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Summer Movements of the Common Five-lined Skink (*Plestiodon fasciatus*) In the Northern Portion of its Range

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***Abstract*.—Common Five-lined Skinks (*Plestiodon* [formerly *Eumeces*] *fasciatus*) are difficult to study due to their small size, secretive habits, and semi-fossorial natural history. Habitat selection and dispersal have been studied at several locations across the range of the species, but few details of movements are known. Our objectives were to use radio-telemetry to gain more insight into skink movements and to test the efficacy of small, lightweight transmitters that we externally attached. We fitted 31 skinks with transmitters that provided up to 16 consecutive days of dispersal information. Movements varied greatly among individuals with some staying close to initial capture sites while most moved tens to hundreds of meters over a short period of observation. We located most of the tracked individuals under cover of woody debris but found they were much more mobile than previous mark-recapture studies suggested. Our tracking supported the idea that traditional home ranges were not occupied, but instead most individuals made regular linear movements while returning to the same locations occasionally. Individuals spent on average just over 30% of their time underground, in grass tussocks, and inside standing trees near the end of the active season. This may partly explain why recapture rates are so low in traditional mark-recapture studies. We developed a correction factor that accounts for this observed bias in microhabitat use that may help in future monitoring efforts. Small, lightweight radio transmitters that we externally mounted worked well for studying Five-lined Skink movements and the method may be useful with other similar sized reptiles.**

Key Words.—dispersal; habitat; lizards; radio tracking; skinks; summer activities; telemetry

Introduction

Knowledge of animal movements is fundamentally important to understand spatial ecology and for more effective conservation. Two common methods used to study movements are mark-recapture (Ferner and Plummer 2016) and radio telemetry (Kingsbury and Robinson 2016). Both methods have their advantages and tradeoffs, and the biology and behavior of the species concerned can challenge effectiveness. Telemetry can offer more efficient and less-invasive relocation of individuals than mark-recapture techniques, but it is important to use devices that will not negatively impact behavior and movement patterns (McMahon et al. 2011). Typically, transmitters are surgically implanted in larger lizards, but the method is more invasive than external mounts (Kingsbury and Robinson 2016). Alternatively, transmitter backpacks can be externally mounted on lizards (Warner et al. 2006; Goodman et al. 2009) but becoming snagged on objects in the environment is a potential issue (Kingsbury and Robinson 2016).

Despite having one of the widest distributions of any lizard in North America (Environment Canada 2014; Powell et al. 2016), few details of Common Five-lined Skink (*Plestiodon* [formerly *Eumeces*] *fasciatus*) movements are known. *Plestiodon fasciatus* is a seasonally active, small-bodied, secretive, semi-fossorial species that spends most of its time under cover (Fitch 1954; Fitch and von Achen 1977; Hecnar 1991; Seburn 1993) and they tend to use a succession of cover objects rather than fixed home ranges (Fitch 1954; Seburn 1990, 1993). These characteristics make studies of movements challenging and few mark-recapture studies of the species have been published (Fitch 1954; Seburn 1990, 1993). Traditional marking methods such as toe-clipping (Fitch 1954; Seburn 1990, 1993) may not be as efficacious with *P. fasciatus* relative to other lizard species based on pain response to clipping and subsequent bleeding (pers. obs.). Ethical concerns also exist with some animal care committees being unlikely to approve of invasive methods such as toe clipping or use of radioactive tracers (e.g. Fitch and von Achen 1977). We did not use PIT tags or elastomer tags because we wanted more details on movements than a mark-recapture method provides. Coelomic implantation of PIT tags or radio transmitters also seem impractical considering the slender form and small size of *P. fasciatus*. Size of implants and surgery often preclude their use in small reptiles (Ferner and Plummer 2016; Kingsbury and Robinson 2016). Surgery also involves increased risk of infection and implanted devices can impair movements (Weatherhead and Blouin-Demers 2004; Lentini et al. 2011). Semi-fossorial habits and use of hollows and cracks in cover objects by *P. fasciatus* have also made external mounting of relatively large transmitters impractical in the past (pers. obs.).

Plestiodon fasciatus occurs across much of the eastern United States and enters Canada (MacCulloch 2002; Powell et al. 2016). Habitat descriptions of *P. fasciatus* vary across its large range (Fitch 1954; Hecnar 1991; Seburn 1993; Quirt et al. 2006; Watson and Gough 2012). Southern populations occur in more closed canopy/wooded areas, while northern populations occur in relatively more open habitats (Fitch 1954; Hecnar 1991; Quirt et al. 2006; Watson and Gough 2012; Brazeau 2016). Essential microhabitat for this species is woody or rock debris that provides critical refuge cover and oviposition sites where females guard and brood their eggs (Fitch 1954; Hecnar 1991, 1994; Quirt et al. 2006). Five-lined skinks spend about 90% of their time under cover objects and make short foraging forays into surrounding areas (Fitch 1954; Fitch and von Achen 1977) where they search for arthropod prey (Judd 1962; Hecnar et al. 2002; Brazeau et al. 2015).

Plestiodon fasciatus are not believed to occupy fixed home ranges but instead use a succession of cover objects moving to a maximum of just over 100 m in a year (Fitch 1954; Seburn 1990, 1993). Mark-recapture studies showed that some individuals can move up to 207 m from points of original capture (mean 18 m, n = 323) with time between captures ranging from 1 d to 47 mo (Fitch 1954). Recapture rates in previous studies were low, and details of movements through the landscape between captures remain relatively unknown.

The Carolinian population of *P. fasciatus* in Canada is designated as Endangered (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2007; Environment Canada 2014) because of historical decline resulting from habitat loss, habitat degradation, and isolation from extreme habitat fragmentation. This population has declined from many historic locations to only eight highly isolated sites (COSEWIC 2007; Choquette et al. 2010). Technological advancement in recent decades has reduced transmitter/battery package size and developed better attachment materials (Robinson et al. 2018) providing more options for studying small-bodied secretive species. Our objectives were twofold: first we wanted to test the efficacy of telemetry using small lightweight externally mounted transmitters, and second, we hoped to gain more insight into the details of skink movements.

Materials and Methods

Study site.—Rondeau Provincial Park (RPP; 42°17'N, 81°50'W) near Morpeth, Ontario, Canada, is a 35 km² sandspit extending 7 km long into Lake Erie. Rondeau contains one of the largest continuous tracks of Carolinian Forest remaining in Canada. The park is surrounded by water, areas of intensive agriculture, and urban development making the peninsula a functional island of terrestrial natural habitat. The RPP skink population is likely the second largest of eight extant populations in the Carolinian zone of Canada. The area has a continental climate with cool winters and warm summers and is characterized by highly changeable weather. For details see Brazeau (2016) or Hecnar et al. (2018).

Fieldwork and radio tracking.—We hand captured skinks from a cover board array that was deployed in 2013 (572 untreated spruce boards 121.9 × 28.6 × 3.8 cm). These boards and other types of cover objects (driftwood, logs, plywood, lumber, bricks, metal roofing) were subsequently used by skinks. We measured each individual, weighed them, and photographed them to identify distinguishing characteristics and catalogue the transmitter attachment. Photographs can be useful to identify individual skinks when coupled with detailed descriptions (Josh Feltham, pers. comm.). We used only individuals of sufficient weight (> 8 g) and without signs of ailments or physical injuries. To avoid potential bias associated with localized effects, we attempted to capture individuals from multiple locations throughout the park. We placed and secured selected individuals in clean cotton bags (20 × 20 cm) for transport to a clean working environment (RPP Visitor Centre) where they were fitted with transmitter units. We used ultra-light (0.4 g) VHF transmitters that had an expected battery lifespan of 21 d (BD2N, Holohil Systems Ltd., Carp, Ontario, Canada). Transmitters weighed < 5% the body mass for all individuals used in the study, a standard suggested for telemetry (Kingsbury and Robinson 2016).

We did not attach transmitters on the torso to reduce the risk of transmitters snagging on objects as individuals burrow or move through hollows. We instead chose the side of the base of the tail as the attachment site to reduce profile and risk of autotomy, because fracture planes occur distal to the basal tail vertebrae (Arnold 1984). Two researchers worked to attach transmitters with one securing the individual by the upper abdomen and hind legs to prevent torsion, while the other cleaned the area with an alcohol-soaked cotton swab and taped the transmitter to the side of the tail just below the cloaca to line up with the hind leg. We found that 3M Transpore tape (1.2 cm width; 3M Corporation, St. Paul, Minnesota, USA) was the best available option for taping the transmitter because of its size and adhesion. Initially, we wrapped surgical tape around the tail twice and placed the transmitter between the two layers. We modified this procedure after discovering a superior option that used surgical tape and 3M Tegaderm Film (6 × 7 cm 1624W; Fig. 1). After initial attempts, it became clear that extreme care must be taken when attaching tape and one must use forceps and scissors as well as

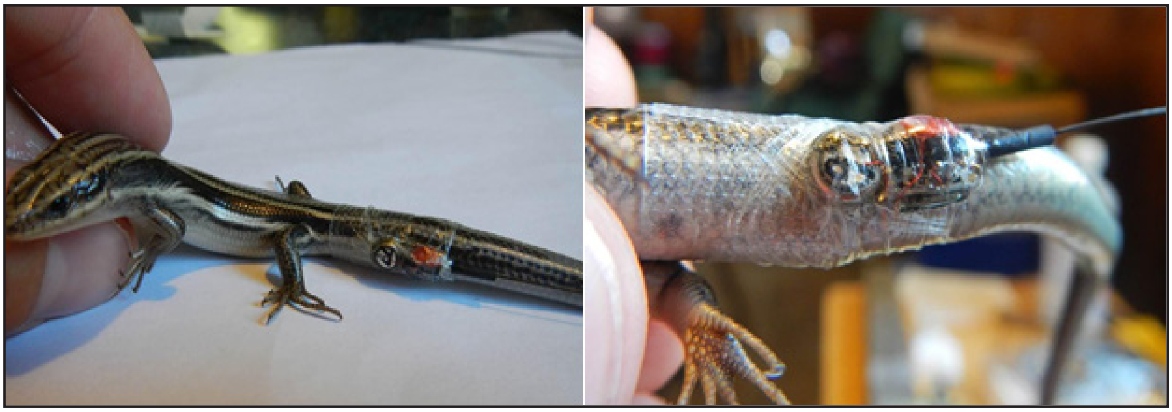

Figure 1. Transmitter attachment position on Common Five-lined Skinks (*Plestiodon fasciatus*). Surgical tape was secured anterior to and beneath the transmitter, which was secured with strip of Tegaderm tape. (Photographed by Daniel Brazeau).

discarding the first inch of tape for each attachment to ensure clean contact and better adhesion. We also clipped antennas to the same length as the tail to prevent possible coiling around vegetation. No individuals autotomized their tails during the transmitter attachment procedure.

We radio tracked adults continuously during post-hatching and pre-hibernation time periods. We fitted 31 individuals (15 male, 16 female) with transmitters and tracked from 5 August to 16 September 2015. Coloration, patterns, morphology, and body size can reliably be used to distinguish between age classes (hatchling, juvenile, adult) and sexes of *P. fasciatus* (Fitch 1954; Hecnar 1991). The red suffusion and larger size of male jaw width allows differentiation between the sexes (Fitch 1954; Hecnar 1991). Most individuals were captured and tracked in the southern half of the dune habitat of the park (Fig. 2).

Analyses.—To assess the relative movements of individuals, we focused on linear travel distances noting total distance moved among all tracking locations, average daily movements, maximum distance between consecutive fixes, maximum displacement (largest linear distance between any points), and we calculated area covered by minimum convex polygon (MCP). We generated maps and calculated minimum convex polygons (MCP) using Quantum GIS software (QGIS Development Team. 2018. Quantum GIS Geographic Information System. Open Source Geospatial Foundation Project. Version 2.18.14. Available at http://qgis.osgeo.org [Accessed 1 November 2018]) with data from the Southwestern Orthophotography Project (SWOOP, Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario, Canada). Because individuals were tracked over varying lengths of time, we also calculated averages for MCP so that they could effectively be compared. We divided tracking fixes into woody debris (boards, logs) and other cover types (grass tussocks, leaf litter, brush, and underground). We pooled numbers of other cover types together for a two-group comparison and used a Chi-square test with Yate's correction applied to determine if skinks occurred more often under woody debris than other cover types. Next, we used a 2 × 2 Contingency Table to determine if the sexes used cover types differently (males, females × woody, other). Because activity levels differ between sexes throughout the active season (Fitch 1954; Hecnar 1991; Seburn 1993), we compared maximum distance between tracking fixes and average daily distance

Figure 2. First location of capture (red dots) in Rondeau Provincial Park near Morpeth, Ontario, Canada, for all Common Five-lined Skinks (*Plestiodon fasciatus*) tracked in 2015. (Photographed by Daniel Brazeau).

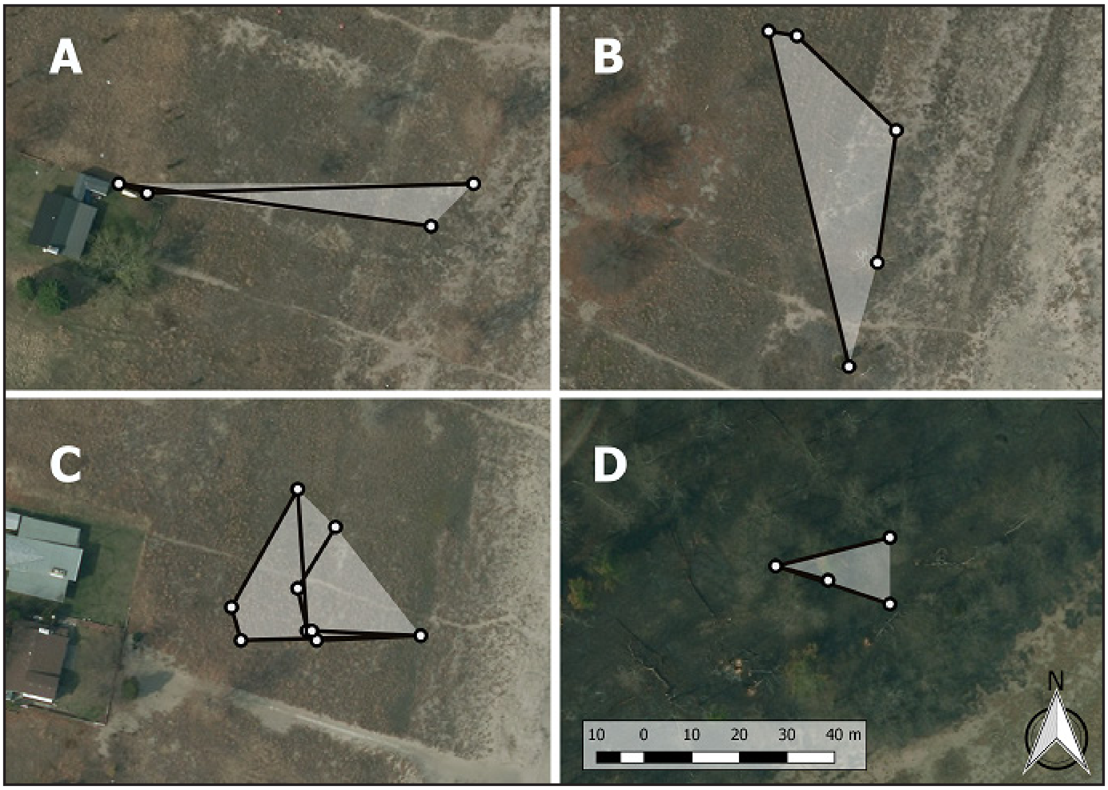

Figure 3. A) Movements of female Common Five-lined Skink (*Plestiodon fasciatus*) ID-20, which spent most of her time within a brick wall at a cottage and moving back and forth to a cover board; (B) male ID-01 had the maximum daily movement but dislodged his transmitter in the bark of a tree stump after only 6 d of tracking; (C) female ID-30, which traveled a total distance of 176 m over 16 d; and (D) male ID-28, which spent most of his time living inside a tree during 16 d of tracking. Daily fixes (white dots), minimum convex polygon (gray shaded areas), and distance traveled daily (black lines) are all displayed. Scale indicator and compass rose in bottom right applies to all panels. (Satellite images from Southwestern Orthophotography Project [SWOOP], Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario, Canada).

between males and females using a Mann Whitney *U* test. We report descriptive statistics as means with standard errors (SE), used $\alpha = 0.05$ for significance, and conducted statistical analyses using SYSTAT 13 (Systat Software, Inc. San Jose, California, USA).

Results

Tracking periods of individuals ranged from 1–16 d with 24 individuals tracked for more than 3 d. The longest total distance observed was a female who moved 176 m over 16 d (ID- 30; Fig. 3c). The largest average daily movements were of a male (ID-1) who moved an average of 22.7 m/d over 6 d (Fig. 3b). The same male had a maximum displacement of 73 m (between two fixes). The longest maximum displacement was 75 m, by a female (ID-20) who was tracked for 13 d (Fig. 3a). An MCP could be calculated for 10 of the 31 individuals tracked. The largest MCP was a female (ID-30) with a total area of 704 m^2 and average MCP of 44 m^2 over 16 d.

Maximum distance moved did not differ between males (mean = 21.2 ± 20.23 [SE] m) and females (mean = 16.2 ± 20.31 m; $U = 99.0$, n =15,16; $P = 0.396$). Similarly, average distances moved by males (6.9 ± 7.19 m) and females (4.4 ± 5.44 m) were not significantly different ($U = 99.5$, n = 15,16; $P = 0.497$). Individuals used a variety of cover types and were often found using grass tussocks or brush. We observed several individuals using tussocks several meters from the nearest debris or cover object for many days at a time. Individuals also used woody debris (mean = 4.7 ± 3.46 d) significantly more often than other types of cover (mean = 2.2 ± 3.30 d; $X^2 = 27.4$, df = 1, $P < 0.001$) and the proportionate use of cover type did not differ between sexes ($X^2 = 0.038$, df = 1, $P = 0.846$; Fig. 4).

Transmitter effectiveness and autotomy.—Using the base of the tail as point of attachment was effective, with individuals retaining transmitters for up to 16 d (mean = 7.2 ± 0.95 d). We retrieved most of the transmitters by the end of the study: eight were autotomized, eight shed, six batteries died, three skinks died (predation), two transmitters snagged on objects, two were removed, and the fate of two was unknown (Table 1). Eight individuals (five females and three males) autotomized

Table 1. Summary of radio tracking data of Common Five-lined Skinks (*Plestiodon fasciatus*) at Rondeau Provincial Park near Morpeth, Ontario, Canada. Total distance traveled between all tracking locations, average daily movements (Average), longest movement between two consecutive tracking fixes (Max), maximum displacement and minimum convex polygon (MCP) as well as minimum convex polygon averaged over total days tracked (MCP Average) are included below. The abbreviation SVL = snout-vent length.

ID	Sex	SVL (cm)	Total (cm)	Weight (g)	Total Distance	Total Days Attached	Max (m)	Average daily (m)	Max displacement (m)	MCP (m^2)	MCP Average (m^2)	Transmitter Retrieval
1	Male	7.6	17.2	11.3	136	6	73.0	22.7	73.0	334	55.66	Snagged
2	Female	7.3	19	9	49	15	33.1	3.3	41.4	175	11.67	Battery Dead
3	Female	7	16.2	8.9	18	7	17.7	2.6	17.7	NA	NA	Dead Skink
4	Male	7.4	15.2	12.1	37	6	36.6	6.2	36.6	NA	NA	Shed
5	Male	7.5	17.7	12.7	77	10	39.0	7.7	40.0	84	8.40	Tail drop
6	Female	6.8	18.1	9.2	0	1	0.0	0.0	0.0	NA	NA	Tail drop
7	Male	7.2	17	11.3	37	9	36.9	4.1	36.9	NA	NA	Shed.
8	Female	7.1	15.6	9.8	0	5	0.0	0.0	0.0	NA	NA	Shed
9	Female	6.5	16	9.2	35	5	35.4	7.0	35.4	NA	NA	Unknown
10	Male	7.1	16.7	11.5	6	5	6.4	1.2	6.4	NA	NA	Shed
11	Male	8.2	17	14.2	37	16	17.0	2.3	20.6	52.5	3.28	Battery Dead
12	Male	8.7	17.5	14.9	0	3	0.0	0.0	0.0	NA	NA	Shed
13	Male	8	16.9	14.7	67	14	23.3	4.8	38.9	226	16.14	Battery Dead
14	Female	6.9	14.3	9.5	0	1	0	0.0	0	NA	NA	Tail drop
15	Female	7.3	18.8	9.4	0	7	0.0	0.0	0.0	NA	NA	Shed
16	Female	7.1	17.8	9.8	42	6	26.0	7.0	29.5	247	41.17	Removed
17	Female	7.3	16.3	11	59	8	24.2	7.4	24.2	111	13.88	Dead Skink
18	Female	7	17.1	9.5	0	4	0.0	0.0	0.0	NA	0.00	Dead Skink
19	Male	7.9	15.8	12.7	47	6	19.2	7.8	19.2	82	13.67	Shed
20	Female	7.6	15.4	11.7	142	13	69.0	10.9	75.0	376.5	28.96	Battery Dead
21	Female	7	16.3	9.3	0	2	0.0	0.0	0.0	NA	NA	Tail drop
22	Male	7.6	17.2	14.5	0	1	0.0	0.0	0	NA	NA	Snagged
23	Male	7.2	17.7	10.9	16	3	11.0	5.3	12.1	NA	NA	Shed
24	Male	6.5	17.1	8.5	0	1	0.0	0.0	0.0	NA	NA	Tail drop
25	Male	7.5	15.5	13.5	30	16	30.4	1.9	30.4	NA	NA	Battery Dead
26	Female	7.3	15.5	11	7	15	7.3	0.5	7.3	NA	NA	Unknown
27	Female	7	16.5	9.3	0	1	0.0	0.0	0.0	NA	NA	Tail drop
28	Male	7.8	14.2	11.4	122	16	25.3	7.6	25.3	168	10.50	Battery Dead
29	Female	7	17.3	8.6	9	4	8.6	2.3	8.6	NA	NA	Tail Drop
30	Female	7.3	17.1	8.8	176	16	38.0	11.0	40.5	704	44.00	Removed
31	Male	7.2	17.5	11.4	0	2	0.0	0.0	0.0	NA	NA	Tail drop

their tails during telemetry with many potential causes. One event was directly attributed to the transmitter antenna wrapping around grasses, while another was possibly caused by tape snagging on grass. Another was attributed to a predation event. We also found a tail adjacent to a transmitter that appeared to have been shed. The autotomy that occurred may be related to the size of individuals, as only two losses occurred for individuals with snout vent length (SVL) > 7 cm. All individuals tracked were > 8.5 g, with one of the longest transmitter retentions by a female (ID-30) with a relatively low weight of 8.8 g and a SVL of 7.3 cm (Table 1).

Discussion

Overall, our study was successful, and it provided insights into the efficacy of radio tracking *P. fasciatus* movements. Using the tail as point of attachment proved to be a valid option for the species with individuals retaining transmitters for up to 16 d. Individuals moved longer distances than we expected based on results from previous mark-recapture studies (Fitch 1954; Seburn 1990, 1993). Despite being a first telemetry study for this species, it also provided insights on *P. fasciatus* behavior.

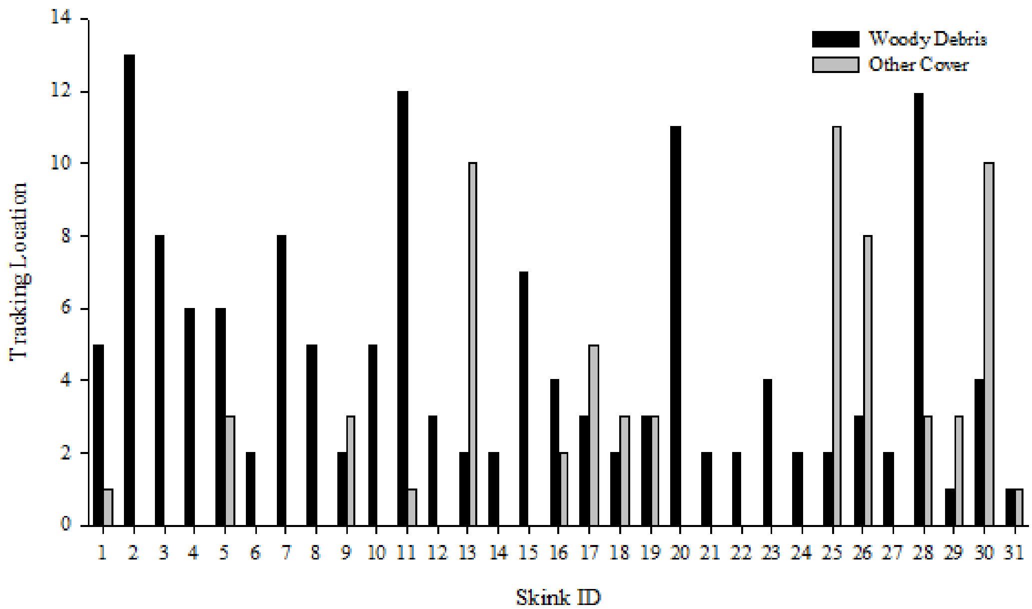

Figure 4. Comparison of microhabitat (woody debris vs. other-cover types) by total number of tracking locations for each individual Common Five-lined Skink (*Plestiodon fasciatus*).

The observed similarity in dispersal distances that we found among sex and age classes concurs with mark recapture studies in Kansas (Fitch 1954) and genetic research in the Great Lakes/St. Lawrence Region population east of our study population (Wick 2004). Although radio-tracked skinks spent significantly more time inside or under woody debris objects, our findings suggest that the probability of individuals being found outside of typical cover locations is considerably higher than expected based on previous studies (Fitch 1954; Hecnar and M'Closkey 1998). Of the other locations, skinks were most often tracked to grass tussocks for several consecutive days and often many meters from the nearest woody cover. These individuals moved within and between dense Bluejoint (*Calamagrostis canadensis*) grass tussocks (Fig. 5), indicating that tussocks can provide adequate cover for daily activities. In many cases, individuals alternated between cover boards and grass tussocks for days at a time. The availability and structure of grass tussocks and other vegetation may be more important as microhabitat providing suitable microclimate, food availability, and protection from predators than previously thought similar to the Northern Prairie Skink (*Plestiodon septentrionalis*; Danielsen et al. 2014).

The pattern of skinks remaining unseen after initial capture under cover objects provides some insight as to what proportion of time individuals actually spend underground or inside trees. This may increase the chance of false negatives during visual cover surveys. Considering that the average probability of subsequent visual detection of a tracked individual under a cover object was 0.696, survey abundance should be corrected by a factor of 1.304 for this time of the activity season. Assuming also that sex ratio in this species is 1:1 (Fitch 1954; Seburn 1990, 1993), and that male surface activity decreases after the mating season (Hecnar 1991; Brazeau 2016), a correction for female biased survey results may be in order: Estimated Total = (Total Observed + Undetected Males) × 1.304 (Hecnar et al. 2018). For example, our total 2015 observed skink abundance was 255 consisting of 77 females, 52 males, five unknown adults, 104 juveniles, 14 hatchlings, and three of unknown age (Stephen Hecnar and Daniel Brazeau, unpubl. report). The first correction would be to add 25 males (i.e., 77–52 = 25); second, add 2.98 females for the adults observed where sex could not be determined, where 77/(77+52) × 5 = 2.98. Next, correct the unknown adults to achieve a 1:1 ratio. There would be approximately three females and two males. The correction would be to add one male (i.e., 3–2). The sex corrected total would be 281 (255 + 25 + 1). Finally, the activity correction would be 366 (281 × 1.304). Thus, the estimated number of skinks actually present is 366

Figure 5. A grass tussock characteristic of those where Common Five-lined Skinks (*Plestiodon fasciatus*) commonly occurred during radio tracking. (Photographed by Daniel Brazeau).

instead of the 255 observed. This is only an approximate estimate that could be improved with further detailed time budgets determined by more extensive radio tracking. This correction factor could also be further tested by a removal experiment where an area is pre-surveyed, fenced, and then counting and removing all skinks until depletion. These results also highlight the importance of multiple site visits to locations suspected of harboring extant skink populations and development of better methods for marking individuals.

Perhaps the most remarkable observation from our telemetry study was of male ID-28, which was found in a Black Oak (*Quercus velutina*) 25 m away from the cover board where he was found the previous day. Over each of the next 5 d, this male was detected inside this partially hollowed tree at heights of > 10 m. In the next week this male travelled back to the board where he was first found, then returned to the same oak tree, and finally back down the tree to a large decayed and hollowed log where the transmitter battery died. Although some climbing activity and nesting inside trees has been noted for *P. fasciatus* (Allard 1909; Force 1930; Kennedy 1956; Cooper et al. 1983) we were not expecting a male to spend as much time inside a living tree at a considerable height.

Several individuals used man-made structures including brick walls, concrete slabs, and discarded building materials at cottages. A female spent several days inside a brick wall moving several meters through hollows each day. She then exited and moved to the dunes but ultimately returned to reenter the brick wall. It was clear that the complex nature of these structures is attractive to some skinks, a fact emphasized by our inability to see the animals while they were using such structures. Skinks have also occasionally over-wintered in park buildings (Hecnar et al. 2012) or used residential and farm buildings for shelter in the region (unpubl. data). Some individuals were also tracked directly adjacent to a road but were never tracked crossing, suggesting avoidance. Previous road mortality surveys at RPP and Point Pelee National Park in the same region suggested that *P. fasciatus* was less susceptible to road traffic mortality than snakes or other vertebrates (Farmer 2007; Farmer and Brooks 2012). A previous habitat study at RPP also found that *P. fasciatus* use of cover objects was negatively correlated with proximity to roads (Brazeau 2016).

Body weight was not the only reliable measure for selecting which skinks would be used in the radio-telemetry study. We also suggest that individuals selected for telemetry should have a SVL > 7 cm to reduce tail autotomy. The rate of tail loss may not be exceptionally high considering it has reached 19% per year in another population nearby our study site (Myschowoda 2015).

There were some unforeseen difficulties and limitations of the taping method of transmitter attachment. Some individuals tracked for longer periods had scale damage apparently caused by abrasion from sand. After extended periods of time the surgical tape accumulated sand that can abrade the scales anterior to the tape. Throughout the study we worked to reduce the attachment materials necessary and this appeared to reduce the effect.

Despite the expected battery lifespan of 21 d, batteries of six individual transmitters died after 13–16 d of tracking (mean = 15 ± 0.5 d). The shorter than expected battery life may have resulted because of extreme environmental conditions. Although summer air temperature under cover boards and other woody debris remains between 21.6–33.4° C, ambient temperature on the dunes can exceed 50° C (Hecnar 1991; Brazeau 2016). Although telemetry is now a viable option for future study of this or other similar species, it could be improved with refinement of attachment methods to ultimately eliminate collection of sand around the tape and extending battery life.

External attachment is a low-cost, low-risk method, which significantly reduces complications often associated with internally/surgically installed transmitters (i.e., infection, long handling, and recovery times). External attachment of telemetry devices using tape has been successfully used with several other lizard species (Germano 2007; Goodman et al. 2009; Jarvis et al. 2014) and snakes (Wylie et al. 2011; Robinson et al. 2018). More importantly this attachment method has been successfully used on the closely related *Plestiodon septentrionalis* that is of comparable size and similar life history to *P. fasciatus* (Pamela Rutherford et al., unpubl. data). Radio tracking may elucidate many unknowns of the behavior and habitat use for *P. fasciatus* and other small secretive species.

Conclusions.—We were able to quickly develop effective external transmitter attachment methods using clear surgical tape and Tegaderm adhesive. Miniature transmitters worked well for signal distance and detecting skinks underground in sand dunes (to 1 m depth) or deep inside prone logs, inside anthropogenic structures, and high in trees. Our results indicate that radio telemetry with external attachment is now a feasible method for studying skink movements and likely those of other small-bodied squamates. The primary drawback of using transmitters was with potential shedding and scale damage in abrasive soils; however, we reduced this with our experience. Further telemetry work on this species is needed (other seasons mating, nesting; other populations).

Our pilot study of movement behavior was limited to just one season and location, but its results were quite revealing. While the degree of movements differed among individuals with some remaining close to their capture sites, most individuals moved surprising distances of tens to hundreds of meters over short time periods. Our results indicate that this species is probably more mobile than previous traditional mark-capture studies have suggested (Fitch and von Achen 1977; Seburn 1993). Our tracking also supports previous studies suggesting that individuals of this skink species do not occupy a fixed home range but have a more linear shifting range (Fitch 1954; Seburn 1993); however, some individuals did return to the same spots or cover objects of original capture.

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