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Flight initiation distance of *Urosaurus ornatus* from the Sierra de Samalayuca, Mexico

Julio A. Lemos-Espinal[1,*], Geoffrey R. Smith[2]

[1] *Laboratorio de Ecología-UBIPRO, FES Iztacala UNAM, Avenida los Barrios 1, Los Reyes Iztacala, Tlalnepantla,edo. de México, 54090, México*
[2] *Department of Biology, Denison University, Granville, Ohio 43023 USA*
* *Corresponding author*. E-mail: lemos@unam.mx

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Abstract. In lizards, flight initiation distance (FID), the distance between a prey individual and a predator when escape begins, can be affected by numerous intrinsic and extrinsic factors, including sex, temperature, and level of conspicuousness. Here we report on a study of FID in a population of Ornate Tree Lizards, *Urosaurus ornatus*, from the Sierra de Samalyuca, Chihuahua, Mexico which are cryptic due to their dorsal coloration blending into their background. *Urosaurus ornatus* in our study population allowed close approaches (mean FID = 65 cm). Mean FID did not differ between males and females. We also found no effect of body, air, or substrate temperature on FID. The short FID we observed may be related to the cryptic nature of *U. ornatus*.

Keywords. Approach distance, anti-predator response, cryptic, lizard, sex, temperature.

For many prey individuals one of the most important decisions that must be made when confronted with an approaching predator is when to begin their antipredator response, which for many prey is flight (Ydenberg and Dill, 1986). Theoretically, this decision should reflect a balance between fleeing too early and losing fitness due to lost opportunities (e.g., foraging, thermoregulation, mating) and fleeing too late and being caught by the predator (Ydenberg and Dill, 1986; Cooper and Frederick, 2007). The distance from the predator to the prey when the prey begins to flee is the flight initiation distance (FID) and is a readily measured aspect of a prey's behavior (Ydenberg and Dill, 1986; Cooper and Frederick, 2007).

For lizards, FID can be affected by numerous intrinsic and extrinsic factors, including body and environmental temperature (e.g., Smith and Lemos-Espinal, 2005; Cooper et al., 2009; Braun et al., 2010; Cooper, 2011a); perch, habitat, or microhabitat characteristics (Cooper, 2003b; Cooper et al., 2009; Morris and Lattanzio, 2020), and sex (Vanhooydonck et al., 2007; Majláth and Majláthova, 2009; Salido and Vicente, 2019). However, these factors do not always affect FID in lizards (e.g., temperature: Martin and López, 2000; Amo et al., 2005; Smith and Lemos-Espinal, 2005; Cooper, 2006; sex: Cooper, 2003a, 2011b; Cooper and Pérez-Mellado, 2011; Kopena et al., 2015). For example, because lizards are ectotherms, temperature, whether body or environmental, can influence their locomotor performance, including sprint speed (van Damme and Vanhooydonck, 2001; Herrel et al., 2007). Thus, when temperature does affect lizard FID, the FID typically decreases with body or environmental temperature since lizards at higher temperatures can usually run faster and therefore can allow a predator to approach closer and still escape compared to lizards at lower temperatures (e.g., Cooper, 2006, 2011b; Cooper et al., 2009; Braun et al., 2010).

Another aspect of a lizard that could affect its FID is the level of crypsis. In general, organisms with effective

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crypsis should remain still and allow close approaches (Cooper et al., 2008). Compared to other aspects of lizards that might affect FID, the effects of conspicuousness are relatively understudied. However, previous work related to the conspicuousness of lizards and FID has generally found that more cryptic or more concealed lizards allow closer approaches than less cryptic or less concealed lizards (Cooper, 2006; Vanhooydonck et al., 2007; Cooper et al., 2009; Cooper and Sherbrooke, 2010).

Here we report on a field study of FID in a population of Ornate Tree Lizards, *Urosaurus ornatus*, from the Sierra de Samalyuca, Chihuahua, Mexico. *Urosaurus ornatus* are distributed from Utah and Colorado to northern Mexico (Wiens, 1993; Haenel, 2007) and their populations often primarily use trees as perches (Baltosser and Best, 1990; Smith, 1996b; James et al., 2003) but some populations are more terrestrial, using rocks as perches (Herrel et al., 2001; Haenel, 2018; Taylor et al., 2018), including the population we studied (see also Gadsden et al., 2021). *Urosaurus ornatus* tend to be relatively small lizards (mean SVL = 50 cm; Smith, 1996b) that are sit-and-wait foragers (Cooper et al., 2001). We examined whether body temperature and sex affect flight initiation distance. In addition, *U. ornatus* can adjust their dorsal coloration and reflectance to match their background (Zucker, 1989; Hamilton et al., 2008), making them cryptic. Given their ability to blend into their background (see Fig. 1), we expected that *U. ornatus* would allow closer approaches compared to other species (i.e., have a relatively short FID). We also predicted that temperatures, both body and environmental, would have little effect on FID since they may rely more on being still and remaining cryptic rather than relying on locomotor performance which can be affected by temperature (e.g., Gilbert and Miles, 2016, 2017).

We studied the FID of *U. ornatus* on 10 and 11 November 1998 in a population at the Ojo de Enmedio, Sierra de Samalyuca, Chihuahua, Mexico ((31°22'48.2"N, 106°35´2.7"W, 1344 m elevation). Ojo de Enmedio is a small ranch located approximately 10 km northwest of the town of Samalayuca (municipality of Juárez, Chihuahua), in the foothills of the extreme northwest of the Sierra de Samalayuca. The vegetation is typical xerophyte scrub of the Chihuahuan Desert.

When we spotted a stationary and undisturbed lizard, one of us (JLE) slowly and directly approached it at a constant speed. The same person always made the approach to promote a more consistent appearance and approach among lizards. We measured FID as the distance between the location where the approaching "predator" was when the lizard first fled and where the lizard was first observed (to nearest cm using a meter tape).

Fig. 1. Photograph of a *Urosaurus ornatus* on a rock substrate demonstrating its cryptic dorsal coloration. Photograph was taken from a population at San José de las Piedras, municipality of Ocampo, Coahuila but the *U. ornatus* from our study site are very similar. Photograph by J.A. Lemos-Espinal.

Since we walked through the study area and did not return to a specific site it is highly unlikely we repeated measuring FID on any individual. We captured all lizards and recorded their sex. We also measured body temperature (T_b), air temperature (T_a: 1 cm above surface at location lizard first observed), and substrate temperature (T_s: on surface at location lizard first observed) to the nearest 0.1 C using a quick-reading cloacal thermometer. All lizards were captured within 1 minute of determining FID. All lizards were in full sun when first observed.

We compared FID between males and females using an analysis of variance on log-transformed FIDs. We used linear regressions to analyze the relationships between FID and T_b, T_a, and T_s. We used JMP Pro 14 (SAS Institute, Cary, North Carolina, USA) to conduct all statistical analyses and used an a-value of 0.05 to determine statistical significance. Means are given ± 1 S.E.

Overall mean FID was 64.7 ± 6.7 cm (n = 50). Mean FID did not differ between males (68.9 ± 8.4 cm; n = 32) and females (57.4 ± 11.2 cm; n = 18; $F_{1,48} = 0.18$, P = 0.67). Flight initiation distance was not affected by T_b (n = 50, $r^2 = 0.057$, P = 0.10), T_a (n = 50, $r^2 = 0.02$, P = 0.34), or T_s (n = 50, $r^2 = 0.03$, P = 0.22).

Urosaurus ornatus in our study population allowed close approaches by the human simulated predator (i.e., mean FID = 65 cm). Indeed, in Samalayuca, it is possible to capture *U. ornatus* directly with one's hands rather than needing to use a lasso (J.A. Lemos-Espinal, pers. observ.). *Urosaurus ornatus* in Arizona also allow similarly close approaches, with a mean FID in males of 90 cm and 64 cm in females (Morris and Lattanzio, 2020). The

short FID we observed, and as has been observed in other *U. ornatus*, may be related to the cryptic nature of *U. ornatus* (Zucker, 1989; Hamilton et al., 2008). The mean FID of *Urosaurus bicarinatus*, a congener but not sister species of *U. ornatus* that occurs further south in Mexico (Wiens, 1993; Reeder and Wiens, 1996) and uses acacia trees as perches (Lemos-Espinal et al., 1997), in the Cañón del Zopilote in Guerrero was 200 cm (Smith and Lemos-Espinal, 2005), which is almost 3x greater than the FID we observed. However, in our experience, *U. bicarinatus* in the Cañón del Zopilote occurs mainly on trees, and although still cryptic, are more readily seen by humans than the *U. ornatus* in the Sierra del Samalayuca (J.A. Lemos-Espinal, pers. observ.). Other phrynosomatid lizards from the southwestern United States and Mexico have greater FIDs (e.g., *Sceloporus virgatus*, 160-310 cm, Smith, 1996a; Cooper and Avalos, 2010; *S. anahuacus*, 260 cm, Smith and Lemos-Espinal, 2005; *S. gadoviae*, 283 cm, Smith and Lemos-Espinal, 2005; *S. jarrovii*, 150-290 cm, Cooper and Avalos, 2010; *S. mucronatus*, 605 cm, Smith and Lemos-Espinal, 2005, *Uta stansburiana,* 210 cm, Keehn and Feldman, 2018). Our results are also consistent with other studied lizards that are cryptic. For example, when in situations in which they are more cryptic, *Phrynosoma modestum* allowed closer approaches than when they were less cryptic, especially at lower temperatures (Cooper and Sherbrooke, 2010), and cryptic species of *Anolis* allow a human to approach closer than other less cryptic species (Cooper, 2006; Vanhooydonck et al., 2007).

We found no effect of body, air, or substrate temperature on FID, perhaps because of the relatively low overall FID we observed. It may be that the FID of cryptic species is less affected by body and environmental temperatures than other species since predator avoidance is not predicated on locomotor performance. This is also consistent with the fact that air and substrate temperature did not affect FID in *U. bicarinatus* (Smith and Lemos-Espinal, 2005). However, the FID of *U. ornatus* in Arizona decreased with increased body and perch temperature (Morris and Lattanzio, 2020), suggesting the situation may be more complex. Indeed, whereas temperature did not affect FID, *U. bicarinatus* that were captured were using perches with lower T_as than those that escaped (Smith and Lemos-Espinal, 2005), indicating that the ability to escape, if not their predilection to flee, may still be related to temperature in these lizards. The lack of effect of temperature on FID has also been observed in non-cryptic lizards (e.g., Martin and López, 2000; Amo et al., 2005; Smith and Lemos-Espinal, 2005; Cooper, 2006). However, in other species of lizards, FID typically decreases with increased body or environmental temperatures (e.g., Cooper, 2006, 2011a; Cooper et al., 2009; Braun et al., 2010), and FID in *Hobrookia propinqua* increases with substrate temperature (Cooper, 2000). The variation in the effects of temperature on FID in lizards needs more study to understand why there is a relationship in some species but not in others.

The lack of a difference in approach distance between male and female *U. ornatus* in our population contrasts with results from another population of *U. ornatus* where male *U. ornatus* had greater FID than females (Morris and Lattanzio, 2020). However, our result is consistent with results from *U. bicarinatus* (Smith and Lemos-Espinal, 2005). In a review of the literature, Cooper (2011b) found that in general most species of lizards show no sexual dimorphism in FID. However, females in some lizards allow closer approaches than males (Majláth and Majláthová, 2009; Vanhooydonck et al., 2017; Salido and Vicente, 2019). Why some populations and species show sexual dimorphism in FID and others do not is not clear and warrants more direct investigation.

In conclusion, the cryptic nature of *U. ornatus* in our population may lead to a short FID since staying still is probably better than fleeing. This supposition is supported by the lack of an effect of temperature, both body and environmental, and sex on FID in this population. However, directly assessing the effect of crypsis on FID is needed to confirm this conclusion.

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