

The flight initiation distance of Smoky rubyspot damselflies (*Hetaerina titia*) is affected by the abiotic environmental conditions

1. Introduction

A common anti-predator behaviour in aerial animals is flight initiation. Upon the acknowledgement or approach of a predator, organisms initiate an escape flight to avoid capture [1]. The flight initiation distance (FID) is the distance between the predator and the prey when the prey organism initiates their escape flight. The FID of an organism is an optimized distance that dynamically varies depending on the specific predator-prey scenario. The cost of remaining or rather the perceived predation risk, could be dependent on a combination of several abiotic, biotic and situational factors. For example, more conspicuous predators are likely to be the easier target prey so selection favors a longer FID that mitigates the cost of the conspicuous phenotype.

This study investigated male *Hetaerina titia* damselfly populations in Costa Rica. In the early breeding season the wings of *H. titia* resemble those of their sympatric congeners [2] – clear wings with a brownish-red spot at the thorax (see figure 1). However, in the peak breeding season on the Atlantic slope of Costa Rica, dark melanin masks the brownish-red spot which means that other sympatric congeners can visually distinguish them as a distinct species. This study investigated whether the melanic morph of *H. titia* is objectively more conspicuous than the common morph. We hypothesized that objectively more conspicuous individuals on the Atlantic slope would have a larger FID under the assumption that melanic individuals show greater risk-aversion than non-melanic individuals under the trade-off hypothesis. This is due to them being more conspicuous to predators. We did not find a relationship between conspicuousness and FID, however, we discovered that the microhabitat of a perched *H. titia* is an important factor affecting FID.

2. Methodology

In this study we conducted flight initiation distance (FID) experiments on male *H. titia* damselflies exclusively. In the Golfito district on the Pacific slope of Costa Rica, we carried out (n=60) trials of our FID experiment across five sites between the 06/24/22 and 07/01/22. In the Limon province on the Atlantic slope of Costa Rica, we carried out (n=47) trials of our FID experiment across three sites between the 07/11/22 and 07/12/22.

Two investigators waded through the centre of a stretch of river at each site and used binoculars to scan the river bank for *H. titia* males perched at territorial height (<1.0m above river surface). Once the focal individual was identified we took a photograph of the side profile of the damselfly (Panasonic Lumix DC-FZ82). The starting point of an approaching investigator (a proxy for an incoming predator) was clearly marked. Then the approaching investigator would stride towards the focal damselfly at a pace of approximately 1m/s and immediately stopped once the individual initiated their escape flight. The stopping point of the investigator was clearly marked. The second investigator would then use a level tape measure to measure the FID and starting distance. To quantify the canopy cover over the initial perch of the focal damselfly, we used the x0.5 zoom function on the front-facing camera of an iPhone to take a skyward photo at the same height and location as the initial perch position.

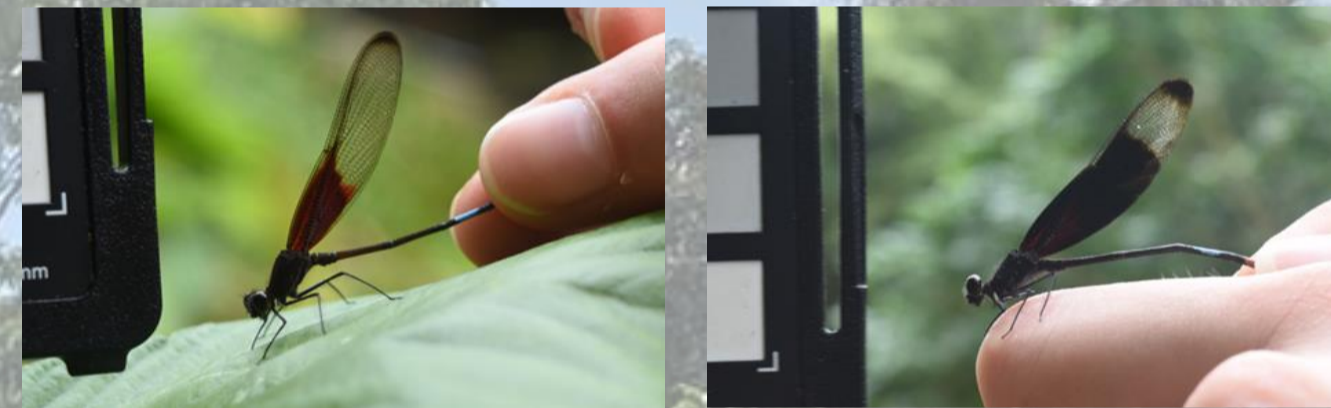


Figure 1: (Left) A mature male *H. titia* from the Golfito district of Costa Rica in the peak breeding season. (Right) A mature male *H. titia* from the Limon province of Costa Rica in the peak breeding season.

3. Results

All six of the linear regression models show that there is no significant correlation between wing pigmentation and FID ($P > 0.05$). However, there is a large difference in the conspicuousness of individuals between the Pacific and Atlantic slope populations (see figure 2). The mean conspicuousness value for individuals on the Atlantic slope is greater than individuals on the Pacific slope ($1.385 > 0.563$).

Gap fraction (GF) describes the what proportion of the canopy cover above the perch is open sky. Two of our linear regression models show that there is a strong positive correlation between GF and FID. When there was a greater proportion of open sky relative to canopy cover over the perched individual, the FID was larger. The mean GF value for the Atlantic slope was greater than the Pacific slope ($0.456 > 0.290$). In this investigation there was a strong link between GF and Cloud cover. Experimental trials where there was a high GF value often had low cloud coverage. These two variables are not dependent on one another but rather cloud coverage on the Pacific slope was always >50% during our experiments and the mean GF was lower. This makes it difficult to disentangle the effect of these two abiotic conditions on FID.

4. Discussion

This study shows that conditions created by canopy cover affect the anti-predator behaviour of *H. titia* damselflies in Costa Rica. In ravine habitats where the canopy cover is less dense and there is more open sky directly above the perch of individuals FID is longer. Potentially, light intensity at territorial perch height in open canopy cover habitats is greater than in closed canopy cover habitats therefore individuals can visually detect the threat of an incoming predator earlier and consequently initiate their escape earlier. Some may argue that, alternatively, open canopy cover habitats provide avian predators with greater light intensity and an improved ability to identify prey targets. Therefore, there are more frequent predation attempts and predation risk is higher.

On the Pacific slope of Costa Rica there were zero days of low cloud coverage during data collection and mean GF value was significantly lower than on the Atlantic coast. This makes it difficult to disentangle these two abiotic variables - we cannot be certain that it was the low GF that was affecting FID if the cloud coverage (a variable that could also affect light intensity) was always high. Further data must be collected to allow us to disentangle the effects of GF and cloud cover on FID.

If abiotic conditions significantly affect the anti-predator behaviour of *H. titia*, it should be considered that drastic changes to the abiotic features of the rainforests and ravine habitats of Costa Rica could affect the levels of predation and, consequently, the population of this species. The ongoing climate crisis and shift to agricultural plantations rather than rainforests could lead to changes in the cloud cover and canopy cover over the habitats of *H. titia*.

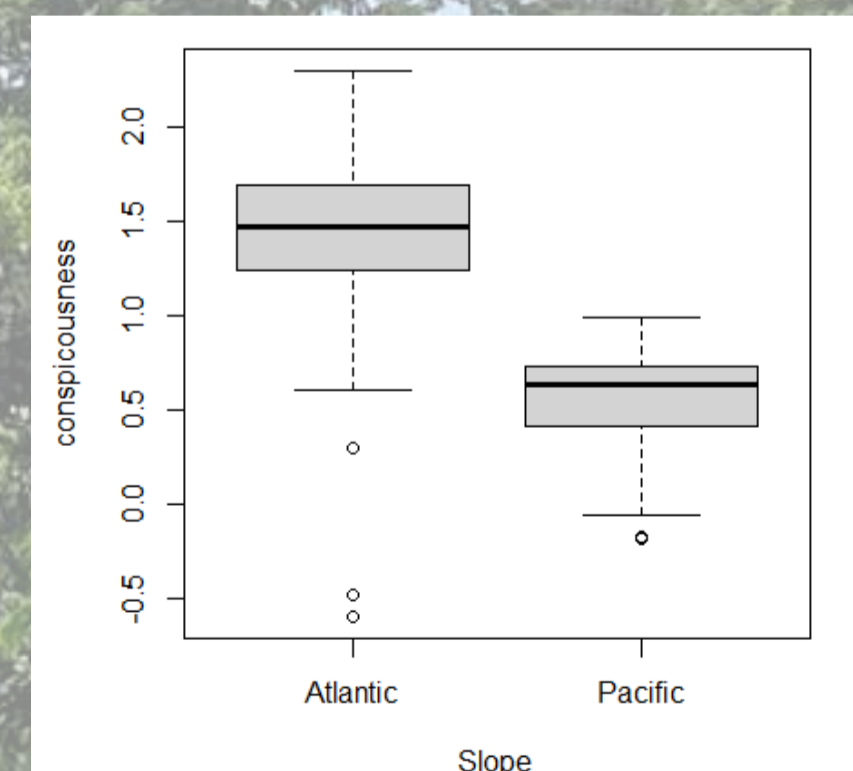


Figure 2: boxplot showing the difference in the median conspicuousness value between the Atlantic and Pacific slope of Costa Rica.

References

- [1] Richardson G, Dickinson P, Burman OHP, Pike TW. Unpredictable movement as an anti-predator strategy. *Proceedings of the Royal Society B: Biological Sciences*. 2018. 285(1885).
- [2] Drury J, Anderson C, Grether G. Seasonal polyphenism in wing coloration affects species recognition in rubyspot damselflies (*Hetaerina* spp.). *Journal of Evolutionary Biology*. 2015. 28(8):1439–52. Available from: <https://doi.org/10.1111/jeb.12665>