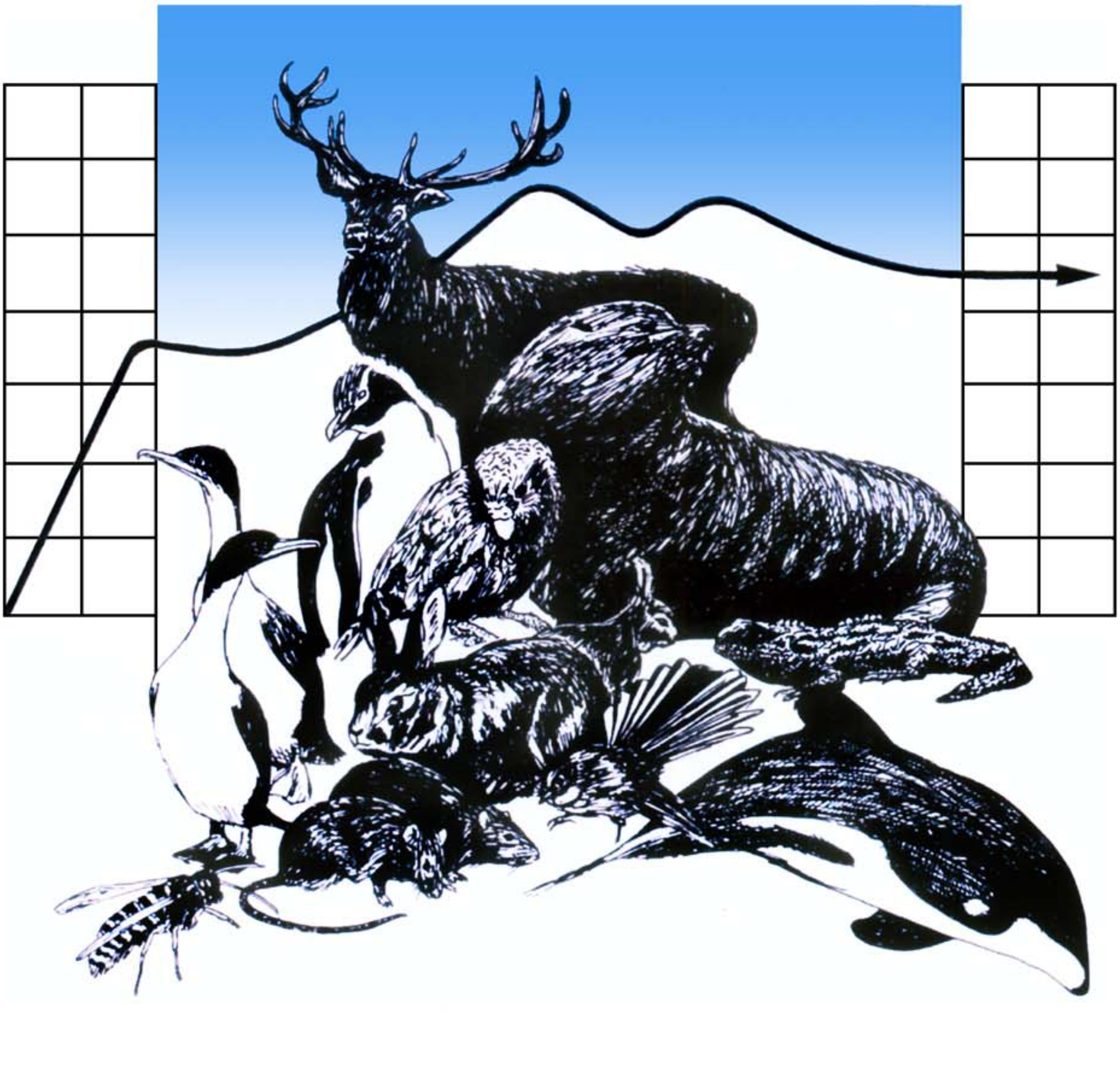
UNIVERSITY of OTAGO

Te Whare Wānanga o Otāgo

NEW ZEALAND

DEPARTMENT OF ZOOLOGY



WILDLIFE MANAGEMENT

Site survey and evaluation of trapping and identification techniques for small scaled skinks (*oligosoma microlepis*)

Konstanze Gebauer

A research report submitted in partial fulfilment of the requirements of the Diploma in Wildlife Management

University of Otago

Year 2008

University of Otago
Department of Zoology
P.O. Box 56, Dunedin
New Zealand

WLM Report Number: 212

Site survey and evaluation of trapping and identification techniques for small-scaled skinks (*Oligosoma microlepis*)

Konstanze Gebauer

3848920

Contents

Index of Figures

Index of Tables

1 Abstract

The small-scaled skink (Oligosoma microlepis) is a small diurnal, heliotherm skinks which is known from a number of small, scattered and isolated populations in the central North Island, New Zeland. The department of Conservation undertook a number of surveys to gain more information on the distribution of the small-scaled skink. This study presents the first attempts to calculate population sizes for three sites near the Springvale Bridge in the Rangitikai River Region. Funnel traps made of fly-screen and a body of wire-mesh have successfully been used to catch individuals and mark them for mark-resight studies. Traps were also successful at one site with low population densities of small-scaled skinks. Noosing small-scaled skinks at easily accessible and small rock-piles proved to be more efficient with more individuals caught in a smaller amount of time. Small-scaled skinks were successfully identified by their natural markings. Population estimates and densities were derived from the resighting of trapped and photographed individuals. The results of this study can now be incorporated in future studies to assess the status of the species and gain more knowledge about the population ecology of the small-scaled skink.

2 Introduction

New Zealand has 28 known skinks species with 22 species belonging to the genus Oligosoma (formerly Leiolopisma, Gill & Whitaker 1996). Oligosoma microlepis, the small-scaled skink, is a diurnal, heliotherm skink reaching a snout-vent length of up to 73mm (Gill & Whitaker 1996). It is distinguishable from all other skink species by its very small body scales which result in a high mid-body scale row count of 38-44 and the tear-drop marking (white spot with black) below each eye. It has been described as grey-brown with prominent longitudinal stripes and speckling by Gill & Whitaker (1996), but Whitaker (1991) also reported very dark brown animals. The undersurface is pale and unspeckeled. The small-scaled skink inhabits rock outcrops, rock piles and screes that are well exposed to the sun

2.1 Conservation history and prior surveys

The first specimen was collected in January 1971 on Motutaiko Island, Lake Taupo (Whitaker 1991). In 1978 further specimens were collected west of Springvale Bridge, Napier-Taihape Road, Rangitikitei Region (Whitaker 1991). The species was formally named in 1990 (Daugherty et al. 1990).

A number of surveys were conducted aimed at determining the distribution of the small-scaled skinks and to discover new populations. In 1991 the Inland Patea District, upper Rangitikai River Catchment (Whitaker 1991) was surveyed, in 1992 the Western Hawkes Bay Region (Hutchinson 1992) and in 1997 the East Taupo Region (Whitaker 1997) detecting about 16 small populations over a range of 295,000ha. Because of its widespread but isolated distribution of only a few populations the species is classified as threatened (IUCN) with a DoC Priority Ranking of A and DoC Classification of in ‘serious decline’.

The knowledge of the ecology of the small scaled skinks is very limited and only a few studies addressed those issues. In 1990 the Wanganui DoC Conservancy conducted an unsuccessful pit trapping study to access the population at the Springvale sites. In 2001 a distribution survey in the same region by Flannagan et al. (2001) determined habitat preferences of the small-scaled skinks. Teal (2006) undertook a population study to describe detection probabilities and important habitat variables. So far no study was aimed at detecting population size.

2.2 Population estimates

One widely used technique to estimate population size are mark-recapture and mark-resight studies (Cormack 1964; Nichols 1992; Seber 1992; Schwarz & Seber 1999; Chao 2001). A sample of animals is captured, marked and released back into the population. The next trapping occasion will result in animals caught that are marked and that are not marked. To calculate the total population the idea is used that the likelihood to encounter a proportion of marked animals from the total number of marked animals is the same as the likelihood to encounter a proportion of animals of 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. To obtain more robust population estimates trapping can be continued. The last decades of research have resulted in adaptations and extensions of the early estimators of population size to different situations that scientists can encounter when dealing with populations of animals (Bartmann et al. 1987; Brownie 1987; Arnason et al. 1991; Buckland 1991; Buckland et al. 2000; Schwarz 2001). Depending on the estimator, previously untagged animals can be tagged to receive capture histories which allows calculating populations size and survival rates (Schwarz & Seber 1999).

With the advancement of computer technology larger data sets can be used to estimate population size and more complex estimators become available for scientists. The computer program NOREMARK (White 1996) calculates population estimates for a number of different situations, including the joint hypergeometric maximum likelihood estimator (JHE) and the Bowden estimator (BE). The JHE is used in a number of studies that found that it is minimal biased and provides proper confidence interval coverage (Bowden & Kufeld 1995). Bartmann et al. (1987) found that the JHE calculates reliable estimates when more then 45% of the population is marked. Fattorini et al. (2007) on the other hand, found that the BE is more reliable than the JHE. Here population estimates of small scaled skinks will be reported for the first time. JHE and BE were used to estimate the population size.

When using estimators to calculate population sizes of small-scaled skinks the underlying assumption of different models should be examined carefully as their violation results in biased estimates (Schwarz & Seber 1999, Kendall 1999). For closed population models it is assumed that the population is static with no additions (immigration, birth) and no deductions (emigration and death) (Neal et al. 1993; Evans et al 1998). This is realised by sampling the populations over short periods of time (Nichols 1992). All animals are assumed to be equally likely to be caught in each sample and do not vary in they capture probability (Pollock 1982). The marker or tag should have not 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).

2.3 Trapping and noosing skinks

To estimate population size where a census of all animals is not possible because of the elusive behaviour of the animals or environmental factors like topography or size of the study area; animals have to be marked so they can be identified. To attach markings animals have to be physically handled. Commonly used methods to catch lizards are catching lizards by hand (Gardner et al. 2007), with a noose (Rodgers 1939), run them down (Carpenter 1959) or use different types of traps. In the literature numerous trap designs for catching skinks can be found. Generally used traps include pit-fall 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 bias and mechanical limitations and trapping success will depend on the species, climate conditions and environmental factors. A number of studies try to identify what trap type is suited best for what animal species (Greenberg et al. 1994; Anthony et al. 2005). The DoC conducted an unsuccessful pitfall trapping study to monitor the small-scaled skink population at Springvale Bridge. Small-scaled skinks live on greywacke rock piles and screes which cover relatively small areas. There were observed occasionally in adjacent vegetation but never far away from the rocks. This makes it unpractical to use pit fall traps as the traps can not be buried in the rock piles without large disturbance to their habitat and burying pit falls around rock piles could cause biased trapping results towards animals living on the edge of the rock outcrops. Various studies tested funnel traps of different built for their effectiveness to catch lizards (Vogt 1941; Carpenter 1959; Hall 1967; Greenberg et al. 1994). During this study funnel-traps designed for the needs of small-scaled skinks and their habitat, and noosing were used to catch small-scaled skinks.

2.4 Photo ID

Different marking techniques are used with lizards. Toe-clipping, PIT microchips and paint-marking are commonly used techniques (e.g. Woodbury et al. 1956; Langkilde & Shine 2006; Gardner et al. 2007). Each technique has their advantages and disadvantages (Beaumont & Goold 2007). All of them require the animal to be caught and handled which is a stressful experience for the animal (Langkilde & Shine 2006). For estimating population size it is also important that the tags are not lost during the study period (Neal et al. 1993). Hudson (1996) studied the natural toe loss of south-eastern Australian skinks and found that toe-loss can occur often in some species. This would have serious implications for marking and identification of skinks. Paint-markings can only be used as long the animal is not shedding its skin which leads to the loss of the mark. False-positive (identified as marked but is not marked) and false-negative (not identified but was marked) identifications influence the population estimate and should be taken into consideration (Stevick et al. 2001).

Markings that are long-lasting and do not require handling of the animal are natural pigmentation and scaring (Woodbury et al. 1956; Auger-Methe & Whitehead 2006; Gilkinson et al. 2007). Photos are taken of animals and their natural markings are used to find matches in photo databases. This technique has the advantage that it is not intrusive, relatively cheap and easy to use (Auger-Methe &Whitehead 2006; Gamble et al. 2008). As animals do not have to be handled, it can be used with species that may be difficult to catch or tag (Gilkinson et al. 2007). Disadvantages are marks that are difficult to distinguish, marks like scars that might disappear or change over time and marks that are not evenly distributed over 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). But this technique has also been used for estimating population size of other species like cheetahs (Kelly 2001), bobcats (Heilbrun et al. 2003), New Zealand sea lion (McConkey 1999), sea otters (Gilkinson et al. 2007) and salamanders (Gamble et al. 2008). In New Zealand photo ID has additionally been used with grand skinks (O.grande) and Otago skinks (O. otagenese) since 2003 for studies on population size and survival (Reardon et al. 2006). The natural markings between the nose and the foreleg are used to identify individuals. This study will use photos of small-scaled skinks to calculated population estimates.

2.5 Objectives of the current study

The North Island Oligosoma spp. skink recovery plan outlines the need to improve the knowledge about the ecology and population of the small scaled skink to assess the conservation status and to investigate the potential for management of the small-scaled skink (Towns et al. 2002). To investigate population ecology of a species scientist have to know how the population size. The aim of this study is to assess the potential use of funnel traps and noosing of skinks for population studies as well the mark-resighting techniques where individuals are recognised by their natural markings. First population size estimates for small-scaled skinks for two study sites are presented here.

3 Methods

3.1 Study area

The small-scaled skink is known from a few isolated population scattered over an area of about 295,000ha in the Inland Patea district (Whitaker 1997). An initial survey of potential sites for this study was conducted between the 14. January and 09. February 2008 to confirm reported small-scaled skink populations. Sites at Motutaiko Island, Boyds, Poronui, Wakemans, Ohinewairua Station and Ngamatea Station (Whitaker 1997) were not visited during this study because of difficult accessibility. Springvale, Kelly Land Co. and Otupae sites (Whitaker 1991; Hutchinson 1992; Flannagan et al. 2001; Teal 2006, and see Appendix 2) were visited and checked for small-scaled skinks. This area around the Springvale Bridge in the Rangitikei River Catchment has been described as the strong hold for the small-scaled sinks (Flannagan et al. 2001). Permission to enter the sites was obtained from the land owners and land managers.

Each site was surveyed on one morning with warm and sunny weather conditions by two observers searching for skinks with binoculars. Sites where surveyed from 2-10m away for up to 1.5h or until small-scaled skinks were seen. When no skinks were visible the site was checked for droppings or skins. Sites were no small-scaled skinks were seen were re-visited one or more times.

During 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 our survey.

3.2 Estimating population size

This study used the JHE and the BE calculated by the computer program NOREMARK (White 1996). To estimate the population size with JHE and BE individual animals have to be marked at the first sampling occasion. The following occasions consist of counting marked and unmarked animals. Animals were counted in the mornings when the skinks were most active and before the rocks became to hot (above 35 C) when skinks retreated into the shade (Teal 2006). The rock piles were small enough to be easily monitored by one observer. During one observation period the highest number of skinks visible at any one time was noted.

The estimators JHE and BE can be used when following assumptions apply:

- The population has to be geographically and demographically closed, which means no immigration, emigration, death or birth should occur during the research period. To address this assumption we observed animals during a short time period after the marking. Juvenile individuals born during the study period where clearly smaller then adults and subadults and were not included in the counts.
- Equal sighting probabilities of all individuals. The size of the rock piles allowed one observer to monitor the whole area. Small-scaled skinks were not observed to move further then 3m away from a rock pile.
- 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.
- The short time period between the marking occasion and re-sighting allows for a reduction in the likelihood that markings were lost which would result in an overestimation of the population size.

3.3 Trapping

The Springvale sites ‘Quarry‘ and ‘Huts’ (Flannagan et al. 2001, Teal 2006) were chosen to assess funnel traps and the possibility of noosing small-scaled skinks. These two sites were identified by Flannagan et al. (2001) as suitable for long-term monitoring and our survey confirmed good populations of small-scaled skinks at those sites. Both sites consist of several greywacke rock piles and screes surrounded by pasture, located on private farmland which is used for sheep and cattle grazing.

Self-made funnel traps were used which can be easily placed on the rock-piles without causing large disturbance. They had to be sturdy so they can be covered partly with rocks. The traps were 17.5cm wide, 21.5cm long and 8.5cm deep with a funnel-opening of 2 x 1.5cm. The traps had the shape of a flat oval tube made out of strong wire mesh. This was lined with fly-screen and fitted from one side with a funnel made out of fly-screen. The back is also covered with fly screen held by wire for easy access. The wire construction allowed for enough ventilation so skinks did not overheat (Figure 1).

Two plots at the Quarry site were chosen for trapping as this site seemed to have the highest skink densities. Later the traps were moved to the Huts site to test them with lower densities of skinks. Trapping was conducted between the 14. February and 18. February 2008 at the Quarry site and between the 18. February and 21. February 2008 at the Huts site. The two plots at the quarry were fitted with two traps each, one baited with 5 live flies and one baited with cat-food (chicken flavour). The bait type was alternated every day between the two traps at one plot to avoid biased results caused by the position of the traps. The traps were positioned at the edge of each plot, the funnel facing towards the centre. Traps were checked twice a day and rebaited when skinks were caught. One trapping session represents 6h in the morning or in the afternoon. Traps were set at 7:00am and checked at 1:00pm and again at 7:00pm to ensure skinks would not be trapped for more then 6 hours.

Small-scaled skinks caught in the traps were measured (Snout-vent-length (SVL), tail length and length of regeneration) and given an individual mark by drawing a number with a golden non-toxic, water-based pen on their back. Photographs were taken from the right and left side and the skink was then released

Figure 1 Trap at plot 1 at the Quarry site

3.4 Noosing

On the 20. and 21. February 2008 it was tested if small-scaled skinks can readily be caught by noosing. This was done at plot 2 of the Quarry site because of the large population of small-scaled skinks there. A noose made of fishing line was fitted at the end of a 1.50m fishing rod. One observer sat next to the rock pile, chose a skink to noose, carefully slipped the noose over the head of skink and pulled it tight. The skink was then lifted to a second person holding a plastic bag to carefully drop the skink inside by loosening the noose. This proved to be the best option to take the skinks off the noose as they move quickly to free themselves.

Small-scaled skinks were immediately measured (SVL, original tail length and length of regenerated tail), marked with a golden non-toxic, water-based pen and photographs were taken from the right and left side. The skink was then released immediately. The whole procedure would not take longer then a few minutes.

3.5 Photo ID

Between the 18. February and the 27. February 2008 photographs of small-scaled skinks were taken at plot 1 at the Quarry site and at the Huts site when weather conditions allowed. A Canon PowerShot S3 IS with 12x optical, 48x digital zoom and 6.0 mega pixels was used. One observer sat close (<2m) to the plot before the sun hit and small-scaled skinks became active. The photos were taken of each individual skink that was visible to the observer. There was no time limit and the observer took photos until he assumed all visible skinks were photographed. The nose to foreleg region was used for identification and had to be focused and clear of objects (Figure 2). A screening process was used to remove photographs that were out of focus, grainy or where the angle or distance did not allow for a good sight of the identification area. The photographs of one session were compared against each other to identify how many individual skinks were seen. To calculate the population estimates one session was defined to be the marking session. Those photos were compared with all photos of the other sessions to identify re-sighting.

Permits for the study were obtained from the Department of Conservation, New Zealand (Permit WA-22496-FAU) and the Animal Ethics Committee, Massay University, Palmerston North, New Zealand (Permit 08/01)

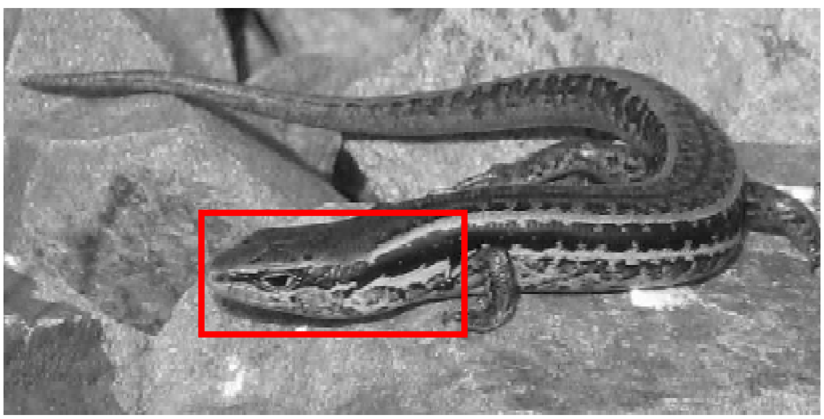


Figure 2 Small-scaled skins (Oligosoma microlepis). The square indicates the nose-foreleg region that is used for identification.

4 Results

4.1 Small-scaled skink populations

Of the thirteen sites that were surveyed ten sites were identified to contained populations of small-scaled skinks. At two sites, Kelly Land Co. Riverbed Flats and Otupae Site 3 no skinks or droppings were visible during the survey. The Riverbed Flats site was visited on three occasions, twice early in the morning and once in the afternoon, each time for 1.5h. Weather conditions were warm, sunny and calm. The Otupae Site 3 was visited one morning for 2h under warm, sunny but windy conditions and no skinks or droppings were found. The Site 1 near the Springvale Bridge described by Whitaker (1991) could not be located as the riverbanks had changed after heavy floods.

All of the Springvale sites seemed to contain good populations of small-scaled skinks whereas only one or few skinks could be seen at the Otupae sites. The occupied sites at Springvale cover an area of 0.23ha. Otupae sites were not measured as the boundaries of occupied rock outcrops were difficult to define.

Following up on the information of Richard Steedman (pers. comm.) about unidentified skinks on the northern slopes of Mt. Aorangi a survey was conducted resulting in one sighting of a small-scaled skink which was observed basking in the sun on boulders at the base of the northern limestone cliffs (NZMS E27745-N61724, altitude 1175m). This new population is the most southern and highest in altitude known so far.

A summary of the survey details is provided in Appendix 3.

4.2 Trapping and noosing

Trapping and noosing success

Traps were operated for seven days at the Springvale Quarry and for three days at the Huts site. At plot 1 and plot 2 of the Quarry site, 5 and 9 skinks were caught during 16 and 31 trapping sessions, respectively. At plot 2 one skink was trapped twice. At the Huts site 4 skinks were caught during 25 trapping sessions, one skink was caught twice. This result in 0.3 animals/trapping session at the Quarry site and 0.2 skinks/trapping session at the Huts site.

Traps baited with flies caught 15 and traps baited with cat-food 5 skinks. Eight skinks were caught during the morning and 12 skinks during the evening. Chi-square tests revealed no significant differences between trapping success at the Quarry and Huts site (χ^2=1.85, p>0.05), so the data was pooled. There was also no significant difference between the number of animals caught in the morning and the afternoon. The number of skinks caught in traps baited with flies was significantly higher than in traps baited with cat-food (Table 1).

During two mornings skinks were noosed at plot 2 at the Quarry site. The first morning 10 skinks were noosed by two people during two hours with one person nosing and the other person measuring and marking the skinks. The second morning 6 skinks were noosed during two hours.

Table 1 Chi-square statistics for the comparison of trapping success between traps at the Quarry and Huts site, traps baited with flies or cat-food and between morning and afternoon sessions.

	χ^2	p
Quarry – Huts	1.85	not significant
Morning – Afternoon	0.25	not significant
Flies – Cat food	4.51	0.034

Small-scaled skinks

Skinks caught at the Quarry site and at the Huts did not significantly differ in their SVL (t=0.627, p>0.05), therefore data was pooled for the following comparisons. There was no significant difference between the SVL of animals caught in funnel-traps or by noosing or between animals caught with traps baited with flies or cat-food. Small-scaled skinks differed significantly in their SVL between morning and afternoon trapping sessions with animals trapped in the afternoon being smaller than animals caught in the morning (Table 2).

Previous tail-loss was identified by the lighter colour of the regenerated tail. Previous tail loss had occurred in 45.5% of the caught skinks, with 22.7 +/- 12.8mm (mean +/- standard deviation) of the original tail remaining.

Table 2 Comparison of the snout-vent length between skinks caught at the Quarry and Huts site, during mornings and afternoons, with noose and funnel-traps and in traps baited with flies and cat-food

	n	mean	Standard deviation	df	t	p (two-tailed)
Quarry	15	56.7	8.8	17	0.627	not significant
Huts	4	59.8	6.6			
Noose	17	60.9	6.2	33	1.64	not significant
Funnel-traps	18	56.8	8.3			
Flies	16	57.6	8.6	19	0.135	not significant
Cat-food	5	58.2	6.9			
Morning	9	61.2	6.6	15	2.627	0.019
Afternoon	8	51.9	8.1			

4.3 Photo ID

It took approximately one hour in the morning to take pictures assumingly of all visible skinks on one plot. Skinks became more active with increased warmth of the rocks and were more difficult to photograph. It proved to be very difficult to obtain left and right pictures of individual skinks. Therefore this strategy was abandoned and as many skinks as possible were photographed without keeping track on left and right pictures of individual skinks. During the screening, photos were rejected that were not in focus, where the animals filled only a small proportion of the picture or with animals that were in unsuitable angles or turning their heads. At plot 1 of the Quarry site 123 photos from the five days of observations were regarded as suitable for identification process. Comparison of left-side and right-side pictures of the small-scaled skinks that were caught in traps or by noosing showed their left- and right-side markings were different, not symmetrical. Photos from the morning-observations were sorted into right- and left-side pictures and the number of individuals photographed from the left and right-side was identified. As the markings are not symmetrical only photos from one side can be used for calculating population estimators. There were 8.4 (+/- 1.5) suitable right-side pictures of individual skinks available per day for population estimates. Photos taken of a skink caught in a funnel-trap and marked as number 9 showed that the animal was shedding on the 19 February. This has implications for the population estimate retrieved from resighting of trapped and paint-marked animals which will be discussed in sections 5.2-5.4

At the Huts site 17 photos from three mornings of observations were suitable for calculating population estimates using the photos of the 4 skinks caught in traps as marked individuals.

4.4 Population estimates

Population estimates for plot 1 at the Quarry site were calculated with the re-sighting data from 18. February to the 21. February 2008. Estimates were calculated using the re-sighting data a) of the 5 animals that were caught in traps and paint-marked and b) of 11 animals that were photographed from their right side on 27 February 2008. The population size was calculated using the JHE and BE of the Noremark software. Table 3 shows that both estimates are very similar in this study for the mark-resighting data and the photo identification data. The resulting population density for plot 1 with an area of 6.3m^2 is 5.4 (+/- 0.4) skinks/m^2.

Table 3 Population size for plot 1 at the quarry site calculated with the joint hypergeometric maximum likelihood estimator (JHE) and the Bowden estimator (BE) using the program NOREMARK (White 1990). m is the number of animals marked.

	Mark-resighting (m=5)			Photo ID (m=11)		
	N	95% CI		N	95% CI	
JHE	34	23	67	37	25	68
BE	31	17	61	35	20	62

For plot 2 of the Quarry site only re-sighting data of 10 paint-marked animals from 4 days was used for calculating population estimates. Here the population sizes calculated by the two different estimators JHE and BE showed strong differences. The population of plot 2 estimated with JHE is 82 (95% CI 57-137) and with BE is 63 (37-104). The area of plot 2 is 31.4m^2. Densities calculated using the population estimates derived with the JHE and BE are 2.6 skinks/m^2 and 2.0 skinks/m^2, respectively.

At the Huts site photos of the 4 skinks caught in traps were used for population estimates. Population sizes calculated with JHE and BE are 11 (9-21) and 9 (5-19) with population densities of 0.4 animals/m^2 and 0.3 animals/m^2, respectively.

5 Discussion

5.1 Distribution of small-scaled skinks

The results of this survey show that small-scaled skink populations persisted on sites that are located on private farmland for 0ver 15 years. The Quarry-site and the Huts site show good numbers of small-scaled skinks. The Riverbed flat site at Kelly Land Co seemed to have low numbers of skinks before as Flannagan (2001) did report no skinks already but few skinks were sited by Teal (pers. comm.) and again no skinks or dropping of skinks were found during this survey. It is not known if the population went extinct for periods of time and was recolonised, or if they persisted in low, sometimes not detectable numbers. The Springvale Bridge population became extinct as changes in the riverbed after large floods destroyed the area where they occurred before. It is also not known how far small-scaled skinks disperse to colonise new habitat patches. Small-scaled skinks were observed to forage in pasture adjacent to the rock piles but no skink was observed more than 3m away. Rock-piles and rock-outcrops are isolated by large distances, sometimes several kilometres. Whitaker (1991) argued that the habitat of rock-piles, screes and rock-outcrops would have been locally isolated before Maori and European settlement, suggesting adaptation to large dispersal distances. After all small scaled skinks have colonised the Quarry site. A number of sites showed increased vegetation cover. As no population data is available for comparison it can not be estimated how this effects the small-scaled skink populations. One new population was discovered at Mt. Aorangi.

5.2 *Trapping and noosing skinks*

The design of our funnel-traps proved successful with flies as bait having higher catch-rates than cat-food. The only slightly lower trap efficiency at the less densely populated Hut site suggests that the funnel traps can be successfully used to detect small populations. The small-scaled skinks were also successfully caught by noosing even by inexperienced observers. Compared to trapping more animals were caught in a shorter time period with noosing. This technique is highly dependant on observers being able to sit close to the rock-pile and to reach all parts of the rock- pile with the noose. Very steep slopes can inhibit an adequate positioning of the observer. The length of the noose should not exceed 1.5 to 2.0m as with increasing length of the noose the precision of placing the noose over the skinks head decreases. Also small numbers of skinks will increase the time needed to noose sufficient numbers of skinks. Which technique to use for a 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. Rock-outcrops provide less places to put traps and trapping results could be highly biased towards skinks having access to this position. They might be even less suitable for noosing, depending on the size and accessibility of the rock-outcrop.

A large proportion of the small-scaled skink population showed previous tail loss. Skinks loose their tails as diversion strategy when being attacked. During this study small-scaled skinks have been repeatedly observed biting the tail of a congener during fights. It is not clear if this can lead to the loss of the tail or parts of the tail. It is also not known if the loss of the tail can lead to reduced survival or status of the skink in the population.

5.3 *Photo ID*

This study resulted in a database of skinks which can be identified by their natural markings. It opens the opportunity to collect population statistics without physically handling the animals reducing stress and possible changes in behaviour which could bias population estimates. Necessary for this type of study is a good digital camera with a powerful zoom. During the screening process photos were rejected that showed one or more of the following flaws: the marking was out of focus, the animal was too far away/ filled only a small proportion of the photo, reflecting light made it difficult to see the markings and markings were not visible because of the position of the animal. The quality of the photos increased during the study period, suggesting increased experience of the observer. The experimental design should clearly state if photos of both sides or only the right or the left side will be used for analysis. Studies of populations inhabiting large rock-piles should include a design which avoids a bias of photos taken from only one area.

Natural markings are more reliable against mark loss than other marking techniques. During this study one skink that was paint-marked shed and lost the markings. As there is not much information about the behaviour and ecology of the small-scaled skinks the frequency and timing of shedding is not known and could not be included in the planning of the project. Mark loss has strong implications for estimating population size. An animal identified as not-marked that is marked will result in overestimating of the population size.

One disadvantage of using natural markings for identification is the time-consuming search of matches in the database. For larger databases markings can be categorised (Auger-Methe & Whitehead 2006). 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 this. The pattern of the skinks is well distinguishable in most cases. With patterns that are very similar the risk of miss-identifications increases (Friday et al. 2000). This can result in false-positive and false-negative identification which result in overestimating or underestimating of population sizes. The observer should be given the chance to get used to the markings and how to differentiate them.

With the use of natural markings, skinks can be identified during long periods of time whereas paint-marks only last until the skink sheds. This provides the opportunity to calculate survival rates and very robust population estimates using the robust model from described by Pollock (1982)

5.4 Population estimates

This study reports the first estimates of population size and densities for the small-scaled skink. There are a number of points that should be taken into consideration when analysing the estimates.

The population estimates calculated show large confidence intervals which could originate from small numbers of samples and small numbers of animals marked. The number of skinks marked for the mark-re-sighting was determined by the number of animals caught in and by the decision of when to stop trapping because numbers were assumed large enough. This was estimated by maximum numbers seen during the initial survey and maximum number reported for the site by former studies. Bartmann et al. (1987) suggested that for small populations a proportion larger than 45% should be marked for reliable estimates and confidence intervals. This study marked 12-16 % of the estimated population at the Quarry sites and 30-45 % at the Huts site. With less than 30% of the population marked, the JHE can lead to overestimating the population size (Bartmann et al. 1987). Fattorini et al. (2007) suggested the BE to be more robust. Taking these two points into consideration the population size of plot 2 will be more likely to be closer to the BE estimate of 63 (37-104) animals than the JHE estimate of 82 (57-137) animals.

It was assumed that the assumption of animals mixing freely between observations and can be sampled randomly was not violated during the studies. Marked animals were observed to use most areas of the rock piles and skinks moved quickly across areas. The size of the rock-piles allowed the observer to sample the whole rock-pile at once. The results of the trapping experiments show a possible violation of this assumption as there might be differences in the behaviour of animals of different size classes. Animals caught during the afternoon were significantly smaller than animals caught in the morning. This could be caused by smaller animals being less active in the mornings.

Another assumption that was found to be violated was that animals do not lose their marks. As reported above at least one animal lost its markings during the re-sighting period at plot 1. This can lead to overestimation of population sizes. In this study the estimate derived by photo identification are very similar. It can be assumed that they are more influenced by the low number of marked animals.

6 Conclusion

The population estimates attained during this study give a good indication about the size of the small-scaled skink population at the Quarry and the Huts as well as densities in which they can occur. The skinks were also confirmed on 10 sites, some of them known to have small-scaled skink population for more then 15 years.

The funnel traps and noosing were successfully used to catch during this study. It will depend on the nature of future studies which technique should be used. The use of photo-identification of small-scaled skinks could avoid trapping in some studies altogether and provide the opportunity for long-term population studies.

7 Recommendations

Future research should concentrate on the population dynamics of the small scaled skinks. Using the robust design described by Pollock (1982) and natural, individual markings of the small scaled skinks will allow to estimate survival rates and the status of the population. It is also important to investigate how isolated the populations are, dispersal and colonisations rates and how native and exotic vegetation influences these. Genetic analysis has been successfully used for studies answering similar questions for the Otago skins and Grand skinks (Berry 2005).

8 Acknowledgments

I would like to thank my host-supervisor Doug Armstrong for accommodation and support during this project. I want especially 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 who also had us 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, Doc Palmerston North 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 that provided the access permit. This study was funded by the Department of Conservation Science Advise Fund.

Lastly but most important I want to thank my partner and loyal field-assistant Tim for his support and patience during this project.

9 References

Anthony, N.M., Ribic, C.A., Bautz, R., Garlang, T. 2005. Comparative effectiveness of Longworth and Sherman live traps. Wildlife Society Bulletin 33: 1018-1026

Arnason, A.N., Schwarz, C.J., Gerrard, J.M. 1991. Estimating closed population size and number of marked animals from sighting data. The Journal of Wildlife Management 55: 716-730.

Auger-Methe, M., Whitehead, H. 2006. The use of natural markings in studies of long-finned pilot whales (Globicephala meals). Marine Mammal Science 23: 77-93

Banta, B.H. 1957. A simple trap for collecting desert reptiles. Herpetologica 13:174-176

Bartmann, R.M., White, G.C, Carpenter, L.H., Garrott, R.A., 1987. Aerial mark-recapture estimates of confined mule deer in pinyon-jupiter woodland. The Journal of Wildlife Management 51: 41-46

Beaumont, E.S., Goold, J.C. 2007. Cheap and accessible method to aid individual photo-identification of grey seals, Halichoerus grypus. Journal of Marine Biological Association U.K. 87: 1337-1343.

Berry, O., Tocher, M.D., Gleeson, D.M., Sarre, S.D. 2005. Effect of vegetation matrix on animal dispersal: genetic evidence from a study of endangered skinks. Conservation Biology 19: 855-864

Bowden, C.D, Kufeld, R.C. Generalized Mark-sight population size estimation applied to Colorado moose. The journal of Wildlife Management 59:840-851

Brownie, C., Clobert, J., Lebreton, J.-D. 1987. Recent models for mark-recapture and mark-resighting data. Biometrics 43:1017-1022

Buckland, S.T. & Garthwaite, P.H. 1991. Quantifying precision of mark-recapture estimates using the bootstrap and related methods. Biometrics 47: 255-268

Buckland, S.T., Goudie, I.B.J., Borchers, D.L. 2000. Wildlife population assessment: Past developments and future directions. Biometrics 56: 1-12

Carpenter, C.C. 1959. A population of the six-lined racerunner Cnemidophorous sexlineatus). Herpetologica 15: 81-86

Chao, A. 2001. An overview of closed capture-recapture models. Journal of Agricultural, Biological, and Environmental Statistics 6: 158-175

Cormack, R.M. 1964. Estimates of survival from the sighting of marked animals. Biometrika 51:429-438

Daugherty, C.H., Patterson, G.B., Thorn, C.J., French, D.C. 1990. Differentiation of the members of the New Zealand Leiolopisma nigriplantare species complex (Lacertilia: Scincidae). Herpetological Monographs 4: 61-76.

Evans, T.A., Lenz, M., Gleeson, P.V. 1998. Testing assumptions of mark-recaprue protocols for estimating population size using Australian mound-building, subterranean termites. Ecological Entomology 23:139-156

Fattorini, L., Marcheselli, M., Monaco, A., Pisani, C. 2007. A critical look at some widely used estimators in mark-resighting experiments. Journal of animal Ecology 76: 957-965

Flannagan, H.J., Blackwell, G.L., Ravine, D.A. 2001. distribution survey and monitoring programme establishment for the small-scaled skink (Oligosoma microlepis) at Springvale Bridge, Rangitikei River, Taihape. Unpublished report, Department of Conservation, Palmerston North, New Zealand

Friday, N., Smith, T.D., Stevick, P.T., Allen, J. 2000. Measurment of photographic quality and individual distinctiveness for the photographic identification of humpback whales, Megaptera novaeangliae. Marine Mammal Science 16: 355-374

Gamble, L., Ravela, S., McGarigal, K. 2008. Multi-scale features for identifying individuals in large biological databases: an application of pattern recognition technology to the marbled salamander Ambystoma opacum. Journal of Applied Ecology 45: 170-180

Gardner, M.G., Bull, C.M., Fenner, A., Murray, K., Donnellan, S.C. 2007. Consistant social structure within aggregations of the Australian lizard Egernia stokesii across seven disconnected rocky outcrops. Journal of Ethology 25: 263-270

Gilkinson, A.K., Pearson, H.C., Weltz, F., Davis, R.W.2007. Photo-identification of sea otters using nose scars. Journal of Wildlife Management 71: 2045-2052

Gill, B., Whitaker, A.H 1996. New Zealand Frogs and Reptiles. David Batemann Ltd. Auckland, New Zealand

Glor, R.E., Flecker, A.S, Benard, M.F., Power, A.G. 2001. Lizard diversity and agricultural disturbance in a Caribbean forest landscape. Biodiversity and Conservation 10: 711-723

Greenberg, C.H., Neary, D.G., Harris, L.D. 1994. A comparison of herpetofaunal sampling effectiveness of pitfall, single-ended, and double-ended funnel traps used with drift fences. Journal of Herpetology 28: 319-324

Hall, R.J. 1967. A simplified live-trap for reptiles. Transacrtions of the Kansas Academy of Science (1903-) 70: 402-404

Heilbrun, R., Silvy, N.J., Tewes, M.E., Peterson, M.J. 2003. Using automatically triggered cameras to individually identify bobcats. Wildlife Society Bulletin 31: 748-755

Hudson, S. 1996. Natural toe loss in south-eastern Australian skinks: implications for marking lizards by toe clipping. Journal of Herpetology 30: 106-110

Hutchindon, W.M. 1992. A survey for Leiolopisma microlepis in Western Hawkes Bay: 9-13 March 1992. unpubl. Report, Department of Conservation, Wanganui, New Zealand

Karlsson, O., Hiby, L., Lundberg, T., Jussi, M., Helander, B. 2005. Photo-identification, site fidelity, and movement of female gray seals (Halichoerus grypus) between haul-outs in the Baltic Sea. Ambio 34: 628-635

Kelly, M.J. 2001. Computer-aided photograph matching in studies using individual identification: an example from Serengeti cheetahs. Journal of Mammology 82: 440-449

Kendall, W.L. 1999. Robustness of closed capture-recapture methods to violations of the closure assumption. Ecology 80: 2517-2525

Langkilde, T., Shine, R. 2006. How much stress do researchers inflict on their study animals? A case study using a scincid lizard, Eulamprus heatwolei. The Journal of Experimental Biology 209: 1035-1043.

McConkey, S.D. 1999. Photographic identification of the New Zealand sea lion: a new technique. New Zealand Journal of Marine and Freshwater Research 33: 63-66

Neal, A.K., White, G.C., Gill, R.B., Reed, D.F., Olterman, H. 1993. Evaluation of Mark-resight model assumptions for estimating mountain sheep numbers. The journal of Wildlife Management 57:436-450

Nichols, J.D. 1992. Capture-recapture models. BioScience 42:94-102

Pradel, R. 1996. Utilization of capture-mark-recapture for the study of recruitment and population growth rate. Biometrics 52:703-709

Pollock, K.H. 1982. A capture-recapture design robust to unequal probability of capture. The Journal of Wildlife Management 46:752-757

Reardon, J.T., Holmes, K., Judd, L., Whitmore, N. 2006. Grand and Otago skink recovery programme compendium and annual report 2006.

Rodgers, T.L. 1939. A llizard live trap. Copeis 1: 51

Seber, G.A. 1992. A review of estimating animal abundance II. International Statistical Review 60: 129-166.

Schwarz, C.J., Seber, G.A.F. 1999. Estimating animal abundance: Review III. Statistical science 14: 427-456

Schwarz, C.J. 2001. The Jolly-Seber Model: More than just abundance. Journal of Agricultural, Biological, and Environmental Statistics 6: 195-205

Stevick, P.T., Palsboll, P.J., Smith, T.D., Bravington, M.V., Hammond, P.S. 2001. Errors in identification using natural markings: rates, sources, and effects on capture and recapture estimates of abundance. Canadian Journal of Fish. Aquat. 58: 1861-1870

Teal, R. 2006. The future of indigenous fauna on private land: a case study of the habitat use of the small-scaled skink (Oligosoma microlepis). Unpublished thesis submitted for a Masters of Science in Conservation Biology at Massey University, Palmerston North, New Zealand

Towns, D.R., Neilson, K.A., Whitaker, A.H. 2002. North Island Oligosoma spp. skink recovery plan. Threatened Species Recovery Plan 48, Department of Conservation, Wellington, New Zealand

Vogt, W. 1941. A practical lizard trap. Copeia 2: 115

Whitaker, A.H. 1991. A survey for Leiolopisma microlepis in the Inland Patea District, Upper Rangitikai River Catchment, Central North Island, with observations on other lizard species: 14-21 January 1991. unpubl. Report, New Zealand Department of Conservation, Wanganui.

Whitaker, A.H. 1997. Small-scaled skinks (Oligosoma microlepis) in the East Taupo Region, Central North Island. Unpublished report, Wanganui Conservancy, Department of Conservation, Wanganui.

White, G.C. 1996. NOREMARK: population estimation from mark-resighting surveys. Wildlife Society Bulletin 24: 50-52

Woodbury, A.M., Ricker, W.E., Cottam, C., Taber, R.D., Pendleton, R.C. 1956. Symposium: Uses of marking animals in ecological studies. Ecology 4: 665-689

10 Appendix 1: Morphological data of skinks caught during this study

Site	ID	SVL (mm)	Tail length (mm)	Length of tail regeneration (mm)	Total tail length (mm)
Quarry Plot 1	1001	57	N/A	N/A	N/A
	1004	38	54	0	54
	1006	51	20	26	46
	1007	60	25	33	58
	1009	46	71	0	71
Quarry plot 2	1002	58	71	0	71
	1003	62	88	0	88
	1005	62	78	0	78
	1008	47	7	40	47
	1010	68	14	46	60
	1011	65	7	37	44
	1012	62	74	0	74
	1013	66	71	0	71
	1014	60	41	17	58
	1015	47	70	0	70
	1016	67	74	0	74
	1017	60	70	0	70
	1018	61	22	34	56
	1019	64	8	42	50
	1020	66	75	0	75
	1021	64	65	0	65
	1022	62	33	30	63
	1023	58	18	32	50
	1024	64	20	31	51
	1025	69	81	0	81
	1026	64	20	41	61
	1027	54	73	0	73
	1028	56	68	0	68
	1029	65	80	0	80
	1030	45	52	0	52
	1031	65	50	7	57
	1032	52	46	0	46
Huts	6001	52	39	24	63
	6002	67	17	47	64
	6003	57	65	0	65
	6004	63	83	0	83

11 Appendix 2: Sites of reported small-scaled skinks populations

✔ - skinks were seen,

✘ – no skinks or droppings were seen,

empty cell – site was not visited.

Grid references refer to the topographic series NZMS 260 maps U20, U21, T20, T21

Site	Site description	Whitaker, 1991	Hutchinson, 1992	Whitaker, 1997	Flannagan et al 2001	Teal, 2006	Gebauer, 2008
Motutaiko Island, Lake Taupo	first population found in 1971, rock face along cliff edge						
Ngamatea Station 1 E27804-N62045; E27801-N62048	greywacke rock outcrops and riverbed boulders	✔					
Ngamatea Station 2 E27805-N62044; E27819-N62084; E27797-N62026					✔		
Ohinewairua Station E27597-N61898 E27599-N61895	greywacke screes and outcrops	✔			✔		
Boyds E27847-N62226	outwash pumice			✔			

Site	Site description	Whitaker, 1991	Hutchinson, 1992	Whitaker, 1997	Flannagan et al 2001	Teal, 2006	Gebauer, 2008
Poronui E27943-N62396	escarpment with pumice boulders and stones			✔			
Wakemans E28262-N62391	greywacke outcrops and screes			✔			
Otupae Range 1 E27806-N61807	greywacke outcrops and scree		✔		✔		✔
Otupae Range 2 E27759-N61834						✔	✔
Otupae Range 3 E27757-N61831						✔	✘
Kelly Land Co. Rangitikei River Flat E27705-N61846	river worn greywacke boulders	✔			✘	✔	✘
Springvale Huts E27711-N61873	greywacke rock outcrops and rock piles				✔	✔	✔
Springvale Bridge E27709-N61863	flood erosion 'bowl', greywacke boulders	✔				river bed changed, described site can not be found	river bed changed, described site can not be found
Springvale Site 1 Quarry E27697-N61871	greywacke rock piles	✔			✔	✔	✔
Springvale Site 2 E27706-N61864	greywacke scree	✔					✔

Site	Site description	Whitaker, 1991	Hutchinson, 1992	Whitaker, 1997	Flannagan et al 2001	Teal, 2006	Gebauer, 2008
Springvale Site 3 E27701-N61858	greywacke rock piles	✘ many droppings					✔
Springvale Site 4 E27701-N61858	greywacke rock piles and scree	✘ few droppings					✔
Springvale Site 5 E27703-N61862	greywacke scree	✔					✔
Mt. Aorangi E27745-N61724	limestone cliff						✔

12 Appendix 3: Details of sites visited during this survey

Site:		**Springvale Quarry**
Reference:		Whitaker, 1991 (Site 6), Flannagan, 2001
Area:		3x24m (incl. Plot 1), 4x10m (Plot 2), 3x3m, 12x6m
Visit 1	Date/time	31 January 2008; 08:00-11:00
	Weather	sunny, hot
	Small-scaled skinks	27
	Comments	
Visit 2	Date/time	31 January 2008; 16:00-18:00
	Weather	sunny, hot
	Small-scaled skinks	3

Figure 3 Greywacke scree at the Quarry site including Plot 1

Figure 4 Plot 2 at the Quarry site

Site: **Springvale Huts**

Reference:		Whitaker 1991
Area:		8x19m, 6x11m, 8.5x10m, 3.5x4.5m
Visit 1	Date/time	01 February 2008; 8:00-11:00
	Weather	sunny, partly cloudy
	Small-scaled skinks	7

Figure 5 Huts site

Site: **Springvale Site 2**

Reference:		Whitaker, 1991
Area:		4 x 5.5m, 7 x 3.5m, 8x13m, 2x12m
Visit 1	Date/time	15 February; 9:00-11:00
	Weather	sunny, partly cloudy
	Small-scaled skinks	4

Figure 6 Site 2

Site:	**Springvale Site 3 and Site 4**
Reference:	Whitaker 1991
Area:	10x5m, 3x1.5m, 6x11m, 30x50m
Visit 1 Date/time	08 February 2008; 10:00-11:00
Weather	sunny, hot
Small-scaled skinks	1 skink at Site 3, 1 skink at Site 4

Figure 7 Site 3 and Site 4

Site:	**Springvale Site 5**
Reference:	Whitaker 1991
Area:	24.5x15m, 5x8m, 14x8m
Visit 1 Date/time	08 February 2008; 8:00-9:45
Weather	sunny, warm
Small-scaled skinks	7

Figure 8 Site 5

Site:		**Kelly Land Co. Riverbed flats**
Reference:		Whitaker 1991, Flannagan 2001
Area:		2x6m, 2x3m
Visit 1	Date/time	03 February 2008; 8:00-10:30
	Weather	overcast, warm
	Small-scaled skinks	0
Visit 2	Date/time	03 February 2008; 15:00-16:30
	Weather	sunny, hot
	Small-scaled skinks	0
Visit 3	Date/time	04 February 2008; 8:30-11:30
	Weather	sunny, warm, calm
	Small-scaled skinks	0
	Comments:	No droppings or skins were found at those rock piles

Figure 9 Riverbed flat site at Kelly Land Co.

Site:	**Otupae Site 1**
Reference:	Hutchinson 1992
Area:	30x50m
Visit 1 Date/time	14 February 2008; 11:00-12:30
Weather	sunny, warm
Small-scaled skinks	1
Comments:	Compared to the photo provided in the report of Flannagan 1992 the site contains much more vegetation

Figure 10 Otupae Site 1

Site:	**Otupae Site 2**
Reference:	Teal 2006
Area:	N/A
Visit 1 Date/time	07 February 2008, 8:30-12:00
Weather	morning frosts, cold winds but sunny
Small-scaled skinks:	0

Figure 11 Otupae Site 2

Site:	**Otupae Site 3**
Reference:	Teal 2006
Area:	N/A
Visit 1 Date/time	06 February 2008; 8:00-12:00
Weather	cold winds but sunny
Small-scaled skinks:	6

Figure 12 Otupae Site 3

Site:	**Mt. Aorangi**
Site description:	on the base of the northern limestone cliffs of Mt. Aorangi
Area:	N/A
Visit 1 Date/time:	16 February 2008; 8:00-11:00
Weather:	sunny, warm
Small-scaled skinks:	1

Figure 13 Mt Aorangi site

ERROR: undefined
OFFENDING COMMAND:

STACK: