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Arboreal behaviour and habitat use in the Nationally Critical Kapitia skink (*Oligosoma salmo*)

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Abstract

The Kapitia skink (*Oligosoma salmo*) is found only on the west coast of Te Waipounamu / South Island, Aotearoa / New Zealand. This critically endangered skink has a moderately prehensile tail that would indicate an ability to climb. However, its only current habitat, a highly modified pasture, lacks vegetation or natural structures that would promote arboreal behaviour. We conducted a pilot study investigating the behavioural activity of a captive, wild-born Kapitia skink at Auckland Zoo in 2020. Over 13 days (24 hours/day) of focal sampling, climbing behaviour was observed for the first time in this species (8%, n = 58/703 mins). The skink was most active in the middle of the day, especially in fine, sunny weather. We suggest further investigations into the range of habitat use for this species. This study supports the importance of exploring potential habitat types beyond what we typically assume as the ideal habitat type (based on its source location) for an organism.

Keywords

Kapitia skink (*Oligosoma salmo*), climbing behaviour, reptile conservation, activity budget

Introduction

The Kapitia skink (*Oligosoma salmo*: Squamata: Scincidae), formerly known as the Chesterfield skink, is a critically endangered species with fewer than 250 mature individuals (Hitchmough et al. 2021). This species was only discovered in 1992, and the sole population is found in a narrow strip of farmland in Chesterfield, Westland, Te Waipounamu / South Island (Melzer et al. 2019). Phylogenetic studies have shown that this species is closely related to the native speckled skink (*O. infrapunctatum*) (Aviss & Lyall 1995; Greaves et al. 2008).

A distinctive observation in Kapitia skinks is that intact or largely intact tails are prehensile (Melzer et al. 2019). In Aotearoa / New Zealand, most native geckos possess variably prehensile tails (McCann 2020), but only a few native skinks have been observed with a prehensile tail, such as the chevron skink (*O. homalonotum*), moko skink (*O. moco*) and shore skink (*O. smithi*) (Barr 2009; van Winkel et al. 2018; Baling, pers. obs.). However, the degree of tail prehensility observed in these species is significantly less than in the Kapitia skink.

Prehensile tails are commonly associated with climbing behaviour. However, this behaviour has not been observed in Kapitia skinks. The current habitat of this species is highly modified pasture, with the presence of introduced predators such as mice (*Mus musculus*) (Norbury et al. 2014). The skinks live in the pasture and seek refuge under inorganic material, driftwood and logs, which provide some protection from predators (van Winkel et al. 2018). There is little vegetation within their current habitat that could promote climbing; however, the coastal location may historically have been occupied by coastal forest (Melzer et al. 2019). Therefore, little is known about the habitat preferences of this species.

In this study, we observed the behaviour and use of resources in a Kapitia skink in the presence of ground and arboreal structures. The study aimed to investigate whether the Kapitia skink showed arboreal behaviour and used arboreal microhabitats. Our objectives were: i) to determine the daily behaviour of Kapitia skinks (particularly climbing behaviour); and ii) to determine whether Kapitia skinks use arboreal structures. This study will: i) contribute to the improvement of husbandry of the captive population to encourage naturalistic behaviour; and ii) provide information relevant to habitat restoration (e.g., choice of vegetation plantings) at release sites.

Methods

Study location and enclosure design

This study was conducted at Auckland Zoo, Aotearoa / New Zealand. The Zoo houses several native species for conservation breeding, including the Kapitia skink. These skinks are located away from public areas of the zoo. The enclosures used for Kapitia skinks provide complex micro-habitats and micro-environments, which have been highly effective in skink husbandry and reproduction (R. Gibson, pers. comm). However, the predominantly terrestrial structures provide little climbing opportunity for the captive skinks. An experimental outdoor enclosure (85 cm × 85 cm × 138 cm, Figure 1A) was set up containing arboreal structures, including a branch and plants (*Coprosma acerosa*, *C. rhamnoides* and *Myrsine australis*). The enclosure was further furnished with three ground refuges, including Onduline (Suresnes, France) roofing and upturned terracotta dishes consisting of a double pot system with damp sphagnum in the bottom and dead cabbage tree (*Cordyline australis*) leaves inside the top to assist the skink's entry and exit, and a layer of leaf litter (soil depth 25 cm, Figure 1B). Food and water were provided on the ground.

Behavioural observation

We introduced an individual skink (adult male) to the experimental enclosure and video recorded it continuously for 24 hours a day for one month in the austral summer of 2020/21 (November 2020). Our video recording setup involved two cameras capable of night vision (Outdoor Dome 700TVL 30 IR LED type: CIR-SR46DGC, IR Lab, Taiwan) and a Bosch DIVAR AN 3000, and videos were viewed on an LCD monitor (LG 22MP57). The skink's behaviour (e.g., climbing, basking and locomotion) (Table 1), microhabitat (e.g., tree, log, leaf litter, refuge), and location in the enclosure for the first 13 days (due to study time constraints) were quantified using the continuous focal sampling method. Climate-condition data (daily temperature, rainfall and hours of sunlight) was collected from the National Climate Database (https://cliflo.niwa.co.nz/, National Institute of Water and Atmospheric Research [NIWA]) for November 2020.

Statistical analysis

First we investigated the active periods of the skink by quantifying the frequency of activity every hour for 24 hours. Then we determined the activity budget and the frequency of the most common behaviours exhibited

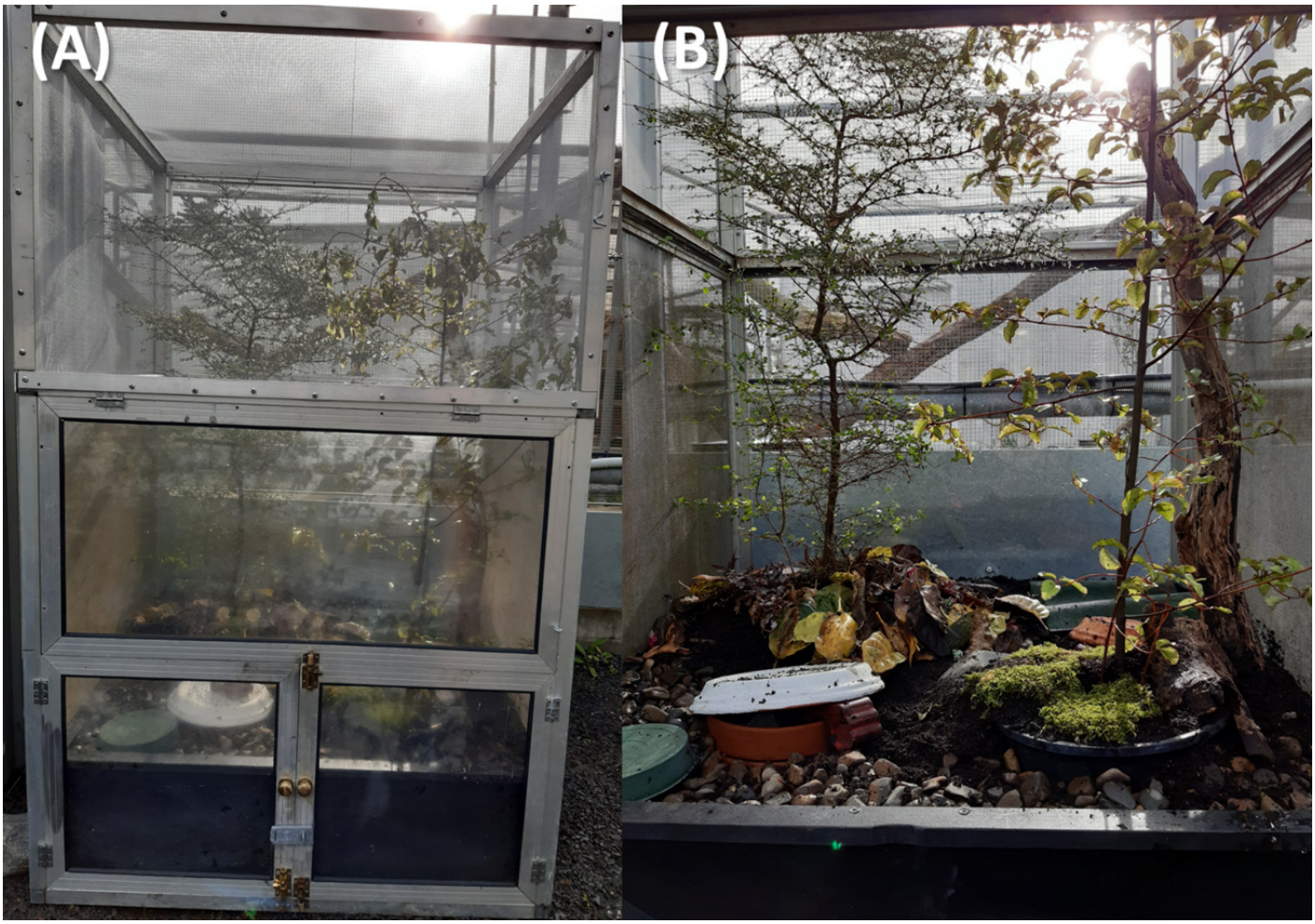

Figure 1. (A) Outdoor enclosure setup (85 × 85 × 138 cm). (B) Furnishing of the enclosure, taken from ground-level view. Photos: Sarah Brill.

Table 1. Kapitia skink ethogram.

Category	Behaviour	Definition
Maintenance	Basking	Flattening of the body on the ground or body lifted off the ground in a still position for over 30 seconds.
	Stationary	Skink stops and pauses, not moving in any direction for 2–29 seconds.
	Foraging	Skink moving through leaf litter and turning head, pointing towards the ground with tongue flicking.
Movement	Locomotion	Skink moving in any direction at a slow or fast pace on a horizontal surface.
	Climbing	Skink moving in any direction on a vertical object.
	Jumping	Leaping into mid-air, where all four feet leave a surface or object and land on a surface or object back on four feet.
	Dropping	Skink falls from a high surface or object and lands on the ground or an object.
Out of sight	Out of Sight	Skink is not visible.

by the Kapitia skink, via calculating the proportion of time spent on each behaviour within 24 hours for 13 days. We excluded the frequency of the animal being out of sight in the final proportion calculation, to focus on active behaviours. We also compared the proportion of time spent arboreally vs. on the ground. Daily activity behaviour was also compared with climate data to determine any association between weather and behaviours.

Results

One adult Kapitia skink was observed for a total of 18,386.5 minutes (13 days) during the summer (November 2020). During this time, the skink was not seen (i.e., out of sight) c. 90% of the time per day. Overall, the Kapitia skink showed active behaviours mainly during the day, where it was most active between 10:00 and 16:00 hrs daily (Figure 2). There was some activity observed – e.g., locomotion, and occasionally stationary but alert – at various times at night (2:00–5:00 hrs).

When the skink was active, it spent most of its time basking (43%, n = 300.6/702.8 mins) and in locomotion (36%, n = 252.1/702.8 mins) in the enclosure (Figure 3). Basking behaviour often occurred near a hide (14%, n = 44.6/300.6 mins), where its body was partially hidden (11%, n = 34.0/300.6 mins) (Figure 4). The skink was observed basking more frequently than in locomotion, while on the ground (basking = 48% vs. locomotion = 38%, n = 268.1/555.7 mins, 213.7/555.7 mins). In contrast, the frequency of basking was slightly less than locomotion while it was arboreal (basking = 22% vs. locomotion = 26%, n = 32.6 /147.0 mins, 38.4/147.0 mins). The skink was mainly stationary when exposed from a hide (19%, n = 17.38/89.7 mins) or leaf litter (36%, n = 32.15/89.7 mins). Much locomotion on the ground included the skink nudging through leaf litter, where it was partially visible under this.

The Kapitia skink showed climbing behaviour, but that was uncommon compared to other active behaviours (8%, n = 57.7/702.8 mins) (Figure 3). Arboreal movement included climbing up or down the branch or wire mesh (the wall of the enclosure) to reach the metal lip (the middle horizontal framing supporting the mesh) above, reaching a maximum climbing height of approximately 70 cm (typical climbing height is c. 44 cm). Prehensile tail use was observed once when climbing up *M. australis*. There were two instances of horizontal jumping: c. 20 cm above ground from the bottom of the branch to the side mesh of the enclosure, and c. 50 cm height from the top of the metal lip down to the leaf litter.

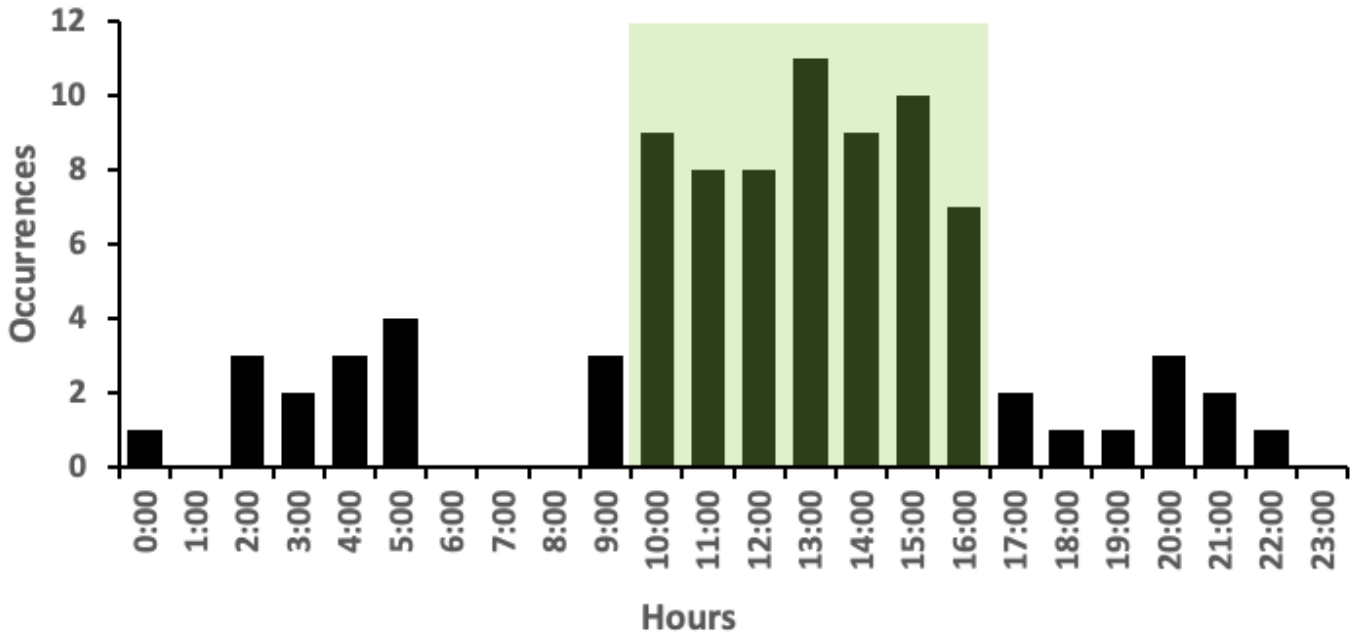

Figure 2. Occurrences of activity of a Kapitia skink each hour for the days observed for 24 hours (total 13 days), showing the most frequent time being active between 10:00 and 16:00 hrs (in green).

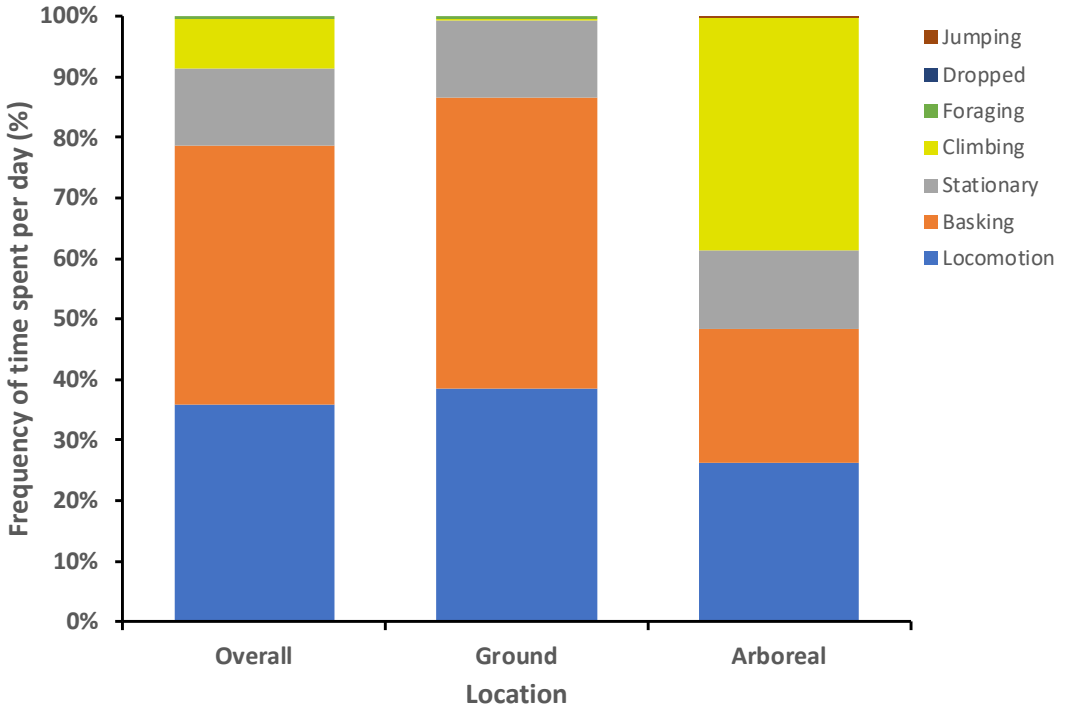

Figure 3. The average overall percentage frequency of time a Kapitia skink spent displaying behaviours per day (left) (n = 1,414.3 mins). The frequency of behaviours displayed on the ground (middle) and arboreal (right) per day on average.

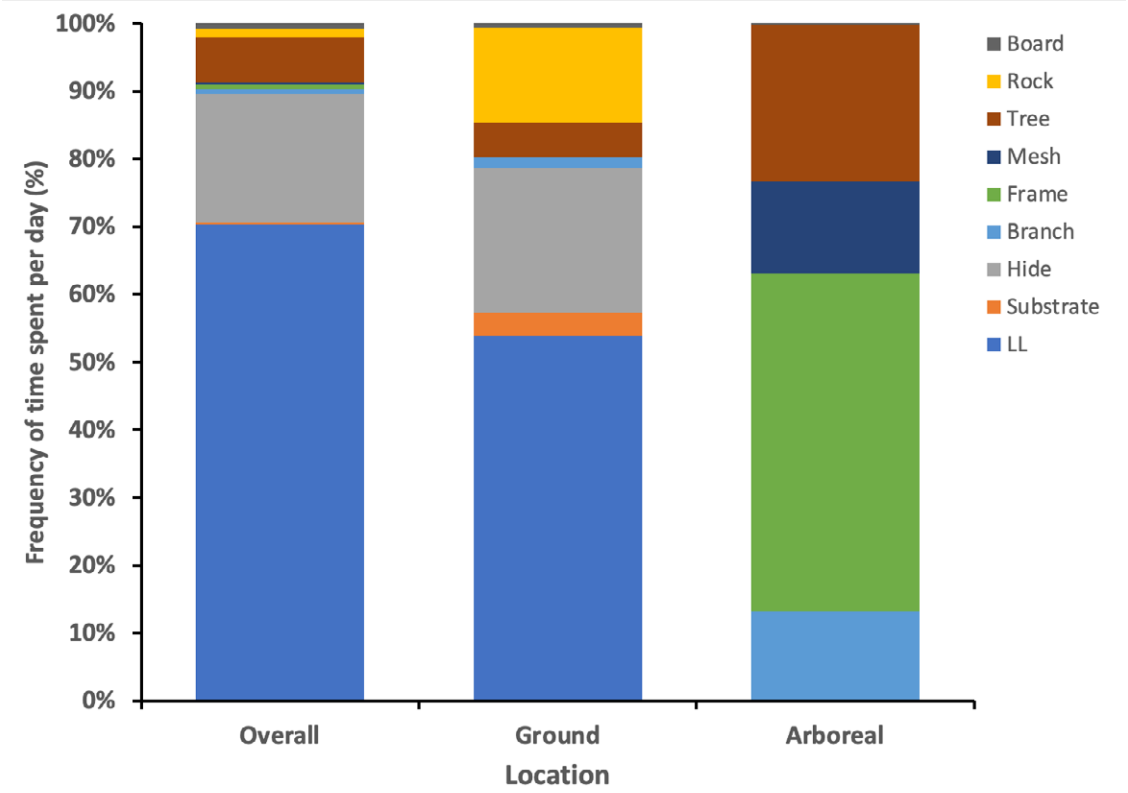

Figure 4. The average overall percentage frequency of time a Kapitia skink spent in different microhabitats (left). The frequency of time spent in microhabitats when the skink was on the ground (middle) and arboreal (right) per day on average.

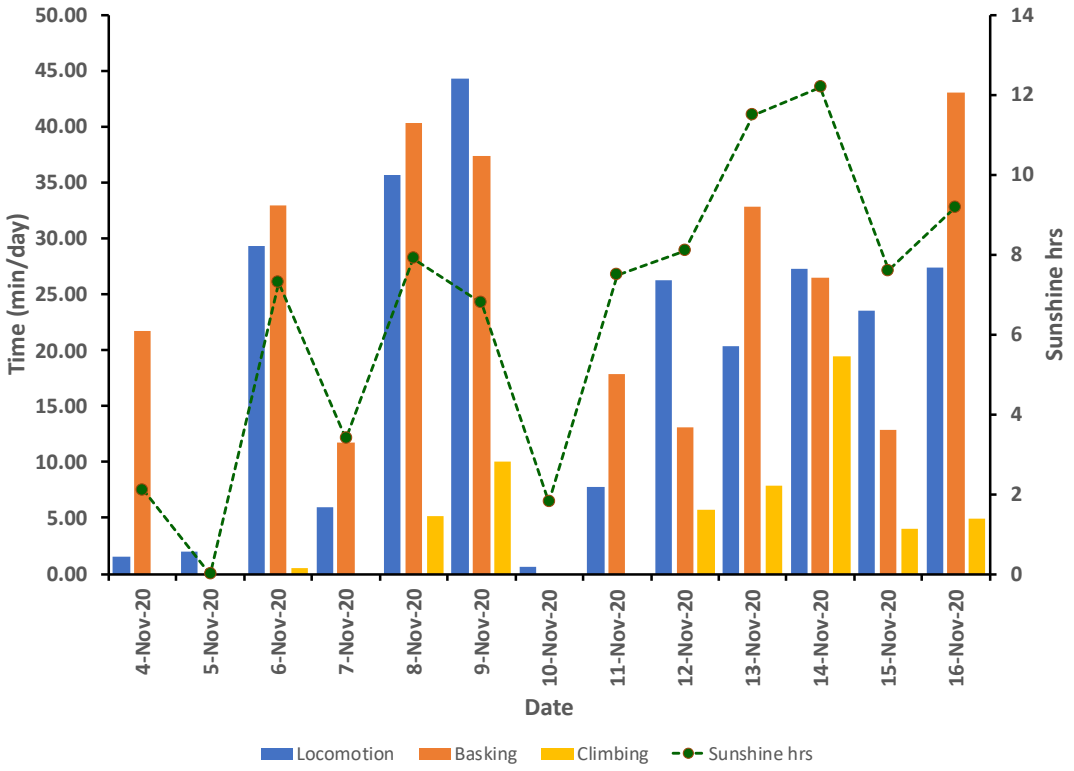

Figure 5. Time spent on active behaviours (locomotion, basking, climbing), along with average daily sunshine hours.

When compared to the weather variables (sunshine hours, sun radiation, temperature and rainfall) over the 13 days, the frequency of the Kapitia skink's two most common active behaviours matched most closely to sunlight, i.e., sunlight hours and sun radiation (Figure 5). When sunlight was low or reduced, activity (locomotion, basking and climbing) was also reduced.

Discussion

This observational study recorded the behavioural activity and habitat use in an individual captive Kapitia skink when introduced into a new enclosure. During the austral summer, the skink showed mainly diurnal activity and demonstrated the first observed instance of climbing behaviour in the species. This observation supports the hypothesis that Kapitia skinks can climb and, although not fully observed in this study, the possibility that the prehensile nature of the tail may be an important component of that behaviour (Melzer et al. 2019).

The activity pattern observed in this study confirms that the Kapitia skink is diurnal and heliothermic (Melzer et al. 2019; van Winkel et al. 2018). The individual Kapitia skink showed activity in the late morning and had increased activity with increased sunlight hours. The study matches other diurnal *Oligosoma* species preferring open habitats and basking in the sun (Montoya & Burns 2007). However, we also recorded the skink being sporadically active at night. Overall, this Kapitia skink spent most of the time moving and basking on the ground. Basking often occurred near a refuge, for easy and quick retreat when threatened. Refuges would also be used for rest and hiding from environmental (weather) conditions (Baling 2003).

Arboreal behaviour was not frequently observed, but when it was, the skink preferred climbing up the larger branch compared to the thin-branched tree or enclosure mesh. The skink was also observed jumping during arboreal activity. Such behaviour is similar to that observed in the native striped skink (*O. striatum*), which is known to be an agile climber and often jumped up or out of arboreal structures in an experimental enclosure (Neilson et al. 2004). The frequency of climbing behaviour in the Kapitia skink could be increased by the provision of arboreal refuges, such as crevices in the tree or behind bark (Baling 2003), or food sources. Aotearoa /

New Zealand skinks that show arboreal tendencies are frequently found climbing through complex shrubs (e.g., *Coprosma* spp. and *Muehlenbeckia* spp.), and feeding on their fruit and berries (Whitaker 1987). Coastal species such as moko skinks commonly feed on *Muehlenbeckia* berries (van Winkel et al. 2018).

This was a pilot study and was limited to one captive adult individual. A full captive experiment on habitat use was cancelled because of a long Covid-19 lockdown in Tāmaki Makaurau / Auckland, and the Zoo translocated the majority of adult Kapitia skinks to a protected reserve within their natural range at the end of November 2021. We recommend further studies on behaviour and habitat use to increase potential or ideal food and refuge resources for population-establishment success.

In conclusion, this study confirms that Kapitia skinks can climb and use arboreal structures. Therefore, arboreal structures (trees and shrubs) and resources (e.g., refuges and food) would likely be exploited if provided in captive-management facilities and should be included in habitat restoration at future release sites.

Data Accessibility Statement

Raw data is available at ResearchGate, http://doi.org/10.13140/RG.2.2.20397.97766

Author Contributions

Marcel Kerrigan: Conceptualisation (supporting); formal analysis (supporting); investigation (equal); data curation (lead); validation (equal); writing – original draft preparation (lead); writing – review and editing (lead); visualisation (supporting).
Sarah Brill: Conceptualisation (lead); methodology (lead); investigation (equal); resources (lead); writing – review and editing (supporting).
Marleen Baling: Conceptualisation (equal); validation (equal); formal analysis (lead); visualisation (lead); data curation (supporting); supervision (lead); writing – review and editing (supporting).

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