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Fluorescent Colors in Orchid Bees (Hymenoptera: Apidae)

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Cores Fluorescentes em Euglossinas (Hymenoptera: Apidae)

RESUMO - Pela primeira vez é relatada em insetos a presença de pigmentos que fluorescem sob luz ultra-violeta. Os pêlos claros dos tergos I, III e IV de *Eulaema niveofasciata* (Friese) são os únicos dentre várias espécies de Euglossina que fluorescem, apoiando recentes estudos taxonômicos que sugerem que essa espécie, endêmica da Mata Atlântica, e *Eulaema bombiformis* (Packard), são realmente espécies distintas. Tal coloração pode ter implicações tanto no comportamento de corte e acasalamento, quanto na advertência a predadores.

PALAVRAS-CHAVE: *Eulaema bombiformis, Eulaema niveofasciata*, luz ultra-violeta

ABSTRACT - The presence of UV-fluorescent pigments is described for the first time in insects. The clear hairs on terga I, III and IV of *Eulaema niveofasciata* (Friese) are the only ones among several Euglossina species which fluoresce, supporting recent taxonomic studies which suggested that this endemic species of the Atlantic Forest domain and *Eulaema bombiformis* (Packard) are really different species. The UV-color pattern may have effects both on mating behavior and warning to predators.

KEY WORDS: *Eulaema bombiformis, Eulaema niveofasciata*, ultra-violet light

Ultraviolet reflectance in animals has attracted much attention recently, particularly among birds (Guilford & Harvey 1998, Banks 2001, Hunt *et al.* 2001). In a specific group of birds, the parrots, this fact has gained in popularity since several species have a yellow pigment that fluoresces under ultra-violet (UV) light (Völker 1937, Boles 1991, Nemésio 2001, Arnold *et al.* 2002), but this kind of pigment has been considered an exclusive attribute of some species of parrots (Völker 1937; Boles 1991; McGraw & Nogare 2004, 2005).

Orchid bees are exclusively Neotropical members of the Apidae family. They are the main pollinators of several hundreds of species of New World's orchids and other plants (Dressler 1982). Most of the 200 known species are small metallic blue or green bees of the genus *Euglossa*. The genus *Eulaema*, on the other hand, comprises 26 species (according to Oliveira 2000) with no metallic hues in the head and thorax, with a predominant black integument and mostly covered with hairs (Lepeletier 1841, Oliveira 2000, Moure 2003). The genus *Eufriesea*, with some 60 species (Kimsey 1982), presents both hairy ("*Eulaema*-like") and metallic ("*Euglossa*-like") species. The cleptoparasitic species of the genera *Exaerete* (six species, see Oliveira & Nemésio 2003, Nemésio & Silveira in press) and *Aglae* (monotypic, see Morato 2001) are also metallic, "*Euglossa*-like" green or bluish bees.

Bees are known for having a trichromatic vision based on ultraviolet, blue and green photoreceptors (Peitsch *et al.* 1992; see also Vorobyev *et al.* 1999 and Kevan *et al.* 2001 and the references therein for more details on bee visual system). Interactions between bees and UV-reflecting flowers are well known (Vorobyev *et al.* 1999, Kevan *et al.* 2001). Thus, bees seem to be ideal candidates among insects to use the UV channel, and fluorescence under UV light would be a possibility in this group of hymenopterans.

The main goal of this study was to test whether orchid bees present pigments that fluoresce under ultraviolet light.

Material and Methods

In order to test the presence of fluorescent pigments in orchid bees, specimens becoming to the hairy genera (*Eulaema* and *Eufriesea*) were chosen. The species tested are listed in Table 1. Bees of the genera *Aglae*, *Euglossa*, and *Exaerete* have very few and sparse hairs compared to *Eulaema* and several *Eufriesea*, and the colorful metallic integument is exposed. Since these metallic colors are structural (see Parker 2000, 2005a), not pigmentary, they may not fluoresce and, thus, metallic bees were not tested for fluorescence.

The fluorescence under UV light can be observed when a UV source falls directly on the area containing the fluorescent

Table 1. List of species of orchid bees examined under ultraviolet light for fluorescence.

Species	Fluorescence
Eufriesea chrysopyga (Mocsáry)	No
E. dentilabris (Mocsáry)	No
E. duckei (Friese)	No
E. eburneocincta (Kimsey)	No
E. flaviventris (Friese)	No
E. nigrohirta (Friese)	No
E. ornata (Mocsáry)	No
E. pulchra (Smith)	No
E. superba (Hoffmannsegg)	No
E. surinamensis (Linnaeus)	No
E. vidua (Moure)	No
E. violascens (Mocsáry)	No
Eulaema boliviensis (Friese)	No
E. bombiformis (Packard)	No
E. cingulata (Fabricius)	No
E. flavescens (Friese)	No
E. helvola Moure	No
E. meriana (Olivier)	No
E. mocsaryi (Friese)	No
E. nigrita Lepeletier	No
E. nigrita - brown mutant	No
E. niveofasciata (Friese)	Yes
E. polyzona (Mocsáry)	No
E. seabrai Moure	No
E. sororia Dressler & Ospina-Torres	No
E. tenuifasciata (Friese)	No

yellow pigment (Parker 2005b). The specific atoms of this kind of pigment have their outer electrons excited when exposed to UV light, in such a way they move to an even outer orbit but falls back to its original orbit in 10^{-8} seconds (see Parker 2005b). In this process, there is emission of heat and a yellow ray, the fluorescence. To test the possible occurrence of this phenomenon in orchid bees, pinned bees were exposed to an ultraviolet source (Hochdruck-Entladungslampe, HgV 125 W, Tungsram, Hungary) in a complete dark room. The species which presented some degree of fluorescence were, thus, identified.

Results

Thirteen species of *Eulaema* and twelve species of *Eufriesea* were examined (see Table 1). An aberrant variation of *Eulaema nigrita* Lepeletier, which presents brown hairs instead of the usual black hairs (see Nemésio 2002) was also tested, but it did not fluoresce. Only *Eulaema niveofasciata* (Friese) specimens showed fluorescence.

Discussion

Eulaema bombiformis (Packard) has been treated as a widely distributed species in the Neotropics, ranging from Central America to the Atlantic Rain Forest of Espírito Santo state, in the southeastern of Brazil. It has been suggested as belonging to a Müllerian mimetic complex with other orchid bees, particularly in the Amazon Basin and Central America (Dressler 1979). Recently, Moure (2003) suggested that the Atlantic Forest population, often treated as a separate subspecies, should be given a full species status, *Eulaema niveofasciata* (Friese).

The hairs of *Eulaema* bees are predominantly black, but several species present also yellow and/or red hairs. Under white light, *E. bombiformis* and *E. niveofasciata* present yellow stripes in the first, third, and fourth terga, a black stripe in the second tergum and red stripes in the three final terga (Fig. 1, top left). However, under ultraviolet light, the yellow hairs of the terga I, III and IV fluoresce (Fig. 1, top right). More interestingly, this phenomenon was only seen in the individuals from the Atlantic Forest population (*E. niveofasciata*), eastern Brazil, and no fluorescence was found among members of the Amazonian population (Fig. 1, bottom), supporting they may represent different species. Reflection of UV light was already observed among insects (Parker 2000, 2005a), and even fluorescence (Rawson 1968), but this is the first record of fluorescence under UV light. Reflection of UV light may result in UV patterns only seen by animals which can see in the UV band. On the other hand, fluorescence under UV light can be also seen by humans and other animals which cannot see the UV band, since what is shown is the fluorescence itself, not the UV color.

The fluorescent pigment of parrots has been suggested as a signal in mate choice (Pearn *et al.* 2001, Hausmann *et al.* 2003, Parker 2005b; but see Nemésio 2003). If the fluorescent pigment of *E. niveofasciata* is functional, it is not possible to discard the mate choice signaling as a possibility. However, other explanations such as warning to predators may be considered, since the abdomen of this species and close allies has the traditional aposematic coloration.

Based on the results here presented, however, a further question deserves an explanation: why only one species out of 25 presented fluorescence? This is highly coincident with the actual figure in parrots, in which only three Neotropical species (among more than 150) have the fluorescent pigment: the Barred Parakeet *Bolborhynchus lineola* (Cassin), the White-bellied Parrot *Pionites leucogaster* Kuhl (Völker 1937), and the Golden Conure *Guaruba guarouba* Gmelin (Boles 1991), although there is no information on how many species were tested (see Nemésio 2001). On the other hand, several Australian species show yellow fluorescence under UV light (Hausmann *et al.* 2003). Parker (2005b) hypothesized that South American parrot species are, mainly, forest-dependent species, whereas Australian ones live in more open habitats. In forested habitats, the

Figure 1. Top left: a male *E. niveofasciata* from the Atlantic Forest under white light. Top right: the same bee pictured on the left under UV light. Bottom left: a male *E. bombiformis* from the Amazon Basin under white light. Bottom right: the same bee pictured on the left under UV light.

light incidence is poor. If fluorescence is actually functional, it would be no advantageous for an individual to present a pigment that fluoresces under UV light if UV light barely reaches it. If Parker's hypothesis is true, and considering that orchid bees are highly associated to forested environments (see Dressler 1982 for a review), the figure of only one or few orchid bee species showing fluorescent colors under UV light may be well understood, suggesting that this phenomenon might occur more often in bee species typical of open, savannah-like environments.

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