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# Microhabitat use by sympatric introduced Italian Wall Lizard, *Podarcis siculus* (Rafinesque-Schmaltz, 1810), and native Five-lined Skink, *Plestiodon fasciatus* (Linnaeus, 1758)

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Non-native lizard species have been introduced across the globe. Their spread is often the result of human interference, either by deliberate release or accidental escape from the pet trade (Michaelides, 2015). Introduced species can cause decreased diversity if they successfully outcompete native species (Catania, 2019). There are multiple cases where the introduction and expansion of a non-native lizard species is associated with the decline of a native lizard species (Nicholson, 2015; Byers, 2002). For example, in Florida, USA, the native *Anolis carolinensis* Voigt, 1832 has narrowed its habitat use and become more arboreal due to its avoidance of the invasive *A. sagrei* Duméril & Bibron, 1837, which is more likely to display and less likely to retreat (Culbertson and Herrmann, 2019). Environmental change from human activity can aid in a non-native species' invasion, and native species can be at a disadvantage due to a mismatch between modified habitat and their phenotype (Catania, 2019; Byers, 2002).

The Italian Wall Lizard, *Podarcis siculus* (Fig. 1B), is native to the Italian peninsula, and is especially adept at succeeding in urban environments, even those that differ significantly from its native habitat (Burke, 2002; Catania, 2019; Byers, 2002; Putman, 2020). It can opportunistically change its diet to fit available food sources, feeding mainly on a variety of arthropods but also consuming molluscs or plant matter when necessary (Zuffi and Giannelli, 2013). Their bold and exploratory behaviour in new environments (Damas et al., 2019), along with their high behavioural plasticity, might explain the propensity of Italian Wall Lizards to be invasive (Damas et al., 2019). Given the prevalence of non-native Italian Wall Lizards and the potential negative effects introduced species can have on native species, understanding how this lizard is able to adapt to a variety of habitats is key to understanding its flexibility.

The Italian Wall Lizard was introduced to Topeka, Kansas, USA in the late 1950s via the pet trade (Oliverio, 2001). Since then, the species has been introduced approximately 43 km away into Lawrence, Kansas where it has been seen in downtown areas, suburban neighbourhoods, parks, and campgrounds. In natural settings, the Italian Wall Lizard occupies the same habitat type as the native Five-lined Skink, *Plestiodon fasciatus* (Fig. 1A). Five-lined Skinks are native to the eastern and central United States, living mainly in naturally forested areas as well as on lightly developed land that includes features such as fences, rock piles, and sheds (Fitch, 1954). The Five-lined Skink feeds on a variety of arthropods, especially spiders and crickets, and some snails (Fitch, 1954). In Lawrence the habitats of the two species overlap, and we have observed them simultaneously perched on the same log or sheltering under the same rock. The degree to which the two species occupy the same microhabitat will provide insight into their potential as competitors, as well as the extent to which the introduced Italian Wall Lizard is a threat to the abundance and persistence of the native Five-lined Skink.

## Materials and Methods

We evaluated habitat use for Italian Wall Lizards and Five-lined Skinks at the Lawrence Hidden Valley Camp, Lawrence, Kansas, USA, a privately-owned preserved natural area occupying ca. 16 ha of forest, prairies, streams, and several human structures embedded within the city (3420 Bob Billings Parkway; 38.9585°N, 95.2823°W; datum = WGS84). We surveyed the study site for lizards on seven non-consecutive days from 2–14 May 2021 when lizards were active (11:45–15:45 h) and the weather was warm with relatively clear skies. We collected data by surveying for surface-active lizards and recording habitat data. For surveys, one to three researchers slowly walked trails in the camp, searching for lizards on different parts of the trail system on each

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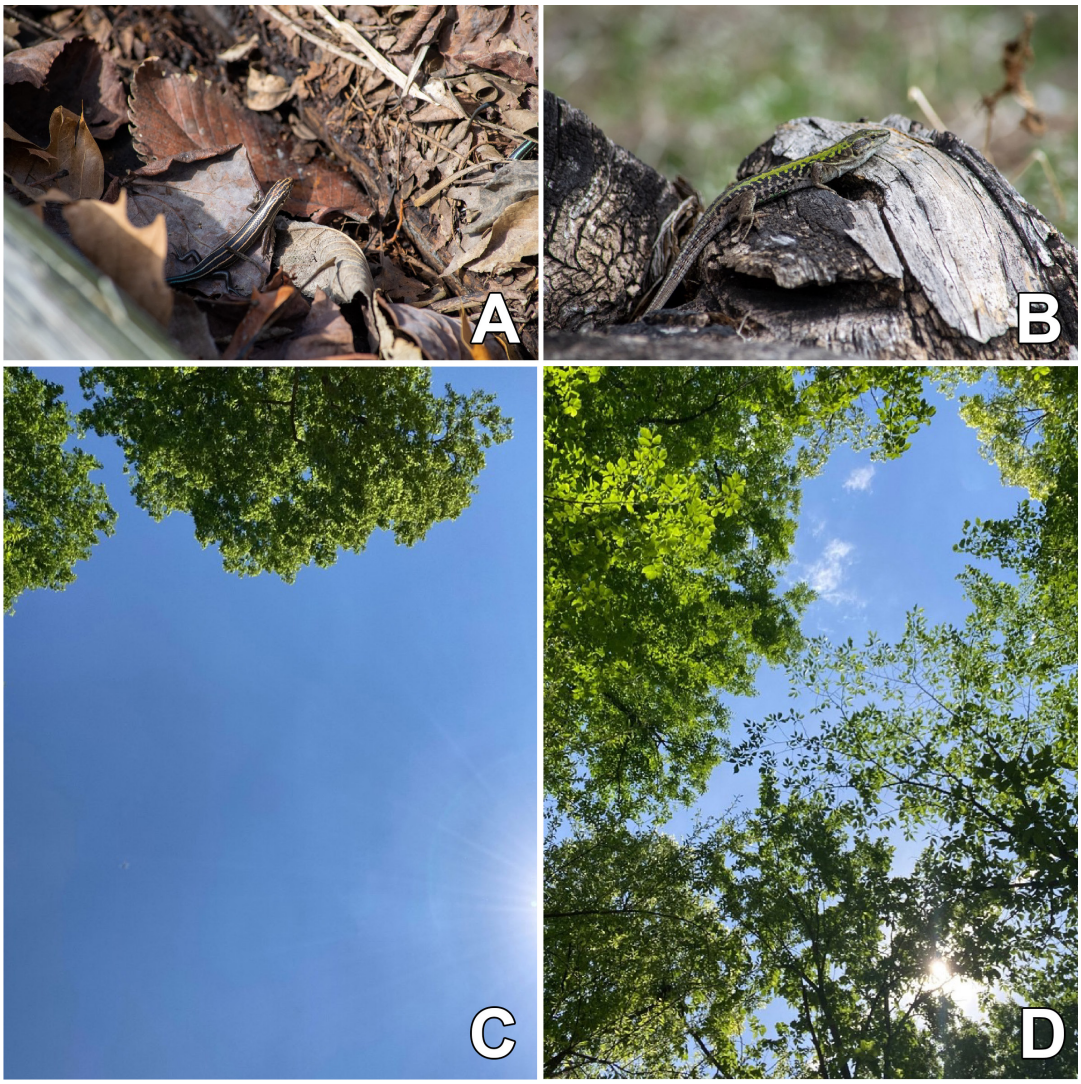


**Figure 1.** Images of a juvenile Five-lined Skink, *Plestiodon fasciatus* (A), an Italian Wall Lizard, *Podarcis siculus* (B), 19% canopy cover (C), and 63% canopy cover (D), all photographed in Lawrence, Kansas, USA..

day of the study. The researchers surveyed the entire camp and each area only once, minimizing the chance of sampling the same lizard twice, and ensuring all habit types were adequately sampled.

When an animal was sighted, we marked its initial location and, if it moved, where the animal took refuge. At the initial sighting location for each animal, we measured perch height, substrate temperature (infrared thermometer guns: Fluke 62 Max), and canopy cover (Fig. 1C, D), as well as distance to refuge for those that moved. For animals that were on the ground, we considered perch height as 0 cm. When an animal took refuge below its starting location, or if it was sighted partially in a refuge, we considered the distance to the refuge as 0 cm. To obtain the percent canopy cover value for each animal, we photographed the area directly above an animal's location, positioning the camera at the location and height where the animal was initially sighted. We analysed the canopy cover using the program Foliage (https://andres-patrignani.github.io/foliage). We conducted statistical analyses using Minitab 19 (State College, Pennsylvania, USA). We explored species differences in habitat metrics using mixed-effects models, with species as a fixed effect and sampling day as a random effect. Distance to refuge was log-transformed prior to analysis.

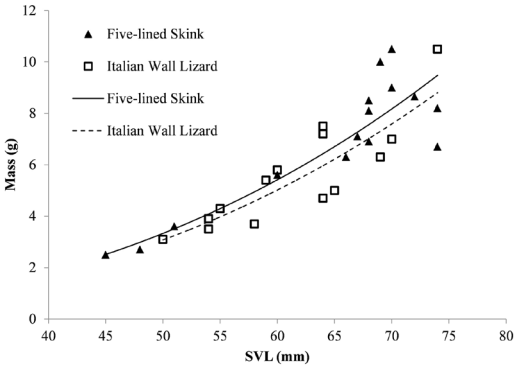


**Figure 2.** Body size relationships for Five-lined Skinks (*Plestiodon fasciatus*) and Italian Wall Lizards (*Podarcis siculus*) in Lawrence, Kansas, USA. Lines represent fitted power functions for snout–vent length (SVL) vs. mass.

**Table 1.** Habitat variable values for initial sighting locations, presented as mean ± standard deviation. Distance to refuge was log-transformed for analysis, but raw values are presented here.

| Habitat Variable | *Plestiodon fasciatus* (*n* = 43) | *Podarcis siculus* (*n* = 37) |
|---|---|---|
| Substrate temperature (°C) | 31.5 ± 7.5 | 34.1 ± 7.8 |
| Perch height (cm) | 7.8 ± 9.9 | 10.3 ± 11.3 |
| Canopy cover (%) | 31.7 ± 23.3 | 11.9 ± 12.8 |
| Distance to refuge (cm) | 16.8 ± 37.9 | 51.3 ± 104.8 |

Separate from the habitat measures, we captured lizards from both species and took morphometric information. We measured snout–vent length (SVL), total length, and tail length using a ruler, and body mass using a spring scale. We compared body size for the two species using a general linear model with SVL, species, and their interaction as predictors of mass. Body size data was log-transformed for analyses.

## Results

We assessed habitat use for 80 animals, 43 Five-lined Skinks and 37 Italian Wall Lizards. Body size did not differ between species (SVL: $t = 1.07$, $df = 25$, $p = 0.29$; Mass: $t = 1.67$, $df = 26$, $p = 0.19$), nor did the scaling relationship between SVL and mass ($F_{1,25} = 0.00$, $p = 0.978$; Fig. 2). We found Italian Wall Lizards on warmer surfaces ($F_{1,74} = 5.42$, $p = 0.023$; Table 1) with less canopy cover ($F_{1,74} = 18.08$, $p < 0.001$; Table 1) than locations occupied by Five-lined Skinks. Canopy cover and surface temperature were not correlated ($r = 0.03$, $p = 0.79$). Distance to refuge did not differ between species ($F_{1,63} = 2.56$, $p = 0.115$; Table 1), with the median distance for both species = 0 cm, meaning most lizards fled by going under the perch on which they were sighted. There was no difference between the species in perch height ($F_{1,77} = 1.15$, $p = 0.287$; Table 1).

## Discussion

We found the two species coexisting in the natural area of our study site, but with some separation in their microhabitat use. In the field, we frequently found Italian Wall Lizards within 1 m of Five-lined Skinks, co-occurring but not apparently interacting. In one instance, individuals walked within 5 cm of each other with no apparent interaction. However, Italian Wall Lizards favoured warmer surfaces that were more open (i.e., less canopy cover) compared to Five-lined Skinks. While both species are basking heliotherms, Italian Wall Lizards might have higher thermal preferences and a greater need to actively thermoregulate (Fitch, 1954; Grbac et al., 2004). Species differences in canopy cover could be related to differences in risks from aerial predators. Conversely, perch heights and distance to refuge did not differ between the two species, suggesting that the two species were not responding differently to aerial predation risk (Vervust et al., 2007). These results differ from those reported by Putman et al (2020), who found that Italian Wall Lizards in California, USA, had much shorter distances to refuge than the native Western Fence Lizard.

Given their similar body size, similar diet (both feed on small invertebrates; Collins et al., 2010), and general overlap in habitat use, the two species are potential competitors. More research is necessary to delineate differences that could promote coexistence. Our results leave open the question of whether the observed patterns of habitat use reflect natural differences between the species, restrictive adjustments by one species in response to the other, or perhaps attraction between species that could arise if proximity to an individual of another species was advantageous in a way that proximity to a conspecific would not. Future research is needed to understand how the two species influence each other.

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