in a fly way, such as along a track, and with vegetation either side and above, than in the open as shown on the left. Adjust the legs to the height which maximises filling the gap in the vegetation. Guy ropes from the top corners of the trap should be tied to pegs or adjacent sturdy vegetation to ensure stability. When checking the bag, keep the bag ties done up and lower one side of the bag carrier as shown on the left. Doing so enables easy access to the bats while reducing the space within the bag from which bats could fly out. Photos by David Watson (a) and Lindy Lumsden (b).

Harp traps used to catch flying–foxes work on the same principle as those used for microbats but are made of yacht masts with horizontal wire cables stretched between them attached at the top and bottom, from which two banks of vertical, nylon–covered wire cables are strung tightly. The trap stands 14 m high and 16 m long, with 120 vertical wires (Tidemann and Loughland 1993). A bag is not used with megabat harp traps: personnel are stationed nearby ready to catch bats as they slide down to the ground. Trapping is usually undertaken adjacent to a flying–fox camp, on dusk or before dawn.

Animal treatment, withdrawal and euthanasia

Small–bodied and nectarivorous bird species should not be kept for longer than one hour post capture. If they are showing signs of stress (drooping eyelids, nodding and/or trembling) they should be placed in a calico bag somewhere dark and warm where they will often improve rapidly. Note that many birds undergo partial fright moult when caught or removed from mist nets, so some loss of contour or tail feathers can occur. It is important not to grasp the tail of any bird during handling (Lowe 1989). If a bird is in poor condition or obvious stress, try placing it in a safe, shaded area. Often, after several minutes, the bird's condition will improve, and it will fly away. If the animal is still there after 10 min or if there is any sign of injury (blood, wings or tongue held strangely) they should be treated by an experienced practitioner. Bats captured in harp traps that are removed after dawn should be kept during the day to be released at the capture point that night on dusk. During the day they should be housed in small numbers in a cloth bag (no more than 10 individuals, if they were together in the trap, otherwise alone) and hung in a dark quiet room or shaded environment. Bats will often enter torpor during the day and so should be well warmed before being released. Euthanasia is rarely needed, and only if for major injuries (e.g. broken limb). If used correctly, injuries and trap deaths in harp traps are rare.

Equipment and maintenance

Mist nets

Nets can only be purchased from specialist distributors, and in Australia are only available for researchers with a mist net endorsement from the Australian Bird and Bat Banding scheme or an appropriate state wildlife research permit. Nets should be stored in their own bag, with any sticks or other debris removed before packing. When erecting or packing up mist nets, they are best kept under tension and should never be allowed to touch the ground. Any broken strands (from branches, animals or personnel) can be readily mended, noting that animals can become badly tangled in nets with large holes. Badly damaged nets should be destroyed. It is usually not possible to repair the very fine monofilament nets used for microbats. Poles can be lengths of bamboo, or fashioned from readily available camping equipment, but very smooth poles are difficult to work with as shelf string loops can slip under tension. Other equipment needed for mist netting are guy ropes, pegs, clean catch bags, plus equipment for processing the animals (typically includes banding pliers if banding is to be undertaken, calipers and weighing scales). A steel 300 mm rule with a perpendicular lip added to one end (a bander's rule) is especially useful for measuring wing length in birds (Lowe 1989). Mist nets and any equipment having been in contact with soil are cleaned and dipped in alcohol (70–90%) and dried before storage. Mist nets are also used illegally to catch wild birds, either for food or to be sold, and are stored securely.

Triplines

Triplining simply requires fine fishing line (e.g. 3 kg breaking strength), tent pegs, lights and animal processing gear.

Harp traps

Harp traps are manufactured and sold by specialist distributors in Australia, and are only available to individuals with the appropriate qualifications and permits. Everything needed to deploy a harp trap comes packed inside a length of sturdy PVC pipe or flexible carry bag, with extra equipment needed for processing the animals including calipers, scales and recording equipment. Correctly deployed harp traps need little cleaning or maintenance, and remain serviceable even with several broken strings. Like mist nets, sections having been in contact with soil are cleaned and dipped in alcohol (70–90%) and dried before storing. If multiple strings are broken (by a branch or wayward animal), they are best repaired indoors by experienced and patient personnel. Ensure that the harp trap bags are completely dry before storage, otherwise they will go mouldy.

Specific qualifications, experience and training

It takes many hours to attain competency in setting mist nets and extracting, identifying, measuring and marking animals safely and efficiently. This competency is best gained under the close supervision of experienced personnel. Setting harp traps and extracting and processing bats is also a highly skilled procedure, best learned by working closely with experienced personnel. If banding of trapped animals is planned, personnel will need to gain an appropriate ABBBS qualification.

Workplace health and safety

General risks

Using harp traps or mist nets to capture birds and bats is a relatively low risk activity, best–practice use involving the usual precautions for working outdoors (e.g. personal protective equipment and safe manual handling procedures). Other than low risk of disease exposure and injury (especially to the hands), personnel should be mindful of trips and falls when moving harp traps and mist net poles. Otherwise, any conditions where additional care is needed (exposure to extreme temperatures; floodwaters) or locations where additional caution is warranted (beside nests of stinging insects, curious livestock or waterbodies containing crocodiles) should be avoided. When triplining, care is needed to avoid tripping over obstacles when moving around in the dark. Personnel working with bats in confined spaces, such as caves and mines, should be experienced at doing so and must establish clear protocols for working in those areas (e.g. Armstrong and Higgs 2002). Cavers will also need to evaluate the risk of human–to–bat disease transmission (Gómez Estrada *et al.* 2020).

Bites and scratches

Both bats and birds can bite and scratch people, but serious injuries are rare. Two groups of birds are noteworthy. Parrots have sharp and very powerful beaks, bites from even small species routinely break the skin, so all parrots should be handled carefully paying particular attention to the head, holding the head away from the hand with two fingers braced either side of the neck. Raptors use their sharp claws and strong feet to dispatch prey, so all owls and birds of prey should be handled with particular attention to their feet, safely held by grasping their legs (see chapter 37). Although gloves can be useful to minimise injury while handling larger birds, extracting birds from nets relies on locating very fine nylon strands, and is best performed without gloves. Flying–foxes have large sharp teeth and claws on their feet and thumbs and should be handled using thick leather gloves. Although the teeth of microbats are much smaller, they can at times break the surface of the skin. The risk of contracting Australian Bat Lyssavirus is exceptionally low, but all researchers should wear gloves, such as nitrile, or thin leather golfing gloves, and be vaccinated (see chapter 24 for additional details).

Disease

Both bats and birds can transmit diseases to people. For birds this risk includes psittacosis (especially from pigeons and parrots), and various forms of influenza (Whitworth *et al.* 2007). In addition to biting or scratching, transmission of some of these diseases occurs via airborne particles. The coronavirus that causes COVID–19, while linked to bats overseas, has not been recorded in any Australian wildlife (Wildlife Health Australia 2020). However, the virus could be transmitted by humans to bats (Botto Nuñez 2020), and appropriate precautions should be taken, including preventing anyone with COVID–19 from handling bats and regularly cleaning equipment. Australian Bat Lyssavirus (ABL) is the main disease of concern for bat researchers. The virus has been recorded in all Australian species of flying–foxes and the yellow–bellied sheathtail bat (*Saccolaimus flaviventris*) (Field 2018). Antibodies for ABL have also been recorded in a range of other microbat species (Field 2018; Prada *et al.* 2019), and so precautions should be taken when handling any species. Anyone handling bats should have a current rabies vaccination and wear puncture–proof gloves. To minimise cross infection between captured animals, catch bags should only be used for single individuals, or small groups of individuals if already clustered together such as in a harp trap. Bags should be washed before re–use, and both mist nets and harp traps should be cleaned of any animal traces (including droppings, feathers and fur) and soil, before being completely dried prior to storage.

Alternative procedures

For those applications where birds or bats need to be captured to be measured, marked or tagged, the only other suitable alternatives are alternative capture methods, including cage traps, canon–nets or other propelled nets (see chapter 16) for birds, or the extraction of bats from nest boxes (chapter 24). Observational identification and counts of birds and bat colonies, and the use of species–specific calls for identification purposes (either *in-situ* or via passive acoustic recorders) usually suffice for most survey and monitoring objectives (Ralph *et al.* 1993); acoustic monitoring is becoming more widely used with bats as call libraries improve (chapter 6). However, for poorly sampled regions or species, bats may still need to be caught to be definitively identified and to compile local call libraries.

Capturing ungulates with corral and pen traps

Andrew J. Bengsen and Jordan O. Hampton

Target taxa

Corral and pen traps are used to capture large–bodied (> 20 kg), free–living, terrestrial mammals. In Australia, they are most commonly used to capture ungulates, such as pigs (*Sus scrofa*), goats (*Capra aegagrus hircus*), deer (Cervidae) and horses (*Equus caballus*) (chapter 24).

Context and scope

Corral and pen traps include a diverse range of enclosures designed to capture multiple individuals of gregarious species at once. The materials and structure used vary depending on target species, but all comprise a rigid physical barrier around a lure (usually bait) or attractive landscape feature (usually a water point), with one or more entry points (Fig. 7.4). They can be portable or semi–permanent. Corral (enclosure) traps typically range in area from 0.25–4 ha and aim to catch social groups of animals at once. Corral traps fitted with long fenced wings to guide driven animals towards the entrance have occasionally been used in Australia, but this technique is not recommended because animals enter the trap in an excited state, which can result in elevated injury and mortality rates (Hampton *et al.* 2019). Pen traps are smaller than corrals and can hold fewer individuals. Specific types of pen traps are also known by other names, including panel, silo and figure 6 traps.

Figure 7.4. Examples of corral and pen trap construction. a) panel–style feral pig pen trap with a push–through side–swinging gate triggered by a rooting bar to reduce non–target captures; photo by Andrew Bengsen; b) Corral trap for fallow deer (*Dama dama*) made with cattle panels and mesh with multiple remotely–triggered drop gates; photo by Andrew Bengsen; c) feral pig pen trap with a push–through entry made from steel reinforcing mesh bent in on itself in a figure 6 shape (photo by Peter Adams); and d) horses in a corral trap showing the potential for self–trauma (photo by Rob Gibbs, NSW NPWS).

Smaller traps designed to capture single large–bodied animals include box, Clover and Stephenson traps. Enclosures > 4 ha are generally referred to as paddock traps and are not usually used to capture animals for research. Large box and paddock traps are not covered in this GOP.

Animal welfare considerations

Corral and pen traps can cause serious physical injury or death to trapped animals if they are not carefully constructed and operated. Reported frequencies of injury and mortality are variable for ungulates captured in corral or pen traps. For example, 2% mortality for feral horses (Scasta 2020) and 6% for feral pigs (Barasona *et al.* 2013). Causes of injury or death can be grouped into four main categories: 1) physical trauma from the trap (including self–trauma); 2) physiological distress from prolonged confinement and exposure to stressors; 3) thermal distress from prolonged exposure to heat or cold; 4) isolation of dependent young.

Traps should be designed and situated to be as target–specific as possible, so that non–target animals are not unnecessarily exposed to these hazards. Gates, gate triggers and other entry points should reduce the risk of capturing non–target species. For example, deer traps can use high tripwires to avoid being triggered by macropods (Mitchell 2016) and pig traps can use rooting bars to reduce the risk of being triggered by many species (e.g. Fig. 7.4a). Remotely triggered electronic latches (e.g. Fig. 7.4b) allow precise control of gate closure timing and can be useful when combined with cameras that send imagery from the trap to a remote location, but they only provide a single capture event. One–way push–through gates (e.g. Fig. 7.4c) allow continuous capture of multiple animals. Remotely triggered traps are also now available that use 4G technology to enable multiple captures.

Physical injury
Animals caught in traps sometimes charge and crash into the trap panels or gates during attempts to escape, when startled or when approached by humans, resulting in injuries, such as snout or muzzle lacerations, fractures and avulsed lips (Sweitzer *et al.* 1997). Animals can also be injured while attempting to jump out of the trap (e.g. broken necks in feral horses, Scasta 2020; Fig. 7.4d). The potential for trap–related injury can be reduced through careful selection of trap location, trap construction materials and methods, and methods for approaching and handling trapped animals (see chapter 24).

Physiological distress
Physiological distress includes a range of potentially harmful physiological responses to stressors, such as the perception of danger, confinement in unfamiliar environments and overcrowding in traps. Acute stress may manifest as hyperthermia and dehydration. Prolonged distress can cause capture myopathy. Trapping and handling procedures must aim to reduce fear, excitation and exertion in trapped animals.

Capture myopathy comprises a suite of syndromes that arise from prolonged distress and physical exertion associated with pursuit, capture and restraint of wild animals (Spraker 1993). It is invariably fatal and characterised by severe muscle breakdown and hyperthermia leading to kidney failure (Breed *et al.* 2019). No reliable treatment is available, so prevention and minimisation are essential (Breed *et al.* 2019). A comparison of corral and pen traps found that biological indicators associated with capture myopathy were greatest in feral pigs captured in corral traps, probably because the larger area within the traps allowed greater physical exertion prior to handling than in smaller pen traps (Barasona *et al.* 2013). Other studies have also reported higher stress and injury rates in pigs captured in larger traps (Sweitzer *et al.* 1997). It is often easier to immobilise animals in pen traps than in large corrals (Fig. 7.4c). Hence, smaller pen traps may be less efficient than corrals for capturing large numbers of animals at once, but they often produce lower rates of capture myopathy and higher rates of survival.

Animals targeted for capture in corral traps are gregarious species, but overcrowding or confinement with individuals from different social groups can cause prolonged distress and physical injury from fighting. Very young animals can also be crushed underfoot. If corral traps are to be used, they should be large enough to provide freedom of movement for large numbers of animals and to allow animals to avoid each other while accessing important resources within the corral, such as water and shade.

Exposure and dehydration

Animals captured in corral or pen traps have limited opportunity to shelter from extreme ambient temperatures. Prolonged exposure to very high or low ambient temperatures can cause dehydration, hyperthermia or hypothermia, all of which can be fatal. High temperatures also increase the risk and severity of capture myopathy (Breed *et al.* 2019; Spraker 1993). The best ways to reduce exposure are to avoid trapping at times and locations where exposure to extreme temperatures is likely and to check traps and clear animals from them regularly. Building traps around or beneath trees provides both shade and transpiration cooling. It may be necessary to provide water in hot environments. Traps should be checked at least daily, and animals should not be held for > 24 h.

Separation of dependent young

Dependent young that do not enter traps with their mother may become separated and die from starvation. Traps should not be set during seasonal birth pulses in species with seasonal reproduction.

General procedures

Trap siting

Traps should be sited at locations with a high probability of being encountered and entered by the target species and low probability of being entered by non–target species. Large mammals often use regular trails (‘pads’) to commute between shelter and feeding areas. Areas on these trails will often satisfy this requirement. Traps should be sited in areas where they are unlikely to be encountered by other people. They should also be positioned in a location where they can be observed remotely and approached by personnel with minimal disturbance. Camera traps linked to communication networks can sometimes be used for remote observation. Trap locations should provide protection from extreme temperatures (i.e. shaded and not placed at a high altitude).

Trap construction

Construction materials, methods and design must be guided by the morphology and behaviour of target and likely non–target species, but certain features can reduce the risk of injury or mortality for all species. Traps are usually constructed using wire netting or panels of rigid wire mesh or metal rails, depending on the target species (Fig. 10.4). Post and rail construction are common for horses. In all cases, trap construction must aim to prevent physical injury to target and non–target species, and to minimise exertion and physiological distress during capture and handling.

Pen traps are often preferable to corrals. Corrals and large pens should be round, rather than acutely angular, as corners can impede the natural flow of animals through the trap and form pressure points where animals can be crushed. Drafting and handling facilities may be necessary to enable safe restraint, handling and release of trapped animals (e.g. Moriarty 2004).

Panels and gates must be able to withstand repeated impact from trapped animals. Panels must be secured to the ground or sufficiently heavy to prevent them from being tipped over or lifted. They must be free of sharp surfaces, edges or projections that can cause injury and any wiring must be finished on the outside of the trap. Mesh size should be sufficiently small to reduce the risk of animals forcing their heads, or parts of their heads, through the mesh under pressure (e.g. ≤ 10 cm for feral pigs, Fig. 9.4a,c) (Sharp 2012; Lavelle *et al.* 2019).

Entry points or gate triggers should be designed to reduce accessibility to non–target species. All gates must be checked to ensure that they work cleanly and close completely so that they do not pose a risk of animals getting stuck while attempting to escape. Gates should close quietly so that they do not induce a startle response.

Consider whether a shroud is appropriate. A hessian or shade cloth shroud around trap panels provides a physical and visual barrier that can help to reduce excitation and escape attempts in trapped animals (Lavelle *et al.* 2019). Shrouding the top section of fences or wire panels can also reduce the risk of macropods being caught by their hind legs when attempting to jump out of the trap (Sharp 2005). Low (0.9–1.2 m) panels or fences can allow macropods to escape from goat traps but will be too low for most other species. Feral pig traps, for example, should be at least 1.5 m high, or be covered, to prevent pigs from escaping.

Free–feeding

Free–feeding is the provision of food at the trap site to condition animals to use the area and enter the trap. Effective free–feeding maximises the number of animals available for capture, reduces the risk of non–target capture and may reduce stress in captured animals. Free–feeding should begin before the trap is constructed using a feed that is safe and attractive for the target species while minimising non–target species that would be susceptible to trapping. Camera traps can be used to identify species consuming feed. Concurrent feeding at several sites can help to identify sites where most effort should be invested. Once target animals have begun feeding regularly, trap materials can be introduced to the site and the trap constructed. The trap can be built in stages to reduce neophobic avoidance. Free–feeding should continue once the trap is built so that target animals become accustomed to entering and feeding within the trap. No feed should be provided outside the trap at this point. Goat traps with a jump down entrance should have an open exit gate during free feeding.

Setting the trap

The trap can be set once target animals are regularly feeding within it. Traps can be open at any time, but should not be armed and set to capture animals during periods of high ambient temperature or when target individuals are likely to be in late stages of pregnancy or have dependent young. To reduce the risk of hyperthermia in hot conditions, traps can be armed only at night and locked open or closed during the day. The inverse approach can be used for diurnal species during cold conditions that may predispose to hypothermia. This approach may also reduce the risk of capturing diurnal or nocturnal non–target species, respectively. The number of traps active at any one time should not exceed the number that can be checked and cleared within a reasonable timeframe.

Approaching the trap
Prior to approaching the trap, it should be observed from a remote or concealed location to determine how many and what type of animals have been captured. If animals have been captured, the trap should only be approached once all required personnel and equipment are prepared for the necessary handling and release operation. Approach the trap quietly, preferably from the main gate side to prevent animals putting pressure on this section of the trap.

Handling and releasing trapped animals
Specific handling procedures will depend on the target species and the tasks that need to be completed. Common tasks include tissue sampling, ear–tagging and the fitting of tracking collars. These techniques are covered in chapters 8 and 9, respectively. Handling and immobilisation of ungulates are covered in chapter 24. All procedures should aim to minimise stress and excitation, both in animals and in handlers, and to complete all operations as efficiently as possible. Chemical immobilisation will often be required, depending on the nature of the tasks to be completed, although some simple tasks such as ear–tagging can sometimes be achieved using physical restraint alone (chapter 14). Handling and chemical immobilisation of ungulates are discussed in chapters 16 and 24. If chemical immobilisation is required, trapped animals can be darted at close range using a dart gun (Fig. 7.4c) or blow pipe, or an injection pole may be used. Mammals captured in corral or pen traps are susceptible to hyperthermia and capture myopathy. Water for dousing should be available to cool animals while they are being handled and prior to release (Sawicka *et al.* 2015).

Animal treatment, withdrawal and euthanasia
Corral and pen trapping can injure trapped animals severely, requiring euthanasia or treatment. Personnel must be able to deal with injured animals promptly and effectively. Procedures for managing possible adverse events must be documented and understood by the trapping team prior to the commencement of operations. Procedures should specify consumables, equipment and personnel that are required on–site to manage injured animals. Procedures for trapping operations must specify monitoring requirements to detect lacerations, fractures, hyperthermia and capture myopathy. Trapping teams must also be equipped to euthanise animals. Additional procedures will be required if animals are to be chemically immobilised. Procedures must also specify classes of animal to be excluded from specific treatments, such as excluding animals in poor condition from being burdened with tracking collars. Minor lacerations (if treated) can be managed by applying a topical antibiotic or antiseptic. Hyperthermia can be managed by dousing with cool water (Sawicka *et al.* 2015). Serious injury, illness or failure to fully recover from chemical immobilisation will usually require euthanasia *in-situ* (see chapter 24).

Equipment and maintenance
Equipment required for trapping will depend on the target species and context. Typical items may include:

- trap panels, gates, gate triggers, posts and wire
- fencing pliers, post drivers
- feed, water troughs
- consumables and equipment for minor first aid

- firearms and ammunition for euthanasia

Specific qualifications, experience and training

Lead investigators or team leaders should have experience in building and operating traps for the target or similar species. At least one person on the trapping team should have experience, and preferably formal training, in euthanasia and chemical immobilisation of wild animals. If using firearms, personnel must have undertaken a firearms safety course and have appropriate certification. Ideally, they would have also undertaken a course in humane destruction of large ungulates. Personnel constructing and operating traps, and handling animals should have demonstrated practical experience in those techniques, under the supervision of someone who has worked with those species or similar taxa.

Workplace health and safety

Trap construction and operation, and handling animals

Trap construction and operation present physical injury hazards relating to heavy lifting, crushes and minor cuts and abrasions. Trapping team members must practice safe lifting methods and should wear robust gloves. Eye protection should be considered. Trapped animals can injure handlers through kicking, biting, crushing or striking with antlers or horns. Handlers should have experience in handling trapped animals of the target or similar species or be under the supervision of somebody with appropriate experience. All handlers must follow pre–arranged procedures, have clear roles and understand other team members' roles. Handlers should practice appropriate hygiene and protective measures, such as wearing gloves, to reduce the risk of contracting zoonoses, such as brucellosis, leptospirosis and Q–fever.

Alternative procedures

Single animals can be trapped in box traps or similar (e.g. Clover traps). They can also be captured using immobilisation drugs delivered by dart projectors, from ground– or helicopter–mounted shooters. Deer and pigs have been captured in drive nets and from net guns fired by helicopter–mounted shooters. Each of these methods has its own hazards and benefits (e.g. Hampton *et al.* 2019).

Capturing arboreal mammals by hook and net

James M. Turner

Target taxa

This GOP applies to possums and gliders (chapter 19).

Context and scope

The technique described in this GOP was born from a need to capture medium–sized arboreal mammals that do not enter standard cage or box traps readily and when tranquiliser–darting, branch–shooting or noose poles are inappropriate (W. Foley, K. Marsh and P. Beale, pers. comm.). Given that the target species are usually nocturnal, the method is conducted in combination with spotlighting (see chapter 5). While few publications describe the hook and net method, it has been used to catch mountain and silky cuscuses, and coppery ringtail possums

(*Phalanger carmelitae*, *Phalanger sericeus* and *Pseudochirops cupreus*, respectively; Salas and Stephens 2004), rock ringtail possums (*Petropseudes dahli*; Runcie 2002) and Lumholtz's tree–kangaroos (*Dendrolagus lumholtzi*; Procter–Gray and Ganslosser 1986). It may also be used to encourage gliding behaviour in greater gliders *Petauroides volans* (NHMRC 2014). Other authors describe shaking small trees to dislodge possums, but without the use of a hook and net (e.g. How *et al*. 1984; Pahl 1987; Munks 1991; Rawlins and Handasyde 2002). It is likely that the method is not often described explicitly in published research. Instead, the technique may simply be disguised as "hand capture", which, while true, does not let the reader assess the technique's potential impacts on the animal and study results. Flagging methods for koalas are described in chapter 20.

The hook and net technique is used when animal capture is necessary for investigation that cannot occur remotely, such as measurement of body mass or morphology, tissue sampling, collar attachment or transponder implantation. Animals are sought actively so baits or lures are not needed. This method typically requires a large sampling effort to catch a sufficient number of individuals, which can be time–consuming and physically demanding, depending on landscape and vegetation types. Capture itself is often rapid, but the duration varies with the position of the target individual on a tree and the density of surrounding vegetation, which can affect pole manoeuvrability.

Animal welfare considerations

Capturing an animal by shaking it out of a tree is stressful to the animal. The active process can last from seconds to minutes and ends in an animal's capture or its escape. While no impact of the technique has been reported in the literature, it can be assumed that it causes fear or distress, and at least a short–term stress response based on published knowledge of animal stress responses to capture (e.g. Buddle *et al*. 1992; Romero *et al*. 2008; Morellet *et al.* 2009; Breed *et al*. 2019). Other negative effects on welfare may include physical injury, disruption of normal behaviour or activities, and the alerting of predators to an individual's presence.

Physiological stress

Tree–shaking and capture is likely to induce a hormonal stress response in target animals, which has the potential to reduce animal fitness in the long–term, although the extent of long–term impact is difficult to predict. Ensuring that personnel are experienced and efficient in all procedures associated with the method will help minimise stress to study animals, because often a subjective judgement must be made in the field on the basis of animal behaviour. For example, if an animal has not been successfully captured after a few minutes of shaking, and it begins to look around and climb with rapid, 'panicked' movements, the capture attempt should be abandoned to avoid causing additional stress. Similarly, if after a few minutes it is apparent that an animal is in a position in the tree where it is unlikely to be dislodged with continued shaking, the attempt should be stopped.

Physical injury

The trajectory of a falling animal is difficult to predict, and an individual may not land in the net after shaking. An animal may strike a branch as it falls or land on the ground awkwardly, causing injury. Experience has shown that all animals that miss the net immediately run for the closest tree or dense ground cover; observations of escape behaviour, and physical examinations after capture have not revealed notable injury. To minimise the risk of injury from falling, it is important not to shake tree branches that are situated above rocky or debris–covered ground or hardened roads/paths.

Behaviour modification
Tree–shaking induces a flight response in animals, which could lead to home range displacement if they leave their current home ranges to escape capture. It may also increase hiding or vigilance behaviour in individuals, reducing the time spent accessing food resources, which could decrease body condition, or finding mates, affecting reproductive success. In general, capture, or attempts at capture, interrupt the normal daily activities of target species, which may result in short– or long–term modifications in behaviour (Morellet *et al.* 2009). With this in mind, studies on animal behaviour or spatial ecology should interpret data collected soon after capture with caution (Morellet *et al.* 2009). The impact of the hook and net technique on animal behaviour may be reduced by minimising site visitation duration or frequency.

Alerting predators
The location of an animal may be revealed to potential predators during or after shaking through illumination of an individual in a spotlight, noise from tree–shaking, defensive vocalisations of animals or olfactory cues from, for example, urination. Predation risk could be minimised by reducing the duration of capture attempts, reducing site visitation frequency, or avoiding an area if the presence of known predators, such as powerful owls (*Ninox strenua*), appears to increase.

General procedures

Locating study animals
Personnel search the study area on foot or from a vehicle if necessary (although vehicle noise may scare target animals), using a spotlight fitted with a red filter (chapter 5) if the target species is nocturnal.

Tree–shaking
After an individual animal has been located, team members keep their distance to minimise disturbance. The pole is assembled as required, depending on animal height above ground, and lifted to the vertical position. Team members approach the tree and assume their roles, depending on team size; ideally, the team includes one pole operator, one or two catchers with nets, one or two people ready to intercept an animal if it runs towards a nearby tree, and one person to maintain a spotlight on the animal. Higher numbers of personnel may be less efficient or impractical in some situations, and capture is possible with fewer people (at least two are required). The pole operator slowly moves the hook towards the branch, taking care not to bump the trunk or other branches on the way, because doing so may motivate the animal to escape by climbing higher (out of reach of the pole) or jumping to a nearby tree. As soon as the hook is on the branch, between the trunk and animal if possible, the pole operator shakes it vigorously to dislodge the animal. If the animal runs towards and over the hook, shaking is ceased to avoid accidental injury. If possible, a branch or small tree can be bent towards the ground so that the animal can be captured by hand, avoiding any risk of injury from falling.

Catching

The net should be held loosely so that an animal does not bounce out of it upon impact. After an animal has fallen into the net, the two sides should be quickly brought together, and the net moved to the ground to increase entanglement and stop an escape. The animal can then be removed from the net carefully and placed in a cotton bag for processing.

Animal treatment, withdrawal and euthanasia

Despite the high impact nature of the technique, injuries are infrequent. Withdrawal from a study may be considered if individuals are often recaptured and frequently exposed to the risk of stress or injury.

Equipment and maintenance

This technique requires custom–made equipment consisting of a pole with a hook for shaking the branch, similar to a traditional panking pole used to shake fruit from a tree, and a net for catching the animal. The pole may vary in design, but the one described below has been used successfully by the first author of this section to capture common ringtail possums.

The pole consists of three, 2-m lengths of interlocking aluminium sections (Fig. 7.5). The diameter of each section is 30-mm with a thickness of 3-mm. Two of the poles have a 26-cm length of steel tubing welded and riveted within their ends, with half protruding, to connect the sections. The base of one pole can then slide over the steel tube of a second pole. Whereas the poles consist of aluminium to reduce weight, these interlocking sections are made of steel for strength. These joins are a weak point of the pole. Aluminium joins tend to bend under the pressure of the pole's weight when raising it from the ground and should be avoided. An 8-mm diameter hole is drilled halfway up the protruding steel tubing and at the corresponding point at the base of the next pole section. An 8-mm bolt can then be inserted through the poles to join them and a wingnut allows rapid fastening by hand. The third pole has a steel hook with a 210-mm diameter and 5-mm thickness, permanently fastened to its end with two bolts. A pole in three sections allows possums to be accessed at three different heights and simplifies transport.

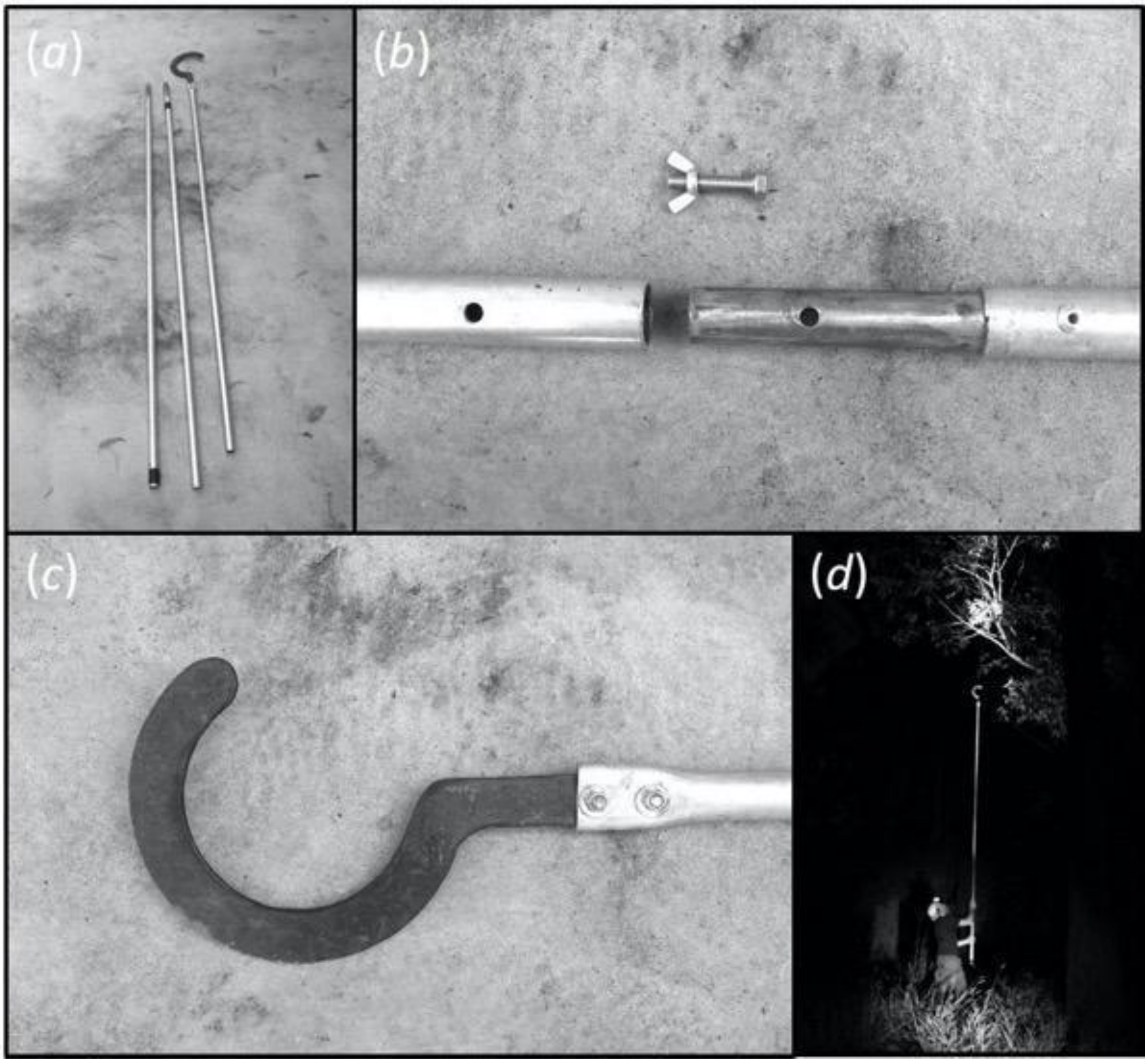

Figure 7.5. Pole with hook for the capture of arboreal mammals. The pole consists of three aluminium sections (a), which are interlocked with steel tubing and fastened with a wingnut and bolt (b). One section contains a steel hook (c). Photograph (d) shows the pole, with two sections connected, being used to reach a tree branch. Photos by James M. Turner.

The net should be sufficiently large to minimise catcher error. The net should contain loose folds to allow it to stretch when a possum falls inside, softening the landing, and of a mesh size that allows claws and fingers to pass easily through and become entangled. Typically, 5 mm anti–bird netting used to cover food plants works well. The net is strung along the lengths of two wooden poles (e.g. broom handles) using cable ties. When a possum falls in, this design allows the two sides of the net to be brought together quickly to prevent the animal from escaping. Other commercially–sold nets may be available, but would likely need modification before their use as possum–catchers; the use of camper's hammocks (Lemos de Sá and Glander 1993) and blankets (Salas and Stephens 2004) in catching falling animals has also been reported. Other useful equipment items will depend on the study objective and the measurements to be made. Equipment may include that used for handling and processing an animal, such as gloves, a cotton handling bag, a spring balance and callipers. Maintenance includes regularly checking for cracks and bends in the pole and tightening the hook's bolts. The net is also checked for holes, entanglements and loose attachment points.

Specific qualifications, experience and training

The hook and net technique is not used broadly, so prior communication or training with an experienced person is essential. As a minimum, team leaders should have experience with field observations of mammal behaviour so that they can make apt, on–the–spot decisions on whether a capture attempt should be continued or stopped. It is useful for team personnel to have spotlighting and animal handling experience and skills, preferably with the target species.

Workplace health and safety

Falling branches and debris

Falling branches, twigs, leaves, bark, dust and other debris may fall onto personnel while shaking a tree. To minimise risk, only the shaker and the net–catcher stand directly under an animal. These personnel should wear protective equipment, including helmets and safety glasses. Other team members stand back from the tree, watch for falling objects and communicate any hazard to the shaker and catcher. All personnel wear personal protective equipment appropriate for working in the bush, such as sturdy footwear and long pants.

Injury from a captured animal

Possums may become aggressive when captured and personnel may be scratched or bitten, which may result in infections, including from potential zoonoses. Appropriate personal protective equipment, such as leather gloves, should be worn when handling and processing animals. Any injuries should be treated immediately.

Alternative procedures

Alternative procedures may include tranquiliser darting (chapter 16), but the appropriateness of this method will depend on the size of the target species. For example, darting of possums may be unsuccessful if darts bounce off individuals with relatively thin soft tissue layers (Webb 2018). Additionally, employing a sharp–shooter to shoot the branch on which the possum is sitting may result in injury if the possum clings to the branch instead of bracing for impact. Use of a noose pole may be restricted by the height above ground of the target animal. These methods are not necessarily lower impact than the hook and method procedure and require specialist expertise. Baited cage traps (see other GOP in this chapter) may be used depending on the target species, but again, are not necessarily lower impact methods, particularly if an animal is caught within a trap for several hours. Additionally, while several studies have used cage traps to capture ringtail possums (e.g. Pahl 1987), success may be site–specific and depend on food availability, habitat type, wariness of traps and humans, familiarity with non–natural items and animal nesting behaviour.

Targeted searches for reptiles and amphibians

Deborah S. Bower, Eric Vanderduys and Helen P. Waudby

Target taxa

Procedures outlined in this GOP are appropriate for most small to medium–sized reptiles (chapter 26) and amphibians (chapter 27) taxa.

Context and scope

This GOP describes general techniques and considerations for targeted (active) searching of specific habitat features (e.g. underneath rocks, litter, timber or peeling bark) and the subsequent hand capture of reptiles and amphibians. Targeted surveys focus on habitat features that study taxa are expected to use for at least part of the day or season (DSEWPC 2011b). Subsequent hand capture permits data collection (e.g. checking sex; body measurements); allows handlers to perform techniques such as mark–recapture and radio tracking; and is required to collect animals (e.g. for use in experimental studies). Targeted searches may be once–off or repeated, depending on the research objectives.

Animal welfare considerations

These methods are likely to be low impact if completed quickly and with appropriate handling procedures for the species of interest. The main potential effects are changes in habitat use as a result of disturbance during active searching. Effects of hand capture on animals vary depending on the physiology of the species and personality of the individual (e.g. some monitor species respond defensively following capture and handling (Ward-Fear *et al.* 2018)). These effects will vary according to the length of time, conditions and procedure undertaken (Langkilde and Shine 2006).

Disruptions to daily activities and habitat use, and alerting of predators

Hand capture of reptiles and amphibians in the wild will disrupt their normal activities (e.g. feeding and foraging; reproduction; social interactions). Factors likely to influence the magnitude of this impact, include the duration of handling following capture, the climate where handling occurs (temperature; moisture), seasonality (e.g. if handling occurs at a critical point in the breeding season, such as capture of frogs while calling), and territoriality or habitat use (e.g. if the animal follows the same route regularly). Investigators should also consider potential negative effects on animals associated with disturbing habitat to search for target individuals (e.g. turning over rocks or logs to search for animals). For example, rocks that were displaced in Sydney sandstone had larger and cooler crevices than restored rocks, reducing their occupancy by reptiles, although the negative effects on habitat use were mitigated to some extent by replacing rocks precisely (Pike *et al.* 2010). Activities may lead to modifications in behaviour, such as increased refuge use, changes in habitat use and patterns of activity (Kerr *et al.* 2004) and reduced thermoregulatory time, which may impose a physiological and behavioural cost (Martín and Lopéz 1999). Study animals may experience increased visibility at their point of release, which could increase the risk of predators targeting them. Animals should always be released in proximity to their shelter or cover and monitored to ensure that they move to cover successfully.

Physiological stress

Physiological stress occurs from prolonged or invasive procedures that may accompany hand capture (Langkilde and Shine 2006). Stress responses could include vomiting, defecating, everting reproductive organs, or laying eggs. Autotomy can occur during handling in lizards and will cause stress to individuals (Langkilde and Shine 2006). In the alpine she–oak skink (*Cyclodomorphus praealtus*), temperature, lizard length and observer experiences all influenced the probability of autotomy (Scroggie and Clemann 2009). Skinks also showed a characteristic tail wagging behaviour before autotomy. Cooling the lizard after capture, pausing activity if tail wagging is observed and training handlers on non–endangered species beforehand may reduce the risk (Scroggie and Clemann 2009). Causes and triggers of stress will vary among species so knowledge of the biology of the target species will enable researchers to reduce stress during handling.

Accidental mortality and disease transmission

Accidental mortality can result from animals overheating or being handled incorrectly (e.g. where breathing is inhibited). For fossorial and rainforest species (with a low critical thermal maximum), direct handling should be avoided where possible. For small skinks a calico bag can be placed over the handler's hand and used to scoop individuals and move them between places to minimise heat transfer (Read and Kearney 2016); frogs can be kept cool and hydrated in a plastic container filled with water. Animals should be handled in a manner appropriate to their morphology (see chapters 26 and 27). Investigators should also follow appropriate hygiene protocols when handling multiple individuals to minimise the risk of spreading diseases, such as chytridiomycosis, particularly when working with amphibians (see chapter 28 for specific protocols).

General procedures

General considerations

Researchers select an appropriate survey method and sampling regime, which will depend on the study objectives and species. For evaluation of species persisting at low densities, or with limited or patchy distributions, surveys may need to be replicated across the study area, randomly or systematically (DSEWPC 2011b). Researchers should document survey effort, including the number of personnel involved in searching for target taxa and the duration of surveys, and record details on environmental conditions and habitat. Active searching can be destructive to habitat, and once displaced, most habitat resources are unlikely to provide exactly the same conditions for the target or non–target taxa. Wherever possible, displaced rocks, timber, and other resources should be replaced as precisely as possible.

Consideration must be given to the species' requirements, such as moisture and temperature needs. Shade is required while handling animals in hot climates. Small, cold–adapted animals can perish rapidly in the heat of hands. Amphibians, particularly tadpoles, require constant hydration. Protocols to reduce the spread of pathogens must be adhered to, such as using single–use plastic clip–lock bags and disinfecting equipment between individuals or populations. The observer should have the appropriate safety equipment (e.g. gloves; bandages) to handle venomous species and species that can inflict damaging wounds (e.g. goannas; crocodiles). However, each study species will have different requirements, and these can change between age classes. For example, nitrile gloves are useful to handle frogs, but are toxic to tadpoles (Cashins *et al.* 2008).

Locate the study animal
The researcher identifies appropriate methods for locating the animal (e.g. active search of specific substrates). Considerations that will determine how to locate the animal will include its movement patterns; diel behaviour patterns (nocturnal; diurnal; crepuscular) and seasonality; the level of risk that the animals pose to the observer if they become distressed; density of the population; and other research techniques being undertaken (e.g. radio–telemetry).

Diurnal active or hand searches are typically employed to target species that use particular habitat resources, such as underneath bark on tree trunks or fallen timber, crevices or weathering rocky outcrops, and under rocks, to name a few. Typically, active searching is best undertaken from mid–morning to late afternoon, but will depend on weather conditions (DSEWPC 2011b). Personnel can wear thick work gloves to turn substrate safely if required and may use a plastic rake or similar implements to check leaf litter for litter–dwelling reptiles. Substrates that need to be lifted (timber; rocks) should be lifted carefully and away from the handler to minimise the risk of being bitten by a snake. Personnel should remain calm and avoid suddenly dropping substrates back onto animals (i.e. if startled suddenly). Rocks and timber or similar substrates should be replaced in the same position once the animal has been captured. Complete removal of bark from trees should be avoided where possible. Leaf litter should be raked firmly (i.e. so that the rake's prongs reach the soil layer) and with consistent movements and replaced as best as possible afterwards.

Restrain the study animal
Once located, movements and noises that may alert, startle or alter the animal's behaviour should be avoided, unless they are required to assist capture. The handler should swiftly and safely restrain the animal. Care should be taken not to pin animals against spikes or other objects that could cause harm, which is a particular hazard when capturing free–living reptiles and amphibians. The amount of handheld pressure and method of appropriate restraint will vary according to the animal's taxon. For example, gently holding the base of the tail while supporting the forebody will assist in restraint of an agamid lizard, but will often result in autotomy in skinks, legless lizards and geckos. Restraint should be achieved in a manner that avoids damage to vital organs. Restraint methods may change for different size classes of the same species (e.g. hatchling crocodiles compared to adult crocodiles – chapter 27). An appropriately firm grip is required because animals may twist, jump or scratch suddenly if not restrained. Experience and careful training dictate the level of pressure required to maintain a firm grip. If animals are to be released, they should be replaced next to or, ideally, under their original substrate, without being squashed.

Animal treatment, withdrawal and euthanasia
The risk of injuring an animal directly through target active searching and handling varies according to the species. Injuries may occur if the study animal becomes chronically stressed, exceeds its temperature limits, if the handler inflicts physical damage, or if predation increases. If euthanasia is required, suitably trained personnel use a technique appropriate to their study species or seek veterinary advice. Factors that may result in a decision to withdraw from the study at any given

point, include obvious changes in the behaviour of the study species, such as changes in habitat use over time (i.e. where the same habitat is searched repeatedly over a period of time). During handling, animals should be monitored continuously for behavioural changes that may indicate signs of stress, such as postural change, increased breathing rate, tail wagging in lizards, colour change, and a reduction in alertness. Monitoring should continue after release while the animal is in sight.

Equipment and maintenance

Equipment will vary depending on the species or taxon, and the nature of the study, but general items may include:

- containment suited to the study species (e.g. clear clip–lock plastic bags for amphibians, plastic tub, or calico bags for small reptiles)
- pathogen protection (e.g. gloves; bags; disinfectant)
- first–aid equipment (e.g. snake bandage; first–aid kit; eye wash)
- note–taking equipment (e.g. notebook; laptop; tablet; voice recorder; clipboard)
- equipment for processing (e.g. calipers; camera; marking equipment)
- shade (e.g. gazebo; tree cover)
- water for amphibians

Specific qualifications, experience and training

The qualifications and experience required to perform the procedure vary depending on the sensitivity of the study species or taxon to handling and design of the study. In general, personnel should have been deemed competent in the technique by a more experienced investigator, and have used the method on the target species or similar taxa. Personnel capturing and handling venomous snakes should have specific experience in doing so.

Workplace health and safety

Dangerous plants and animals

In some cases, personnel may wear or employ protective equipment (e.g. gloves for venomous snakes). For some species it will be important for personnel to complete hand capture in pairs (at least) to minimise the risk of injury to researchers. For example, when handling dangerous species such as large goannas, venomous snakes and crocodiles. Additionally, personnel should pay attention to their surroundings as hand capture of harmless animals, such as frogs has resulted in medical emergencies for handlers when snakes and spiders were in the process of preying on the target animal and envenomed the handler during the capture event. Handlers should also be aware of other dangerous plants and animals nearby during hand capture; centipedes can be mistaken for squamates and spiny plants can inflict damage to the handler and target animal.

Alternative procedures

Researchers should consider if study questions could be answered with, for example, remote monitoring equipment (e.g. acoustic recorders and wildlife monitoring cameras), or other technologies (e.g. long distance photography), which may be appropriate to answer study questions, and potentially lower in impact than active searching and hand capture.

Capturing macropods with draw–string traps

Graeme Coulson and Clare Death

Target taxa

Draw–string traps allow the capture and safe handling of medium– to large–bodied macropods, such as red–necked wallabies and eastern grey kangaroos (Coulson 1996; Coulson *et al.* 2003) (chapter 21). The technique may also be applicable to other mammals, such as common wombats that habitually move under fences (e.g. Coates 2013) (chapter 19).

Context and scope

This GOP describes a method for capturing medium– to large–bodied macropods in situations where they routinely move through fences, often squeezing underneath or through narrow gaps. Chemical immobilisation, which is required after initial capture and manual restraint, is covered elsewhere in the book (chapters 16 and 21).

Animal welfare considerations

Several categories of potential animal welfare impacts are associated with draw–string traps: a) stress and trauma from being pushed towards a trap before darting, b) pain, stress and injury from confinement and restrain during capture, c) stress when evading capture, d) anaesthetic complications, and e) capture myopathy. Of these, serious injury and myopathy are generally associated only with passive, unattended traps as used in New Zealand (Latham *et al.* 2019). The authors strongly advise against the use of such traps, which should never be left unattended. In contrast, draw–string traps that are operated actively have very few negative effects on welfare (Coulson *et al.* 2003).

Stress before and after capture

Exertion caused by driving animals towards a trap can increase the risk of hyperthermia and physical trauma from collisions with fencing and other solid objects. Confinement in netting and manual restraint induces immediate stress and involves some risk of physical trauma while struggling against restraint. Prolonged confinement prior to immobilisation is likely to exacerbate these effects and must be avoided. Large pouch young pose a particular risk if ejected or escaped from the pouch: they must be quickly separated from the mother and placed in a cloth bag to avoid injury from kicks while the mother is restrained manually.

Failure to capture

Transient stress can occur when the trap is closed too soon, causing the animal to back away and flee, or closed too late, allowing the animal to force a passage through the draw–string and escape.

Anaesthetic complications

Field anaesthesia is challenging, and immobilised animals can experience a range of complications, which are covered elsewhere in the book (chapters 17 and 22).

Capture myopathy

Capture myopathy is possible if excessive ‘pushing’ occurs before capture, especially during warmer weather. Myopathy would be inevitable if confinement in the trap is prolonged, but that is not an element of the method, as all trapped animals are attended to immediately. This issue is discussed in detail elsewhere (chapters 17 and 22).

General procedures

Installing traps

Draw–string traps should be installed in places where animals have already established a runway and are regularly pushing under or through the fence (Fig. 7.6a). The fence can further be modified by enlarging the passage at the trap site to encourage its use, as well as eliminating alternative access points by reinforcing the fence and blocking holes beneath it. Traps are installed by placing a weld–mesh frame at right angles to the hole in the fence and securing a second weld–mesh floor to the ground. Care should be taken to ensure that all metal components are smooth and do not project into the runway. Once the trap site is being used consistently by the target species, the trap can be erected in stages to allow the animals to habituate to it. A section of netting is suspended within the weld–mesh frame and tied to the floor to create a tunnel. Draw–strings at each end of the tunnel are closed by an operator pulling the connected rope from a permanent hide, erected 10–20 m from the trap, on the same side of the fence. All ropes and other materials should be installed prior to a trapping session.

Figure 7.6. Use of the draw–string trap to capture eastern grey kangaroos (*Macropus giganteus*): a) a trap set in a gap in a security fence; b) one kangaroo enters a trap, as two others follow; c) a kangaroo enters the trap, as viewed by the operator in the hide; and d) a recumbent kangaroo in the trap netting after chemical immobilisation. Photos by Graeme Coulson (a, b, c) and Sophie Petit (d).

Trapping times and duration

Draw-string traps rely on natural movements of the target species, so trapping is normally conducted at dawn and dusk, when animals move between foraging areas and cover. Familiarity with the site, including the daily movement habits of the target species, is essential to the success of this trapping method. Trapping can be accelerated by encouraging target animals to approach the trap, which is best done by positioning one or two people in the open, at a non–threatening distance from the animals, to induce animals to seek refuge sooner in the morning; this approach usually cannot be used in reverse in the evening. Additional people should be coordinated by means of hand signals, mobile phones or two–way radios, but silence must be maintained as animals approach the trap. The active 'pushing' of animals is generally unproductive (Coulson 1996) and poses the risk of the animals colliding with fences and other objects or becoming stressed and/or hyperthermic. In hot weather, natural movements are likely to be restricted to cooler times of day, but trapping should be conducted only at safe temperatures (e.g. < 30°C). Trapping is also possible at night, under natural or artificial light aided by binoculars or night–vision devices (Coulson 1996), although identification of target animals is then more difficult. Trapping can be continued until no further animals approach the trap. However, each capture causes disturbance to any target animals nearby, and resetting the trap will deter nearby animals, so the interval between sequential captures could be at least 30 min.

Operating traps and removing animals

A trap is operated from inside the hide. The method is highly selective: the operator can allow non–target animals to pass through the trap while waiting for a target animal to approach (Fig. 7.6b, c). Once the target animal has entered the trap, the operator pulls the rope vigorously to close each end of the netting rapidly and secures the rope before leaving the hide and going to the trap. The operator then restrains the animal by squatting or kneeling on the netting on either side of the animal, injects the immobilising agent into the hind limb musculature, and maintains physical restraint during induction. Placing a fabric cover over the eyes of restrained animals is advisable while awaiting the onset of sedation (Fig. 7.6d). Once the animal is immobilised, the operator releases the draw–strings and the animal can be removed from the trap.

Chemical selection and dosage calculation

The chemicals chosen for immobilisation and their recommended dosages are covered in more detail elsewhere in the book (chapter 21). Zoletil® (tiletamine–zolazepam) has been used to immobilise animals in all draw–string trapping projects to date (e.g. Wilson *et al.* 2013; Death *et al.* 2019).

Securing traps between sessions

Animals are encouraged to continue to move through the trap between capture sessions by tying the netting securely to the outer frame, so that animals can pass through it. Failure to do so will result in the netting becoming dislodged over time so that it hangs down, partially blocking the route through the fence and creating an entanglement hazard.

Animal treatment, withdrawal and euthanasia

Manually–operated draw–string traps pose few risks to target animals. Minor abrasions, from contact with the substrate or netting, can be treated by cleaning the area with a topical skin cleansing agent (e.g. dilute chlorhexidine or povidone-iodine) and/or application of a topical wound spray or powder if deemed appropriate by the advising veterinarian. Severe trap injuries will be avoided if no sharp edge is present in the trap construction. Veterinary opinion and treatment may be necessary for trapped animals that have incurred severe injuries or appear to be suffering from capture myopathy.

Equipment and maintenance

Equipment required for draw–string trapping includes:

- binoculars
- night–vision equipment (if required)
- mobile phone (for text messaging field assistants)
- syringes and needles of appropriate volumes and gauges (ensure you have more than you need)
- if appropriate, gloves and mask
- veterinary chemicals (ensure you have more than you need)
- data sheets and veterinary chemical use logbooks
- spare batteries or power banks for electronic equipment
- spare clothes pegs, tent pegs, rope etc. for trap repair

Specific qualifications, experience and training

Personnel should have practical experience in capturing and handling large wild animals. Personnel administering veterinary chemicals will typically need to be working under the direct supervision of a veterinarian or possess accreditation to perform the method (requirements vary by jurisdiction). Ideally, personnel will have completed a chemical immobilisation training course.

Workplace health and safety

Draw–string trapping is a low–risk technique for field biologists. Safety risks include a) self–injection with immobilisation chemicals, b) being scratched or kicked by recumbent animals, and c) zoonotic hazards, such as urine, faeces, blood– or saliva–borne pathogens (e.g. Q–fever). All staff should be trained in appropriate responses to self–injection. Animal handlers should be vaccinated against Q–fever, wash hands after captures, and avoid inhaling dust that may be contaminated by animal urine, faeces or birthing fluids.

Alternative procedures

Alternative capture methods that can be used in place of draw–string traps are cage traps for medium–sized macropods (e.g. Di Stefano *et al.* 2005), such as wallabies (see earlier GOP in this chapter), and pole syringe (e.g. King *et al.* 2011) or darting (e.g. Roberts *et al.* 2010) for larger species (see chapter 16).

Capturing wombats and macropods by stunning and netting

David Taggart, Graeme Finlayson and Graeme Coulson

Target taxa

This GOP applies to wombats (chapter 19) and macropods (chapter 21), but may also apply to rabbits (chapter 24).

Context and scope

This GOP describes the capture of wombats and macropods via stunning followed by netting (or sometimes simply by manual restraint). The method is effective for capturing a range of species, including European rabbits (*Oryctolagus cuniculus*; Shepherd *et al*. 1978), red (*Osphranter rufus*) and western grey kangaroos (*Macropus fuliginosus*) (Robertson and Gepp 1982), swamp (*Wallabia bicolor*) and red–necked wallabies (Di Stefano *et al.* 2005; Garnick and Coulson 2020), and southern hairy–nosed wombats (*Lasiorhinus latifrons*) (Taggart *et al*. 2003). Detail is also provided for some of the specific capture and handling details associated with this method for key taxa. Other aspects of handling and immobilisation of these taxa are covered in chapters 19 and 21.

Stunning was developed originally for capturing macropods (Robertson and Gepp 1982). Stunning relies on a combination of light and sound that interferes with the natural behaviour of the target animal, which improves the likelihood of capture considerably. Stunning occurs as a bullet travels at supersonic speed ~10–20 cm above an animal's head, or between its ears, with the sound wave created by the bullet temporarily deafening or confusing the animal. This sound or shock wave is the consequence of the bullet travelling faster than the sound waves it produces, causing the wave fronts to pile up on one another, and resulting in the constructive interference of many wave fronts (Halliday *et al.* 1993). This interference is believed to create the pressure that temporarily deafs the target animal. If successful for macropods, a targeted animal will drop its head and stand still for up to 30 sec until disturbed. In other species, such as rabbits, the resulting shock wave causes an apparent confusion, such that the rabbit does not flee, but runs around in proximity to where it was stunned, increasing the probability of capture. In all cases, the dazzling of the target animal with a spotlight at the same time allows the netter to approach undetected. Stunning is the most efficient method of capturing wombats, with one in every 3–4 wombats observed at night caught, and is superior to cage trapping, which should only be used if a particular animal needs to be caught from a known warren (e.g. for collar removal or a health check). For wombats, if the stunning is successful, the animal will remain motionless for 1–2 min (Taggart *et al.* 2003).

Animal welfare considerations

Several categories of potential animal welfare impacts are associated with the capture and handling of wombats and macropods by stunning: a) stress, pain and trauma from restraint during capture; b) stress when evading capture; c) anaesthetic complications; d) capture myopathy (mainly an issue for macropods); e) stress and trauma during transportation and handling.

When using firearms for stunning
Firing a bullet near a target animal presents a risk of death and stress to the animal. Firearms safety procedures must be adhered to during stunning. Only one trained and skilled marksman is responsible for all firearms, ammunition and shooting components of this method, on any one field trip. The risk of animals being shot is negligible if the shooter remains constant, the rifle is fitted with a variable telescopic sight, the shot is taken from a resting position, and the shot is placed no closer than 10–20 cm above the animal's head.

During netting
Confinement in netting and manual restraint induce immediate stress in target animals and involve some risk of physical trauma while they struggle against restraint. This risk is more pronounced in macropods than in wombats because macropods typically kick out with their hind legs or attempt to jump while netted. Prolonged confinement prior to immobilisation is likely to exacerbate these effects and must be avoided, particularly in macropods. Southern hairy–nosed wombats tend to settle quickly in a net if undisturbed, whereas common wombats (*Vombatus ursinus*) remain very active in the net following capture. For macropods, ejection or escape of medium to large pouch young is a real risk, so they must be separated quickly from the mother and placed in a cloth bag to avoid injury from kicks while the mother is restrained. Unlike macropods, wombats do not eject pouch young during capture or handling − possibly because of the tightness of the pouch during all pouch young stages, and the shorter limbs and lack of overall flexibility of wombats compared to that of macropods.

During failed capture attempts
Failed capture attempts only result in transient stress. Macropods that evade capture by netting or stunning simply hop away. Unsuccessful netting or stunning of a wombat results in the animal retreating underground for a period of time, but this response is a negligible issue in terms of welfare.

Risks associated with anaesthesia
Field anaesthesia can be challenging, and immobilised animals can experience a range of complications, which are covered elsewhere in the book (chapters 16, 19 and 21).

Capture myopathy
Capture myopathy is not a risk for wombats. However, larger macropods are particularly prone to myopathy, as are some smaller macropod species (e.g. rock–wallabies), but not others (e.g. tammar wallaby, *Notamacropus eugenii*) (McMahon *et al.* 2013). Capture myopathy is possible if excessive 'pushing' occurs before capture, especially during warmer weather. Myopathy would be inevitable if confinement in a net was prolonged, but that is not an element of either method, as all captured animals are attended to rapidly. An intramuscular injection of vitamin E (Vogelnest and Woods 2008) helps reduce stress following capture.

General procedures

Netting and stunning

Wombats can be captured at night by spotlighting and netting, or by spotlighting, stunning and netting (Taggart *et al.* 2003; see chapter 4 for more details relating to spotlighting). These activities are generally undertaken by personnel positioned on the back of a utility vehicle, which is driven slowly (< 10 km/h). The procedure requires a driver, 1–2 netters, a spot–lighter, and a shooter. When a wombat is sighted (~30–80 m), the vehicle is stopped. The shooter then aims the rifle 10–20 cm above the wombat's head while the spot–lighter trains the spotlight on the animal. Silence is essential. The shot is fired, and the netters then run along the edge of the spotlight beam until they reach and net the wombat. To secure animals following netting, personnel should stand on the handle or frame of the net until assistance arrives. Doing so is particularly important for wombats, which are very strong.

Macropods can be captured by stunning in much the same way as wombats, but a larger crew is required. Once a target animal has been located and is 'propped' in the beam of the spotlight, two pairs of 'runners' wait beside the vehicle until the shooter fires the shot. If the stun is successful, the animal will drop its head and remain motionless. Immediately after the shot, the 'runners' sprint along the edge of the beam and restrain the macropod manually, the first pair holding it by the tail or using a body tackle, and the second pair approaching to restrain the hind feet, tail and head. Additional personnel may be required to hold large animals. As soon as they are tackled, macropods regain consciousness and will struggle vigorously, so a high degree of handling skill and team coordination is required. A brief procedure, such as quickly fitting ear tags or a collar, can be completed by experienced personnel while the animal is restrained. Afterwards, it can be allowed to leave by first releasing the limbs and, once personnel are out of the way, releasing the tail. Longer procedures will require chemical immobilisation to avoid restraint–induced myopathy.

Transfer of captured animals from nets to bags

Once netted, animals are restrained within the net and generally transferred into a hessian sack or similar (see 'Equipment and maintenance') for processing. Wombats are powerful animals that are difficult to restrain or maintain a grip on. In order to transfer the wombat from the capture net to a bag, the wombat should be manoeuvred and blocked into a corner of the net. The loose netting around the wombat is then gathered in behind the animal's forearms, so that no loose netting is present around the animal's body from the forearms forward. The wombat, tightly secured within the net, and the net and handle, are picked up together and the wombat, rear end first, is dropped gently into the open bag. The bag is held wide open by two other personnel. These personnel are responsible for closing and securing the bag rapidly. Personnel should be aware that wombats can jump, although not very high. Bags should be double–tied as wombats can push the tie off the end of a bag if not secured properly. Once inside the dark bag or sack, wombats become calm very rapidly, and may fall asleep. Alternatively, some operators restrain common wombats in the net by standing on the frame and mesh, injecting them with Zoletil®, and then removing them from the net and placing them in the sack.

Small– to medium–sized macropods should be secured by the base of the tail, removed from the net and placed head first into an open sack held by other personnel (see chapter 21). The sack should be pulled up over the animal rather than the handler trying to move the animal down into the sack. This procedure will prevent the animal grabbing hold of the sack rim as it is directed into the bag. The hind legs and toes must be facing away from all personnel as animals may kick out. Some medium–sized macropods may try and spin during bagging. To stop this movement, the animal is allowed to put its forearms on the ground, and the procedure is repeated rapidly. Animals will typically remain relatively quiet if a dark sack is placed over their heads and noise kept to a minimum.

Stunning and Netting
This method only works at night when the spotlight hides the approach of the netters, but otherwise can occur at any time when the animals are active. Nights with little or no moonlight are best. Time from sighting to capture typically takes < 5 min. Stunning of wombats works best between 12–18°C, with few stuns achieved below 6°C and above 24°C, and also works best at higher humidity ≥ 50%.

Transport to a site for processing
If animals are being transported away from the capture site by vehicle for processing, they must be secured in their sacks to the vehicle tray or the sack placed in a pet crate to ensure that animals do not roll or bounce off the utility's tray once the vehicle is moving. Sedation for transporting small macropods or wombats is unnecessary. The authors of this GOP have transported over 100 small macropods in darkened pet crates or suspended sacks over hundreds of km without incident. Wombats are always transported in secured sacks (clipped to the vehicle) so that they are not at risk of rolling or bouncing off a moving vehicle. Risks of myopathy in macropods are greatest at capture and on warm days, and not during transport. The authors' experience has been that once placed in the dark (e.g. individual darkened pet crates, or hanging suspended in sacks) with adequate ventilation, macropods remain calm and very quiet during transport. Additionally, some forms of sedation (e.g. Diazepam) can be detrimental as sedated animals may lose the ability to regulate body heat and posture resulting in death. For example, the authors are aware of the death of multiple bridled nailtail (*Onychogalea fraenata*) and tammar wallabies following sedation and transport (D. Schultz pers. comm).

Chemical selection and dosage calculation
The chemicals chosen for immobilisation of macropods and wombats and their recommended dosages are covered in more detail elsewhere (chapters 16, 19 and 21). Zoletil® (tiletamine–zolazepam) has been used to immobilise large macropods and wombats in most trapping–based research projects to date (Taggart *et al.*1998; Finlayson *et al.* 2010; Wilson *et al.* 2013; Death *et al.* 2019).

Animal treatment, withdrawal and euthanasia
Generally, no specific animal injury is associated with stunning and netting wombats. Veterinary opinion and treatment may be necessary for trapped macropods that appear to be suffering from capture myopathy, although in mild cases, maintaining animals in a cool, dark, quiet location can alleviate distress markedly, and render animals fit for release.

Equipment and maintenance
Key equipment required for the capture of macropods and wombats includes:
- spotlight (100–Watt hand–held or car–mounted halogen, or equivalent).

- long–handled heavy–duty hand–held capture nets. Wombat nets (made from tennis court netting) with a net area of 70 × 65 cm and 170 cm handle. Macropod and rabbit nets with an 80 cm hoop diameter and 150 cm handle.
- 0.22 calibre magnum, bolt action rifle with telescopic sights (× 4 magnification minimum).
- sturdy utility vehicle with a flat tray back to allow for easy and rapid dismount, and a spot lighting and shooting frame mounted on its tray.
- roof–mounted gun rack.
- catch bags or sacks. For large macropods and wombats, sacks can consist of hessian or green stripe bags (Colquhoun's Pty Ltd, South Australia).
- GPS to record location of animal captures.

Specific qualifications, experience and training

Personnel should have practical experience in capturing and handling large wild animals before attempting to capture animals on their own. Shooters will need to possess a state–based firearms licence (Table 7.2) and must have demonstrated experience in this method before being deemed competent by a more experienced supervisor. Importantly, the same shooter or shooters should be used for each field trip and each evening. Personnel administering veterinary chemicals will typically need to be working under the direct supervision of a veterinarian or possess accreditation to perform the method (requirements vary by jurisdiction). Ideally, personnel will have completed a chemical immobilisation training course.

Table 7.2. Relevant firearms legislation and codes.

Jurisdiction	Firearms legislation and regulations
Commonwealth	*National Firearms Safety Code 2002*
Victoria	*Victoria Firearms Act 1996* *Firearms Regulations 2018*
Tasmania	*Tasmania Firearms Act 1996* *Firearms Regulations 2016*
South Australia	*South Australia Firearms Act 2015* *Firearms Regulation 2017*
New South Wales	*New South Wales Firearms Act 1996* *Firearms Regulation 2017*
Queensland	*Queensland Weapons Act 1990* *Weapons Regulation 2016*
Western Australia	*Western Australia Firearms Act 1973* *Firearms Regulations 1974*
Australian Capital Territory	*Firearms Act 1996*
Northern Territory	*Firearms Act 1997*

Workplace health and safety

Safety risks include a) self–injection with immobilisation chemicals, b) being scratched, bitten or kicked by recumbent animals, and c) zoonotic hazards, such as urine, faeces, blood– or saliva–borne pathogens (e.g. Q–fever). All staff should be trained in appropriate responses to self–injection. Animal handlers should be vaccinated against Q–fever, wash hands after captures, and avoid inhaling dust that may be contaminated by animal urine, faeces or birthing fluids. Stunning and netting are low–moderate risk techniques for field biologists. Apart from the risks mentioned above, additional safety risks include a) tripping over while running in darkness to catch an animal, b) not holding onto the safety bars and rails available on the vehicle and falling off the back of a very slow (<10 km/h) moving or stationary vehicle, and c) lifting injuries. Being shot is not a risk associated with stunning, as no person leaves the back of the vehicle until the stunning shot is fired.

Alternative procedures
For macropods, alternative procedures may include capture with drawstring or cage traps (see earlier GOP in this chapter) and immobilisation by darting (chapter 16). For southern hairy–nosed wombats, stunning provides a substantially increased rate of capture compared to just chasing an animal under spotlight with a net, and both methods are far superior to success rates associated with cage trapping wombats. Similarly for rabbits and kangaroos, without using a shot fired above the animal, capture success is greatly reduced or near impossible with a hand–held net.

Foot–hold trapping for eutherian carnivores

Paul D. Meek, Damian S. Morrant and Guy A. Ballard

Target taxa
This GOP applies to eutherian carnivores (see chapter 22).

Context and scope
Foot–hold trapping is widely used to capture dingoes, feral dogs, hybrid dogs/dingoes, foxes and cats in Australia (Meek 1995; Meek *et al.* 2018a), for pest control and research. The method involves deploying rubber–lined, off–set jaw traps to capture target species by the front foot where they are tethered until released. Traps are placed in specific locations frequented by the target species (e.g. scent marking stations, resting locations, feeding areas or travel paths). Traps are commonly set along roads, but exact placement depends upon species, habitat and season. Consequently, traps may also be set along water courses, fence–lines, edges of ploughed fields and animal pads. Animals can be lured to trap–sets with olfactory (scent–based) lures, auditory (sound) or visual lures. Alternatively, experienced investigators can set un–lured traps successfully along tracks and pop–holes in fences (Fournier 2011). Foot–hold traps are generally the most efficacious means of capturing introduced mammalian carnivores for research purposes. These trap types pose a range of risks to captured animals. Recommendations for minimising risks have been described in detail in existing standard operating procedures (SOP), codes of practice (COP) and best practice guidelines (BPG) (Sharp and Saunders 2008; Meek *et al.* 2020a; also see chapter 22).

Animal welfare considerations
Foot–hold trapping may cause high stress and injury to captured animals (Kreeger *et al.*1990; Lossa *et al.* 2007; Marks 2010). It should only be undertaken by experienced practitioners following detailed SOP, legislation and BPG, as noted above.

Physiological stress, exhaustion and dehydration

Capture and restraint by a trap will cause stress to animals (Kreeger *et al.* 1990; White *et al.* 1991; Marks 2010), although common behaviours of trapped animals also include extended periods of resting and sleeping (pers. obs.). Approaching trapped animals elevates anxiety and promotes attempts to escape. Risk of injury may be greatest at this time. Captured animals should be captured, restrained and/or sedated promptly or euthanised swiftly where euthanasia is necessary. Where injuries are sustained, post–release myopathy can occur (Cattet *et al.* 2003). Animals caught in foot–hold traps typically expend energy attempting to escape. Effort varies between species, individuals and can be influenced by seasonal behaviours, such as breeding. Animals can display symptoms of exhaustion and dehydration (Powell 2005) depending on local conditions.

Direct injury
Injury during capture ranges from mild bruising and localised swelling to lacerations, damaged teeth, dislocations, broken bones and rarely, death (Meek *et al.* 1995; Fleming *et al.* 1998; Marks 2010). Well maintained traps with appropriate swivels and springs should be used, and traps should be checked as soon as possible after sunrise each day. Irrespective of treatment, released animals may experience post–release soreness, ischaemia and myopathy (Cattet *et al.* 2008), or show no effect (Bubela *et al.* 1998). While these techniques are associated with a low risk of indirect effects, such as exposure or predation, foot–hold trapping with rubber–lined, off–set jaw traps very rarely results in death (Fleming *et al.* 1998).

Abandonment of young and pack separation
Animals that travel in packs, with mates, siblings or young may be separated during capture, but risk of abandonment is low because most species leave young at dens while foraging. Dependent young could be disadvantaged if a parent is restrained for extended periods.

Exposure to predation
Although predation of trapped animals (targets and non–targets) by other predators including foxes, wedge–tailed eagles and canines does occur (Meek and Brown 2017), the occurrence and risk are generally low. Trapping of adults during whelping season might result in an increased risk of predation on juveniles.

General procedures

Preparation
Foot–hold trapping requires a good understanding of the target species' biology and ecology to ensure selection of appropriate traps sites and lures. Awareness of how animals use their landscape is valuable. Reconnaissance to locate spoor, with and without the aid of sniffer dogs (chapter 6), and camera trapping can be informative. Detecting relevant animal signs, including that of non–targets, assists in making sound decisions about trap placement to maximise the likelihood of catching the target species and minimising or removing the possibility of capturing non–target animals. Familiarity with COP, SOP and BPG will ensure trapping programs are undertaken with due diligence. Appropriate trap type and trap fittings specific to capturing the target animal is necessary. Placement of traps must minimise risk of indirect injury to trapped animals during capture escape attempts. Trappers must be experienced and familiar with relevant legislation, COP, SOP and BPG, and safe removal of study animals from foot–hold traps and safe practices for euthanasia.

Assess exposure risk
Trappers must undertake a risk assessment to ensure all traps can be visited as soon as possible after the animal has been captured. Since this timing is difficult to predict in practice it often means checking traps as soon as practicable after sunrise and before midday (depending on site weather). Checking traps at those times means that most animals spend few hours in traps because most predators are nocturnal or crepuscular. More frequent checks may be required depending on local conditions. Continually assessing weather conditions prior to and during trapping programs helps ensure trapped animals are not exposed to heavy rainfall, extreme heat or cold and other dangerous conditions. Trapper servicing of traps within 24 h of setting must be assured, which can mean checking water crossings and monitoring track conditions with respect to wet weather.

Trap choice and maintenance
A wide range of traps is used in Australia (Meek *et al.* 2018a). Suggestions that bigger traps are faster and better than smaller traps are unfounded (Meek *et al.* 2018b). Trap type and size should be decided based on the target species and any risks posed by the preferred trap design. In research trapping programs, traps larger than size # 3 and those with 4–coil springs are generally too large and over–engineered for safe use. Likewise, long drag chains (>50cm) and drags with sharp points tend to promote unacceptable injuries. Traps should be carefully checked and serviced (no sharp edge or burr, intact rubbers, free–moving swivels and operating springs) to ensure no additional risk is posed to animals by the device during capture or restraint in the trap (Meek *et al.* 2020a).

Appropriate trap location selection
Traps are placed to minimise any additional injury or duress from capture. Traps must not be set where risks to captured animals, including non–target species, are likely. Risks such as exposure, drowning, entanglement, puncture wounds, interference by members of the public, pets, guardian animals and insect attack are considered.

Trap devices and alerts
Lethal trap devices and trap alerts can be used in areas where visitation to traps is problematic. Lethal trap devices (Meek *et al.* 2019) should only be used where animals are not required alive for the study. Trap alerts are intended to enable trap checking to be undertaken remotely (e.g. via satellite) and are triggered irrespective of target or non–target captures (Meek *et al.* 2020b). Tranquiliser trap devices (Marks *et al.* 2004) are not used in Australia, but do offer a means of reducing capture stress.

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Animal treatment, withdrawal and euthanasia
Deciding when not to trap, or to cease trapping, can be difficult, but is extremely important. When injuries are sustained by an animal during capture and handling, practitioners must decide whether to continue, treat or release the animal. Treatment for swelling at the point of capture must be undertaken as soon as the trap is removed (see chapter 23). Where injuries are severe, euthanasia must be undertaken. Researchers and trappers should be prepared for this eventuation.

Equipment and maintenance
Trapping equipment will vary with practitioners' preferences and study objectives, but would typically include the following:

- suitable traps for the target species and conditions (influenced by relevant jurisdictional legislation and approvals)
- chain assemblies, including heavy duty swivels, in–line springs and stakes or drags
- trap setting tools
- gloves
- lures
- camera traps
- lethal trap devices or tranquiliser trap devices
- restraining and handling equipment
- rifle and ammunition or other legal means of euthanising animals
- consumables for treatment of captured animals, such as Hirudoid® cream for trapped feet, and Chloramide or Cetrigen® sprays for treating minor wounds.
- hand cleaning and other hygiene consumables
- trapping signs
- GPS receiver or suitable phone app for relocating traps
- notebook or similar

Specific qualifications, experience and training
Foot–hold trapping for research should not be undertaken without some level of and training for the procedure or without direct supervision of a competent trapper. If euthanising animals with a rifle, personnel should hold an appropriate firearms licence (see Table 7.2). Additional competencies may be required to undertake chemical euthanasia, depending on legislation and the governing ethics committee's requirements.

Workplace health and safety
Trapping carnivores poses a range of workplace safety risks for the practitioner and the public, including vehicular accidents, injuries from trapping and animal handling equipment, injuries from trapped animals and zoonotic diseases during handling, and from euthanasia procedures.

Access

Trapping can be undertaken on roads or off–trail, so road associated danger exists especially in working forests, rubbish tips, farms or mine sites where machinery can be operating. Quad bikes and side–by–side vehicles are widely used by trapping practitioners; relevant safe work practices must be adhered to.

Trap setting

Trapping related injuries from padded foot–hold traps are less likely than with steel–jaw traps. Lacerations and bruising can occur to the operator during setting, such as when jaws are triggered accidently. Back injury can occur when attempting to remove trap–stakes.

Animal handling

Procedures for removing trapped animals from traps are outlined in chapter 22, including risks from bites and scratches.

Hygiene
Parasites carried by eutherian carnivores pose serious health risks to practitioners from direct contamination or secondary contamination from trap and equipment handling. Safe work practices must be adopted, disposable nitrile gloves should be used, and soap and water readily available for washing handling equipment and hands. Handling traps and trap paraphernalia (including lures) with bare hands should be avoided.

Firearms and lethal drugs
Firearms, or approved chemicals for lethal injection must be carried with appropriate permissions and licences. Requirements should be discussed with land managers well ahead of trapping programs. Firearms and veterinary chemicals must be stored appropriately, consistently with legislation and protocols.

Alternative procedures

Foot–hold traps are the most effective means of catching eutherian carnivores for wildlife research that requires direct use of the animal. Alternative, less efficacious methods include cage trapping, snaring, netting and darting. However, these alternatives are not necessarily of lower impact than foot–hold trapping.

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