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A capture technique for free-ranging eastern grey kangaroos (*Macropus giganteus*) habituated to humans

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Abstract. Available methods to capture free-ranging kangaroos differ in ease of use, selectivity, risk of injury and suitability to specific environments. We describe a simple technique involving the syringe from a 'jabstick' attached to an extendable, aluminium pole. We also examine responses of eastern grey kangaroos (*Macropus giganteus*) to a range of doses of Zoletil®. We captured 307 eastern grey kangaroos that were habituated to humans in Victoria, Australia, from November 2007 to October 2009. We approached kangaroos on foot, and injected the hind limb muscle mass with the pole syringe extended up to 4.85 m. We used Zoletil® 100 at a dose rate of 4.1 ± 1.3 mg kg^{-1} (mean $\pm$ s.d., $n = 274$). Induction was rapid (4.3 ± 2.0 min, $n = 185$) and only weakly related to dose ($r^2 = 0.06$). There was no clear relationship between age, sex or body condition and induction time. This pole syringe technique can be successfully and safely used wherever animals can be approached closely, regardless of body condition. The technique provides an effective means to immobilise habituated kangaroos for research and management.

Introduction

Marked individuals are required for many studies of the ecology, behaviour and management of wild animals. Methods used to capture free-ranging macropods differ in ease of use, selectivity, risk of injury to both the animal and the handler, and suitability to specific environments (Coulson 1996). Researchers often use syringe darts, propelled by blowpipe, compressed gas, powder charge or bow string, to administer immobilising compounds into the haunch of kangaroos (Higginbottom 1989; Roberts *et al*. 2010). Disadvantages of darting, however, include injuries from high-velocity dart impact and dartguns may be unsuitable or illegal in semiurban areas. Restraining chemicals can also be administered through baiting of grain or water at habitual feeding or drinking points (Arnold *et al*. 1986) but because there is no control over the amount of drug consumed, animals show varied responses from underdosing to overdosing. An additional drawback to baiting is that non-target species may consume the bait.

Alternative methods for physically immobilising large macropods include cannon netting (Edwards *et al*. 1994), drawstring traps in fences (Coulson 1996; Coulson *et al*. 2003), 'stunning' (Robertson and Gepp 1982) and herding (Jarman and Taylor 1983). There is considerable risk of injury to the animal during immobilisation in all the above methods. Stunning also poses definite risk of injury to the catchers, who run in darkness and tackle a kangaroo, as does herding, where kangaroos are driven into nets and caught by hand.

Chemical restraint using a 1 : 1 mixture of tiletamine hydrochloride and zolazepam hydrochloride (commercially available as Zoletil® or Telazol®) has been used for over three decades (Eads 1976; Boever *et al*. 1977) on a variety of mammals. Tiletamine is a dissociative anaesthetic that provides analgesia while zolazepam is a benzodiazepine tranquiliser that acts as an anticonvulsant and muscle relaxant (Lin *et al*. 1993). This drug combination provides relatively quick induction times but long recovery periods. It has been used in free-ranging primates (Glander *et al*. 1991), carnivores, particularly ursids (Stirling *et al*. 1989), and ungulates such as cervids (Chai and le Gendre 2001), often in combination with a reversible agent, such as xylazine. A wide range of doses of tiletamine–zolazepam (2–25 mg kg^{-1} body mass: Schobert 1987) can be safely administered to marsupials, including eastern grey kangaroos (*Macropus giganteus*) (Viggers and Hearn 2005; Roberts *et al*. 2010).

In some places, kangaroos are habituated to people and will tolerate close approach. Here we describe a simple technique for use in these situations, involving the syringe from a 'jabstick', commonly used by veterinarians, attached to an extendable pole. We also assess responses of eastern grey kangaroos to various dose rates of Zoletil® and investigate the effects of sex, age, body condition and female reproductive state on induction time.

Materials and methods

We immobilised eastern grey kangaroos from November 2007 to October 2009 at two sites in Victoria: Anglesea Golf Club

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(38°24′S, 114°10′E) and Wilsons Promontory National Park (38°57′S, 146°17′E). We approached on foot, and injected kangaroos using a 10-mL Paxarms syringe (Timaru, New Zealand) attached to the end of a pole (Fig. 1). We used one of two telescopic aluminium poles; the shorter pole (1.35 m) consisted of one extension (Wildlife & Animal Capture, Warwick, Qld, Australia) and a longer pole (4.85 m) consisted of two extensions (Ettore 'REA-C-H' telescopic pole, Alameda, CA, USA). We spray-painted the two distal sections black so that the long pole would be less reflective at night.

We loaded the syringe with Zoletil® 100 (100 mg mL^{-1} of tiletamine hydrochloride–zolazepam hydrochloride mixture; Virbac Pty Ltd, Milperra, NSW, Australia) and approached kangaroos while they held their head down and their back horizontal to the ground. We pushed the syringe into the hind limb muscle mass so that the drug was injected as the needle punctured the skin. Upon injection, kangaroos usually hopped a few steps and resumed their activities or stood upright. We waited for the animal to assume lateral recumbency and approached after an additional 2–5 min, to allow the drug to take full effect. If the animal was not completely immobilised at this point (26% of captures), we administered an additional dose using a 3-mL hand-held syringe (Fig. 1), giving the same as the initial dose or a half dose, depending on the behaviour of the animal. We defined induction as the time (in minutes) elapsed between the first injection and recumbency, because the latter was easier to detect than other stages of induction, such as initial ataxia or complete inability to move. In the rare cases when the animal was recumbent, stood up and then was recumbent again, we used the second recumbency as our measure of induction.

Occasionally, we undertook captures after dark at the national park (31 captures or 10%). One of us approached the kangaroo with the pole syringe and a headlamp to distract the animal. Another person followed behind and shone a spotlight on the kangaroo once it had received an injection, to ensure that it was not lost from sight before lying down.

We fitted immobilised animals with collars and Allflex eartags (Capalaba, Qld, Australia) for individual identification. We marked large pouch young (>950 g) with small Leader eartags (Craigieburn, Vic., Australia) after their mothers had been immobilised. After taking standard body measurements (Poole *et al*. 1982), we left kangaroos to recover in a heavy jute bag in the shade and sheltered from adverse weather. Kangaroos took ~1–3 h to recover from the drug but recovery times were not monitored to avoid disturbance. There were no wild dogs in either study area although there were red foxes (*Vulpes vulpes*). Our handling procedures were approved by The University of Melbourne Animal Ethics Committee (AEC 06146 and AEC 0810628.1).

We injected Zoletil® 100 at an initial dose rate of 4.1 ± 1.3 mg kg^{-1} (mean ± s.d., $n = 274$). The drug volume ranged from 0.3 to 3.1 mL, based on our visual estimate of body mass, and was equivalent to 0.8–10.0 mg kg^{-1}. In general, subadults that appeared to weigh 10–18 kg received ~0.6–0.8 mL, adult females 1.0–1.2 mL and adult males 1.5–2.5 mL.

We estimated body condition separately for each sex as the standardised residual of the linear regression of logged body mass on hind leg length (Schulte-Hostedde *et al*. 2005). The regression equations were log(mass) = 0.00256(leg length) + 0.125 for males ($n = 60$, $r^2 = 0.95$, $P = 0.0001$) and log (mass) = 0.00252(leg length) + 0.144 for females ($n = 263$, $r^2 = 0.84$, $P = 0.0001$). We carried out statistical analyses (simple and multiple regressions using linear models and *t*-tests) with R ver. 2.9.1 (R Development Core Team 2009). The response variable was induction time while predictors included initial dose, sex, age (subadult or adult), body condition, presence of young in the pouch, and site. Males were considered to be subadults up to 25.5 kg body mass, while females were subadults up to 18.5 kg body mass. We included several two-way interactions with site, because kangaroos appeared easier to approach at the golf course than at the national park. We also performed a separate analysis for adult females to assess whether or not the presence of a pouch young affected induction time. We chose the best linear model in multiple regressions according to Akaike's Information Criterion (Burnham and Anderson 2004). When models differed by less than two units, we selected the most parsimonious model (Quinn and Keough 2002).

Results

We captured kangaroos 194 times over 49 days at the Anglesea Golf Club using mostly the shorter pole, and 113 times over 37 days at the Wilsons Promontory National Park using the long pole. In total, we captured 237 adult females, 17 subadult

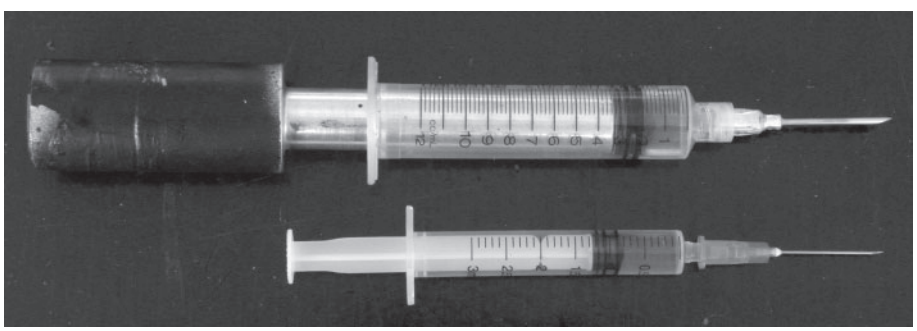

Fig. 1. The 10-mL Paxarms pole syringe (upper), consisting of a metal base (55 mm long), a metal plunger (75 mm long) with a black rubber piston and a 1.6 × 25-mm needle, compared with a standard 3-mL syringe (lower) loaded with a 0.8 × 25-mm needle.

females, 35 adult males and 18 subadult males. Most recaptures were of previously marked adult females. Since the number of injections required ($n = 43$ records), initial dose ($n = 38$) and induction time ($n = 12$) did not differ significantly between first and second captures (paired t-tests, $P \geq 0.18$), all 307 captures were considered in the analyses. Sample sizes differ among comparisons because, in some cases, incomplete first injections or inability to monitor time to recumbency did not allow us to measure all variables for the same individuals.

When the barrel of the syringe broke (23 times), we could not estimate the amount of drug administered or calculate doses. We also did not consider induction times for those captures. Of 237 adult females captured, 69% were carrying pouch young and we marked 83 large young. There were no injuries and only one death. We injected a female at the national park that appeared very emaciated, had a condition score of –0.116 (the lowest of all females captured) and did not recover from immobilisation. All of the animals captured at the golf course were seen alive three months later, and all but two in the national park were seen alive two months later. One pouch young was abandoned (mass = 1.2 kg); all others were seen in their mother's pouch after she had recovered from the drug.

Induction time averaged 4.3 ± 2.0 min ($n = 185$). In a multiple regression on induction time, the only factors retained in the best model were dose and site, with a significant interaction between dose and site ($R^2 = 0.12$) (Table 1). This was due to a negative relationship between dose and induction time at the national park, but not at the golf course (Fig. 2). Sex, age and body condition (Fig. 3) were not included in the final model. The presence of a pouch young was not included in the final model when considering only adult females ($R^2 = 0.09$) (Table 2). Again, the only factors retained in the final model for adult females were dose, site and their interaction. Kangaroos at the golf course received lower doses on average (3.9 ± 1.2, $n = 179$ versus 4.4 ± 1.3 mg kg^{-1}, $n = 95$, $t = -3.14$, $P = 0.002$) and took ~1 min longer to respond to the drug (4.8 ± 2.2, $n = 98$ versus 3.7 ± 1.7 min, $n = 87$) although there was considerable variation in individual response at both sites (Fig. 2).

Discussion

The extendable pole syringe was effective at capturing kangaroos in two sites where animals were habituated to humans. Potential sites where the technique could be used include

Table 1. Multiple regressions for several linear models of induction time for eastern grey kangaroos immobilised with a pole syringe at two sites (Anglesea Golf Club and Wilsons Promontory National Park) in Victoria (n = 182)

The equation for the selected model is INDUCTION = 0.71(DOSE) + 1.68(SITE) – 0.63(DOSE*SITE) + 2.85. AIC = Akaike's Information Criterion, ΔAIC = the difference in the value of AIC between the model and the chosen model (in bold). SITE was coded as 1 for the golf course and 2 for the park

Response variable	Predictors	% deviance	AIC	ΔAIC
Induction time (min)	DOSE+SITE+AGE+SEX+CONDITION+ DOSE*SITE+SEX*SITE+CONDITION*SITE	13.4	763.1	+1.8
	DOSE+SITE+AGE+SEX+DOSE*SITE+SEX*SITE	13.7	760.5	–0.8
	DOSE+SITE+AGE+DOSE*SITE	12.9	760.3	–1.0
	DOSE+SITE+DOSE*SITE	**11.9**	**761.3**	**0**
	DOSE	5.5	772.2	+10.9
	SITE	6.6	781.1	+19.8

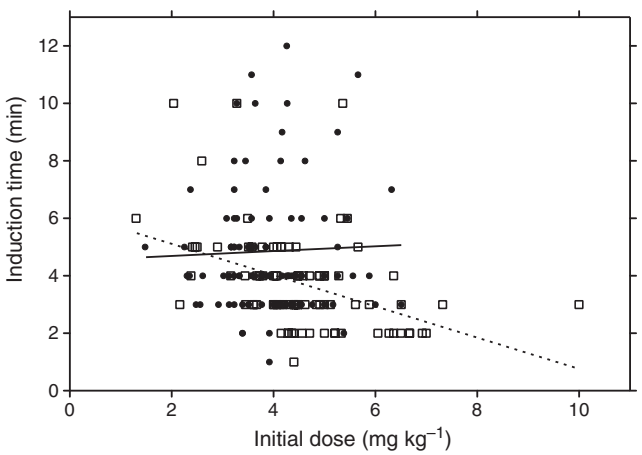

Fig. 2. Time to lateral recumbency versus initial dose of Zoletil® for 95 eastern grey kangaroos at Anglesea Golf Club (● and solid line, $r^2 = 0.001$) and 87 kangaroos at Wilsons Promontory National Park (□ and dotted line, $r^2 = 0.17$).

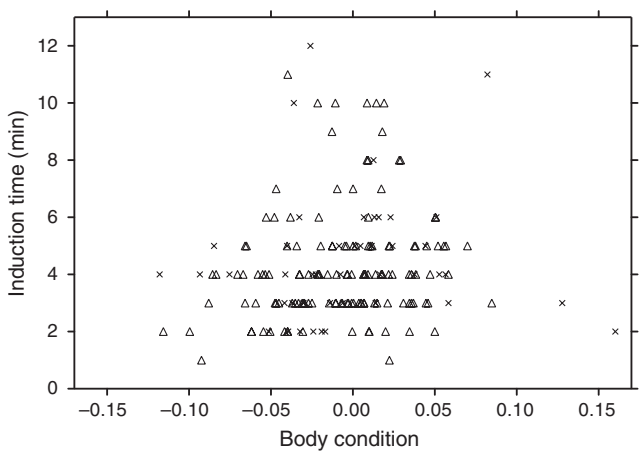

Fig. 3. Time to lateral recumbency versus body condition (standardised residuals of the linear regression of logged body mass on hind leg length) for 44 male (×) and 139 female (△) eastern grey kangaroos.

Table 2. Multiple regressions for several linear models of induction time for adult female eastern grey kangaroos immobilised with a pole syringe at two sites (Anglesea Golf Club and Wilsons Promontory National Park) in Victoria (n = 125)

The equation for the selected model is: INDUCTION = 0.84(DOSE) + 2.50(SITE) – 0.78(DOSE*SITE) + 2.03. PY = presence of pouch young, AIC = Akaike's Information Criterion, ΔAIC = the difference in the value of AIC between the model and the chosen model (in bold). SITE was coded as 1 for the golf course and 2 for the park

Response variable	Predictors	% deviance	AIC	ΔAIC
Induction time (min)	DOSE+SITE+PY+CONDITION+DOSE*SITE+ PY*SITE+CONDITION*SITE	6.7	529.8	+7.4
	DOSE+SITE+PY+DOSE*SITE+PY*SITE	8.0	526.2	+3.8
	DOSE+SITE+DOSE*SITE	**9.4**	**522.4**	**0**
	DOSE	5.5	531.1	+8.7
	SITE	2.7	533.9	+11.5

golf courses, fauna parks and periurban reserves, campgrounds and other places with frequent human visitation. In these areas, there is often a need to capture kangaroos for management, public safety or amenity, or for animal welfare reasons. As long as the kangaroos can be approached within 5 m, this technique is simpler than any of those previously described, which require weapons permits, safety awareness training and practice shots (darting and stunning), extensive fencing (draw-string traps), setting of nets (draw-string traps and cannon netting), careful distribution and monitoring of bait (baiting) or a coordinated team of skilled assistants (herding, stunning and cannon netting). Mortality rates have been reported as 2% for stunning (Robertson and Gepp 1982) and 4.5% for baiting (Arnold *et al*. 1986). In contrast, the pole syringe caused no injuries and only 0.3% capture-induced mortality. We suggest that kangaroos appearing in extremely poor condition should not be immobilised with this technique, except for euthanasia.

Zoletil® immobilised 82% of kangaroos within 5 min, confirming the rapid induction reported in other macropodid species. We could explain only a small proportion of the variance in induction time by considering dose and site. The relationship between dose and induction time was weak at the national park and non-existent on the golf course, where induction took ~1 min longer, on average, possibly because of the slightly larger size of kangaroos on the golf course, where we also used a slightly lower dose. Therefore, variability in individual response due to unmeasured variables appears much greater than that predicted by dosage, and increasing dosage will not necessarily lead to reliably faster induction. Mean induction time was 1.9 min in red-necked wallabies (*Macropus rufogriseus*) (von Degerfield 2005) and 7.9 min in agile wallabies (*Macropus agilis*) and 7.6 min in red kangaroos (*Macropus rufus*), where it was extremely variable among individuals (Boever *et al*. 1977; Stirrat 1997), similar to our findings.

Roberts *et al*. (2010) reported that in eastern grey kangaroos, induction time was 8.3 min with a mean dose of 4.8 mg kg^{-1}, with no effect of body mass on induction. We found that dose affected induction time at only one study area in a multivariate analysis. Body mass and condition do not appear to have a strong effect on induction time for Zoletil® in kangaroos.

We did not measure duration time because recovery included a phase when the animal was able to stand but was very wobbly and prone to falls. In both study sites, the presence of an observer would have stimulated behaviours that could have led to injury to the animal or to a pouch young when present. On the golf course, we placed animals in sites as hidden from view as possible to reduce the chance of encounters with golfers during recovery.

Optimal dose rates of Zoletil® vary among species (Lin *et al*. 1993), being 4.1 mg kg^{-1} for red kangaroos (Boever *et al*. 1977), ~10 mg kg^{-1} for agile wallabies (Stirrat 1997) and 12.9 mg kg^{-1} for red-necked wallabies (von Degerfield 2005), consistent with decreasing dose rates as mean adult size increases (Schobert 1987). A dose of 5 mg kg^{-1} was considered an underdose for agile wallabies but 13.4 mg kg^{-1} was deemed safe (Stirrat 1997). We used a mean dose rate of 4.1 mg kg^{-1}, which provided immobilisation for the approximate 30 min required to attach a collar and eartags and take body measurements. Increasing the dose would increase the cost and possibly increase the risk to the animals but would probably have little effect on induction time.

We found no differences in the response of males and females. Sexual differences reported in the literature are inconsistent. Female agile wallabies had shorter induction times than males, but males appeared more deeply sedated than females (Stirrat 1997).

In conclusion, this technique is very safe and effective where kangaroos can be approached to within 5 m, regardless of body condition. It provides an effective means to immobilise habituated kangaroos for research and management.

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