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Habitat use by southern forest geckos, *Mokopirirakau* aff. *granulatus* 'southern forest' in the Catlins, Southland

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Abstract

Basic biological information is critical to evaluating conservation requirements for native taxa, but is lacking for many cryptic New Zealand lizard species. Southern forest geckos, *Mokopirirakau* aff. *granulatus* 'southern forest', are known only from anecdotes, museum specimens and discoveries of an individual at each of three sites during recent surveys in the Catlins. We used systematic searching, photo identification and radio telemetry at one of these sites (Tahakopa Valley) to investigate habitat use of southern forest geckos. Forty hours of searching in 2010-11 yielded 28 sightings of 17 individuals including four juveniles (indicating that a breeding population exists). Most geckos were found by searching a boulder used as a diurnal retreat site or in mānuka, *Leptospermum scoparium*. Two geckos were radio-tracked; both remained within 5 m of capture and exhibited primarily nocturnal behaviour. We recommend further survey work to identify populations and monitoring to evaluate the need for conservation intervention.

Key Words

Cryptic species, habitat modification, monitoring, natural history, photo identification, reptile, retreat site selection, systematic searching.

Introduction

A strong need exists for basic biological information, such as knowledge of habitat use and behaviour, for many cryptic species in New Zealand in order to optimise sampling techniques, and to accurately evaluate threat status, population trends and responses to any management interventions. This applies to many of New Zealand's visually cryptic lizards (Hare et al. 2007), including the forest gecko complex (*Mokopirirakau* spp.; Bell 2009).

Southern forest geckos (also known as blue-eyed geckos), *Mokopirirakau* aff. *granulatus* 'southern forest' are among the least known lizard species in New Zealand, and are nocturnal and cryptic in both colouration and behaviour (Tocher et al. 2000). In the latest threat classification process, southern forest geckos were classified as 'At Risk - Declining', with the qualifiers that they are 'Data Poor', 'Range Restricted' and 'Sparse' (Hitchmough et al. 2010). Their natural distribution is likely to have spanned the majority of the 131 400 ha of indigenous forest in the Catlins District, Southland (Wilson 1993; Jewell 2011). However, anecdotal evidence suggests that the species has undergone a pronounced range contraction as a result of forest clearance (estimated at 423 ha per year between 1861 and 1991 on the land (68 200 ha) designated for farming; Wilson 1993) and may now only exist in a few remnant, isolated patches of native bush within their former range (Tocher et al. 2000; Hitchmough et al. 2010).

Southern forest geckos are known primarily from anecdotes, although a few (mostly poorly-labelled) specimens exist in the Otago and Riverton Museums (Tocher et al. 2000). They are

most closely related to undescribed Roys Peak geckos in the *Mokopirirakau* aff. *granulatus* complex (Nielsen et al. 2011). The only targeted survey work on the species to date consists of a one week survey conducted in January 1997 in which promising gecko habitat was searched, but only two individual southern forest geckos were found (Tocher et al. 2000). Consequently, no detailed information exists on any population of southern forest geckos.

A southern forest gecko was discovered in the Tahakopa Valley, inland of Papatowai in the Catlins District, Southland (exact location not given to protect the population), in 2007 during a general lizard survey (Bell & Jewell 2007). Our objectives in this study were to evaluate the abundance and demographics of the Tahakopa Valley population, and to use it to document habitat use and behavioural patterns of southern forest geckos.

Materials and methods

The study site comprises three main habitat types, namely regenerating mānuka (*Leptospermum scoparium*) forest, a *Coprosma* spp. shrubland and mature forest dominated by rimu (*Dacrydium cupressinum*) and kamahi (*Weinmannia racemosa*). The site is not part of a pest control operation; as such brushtail possums (*Trichosurus vulpecula*) and rats (*Rattus* spp.) are abundant (commonly seen) at the site, and the full range of introduced predators are likely to be present (although we have not done any work targeted at evaluating predator levels).

We conducted 18 dedicated searches for southern forest geckos at the Tahakopa Valley site between April 2010 and March 2011. Searching techniques used included both timed hand searching of potential refugia (e.g. beneath rocks and vegetative cover on top of boulders, on tree trunks and at the base of trees) during the day and timed spotlighting at night (looking for both body shape and eye shine). During each site visit, a description of weather was made. For each gecko observed, we recorded age and sex, described the habitat being used by the gecko and took identification photos. Photo identification using natural markings has been developed as an alternative technique to tagging animals for individual recognition (e.g. Arzoumanian et al. 2005; Gamble et al. 2008) and is a reliable technique for identifying other New Zealand lizards (e.g. jewelled geckos, *Naultinus gemmeus*; Knox 2010, C. Knox, unpubl. data). Southern forest geckos have distinct dorsal patterns allowing for individual recognition based on photos (P. Melgren, pers. obs.; Fig. 1).

A pilot radio telemetry study to investigate habitat use by southern forest geckos was conducted from 17 March to 4 April 2011. We searched for geckos both during the day (timed hand searching) and at night (timed spotlight searching) to (1) find geckos large enough to carry a radio transmitter and be tracked during the study, and (2) obtain additional sightings data on smaller geckos to supplement the information obtained during the April 2010 to March 2011 survey. Night searches were conducted when the temperature was above 7°C and when not raining. In addition to searching, we set nine funnel traps baited with canned pear and fish-based cat food at the base of trees and shrubs in which geckos had been seen during our earlier survey (April 2010 to March 2011).

For each gecko captured we recorded time, temperature, a GPS position, morphometric measurements, a description of gecko activity and a habitat description. We took standard morphometric measurements: age (adult, sub-adult or juvenile), sex, reproductive status (for adult females only, by palpation), snout-to-vent length (SVL), vent-to-tail length (VTL), length of the regenerated portion of the tail, and mass. The habitat description at each point of capture for a gecko comprised of vegetation species, substrate, height of gecko above ground, amount of cover (distance to the edge of the tree) and distance to forest edge.

We used 0.7g BD-2 transmitters from Holohil Systems Ltd to investigate habitat use and movement patterns of geckos. Transmitters were fitted to adult geckos weighing ≥ 9.3 g (i.e. ≤ 7.5% of gecko body weight) with micropore self-adhesive tape using an external 'backpack' design (Salmon 2002; Hoare et al. 2007a). The tape was coloured black with a xylene-free permanent marker to minimise the chance of geckos being detected by predators and a small piece of reflective tape was attached to each side of the transmitter to aid searchers in finding geckos at night.

Radio-tagged individuals were tracked four times in each 24-hour period, once during the day to find retreat sites (if used) and three times at night during their activity phase (two hours after dusk, middle of the night and two hours before dawn). Temperatures, habitat use and gecko activity (if sighted) were recorded for each tracking event. Habitat variables recorded for each gecko observation included orientation, vegetation species, substrate type, height above ground, amount of cover (distance to the edge of the tree) and distance to forest edge.

Results

Between 6 April 2010 and 30 March 2011, we made 18 visits to the Tahakopa Valley site to search for southern forest geckos (Table 1). Of these, ten were daytime visits and took place primarily in the mid- to late-afternoon, and eight were night searches, from the early evening through until the middle of the night (Table 1). Duration of searches averaged 132 minutes (i.e. 2.2 person hours; range 60 to 235 mins). Search effort during this period totalled 40 person hours, and yielded 28 sightings of 17 individual southern forest geckos (0.7 gecko sightings per person hour; Table 1). Individual geckos were seen between one and four times during the survey. The greatest distance moved by an individual between first sighting and resighting was 8.5 m. All gecko sightings were made at temperatures of 10°C or higher (Table 2), most were made during warm, overcast weather and none were observed during rain (Table 1). Of the 11 geckos found on vegetation, the majority (eight geckos; 73%) were on mānuka, one was on a *Coprosma propinqua* shrub and two were on short pasture grass.

The majority of geckos seen (17 of 28 sightings; 61%) were found by hand searching of diurnal retreat sites (Table 2). Of the 17 geckos found by hand searching during the day, 15 were found beneath rock slabs on top of a large boulder. Temperatures under these slabs can be 8°C above ambient temperature; one evening when the ambient temperature had dropped to 7°C, the temperature beneath a slab on the boulder was recorded as 15°C. Two of the geckos seen beneath rock slabs during the day (a juvenile and a sub-adult) were actively basking in the late

afternoon at ambient temperatures of 12 and 13°C. These geckos had most of their bodies concealed by the rock slabs, but snouts exposed in direct sunlight. The other two geckos found during the day were found on the base of mānuka (*Leptospermum scoparium*) trees, one of which was completely concealed beneath fronds of an adjacent crown fern (*Blechnum discolor*; Table 2).

Eleven gecko sightings were made at night, during the active phase of the geckos. Of these, the majority (7 of 11; 64%) were found on the trunk, branches or foliage of mānuka (six geckos) or *Coprosma propinqua* (one gecko) at heights of 0.1 to 4.5 m above ground, two were on top of the large boulder used as a diurnal retreat site and two were found on grass moving between the large boulder and a nearby patch of regenerating mānuka forest (Table 2). During the survey, geckos were observed actively hunting for both a native harvestman and a noctuid moth, *Graphania plena*.

In addition to these gecko sightings, gecko scats were observed around both the large granite boulder commonly used as a retreat site and a log at the base of a *Coprosma propinqua* bush in which an adult female was subsequently found. Despite active hand searching for sloughed skins none were found.

During the three week radio-telemetric study (March-April 2011), the Catlins experienced an unusually cool period of weather and night-time temperatures often fell between 10°C (below which geckos are rarely found; Werner & Whitaker 1978, Table 2). As such, we found only

seven geckos during 87 person hours of searching during this period, five sub-adults and two adults (0.08 geckos per person hour; Table 3). Five of the seven geckos were found in mānuka or *Coprosma propinqua* shrubs by spotlighting at night, and two were found by hand searching of potential diurnal retreats sites (one beneath loose rocks on top of a boulder and one in the skirt of a rimu tree; Table 3). The gecko found in a rimu tree was the only gecko located in an area of mature forest at the site; all other sightings were in the adjacent area of secondary, mānuka-dominated forest and *Coprosma*-dominated shrubland. Based on photo identification, five of the seven geckos represented resightings of animals seen during the April 2010 to March 2011 survey while the other two had not been seen before. No geckos were caught in funnel traps placed within known territories.

We attached radio-transmitters to the two adult geckos found (both pregnant females, SVL 88 and 73 mm and weighing 13.6 and 11.3 g, respectively) and radio-tracked them from their date of capture to the conclusion of the study (12 and 5 days, respectively). Neither of the geckos radio-tracked moved far. The first was captured by hand searching during the day inside the dense, dry leaves of a rimu skirt, 2.2 m above ground. It remained concealed within the skirt for two days before climbing the trunk of the rimu tree and into the neighbouring kamahi tree, remaining in the canopy of the kamahi, ca. 5 to 7 m above ground for the next 10 days. The second radio-tracked gecko was found by night-time spotlighting on the branch of a *Coprosma propinqua* bush 1.1 m above the ground. It remained in the same *Coprosma* bush for the 5 day duration of the study, and moved through the bush using the trunk and branches between 0.1 and 0.6 m above ground.

Discussion

Results of the southern forest gecko survey reported here represent an important advance in basic biological knowledge for this species, and extend the one-week Catlins-wide survey for southern forest geckos reported by Tocher et al. (2000) and the two month general lizard survey reported by Bell and Jewell (2007). Our 28 sightings of 17 individuals between April 2010 and March 2011 (0.7 geckos per person hour), and evidence of breeding, suggest that the Tahakopa Valley site holds a low-moderate southern forest gecko population (compared to encounter rates of 0.3 to 4.6 sightings per person hour from systematic searching for other New Zealand geckos; Hoare et al. 2007a; Bell 2009). Finding an adult female southern forest gecko with a SVL of 88 mm extends the maximum known size of individuals of this species by 5 mm (Jewell 2011).

As with the two sites in which southern forest geckos were discovered during the 1997 survey (Tocher et al. 2000), the Tahakopa site is relatively disturbed, comprising a small patch of mature podocarp forest and adjacent regenerating mānuka and *Coprosma* shrubland amidst a plantation forestry landscape. Together, these findings support the hypothesis that southern forest geckos have survived extensive habitat modification in the Catlins by persisting in small remnant patches of undisturbed forest and recolonise secondary forest from these patches (Tocher et al. 2000). However, their current, presumably disjunct, distribution comprising small, isolated populations, within the Catlins and the ongoing threat posed by introduced predators continues to make this species of conservation concern (as indicated by Hitchmough et al. 2010). Furthermore, despite the Tahakopa Valley site holding the only known population of this species, we have insufficient data to know whether this population is viable. Because of the low

recruitment rates and late maturity of New Zealand geckos (Cree 1994), coupled with pressure from introduced predators on the mainland (e.g. Hoare et al. 2007b; Reardon et al. in press), it is possible that population growth at Tahakopa Valley is negative. Robust monitoring of the population will be needed to evaluate this.

Both hand searching during the day (inactive phase) and spotlighting at night (active phase) yielded sightings of southern forest geckos during this survey. A number of geckos in the population used a large boulder, partially covered with vegetation and with loose granite rocks on it as a day-time refuge (Table 2), presumably because of the thermoregulatory opportunity it provided (reaching temperatures 8°C higher than ambient temperature). However, others (including the two adult females that we radio-tracked) did not appear to use diurnal retreat sites continuously, either using them sporadically (e.g. dead rimu foliage; tree base concealed by shrubs) or simply using the same habitat during the day as during their night-time activity phase. The lack of reliance of forest geckos on diurnal retreat sites suggests that, although searching potential retreat sites can yield sightings, artificial retreats are unlikely to provide a reliable monitoring tool for this gecko complex. This result supports findings of Bell (2009) who detected 0.041 forest geckos, *Mokopirirakau granulatus*, for every 1 closed cell foam cover checked and no geckos using wooden retreats at the Zealandia ecosanctuary in Wellington. Furthermore, during the 2007 survey at the Tahakopa Valley site, the single southern forest gecko found was located by spotlighting at night; none were found by hand searching or the use of artificial retreats (Bell & Jewell 2007).

Night-time spotlighting in optimal weather conditions (mild (> 10°C), preferably overcast, no rain) proved a useful technique for finding southern forest geckos in relatively low secondary mānuka forest and shrubland (Table 2). This suggests that timed spotlight transects in optimal conditions are likely to remain the favoured technique for monitoring this species at present. However, detection rate of forest geckos using this technique is low, particularly in suboptimal weather conditions, and is likely to be much lower in tall, mature forest; there is no reliable technique for arboreal geckos in mature forest at present. Furthermore, we acknowledge that the information on sightings of geckos presented in this study is likely to be biased towards observable habitat and that a longer duration radio telemetry study with a better sample size would be required to evaluate habitat use objectively.

The Tahakopa Valley population of southern forest geckos documented here is, at present, the only known population of the species. The only other recent records of this species elsewhere in the Catlins are of individual sightings at two sites from the January 1997 survey (Tocher et al. 2000). In order to ensure the persistence of this species, we recommend that surveys be undertaken to confirm whether populations exist at the sites where individuals were found by Tocher et al. (2000), and to investigate other sites identified by locals as possibly having southern forest gecko populations (some are mentioned in Tocher et al. 2000, but only one was investigated during the 1997 survey). We also suggest that other potential sites with suitable habitat be identified based on knowledge obtained in this study and that of Tocher et al. (2000) and surveyed. In order to evaluate trends and the need for management, we recommend population monitoring using systematic searching (timed hand and spotlight searching) at the Tahakopa Valley site and one other site if another population is discovered. The translocation of

founder individuals from the Catlins into a predator-proof sanctuary should be considered if population declines are detected in remnant populations, or if habitat fragments in which they remain is to be cleared.

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Table 1. Search effort and summary results of a southern forest gecko survey conducted from April 2010 to March 2011 in the Tahakopa Valley, Catlins.

Date	Time of day	Start time	Duration (mins)	Weather	No. geckos sighted
6/04/2010	Afternoon	13:00	150	Overcast, SW breeze	3
4/05/2010	Afternoon	16:30	150	Sunny, calm	3
16/06/2010	Afternoon	15:00	90	Sunny, calm	3
21/08/2010	Afternoon	15:10	125	Overcast, S breeze	0
7/11/2010	Evening	18:30	60	Partially cloudy, sunny	2
26/12/2010	Evening	21:00	220	Clear, sunny	2
2/01/2011	Afternoon	15:00	235	Sunny, calm	2
3/01/2011	Afternoon	16:00	120	Partially cloudy, sunny	1
9/01/2011	Evening	21:00	150	Overcast	0
22/01/2011	Evening	21:00	180	Cloudy, calm	2
11/02/2011	Evening	23.15	115	Overcast, warm	4
12/02/2011	Afternoon	16:00	90	Drizzling prior to search	1
13/02/2011	Afternoon	15:30	60	Overcast	0
19/02/2011	Evening	21:00	180	Cloudy, calm	0
27/02/2011	Evening	21:00	150	Overcast	2
3/03/2011	Afternoon	15:00	80	Sunny, calm	0
4/03/2011	Evening	21.45	105	Overcast, calm	2
5/03/2011	Midday	11:00	120	Overcast, calm	1

Table 2. Demographics and habitat use for the 17 geckos observed during a survey for southern forest geckos in the Tahakopa Valley, Catlins (April 2010 to March 2011). 'Gecko' is a unique code for an individual gecko, based on photo identification using dorsal patterns, 'N/R' stands for 'new sighting' or 'recapture'; 'T' = temperature; 'In retreat?' refers to whether the gecko was found in its diurnal retreat site ('Y') or not ('N'); 'Height (m)' refers to height of the gecko above the ground.

Date	Sighting No.	Gecko	N/R	Age	Sex	Time	T (□C)	Habitat	In retreat?	Height (m)
6/04/2010	1	SFG1	N	Adult	F	13:07	14	Beneath rock slab on boulder	Y	
6/04/2010	2	SFG2	N	Sub-Adult		13:09	14	Beneath rock slab on boulder	Y	
6/04/2010	3	SFG3	N	Juvenile		13:10	14	Beneath rock slab on boulder	Y	
4/05/2010	4	SFG2	R	Sub-Adult		17:00	15	Beneath rock slab on boulder	Y	
4/05/2010	5	SFG3	R	Juvenile		17:00	15	Beneath rock slab on boulder	Y	
4/05/2010	6	SFG4	N	Juvenile		17:00	15	Beneath rock slab on boulder	Y	
16/06/2010	7	SFG5	N	Juvenile		15:01		Beneath rock slab on boulder	Y	
16/06/2010	8	SFG6	N	Juvenile		15:01		Beneath rock slab on boulder	Y	
16/06/2010	9	SFG7	N	Juvenile		15:01		Beneath rock slab on boulder	Y	
7/11/2010	10	SFG6	R	Juvenile		18:50	12	Beneath rock slab on boulder	Y	
7/11/2010	11	SFG8	N	Juvenile		18:50	12	Beneath rock slab on boulder	Y	
26/12/2010	12	SFG8	R	Juvenile		21:30	12	Grass	N	0
26/12/2010	13	SFG9	N	Adult		22:15	12	On boulder	N	1
2/01/2011	14	SFG8	R	Juvenile		21:40	12	Beneath rock slab on boulder	Y	
2/01/2011	15	SFG6	R	Juvenile		16:21	12	Beneath rock slab on boulder	Y	
3/01/2011	16	SFG7	R	Juvenile		16:40	13	Beneath rock slab on boulder	Y	
22/01/2011	17	SFG10	N	Sub-Adult		22:30	10	On boulder	N	1
22/01/2011	18	SFG11	N	Adult	M	23:40	10	Grass	N	0
11/02/2011	19	SFG12	N	Juvenile		22:22		Climbing mānuka branch	N	1.8
11/02/2011	20	SFG13	N	Adult	F	23:55		In canopy of mānuka	N	4.5
11/02/2011	21	SFG3	R	Juvenile		22:31		Beneath rock slab on boulder	Y	1

Date	Sighting No.	Gecko	N/R	Age	Sex	Time	T (□C)	Habitat	In retreat?	Height (m)
11/02/2011	22	SFG14	N	Adult	F	0:00		On *Coprosma propinqua* branch	N	2
12/02/2011	23	SFG13	R	Adult	F	16:21		On base of mānuka tree beneath crown fern	Y	0.1
27/02/2011	24	SFG15	N	Adult	F	22:30	11	In canopy of mānuka	N	2
27/02/2011	25	SFG15	N	Adult	M	23:21	11	On base of mānuka tree	N	0.1
4/03/2011	26	SFG16	R	Adult	M	22:09		On mānuka branch	N	2
4/03/2011	27	SFG17	N	Juvenile		22:34		On mānuka branch	N	1.8
5/03/2011	28	SFG16	R	Adult	M	11:00		On base of mānuka tree	Y	0.1

Table 3. Morphometrics of southern forest geckos, *Mokopirirakau* aff. *granulatus* "southern forest", located during the radio-telemetric study, 17 March to 4 April 2011, in the Tahakopa Valley, Catlins. 'Time' refers to time of capture; 'T' = temperature at capture; 'Repro. status' = reproductive status of adult females ('P' = pregnant; 'NP' = not pregnant); 'SVL' = snout-vent length; 'VTL' = vent-tail length; 'R' = length of the regenerated portion of the tail if incomplete or 'c' for complete; 'Tx' = transmitter attached and gecko radio-tracked. The sub-adult seen on 20 March was not captured or measured.

Date	Time	T (°C)	Age	Sex	Repro. status	SVL (mm)	VTL (mm)	R (mm)	Mass (g)	Tx	Habitat
17 March	17:05		Sub-adult			54	57	0	3.8	No	Beneath rock slab on boulder
20 March	23:25		Sub-adult							No	Branch of mānuka tree, 1.8 m above ground
24 March	11:30	14.1	Adult	F	P	88	57	46	13.6	Yes	Under dead rimu leaves against trunk, 2.2 m above ground
26 March	21:25	14.6	Sub-adult	F	NP	56	62	c	5.9	No	In canopy of mānuka tree, 2.9 m above ground
28 March	21:05	12.4	Sub-adult	M		67	70	c	7.9	No	In mānuka foliage, 1.8 m above ground
30 March	22:45	10.4	Sub-adult			53	54	c	3.8	No	In canopy of mānuka tree, 2.8 m above ground
31 March	00:15	9.8	Adult	F	P	73	73	c	11.3	Yes	On *Coprosma propinqua* branch, 1.1 m above ground

Figure 1. Evidence of variation in the dorsal patterns and the maintenance of dorsal shape variation over time in southern forest geckos, *Mokopirirakau* aff. *granulatus* 'southern forest' in the Catlins. Photos (a) and (b) are of the same individual captured on 6 April 2010 and 28 February 2012, respectively, and photo (c) is of a different individual.

(a) (b) (c)