

Survey of Bioluminescent Coleoptera in the Atlantic Rain Forest of Serra da Paranapiacaba in São Paulo State (Brazil)

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Abstract: Brazil is the country with the largest number of bioluminescent beetle species in the world. However, estimates suggest that this number could much be higher, since many species remain to be discovered. In this work we made a survey of the species of bioluminescent beetles in Serra de Paranapiacaba – the largest remnant of Atlantic Forest in São Paulo State. The survey was done at Intervales State Park, Carlos Botelho State Park and municipality of Tapiraí and the following species were collected: *Aspisoma lineatum*, *Aspisoma physonotum*, *Aspisoma fenestrata*, *Cratomorphus besckey*, *Cratomorphus distinctus*, *Photinus penai*, *Photinus* sp₁, *Photinus* sp₉, *Ethra* aff. *malleidicta* or *axilaris*, *Ethra* aff. *adicta*, *Lucidotini incertae sedis*, *Cladodes flabellicornis*, *Cladodes demoulini*, *Amydetes lucermuta*, *Bicellonycha* sp₈, *Bicellonycha ornaticollis*, *Pyrogaster lunifer*, *Pyrogaster moestus*, *Pyrogaster* sp₂, *Pyrogaster* sp₅, *Pyrogaster* sp₆, *Photuris lugubris*, *Photuris* sp₁, *Photuris* sp₇, *Stenophrixotrix* sp₁, *Brasilocerus* sp₁, *Pseudophengodes* sp₁, *Hapsodrilus pyrotis*, *Hypsioptalmus* sp₁, *Ptesimopsia luculenta*, *Pyroptesis cincticollis*, *Pyrearinus brevicolis*, *Pyrearinus candelarius*, *Pyrearinus micatus*, *Pyrophorus divergens*. Our data show that Serra de Paranapiacaba is the second richest area in São Paulo state, especially in elaterids, with unique species typical of this area and species common to other investigated sites such as the Biological Station of Boracéia (in Salesópolis county) and the urbanized areas in the between Campinas - Sorocaba- São Paulo, originally covered to the Atlantic Rainforest.

Keywords: *Lampyridae*, *Phengodidae*, *Elateridae*, *Elateroidea*, *Staphylinidae*, *bioluminescence*, *Fireflies*, *Atlantic Rainforest*.

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Resumo: O Brasil é o país que possui o maior número de espécies de coleópteros bioluminescentes no mundo. Entretanto, estimativas sugerem que este número possa ser bem maior, dado que muitas espécies ainda não foram descritas. Neste trabalho foi realizado um levantamento das espécies de coleópteros bioluminescentes em três localidades na Serra da Paranapiacaba – a maior área remanescente contígua de Mata Atlântica no país, com associação ao respectivo habitat. No Parque Estadual Intervales, Parque Estadual Carlos Botelho e Tapiraí foram coletadas as seguintes espécies: (Lampyridae) *Aspisoma lineatum*, *Aspisoma physonotum*, *Aspisoma fenestrata*, *Cratomorphus besckey*, *Cratomorphus distinctus*, *Photinus penai*, *Photinus* sp₁, *Photinus* sp₉, *Ethra* aff. *malleidicta* ou *axilaris*, *Ethra* aff. *adicta*, *Lucidotini incertae sedis*, *Cladodes flabellicornis*, *Cladodes demoulini*, *Amydetes* sp₁, *Bicellonycha* sp₈, *Bicellonycha ornaticollis*, *Pyrogaster lunifer*, *Pyrogaster moestus*, *Pyrogaster* sp₂, *Pyrogaster* sp₅, *Pyrogaster* sp₆, *Photuris lugubris*, *Photuris* sp₁, *Photuris* sp₇; (Phengodidae) *Stenophrixotrix* sp₁, *Brasilocerus* sp₂, *Pseudophengodes* sp₁; (Elateridae) *Hapsodrilus pyrotis*, *Hypsioptalmus* sp₁, *Ptesimopsia luculenta*, *Pyroptesis cincticollis*, *Pyrearinus brevicolis*, *Pyrearinus candelarius*, *Pyrearinus micatus*, *Pyrophorus divergens*. Estes dados mostram que esta constitui a segunda área mais rica em espécies luminescentes do Estado de São Paulo, depois da Est. Biológica de Boracéia, especialmente em elaterídeos, com espécies únicas características destas localidades e espécies comuns à outras áreas investigadas, como as da Estação Biológica de Boracéia (Salesópolis, SP) e áreas urbanizadas no triângulo Campinas - Sorocaba - São Paulo, originalmente cobertas por Mata Atlântica.

Palavras-chave: *Lampyridae*, *Phengodidae*, *Elateridae*, *Elateroidea*, *Staphylinidae*, *vaga-lumes*, *bioluminescência*, *mata atlântica*.

Introduction

Brazil has the largest diversity of luminescent beetles in the world, about 500 described species, corresponding about 23% of described species in the world (Costa 2000; Viviani *et al.* 2010). These species are distributed mainly in the three main families of Elateroidea: Lampyridae, Phengodidae and Elateridae. Furthermore, two species of luminescent Staphylinidae were reported (Costa *et al.* 1986; Rosa 2010). These species are distributed mainly in the following biomes: Atlantic Rainforest, Cerrado (Savannah), Pantanal (Marshies) and Amazon Rainforest. Among these ecosystems, the Atlantic Rainforest is one of the richest and also most threatened ones, currently with only around 7-8% of the original cover or 11.4-16% when considering the the small woods (Ribeiro *et al.* 2009).

Despite their biodiversity, taxonomic and systematic studies on bioluminescent beetles in Brazil are still scarce. Detailed modern taxonomical studies are found mainly for Elateridae by Costa e collaborators (Costa *et al.* 1988, Costa 1971a, 1971b; 1972, 1975). However, the families Lampyridae and Phengodidae lack recent reviews and their systematics remains troublesome. Some studies on the biology and ecology were performed for some species of Elateridae (Costa 1975, Costa *et al.* 1988) and Phengodidae (Costa *et al.* 1999, Viviani & Bechara 1997). In the family Lampyridae, bionomic studies were done for two semi-aquatic species of *Aspisoma* spp. (Costa *et al.* 1988, Viviani 1989), *Aspisoma lineatum* Gyllenhal, 1817 (Viviani *et al.*, 2012), some lampyrid species of São Paulo State (Viviani 2001) and for *Photuris fulvipes* Blanchard 1837 (Rosa 2007). Recently, the genus *Amydetes* was revised with the description of several new species (Da Silveira and Mermudes, 2014).

Considering the growing importance of fireflies and bioluminescent beetles as potential environmental indicators (Viviani *et al.* 2010), mainly for the impact of artificial night-lighting (Lloyd 2006; Viviani *et al.*, 2010; Hagen *et al.*, 2014), and their importance for scientific studies and in biotechnology as source of bioluminescent reagents (Viviani 2007), it is urgent to make biodiversity surveys to aid conservation and bioprospection programs.

The Atlantic Forest is, after the Amazon, the second largest forest type in South America. The last corridor of this forest is located mostly in São Paulo state, being composed of a series of protected areas with more than 17.300 km² of forests (Galletti Jr *et al.* 2008). Considering the lack of knowledge about bioluminescent beetles in Brazil, in the nineties, and especially from 2006 we made surveys in the Atlantic rain forest. We already made lists of species occurring near the urban areas of Campinas, Rio Claro, Sorocaba and Votorantim cities in São Paulo State, which were mostly covered by seasonal Atlantic rain forest in the past (Viviani 2001, Viviani *et al.* 2010) and more recently about the bioluminescent species occurring in the hotspot of Biological Station of Boracéia located in the second largest remnant of Atlantic rain forest of Serra do Mar, along the coastline (Viviani & Santos 2012).

In this study we present a first survey made from 2007-2012 in the largest and most preserved remnant of Atlantic rain forest in São Paulo State, which is located along of Serra da Paranapiacaba, including three main investigated sites: (I) Cachoeira do Chá in the municipality of Tapiraí at its Northern border; (II) Parque Carlos Botelho in the middle and (III) Parque Intervalles in the Southern part.

Materials and Methods

Habitats description. The investigated sites are located in a largest continuous remnant of Atlantic rain forest along the

scarp chain Serra da Paranapiacaba, which is a subdomain of the Serra do Mar scarp chain, located about 100 km from the coast between the hydrographic basins: Sorocaba-Médio Tietê, Paranapanema and Ribeira-Southern Shore. The main kind of forest is dense mountain ombrophyl forest (Fig.1) with the following phytophysionomic divisions: (I) mountain forest located over the mountains which include tall trees; (II) humid forest located between mountains over water bodies, which includes similar vegetation to the former habitat but with the presence of species better adapted to humid environments; (III) marshy areas at the borders of water bodies and streams which display typical grasses, and (IV) open fields surrounding the reservation or along thoroughfares opened in the forest. The following sites were investigated:

Cachoeira do Chá, Tapiraí. (24°01'47.50"S - 47°3429.47"W, 595m asl). This is a trail located along a stream at the Northern border of the large remnant, bordered by the route SP-79 and located 15 km from Tapiraí municipality. In this site the mountains display an escarpment ending at Ribeira River Valley.

Carlos Botelho. (24°03'46.48"S - 47°59'30.31"W, 763m asl). This park features a rugged terrain in the upper level followed by escarpment ending at the Ribeira River Valley in the lower part (Fig.1). Located in the north, at higher elevations there is a watershed of Ribeira River Valley Basin and another (Taquaral river) of Paranapanema River Basin. The mountains have dense rain forest (Montana forest), whereas in the lower part of the drive at the southeast, the vegetation is composed mainly by lowland tropical rain forest (Submontana forest). The survey sites within this unit are located near the headquarters, in the Northern part of the Park in the municipality of São Miguel Arcanjo.

Fazenda Intervalles. (24°16'12.46"S - 48°25'17.11"W, 826m asl). This site is located on the Serra da Paranapiacaba, and also on the Planalto de Guapiara, with very rough relief cut by head-water streams. The study site in this reserve was located between Guapiara and Ribeirão Grande municipalities. The present forest coverage is characterized as Montana forest as described above and the differential in this area is the geological and geomorphological formation, with many valleys and hills. The investigated areas were all located in the protected area, with the trails in the northwestern part of the Park.

Collecting techniques. The collecting and observations were originally done in 1991 and 1993 at Intervalles, and then yearly from 2007-2012. In Intervalles, collecting and observations were done in the period of October-April and eventually in July. In Carlos Botelho the observations and collecting were made weekly between July and December from 2007-2010. In Tapiraí, observations were done from 2009-2012, with sporadic visits in the same period from November through March.

Adult lampyrids and elaterids were located by their own light at night and collected in flight with entomological net, or in the bushes or in the litterfall, during the period from August to April. They were also collected on the foliage during the day, especially diurnal lampyrids. Luminescent click-beetles and even some lampyrids such as *Cratomorphus distinctus* Olivier 1895 firefly could also be attracted to green chemiluminescent light sticks. Adult male phengodids were collected, in rare occasions, on soil and on the grass. Firefly larvae were collected on the undergrowth, in litterfall

Bioluminescent Beetles of Serra da Paranapiacaba

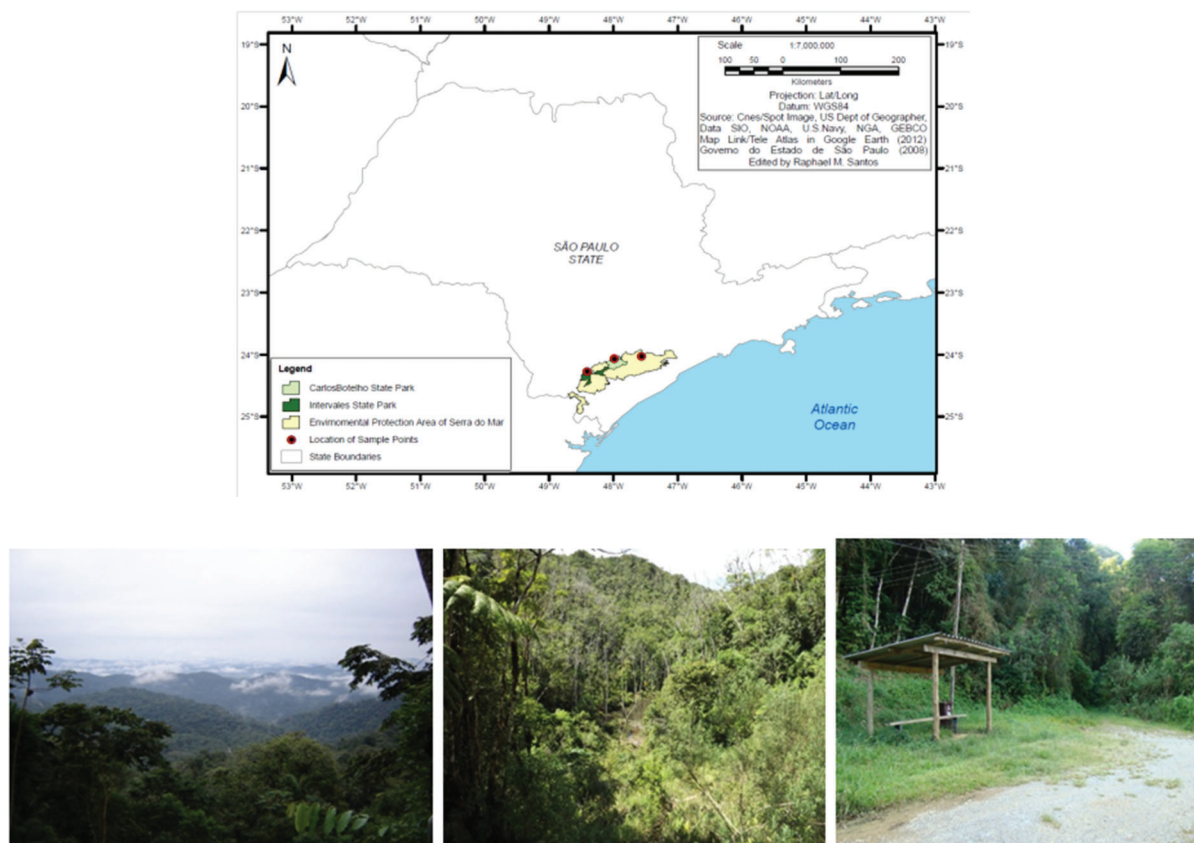


Figure 1. (Upper panel) Map of São Paulo State showing the investigated sites; (Lower panels) main vegetation types on the study area: (a) Mountain Atlantic Rainforest in the top of hills in Carlos Botelho State Park, here the view of the Submontane Forest in the Ribeira Valey Basin is shown; (b) Humid forest at Carlos Botelho State Park. View of a marshy area along riparian woods in the Taquaral stream; (c) Open field with vegetal species more light tolerant, including grasses at the ground level and creepers at the edge of woods. This image represents a site with occurrence of *Bicellonycha* sp8. – a brazilian synchronous firefly – in Intervalles State Park.

Figura 1. (Painel superior) Mapa do Estado de São Paulo, com os pontos onde foram realizados os levantamentos; (Painéis inferiores) principais tipos de vegetação nas áreas de estudo. (a) Floresta Atlântica Montana no Parque Estadual Carlos Botelho, aqui é mostrado a vista para a Floresta Submontana no Vale do Ribeira; (b) Floresta pluvial no Parque Carlos Botelho. Vista de uma área brejosa de mata ripária no Rio Taquaral; (c) Área aberta com espécies vegetais mais tolerantes à luminosidade, como gramíneas e lianas. Esta imagem apresenta um local com ocorrência de *Bicellonycha* sp8 – um vagalume sincrônico brasileiro – no Parque Estadual Intervalles.

and soil at night, by the location of their glows (Viviani 2001, Viviani *et al.* 2010). Phengodid larvae were also collected at night in the soil, in embankments, and eventually on the underbrush by location of their luminescence (Viviani & Bechara 1997).

Identification. Specimens of fireflies and their larvae were identified first by comparison with scientific collection of Professor Viviani at UFSCar, which was previously identified by comparison with the collections of Museu de Zoologia da Universidade de São Paulo (São Paulo, Brazil), Natural History Museum of Paris (France) and British Museum (London, UK). Some species were identified by Dra. S. P. Rosa during her visit at the Natural History Museum of Paris (France). Elateridae species were previously identified by Dra. C. Costa (MZUSP) and Dra. S. P. Rosa. Several lampyrid and phengodid species could not be identified, and were catalogued by the name of the genus followed by a specific number (separated in morph species), according to Viviani & Bechara (1997) and Viviani (2001). The specimens were deposited in the collection in UFSCar under curatorship of V. Viviani.

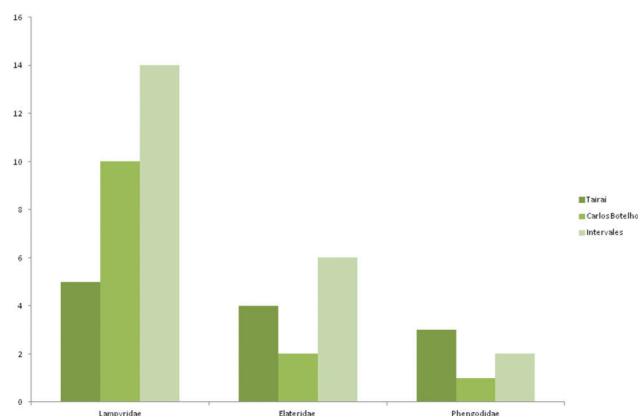


Figure 2. Number of bioluminescent Coleoptera species of different families in each site of the Serra da Paranapiacaba.

Figura 2. Número de espécies de coleopteros bioluminescentes por família em cada local de coletas e observações na Serra da Paranapiacaba.

Table 1. Species of bioluminescent beetles collected in the three different sites of Serra de Paranapiacaba.**Tabela 1.** Espécies de besouros bioluminescentes coletados nas três localidades de estudo na Serra de Paranapiacaba.

Taxon	Tapiraí	PECB	PE Intervals	Reference collection
Lampyridae				
Cratomorphini				
<i>Aspisoma lineatum</i> Gyllenhal		ok (4)		Col. MZUSP
<i>Aspisoma physonotum</i> Gorham, 1884			ok (2,3)	Col. MZUSP
<i>Aspisoma</i> sp2	ok (1,2)		ok (1,2)	Col. V. Viviani
<i>Cratomorphus besckei</i> Olivier 1895	ok (2)		ok (2)	Col. MZUSP
<i>Cratomorphus giganteus</i> Druty, 1782	ok (1)	ok (1)	ok (1)	Col. MZUSP
Photinini				
<i>Photinoides jenai</i> McDormott, 1963	ok* (1,2,3,4)	ok (1,2,3,4)	ok (1,2,3,4)	Col. MZUSP
<i>Photinus</i> sp ₁		ok (1)	ok (1)	Col. V. Viviani
<i>Photinus</i> sp ₉	ok (2)			Col. V. Viviani
Lucidotini				
<i>Ethra aff. maledicta or axilaris</i>		ok (1)		*
<i>Ethra aff. adicta</i>			ok (1)	*
Lamprocerini				
<i>Cladodes demoulini</i>			ok (1)	Col. MZUSP
<i>Cladodes flabellicornis</i>		ok (1)		Col. V. Viviani
Amydetinae				
<i>Amydetes lucernuta</i>			ok (4)	-
Photurinae				
<i>Bicellonycha</i> sp.		ok (3,4)		-
<i>Bicellonycha</i> sp ₈	ok* (3,4)		ok (3,4)	Col. V. Viviani
<i>Pyrogaster lunifer</i> Eschscholtz, 1822		ok (1)		Col. V. Viviani
<i>Pyrogaster moestus</i> Germar 1824		ok (1,2)	ok (1,2)	Col. V. Viviani
<i>Pyrogaster</i> sp ₃			ok (1)	PORTO (2011)
<i>Photuris lugubris</i> Gorham 1881		ok (1,2)	ok (1,2)	Col. V. Viviani
<i>Photuris</i> sp ₇			ok (1)	Col. V. Viviani
Phengodidae				
Mastinocerini				
<i>Stenophrinxotrix</i> sp ₁	ok (1)	ok (1)	ok (1)	Col. V. Viviani
<i>Brasilocerus</i> sp ₁	ok (1,2)			-
<i>Phrixotrix hirtus</i> Olivier, 1909	ok* (2)			Col. V. Viviani
Phengodini				
<i>Pseudophengodes</i> sp ₁			ok (1,2)	-
Elateridae				
Agrypininae/Pyrophorini				
<i>Hapsodrilus pyrotis</i> Germar, 1841	ok (1)		ok (1)	Col. MZUSP
<i>Pyroptesis cincticollis</i> Germar 1841	ok (1,3)		ok (1,3)	Col. MZUSP
<i>Ptesimopsia luculenta</i> Germar, 1841			ok (1,2)	Col. MZUSP
<i>Pyrearinus brevicollis</i> Eschscholtz 1829		ok (1)		Col. MZUSP
<i>Pyrearinus candelarius</i> Germar 1841			ok (1)	Col. V. Viviani
<i>Pyrearinus micatus</i> Costa 1978	ok (1,2)		ok (1,2)	Col. V. Viviani
<i>Pyrophorus divergens</i> Eschscholtz 1829	ok (1)	ok (1)	ok (1)	Col. V. Viviani

Legenda: ok = ocorrência; ok* = ocorrência mas sem material fixado; (1) = floresta Montana; (2) = floresta úmida; (3) = áreas brejosas; (4) = áreas abertas. ** identificação pela chave.

Legend: ok = collected; ok* = occurrence recorded but no fixed material; (1) = montane forest; (2) = umid forest; (3) = marshy areas; (4) = open field. ** identificação pela chave.

Results and Discussion

Taxonomic survey. Thirty one species of luminescent beetles were cataloged in the Serra da Paranapiacaba: 20 Lampyridae, 7 Elateridae, 4 Phengodidae and 1 Staphylinidae (Table 1).

The richness of each family of luminous beetles in each conservation unit is summarized in Figure 2.

Lampyridae (Fig. 3). The number of observed lampyrid species was 10 in Carlos Botelho and 14 in the Intervals.

In Tapiraí only five species were found (see Table 1). The smaller number found in Tapiraí could be due to the lower frequency and smaller scanned area of collecting made in this site. The following species were unique to Carlos Botelho: *Aspisoma lineatum*, *Photinus* sp₁, *Ethra aff. maledicta or axillaris*, *Lucidotini incertae sedis*, *Cladodes flabellicornis*, *Pyrogaster lunifer*, *Pyrogaster* sp₅ and *Pyrogaster* sp₆. Seven species were found at Intervals but were not been found in Carlos Botelho and Tapiraí: *Aspisoma physonotum*, *Aspisoma fenestrata*, *Amydetes lucernuta*, *Bicellonychia ornaticollis*, *Pyrogaster moestus*, *Photuris* sp₁ and *Photuris* sp₇.

Bioluminescent Beetles of Serra da Paranapiacaba



Figure 3. Some species of fireflies sampled on SA de Paranapiacaba: (a) *Cratomorphus giganteus*; (b) *Cratomorphus besckei*; (c) *Aspisoma lineatum*; (d) *Aspisoma physonotum*; (e) *Aspisoma sp₂*; (f) *Photinoides jeni*; (g) *Photinus sp₁*; (h) *Photinus sp₉*; (i) *Aethra aff. malleidicta* or *axilaris*; (j); (k) *Amydetes lucernuta*; (l) *Cladodes flabellicornis*; (m) *Cladodes demoulini*; (n) *Photuris lugubris*; (o) *Photuris sp₇*; (p) *Pyrogaster moestus*; (q) *Pyrogaster lunifer*; (r) *Pyrogastes sp₃* (ref. Diego S. Porto).

Figura 3. Algumas espécies de lampirídeos coletadas na SA de Paranapiacaba: (a) *Cratomorphus giganteus*; (b) *Cratomorphus besckei*; (c) *Aspisoma lineatum*; (d) *Aspisoma physonotum*; (e) *Aspisoma sp₂*; (f) *Photinoides jeni*; (g) *Photinus sp₁*; (h) *Photinus sp₉*; (i) *Aethra aff. malleidicta* ou *axilaris*; (j); (k) *Amydetes lucernuta*; (l) *Cladodes flabellicornis*; (m) *Cladodes demoulini*; (n) *Photuris lugubris*; (o) *Photuris sp₇*; (p) *Pyrogaster moestus*; (q) *Pyrogaster lunifer*; (r) *Pyrogastes sp₃* (ref. Diego S. Porto).

There is a unique species which was collected only in Tapirai – *Photinus sp₉* – which displays a different bioluminescent signal from other *Photinus* species collected in Brazil, being characterized by a bimodal flash with bioluminescence spectrum peaking at

561 nm which is slightly blue-shifted in relation to other species of the genus found in the region (Viviani *et al.* 2010). **Phengodidae.** Only four species of phengodids were found in Paranapiacaba. In Carlos Botelho only the arboreal *Stenophrixotrix sp₁* larvae were

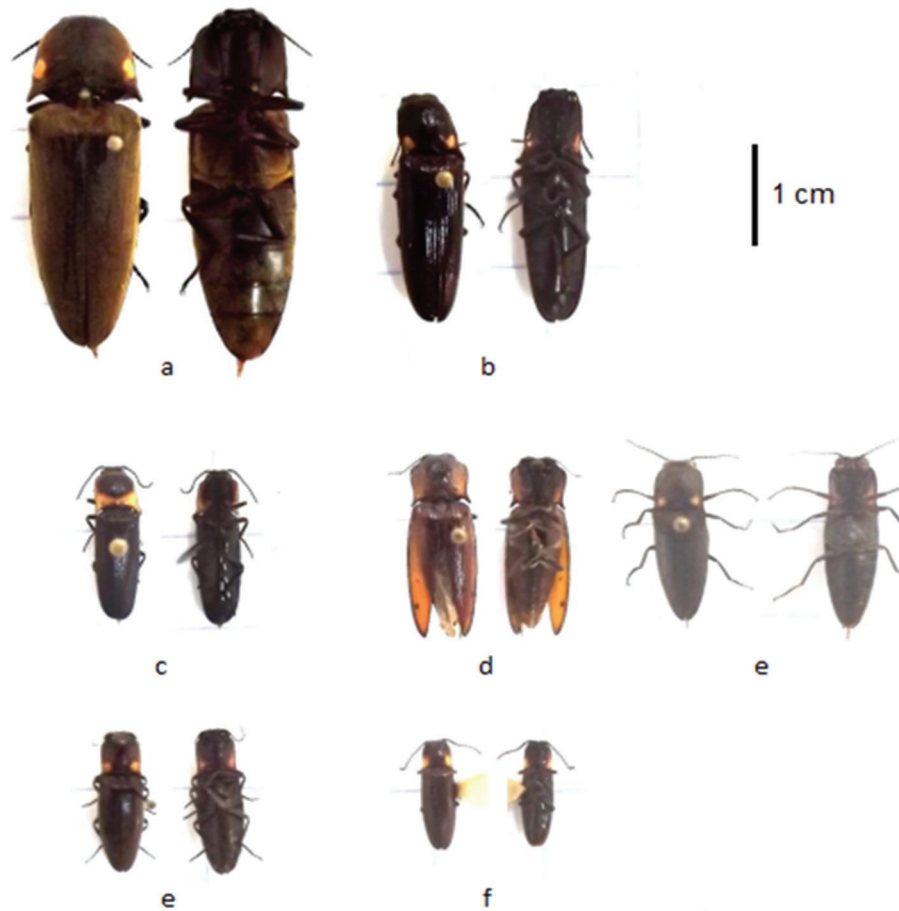


Figure 4. Bioluminescent click-beetles of SA de Paranapiacaba: (a) *Pyrophorus divergens*; (b) *Ptesimopsia luculenta*; (c) *Ptesimopsia cincticollis*; (d) *Pyrearinus candelarius*; (e) *Pyrearinus micatus*, (f) *Pyrearinus brevicollis*; (g) *Hapsodrilus pyrotis*.

Figura 4. Elaterídeos bioluminescentes da SA de Paranapiacaba: (a) *Pyrophorus divergens*; (b) *Ptesimopsia luculenta*; (c) *Ptesimopsia cincticollis*; (d) *Pyrearinus candelarius*; (e) *Pyrearinus micatus*, (f) *Pyrearinus brevicollis*; (g) *Hapsodrilus pyrotis*.

found. In Tapiraí *Brasilocerus* sp₂ and *Phrixotrix hirtus* were found and in Intervalles *Pseudophengodes* sp₁. The arboreal *Stenophrixotrix* sp₁ was common to all three areas. When compared with Boraceia, the number of species and abundance of phengodids was lower. The following species were found in both places: *Brasilocerus* sp₂, *Phrixotrix hirtus* and *Stenophrixotrix*.

Elateridae (Fig. 4). The studied area was especially rich in luminescent click-beetles, with eight species: *Hapsodrilus pyrotis* Germar 1841, *Hypsiophthalmus* sp₁, *Ptesimopsia luculenta*, *Pyrearinus brevicollis*, *Pyrearinus candelarius*, *Pyrearinus micatus*, *Pyrearinus* sp., *Pyrophorus divergens*. All these species were found at Intervalles.

In Tapiraí, four species of bioluminescent click-beetles were found: *Pyrophorus divergens*, *Hypsiophthalmus* sp₁, *Pyrearinus micatus* and *Pyrearinus meatus*: The species *Hapsodrilus pyrotis*, *Ptesimopsia luculenta* and *Pyrearinus candelarius* were not observed in Tapiraí and Carlos Botelho. Comparatively, Boraceia Biological Station showed only three species (*Pyrophorus divergens*, *Pyrearinus micatus* and *Hapsodrilus pyrotis*) and the municipalities of Campinas and Sorocaba four species (*Hapsodrilus ignifer*, *Pyrearinus candelarius*, *Pyrearinus micatus* and *Pyrophorus divergens*).

Considering that the surveys were conducted in the same morphoclimatic domain and continuous geographic Mountain Tropical Rain Forest, it was surprising that several of these species were not found more widely distributed among these areas. This could be due to two reasons: (1) there is more heterogeneity in the habitats than assumed, and the same kind of specific habitats were not sampled in the three localities, or (2) because the survey was not conducted simultaneously in the three areas. In this case, the seasonality of adults of a given species may vary between areas.

Comparison with other sites of Atlantic forest. When comparing this survey to Biol. St. of Boraceia, which is the second largest remnant of Atlantic Rainforest in São Paulo State, Paranapiacaba remnant showed a slightly smaller biodiversity. The following species were found in common in these two sites: *Aspisoma physonotum* Gorham 1884, *Cratomorphus besckei* Olivier 1895, *Cratomorphus distinctus* Olivier 1895, *Photinus penai* Germar 1824, *Cladodes flabellicornis* Motsch 1853, *Pyrogaster moestus* Germar 1824, *Pyrogaster* sp₂, *Photuris lugubris* Gorham 1881, *Photuris* sp₇, *Hapsodrilus pyrotis* Germar 1841, *Pyrophorus divergens* Eschsholtz 1829 and *Pyrearinus micatus* Costa 1978. Paranapiacaba forests were especially rich in

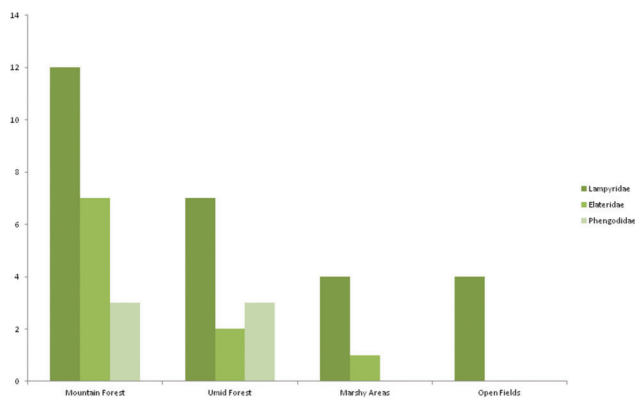


Figure 5. Distribution per habitat of the main families of bioluminescent beetles in Serra da Paranapiacaba.

Figura 5. Distribuição por habitats de famílias de besouros bioluminescentes da Serra de Paranapiacaba.

elaterids, whereas Boracéia was richer in fireflies. When compared with the fragmented remnants of the semi-seasonal forests and secondary growths of urbanized areas of Campinas, Sorocaba and Rio Claro municipalities, only the following species were found in common: *Aspisoma lineatum*, *Aspisoma physonotum* Gorham 1884, *Cratomorphus distinctus* Olivier 1895, *Photinus* sp₁, *Photinus* sp₂, *Amydetes lucermuta*, *Bicellonycha ornaticollis* Blanch, *Pyrogaster moestus* Germar 1824, *Photuris* sp₇, *Pyrearinus micatus* Costa 1978 and *Pyrophorus divergens* Eschsholtz 1829. Thus, the species: *Aspisoma fenestrata*, *Ethra aff maledicta* or *axillaris*, *Bicellonycha* sp₈, *Pyrogaster lunifer* Eschsholtz., *Photuris* sp₁, *Brasilocerus* sp₂, *Hypsiophthalmus* sp₁, *Ptesimopsia luculenta*, *Pyrearinus brevicolis* and *Pyrearinus* sp₁ were apparently unique to Paranapiacaba forests.

The frequency of species per family in places where they are visibly more abundant is shown on Fig. 5. There is an apparent trend for greater richness for all families in Mountain Forest. More refined analysis with quantification of abundance is however required, to confirm whether the diversity of habitats is significant or not. Marshy areas seem to harbor a lower number of species.

Conclusions

The Serra de Paranapiacaba displays the second largest diversity of luminescent beetles in the Atlantic rain forest morphoclimatic domain of São Paulo state, with 34 species. Some species are common to sampled areas of semi-seasonal forest close to urbanized areas of inner São Paulo state and to the second largest and most preserved area of Biological Station of Boracéia. This area is especially rich in elaterid luminescent beetles, but displays poorer diversity of Phengodidae.

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