SHORT COMMUNICATION

Detectability, movements and apparent lack of homing in *Hoplodactylus maculatus* (Reptilia: Diplodactylidae) following translocation

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Abstract: Translocation is an important tool in the conservation of New Zealand reptiles. Despite this, it is generally not known how *Hoplodactylus* geckos respond to being translocated, partly because they are difficult to monitor. In this opportunistic study, 11 common geckos (*H. maculatus*) were captured from a site at Birdlings Flat (South Island, New Zealand) that was destined for destruction, and released in native coastal shrubland 1 km away. Geckos were sampled monthly using pitfall traps and artificial retreats, with only the latter method yielding captures. Ten out of 11 translocated geckos remained at the release site, and translocated animals moved equivalent distances to resident geckos (n = 13) over a 1-year period following translocation. Although studies spanning multiple decades may be needed to determine whether translocations of *Hoplodactylus* geckos are ultimately successful given their life-history traits, the development of an effective detection method is nonetheless a useful contribution.

Keywords: artificial retreats; Birdlings Flat; detection; gecko; pitfall trapping

Introduction

Translocation, defined here as the deliberate transport of organisms from one place to another (Reinert 1991), is a vital conservation tool. This is especially so in New Zealand, where offshore islands that have been cleared of introduced mammalian predators provide sanctuary for many threatened species now absent or rare on the mainland (Saunders 1995). However, doubts have been raised about the effectiveness of this technique when applied to amphibians and reptiles, leading some researchers to caution against the use of translocations in most cases (e.g. Dodd & Siegel 1991; Reinert 1991). This is partly because it is difficult to determine whether a translocation has succeeded or failed. Some researchers consider translocations to be successful when they produce populations that are self-sustaining, or at least stable (Griffith et al. 1989; Dodd & Seigel 1991). Several New Zealand lizard translocations now meet this criterion (e.g. Thomas & Whitaker 1994; Towns & Ferreira 2001). Others have argued that a translocation can only be deemed successful when the population consists entirely of locally born individuals in addition to being self-sustaining (Wolf et al. 1996; Towns & Ferreira 2001). Establishing whether translocations are successful using these criteria requires biologically based, long-term monitoring programmes, with the required time frame depending on the life-history characteristics of the species (Dodd & Siegel 1991).

Many of New Zealand's reptile species have low recruitment rates coupled with late maturity and extreme longevity, leading to low rates of population increase following translocation to offshore island sanctuaries (Cree 1994; Towns & Ferreira 2001). For instance, free-living geckos in the genus *Hoplodactylus* can take up to 8 years to reach sexual maturity (Sheehan et al. 2004), produce a maximum of two offspring per female per year, which is reduced to less than one per year in some cool-climate populations that have biennial reproduction and an average clutch size well below two (Cree & Guillette 1995), and are capable of living to at least 42 years of age (Lettink & Whitaker 2006). A commitment spanning multiple decades may therefore be needed to determine whether or not translocations of these species are successful (Towns

& Ferreira 2001). An additional difficulty encountered for *Hoplodactylus* geckos is their ability to climb out of pitfall traps (Whitaker 1982; Wotton 2002), thereby escaping detection.

Even when it is possible to account for the long timescales involved, measuring the success of translocations can also be impeded by a lack of suitable detection methods. Furthermore, detection difficulties are hampered by poor information on post-release behaviour. For translocated reptiles, commonly measured behaviours include the ability of individuals to home back to their capture site successfully when released over a range of distances, the time taken to do so, and the homing mechanism employed (e.g. Mayhew 1963; Marshall 1983; Ellis-Quinn & Simon 1989; Hein & Whitaker 1997; Freake 1998; Stanley 1998; Zuri & Bull 2000; Jennsen 2002; Gruber & Henle 2004; Sullivan et al. 2004). Previous research on *Hoplodactylus maculatus* revealed that geckos that had been moved a short distance (110 m) outside their home range took up to 32 days to be detected back at their capture site (Marshall 1983); however, findings from that study were hampered by the use of a relatively ineffective detection method (pitfall trapping). The objectives of the present study were twofold: (1) to compare the detectability of common geckos following translocation using two different sampling methods (pitfall trapping and artificial retreats); and (2) to examine the movements of translocated geckos for 1 year following release, and to compare these with movements made by a representative sample of resident geckos living at the release site. Resident lizards were sampled regularly at this site as part of a separate study that compared their use of three artificial retreat designs (Lettink & Cree, in press). It was hypothesised that translocated geckos would move greater distances than their resident counterparts while establishing new territories or attempting to home back to the original site of capture. It was not known whether geckos would be capable of homing over the 1-km translocation distance.

Methods and materials

Study site and species

The translocation was conducted at Birdlings Flat (172°42'E, 43°49'S) at the eastern end of Kaitorete Spit, South Island, New Zealand. Dominant vegetation at this site included divaricating shrubs (primarily *Coprosma propinqua, C. crassifolia, Melicytus alpinus* and matagouri *Discaria toumatou*), the scrambling vine *Muehlenbeckia complexa*, and a mixture of native and introduced pasture grasses. The site was grazed periodically by sheep and cattle, and was considered to be suitable lizard habitat based on the vegetation present (Whitaker 1987) and previous observations of *H. maculatus* in the vicinity (Freeman 1997; M. Lettink, pers. obs.). *Hoplodactylus maculatus* is considered to be a cryptic species complex (Daugherty et al. 1994), and the Canterbury form encountered in this study is regarded as a distinct and threatened species for national conservation purposes (Hitchmough et al. 2007). The term *H. maculatus* is used here pending formal description of the species.

Translocation

On 13 October 2003, 11 *H. maculatus* were captured by hand from a woodpile (destined for destruction) on private land at Birdlings Flat. All geckos were given a unique toe-clip combination. No more than one toe was removed from each foot, and natural toe-loss was integrated into the system to avoid the unnecessary removal of toes. Gecko weight (measured to the nearest 0.1 g using a Pesola spring balance) and snout-to-vent length (SVL; measured to the nearest 1 mm using a clear plastic ruler) were recorded. Mature males were identified by the presence of a hemipenial sac and cloacal spurs. Geckos lacking male reproductive structures and with an SVL exceeding that of the smallest gravid female captured during previous surveys at Birdlings Flat (50 mm; M. Lettink, unpubl. data) were assumed to be females. Geckos were kept overnight in cotton holding bags prior to their release beside an artificial retreat in the middle of the monitoring area (described below), which was located about 1 km west of Birdlings Flat.

Post-release monitoring

A monitoring area containing 30 artificial retreat 'stations' spaced 5 m apart in a 5×6 grid was established 1 week before the translocation. Within this area, 20 pitfall traps, also spaced 5 m apart, were installed in a 4×5 grid, so that each pitfall trap was situated an equal distance between four neighbouring artificial retreat stations. Each station consisted of three retreats of different designs, as follows: (1) a triple-layered Onduline (http://www.onduline.co.nz) stack, made up of three sheets of corrugated bitumen roofing (400 × 280 mm) separated by lengths (1–2 cm) of 10-mm circular pine dowel glued beneath the corners and centre of each sheet, and weighed down with one or two small rocks; (2) a triple-layered stack of corrugated iron sheets (450 × 230 mm) set up with spacers as described above; and (3) a concrete roofing tile (390 × 320 mm) (Fig. 1). Artificial retreats were checked monthly (by sequential overturning of each layer) between December 2003 and November 2004 (a total of 1080 trap-days) by one or two observers. Capture sessions were typically conducted early in the morning under an overcast sky with cold or cool ambient temperatures (usually ≤ 15°C) to minimise

Figure 1. Artificial retreat station consisting of three retreat types (clockwise from top left): (1) concrete tile; (2) triple-layered Onduline stack; and (3) triple-layered corrugated iron stack. (Note: the vegetation cover surrounding this station was atypically sparse and shown here to provide a clear view of the retreat types and layout.)

the risk of escapes. Geckos were placed in holding bags until all artificial retreats had been overturned; they were then released at their capture site following marking and measuring, as described above.

Pitfall traps were operated daily for four consecutive days approximately 2 weeks after each monthly check of artificial retreats (total of 960 trap-nights). The traps (180-mm-deep, 4.5-L square, white 'Spacesavers'; Containment Solutions, Christchurch) were dug into the ground, leaving their rims flush with the surface. Small holes were drilled into the bottoms of traps to allow moisture to drain out. Pitfall traps were covered with plywood lids that were secured with steel pegs 1–2 cm above each trap and were baited every second day with small (c. 1 cm^3) pieces of canned pear. When not in use, sticks were left inside the traps, enabling lizards to climb out.

Statistical analyses

Program DENSITY (Efford 2004) was used to compare the movements of translocated geckos with data obtained for 13 resident geckos that were marked during the first capture session (making them equally available for capture throughout the study). The statistic used was *d*-bar, the mean distance between the n_i successive capture locations ($x_{i,j}$, $y_{i,j}$) of an individual *i*, pooled across all recaptured individuals:

$$\overline{d} = \frac{\sum_i \sum_{j<n_j} \sqrt{(x_{i,j} - x_{i,j+1})^2 + (y_{i,j} - y_{i,j+1})^2}}{\sum_i (n_i - 1)}$$

A *t*-test was used to compare the average capture rate of translocated versus resident geckos. Chi-squared analysis was used to determine whether the mean distance moved between successive captures differed for translocated versus resident geckos. All statistical tests were conducted in Program R (R Development Core Team 2004).

Results

The sample of translocated geckos consisted of nine adults (four males and five females; SVL range = 55–62 mm) and two juveniles that were identified retrospectively as one female and one male (SVL range = 44–45 mm). The resident sample consisted of 12 adults (six males and six females; SVL range = 51–65 mm) and one neonate (SVL = 33 mm). No translocated or resident geckos from the sample used for the comparison of movements were captured in pitfall traps over the 1-year study. In contrast, the use of artificial retreats resulted in 60 captures of 10 translocated geckos. One adult female was not seen again following translocation. Most (9 out of 11) of the translocated geckos were recaptured during the first capture session (approximately 6 weeks after release); three of these were found at the release site. Five individuals had moved to adjacent retreats, and one gecko was found in a retreat that was 10 m from the release site. All recaptured geckos gained weight after the translocation. On average, translocated geckos were recaptured 5.5 ± 1.22 (SE) times during the study (range = 0–11). The mean capture rate of translocated geckos was not significantly different from that of residents (mean capture rate of resident geckos = 4.0 ± 0.93, range = 1–10) ($t = 0.96$, d.f. = 22, $P = 0.35$).

Resident and translocated geckos showed very similar patterns in their movements (Table 1). Approximately three-quarters of successive captures of individuals were made within a distance of ≤ 5 m, and the maximum distances moved were similar (19 m for translocated geckos and 15 m for resident geckos). The mean distance moved between successive captures was 3.3 ± 0.5 m for translocated geckos ($n = 50$ captures) and 3.4 ± 0.7 m for residents ($n = 32$ captures). In both cases, just over half of all successive captures were made at the same site. Common geckos used Onduline retreats more intensively ($n = 70$ captures) than corrugated iron retreats ($n = 38$ captures) and concrete tiles ($n = 4$ captures), a trend that was also seen in the study that examined use of artificial retreat designs by lizards at Birdlings Flat (Lettink & Cree, in press).

Discussion

The study revealed that artificial retreats were a more effective method than pitfall traps for detecting translocated common geckos. Similarly, Sutton et al.

Table 1. Distance between successive captures of translocated and resident common geckos (*Hoplodactylus maculatus*) expressed as a cumulative percentage (%) of the total captures obtained for each group. Geckos were captured from artificial retreats at Birdlings Flat, New Zealand, from December 2003 to November 2004. Differences in movements between translocated and resident geckos were not significant ($\chi^2_4 = 0.13$, $P = 0.99$).

	0 m	≤ 5 m	≤ 10 m	≤ 15 m	≤ 20 m
Translocated geckos (n = 50 captures)	54	76	98	98	100
Resident geckos (n = 32 captures)	56	74	90	100	100

(1999) found that plywood cover boards were a more effective means of detecting sand skinks (*Neoseps reynoldsi*) than were pitfall traps with drift fences. In addition to increased detection efficiency, artificial retreats had several other advantages over pitfall traps. In this study, artificial retreats were easy to install and required almost no maintenance (spacers between sheets occasionally had to be re-glued). Conversely, drift-fence and pitfall trap configurations can take considerable time and effort to install, and require constant attention (Kjoss & Litvaitis 2001). Since animals are not physically constrained within retreats, accidental deaths through heat stress, predation or unsecured traps are generally avoided (Grant et al. 1992). Artificial retreats may also cause less habitat disturbance (Sutton et al. 1999), and their use requires little skill, thereby eliminating problems with observer bias associated with other search techniques (Lettink & Patrick 2006). However, extra measures may be needed where artificial retreats are placed at sites prone to stock or human disturbance, including vandalism (e.g. Reading 1997; Webb & Shine 2000).

By using artificial retreats it was possible to detect all except one of the geckos at the release site following translocation, suggesting that either the animals did not attempt to home over the 1 km they were translocated, or quickly returned to settle at the release site after an initial unsuccessful attempt at homing. Contrary to the hypothesis, translocated geckos did not move greater distances than resident animals. However, since monitoring did not start until 6 weeks after the translocation, we cannot rule out the possibility that geckos moved more frequently and over longer distances in the initial weeks following the translocation. When homing is successful in lizards, it usually occurs relatively quickly after displacement. For instance, return to the capture site was achieved within an average of 3 days for tropical Anole lizards *Anolis cristatellus* that had been moved up to 62 m (Jenssen 2002), an average of 24 days for common geckos (*H. maculatus*) displaced 110 m (Marshall 1983), 2–34 days for grand skinks *Oligosoma grande* moved 20–75 m (Stanley 1998), and 2–30 days in Gila monsters (*Heloderma suspectum*) moved up to 1 km (Sullivan et al. 2004). Irrespective of whether common geckos in the present study moved greater distances in the weeks following translocation, it appeared they had settled into their new environs within 6 weeks.

Some limitations and uncertainties remain. Firstly, animals moving off the sampling grid have no chance of being detected, so the ability to infer movement patterns, homing and survival is limited by size of the trapping grid. In this study, the size of the sampling grid was thought to be adequate based on the small home ranges and limited movement documented for *H. maculatus* at Turakirae Head (Whitaker 1982). Secondly, due to the opportunistic nature of this study, the sample size was limited and the demographic composition of the release group could not be manipulated. However, findings were consistent across individuals despite this limitation. Thirdly, the introduction of translocated geckos into the established territories of residents may have altered the movement patterns of both groups. Finally, it is likely that the presence of artificial retreats altered the spatial distribution and movements of geckos. Unfortunately, there was no way of investigating these last two possibilities due to the lack of effective, alternative sampling methods for *H. maculatus*. Although spotlighting (Whitaker 1967) can be used to locate nocturnal geckos, a direct comparison of movements would be difficult because this method targets active geckos rather than inactive geckos within diurnal retreats. A comparison of the detectability of common geckos using spotlighting compared with the Onduline retreats used in this study would be of interest.

In conclusion, the development of an effective sampling method permitted the detection and quantification of movements of common geckos at the release site up to 1 year following translocation. Since geckos were translocated into an existing population, translocation success could not be measured as it would be for the establishment of a new population. However, results suggest that artificial retreats are likely to be useful in other translocations of New Zealand reptiles, providing both an effective detection method and instantaneous refuges at sites where these are lacking.

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