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Distribution extension of *Flirtea picta* Perty, 1832 (Opiliones: Cosmetidae) to Brazilian Atlantic Forest with notes on ecology

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Abstract: Herein we report the first record of the *Flirtea picta* Perty, 1832, harvestmen from the Atlantic Rainforest (Michelin Ecological Reserve – Igrapiúna – Bahia, Brazil). In Brazil, this study extends the distribution of the species, previously known only in Amazonas and Pará states. We collected 157 individuals in three environments: tree-fall gaps, inner forest and edge forest. A brief comment on some ecological aspects of this species is also presented.

Key words: geographical range; Neotropical region; tree-fall gaps; harvestmen ecology

The harvestmen represent the third largest order in terms of species richness in Arachnida, with 6,616 described species (Kury 2015). Just in Brazil, about 1,000 species have been described to date (Kury 2015), and the Southeast region has the highest species richness, with the states of São Paulo and Rio de Janeiro having 232 and 216 species respectively (Pinto-da-Rocha 1999). Other regions of Brazil as the Center, North and Northeast are incipient sampled (Pinto-da-Rocha 1999), so it is necessary to intensify inventories in these lesser known regions. Also, is important to know the distribution of harvestmen species because these organisms are good models for biogeographical studies (DaSilva et al. 2015; Pinto-da-Rocha et al. 2005).

The Opiliones order is divided into four suborders: Cyphophthalmi, Dyspnoi, Eupnoi and Laniatores (Giribet et al. 2010). The suborder Laniatores has the greatest diversity of species with more than 4,100 described species (Kury 2011) and they have a pantropical distribution (Machado et al. 2007). Among the Laniatores, the family Cosmetidae is the second most diverse of the suborder and is distributed from southern United States to Argentina (Kury and Pinto-da-Rocha 2002). The genus *Flirtea* (Cosmetidae: Cosmetinae) have 30 species cataloged until now (Kury 2003). The species *Flirtea picta* Perty, 1832, was described to the Amazon forest, and there are few records of it. According to the catalogue of Kury (2003), this species has occurred for the following locations: Honduras; Cerro Azul and Natá (Panama); Rio Negro (Amazonas, Brazil) and Pará (Brazil). From arachnological surveys developed in Bahia, we collected in Michelin Ecological Reserve (Igrapiúna, south of Bahia). The aim of this study is to extend the distribution of *F.picta*, presenting some ecological aspects of the species.

In this study, specimens of *Flirtea picta* (Figure 01) were recorded in the "Mata da Vila Cinco" (Vila Cinco forest), Michelin Ecological Reserve (13°50′ S, 039°10′ W) located between the municipalities of Igrapiúna and Ituberá in Bahia (Brazil). This reserve has a spatial extend of 3,096 ha and is distanced by 18 km from the Atlantic coast, with an average elevation of 383 m. This region is characterized by a variety of ecosystem types, like the Atlantic Rainforest (Flesher and Laufer 2013). The "Mata da Vila Cinco" (190 ha), one of four fragments of the Michelin Ecological Reserve, presents patches of primary forest (17–20 m forest canopy) located within its northern section. In southern section of this forest fragment, secondary forest is most characteristic, in which tree height typically ranges from 8–13 m. The specimens were captured in surveys carried from July 2009 to October 2010 (on a bimonthly basis).

For the sampling, we selected 15 points of 50 m^2 (distant from each other a minimum of 50 m) distributed in three habitat categories: tree fall gaps, inner forest, and forest edge (including five points per

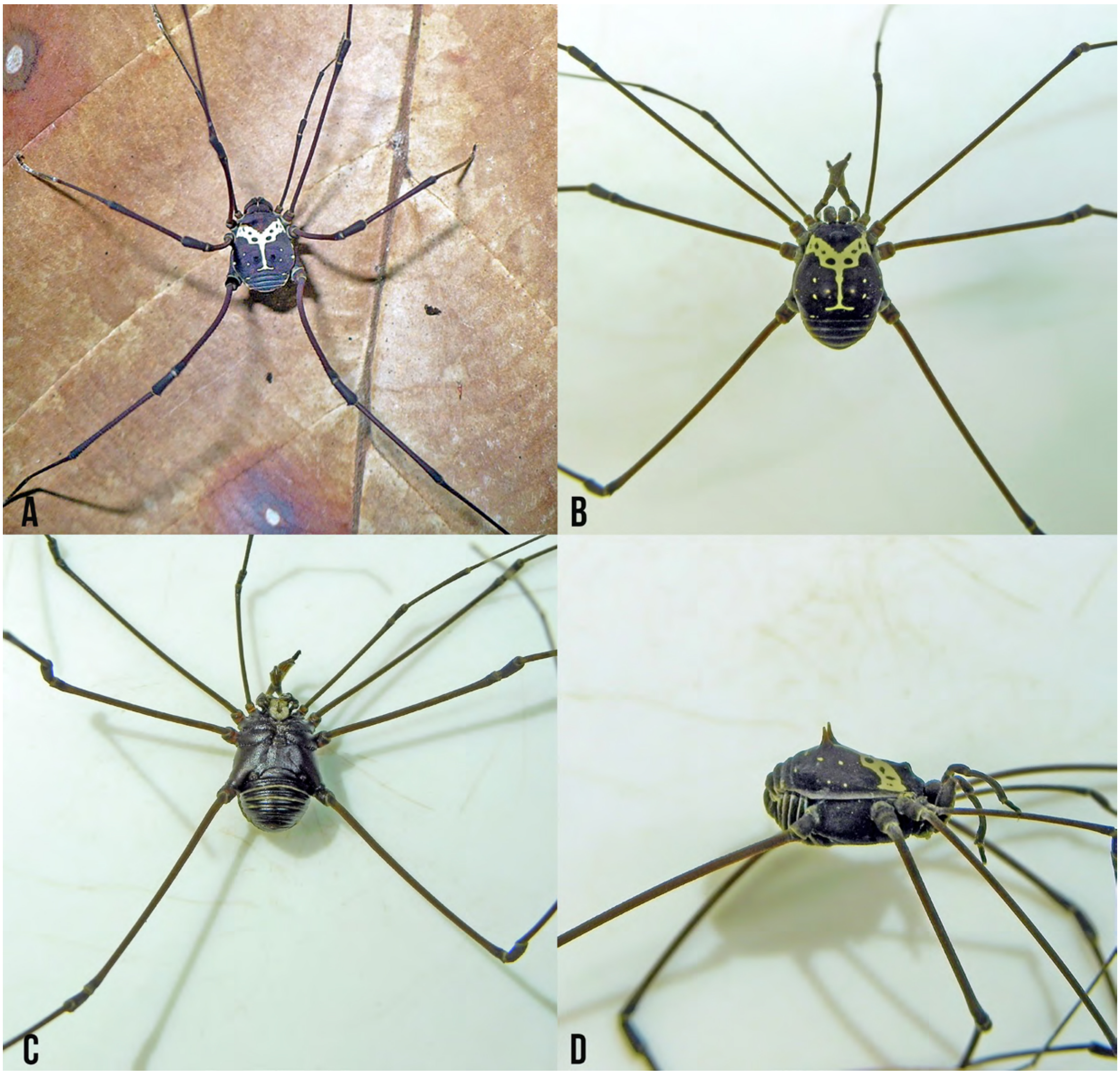

Figure 1. *Flirtea picta* Perty, 1832 (Opiliones: Cosmetidae) collected in the Mata da Vila Cinco, Michelin Ecological Reserve (Igrapiúna, Bahia, Brazil). (**A** and **B**) Dorsal view. (**C**) Ventral view. (**D**) Lateral view.

category). In each point, individuals were captured by night visual search and hand-collected by two collectors, for 1 h. The samples were realized simultaneously in three habitat categories. The efficiency of this method will vary with the visual acuity of the collector (Curtis, 2007). In all collections, the environmental variables of each sampling point were measured (Table 1): leaf litter depth, leaf litter cover, herbaceous vegetation cover, volume of the fallen trunks in decomposition, soil temperature, air temperature, relative air humidity and light intensity. Collected harvestmen were identified to species level and deposited at the Arachnology Sector of the National Museum, Rio de Janeiro, Brazil (MNRJ 08037, MNRJ 08040, MNRJ 08144; Curator: Adriano B. Kury). In order to compare *Flirtea picta* abundance in the three areas studied (i.e., tree-fall gaps, inner forest and forest edge) we realized an Analysis of Variance (ANOVA One-Way), when the result was significant it was analyzed the significance (*p* value) of Tukey-Kramer Multiple Comparisons Test. To assess the influence of environmental variables on the individuals' distribution, a Multiple regression was performed. The software

Table 1. Mean and standard deviation (SD) of environmental variables (leaf litter depth, leaf litter cover, herbacious vegetation cover, volume of the fallen trunks in decomposition, soil temperature, air temperature, relative air humidity and light intensity) measured in the three environments studied (TG = tree-fall gap; IF = inner forest and FE = forest edge). *Measured in the scale of Fournier (1: 0–25%; 2: 26–50%; 3: 51–75%; 4: 76–100%).

Environmental variables	TG	IF	FE
Leaf litter depth (cm)	2.7 (0.58)	3.2 (0.70)	2.4 (0.71)
Leaf litter cover*	3.5 (0.64)	3.9(0.35)	3.4 (0.67)
Herbacious vegetation cover*	3.3 (0.82)	2.2 (0.79)	3.1 (0.85)
Volume of the fallen trunks in decomposition (m^3)	2.05 (0.04)	1.40 (0.03)	1.71 (0.04)
Soil temperature (°C)	23.8 (1.88)	23.6(1.51)	23.8 (1.34)
Air temperature (°C)	27.8 (1.28)	23.3(1.52)	25.1 (1.49)
Relative air humidity (%)	70 (10.78)	76 (10.14)	71 (10.20)
Light intensity (Lux)	4406 (11634)	412 (1444)	2571 (9181)

used to perform the analysis was GraphPadInStat© 3.0 (GraphPad Software, San Diego, California, USA, http://www.graphpad.com).

We collected 157 individuals: tree-fall gaps (n = 48), inner forest (n = 73) and edge forest (n = 36). The months in which the individuals had the highest abundance were March (n = 34) and May (n = 47), the rainy season in the region, which takes place between February and July (unpublished data from the meteorological station of Michelin Plantations of Bahia). Abundances differed significantly among the three study sites ($F= 5.24$; $df= 2$; $p = 0.0231$). Comparing peer-to-peer, there were significant differences only between inner forest and the edge ($q = 4.487$; $p<0.05$). This difference may be occurring because the edges of the fragments promote changes in biotic and abiotic conditions compared with the interior of forests and, therefore, can influence the community structure (Godefroid and Koedman 2003). The absence of difference in the abundance of individuals between tree-fall gaps and edge may be because these two areas present similarity of certain environmental variables. The higher luminous intensity, characteristic of tree-fall gaps (Whitemore 1990; Patrick et al. 2012), for example, can also be found in environments of the edge (Murcia, 1995), like observed in this study (Table 1). Therefore many species of Opiliones can be sensitive to environmental changes that occur in those environments.

The results of multiple regression ($F=1.55$; $R^2=0.73$; $p=0.3318$) revealed no significant influences of environmental variables measured on the abundance of *Flirtea picta*. This result was not expected, since the harvestmen are sensitive to various environmental variables, especially temperature and humidity (Curtis and Machado 2007; Almeida-Neto et al. 2006; Resende et al. 2012). Moreover, Proud et al. (2012), demonstrate that the microhabitat preferences (logs, leaf litter, foliage and trees), some of those were measured in this study, can influence the distribution of species and the amount of fallen trunks appears to exert controlling influences on

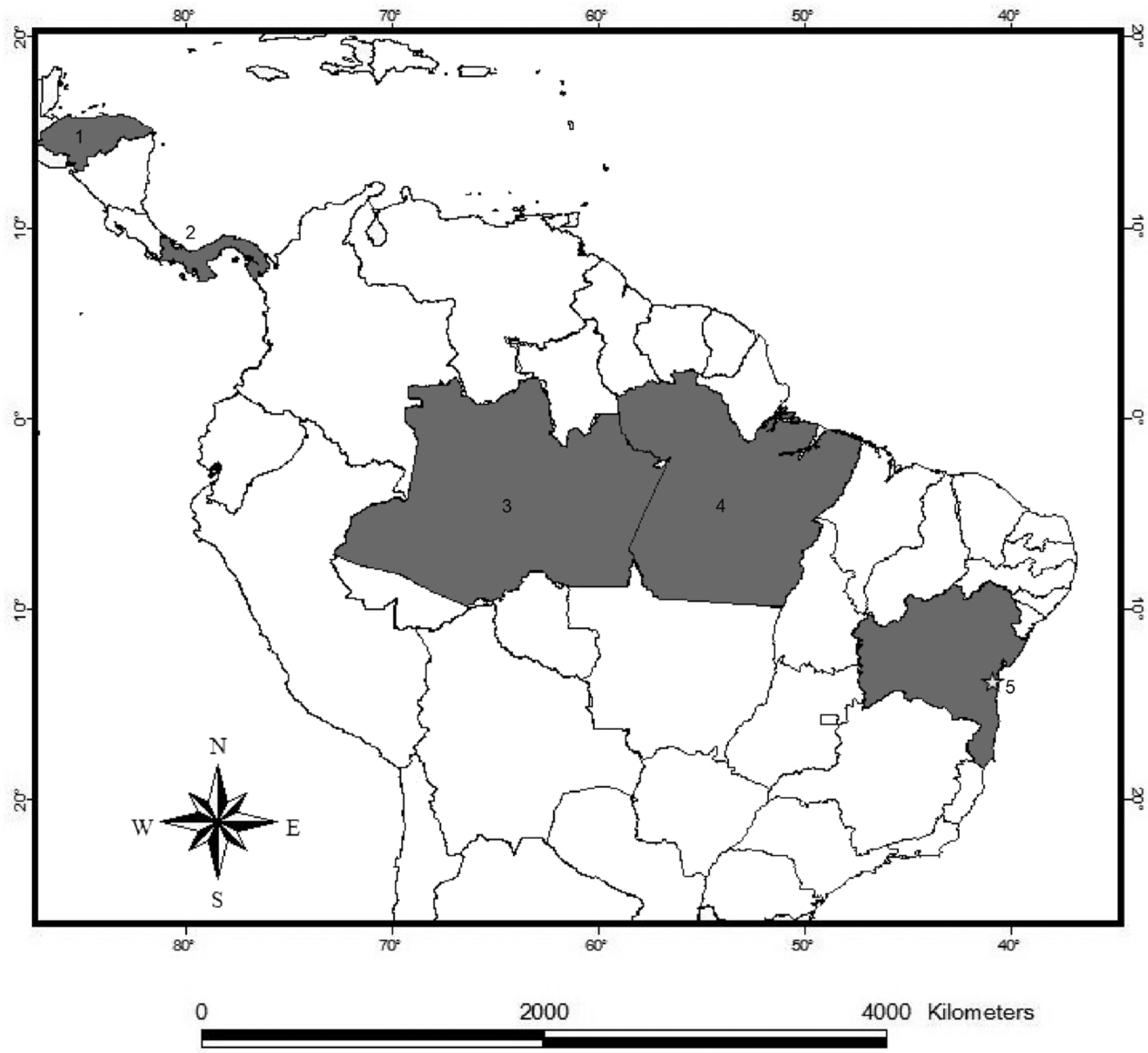

Figure 2. Known distribution (shaded areas) of *Flirtea picta* species (Opiliones: Cosmetidae). 1, Honduras (Roewer 1912); 2, Natá and Cerro Azul, Panama (Roewer 1912; Goodnight and Goodnight 1947, respectively); 3, Rio Negro, Amazonas, Brazil, type locality (Perty 1832); 4, Pará (Roewer 1912); and 5, Michelin Ecological Reserve, Igrapiúna (Bahia, new record, present study).

the distribution of harvestmen (Curtis and Machado 2007; Podgaiski et al. 2007). Probably, environmental variables not measured in this survey (i.e., others microhabitats and intraespecific/interespecific competition) can be influencing the distribution of this species. Future studies could include these other environmental variables. It is important to mention that although we use the nocturnal manual method, because this method covers ground/litter microhabitats as well as the vegetation layer (Tourinho et al. 2014), the use of other techniques can be useful to access the individuals in different microhabitats (Curtis 2007; Tourinho et al. 2014).

This study extends the distribution of the species in Brazil, previously known only from Amazonas and Pará (Kury 2003). This species had been recorded for Montane Tropical Forest (Cerro Azul, Panama; Goodnight and Goodnight, 1947) and Amazon Rainforest (Rio Negro, Brazil; Perty, 1832). This new record extends the species' distribution by approximately 1,680 km from Pará (Brazil) and 2,478 km from the Rio Negro (Brazil) (Figure 2). The exact sites of occurrence of this species in Honduras, Rio Negro and Pará were not possible to be identified because they were not available in the original papers (Figure 2). Because of the disjunct distribution, we suggest molecular and taxonomic studies to assess the situation of this species.

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