

ORIGINAL ARTICLE

Biodiversity of Cetoniinae beetles (Coleoptera: Scarabaeidae) in introduced and native habitats in the Brazilian Atlantic Forest

Anderson PUKER¹, Henrique L. AD'VINCULA², Vanesca KORASAKI³,
Felipe N. F. FERREIRA⁴ and Jesús OROZCO⁵

¹Programa de Pós-Graduação em Entomologia, Departamento de Entomologia, Universidade Federal de Viçosa, Viçosa, Brazil,

²Centro de Ensino Superior de Juiz de Fora, Juiz de Fora, Brazil, ³Departamento de Biologia, Setor de Ecologia, Universidade Federal de Lavras, Lavras, Brazil, ⁴Departamento de Biologia Geral, Universidade Federal de Viçosa, Viçosa, Brazil; and

⁵Department of Zoology and Entomology, Rhodes University, Grahamstown, South Africa

Abstract

The ecology of the beetles of the subfamily Cetoniinae (Coleoptera: Scarabaeidae) is relatively poorly known worldwide. In the neotropics in particular, there are far less studies than in other biogeographic regions. In part due to this lack of knowledge, cetoniines are not considered indicators of habitat quality in the Neotropical region. In this study, we compare the abundance, diversity, and species composition of cetoniines in three different habitats in Brazil: two exotic (*Brachiaria* pasturelands and eucalyptus plantation) and one native (Brazilian Atlantic Forest). We also provide diagnostic images of both sexes and of the genitalia of males of all species to facilitate species identification in further studies. The beetles were collected weekly from September to December 2012 with traps baited with fermented fruit, in five eucalyptus plantations (*Eucalyptus grandis* Hill ex Maiden), five exotic pasturelands (*Brachiaria* spp.), and five patches of Brazilian Atlantic Forest. The abundance and diversity of cetoniines was found to be lower in the eucalyptus plantations and about the same in the forest and pasturelands. The low diversity found and the little information available on the ecology of Neotropical Cetoniinae is insufficient to propose these beetles as candidates for the habitat evaluation in Brazil.

Key words: community specialization, diversity, flower beetles, forest fragments, habitat loss.

INTRODUCTION

Most terrestrial ecological studies based on insects in the Neotropical region are focused on few taxonomic groups, such as ants, dung beetles, and butterflies. These three groups no doubt play important roles in both primary and disturbed habitats (Schulze *et al.* 2004). Nevertheless, the taxonomic impediment is the main reason that there are fewer studies on other insect groups.

Cetoniine beetles (Coleoptera: Scarabaeidae: Cetoniinae) are commonly known as fruit or flower beetles. Around 4000 species are known worldwide (*sensu* Krikken 1984; Krajcik 1999), 300 of which are estimated to occur in the American continents (Orozco 2012a). In Brazil, 72 species distributed in 24 genera [Cetoniini (one species), Cremastocheilini (four genera, seven species), Gymnetini (16 genera, 55 species), Incaini (two genera, seven species) and Trichiini (one genus, two species)] are known (A. Puker & F. Z. Vaz-de-Mello, unpubl. data, 2013). Adults are medium to large-sized (0.5–15.0 cm) beetles with a variable bright coloration and a typically diurnal habit. Most can be found on ripe fruits and flowers, being many species relatively easy to collect using traps baited with fermented fruit. The larvae are predominantly saprophagous or saproxylophagous, and are frequently found in the soil, rotten wood, tree cavities, and feces.

Correspondence: Anderson Puker, Programa de Pós-Graduação em Entomologia, Departamento de Entomologia, Universidade Federal de Viçosa, 36570-000, Viçosa, Minas Gerais, Brazil.
Email: pukeragro@gmail.com

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Cetoniine phenology, population dynamics, habitat associations, and potential use as ecological indicators have been investigated by Donaldson (1981), Thomas (1993), Morón (1995), Bouyer *et al.* (2007), Touroult and Dalens (2010), Puker *et al.* (2012), Rodrigues *et al.* (2013), among others. Despite the importance of some species as pollinators (e.g. Singer & Cocucci 1997; Micó & Galante 1998; Peter & Johnson 2009) the functional role of most is still unknown. Recent research in Benin (West Africa) found a strong relationship between cetoniine diversity and habitat type suggesting that cetoniines might be used as indicators in the area when used together with information from other taxa (Touroult & Le Gall 2013).

In Brazil, exotic monocultures such as pastures of *Brachiaria* spp. for cattle, and eucalyptus plantations for the charcoal and paper industries, can be widely found and continue to be established. The impact of these exotic habitats on the native diversity is presumed to be negative but is still mostly speculative. As a step towards the understanding of the response of the native biodiversity to these exotic habitats, we compare the abundance, diversity, and species composition of Cetoniinae beetles in native (Brazilian Atlantic Forest) and exotic habitats (eucalyptus plantations and pasturelands of *Brachiaria* spp.). Our results also provide information on the possible use of Cetoniinae beetles as bioindicators and their diversity in this part of Brazil.

MATERIALS AND METHODS

Study area

The study was conducted in Rio Novo, state of Minas Gerais, Brazil (21°28'20" S, 43°09'02" W). The climate of the region is mesothermal (Cwa) according to the Köppen classification (Peel *et al.* 2007), with average monthly temperatures and rainfall during the rainy season (October to March) of 24°C and 230 mm, respectively. Five areas were selected in each of three different habitats: two exotic (*Brachiaria* pasturelands and eucalyptus plantations) and one native (Brazilian Atlantic Forest). The sites were separated by a minimum distance of 1.6 km and a maximum of 2.3 km.

The eucalyptus areas selected (*Eucalyptus grandis* Hill ex Maiden) were of six years of age and covered ~6 ha each with spacing of 3 m between plants (density = 1111 plants ha⁻¹). The exotic pastureland areas were part of a large 180 ha plot planted with *Brachiaria* spp. used for cattle. Small patches of native vegetation and termite mounds (*Cornitermes* sp.) are dispersed in the grasslands. The patches of Brazilian Atlantic Forest covered ~20 ha each and included

native regenerated vegetation (> 35 years) of the lower montane semideciduous type. The forest patches are surrounded by exotic pasturelands and eucalyptus plantations.

Sampling protocol

In each of the 15 collecting areas (5 per habitat), we installed two linear transects with a length of 200 m parallel to the edges. The transects were 100 m from each other and started at 200 m from the habitat edge. In each transect we placed five traps 50 m apart from each other. The traps were installed in trees at ~2.0 m height and were baited with ~250 mL of a mix of sugarcane juice and pineapple fermented for ~72 h. Plastic containers (2 L) containing four lateral windows measuring 4 × 8 cm, and located ~18 cm above the base were used as traps. The traps were examined weekly from September to December 2012, each trap remaining active in the field for 48 h during each week.

The beetles were identified by the first (AP) and last author (JO). Vouchers are deposited at the collection of the Laboratory of Community Ecology (Universidade Federal de Viçosa [UFV], Viçosa, Minas Gerais, Brazil). A key to species for the material collected in this study can be found in Appendix S1 in the Supporting Information.

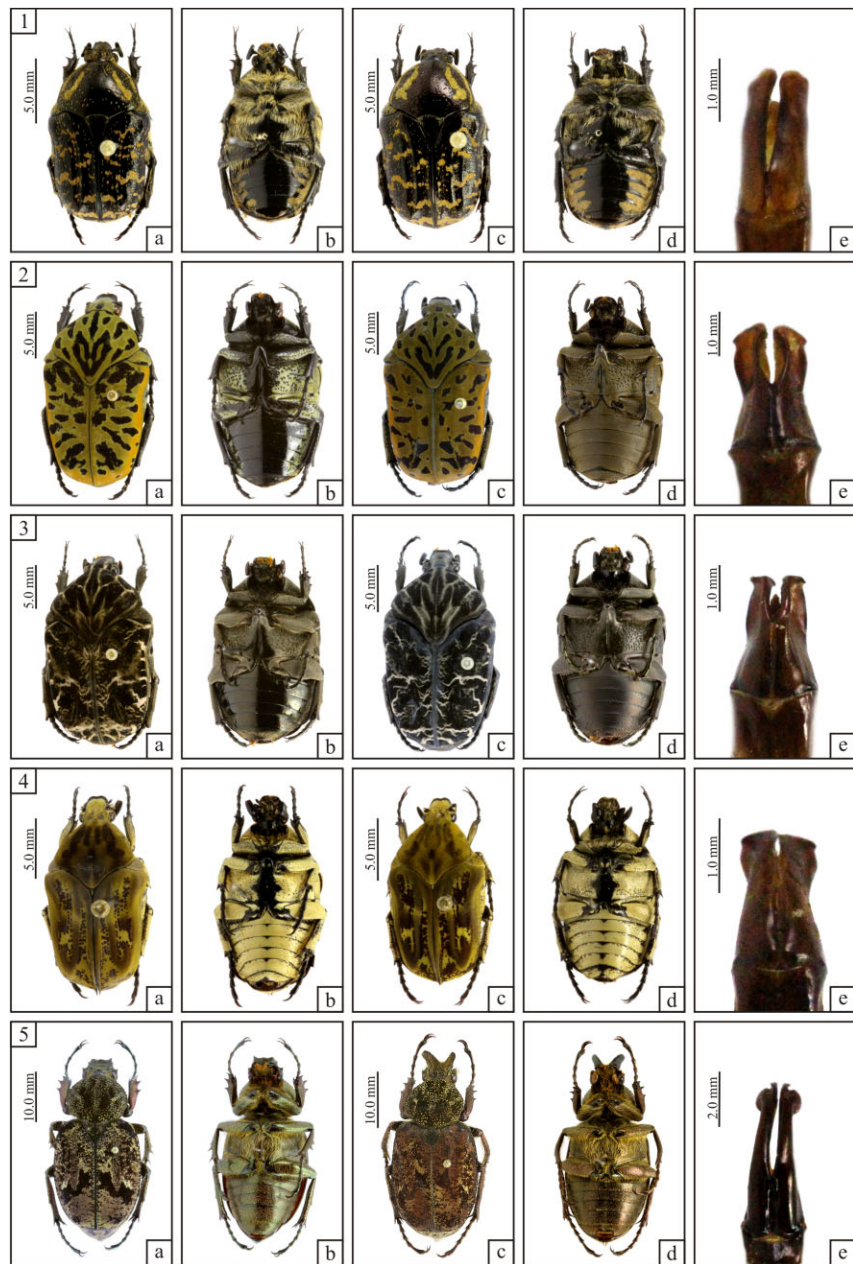
Data analysis

We consider the transects within each system as replicates, being 10 replicates sampled per habitat. We used generalized linear models (GLMs) to verify the role of the three habitats (explanatory variables) on the abundance and richness (response variables) of the beetles. All GLMs were submitted to residual analysis, so as to evaluate adequacy of error distribution (Crawley 2002). All analyses were performed using R (R Development Core Team 2013).

The collecting effort was evaluated using a species accumulation curve with a 95% confidence interval. Non-metric multidimensional scaling (NMDS) analysis was used to examine differences in species composition between the habitats. We also performed an analysis of similarity (ANOSIM) (Clarke & Warwick 2001) to verify statistical differences between groups formed by the NMDS. These analyses were performed using Primer v.6 (Clarke & Gorley 2006).

RESULTS

A total of 651 individuals distributed in five species were collected: *Euphoria lurida* (Fabricius) (Fig. 1), *Gymnetis*



Figures 1–5 1 *Euphoria lurida* (Fabricius); 2 *Gymnetis pantherina* Blanchard; 3 *Gymnetis undata* (Olivier); 4 *Hoplopyga albiventris* (Gory & Percheron); and 5 *Inca bonplandi* (Gyllenhal). Female (a) dorsal and (b) ventral view; male (c) dorsal and (d) ventral view; and (e) parameres.

pantherina Blanchard (Fig. 2), *Gymnetis undata* (Olivier) (Fig. 3), *Hoplopyga albiventris* (Gory & Percheron) (Fig. 4) and *Inca bonplandi* (Gyllenhal) (Fig. 5). The highest species number was found in the pasturelands with five species, followed by the Brazilian Atlantic Forest with four, and the eucalyptus plantation with two (Table 1).

Abundance ($F_{2,27} = 10.735$, $P = 0.0003$) and richness ($F_{2,27} = 9.9611$, $P = 0.0005$) were lower in the eucalyptus plantation and were similar between the Brazilian Atlantic Forest and the pasturelands (Fig. 6). Species

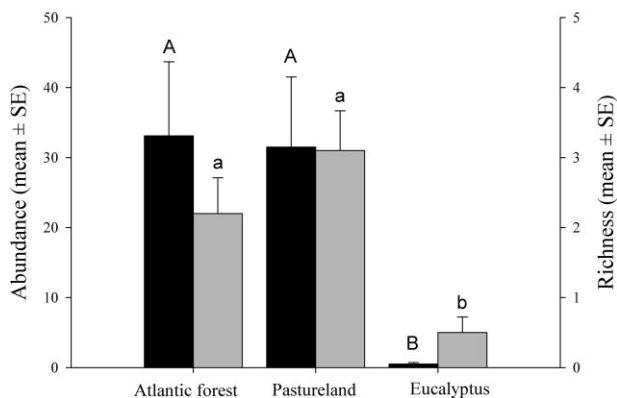
composition was statically different among habitats (ANOSIM, $R = 0.57$, $P < 0.001$) (Fig. 7). The species accumulation curve shows that the collecting method and sampling effort were adequate and sufficient (Fig. 8).

DISCUSSION

As expected, cetoniine abundance and diversity were lower in the eucalyptus plantation. Patches of Brazilian

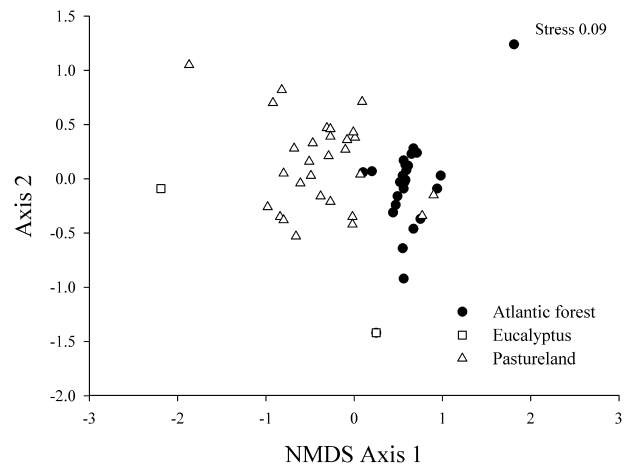
Table 1 Abundance and richness of Cetoniinae beetles (Coleoptera: Scarabaeidae) in Rio Novo, Minas Gerais, Brazil from September to December 2012

Taxon	Eucalyptus	Pastureland	Atlantic Forest	Total
Cetoniini				
<i>Euphoria lurida</i> (Fabricius)	4	114	2	120
Gymnetini				
<i>Gymnetis pantherina</i> Blanchard	1	48	90	139
<i>Gymnetis undata</i> (Olivier)		129	195	324
<i>Hoplopyga albiventris</i> (Gory & Percheron)		9		9
Incaini				
<i>Inca bonplandi</i> (Gyllenhal)		18	41	59
Total number of individuals	5	318	328	651
Total number of species	2	5	4	5

**Figure 6** Observed mean abundance and richness of Cetoniinae beetles (Coleoptera: Scarabaeidae). Different letters for bars of the same color indicate a significant difference ($P \leq 0.0005$).

Atlantic Forest and adjacent pasturelands showed similar values in abundance and richness. Nevertheless, the differences in species composition between native and exotic habitats were not as drastic as expected. Similar results have been observed in Ghana where some cetoniine species were found to be resistant/tolerant to habitat changes (Mudge *et al.* 2012).

Despite the strong sampling effort employed (see Fig. 8), we recorded a cetoniine diversity lower than expected for the area. For instance, in other fragments of Brazilian Atlantic Forest located less than 300 km from the study site, Gonçalves and Louzada (2005) collected five species during a 48 h sampling period. Of the three identified species in their study (Gonçalves & Louzada 2005), only *G. pantherina* (Fig. 2) was found in our traps. Similarly, in a patch of Brazilian savanna (Cerrado), Rodrigues *et al.* (2013) using a similar sampling protocol captured nine species, of which only *E.*

**Figure 7** Distribution pattern of the sampling points based on species composition of Cetoniinae beetles (Coleoptera: Scarabaeidae) according to grouping performed with NMDS utilizing the Bray-Curtis index.

lurida (Fig. 1) and *G. pantherina* (Fig. 2) were common to our study.

Certain species showed preference for determined habitats. For example, *H. albiventris* (Fig. 4) was found exclusively in pasturelands. In the pastures sampled, termite mounds of *Cornitermes* sp. are highly abundant, these being absent from the eucalyptus plantation and the Brazilian Atlantic Forest. These nests provide an ideal place for the development of species of *Hoplopyga* Thomson (Micó *et al.* 2001; Puker *et al.* 2012) including *H. albiventris* (Luederwaldt 1911). The exclusive presence of *H. albiventris* in pasturelands is likely to be directly related to the presence of these termite mounds.

Euphoria lurida (Fig. 1), is a known generalist (Orozco 2012b) here showing a strong preference

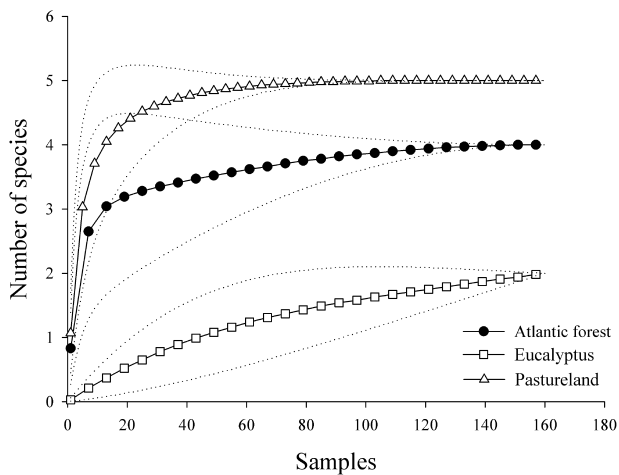


Figure 8 Individual-based species accumulation curve for Cetoniinae beetle communities (Coleoptera: Scarabaeidae). Dotted lines represent 95% confidence interval.

for open habitats (pastureland). *Gymnetis pantherina* (Fig. 2) is also a generalist being found in a variety of habitats including patches of Brazilian savanna (Cerrado) (Rodrigues *et al.* 2013), urban landscapes (Orozco & Pardo-Locarno 2004), and in this study being equally found in both pastures and forest. Neither one of these two species, despite their generalist habits, occur in strong numbers in the eucalyptus plantation (see Table 1). Adults of *Euphoria* Burmeister have been found feeding on a variety of plant tissues (flowers, petals, pollen, nectar, sap, fruit, shoots, roots) and feces (cow, horses, human) (e.g. Orozco 2012b) while their larvae are commonly found in decaying organic matter, cattle manure, ant trash deposits, and within the nests of rodents (e.g. Micó *et al.* 2000). The larvae of *Gymnetis* MacLeay, as with many other cetoniines, feed on decaying organic matter while the adults feed on fruit (Morón & Arce 2002; Neita *et al.* 2006). The availability of such resources for both *E. lurida* (Fig. 1) and *G. pantherina* (Fig. 2), and also for other cetoniines, is scarce in the eucalyptus plantation, and explains their low abundance and the absence of the other three species.

Larvae of *Inca* Lepeletier & Serville have been found feeding on rotting tree trunks (Morón 1983; Costa *et al.* 1988), while adults sometimes are found at flowers and sap flows (P. C. Grossi, pers. comm., 2012; Boos & Ratcliffe 1985). Adults of *I. bonplandi* (Fig. 5) are highly abundant in patches of Brazilian Atlantic Forest and surrounding habitats of the Brazilian southeast, being relatively easy to collect using traps baited with fermented pineapple. The high abundance in pastures with exotic grass adjacent to their native habitat (Brazilian Atlantic Forest) is not surprising.

In the course of our identifications we had difficulties separating *G. undata* (Fig. 3) from *Gymnetis chalcipes* Gory & Percheron. We concur with Di Iorio (2013) on the need to revise the status of *G. chalcipes*. Based on the distribution of these two species and the lack of unconfounded diagnostic characters we suspect these two are conspecific.

In summary, the low diversity found and the little information available on the ecology of Neotropical Cetoniinae is insufficient to propose these beetles as candidates for the evaluation of habitat changes in Brazil. Further studies to assess the effects of introduced and native ecosystems on the biodiversity of Neotropical Cetoniinae as well as a comparison of different collecting methodologies are needed.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix S1 Key for identification of the species of Cetoniinae (Coleoptera: Scarabaeidae) from Rio Novo, Minas Gerais, Brazil.

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