SHORT COMMUNICATION

Light attraction hypothesis in Arachnids: a new test in neotropical forests

Hadrien Lalagüe[1] and **Julien Pétillon**[2,3]: [1]UMR EcoFoG, AgroParisTech, CNRS, CIRAD, INRAE, Université des Antilles, Université de Guyane, Campus Agronomique, BP 316, 97379 Kourou Cedex, France; E-mail: hadrienlalague@yahoo.fr; [2]UMR CNRS Ecobio, Université de Rennes 1, Rennes, France; [3]Institute for Coastal and Marine Research, Nelson Mandela University, Port Elizabeth, South Africa

Abstract. Patterns of phototaxis are incompletely characterized in arachnids and hardly generalizable because of large variations in orders, families, species, environments, and methods employed. In a neotropical forest of French Guiana, we tested the effect of both light and diameter on pitfall trap catches. Light had a significant effect on capture rates of all arachnids and on Araneae alone, with more individuals caught in lit traps. Without light, pitfall diameter had no effect on capture rates, while in lit traps, significantly fewer individuals were captured only in smaller traps. Light trapping is thus a promising tool to complete inventories in tropical forests. This field experiment calls for further studies of the mechanisms by which arachnids are attracted by light, especially by unraveling an actual phototaxis from indirect effects like prey attraction.

Keywords: French Guiana, pitfall trap, phototaxis, diameter effect.

https://doi.org/10.1636/JoA-S-22-031

Artificial light acts as a signal that alters the behavior of a wide range of animal species (Gaston et al. 2013), mainly by directly triggering attraction or repulsion. Phototaxis behavior was largely investigated in insects, which revealed a majority of positive phototaxis cases at adult stages (e.g., Kim et al. 2019). Yet, little is known about the phototactic responses in arachnids. A well-known example of positive phototaxis has been demonstrated for two species of camel spiders (Solifugae: Linsenmair 1968). This feature was then used to lure and trap them in three studies (Conrad & Cushing 2011; Cushing & González-Santillán 2018; Graham et al. 2019). In the last study, Graham et al. (2019) evaluated the efficiency of trapping under lit and unlit conditions and showed that lit traps captured a higher number of camel spiders than the unlit traps. Similarly, higher abundance and diversity were found in grassland plots under artificial light compared to unlit plots for several arthropod orders, including Araneae (McMunn et al. 2019). By contrast, light had no effect on most wandering wolf spiders *Rabidosa rabida* (Walckenaer, 1837) with only 24.2% of individuals showing a positive phototaxis (Lizotte & Rovner 1988). Other studies that investigated the effect of artificial light on the behavior of nocturnal arachnids mainly focused on orb-web spiders and demonstrated both positive (Heiling 1999; Heiling & Herberstein 1999) and negative phototaxis (Nakamura & Yamashita 1997; Gomes 2020).

Most previous studies took place in temperate zones and open environments (desert, grasslands, riversides, urbanized area), none being undertaken in tropical rainforest forests that are characterized by a very dark understory and where the high vegetation density may decrease the artificial light range. In such a closed environment, it is unlikely that arachnids navigate at night by traveling at constant angle to the moon or stars. Therefore, the use of artificial light is not expected to disorient or attract them.

In this study, we investigated the light attraction hypothesis on Arachnida in a neotropical rainforest with a protocol slightly modified from that of Graham et al. (2019). The sampling took place in the nature reserve Trésor on the Mountains of Kaw in French Guiana (4°36′31.204818”N, 52°16′47.531959”W). To minimize the impact of sampling in this nature reserve, only adults and juveniles from Mygalomorphae of interest were collected, while all the others were identified at the order or sub-order level, counted and released. To capture live specimens, we used pitfall traps with their inner walls covered by polytetrafluoroethylene (PTFE) that drastically decreases the adhesion of spider's scopula and prevents escape (Poerschke et al. 2021). Tests prior to the field sampling were successfully conducted in laboratory using four adults of *Ephebopus murinus* (Walckenaer, 1837) and *Ctenus* sp. (Theraphosidae and Ctenidae families, respectively). Pitfall traps were arranged in lines of three traps each. Two lines of pitfall traps were set per plot, with two plots in each of the 3 locations: a talweg close to a small river, mature forest on a hill plateau and disturbed forest close to a road. One of the two lines of pitfall traps per plot was equipped with an incandescent 4W light from a CDC (Centers for Disease Control) trap positioned 60cm above the central pitfall trap and powered by a rechargeable battery. This kind of light is known to attract a large spectrum of airborne insects (Wakefield et al. 2016). The three locations were separated on average by 192 m ($SD = 15$), the plots within a location were separated on average by 75 m ($SD = 23$) and the lines of pitfall traps within a plot were separated on average by 25 m ($SD = 12$). The distance between plots and lines of pitfall traps depended on the vegetation density to ensure that light was not visible from the unlit line of pitfall traps. Each line of pitfall traps was covered by an 8×3 m polyethylene tarp to protect them from rain. A polyethylene drift-fence of 8 m long and 30 cm high was set across the line of pitfall traps to maximize the capture rate (Boetzl et al. 2018). Three diameters of pitfall traps, 20, 30, and 40 cm with the same depth of 20 cm, were used in each line. We tested such large pitfall traps because Brennan et al. (1999) showed a correlation between pitfall diameter and capture rate within a range of 4.3 to 17.4 cm, and because large Mygalomorphae are not captured with the traps of 10 cm of diameter previously used in French Guiana (Privet et al. 2018, 2020). Dead leaves were placed on the bottom to provide refuge and minimize possible interactions between trapped specimens. All traps were checked every morning for five consecutive days, and the number of trapped specimens was recorded in each pitfall trap. As we had no specific hypothesis regarding location effects, and to increase sample size, we show results of a model with the data from the three locations combined (Fig. 1). For all arachnids, adding location to the model did not change the outcome regarding the effect of light. Analyses were conducted with R 4.1.2 (R Core Team, 2021) and the package *stats*.

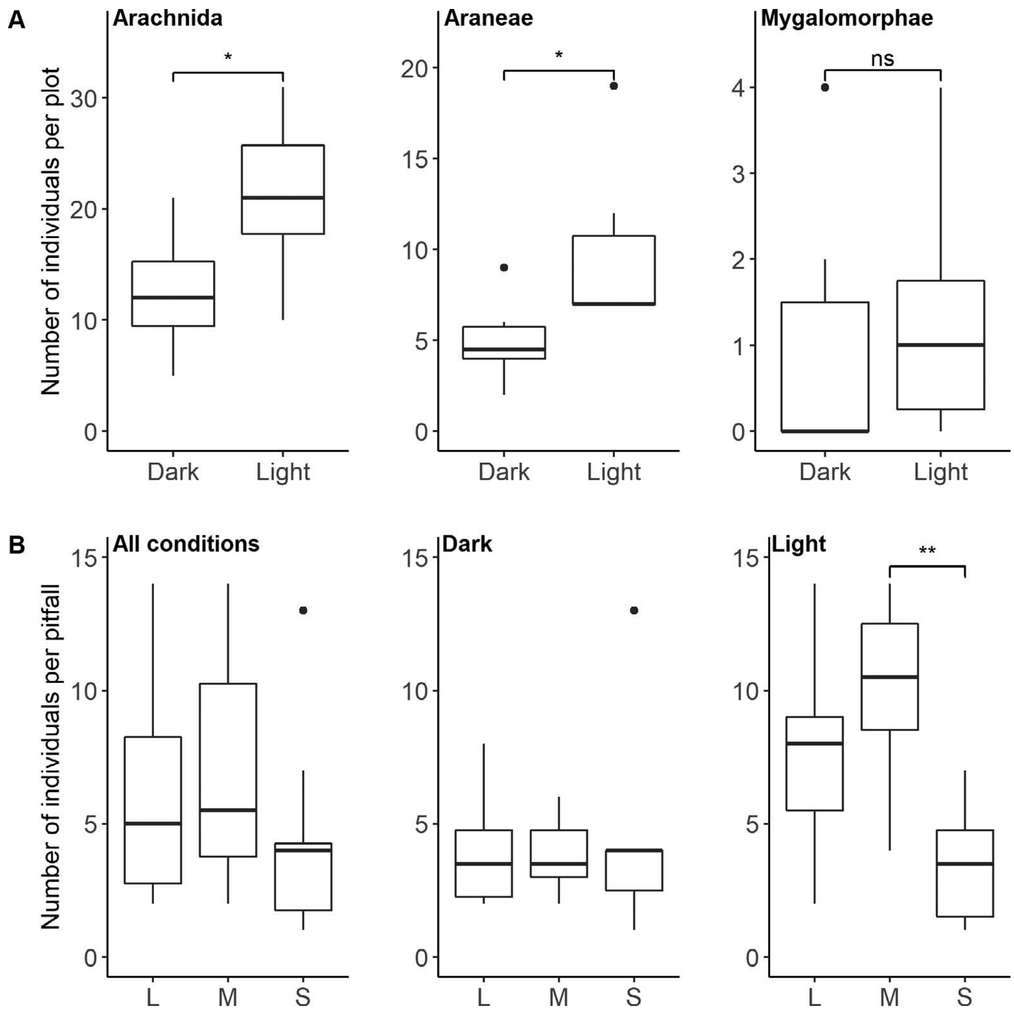

Figure 1.—**A.** Effect of light on pitfall capture rates; dark corresponds to lines of pitfall traps without light, and light corresponds to lines of pitfall traps equipped with light. **B.** Effect of pitfall diameters on capture rates; L: large, 40cm; M: medium 30cm; S: small, 20cm. *: $P<0.05$; **: $P<0.01$.

Normality of the datasets was checked with Shapiro-Wilk normality test and equality of the variance was checked with Fisher's F-Test (function *var.test*). For all arachnids we used Student's t-test (function *t.test*). For Araneae alone and Mygalomorpahe alone, as one of the groups was not normally distributed (lit group and unlit group respectively), nonparametric Wilcoxon rank sum test was used (function *wilcox.test*). In this study, we hypothesized that light has no effect on the capture rate and that larger pitfall trap diameters have higher capture rate.

A total of 202 arachnids were trapped, mostly composed of Opiliones (49.5%), followed by Araneae (44%,). Only 14 (6.9%) Mygalopmorphae, 11 (5.4%) Scorpiones were captured, and only one specimen (0.5%) of Amblypygi and Uropygi were captured. Concerning arachnids, the number of captures was higher in lit traps ($M = 21.2$; $SD = 7.4$) than in unlit traps ($M = 12.5$; $SD = 5.6$); Student's t-test $t(10) = -2.29$, $P = 0.045$). Concerning the Araneae alone, the number of captures was higher in lit traps ($M = 9.8$, $SD = 4.9$) than in unlit traps ($M = 5.0$, $SD = 2.4$); Wilcoxon rank sum $W = 4$, $P = 0.028$). Probably due to the low sample size, no significant effect was found for Mygalomorphae ($W = 14$, $P = 0.55$), despite the same tendency of lit pitfall trap capturing a greater number of individuals ($M = 1.3$; $SD = 1.5$) than in unlit pitfall traps ($M = 1.0$; $SD = 1.7$). It is also interesting to note that, among the 11 Scorpiones, 8 were trapped in the lit pitfall traps. The higher number of arachnids in lit pitfall traps may be explained either by direct positive phototaxis or by higher abundance of prey, as it is well known that many groups of insects are attracted by artificial lights. As an example, McMunn et al. (2019) also found a higher abundance of arthropod predators in plots under artificial light compared to unlit plots.

Without light, pitfall trap diameter had no effect on the capture rate, which is contrary to the results of Brennan et al. (1999) who found a positive relationship between capture rate and pitfall trap diameter (ranging in their study from 4.3 to 17.4 cm). With light, a significant difference was observed between the diameters of 20 vs. 30 cm (Student's t-test $t(10) = 3.68$, $P = 0.004$), with fewer arachnids captured in pitfall traps of the smaller diameter. Even if the difference was not significant between the 30 and 40 cm diameters, it is interesting that the larger diameter did not collect more arachnids than the medium diameter. The presence of the light right above the central pitfall trap of medium diameter may explain the higher capture rate compared to pitfall traps farther from the light source. This result strengthens the strong effect light has on tropical arachnids.

It remains uncertain whether the higher capture rate under the light treatment was directly due to phototaxis or indirectly due to an increase in insect activity in the vicinity producing both substrate and airborne vibrations. Nevertheless, these preliminary results are promising for further studies in the diversity of arachnids in tropical rainforests.

ACKNOWLEDGMENTS

This work was funded by the Réserve Naturelle Régionale Trésor. We thank the agents of the reserve for their valuable help before and during the fieldwork. The study was authorized with the sampling permit 2021-6854. We thank the Institut Pasteur de Guyane and Stanislas Talaga for the loan of the CDC traps. We finally thank Seyna Smoes, Mathieu Robain, Nathan Zuanon and Guillaume Mazeau, the students from the FTH classes managed by Agro-ParisTech for their help during the fieldwork, and Yael Lubin and two anonymous referees for comments on an earlier draft.

LITERATURE CITED

Boetzl FA, Ries E, Schneider G, Krauss J. 2018. It's a matter of design-how pitfall trap design affects trap samples and possible predictions. *PeerJ* 2018:1–14.

Brennan KEC, Majer JD, Reygaert N. 1999. Determination of an optimal pitfall trap size for sampling spiders in a Western Austalian Jarrah forest. *Journal of Insect Conservation* 3:297–307.

Conrad KR, Cushing PE. 2011. Observations on hunting behavior of juvenile *Chanbria* (Solifugae: Eremobatidae). *Journal of Arachnology* 39:183–184.

Cushing PE, González-Santillán E. 2018. Capturing the elusive camel spider (Arachnida: Solifugae): Effective methods for attracting and capturing solifuges. *Journal of Arachnology* 46:384–387.

Gaston KJ, Bennie J, Davies TW, Hopkins J. 2013. The ecological impacts of nighttime light pollution: A mechanistic appraisal. *Biological Reviews* 88:912–927.

Gomes DGE. 2020. Orb-weaving spiders are fewer but larger and catch more prey in lit bridge panels from a natural artificial light experiment. *PeerJ* 8:e8808

Graham MR, Pinto MB, Cushing PE. 2019. A test of the light attraction hypothesis in camel spiders of the Mojave Desert (Arachnida: Solifugae). *Journal of Arachnology* 47:293–296.

Heiling AM. 1999. Why do nocturnal orb-web spiders (Araneidae) search for light? *Behavioral Ecology and Sociobiology* 46:43–49.

Heiling AM, Herberstein ME. 1999. The importance of being larger: Intraspecific competition for prime web sites in orb-web spiders (Araneae, Araneidae). *Behaviour* 136:669–677.

Kim KN, Huang QY, Lei CL. 2019. Advances in insect phototaxis and application to pest management: a review. *Pest Management Science* 75:3135–3143.

Linsenmair KE. 1968. Zur Lichtorientierung der Walzenspinnen (Arachnida, Solifugae). Zool. Jahrbücher. *Zoologische Jahrbücher Abteilung für allgemeine Zoologie und Physiologie der Tiere* 74:254–273.

Lizotte RS, Rovner JS. 1988. Nocturnal capture of fireflies by lycosid spiders: visual versus vibratory stimuli. *Animal Behaviour* 36:1809–1815.

McMunn MS, Yang LH, Ansalmo A, Bucknam K, Claret M, Clay C, et al. 2019. Artificial light increases local predator abundance, predation rates, and herbivory. *Environmental Entomology* 48:1331–1339. doi:10.1093/ee/nvz103

Nakamura T, Yamashita S. 1997. Phototactic behavior of nocturnal and diurnal spiders: negative and positive phototaxes. *Zoological Science* 14:199–203.

Poerschke B, Gorb SN, Schaber CF. 2021. Adhesion of individual attachment setae of the spider *Cupiennius salei* to substrates with different roughness and surface energy. *Frontiers in Mechanical Engineering* 7:1–11.

Privet K, Courtial C, Decaens T, Djoudi EA, Vedel V, Ysnel F, et al. 2018. Spider assemblage structure in a neotropical rainforest-inselberg complex: Ecological and methodological insights from a small-scale intensive survey. *Tropical Ecology* 59:21–34.

Privet K, Vedel V, Fortunel C, Orivel J, Martinez Q, Cerdan A, et al. 2020. Relative effciency of pitfall trapping vs. nocturnal hand collecting in assessing soil-dwelling spider diversity along a structural gradient of neotropical habitats. *Diversity* 12:81.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Online at https://www.R-project.org/

Wakefield A, Broyles M, Stone EL, Jones G, Harris S. 2016. Experimentally comparing the attractiveness of domestic lights to insects: Do LEDs attract fewer insects than conventional light types? *Ecology and Evolution* 6:8028–8036.

Manuscript received 20 May 2022, revised 8 June 2022, accepted 1 July 2022.