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Comparing the use of time-lapse photography and visual observations for post release monitoring of Otago Skinks

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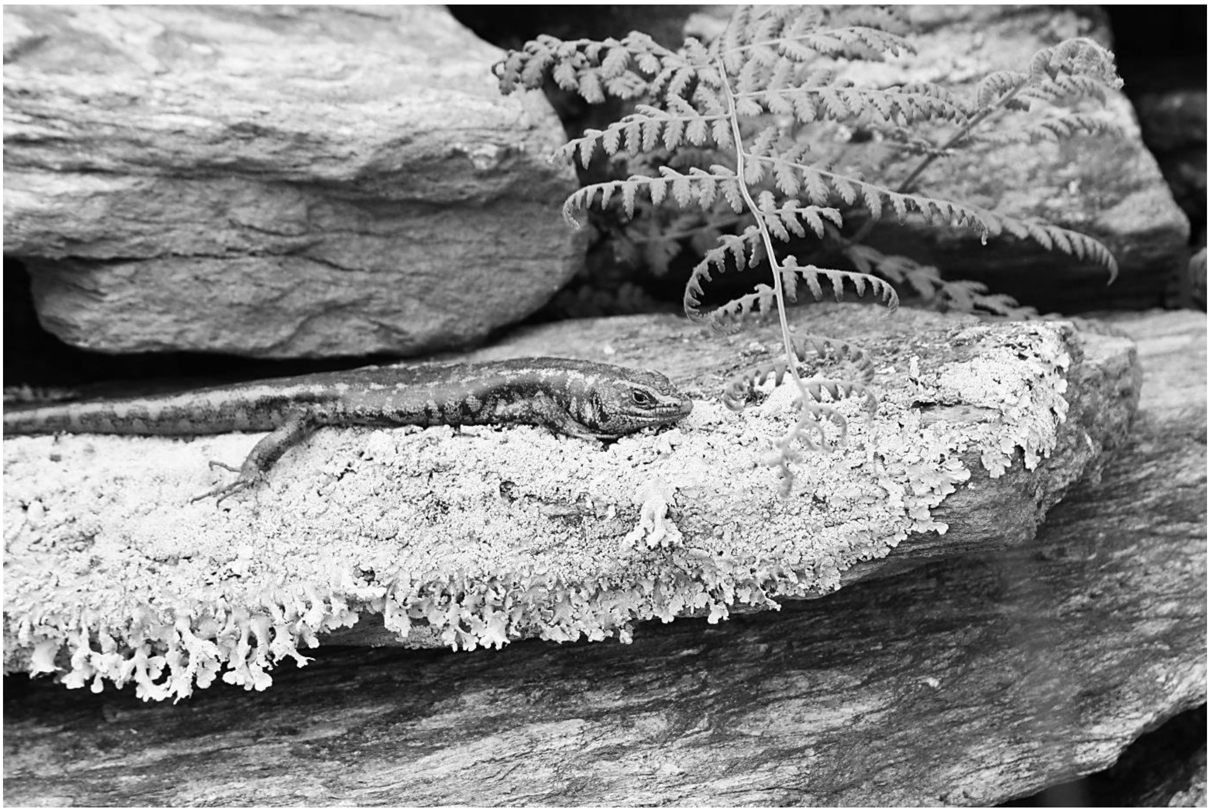

Introduction

New Zealand has 110 species of reptiles (Hitchmough et al., 2012), most of which are classified as at-risk or threatened by the New Zealand threat classification system (Hitchmough et al., 2012). The Otago skink is New Zealands largest species of skink and is classified as Threatened-Nationally Endangered (Hitchmough et al., 2012), as their current range is restricted to a mere 8% of their original range, the population is in decline, and continuation of the species is dependent on conservation measures to manage threats (Hitchmough et al., 2012). The remaining population is estimated as just over 2000 individuals (Chapple, 2010), most of which occur at Macraes Flat in the Waitaki District, South Island, with a small remnant population near Lake Hawea (Norbury et al., 2007), and a small population recently established in a mammal proof fence near Alexandra (Sidaway & Sidaway, 2013).

The decline in Otago skinks has mainly been attributed to predation by introduced mammals, and habitat modification by conversion of tussock to pasture (Norbury et al., 2007). The remains of Otago skinks remains have been found in the stomachs of feral cats (*Felis catus*) (Middlemiss, 1995), and other species of skink are commonly preyed upon by ferrets (*Mustela* *putorius furo*) and stoats (*Mustela ermine*) (Norbury, 2001), Magpies (*Cracticus tibicen*) (McIlroy, 1968), and hedgehogs (*Erinaceus europaeus occidentalis*) (Jones et al., 2005). When predators are removed or suppressed in an area Otago skink populations improve, with the greatest abundance in the centre of the predator suppressed area, or inside a mammal proof fence (Reardon et al., 2012). The conversion of tussock to pasture has resulted in reduced cover for skinks moving between tors, making them more vulnerable to predation (Whittaker, 1996), as well as diminishing the native fruit *Coprosma taylorae* and *Leucopogonfraseri* which are an important food source for Otago skinks during the summer and autumn months (Tocher, 2003).

Otago skinks have been collected and held in captivity since the mid 1960’s, and since recent improvements in animal husbandry have had good breeding success in captivity, with captive skinks reproducing at a smaller size and producing larger litters than their wild counterparts (Collen et al., 2009). There is a captive management plan in place to secure the species in captivity to provide skinks for reintroductions into secure habitats, and research into techniques that can be used for skink conservation (Collen et al., 2009). Skinks from captive stock have been used to reintroduce a small population of 12 skinks into a predator proof enclosure in Alexandra in 2009; nine of which are known to have survived the first winter, and breeding has occurred (Sidaway and Sidaway, 2013).

Otago skinks are difficult to monitor in the wild as they are a cryptic species and have a detection probability of <1, and have a high startle response to an approach by an observer (Roughton, 2005; Roughton and Sedon 2006). Otago skinks can also have a home range of 200 - 54000m^2, with males having considerably larger home ranges than females (Germano, 2007). To improve monitoring, it is recommended that Otago skinks are only surveyed in favourable weather conditions (Coddington and Cree, 1997; Roughton, 2005), as detection is highest in warm, dry, still and sunny conditions (Codington & Cree, 1997).

The present study aims to investigate the use of time lapse photography for post-translation monitoring of Otago skinks, and compare data collected by visual observation with data from time lapse cameras. Time lapse photography / video recordings are a way to monitor species without sending an observer into the field. It can remove the effect of the observer's presence which can change the natural behaviour of the target species (Todd, 2005; Ecroyd, 1996). Time-lapse and video photography have been used for reptiles to observe mating behaviour in *Hoplodactylus macilatus* (Todd, 2005), retreat site selection in velvet geckos (*Oedura lesueurii)* (Downes and Shine 1998), habitat use and activity patterns of striped skink (*Oligosoma striatum*) (Neilson et al., 2004) and behaviour in the field in pygmy blue tongued lizards (Milne et al., 2003). It is can also be used to monitor survival predation of species that reliably return to an area, such as nest sites (Brown et al., 1998; Pietz & Granfors, 2000).

It is hypothesised that time-lapse camera footage and visual observations will give similar information about local abundance for the area closest to the camera, but detections will decrease as distance from the camera increases. There is likely to be more skinks detected when weather conditions are still, dry and sunny using both techniques, as this is when skinks are most likely to emerge (Coddington and Cree, 1997, Hoare et al., 2009). It is expected that some behaviours, such as interactions between two skinks will be able to be identified using time-lapse photography, but only footage from the tor closest to the camera is expected to give photo identification (ID) information.

Method

The observation period was over the austral summer months from the 17th December 2013 until the 28th February 2014. All observations were made in the Otago skink enclosure at the Orokonui Ecosanctuary, Dunedin, Otago where 30 Otago skinks (*Oligosoma otagense)* were released on the 20th November 2012. One juvenile was seen being eaten by another, larger skink less than an hour after the release, so the maximum number of skinks in the study was 29.

Prior to release all skinks were sexed and photographed from both sides, focusing on the nose to foreleg region as this area has distinct markings that are stable over time (Reardon et al., 2012). These images were recorded with the identity of the skink for later use in photo identification of these skinks. Any unusual observations were also recorded, such as scars or tail loss.

For visual observations the enclosure was split into 8 separate rock formations or tors, numbered 1-8 going in a clockwise direction with the sculpture of Tane Mahuta on tor 1. The location of each skink was recorded as the nearest tor to where it was photographed.

Data loggers set to record hourly temperature readings were placed in three locations in the enclosure, two were placed in copper model skinks and placed on rocks in sunny north facing sites in the enclosure to simulate potential temperatures that can be achieved by basking, and one was placed under a rock, 20cm into a tor to measure retreat temperature.

A UOVision UV565 time lapse camera was set up at a height of 155cm looking SSE over the northern facing area of three connected rock formations in the enclosure. The three rock formations in the field of view were broken up into three areas, "short distance" (2.15 to 4.2m from the camera, area 44.1m^2) "middle distance" (4.2m to 7.2m from the camera, area 57.0m^2) and "long distance" (7.2m-10.3m from the camera, 62.7m^2), these areas corresponded with rock formations 4, 3 and 2 respectively. Each area had a vertical height of 0.4m.

The camera was set to take an 8MP, 3264x2448, high definition photograph every 10 minutes between 6am and 9pm, as Otago skinks are known to be diurnal (Norbury et. al., 2007). It is expected that photos every 10 minutes should be adequate to get an estimate of the number of skinks using the areas visible at any one time as skinks spend hours at a time basking in the sun (Cree, 1994).

Human observations were made for 60 minutes, on 16 occasions over the observation period, aiming to photograph all skinks that were visible over that time period. The observer would slowly approach the fence of the enclosure, and stand very still scanning the area for any visible skinks, then move in a clockwise direction around the edge of the enclosure and attempt to photograph every skink that was visible over a 30 minute period, sometimes manoeuvring carefully to get a clear photograph focusing on the side of the skink between the head and front legs for photo ID. If the skink could not be photographed, it was not counted. Observations of the skinks' behaviour and the nature of any interactions with other skinks, as well as injuries and tail-loss were also made by the observer. The location of each skink at the time of photographing was also recorded as the nearest rock formation. The presence of the observer did not appear to cause the skinks to alter their behaviour, and due to the public position of the skink enclosure the skinks were often exposed to people talking and pointing right beside the fence.

If no skinks were sighted within the first 20 minutes of observations then the observer would record no skinks for that day.

The photos from the time-lapse camera were analysed by eye. Every visible skink in the frame was counted and the rock formation that they were on or closest to was recorded. Their behaviour, if it could be determined, and any interactions or close proximity with other skinks was also recorded, as well as whether any skinks could be positively identified using the photos from the release.

The photographs from the visual observer were also analysed and all skinks were identified using the archived photographs from the release date.

The total count for each observation period was compared with the maximum number visible in the time-lapse camera footage over the time that the visual observations happened.

Interactions

Interactions were defined as two skinks touching, basking within 10cm of each other, or behaviourally reacting to the presence of another skink. The nature of interactions was recorded as either peaceful or aggressive; peaceful interactions were skinks were basking near to each other without disturbance, or one skink moving past another without provoking a reaction. Aggressive interactions were interactions that resulted in either a fight, or chase. Close proximity was defined as skinks between 10 and 30cm of each other, or sharing the same rock with no behavioural change observed.

Analysis

A T.test was used to compare time-lapse footage counts with counts by the visual observer, and the number of skinks detected using visual observation and time-lapse footage was compared across the three tors using Fisher's exact test for count data.

Generalise additive models (GAMs) were used to test for a relationship between the methods (method) used and skink detection (skinks) over three rock tors (tor). The statistical program R (version 2.15.3; The R Foundation for Statistical Computing 2013) was used to construct the GAMs. Other factors that were considered that were likely to influence skink detections were: the time of the observations (hour), the amount of rain (rain), copper model skink temperature (CM), and the temperature from 20cm into a rock tor (shade). For copper model temperature, and inside rock tor temperature where the relationship between model parameters and skink counts was non-linear a smoothing function was used.

The global starting models specified that skink detection was an additive function of {skinks~method+tor + hour + rain + CM + shade}.

This model was compared with 12 less complicated models that included different additive and interactive combinations of the parameters from the global model, and a null model of {skinks~1}. Akaike's Information Criterion adjusted for small sample sizes (AICc) was used to assess relative model fit. The difference between the score of the top model and the scores of the other models (dAIC) was used to select the model that best estimated the number of skinks detected. All models with dAICc <2 were considered to have substantial support, models with dAIC <4 were considered to have moderate support, and models with dAIC>10 were essentially not supported (Burnham & Anderson 2002).

Results

Overall, there were significantly fewer skinks detected using time-lapse footage compared with the visual observations ($t=2.47$, $p=<0.05$), and there was a significant difference between time-lapse footage and visual observations across the three tors ($p=0.01921$). Tor 4 had the highest number of detections using both methods. Detections by the visual observer decreased marginally between tor 4 and 3, and tor 3 and 2, and detections by the time-lapse footage decreased between 4 and 3, and then dropped rapidly to zero detections between tor 3 and 2. (Figure 1). Over the entire study period Skinks were only detected 47 times on tor 2 using the time-lapse footage, compared with 1017 skinks detected on tor 4 (Table 1). The highest numbers of skinks were detected in the middle of the day, between 11am and 2pm (Figure 2). Skinks were only active when there was no rain or light precipitation (Figure3). There was a positive relationship between the number of skinks detected using both methods and the temperature measured inside a copper model skink, until the temperature reached between 36°C and 37.5°C when there was a rapid decrease in skinks visible using visual observations; the time-lapse footage did not show a rapid decrease (Figure 4). The number of skinks detected appears to be highest when the temperature 20cm into the rock tor is between 10.5°C and 17.5°C, above and below these temperatures fewer skinks were seen using both methods (figure 5).

Table 1. Total skink counts made using visual observation and time-lapse footage over the times visual ovservations were being made (n=16), and the total number of skinks seen using time-lapse footage over the study period, 17th December – 28th February.

Method	Tor 4	Tor 3	Tor 2
Visual Observation	15	14	6
Time-lapse during observation	12	8	0

Total Time-lapse 17th December – 28 February	1194	693	47

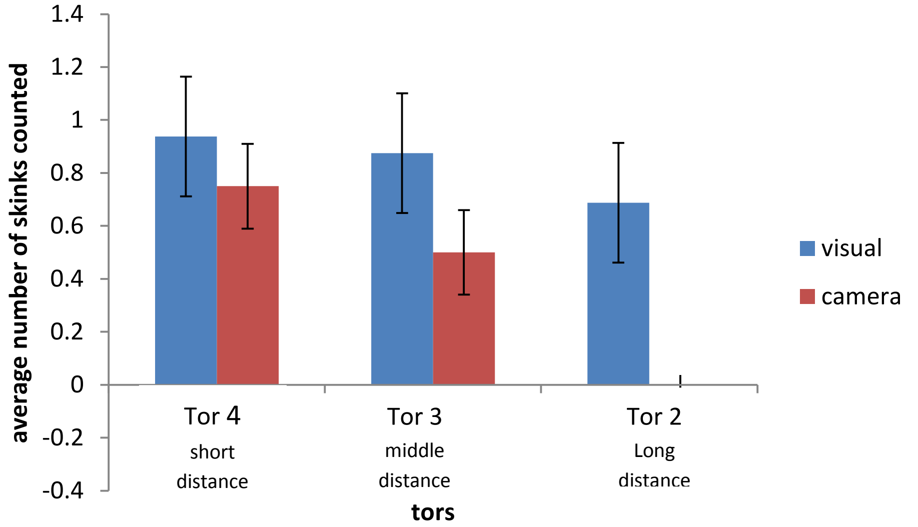

Figure 1. Average number of skinks detected on each tor using visual observations (n=16) and time-lapse camera footage (n=16). Distance on the x axis is relative to distance on the y axis. Error bars show standard error.

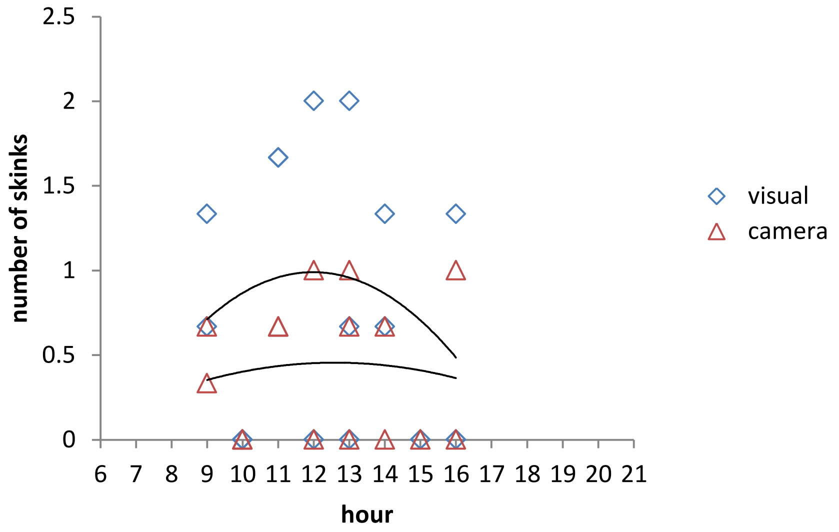

Figure 2. Number of skinks detected at different times of the day using visual observations (n=16) and time-lapse footage (n=16).

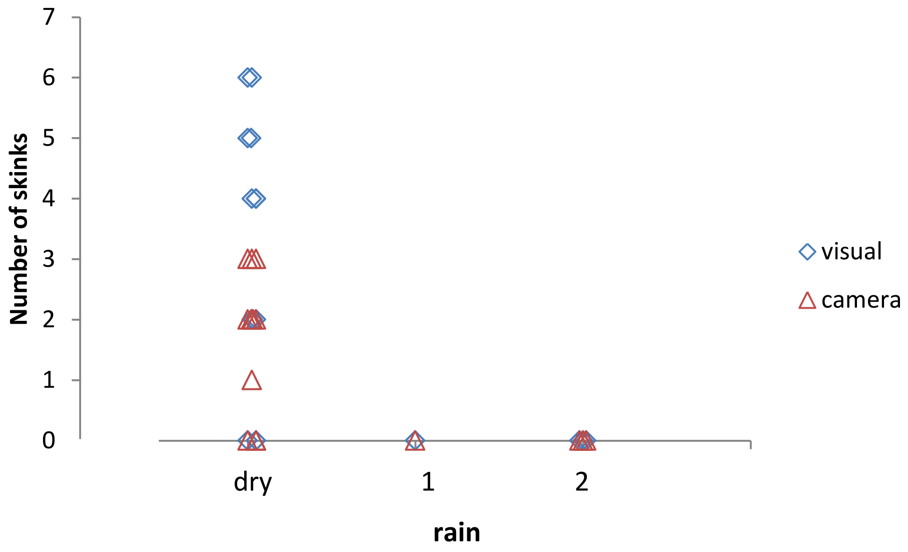

Figure 3. Number of skinks detected by visual observations (n=16 and time-lapse footage (n=16) in response to precipitation. dry = no airborne moisture, 1 = light precipitation from low cloud, 2 =rain.

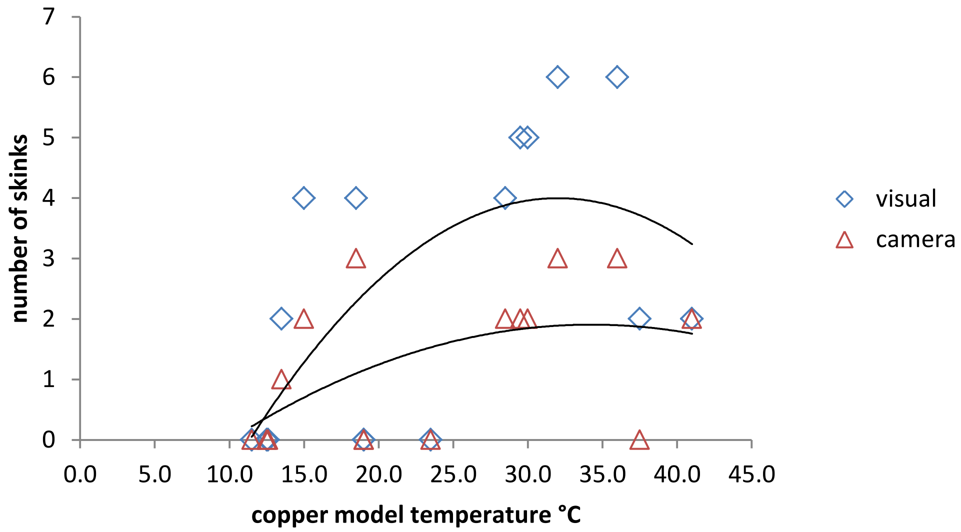

Figure 4. Number of skinks detected by visual observations (n=16) and time-lapse footage (n=16) in response to temperature measured using a copper model skink placed in full sunlight.

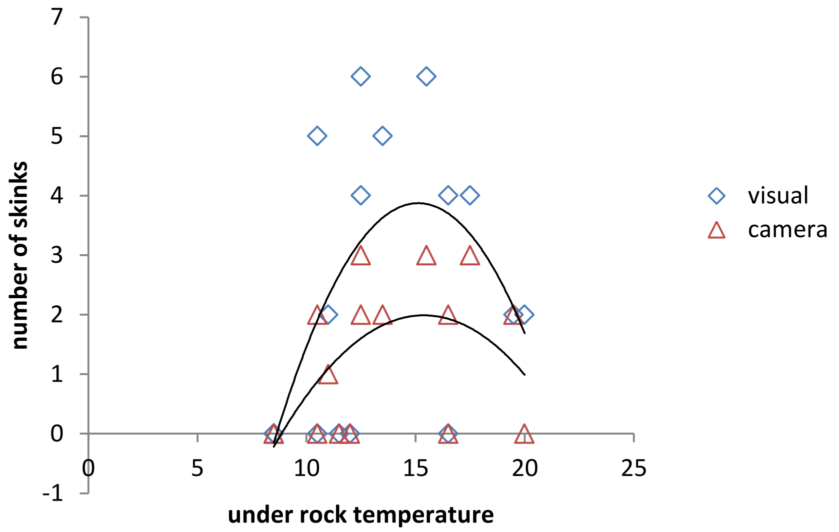

Figure 5. Number of skinks detected by visual observations (n=16), and time-lapse footage (n=16) in response to the temperature measured under a rock, 20cm into a rock tor.

The highest ranking model was model {skinks~method+tor+rain+CM+retreat} which had 63% support as indicated by the model weight. The next highest ranking models have considerably less support with dAICs of >4 (Burnham & Anderson 2002). According to the highest ranking model, skink counts varied between methods, and were also affected by the tor, time of day observations were made, whether there was any rainfall, and the temperature that could be reached inside a copper model placed in full sunlight (Table 2).

Table 2. Candidate Generalised Additive Models comparing visual and time-lapse photography methods of skink counts (s) of Otago Skinks (*Oligosoma otagense*) in Orokonui, Dunedin, December-February 2013/14. The model with the highest rank is indicated by the lowest Akaike's Information Criterion (AIC) score and the highest weight. dAIC indicates the difference in AIC scores from the highest ranking model, and df = the number of parameters. Method = the method used, hour = time of observations, CM=(smoothed) copper model temperature, retreat =(smoothed) retreat temperature. The effects tor, hour, rain, CM and retreat are additive, as indicated by the + symbol, an interaction between method and tor is indicated by the * symbol.

model	AICc	df	dAICc	weight
skinks~method+tor+rain+CM+retreat	209.0	7	0.0	0.6305
skinks~method+tor+rain+CM	213.0	6	4.0	0.0829
skinks~method+rain+CM+retreat	213.6	6	4.4	0.0692
skinks~tor+rain+CM+retreat	213.8	6	4.9	0.0557
skinks~method*CM+rain+tor+retreat	214.0	8	5.0	0.0517
skinks~method+tor+CM	214.4	5	5.5	0.0411
skinks~method*tor+rain+CM+retreat	214.6	8	5.6	0.0386
skinks~method+rain+CM	217.1	5	8.1	0.0109
skinks~method*tor+rain+CM	217.2	7	8.2	0.0103
skinks~method*tor+CM	217.4	6	8.5	0.0092
skinks~method*tor	242.2	5	33.3	< 0.001
skinks~1	245.0	2	36.0	< 0.001
skinks~method*tor+hour	334.3	12	125.3	< 0.001
skinks~method+tor+rain+hour+CM+retreat	620.8	14	411.8	< 0.001

Photo Identification from time-lapse photos.

The photo quality from the time-lapse cameras was grainy, even with the camera on the highest quality setting. Only skinks on tor 4 (tor nearest the camera) were clear enough to identify as skinks further away were too small to make out the markings. It was not possible to identify any skinks further than 2.75m from the camera. Of the 1031 photographs containing 1212 skinks on tor 4, 230 of them had skinks that could be identified by their markings. The five skinks that were identified were: W31024 (M), W31017 (F), W31020 (M), W31030 (M) and, W31015 (M). The skink W31010 (F) was also able to be identified due to the loss of most of its tail early in the study; it was the only skink in the closed population recorded as having a large degree of tail loss. All of the skinks identified in the time-lapse footage were also recorded as present on that tor by the visual observation data.

Behaviour and Interactions

Over the study, no interactions; peaceful or aggressive, were detected in the time-lapse cameras during the times that the observer was present. The observer also was not able to photograph any skinks interacting peacefully within the field of view of the cameras, or basking in close proximity. However, the observer did see the male B10115 retreat under a rock by climbing over another skink that was under a rock. When it moved, the observer was able to see a distinctive scar on its shoulder and could identify it as the female B10116 from the release datasheet. Two fights were witnessed by the observer over the study period; the first was on the 6th of January, two unphotographed skinks on rock formation 4 were seen fighting, one was able to be visually identified as the male O80022 by its unusual pale markings, and the other retreated before it could be identified. The second fight was on the 29th of Janurary, on rock formation 3 between the male W31031, and another unidentified skink.

Outside of the field of view of the time-lapse cameras the observer witnessed four peaceful male-female interactions, as well as and two male-male in close proximity but not interacting.

Outside of the times the observer was present, the time-lapse cameras were able to detect 43 occasions where skinks were observed interacting, or in close proximity. Most of them appeared to be peaceful with skinks basking near to one another and on some occasions touching or appearing to be following one another. Where photo identification was possible, all interactions were between the female W31017 and one of 3 males; W31024, W31030 and W31020 on rock formation 4.

Discussion

In the present study, visual observers were consistently able to detect more skinks than the time lapse camera footage on days when there were skinks available to be seen. There was a significant difference between visual and time-lapse observations for tor 2(the tor furthest from the camera), with none of the skinks detected on tor 2 by the observer detected by the time-lapse footage (figure 1). Most of the rocks on all three of the tors in the field of view of the camera were visible to the camera, however, there were some available basking rocks that were obscured, and on some of the observation days there were skinks basking ok these rocks where they may have been unavailable to be seen by the camera. It is unlikely that these skinks influenced the count, as there was not a significant difference between visual and time-lapse observations on tors 3 and 4 (figure 1).

Over the study period Skinks were only detected 47 times on tor 2 using the time-lapse footage, compared with 1194 skinks detected on tor 4, and 693 on tor 3 (Table 1). On all of these occasions the skink was seen fully laid out, lying across the surface of the rock that was angled to the camera. No skinks lying across the tops of rocks, partially obscured by rocks, or emerging from underneath rocks were detected, whereas on tors 3 and 4 skinks could be detected by a change in the outline of a rock where a skink was lying across the top of it, and could also be seen coming out from under rocks.

On days when there were skinks available to be seen, most skinks that were present were seen and photographed by the observer within the first 20 minutes of the observation period, and remained present throughout the observation. This suggests that if a skink was available to be seen, it remained available throughout the observation period to be detected by the cameras.

The highest ranking model (table 2) shows that the factors; method used, tor, rain, copper model temperature, and rock tor temperature were all predictors of the number of skinks visible at any one time. The climatic variables identified in the model are compatible with those predicted by Hoare et al., (2011), and Coddington and Cree (1997) to influence number of skinks visible.

Skink detections increased as copper model temperature increased up until 36°C, but decreased when temperatures reached 37.5°C (figure 4). A similar trend was seen with inside rock tor temperatures, where skink detections were highest between 10°C and 16°C, with fewer skinks detected above and below those temperatures (figure 5). One data point stands out; at 10am on the 6th Feb the copper model temperature read 23.5°C. However, there were no skinks visible. Further analysis of the data reveals that overnight the copper model temperature got down as low as 1.5°C, and 6.5°C inside the tor. The temperature inside the rock tor at the time of the observations was only 8.5 °C, which was the lowest measured, so the skinks may not have had a chance to respond to the high potential temperature. Otago skinks large body temperature takes a long time to reach optimal temperature, so Otago skinks are selective about what conditions they emerge in and are unlikely to emerge in marginal windy, damp or cold conditions (Coddington and Cree, 1997). At low temperatures, skinks maximum sprint speed is impaired, and skinks are less effective at digesting food (Besson and Cree, 2011). The preferred body temperatures of congeneric McCanns skinks and other southern reptile species was between 20°C and 27°C (Besson & Cree, 2011). Skinks in laboratory conditions maintain their body temperatures at close to optimum for achieving maximum sprint speed (Gaby et al., 2011). On warm days retreat temperature was near to the skinks optimum, so once they had reached optimum temperature, they would have cooled slower and been able to perform at maximum efficiency without spending more time basking (Besson & Cree, 2011).

The temperature measured in the copper models was used as a proxy to provide an indication of potential temperature achievable by basking. The copper models that were used are calibrated to measure the potential maximum body temperature of the co-generic McCanns skink (*Oligosoma mccanni)* which is smaller in size than Otago skinks, with a maximum shout vent length (SVL) of 72.5mm (Patterson & Daugherty, 1990), compared with Otago skinks which have a maximum SVL of 130mm (Cree 1994). The larger size of Otago skinks means they may have a higher potential maximum temperature, but may also take longer to achieve it (Stevenson, 1985).

There were only three days in the study where it was raining, and one day when low cloud was causing a lot of moisture; no skinks were recorded on tor 2, 3 or 4 on these days. Other studies have also found that skink numbers counts are low in damp conditions (Coddington & Cree, 1997;Hoare et al., 2009). However, there was a skink seen basking on another tor in the enclosure in low cloud, and at times when the observer was not present skinks were detected in the time-lapse footage outside on wet rocks between showers, but this was not commonly observed.

One limitation of the study is the the time-lapse camera only took photographs every 10 minutes, this means it could have missed a time when there were more skinks visible, however, the camera was set to take photographs every 10 minutes for 77 days, resulting in 90 images per day, and a total of 6930 images. Of these images, 1427 of them had skinks visible. The maximum number of skinks seen at one time in all of these 1427 photographs was five.

Another limitation was the small selection of climate variables that were measured. By chance most of the observation days were on days with light to moderate wind. Wind has been found to influence skink emergence (Coddington & Cree, 1997), with fewer skinks seen on windy days.

There were also a limited number of attachment sites for the time-lapse cameras. It was not possible to have replicates with another camera focused over a different site, as the camera had to be attached to a fencepost around the edge of the enclosure to minimise disruption to the public viewing, and there were no other sites where more than one tor could be focused on without obstruction by foliage. Another site, such as a more vertical cliff-like formation, or a site with larger rocks may have given the camera an almost unobstructed view of all potential basking sites, and made it easier to detect skinks. Further study is needed to determine whether the accuracy of counts from time lapse cameras changes with different rock formations.

The skinks used in this study were captive bred and reared, which has been found to cause changes in phonotypic effects, such as increasing the weight:SVL ratio (Connolly and Cree, 1997), so skinks released in the enclosure are likely to be heavier and slower than wild skinks. Heavier animals take longer to heat up, but also take longer to cool than their lighter wild counterparts (Stevenson, 1985), so may have different behaviour and basking patterns to their wild counterparts. The skinks in this study also appeared to be less responsive to the presence of people than wild skinks, allowing the observer the ability to get close and walk around while photographing skinks. On two occasions Otago skinks were observed basking right up against a glass window with people walking past less than 0.5m away, and people were often seen pointing and talking less than 1m from a basking skink. Wild skinks are more sensitive to approach by humans; the average distance before an observer elicits a startle response is 2m (Roughton, 2005).

Photo ID using time-lapse photography

The present study also looked at skinks in a confined area at high density; however, skinks in the wild have home ranges from 200m-54000m in size, and are likely to be at much lower densities (Germano, 2007; Roughton, 2005). Time-lapse cameras would need to be trialled at low density sites, or areas of known skink presence in a wild population before conclusions can be made at their effectiveness at monitoring an unconfined population.

Of the 1017 photographs with skinks visible on rock formation 4, only 228 of them contained skinks that were able to be positively identified. For a skink to be identified it had to be within 2.75m of the camera and orientated at near 90 degrees. Six skinks, out of the original 30 released were able to be identified using rock formation 4, five of these skinks had very distinctive, clear black and gold markings enabling them to be easily identified, and the sixth skink; W31010, did not have clear markings that could be distinguished, but had lost most of its tail prior to the camera set up, and was the only skink over the course of the study to have had such dramatic tail loss recorded. One limitation with using the time-lapse footage to photo ID skinks was that even when skinks were correctly oriented, lighting conditions such as glare and shadow could obscure the markings, making them difficult to make out. The image was also very grainy after zooming in far enough to make out the skinks individual markings, so even a photo in perfect conditions may not be able to be used for photo ID. Another limitation in this study was the initial archive photos taken for photo ID only documented the side of the head, between the nose and the foreleg, however this region of the skink was often not visible, either because the skinks head was facing towards or away from the camera, or glare reflecting off the skinks skin obscured the markings. Future studies attempting to use time-lapse camera footage for photo ID should attempt to get a photo that shows the top of the skinks head also.

Behaviour and Interactions

Very few interactions were observed over the course of the study. Only two aggressive confrontations between a male and another unidentified skink were recorded by the observer, and there were no non-aggressive interactions in the study area. The confrontations were very fast, lasting only a few seconds. To capture aggressive interactions with time-lapse photography, photos would have to be taken much more frequently than the 10 minute intervals used in this study. Skinks interacting peacefully were observed basking together for minutes at a time and images from time-lapse footage was able to identify peaceful interactions between the female W31017, and 4 males; W31024, W31030, and W31020, over the duration of the study. No male-male interactions were observed by the time-lapse camera, although two males were seen basking in close proximity outside of the study area.

Some behaviours were able to be observed using the time-lapse footage, these behaviours included; basking, 2 occasions of eating; one an insect, another a berry, climbing rocks/ traveling, and emerging/basking with only head exposed. Hunting was not able to be identified using the time-lapse photos, but was a commonly observed behaviour using visual observations, with five skinks witnessed physically catching and eating flies.

Using the time-lapse footage magpies were observed in the skink enclosure on five occasions over the study which suggests some predation as magpies are known to prey on skinks (McIlroy, 1968). No predation events were captured on camera, but three adult skinks 080022 (M), O90149 (F), and W31016 (M), and one juvenile skink were not detected after the 23rd of December, and one skink W31010 (F) suffered the loss of almost its entire tail.

Recommendations and conclusions

Time-lapse footage is time consuming to set up and analyse, and for the most part visual observers are able to obtain a similar amount of information in a shorter amount of time. However, if time-lapse footage is to be used in the monitoring of Otago skink populations it could be a useful tool in estimating the occupancy of a rock tor after a presence/absence survey, and observing social interaction and the activity budget of Otago skinks without behavioural interference from an observer. Although how it performs in areas of lower density would have to be assessed before putting it into use. To get information about the number of skinks using an area, the camera should not be placed more than 7 metres from the tor, and if specific behaviour and information about individual skinks is required, the camera should not be placed more than three metres from the tor. Climate data on temperature and rainfall can be used to save time and selectively monitor days when skinks are likely to be active and visible to the camera. The time-lapse footage was only able to positively identify six individual skinks out of the 30 skinks released into the enclosure, so multiple cameras would need to be set up to assess factors such as survival or movement of a population post-translocation.

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Appendices

Table of survival of Otago skinks released on 20th November 2013 until the 28th February 2014 (n=30). M= male, F= female, J= Juvenile. 1 indicates present, coloured bars are skinks that had not been seen since 31January.

	Sex	28/11/13	3/12/13	13/12/13	14/12/13	19/12/13	23/12/13	6/01/14	24/01/14	25/01/14	29/01/14	31/01/14	1/02/14	6/02/14	11/02/14	28/02/2014	SVL	VTL	R	Observatio
B10108	F	1	1	1	1		1		1			1		1			119	158	c	
B10115	M	1			1		1		1		1	1	1				124	139	1	Moulting
B10119	M	1		1	1		1	1	1			1	1	1		1	98	128	c	
B10116	F	1		1	1		1		1			1		1			126	147	1	Poor condit
080022	M	1	1	1													103	134	c	Pale
050090	M	1	1	1	1		1				1			1			110	146	c	Kink at end
W31029	M		1	1			1		1		1		1	1			102	136	37	
090149	F	1		1	1		1										102	137	c	
W31026	M	1		1	1				1			1				1	113	124	46	necrotic tip
W31028	M			1	1		1				1	1	1	1			102	150	19	
W31010	F	1	1	1			1	1	1			1					113	133	1	
W31032	F	1	1	1	1		1					1	1				103	34	0	Missing mo
W31030	M										1	1		1			110	140	c	
W31031	M	1		1	1		1	1	1		1	1	1	1		1	108	165	c	Very long ta
W31020	M	1	1	1				1				1	1				113	145	24	
W31019	M	1		1	1	1	1				1		1	1			107	149	c	Head looke
W31027	F	1		1	1		1	1	1			1		1	1		123	78	2	
W31022	J																66	105	c	
W31025	M				1						1	1	1	1		1	123	166	c	protruding
W31023	F	1	1	1								1				1	110	140	69	
W31021	J																70	116	c	
W31024	M		1	1			1	1	1				1	1	1	1	92	140	c	
W31012	F	1		1	1		1		1			1	1	1		1	113	138	48	
W31013	F			1	1		1		1			1	1	1	1	1	108	117	31	
W31016	M			1	1		1										109	154	c	
W31017	F			1	1				1		1	1	1		1		110	139	18	
W31014	M				1		1							1			109	148	c	
W31018	F						1		1			1		1		1	112	147	c	
W31011	F						1	1	1		1	1	1	1			124	153	17	
W31015	M							1							1	1	113	136	17	