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

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13 **Abstract**

14

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

24

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

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

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

48 In this study, we investigated the light attraction hypothesis on Arachnida in a neotropical rainforest
49 with a protocol slightly modified from that of Graham et al. (2019). The sampling took place in the
50 natural reserve Trésor on the Mountains of Kaw in French Guiana (4°36'31.204818"N,
51 52°16'47.531959"W). To minimize the impact of sampling in this nature reserve, only adults and
52 juveniles from Mygalomorphae of interest were collected, while all the others were identified at
53 the order or sub-order level, counted and released. To capture live specimens, we used pitfall traps
54 with their inner walls covered by polytetrafluoroethylene (PTFE) that drastically decreases the
55 adhesion of spider's scopula and prevents escape (Poerschke et al. 2021). Tests prior to the field
56 sampling were successfully conducted in laboratory using four adults of *Epebopus murinus*

57 (Walckenaer, 1837) and *Ctenus* sp. (Theraphosidae and Ctenidae families, respectively). Pitfall
58 traps were arranged in lines of three traps each. Two lines of pitfall traps were set per plot, with
59 two plots in each of the 3 locations: a talweg close to a small river, mature forest on a hill plateau
60 and disturbed forest close to a road. One of the two lines of pitfall traps per plot was equipped with
61 an incandescent 4W light from a CDC (Centers for Disease Control) trap positioned 60cm above
62 the central pitfall trap and powered by a rechargeable battery. This kind of light is known to attract
63 a large spectrum of airborne insects (Wakefield et al. 2016). The three locations were separated on
64 average by 192 m ($SD = 15$), the plots within location were separated on average by 75 m ($SD =$
65 23) and the lines of pitfall traps within plot were separated on average by 25 m ($SD = 12$). The
66 distance between plots and lines of pitfall traps was depended on the vegetation density to ensure
67 that light was not visible from the unlit line of pitfall traps. Each line of pitfall traps was covered
68 by an 8 x 3 m polyethylene tarp to protect them from rain. A polyethylene drift-fence of 8 m and
69 30 cm high was set across the line of pitfall traps to maximize the capture rate (Boetzl et al. 2018).
70 Three diameters of pitfall traps, 20, 30, and 40 cm with the same depth of 20 cm, were used in each
71 line. We tested such large pitfall traps because Brennan et al. (1999) showed a correlation between
72 pitfall diameter and capture rate within a range of 4.3 to 17.4 cm, and because large
73 Mygalomorphae are not captured with the traps of 10 cm of diameter previously used in French
74 Guiana (Privet et al. 2018; Privet et al. 2020). Dead leaves were placed on the bottom to provide
75 refuge and minimize possible interactions between trapped specimens. All traps were checked
76 every morning for five consecutive days, and the number of trapped specimens was recorded in
77 each pitfall trap. As we had no specific hypothesis regarding location effects, and to increase
78 sample size, we show results of a model with the data from the three locations combined. For all
79 arachnids, adding location to the model did not change the outcome regarding the effect of light.
80 Analyses were conducted with R 4.1.2 (R Core Team, 2021) and the package *stats*. Normality of
81 the datasets was checked with Shapiro-Wilk normality test and equality of the variance was
82 checked with Fisher's F-Test (function *var.test*). For all arachnids we used Student's t-test (function
83 *t.test*). For Araneae alone and Mygalomorphae alone, as one of the group was not normally
84 distributed (lit group and unlit group respectively), nonparametric Wilcoxon rank sum test was
85 used (function *wilcox.test*). In this study, we hypothesized that light has no effect on the capture
86 rate and that larger pitfall trap diameters has higher capture rate.

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

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

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

114

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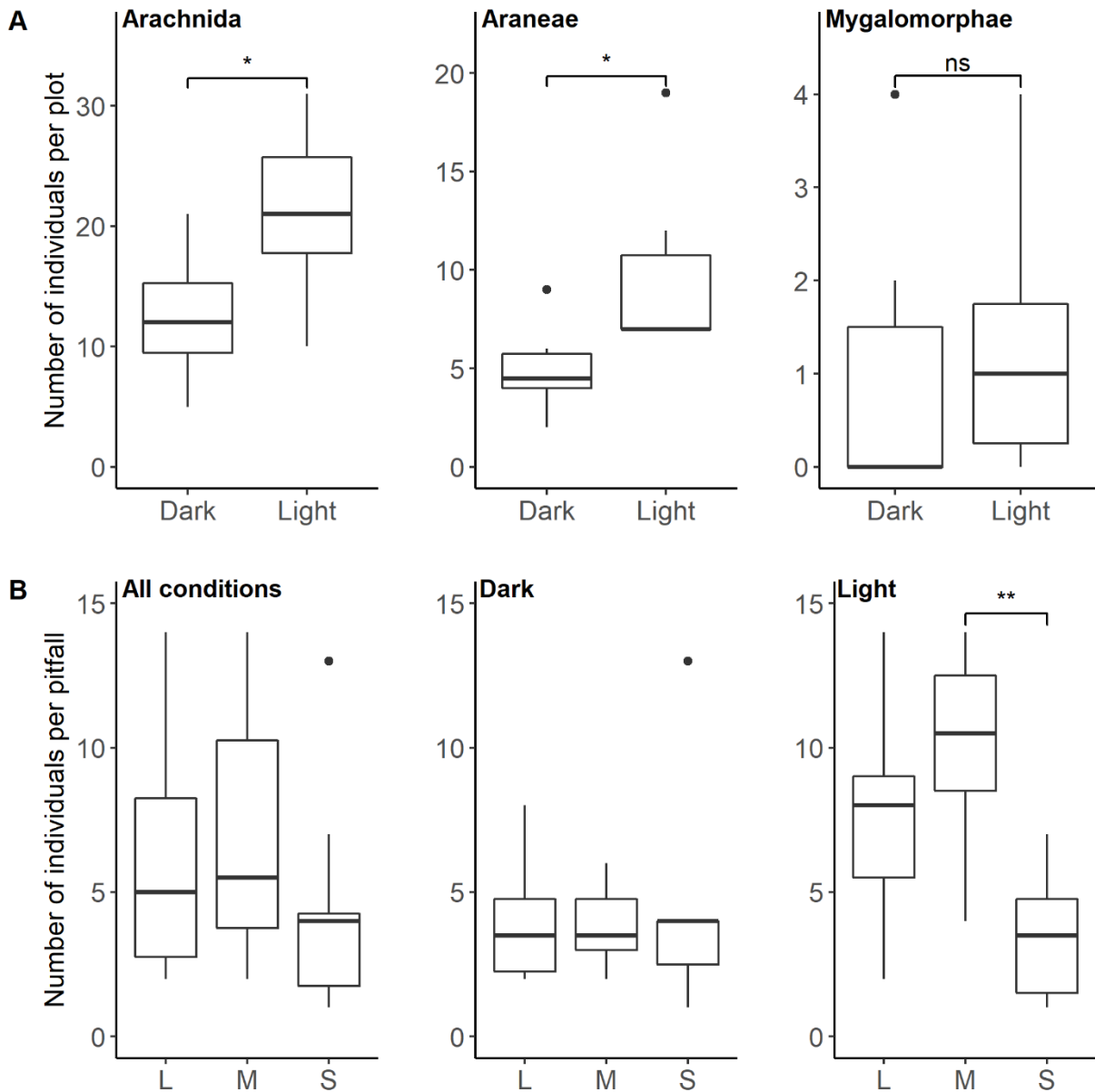
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172

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

176



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