Trapping and identification techniques for small-scaled skinks (*Oligosoma microlepis*)

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DOC RESEARCH & DEVELOPMENT SERIES 318

Published by
Publishing Team
Department of Conservation
PO Box 10420, The Terrace
Wellington 6143, New Zealand

DOC Research & Development Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff or external contractors funded by DOC. It comprises reports and short communications that are peer-reviewed.
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ISSN 1176-8886 (hardcopy)
ISSN 1177-9306 (web PDF)
ISBN 978-0-478-14702-5 (hardcopy)
ISBN 978-0-478-14703-2 (web PDF)

This is a client report commissioned by Wanganui Conservancy and funded from the Science Advice Fund. It was prepared for publication by the Publishing Team; editing by Amanda Todd and layout by Lynette Clelland. Publication was approved by the General Manager, Research and Development Group, Department of Conservation, Wellington, New Zealand.

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ABSTRACT

The small-scaled skink (*Oligosoma microlepis*) is a small, diurnal, heliothermic skink that is known from a number of small, scattered and isolated populations in the central North Island, New Zealand. This study presents the first attempt to estimate population sizes of this species at five sites near the Springvale Bridge in the Rangitikei River region. Funnel traps made of fly-screen and strong wire mesh were successfully used to catch small-scaled skinks. At easily accessible rock piles, noosing proved to be a more efficient capture technique than trapping, with more skinks caught over a smaller amount of time. Small-scaled skink individuals were successfully identified by their natural markings. Population estimates and densities were derived from the resighting of photographed individuals at five sites at Springvale Station. The results of this study can now be incorporated into future studies to assess the status of the species and gain more knowledge about its population ecology.

Keywords: *Oligosoma microlepis*, mark-resight, population estimates, photo identification, funnel traps, noosing

Gebauer, K. 2009: Trapping and identification techniques for small-scaled skinks (*Oligosoma microlepis*). *DOC Research & Development Series 318*. Department of Conservation, Wellington. 24 p.

1. Introduction

There are 28 known skink species in New Zealand, 22 of which belong to the genus *Oligosoma* (formerly *Leiolopisma*; Gill & Whitaker 1996). *Oligosoma microlepis*, the small-scaled skink, is a diurnal, heliothermic skink that reaches a snout-vent length of up to 73 mm (Gill & Whitaker 1996). It is distinguishable from all other skink species by its very small body scales, which result in a high mid-body row count of 38–44 scales, and the tear-drop marking (white spot with black) below each eye (Whitaker 1991). Gill & Whitaker (1996) described this species as being grey-brown, with prominent longitudinal stripes and speckling. Whitaker (1991) additionally reported very dark brown animals. The undersurface of the body is pale and unspeckled. Small-scaled skinks inhabit rock outcrops, rock piles and screes that are well exposed to the sun.

1.1 CONSERVATION HISTORY AND PRIOR SURVEYS

The first small-scaled skink specimens were collected in January 1971 on Motutaiko Island, Lake Taupo (Taupomoana) (Whitaker 1991). In 1978, skinks were collected west of Springvale Bridge on the Napier–Taihape Road, Rangitikei Region (Whitaker 1991), which were also identified as small-scaled skinks. The species was formally named in 1990 (Daugherty et al. 1990).

The Department of Conservation (DOC) has conducted a number of surveys to determine the distribution of the small-scaled skink and to discover new populations of the species. Surveys were undertaken in the inland Patea district, upper Rangitikei River catchment, in 1991 (Whitaker 1991), the western Hawke's Bay region in 1992 (Hutchinson 1992), and the east Taupo region in 1997 (Whitaker 1997). Collectively, these surveys detected about 16 small populations of small-scaled skink over a range of 300 000 ha. Because of its widespread but isolated distribution of only a few populations, the species is classified as threatened internationally (IUCN 2009), with a DOC threat classification of 'Serious Decline' (Hitchmough et al. 2007).

There is only very limited knowledge about the ecology of small-scaled skinks, with only a few studies having addressed this. In 1990, Wanganui Conservancy (DOC) conducted an unsuccessful pit-fall trapping study to assess the population at the Springvale Station sites (Whitaker 1997). Flannagan et al. (2001) carried out a distribution survey in the same region to determine habitat preferences of small-scaled skinks, and Teal (2006) undertook a population study to describe detection probabilities and important habitat variables.

1.2 ESTIMATING POPULATION SIZE

To estimate population size, animals in a population must be individually identifiable if a census of all animals is not possible, e.g. because of the elusive behaviour of the animals or environmental factors such as topography or size of the study area. Where identification requires individuals to be marked, animals may have to be caught and handled.

1.2.1 Capturing skinks

Commonly used methods for catching lizards are catching by hand (Gardner et al. 2007), catching with a noose (Rodgers 1939), running them down (Carpenter 1959) or using various types of traps. Numerous trap designs for catching skinks can be found in the literature. Generally used traps include pitfall traps, funnel traps, glue traps and Elliot traps (Rodgers 1939; Vogt 1941; Banta 1957; Glor et al. 2001; Anthony et al. 2005; Gardner et al. 2007). Each trap type has its own inherent biases and mechanical limitations, and trapping success depends on the species, climate conditions and environmental factors. A number of studies have attempted to identify which trap type best suits particular species (Greenberg et al. 1994; Anthony et al. 2005), and various studies have tested the effectiveness of different designs of funnel traps for catching lizards (Vogt 1941; Carpenter 1959; Hall 1967; Greenberg et al. 1994).

Small-scaled skinks live on greywacke rock piles and screes, which cover relatively small areas. They have been observed occasionally in adjacent vegetation, but never far away from the rocks (pers. obs.). On this terrain, it is impractical to use pitfall traps, as traps cannot be buried within the rock piles without causing large disturbance to the skinks' habitat, and by burying pit-fall traps around rock piles trapping results may be biased towards animals that live on the edge of the rock outcrops. Therefore, noosing and funnel trapping would seem to be better suited trapping techniques for small-scaled skinks and the habitat they use.

1.2.2 Marking skinks

Various techniques for marking lizards are reported in the literature. Commonly used techniques include toe-clipping, passive integrated transponder (PIT) microchips and paint-marking (e.g. Woodbury et al. 1956; Langkilde & Shine 2006; Gardner et al. 2007). Each technique has its advantages and disadvantages (Beaumont & Goold 2007). For estimating population size, it is important that any marks are not lost during the study period (Neal et al. 1993). Hudson (1996) studied the natural toe loss of southeastern Australian skinks and found that toe loss can occur often in some species. Toe loss also occurs frequently in small-scaled skinks (pers. obs.). This would have serious implications for marking and identifying toe-clipped skinks because false identifications influence the population estimates (Stevick et al. 2001). Paint-markings can only be used until a marked animal sheds its skin, at which time the mark will be lost. All of these techniques require capture and handling, which can be stressful for animals (Langkilde & Shine 2006).

Natural pigmentation and scarring are long-lasting markings that do not require an animal to be handled (Woodbury et al. 1956; Auger-Methe & Whitehead 2006; Gilkinson et al. 2007). Photographs are taken of animals and their natural markings, and are matched to images held in photo databases. This technique has the advantages of being unintrusive, and relatively cheap and easy to use (Auger-Methe & Whitehead 2006; Gamble et al. 2008). It can be used with species that may be difficult to catch or tag. (Gilkinson et al. 2007). Disadvantages are that natural markings may be difficult to distinguish, marks such as scars may disappear or change over time, and marks may not be evenly distributed across all animals in the population (Stevick et al. 2001; Auger-Methe & Whitehead 2006; Gilkinson et al. 2007).

The use of photo identification has a long history in mark-resight studies of whales, dolphins and seals (e.g. Karlsson et al. 2005; Auger-Methe & Whitehead 2006). This technique has also been used for estimating population size of other species, including cheetahs (*Acinonyx jubatus*) (Kelly 2001), bobcats (*Lynx rufus*) (Heilbrun et al. 2003), New Zealand sea lions (*Phocarctos hookeri*) (McConkey 1999), sea otters (*Enhydra lutris*) (Gilkinson et al. 2007) and salamanders (*Ambystoma opacum*) (Gamble et al. 2008). In New Zealand, photo identification has additionally been used with grand skinks (*Oligosoma grande*) and Otago skinks (*O. otagenese*) since 2003, for studies on population size and survival (Reardon et al. 2007).

1.3 OBJECTIVES

The North Island *Oligosoma* spp. Skink Recovery Plan (Towns et al. 2002) outlines the need to improve knowledge about the ecology and populations of the small-scaled skink, to assess its conservation status and to investigate the potential for management. Knowledge about population size and survival rates is important for building management strategies.

The aims of this study were to:

- Confirm reported sightings of small-scaled skink populations through a site survey
- Assess the potential use of funnel traps and noosing for population studies of small-scaled skinks
- Determine whether individuals could be recognised by their natural markings from photographs
- Make population estimates using mark-resight models

Permits for this study were obtained from the Department of Conservation, New Zealand (Permit WA-22496-FAU), and the Animal Ethics Committee, Massey University, Palmerston North, New Zealand (Permit 08/01). Permission to enter the sites was obtained from the land owners and land managers.

2. Methods

2.1 SITE SURVEY

An initial survey of potential sites for this study was conducted between January and March 2008, to confirm reported small-scaled skink populations. The area around the Springvale Bridge in the Rangitikei River catchment has been described as the stronghold for small-scaled skinks (Flannagan et al. 2001). Sites at Springvale Station (Sites 2–5, Huts Site and Quarry Site), Kelly Land Co. Riverbed Flats and Otupae (Whitaker 1991; Hutchinson 1992; Flannagan et al. 2001; Teal 2006) were visited and checked for small-scaled skinks (Fig. 1). Sites at Motutaiko Island, Boyds, Poronui, Wakemans, Ohinewairua Station and Ngamatea Station (Whitaker 1997) were not visited during this study because of difficulties with access. During the course of this study, Richard Steedman from the Aorangi Awarua Trust reported unidentified skinks at the northern slope of Mt Aorangi. Permission to enter the trust land was granted and the site was included in this survey.

Teal (2006) showed that highest detection probabilities are obtained under sunny and warm weather conditions. Therefore, each potential study site was surveyed once, during the morning, on a day with warm and sunny weather conditions. Surveys were carried out by two observers, who searched for skinks using binoculars. Sites were surveyed at a distance of 2–10 m for up to 1.5 h or until small-scaled skinks were seen. When no skinks had been observed after 1.5 h, the site was checked for droppings or skins. Sites where no small-scaled skinks or indications of their presence were seen were re-visited one or more times. Photographs were taken of all sites and are held at Palmerston North Area Office, DOC.

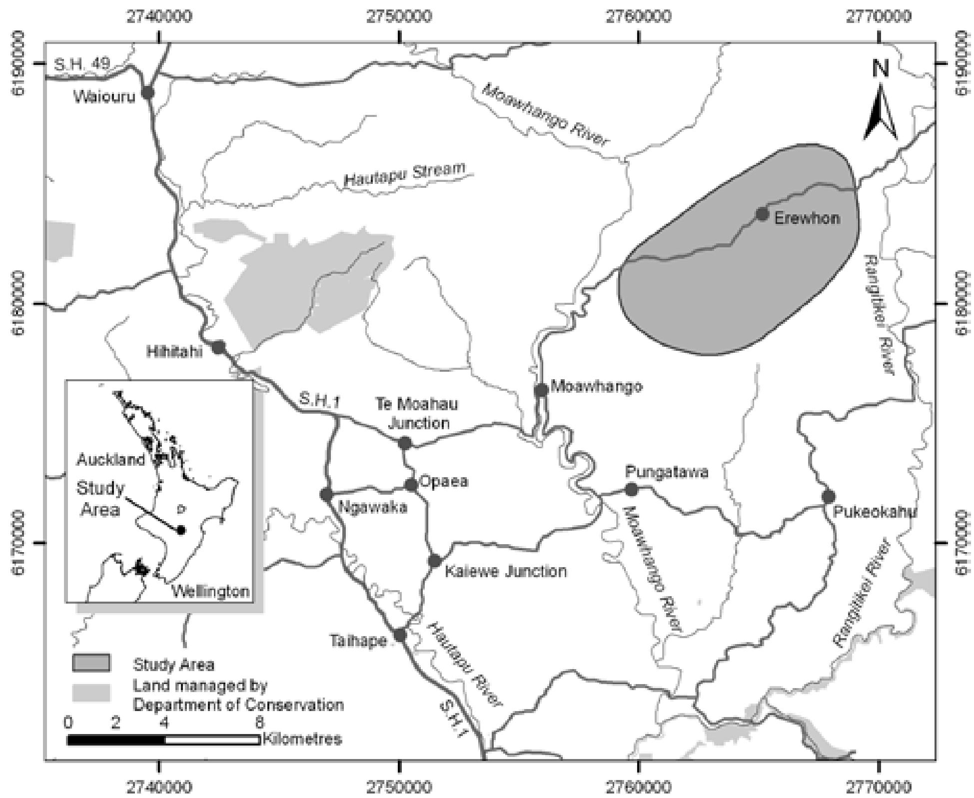

Figure 1. General location of small-scaled skink (*Oligosoma microlepis*) study populations, North Island, New Zealand.

2.2 TRAPPING AND NOOSING

Two Springvale Station sites, 'Quarry' and 'Huts' (Flannagan et al. 2001; Teal 2006), were chosen to assess the potential use of funnel traps and noosing to capture small-scaled skinks. Both sites consist of several greywacke rock piles and screes surrounded by pasture, and are located on private farmland that is used for sheep and cattle grazing.

2.2.1 Funnel traps

Funnel traps made by the researcher were used. Each trap was a flat oval tube made out of strong wire mesh that was lined with fly-screen. One side of the tube was fitted with a funnel made out of fly-screen, and the back was also covered with fly-screen held by wire for easy access. The wire construction allowed ventilation, so skinks did not overheat, and was sturdy enough to be covered with rocks to blend into the environment and provide shade (Fig. 2). The traps were 17.5 cm wide, 21.5 cm long and 8.5 cm deep, with a funnel opening of 2 × 1.5 cm, and were able to be easily placed on the rock piles with minimal disturbance.

The Quarry site was initially chosen for trapping, as it seemed to have the highest skink densities. The traps were then moved to the Huts site, to test their success at a site with lower densities of skinks. Trapping was conducted between 14 and 18 February 2008 at the Quarry site, and between 18 and 21 February 2008 at the Huts site.

The Quarry site consists of four greywacke screes, each of different size, spread over an area of about 1 ha of pasture that is grazed by sheep and cattle. Two discrete greywacke screes with good accessibility for observers were chosen for trapping. Plot 1 comprised a greywacke scree of 2 m × 6 m, which was located about 10 m away from the next nearest greywacke scree. Plot 2, which was

Figure 2. Funnel trap on greywacke scree. (Photo: Timothy Lever.)

10 m × 4 m, was a discrete part of a larger scree that was located on a steep slope and was separated from the rest of the scree by a strip of pasture 1.5 m wide, including a stock track.

Two funnel traps were placed at each plot, one of which was baited with five live flies and the other with cat food (chicken flavour). The bait type was alternated each day between the two traps at each plot to prevent the position of the traps from biasing the results. The traps were positioned at the periphery of each plot, with the funnel facing towards the centre. Traps were checked twice a day and were re-baited when skinks were caught. Traps were set at 7.00 a.m. and checked at 1.00 p.m. and 7.00 p.m. to ensure that skinks would not be trapped for more then 6 h. Thus, one trapping session represents 6 h in the morning or the afternoon. At Plot 2, the number of traps was increased to four from 16 February onwards, to increase the number of skinks caught. Traps were taken from Plot 1 on 17 February, to allow the re-sighting study to begin and the traps to be used at the Huts site.

The Huts site comprises three greywacke screes, each of different size, located in 0.5 ha of pasture, which is also grazed by sheep and cattle. The plot used at this site was an 8 m × 4.5 m area on a larger scree, which was separated from the rest of the scree by a 1-m-wide band of greywacke covered in vegetation. The same protocol applied to the Quarry site was also applied here, with four traps used over the whole area, beginning with the afternoon session on 18 February and ending with the morning session on 21 February.

Each small-scaled skink caught in a trap was measured (snout–vent length (SVL), tail length and length of regenerated tail) and given an individual mark by drawing a number on its back using a golden, non-toxic, water-based pen. Photographs were taken of each skinks's right and left profile, after which it was released.

2.2.2 Noosing

A trial of catching small-scaled skinks by noosing was conducted on 20–21 February 2008. Plot 2 of the Quarry site was chosen for this experiment because of its large population of small-scaled skinks. A noose made of fishing line was fitted to the end of a 1.5-m-long fishing rod. One observer sat next to the rock pile, chose a skink to noose, carefully slipped the noose over the head of the skink and pulled it tight. The skink was then lifted to a second person holding a plastic bag, who carefully dropped the skink inside by loosening the noose; this proved to be the best way to remove skinks from the noose, as they move quickly to free themselves.

Each skink was immediately measured (snout–vent length (SVL), original tail length and length of regenerated tail), marked with a golden, non-toxic, water-based pen, and had its right and left profile photographed. The skink was then released. The whole procedure took a few minutes per capture.

2.3 PHOTO IDENTIFICATION

To evaluate the utility of using natural markings to identify individual small-scaled skinks, the symmetry and recognisability of individuals were tested.

Multiple photographs of paint-marked small-scaled skinks were taken at Plot 1 and Plot 2 at the Quarry site, and at the Huts site. A Canon PowerShot S3 IS 6MB camera with 12× optical and 48× digital zoom was used. One observer sat close to the plot (< 2 m away) before sunlight reached the area and small-scaled skinks became active. The nose to foreleg region was used for identification (Fig. 3). A screening process was used to remove photographs that were out of focus or grainy, or where the angle, distance or obstructions prevented a good view of the identification area. Adobe Photoshop Elements 6.0 was used to cover the paint markings of each skink in the photographs. Symmetry was assessed by comparing right and left profile pictures of 30 captured skinks. The left profile picture was flipped horizontally with Adobe Photoshop Elements 6.0 software. The nose–foreleg region was then compared with the right profile photograph and rated as different or symmetric.

Recognisability was tested using ten volunteers who had no previous experience with small-scaled skinks or photo identification of animals. The volunteers were initially given a short presentation about small-scaled skinks and the idea of estimating population size using mark-resight data, including an example of how to match two photographs of an individual small-scaled skink. They were instructed to compare the tear-drop markings under the eyes, the regions around the ear opening and above the leg, as well as the white markings between the ear and foreleg. Volunteers were then given a handout with right profile photographs of seven different small-scaled skinks. They were shown a sequence of 16 right-profile photographs and had to decide which photographs matched one of the seven skinks on the hand-out. Eight photographs (50%) matched individuals shown on the hand-out, whilst the remaining photographs were of skinks not shown on the handout. There was no time-limit set for the volunteers to identify individual skinks. The test was scored using a simple point system, with one point for a correct match and no points for an incorrect match.

Figure 3. Small-scaled skink (*Oligosoma microlepis*), showing the nose–foreleg region used for identification (square). (Photo: Timothy Lever.)

2.4 POPULATION ESTIMATES

Mark-recapture and mark-resight studies are used widely to estimate population size (Cormack 1964; Nichols 1992; Seber 1992; Schwarz & Seber 1999; Chao 2001). A sample of the population is captured, marked and released back into the population. On the next trapping occasion, animals that are both marked and unmarked will be caught. The proportion of marked:unmarked individuals is used to estimate the total population size, based on the assumption that the likelihood of encountering that proportion of the total number of marked animals equals the likelihood of encountering the same proportion of animals in the whole population (White 1996; Schwarz & Seber 1999). After two trapping occasions, the Lincoln-Petersen estimator can be used to calculate the total population size (see Buckland et al. 2000). To obtain more robust population estimates, trapping can be continued.

Over the last few decades, the early estimators of population size have been adapted and extended to accommodate different situations that scientists may encounter when dealing with animal populations (Bartmann et al. 1987; Brownie et al. 1987; Arnason et al. 1991; Buckland & Garthwaite 1991; Buckland et al. 2000; Schwarz 2001). With the advancement of computer technology, larger datasets can be used to estimate population size and more complex estimators have become available for scientists. With some estimators, previously untagged animals can be tagged to develop capture histories, which allows calculation of population size and survival rates (Schwarz & Seber 1999).

When using estimators to calculate population sizes, the underlying assumptions of different models should be examined carefully to avoid violations that may result in biased estimates (Kendall 1999; Schwarz & Seber 1999). Closed population models assume that the population is static, with no additions (immigration and birth) and no deductions (emigration and death) (Neal et al. 1993; Evans et al. 1998). This can be realised by sampling the populations over short periods of time (Nichols 1992). It is also assumed that all animals are equally likely to be caught in each sample (Pollock 1982). The marker or tag should have no impact on the behaviour and survival of the animals (Evans et al. 1998), and tags should not be lost during the sampling period (Schwarz & Seber 1999).

Photographs of small-scaled skinks were taken at one plot at each of Springvale Station Sites 2, 3 and 5, and at two plots at each of the Quarry site and the Huts site between 1 February and 4 March 2008. It was not possible to obtain photographs over all greywacke screes at each site because of time limitations. Therefore, calculated population estimates are not total population estimates for these sites. Plots were discrete greywacke screes surrounded by pasture, which resulted in different-sized plots depending on the greywacke scree available. It was assumed that each plot contained one sub-population of the total population of the site, and that very few or no immigrations and emigrations occurred between sub-populations during the study period. The area of the greywacke plots used was calculated by measuring the two diameters and using the formula for an ellipse.

A Canon PowerShot S3 IS 6 MB camera with 12× optical and 48× digital zoom was used. One observer sat close to the plot (< 2 m away) before sunlight reached the area and small-scaled skinks became active. Photographs were taken of each individual skink visible to the observer. There was no time limit—the observer took photographs until it was assumed all visible skinks had been photographed. The nose to foreleg region was used for identification, and had to be in focus and clear of objects (Fig. 3). A screening process was used to remove photographs that were out of focus or grainy, or where the angle or distance did not allow for a good sight of the identification area. To identify how many individual skinks were seen during a session, photographs from one session were compared against each other. Those photographs were then compared with photographs of individual skinks seen during former sessions to identify re-sightings.

Likelihood-based closed population capture-recapture models in MARK (White & Burnham 1999) were used to calculate population estimates in this study. These models include the following assumptions:

- The population is geographically and demographically closed. To address this assumption, we observed animals over a short time period following marking. Juvenile individuals born during the study period were clearly smaller than adults and subadults and were not included in the counts. Study plots were assumed to hold an entire sub-population of the site.
- All individuals have equal sighting probabilities. The size of the rock piles allowed one observer to monitor the whole area. Small-scaled skinks were not observed to move further than 3 m away from a rock pile during the observation period.
- Marked individuals mix fully with unmarked individuals between samples. Counts were conducted once a day in the mornings, allowing the skinks to 'fully mix' between samples.
- Individual marks can be reliably distinguished and marks are not lost. Natural markings proved to be distinguishable between individuals and would not be lost during the observation period.

3. Results

3.1 SITE SURVEY

Populations of small-scaled skinks were found at 10 of the 13 sites surveyed. No skinks or droppings were visible during this survey at two sites: Kelly Land Co. Riverbed Flats and Otupae Site 3. The Riverbed Flats site was visited on three occasions, twice early in the morning and once in the afternoon, for 1.5 h per visit; weather conditions were warm, sunny and calm. Otupae Site 3 was visited one morning for 2 h under warm and sunny but windy conditions. Springvale Station Site 1 near the Springvale Bridge, which was described by Whitaker (1991), could not be located, as the riverbanks had changed following heavy floods.

With the exception of Riverbed Flats, all Springvale Station sites surveyed seemed to support good populations of small-scaled skinks, whereas only one or a few skinks were seen at the Otupae sites. The occupied sites at Springvale Station covered an area of 0.23 ha. The area of the Otupae sites was not measured, as the boundaries of occupied rock outcrops were difficult to define.

Following up on information about unidentified skinks on the northern slopes of Mt Aorangi (Richard Steedman, pers. comm.), a survey was conducted that resulted in one sighting of a small-scaled skink. This individual was observed basking in the sun on boulders at the base of the northern limestone cliffs, at an altitude of 1175 m a.s.l. This new population is the most southern and highest in altitude that is known of to date. A summary of the survey details is provided in Appendix 1.

3.2 TRAPPING AND NOOSING

Funnel traps were operated for 7 days at the Springvale Station Quarry site and for 3 days at the Huts site. At Plot 1 and Plot 2 of the Quarry site, five and nine skinks were caught during 16 and 30 trapping sessions, respectively; at Plot 2, one skink was trapped twice. At the Huts site, four skinks were caught during 26 trapping sessions; one skink was caught twice. This converts into a capture rate of 0.3 skinks/trapping session at the Quarry site and 0.2 skinks/trapping session at the Huts site. There was no significant differences between trapping success at the Quarry and Huts sites ($\chi^2 = 1.85$, df = 1, $P > 0.05$), so the data were pooled for all further analyses.

Significantly more skinks were caught in traps baited with flies ($n = 15$) than in traps baited with cat food ($n = 5$) ($\chi^2 = 4.51$, df = 1, $P < 0.05$). There was no significant difference between the number of animals caught in the morning ($n = 8$) and the afternoon ($n = 12$) ($\chi^2 = 0.25$, df = 1, $P > 0.05$).

On two mornings, skinks were noosed at Plot 2 at the Quarry site. On both mornings, six skinks were caught over 2 hours by a two-person team, with one person noosing and the other measuring and marking the skinks.

Skinks captured at the Quarry and the Huts sites did not significantly differ in their SVL ($t = 0.627$, df = 17, $P > 0.05$); therefore, data were pooled for the following comparisons. There was no significant difference between the SVL of animals caught in funnel traps or by noosing (t = 1.337, df = 28, $P > 0.05$), or between animals caught with traps baited with flies or cat food (t = 0.135, df = 19, P = 0.135). There was a significant difference in the SVL of small-scaled skinks captured in the morning and afternoon trapping sessions (t = 2.627, df = 15, P = 0.02), with animals trapped in the afternoon being smaller than animals trapped in the morning.

3.3 PHOTO IDENTIFICATION

The comparison of left and right-profile photographs of the small-scaled skinks revealed differences and no symmetry between markings for all 30 animals. Right profile photographs were chosen to be used for the evaluation with the volunteers. The volunteers reached a mean score (± SD) of 14.1 ± 1.5 of the possible 16 points, i.e. 88.1% of the photographs were identified correctly (or the misidentification rate was 11.9%). Of the 18 misidentifications, 15 were false positives (two photographs were identified as the same animal but were different) and three were false negatives (two photographs were identified as different but were of the same animal). Ten different photographs led to these misidentifications; six photographs were always identified correctly. One photograph, which accounted for four misidentifications, showed the right profile of a skink turning its head slightly towards the camera. On most other photographs, the skinks did not have their heads turned in any direction.

3.4 POPULATION ESTIMATES

The total area of all greywacke screes on which small-scaled skinks were observed at Springvale Station was about 0.23 ha. The area of the plots from which population estimates could be calculated was about 0.02 ha, about one-tenth of the total area. Photographs were taken during five sampling occasions at both plots at the Quarry site, four sampling occasions at the plot at the Huts site, and three sampling occasions at plots at Sites 2 and 5. Because of weather conditions, only two sampling occasions were possible at plots at Site 3. It took approximately 1 h in the morning to take pictures of all visible skinks at one plot. Skinks became more active and more difficult to photograph with increasing warmth of the rocks. It proved too difficult to obtain both left and right profile photographs of each individual. Therefore, either profile was taken, depending on what could be viewed, so that as many skinks as possible could be photographed. Table 1 presents the number of pictures used to establish capture histories and calculate population estimates.

The minimum number of animals known alive (MNA) was derived from the database of individuals identified at each site (Table 2). Plot 2 at the Quarry site had the largest population estimate (78 animals), followed by Site 5 (66 animals). The smallest population was estimated for Site 3 (only 9 animals). Population densities ranged from 4.8 animals/m^2 at Plot 1 at the Quarry site, to 0.2 animals/m^2 at the plot at Site 3 (Table 3). Across all plots used for population estimates, there was a total of about 252 animals living on c. 0.02 ha, giving a mean population density of 1.8 ± 1.7 animals/m^2.

TABLE 1. NUMBER OF SMALL-SCALED SKINK (*Oligosoma microlepis*) PHOTOGRAPHS TAKEN AT EACH PLOT.

SITE	OBSERVATION DAYS	TOTAL NUMBER OF PHOTOS	PHOTOS PER DAY	
			MEAN	SEM
Quarry Plot 1	5	41	8.2	1.6
Quarry Plot 2	5	90	18.0	4.1
Huts	4	13	3.2	0.9
Site 2	3	16	5.3	1.5
Site 3	2	7	3.5	0.7
Site 5	3	30	10.0	2.6

TABLE 2. MINIMUM NUMBER OF ANIMALS KNOWN ALIVE (MNA) AND POPULATION ESTIMATES OF SMALL-SCALED SKINKS (*Oligosoma microlepis*) AT SIX PLOTS AT FIVE SITES AT SPRINGVALE STATION.

SITE	MNA	ESTIMATE	SE	95% CONFIDENCE INTERVAL	
				LOWER	UPPER
Quarry Plot 1	29	45	9	35	73
Quarry Plot 2	57	79	8	67	102
Huts	9	10	2	9	20
Site 2	13	43	37	17	208
Site 3	6	9	6	6	39
Site 5	15	67	27	38	158

TABLE 3. POPULATION DENSITIES OF SMALL-SCALED SKINKS (*Oligosoma microlepis*) AT SIX PLOTS AT FIVE SITES AT SPRINGVALE STATION.

SITE	POPULATION ESTIMATE	PLOT SIZE (m^2)	POPULATION DENSITY (ANIMALS/m^2)
Quarry Plot 1	45	9.4	4.8
Quarry Plot 2	79	31.4	2.5
Huts	10	27.8	0.4
Site 2	43	36.5	1.2
Site 3	9	39.3	0.2
Site 5	67	47.1	1.4

4. Discussion

4.1 SITE SURVEY

Populations of small-scaled skinks have persisted at sites that are located on private farmland for over 15 years. There were good numbers of small-scaled skinks at both the Quarry site and the Huts site. Both these sites were already identified by Flannagan et al. (2001) as suitable for long-term monitoring. It appears that the Riverbed Flat site at Kelly Land Co. has a very low population of skinks: Flannagan et al. (2001) found no individuals, Teal (2006) reported very few, and neither skinks nor their droppings were found there during this survey. It is not known if the population has gone through several extinction/recolonisation cycles, or if individuals have persisted at low, sometimes undetectable numbers. The Springvale Bridge population may be extinct, as large floods have resulted in changes in the riverbed and destroyed the area where skinks previously occurred.

4.2 TRAPPING AND NOOSING

The design of the funnel traps proved successful, and flies as bait resulted in higher catch-rates than cat food. Small-scaled skinks were also successfully caught by noosing, even by inexperienced observers. More animals were caught in a shorter time period by noosing than by trapping. However, noosing is highly dependent on observers being able to sit close to the rock pile and being able to reach all parts of the rock pile with the noose. Very steep slopes can inhibit the observer's position and the length of the noosing pole should not exceed 1.5–2 m or it becomes difficult to place the noose over the skink's head. Furthermore, where only small numbers of skinks are present, a greater amount of time will be required to noose sufficient numbers. Therefore, the optimal capture technique for a particular study will depend on the number of skinks needed, the time available and the habitat the skinks live in.

Neither trapping nor noosing was tested on small-scaled skinks inhabiting rock outcrops. On rock outcrops, fewer places are suitable for trap placement, so that trapping results could be highly biased towards skinks that have access to suitable positions. Rock outcrops might be even less suitable for noosing, depending on their size and accessibility.

4.3 PHOTO IDENTIFICATION

The non-symmetrical markings on small-scaled skinks should be considered when planning a mark-resight study. For each individual, both right- and left-profile photographs should be taken, or the study should use either right- or left-profile photographs only. For databases used in long-term studies, both right- and left-profile photographs should be used to allow for correct matching after long periods of time or when only a photograph of one side is available.

A good digital camera with a powerful zoom is necessary for this type of study. During the screening process we employed, photographs that showed one or more of the following flaws were rejected: the marking was out of focus; the animal was too far away or filled only a small proportion of the photograph; reflected light made it difficult to see the markings; or markings were not visible because of the position of the animal. The quality of the photographs increased during the study period, suggesting increased experience of the observer.

The test with inexperienced volunteers showed that markings on individual skinks could be distinguished in most cases. Friday et al. (2000) reported that patterns with large similarities and high complexity increase the risk of misidentification. This can lead to false-positive and false-negative identifications, resulting in population size being under- or overestimated. Volunteers became more confident after comparing a number of photographs, suggesting that observers need to get used to the markings and how to differentiate between them.

One disadvantage of using natural markings for identification is the time-consuming search for matches in a database. With larger databases, markings can be categorised (see Auger-Methe & Whitehead 2006), reducing the number of pictures to choose from. This not only reduces time, but may also reduce the risk of misidentification (Beaumont & Goold 2007). For the small-scaled skink, the colour pattern of the tear-drop below the eye (e.g. black-white, black-white-black, white-black, no/white tear-drop) might prove suitable for categorisation.

4.4 POPULATION ESTIMATES

This study resulted in a database of small-scaled skinks that can be individually identified by their natural markings. This presents an opportunity to collect population statistics without physically handling the animals, which will reduce stress and possible changes in behaviour, both of which could bias population estimates.

Natural markings are less susceptible to mark loss than artificial marks: during this study, at least one skink that was paint-marked lost its markings on shedding its skin; it was later identified by its natural markings. Therefore, with the use of natural markings, skinks can be identified over long periods of time. This allows calculation of survival rates and very robust population estimates using the model described by Pollock (1982). The large confidence interval for the population estimate at Site 3 indicates that the proportion of animals photographed was very small. More sampling occasions would lead to smaller confidence intervals and better estimates.

As mentioned in section 2.4, mark-resight models include several assumptions. We addressed these where possible, but some of these assumptions may have been violated. One assumption of mark-resight models is that individuals can be reliably identified. The possibility of misidentification was not included in the model used to estimate the population size because of the small amount of data available (due to the weather conditions). However, the evaluation of photo identification with volunteers showed that there was a tendency toward false-positive misidentifications, which would cause underestimation of the population size. A second assumption of these models is that the population is closed.

To address this, the experimental design of this study tried to use short time periods and clearly defined plots to reduce the probability of immigration and emigration. However, without information on dispersal behaviour and distances travelled by small-scaled skinks, migration cannot be entirely ruled out.

This study estimated that 252 small-scaled skinks inhabit 0.02 ha of the total 0.23 ha where populations of this species have been observed at Springvale Station. Large variations in the observed population densities do not allow a reliable estimate of the total population of Springvale Station.

5. Conclusions

The presence of small-scaled skinks was confirmed at 13 sites, some of which are known to have had small-scaled skink populations for more than 15 years. This study shows that small-scaled skinks can be identified by their natural markings. The use of photo identification of small-scaled skinks could replace trapping in some studies and provide the opportunity for long-term population studies. The population estimates obtained give a good indication of the size of the small-scaled skink population at plots on five sites at Springvale Station, as well as the densities at which they can occur. Funnel trapping and noosing were both used successfully to catch small-scaled skinks during this study. The optimal capture technique will depend on the nature of future studies.

6. Recommendations

Future research should concentrate on the population dynamics of small-scaled skinks. Using the robust design described by Pollock (1982), it is possible to estimate survival rates and the status of each individual population. It is important to investigate how isolated the populations are, as well as dispersal and colonisation rates and how these are influenced by native and exotic vegetation. Genetic analysis has been successfully used to answer similar questions for Otago skinks (*Oligosoma otagense*) and grand skinks (*Oligosoma grande*) (Berry et al. 2005).

7. Acknowledgements

I would like to thank my host-supervisor Doug Armstrong for accommodation and support during this project. I especially want to thank Rowena Brown for providing lots of useful information and a room. I also want to thank all the farm managers that permitted us to enter their land: Keith and Brenda from Springvale

Station who also allowed us to stay at the Huts, Gary and Mary from Otupae Station, and Steve and Rachel from Kelly Land Co. I would like to thank Vivienne McGlynn, Palmerston North Area Office, DOC, for helpful advice and support, as well as Richard Steedman, who provided the information for the new small-scaled skink population, and the Aorangi Awarua Trust for providing the access permit. Lastly, but most importantly, I want to thank my partner and loyal field-assistant Tim for his support and patience during this project.

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Appendix 1

DETAILS OF SITES SURVEYED FOR SMALL-SCALED SKINKS (*Oligosoma microlepis*)

SITE NAME (ASSOCIATED REFERENCE*)	AREA	DATE, TIME	SITE VISITS		
			WEATHER	No. SKINKS	COMMENTS
Springvale Quarry (1,2)	3 m × 24 m 4 m × 10 m	31 Jan 2008, 0800–1100	Sunny, hot	27	
	3 m × 3 m 12 m × 6 m	31 Jan 2008, 1600–1800	Sunny, hot	3	
Springvale Huts (1)	8 m × 19 m 6 m × 11 m 8.5 m × 10 m, 3.5 m × 4.5 m	01 Feb 2008, 0800–1100	Sunny, partly cloudy	7	
Springvale Site 2 (1)	4 m × 5.5 m 7 m × 3.5 m 8 m × 13 m 2 m × 12 m	15 Feb 2008, 0900–1100	Sunny, partly cloudy	4	
Springvale Site 3 (1)	10 m × 5 m 3 m × 1.5 m 6 m × 11m	08 Feb 2008, 1000–1100	sunny, hot	1	
Springvale Site 4 (1)	30 m × 50 m	08 Feb 2008, 1000–1100	Sunny, hot	1	
Springvale Site 5 (1)	24.5 m × 15 m 5 m × 8 m 14 m × 8 m	08 Feb 2008, 0800–0945	Sunny, warm	7	
Kelly Land Co. Riverbed Flats (1, 2)	2 m × 6 m 2 m × 3 m	03 Feb 2008, 0800–1030	Overcast, warm	0	No droppings or skins
		03 Feb 2008, 1500–1630	Sunny, hot	0	
		04 Feb 2008, 0830–1130	Sunny, warm, calm	0	
Otupae Site 1 (3)	30 m × 50 m	14 Mar 2008, 1100–1230	Sunny, warm	1	More vegetation was present than seen in the photograph in Flannagan et al. (2001)
Otupae Site 2 (4)	N/A	06 Feb 2008, 1100–1300	Sunny, cold winds	0	
		07 Feb 2008, 0830–1200	Morning frosts, sunny, cold winds	0	
Otupae Site 3 (4)	N/A	06 Feb 2008, 0800–1100	Sunny, cold winds	6	
Mt Aorangi	N/A	16 Mar 2008, 0800–1100	Sunny, warm	1	

* References: 1—Whitaker (1991); 2—Flannagan et al. (2001); 3—Hutchinson (1992); 4—Teal (2006).