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Resultados de pesquisas limnológicas e afins na área de captação do Rio Amazonas e regiões tropicais adjacentes, realizadas em cooperação entre o Instituto Nacional de Pesquisas da Amazônia (INPA), com sede em Manaus/Amazonas, Brasil, orgão vinculado ao Ministério da Ciência e Tecnologia (MCT), e o Instituto Max-Planck para Limnologia, Grupo de Trabalho Ecologia Tropical, em Plön (Holstein), República Federal da Alemanha.

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Fundada por / Gegründet von
DJALMA BATISTA e / und HARALD SIOLI

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Preface

Dear readers of AMAZONIANA, dear colleagues,

At the beginning of 1965 Prof. Dr. Harald Sioli, Director of the Max-Planck-Institute for Limnology (MPIL) at Plön, Germany, and Prof. Dr. Djalma Batista, Director of the National Institute for Amazonian Research (INPA) at Manaus, Brazil, founded a new scientific journal for the promotion of limnology and landscape ecology in Amazonia, and to strengthen the Brazilian - German cooperation within the Amazon basin. In 1968 the Brazilian editorship passed to Prof. Dr. Heitor Grillo and in 1972 to Dr. José Cândido de Mello Carvalho, both from Rio de Janeiro. After his retirement (and my nomination as Head of the Tropical Ecology Working Group at the MPIL), Prof. Sioli invited me to assume the function of the German editor (as of 1982). In 1992, I invited Prof. Dr. Francisco de Assis Esteves (Rio de Janeiro) to act as Brazilian editor, and Prof. Dr. Joachim Adis (MPIL) to become the executive editor. Prof. Adis has coordinated all editorial work since, with the help of Dr. Bernd Friebe at Giessen, Germany (1992-1994) and Prof. Dr. Ulrich Saint-Paul at Bremen, Germany (1995-2007).

In 1965, the first fascicle of AMAZONIANA was published, and became the main journal for limnological research in Amazonia. Since that time, 19 volumes with 4 fascicles each have been published, and AMAZONIANA has become a rich source of scientific information about Amazonia for students and scientists. However times have changed, with the increasing interest of the scientific community in the Amazon basin the number of studies have increased dramatically. To cope with the rising number of publications INPA founded a new journal (ACTA AMAZONICA) in 1971, that published a wide range of papers about the area. In addition, other scientific journals now accept papers about different aspects of research within this region. In response to the increasing demand on comparative studies of wetlands and water bodies, in 1990 the editorial board of AMAZONIANA opened the journal to papers dealing with all types of wetlands in tropical South America. This allowed the acceptance of papers of other regions e.g. the Pantanal of Mato Grosso, that have many similarities with Amazonian floodplains, but also show considerable differences.

It is the rule in the Max-Planck-Society that with the retirement of directors the respective departments and working groups are closed, this allows flexibility to cope with new scientific challenges. This time has now come for the MPIL in Plön, with the retirement of Prof. Lampert (Head of the Department Ecophysiology) in September 2006 and my retirement in June 2007, Limnology and Tropical Ecology will end at the Max-Planck-Institute in Plön. The editorial board of AMAZONIANA has discussed different ways to continue the publication of the journal, but we came to the conclusion that without the active scientific cooperation between MPIL (Plön) and INPA (Manaus), AMAZONIANA would loose its characteristic profile and identity. Furthermore,

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financial support of the Max-Planck Society will end and with that the invaluable input given by members of the institute (mainly by Prof. Adis and his technical staff Ingrid Ploog and Herbert Kiesewetter), to guarantee the quality of the journal. Therefore we came to the conclusion that the end of the Tropical Ecology Working Group is an appropriate moment to also cease publication of the journal AMAZONIANA.

The editorial board of AMAZONIANA would like to thank the Max-Planck Society for its long lasting financial support of the journal, our technical staff for their invaluable help, the authors for submitting manuscripts and last but not least the readers for their interest in the journal. A period of fruitful research and cooperation between MPIL Plön and INPA Manaus, documented by AMAZONIANA has come to an end. Its time to say goodbye.

Plön, June 2007 Prof. Dr. Wolfgang J. Junk

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Wetland vegetation of the lower Orinoco Delta plain (Venezuela): A preliminary approach

by

T. Vegas-Vilarrúbia, M.E. Ponce, O. Gómez & L. Mora

Dr. Teresa Vegas Vilarrúbia, Dep. Ecologia, Facultat de Biologia, Universitat de Barcelona, Av. Diagonal 645, Edf. Ramon Margalef, 08028, Barcelona, Spain; e-mail: tvegas@ub.edu
Dr. Maria Elena Ponce, Geohidra Consultores C.A., Edif. Geohidra, Calle Razetti, Los Chaguaramos Caracas, Venezuela; e-mail: mauritiaponce1@cantv.net
Dr. Oscar Gómez, Gerencia Corporativa de Ambiente e Higiene Ocupacional, Centro Empresarial Parque del Este (CEPE), piso 10, Avda. Francisco de Miranda, Los Dos Caminos, Caracas, Venezuela; e-mail: gomezos@pdvsa.com
MSc. Luis Mora, Environmental Managemen Office, Aimvenca, C.A., Sigo I, Complejo Criogenico de Jose, Estado Anzoátegui, Puerto La Cruz, Venezuela; e-mail: lumora@cantv.net
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Abstract

This is a preliminary study of the vegetation of a potential oil prospecting zone of remote areas of the Orinoco Delta. It aims to provide a scientific basis to delineate efficient conservation strategies. Flora, life and growth forms were examined along with ethnobotanical aspects, as there are three Warao Indian settlements in the area. Various vegetation patterns were identified from satellite images and aerial photographs: swamp and palm forests, mangroves, shrubland and meadows. The first vegetation map of the zone was elaborated (1:25.000). Over 500 botanic samples encompassing 77 families, 148 genera and 205 species were collected. Twenty-two families had 3 to 20 species, the remaining families had only one or two, being Orchidaceae, Araceae and Bromeliaceae the best represented ones. Endemic species known for the Venezuelan Guayana were not observed in the study area. A non-gramineous meadow, not reported before for the Venezuelan Guayana, combines three dominant species, the fern *B. serrulatum* and the cyperaceous herb *Lagenocarpus guianensis*. The main forest forming species showed morphological adaptations to flood and anoxic conditions, for which they are expected to be particularily sensitive to oil pollution. Around 40 % of the plants species used by the Warao Indians in the study area are for medical purposes.

Keywords: **Biodiversity, swamp forest, *Mauritia* sp., meadow, mangrove, natural resources.**

Resumo

Este é um estudo preliminar de vegetação de uma potencial zona de prospecção de crude em áreas remotas do Delta de Orinoco, de modo a fornecer uma base científica para o delineamento de estratégias eficientes de conservação. Flora local, formas de vida e crescimento foram examinados conjuntamente com aspectos de etnobotânica, devido à presença de três povoamentos de índios Warao nesta região. Vários padrões de

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vegetação foram diferenciados com base em imagens de satélite e fotografias aéreas: paúis e florestas de palma, mangais, áreas arbustivas e pradarias. Elaborou-se o primeiro mapa de vegetação da zona (1:25.000). Mais de 500 amostras botânicas englobando 77 famílias, 148 géneros e 205 espécies foram recolhidas. Vinte e dois famílias incluem 3 a 20 espécies, enquanto as restantes famílias abrangem apenas uma ou duas espécies, sendo Orchidaceae, Araceae e Bromeliaceae as melhor representadas. Na presente área de estudo não foram observadas espécies endémicas características da flora da Guiana Venezuelana. Um prado não-gramináceo, dominado pelo feto *B. serrulatum* e a Cyperacea *Lagenocarpus guianensis*, é pela primeira vez descrito para a Guiana Venezuelana. Nas formações florestais, as principais espécies apresentam adaptações morfológicas para resistir a cheias e condições de anóxia, pelo que se espera serem particularmente sensíveis à poluição por petróleo. Cerca de 40 % das espécies de plantas utilizadas pelos índios Warao são empregadas a fins medicinais.

Introduction

One of the main objectives of nature conservation activities is to assure the long-term survival of the largest possible number of species, in accordance with the precautionary principle (CLUBBE 1996). To promote conservation, information about species location, descriptions, specific composition and the needs of natural communities is urgently required, in particular about high biodiversity hot spots. However, in recent times, taxonomic concern for biodiversity has been accompanied by a dismissal of the basis of biodiversity work, which involves the proper description of taxa (VALDECASAS et al. 2000).

Venezuela has been qualified as one of the six South American "megadiversity" countries (WWF & IUCN 1994). The Orinoco Delta region largely contributes to this perception, as it is a landscape with considerable biogeographical significance that concentrates an important number and variety of species (STEYERMARK et al. 1995). When the Orinoco reaches its delta, it splits in over 30 river branches and 300 labyrinth-like currents (caños) before flowing into the Atlantic Ocean. This gives rise to numerous islands, riversides and vast wetlands. Luxuriant swamp forests and several types of mangroves grow in these environments that are rich in terrestrial and aquatic fauna (LINARES 1998). Access to this remote region is difficult, unsafe and expensive, which may explain the current lack of scientific information.

In 1896, the North American botanist H.H. Rugby assembled the first lower Orinoco Delta region plant collections, (STEYERMARK el al. 1995). Since then, national and foreign botanists have put together other collections (SOCIEDAD DE CIENCIAS NATURALES LA SALLE 1954; DANIELO 1964; STEYERMARK 1968, 1979; DELASCIO CHITTY 1985; COLONNELLO 1995; COLONELLO & MEDINA 1998; MONTOYA 2003). In addition, some existing vegetation-related studies, which are not strictly floristic, are considered to be pioneers for the region (MÜLLER 1959; VAN ANDEL 1967; PANNIER 1979; SHEIHING & PFEFFERKORN 1984; HOFFMAN 2002; RABOLD 1990). The results of these explorations have made it clear that, to a large extent, the flora of the Orinoco Delta belongs to the physiographic and biogeographical region of the South American Guayana. The Venezuelan Guayana (VG), located in the Guayana Shield, is the main core of this region (STEYERMARK et al. 1995). Documents dealing with land use planning also contain useful information (TAMAVENCA 1971; MARNR 1982, 1983-1984; CANALES 1985; ASERRADERO ZAMORA 1996; MANACA ORINOCO C.A. 1993).

In the nineties, different initiatives came together to promote oil prospecting in extensive areas of the upper, middle and lower Orinoco Delta (LANDER 1997). Little or no environmental and ecological information was available for these areas. To date, the best floristic and biogeographical descriptions of the Orinoco delta plains are furnished by STEYERMARK et al. (1995), but there are still to general for specific managerial purposes. Therefore it became essential to inventory the existing and still unknown natural elements of the study area to delineate concrete conservation strategies. Such inventories would also provide scientific knowledge that could become unobtainable if these pristine environments are disturbed or lost.

This paper is a preliminary study of the different vegetation formations in a vast potential oil and gas prospecting area of the lower Orinoco Delta. It gives an insight into the so far poorly known vegetation of the Orinoco Delta. It also represents a baseline state against which changes in distribution and extention of vegetation formations and transformation of areas can be assessed through time. The first vegetation map of the area is provided. Species richness, endemisms related to the Venezuelan Guayana region and aspects related to ethnobotany are assessed as biodiversity values.

The study site

The Orinoco Delta is a large wetland formed by a fluviomarine sedimentary plain. It covers a surface area of 42,000 km^2, has slopes <1 % and elevations <10 m a.s.l. Geologically it is located in the sub-basin of Maturín which is part of the Eastern Venezuela basin. Structurally, it is an active faults zone (GONZÁLEZ DE JUANA et al. 1980). Seismic evidence and natural oil seeps have shown the existence of crude oil. Subsidence, tectonic and geotectonic processes, and the effect of fluvial inputs and marine currents as well, have given raise to three distinct physiographic landscapes: a) the Upper Delta with prevalent fluvial processes of sedimentation; b) the Middle Delta, dominated by swampy fluviomarine plains; c) the Lower Delta, next to the Atlantic Ocean. This lower area is the most extensive and includes marshes, estuaries and minor fluviomarine forms that are subjected to tidal influence (DELASCIO CHITTY 1985; WARNE et al. 2002). The study area extends over 941.9 km^2. It is situated between Punta El Tigre and Punta Tolete. To the north, it borders the Atlantic Ocean along 80 km of coast. It also extends about 20-30 km inland (Fig. 1). A moist tropical climate prevails, with precipitations surpassing 1800 mm year^{-1} (PDVSA 1992). Flood conditions are almost permanent throughout the year. The area is drained by shallow water channels called "caños", which are subjected to the tidal dynamics of marshy-swampy areas. These channels join at Cocuina island (Fig. 1). Soils are organic and hydromorphic and include: Tropofibrists, Tropohemists, Sulfhemists, Hydraquents and Sulfaquents having bad drainage, acidic pH and a low base exchange capacity (MARNR 1982; PDVSA 1992). Apart from the hydrological impacts of damming Caño Mánamo (COLONELLO & MEDINA 1998), human activities still had little effect on the delta processes and environment. Three Warao Indian settlements exist in the mouth of the Orinoco; at Mariusa, Cocuina and Macareo caños outlet (Fig. 1).

Material and methods

A vegetation map of the study area (1:25,000) was elaborated using photogrammetry and remote sensing techniques to interpret the different plant communities' spatial patterns. The 1997 Amoco Ven mission provided color aerial photographs of about 60 % of the study area to a scale of 1:25,000. They were rectified, restituted, interpreted and finally divided into sectors on a digitalizing table. The remaining 40 % of the study area was examined with the help of scene 001/053 (July 1991) of a Landsat 5-TM (7-channel scanning radiometer) satellite image. Combinations of infrarred bands (mid-infrared band 5, near-infrared band 4, and visible band 2) were utilized to outline different vegetation formations and operational types (UNESCO, 1993; BERRY et al. 1995). A non-supervised classification (isodata) was applied on the Landsat-image to corroborate the definition of the vegetation units based on the aerial photographs interpretation. Scene 233/053 (December 1986) was used only as reference to visualize cloudy areas. To designate structural vegetation categories and draw up the map legend, we combined photogrametry and field verification. The main criteria applied were canopy cover, height and density. The obtained photogrammetric and digital classifications based on visual patterns were supported by an extensive and thorough field survey comprising 227 regularely distributed checking points (1 point/4 km^2). Canopies were categorized "in situ" as "height" (30-20 m), "mid" (19-5 m) and "low" (<5 m). Canopy density was qualified as "dense" when it was uneven and tree crowns touched each other with interlocking; "mid" when it was regular and tree crowns touched each other without interlocking, and "open" when tree crown did not touch each other leaving canopy gaps or clearings. These data were complemented by identifying the most frequent combination of forest forming species in each checking point, with the help of specialized literature (STEYERMARK el al. 1995). Dasonomic and floristic data were then associated to each distinct vegetation formation and type previously identified on the image. The original color vegetation map was delivered to the Venezuelan Ministry of the Environment and Natural Resources (MARNR) as part of the baseline study of the area (GEOHIDRA CONSULTORES 1998). A simplified version of this map on a 1:400,000 scale is provided in this paper, showing only five vegetation formations (Fig. 2), and a summary of the preliminary vegetation types encountered (Table 1).

Field work to assess species richness and life forms was carried out between April and June 1998 with the help of helicopter flights. The selection of sampling points for plant collection was based on a preliminary version of the vegetation map and on field accessibility (helipads). In forested and shrub areas, floristic description was undertaken in 0.1 ha plots: 28 in swamp forests (SF), 16 in mangroves (MG), 8 in palm forests (MO), 3 in shrubland (SHR) and 4 in wooded meadows (MD). In 16 treeless meadows, species were identified along 50 m^2 strips of herbaceous vegetation. Figure 1 shows the 59 locations of the plots and strips. Botanical samples and their replicates were collected, labeled and preserved with 70 % isopropyl alcohol. Collected specimens were deposited in the Universidad Nacional Experimental de Los Llanos Ezequiel Zamora (UNELLEZ) herbarium. Botanists from this herbarium carried out most of the taxonomic determinations. Species were classified according to their life (RAUNKIAER 1934) and growth forms (MÜLLER-DOMBOIS & ELLENBERG 1974; VARESCHI 1992). If species were or not endemic of the Venezuelan Guayana was checked against the "Flora of the Venezuelan Guayana" (STEYERMARK et al. 1995), the Internet database W3 TROPICOS and the checklist of the Biological Diversity of the Guianas program of the Smithsonian Institute. Qualitative ethnobotanical information was collected "in situ" from the indigenous Warao population settled at Cocuina, with the help of José Güiria and Pedro Guarena, two Warao guides, which lived in the study area and were incorporated into the project.

Results

Vegetation patterns

Swamp forest, meadow, mangrove, *Mauritia flexuosa* palm forest (locally known as "morichales"; GONZÁLEZ 1987), and shrubland were the main vegetation formations found. They were arranged in a mosaic pattern, covering 34,477 ha (36,8 %), 30,752 ha (32,8 %), 20,696 ha (22,1 %), 4,827 (8,41 %) ha and 3,070 ha (3,27 %) of the study area, respectively (Fig. 2). Meadows and swamp forests were the best represented in terms of coverage, swamp forests and mangroves showed the most conspicuous patterns. Vegetation cover patterns based on density, height and species arrangement enabled different and preliminary vegetation types to be distinguished within each plant formation. Different combinations of the most frequent species were observed in each category (Table 1). *Rhizophora mangle* and *R. racemosa* were the most frequent among mangrove trees. Mangroves of *R. mangle*, *Avicennia germinans* and *Laguncularia racemosa* either grew along the ocean coast - exposed to direct tidal action and marine currents - or in more inland positions in basins or depressions. *Rhizophora* spp. formed dense gallery forests bordering the caños tens of kilometers upstream. In more inland ecotonal areas, mangrove stands were mixed with palms (*Euterpe* spp.) and the tree *Pterocarpus officinalis*. Swamp forests grew behind the mangrove belt, being the most conspicuous species *Tabebuia insignis* var. *monophylla*, *Pterocarpus officinalis* and

Diospyros lissocarpoides (Table 1). They developed landwards into the interdistributary alluvial plains, extending onto terrain flooded by water from pluvial, fluvial or fluvio--marine origin. The understory is open and trees can reach 30 m in height. Many of them have pneumatophores and adventitious, tabular or stilt roots. *P. officinalis* was one of the best equipped trees to succeed in swampy, oxygen-depleted environments. The swamp forest was still relatively pristine, with only occasional human intervention. *Mauritia flexuosa* is the most important species in palm forests locally known as "morichales" ("cananguchales" in Colombia, "buritizales" in Brazil), followed by *T. insignis* and *P. officinalis* (Table 1). The "morichales" were most frequently located between forests and meadows. However east of the Cocuina Island along the caño Simoina (Fig. 2), they occurred in patches within the meadow matrix. This vigorous palm tree sometimes attains 30 m in height. It has a flabelliform crown made up of 10-14 large costa-palmate leaves, which are about 6 m long. *M. flexuosa* was never found exposed to brackish water inputs. Shrubland was sparse and azonal. It appeared in isolated patches, growing between mangroves and swamp forests. It consisted of stunted-looking shrubs, with stems oriented to the west probably due to influence of the winds. The main species were *Chrysobalanus icaco* and *Ilex martiniana* (Table 1). Meadows evolved mostly within the deltaic plain away from the caño's influence in areas with bad drainage and long-lasting floods. They were characterized by a continuous 1-1.5 m high herbaceous cover. Isolated or patchy wooded components were occasionally observed. Meadows were dominated by the fern *Blechnum serrulatum* and the cyperaceous herbs *Lagenocarpus guianensis* and *Rhynchospora gigantea*, which prevailed both in treeless and wooded meadows. *I. martiniana* and *M. flexuosa* were the main woody elements (Table 1).

Species richness

A floristic inventory of the study area is provided in Appendix 1. It indicates the species identified, their life and corresponding growth forms, and the plant formations where they were found. In total, 583 botanic samples and their replicates were collected. Their identification resulted in 77 families, 148 genera and 205 species (192 phanerogams and 13 cryptogams). Nineteen families had between 3 and 20 species; the remaining 55 had only one or two. Orchidaceae was the best represented family with 9.8 % of the total number of species and 14 genera. Araceae accounted for 5,9 % of the species and 6 genera, Bromeliaceae for 5,4 % and 4 genera, and Moraceae, Fabaceae, Clusiaceae and Arecaceae each accounted for 4,4 % of the species. Total species distribution among the five plant formations was as follows: 152 (74,5 %) in swamp forests, 75 (36,8 %) in mangrove, 49 (24,0 %) in "morichales", 51 (25,8 %) in shrubland and 33 (16,2 %) in meadows. Regarding species distribution among vegetation types, 131 (64,2 %) species appeared only in one type of vegetation. Only 8 (3,9 %) species were found in all five types. Over 55,3 % of the plant species collected in the swamp forest was not found in the other vegetation types. This percentage was 34,7 % in mangroves, 18,4 % in "morichales", 5,9 % in shrubland and 27,3 % in meadows. Tree species of the forested areas in 0.1 ha plots was 13-31 (average 20±6 sp.) in SF, 1-19 (average 10±4 sp.) in MG and 2-16 (in average 10±6 sp.) in MO. We did not collect samples until species saturation, due to the preliminary nature of this work. Therefore, an increase in species richness is expectable with increasing sampling area.

Life and growth forms

Figure 3a shows the distribution of life forms within the plant formations. Phanerophytes were predominant, followed by hemicryptophytes. Therophytes, helophytes and hydrophytes were rather rare. Regarding growth forms, transport and support functions were mostly provided by tree-like structures (Fig. 3b). Epiphytic forms of Orchidaceae, Araceae and Bromeliaceae were frequent, especially in swamp forests and mangroves. In mangroves, Orchidaceae accounted for 20 % of the species encountered, Araceae for 36,4 % and Bromeliaceae for 63,6 %. Lianas preferentially grew in forest and shrublands; herbaceous growth forms, such as ferns and Cyperaceae, in meadows.

Ethnobotanical aspects

The Warao are the aboriginal inhabitants of the Orinoco Delta. They call themselves "people of water" or "people of canoe". In the study area they live in palaffites along the mangrove shores or in open waters, like in Mariusa and Cocuina. Handicraft and subsistence fishing and hunting, and harvesting of forest products constitute the main land uses in these communities. Table 2 summarizes the ethnobotanical information collected in the field. It includes 29 plant species, their corresponding Warao and scientific names, and their uses in the afore mentioned communities. Of the reported species, 37,9 % are allotted to health care, 27,5 % to food supply, 27,5 % to weapon, canoe, and tool production, 20,7 % to buildings, 3 % to handicraft and 3 % to commercialization.

Discussion

The wetland forests of the lower Orinoco Delta correspond to the Tropical Ombrophilous Forest Formation (HUBER & ALARCÓN 1988; UNESCO 1973). Relatively little is known about them in comparison to their homologous of the upper, middle and lowland (non-delta) reaches of the basin, which have high species diversity (HUBER 1995). There are no single or generally accepted methods for assessing species diversity. One of its most basic expression is species richness (BEGON et al. 1999; WHITTAKER et al. 2001). Tree species number in 0.1 ha plots of wetland forests in the study area were between 1 and 31, being SF the most diverse. URREGO (1997) recorded 139 species in plots of 0.6 ha in the Colombian Amazon swamp forests. In the Amazonian Pantanal region, forest studies yielded 18 and 42 species in 0.33 ha, 11 species in 0,42 ha, 33 species in 0,49 ha (SOUZA et al. 1997), 7 species in 0,2 ha (DUBS 1994) and 12 species in 0.1 ha (DAMASCENO-JUNIOR et al. 2005). In the Amazon estuary near Bélem, CATTANIO et al. (2002) reported 45 and 67 species in 0,2 ha plots.These examples and others found in the literature show differences in the sample sizes and criteria employed, making comparisons of species richness with our results difficult. However, it is a general statement that forested wetlands have lower species richness if compared with their upland, alluvial or "terra firme" counterparts (KLINGE et al. 1973; GENTRY & ORTIZ 1993; PETERS 1994; DALY & MITCHELL 2000; ELLISON 2004). It has been suggested that species richness within forested wetlands may be controlled by the cumulative number of environmental constraints (KEOGH et al. 1998). In fact, wetland forests of Punta Pescador develop in a deltaic environment where prolonged flooding (5-10 months), oxygen-poor flood water (0.52±0.72 mg/L), low pH of soil and water (averages 5.06±1.15 and 4.84±133 units respectively), and periodic (semi-diurnal tides) or occasional exposition to brackish water inputs are common

(VEGAS-VILARRÚBIA et al. 2006; GEOHIDRA CONSULTORES 1998). The combined effects of these variables makes it difficult for some species to become established, while others are highly specialized to survive in adverse habitats, like *P. officinalis* (WEAVER 1997; SAUR et al. 1998). This may result in distinct composition of plant communites growing in highly heterogeneous environments at a local scale.

The study area assembled 2,1 % of the species reported for the VG. To date, from the 9411 species reported for this region 2136 species (22.7 %) and 34 genera (1.9 %) are endemic (BERRY et al. 1995). From the species collected in the study area, 193 had been reported in the "Flora of the Venezuelan Guayana" as non endemic for this region, while the 12 remaining species (Annex 1) were not included in this work (STEYERMARK et al. 1995). Among the latter 12, *Pachira insignis*, *Epiphyllum hoockeri*, *Sloaena durissima*, *Reimarochloa aberrans* and *Boehmeria grandiflora* had been found in other places of the Guayana Shield. The remaining 7 species are common in Central or Northern South America outside of the Guayana region.

Mauritia palms are native flora in the lowlands of the Amazon and Orinoco (CLAY & CLEMENT 1993; RULL 1998). They grow in a variety of vegetation types (MÜLLER 1959; GONZÁLEZ 1987; TISSOT et al. 1988), but most often occur in nearly pure stands of gallery forests along water courses (HUBER 1986; PETERS et al. 1989, GONZÁLEZ 1987). They are found less frequently over wide areas of badly drained alluvial plains, such as those in Punta Pescador. To survive *M. flexuosa* has secondary roots where air can circulate freely (GRANVILLE 1974, 1992). In the study area the "morichales" develop on silt, peaty and very acidic, soils covered with almost anoxic flood water (VEGAS VILARRÚBIA 2006). URREGO (1997) reported ample *M. flexuosa* forests evolving in flooded alluvial basins under similar conditions in Colombia's Middle Caquetá region. According to GONZÁLEZ (1987), this species' seedlings are strongly light dependent and only grow in open places. This suggests that isolated individuals or stands of *Mauritia* evolving in some meadow matrices may correspond to early development stages that gradually expand to the neighboring swamp forest. Another possibility is that some stands are remains of fragmented "morichales". Alternatively, they may represent secondary growth stands substituting swamp forests affected by fires. *Mauritia* can rapidly colonize habitats created by fire (RULL 1999). In fact, fire is an active disturbance factor in the area. We observed evidences of a recent fire in a meadow within the study area. We also noted no less than five fires burning simultaneously in the neighborhood during the dry season, coinciding with a peak of fire activity in the Orinoco Delta (GRÉGOIRE et al. 1998).

The Punta Pescador meadows were found to differ floristically from the middle and lower Orinoco Delta described by HUBER (1995). According to this author, *B. serrulatum, Acrostichum aureum, Cyperus articulatus* and *Scleria* spp. (Cyperaceae) formed dense, herbaceous communities growing on water-logged histosols in middle Orinoco Delta meadows. Other lower Orinoco Delta meadows were dominated by the giant herb *Montrichardia arborescens* (Araceae) growing in nearly pure stands, with an odd appearance. Except for *B. serrulatum*, neither of these species was conspicuous in the study area. The non-gramineous meadows described in this paper combine two dominant species, the fern *B. serrulatum* and the Cyperacea *Lagenocarpus guianensis*. These cover a vast surface area and represent an Orinoco Delta meadow type that has not been reported before. The underlying soils resemble those supporting the "morichales".

Shrubland was dispersed in azonal patches. According to HUBER (1995), most VG shrublands are restricted to rock outcrops, sandy soils or peat. However, in the study area the shrubland appeared in swampy back-mangrove zones. In beach environments, *Chrysobalanus icaco* forms scrubs on coastal sand and dune substrates (SCHNEE 1984; VARGAS-SIMON et al. 1997). Back-mangrove environments differed greatly from typical beach and dune habitats. The substrate consisted of peaty organic soil, composed mainly of silt and clay. It was water saturated almost year round. *C. icaco* has been observed in similar conditions in wetlands of Mexico, Guatemala and Hawaii (SMITH 1985; RAMSAR 1999; UNEP-WCMC 2004). It is not clear whether the study's area *C. icaco* shrubland is a natural vegetation formation, such as an early successional regrowth of disturbed forest. In any case, it has not yet been described as a shrub formation of the VG region.

Mangroves develop in a variety of situations in Punta Pescador: beside river channels, along the coastal fringe, within depressions or basins, representing a transition to more inland environments (Table 1). They tolerate a wide range of water salinity values (0,1-31,4 ‰) depending on the season (GEOHIDRA CONSULTORES 1998). In areas with fairly flat topography, like the lower Orinoco Delta alluvial plains, different mangrove types are a result of local hydrology and geomorphology (CINTRÓN et al. 1985; cited in CINTRÓN & SHAEFFER 1992; KJERFVE 1990). The profile of the study area's mangrove forests fitted the schemes proposed by these authors: fringe, basin and riparian mangroves. Mangroves form a belt along riversides and shorelines of the central and eastern coast, where they are subject to sediment deposition and permanent tidal flood. From a sedimentological point of view, protection from wave action and an adequate supply of silt and clay are essential to provide a suitable environment for growing mangrove trees (CHAPMAN 1976). However, the north-western coastal shoreline, which has no mangroves, is subjected to marine erosion and sediment starvation. Mangrove colonization is probably restrained by the effect of strong currents at the Boca de Serpientes constriction (WARNE et al. 2002). A particular characteristic of the deltaic mangroves was the frequency of epiphytes growing on mangrove trees. This could be explained by the lower Delta region's high precipitation levels. Most epiphytic seed plants and ferns are found in tropical rainforests, as they require high humidity.

A more detailed floristic, phenologic and physiognomic description of the plant formations (Fig. 2) and vegetation types (Table 1) is needed, to confirm and refine the preliminary classification and the vegetation map offered. The mosaic arrangement of plant formations probably reflects the interplay of seasonal fluvial dynamics with the action of semidiurnal tides, environmental constrains and short-middle term and historic processes and evolution. The complex deltaic dynamics at work is likely to create a variety of changing habitats resulting in combinations of diverse plant species, at different stages of development. However, the specific cause-effect relations are still under documented.

In the study area grow plant species that may be particularly sensitive to oil spills beyond the inherent toxicity of the oil itself. They have pneumatophores, adventitious roots and hypertrophied lenticels to facilitate respiration that can be mechanically obstructed by crude oil coating. Physical suffocation causes dead. These structures use to be located in the same portions of the intertidal zone most heavily affected by stranded oil (DICKS 1986; Böer 1993; GARRITY et al. 1994; HOFF et al. 2002). In the study area *Pterocarpus officinalis, Symphonia globulifera, Rhizophora* spp., *Avicennia germinans, Laguncularia racemosa, Mauritia flexuosa* and *Euterpe oleracea* had such adaptations. Most of them are dominant forest forming species, thus we suspect that oil spill damages would imply more than the death of the single species and strongly impact the community level as well. This supposition is based on the traditional ecological approach, stating that dominat species are the ecological controllers of the ecosystem processes (LOUREAU et al. 2001). If these controlers are damaged, the ecosystems will suffer. Additionally, in anoxic soils oil degradation is inhibited, thus oil may persist for very long periods in peaty and muddy sediment (HOFF et al. 2002) like those of the study area. Salt tolerant and strictly fresh water species coexist in Punta Pescador, and are only separated by short distances. A further handicap in wetland areas is that draining, dredging and channeling needed to install infrastructures and transport routes during oil prospecting and production, can involuntarily induce hydrological changes. Freshwater species may be threatened by abnormal intrusions of salty water, while dilution of brackish water by freshwater influx would produce changes in salt-tolerant vegetation (BALDWIN & MENDELSSOHN 1998).

The Orinoco delta has been recognized as the home of the Warao Indians since early Indo-Hispanic times (WILBERT 1993). To date 21, 125 Warao live in the Orinoco delta, representing 20 % of the Delta Amacuro State's population (INDIGENOUS CENSE 1991). The "morichales" form part of the Indians life. *M. flexuosa* provides them with food, drink, and material for their tools, housing and socio-religious customs (DELASCIO CHITTY 1985; WILBERT 1996). The Warao use other local plants as well, such as *Euterpe* spp., *Chrysobalanus icaco* and *Diospyros lissocarpoides* for food, *Pterocarpus* spp. for handicrafts, *Montrichardia arborescens, Tabebuia aquatilis* and *Symphonia globulifera* for medicinal applications and different species of mangrove for housing. In the study area, nearly 40 % of the plant species used by the Warao aborigines are for health care.

If the structures and processes supporting the integrity of the Orinoco Delta's ecosystems, the services, uses and benefits provided are to be preserved, we should be cautious about exploiting the natural resources. Our understanding of the interrelations between the processes and structures on which life support functions rely is still incomplete. On the other hand the Orinoco Delta's importance as a source of medicines is largely unknown. Bioprospecting of wild species is essential to establish the biochemical value of the area, ideally letting the indigenous people take part of the lucrous results. Therefore, existing knowledge does not enable sound and sustainable resource management to be supported in the Orinoco Delta region. In comparison, its reputation as a huge source of oil and gas has grown constantly since the beginning of the last century. Environmental management associated with any kind of resource exploitation of the Orinoco Delta' resources should set ecological limits and provide direction and guidance. Up to date, the only practical way to conserve biodiversity is to protect natural vegetation.

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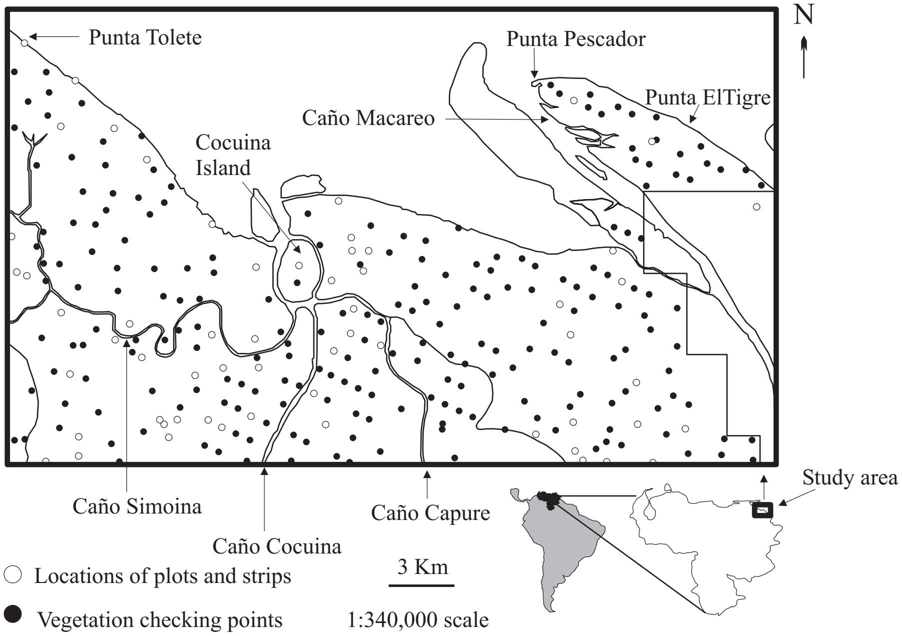


Fig. 1:
Location map. Position of vegetation plots, strips and checking points within the study area.

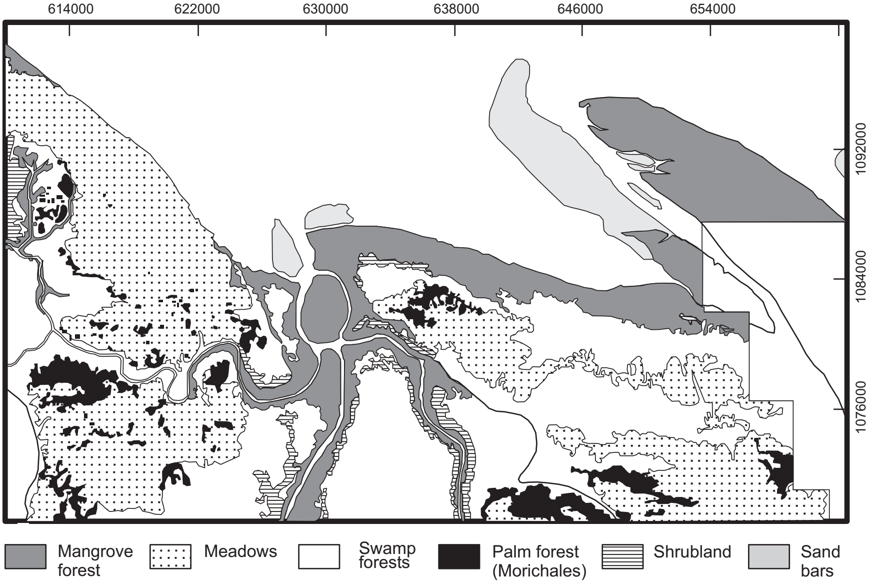
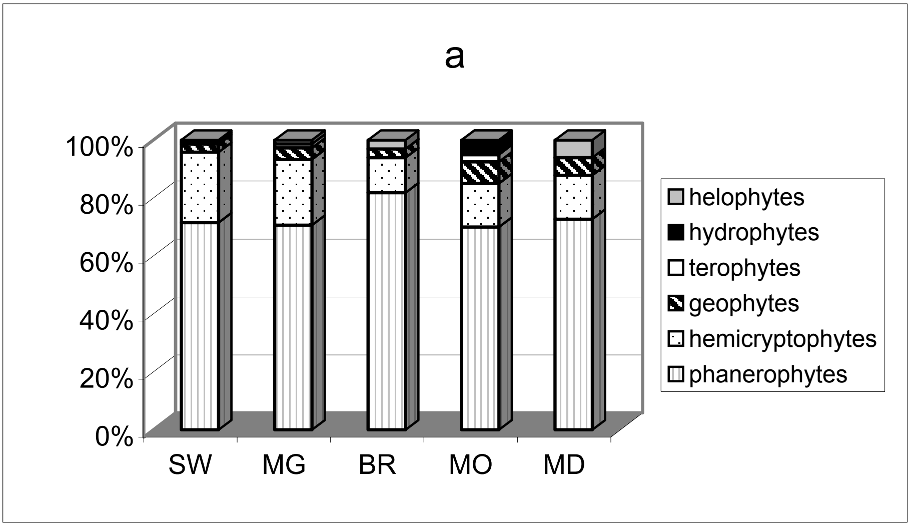


Fig. 2:
Vegetation map.



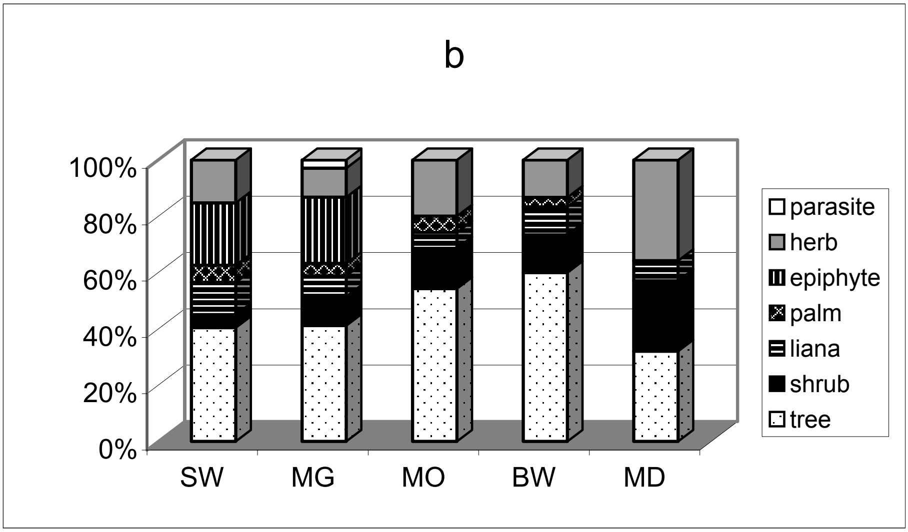


Fig. 3:
a: Distribution of life forms among the different vegetation units. **b**: Distribution of growth forms among the different vegetation units.

Table 1: Plant formations and combinations of the most frequent species.
cf: coastal fringe; *bd*: basin or depression; *r*: riverside, interior fringe.

Plant formations	**Combiantion of the most frequent species**
Swamp forest	
Low open	*Ilex martiniana, Rhizophora mangle, Ouratea cassinifolia, Tabebuia insignis* var. *monophylla, Pterocarpus. officinalis, T. insignis* var. *monophylla, T. insignis* var. *monophylla, Mauritia flexuosa*
Low mid	*P. officinalis, Diospyros. lissocarpoides, P. officinalis, R. harrisonii, P. officinalis, T. insignis* var. *monophylla, D. lissocarpoides, Chrysobalanus. icaco, T. insignis* var. *monophylla, M. flexuosa, D. lissocarpoides, T. insignis* var. *monophylla, P. officinalis, Ch. icaco*
Low dense	*Eugenia coffeifolia, Clusia grandiflora*
Mid open	*P. officinalis, T. insignis* var. *monophylla*
Mid mid	*T. insignis* var. *monophylla, D. lissocarpoides* *P. officinalis, Symphonia globulifera, P. officinalis, S. globulifera*
Mid dense	*T. insignis* var. *monophylla, O. cassinifolia*
Mangrove forest	
Mid dense	*Avicennia germinans, Rhizophora mangle* (*cf*)
Mid mid	*Laguncularia racemosa, Rhizophora racemosa* (*cf*), *R. racemosa* (*cf*), *R. racemosa, Rhizophora harrisonii* (*cf*), *R. mangle, R. racemosa* (*bd*)
High open	*R. racemosa, Ilex guianensis* (*bd*)
Low open	*Laguncularia racemosa, I. guianensis* (*bd*)
High dense	*R. mangle, Cassipourea guianensis* (*bd*), *A. germinans, R. mangle* (*bd*)
Mid mid	*D. lissocarpoides, R. racemosa* (*r*)
Palm forest or Morichal (Mo)	
Mid mid Mo	*M. flexuosa, T. insignis* var. *monophyla, M. flexuosa, P. officinalis*
Mid open Mo	*M. flexuosa, Tapira guianensis*
Shrubland (Shr)	
Mid dense Bw	*Ch. icaco, I. guianensis*
Herbaceous vegetation or meadows (Md)	
treeless	*Lagenocarpus guianensis, Blechnum serrulatum*
with bushy elements	*B. serrulatum, Rhynchospora gigantea, Rhynchantera grandiflora, B. serrulatum, L. guianensis, Montrichardia arborescens, Sagittaria lancifolia, Rhy. grandiflora, Mo. arborescens*
with woody elements	*B. serrulatum, Rh. gigantea, M. flexuosa, B. serrulatum, I. martiniana, Mo. arborescens, B. serrulatum, I. martiniana, T. insignis* var. *monophyla*
with individual trees	*B. serrulatum, M. flexuosa, T. innsignis* var. *monophyla*

Table 2: Plant species commonly utilized by the Warao Indians.

Species	**Utilization**
Annona glabra	food supply
Avicennia germinans	building
Bactris campestris	weapon fabrication
Calophyllum brasiliense	building
Cassipourea guianensis	tool fabrication
Chrysobalanus icaco	food supply
Diospyros lissocarpoides	medicinal use
Epiphyllum phyllantus	medicinal use
Euterpe oleracea	food supply
Euterpe precatoria	food supply
Euterpe sp.	commercialization
Ficus sp.	medicinal use
Malouetia flavescens	tool fabrication, medicinal use
Manilkaria bidentata	food supply
Mauritia flexuosa	food supply, building, tool and weapon fabrication
Miconia prasina	food supply
Montrichardia arborescens	medicinal use
Norantea guianensis	furniture fabrication
Phitecellobium inequale	building
Phthirusa pyrifolia	medicinal use
Phoradendron piperoides	medicinal use
Pterocarpus officinalis	handicraft art
Rhizophora harrisonii	building
Rhizophora mangle	building
Rhizophora racemosa	building, food supply
Sarcostema claususm	medicinal use
Symphonia globulifera	canoe fabrication, building, medicinal use
Tabebuia insignis var. *monophylla*	medicinal use, paddle fabrication
undetermined species	medicinal use
Virola surinamensis	canoe fabrication

Table 3: Averages of physical and chemical variables of soils and flood waters (modified from Geohidra Consultores, 1998).

	Mangrove		**Shrubland**		**Swamp forest**		**Morichal**		**Meadow**	
Variables	**surface**[1]	**bottom**[2]	**surface**[1]	**bottom**[2]	**surface**[1]	**bottom**[2]	**surface**[1]	**bottom**[2]	**surface**[1]	**bottom**[2]
Granulometry:										
sand (%)		14.6±2.4		6.26±2.3		8.47±1.20		8.78±3.8		9.18±1.7
silt (%)		63.3±1.90		78.2±4.30		66.5±1.5		58.9±2.3		60.7±1.6
clay (%)		22.2±1.5		15.6±4.20		24.9±1.50		33.3±5.2		30.1±2.0
Organic matter (%)	37.9±1.26	6.58±0.29	39.2±1.91	7.77±0.88	39.0±0.87	6.68±0.26	41.7±1.63	7.13±0.65	40.3±0.76	7.32±0.30
Natural moisture (%)	79.6±1.32	53.1±1.09	80.0±4.07	49.6±2.66	84.7±0.88	51.6±0.90	85.6±2.42	52.6±2.05	87.8±0.75	53.3±2.44
Soil salinity (%)	1.80±0.12	1.59±0.10	0.94±0.20	0.78±0.12	0.35±0.06	0.48±0.05	0.06±0.02	0.22±0.03	0.22±0.106	0.48±0.06
Soil pH	5.96±0.11	6.78±0.07	5.40±0.17	6.71±0.18	4.59±0.08	6.49±0.06	4.09±0.17	6.21±0.09	4.39±0.06	6.47±0.06
Thickness of the organic layer (m)	0.65±0.07		1.33±0.16		1.44±0.75		2.70±0.26		2.78±0.11	
Water salinity (‰)	3.58±0.35		3.02±0.23		0.96±0.19		0.91±0.74		0.55±0.21	
Water pH	5.64±0.28		3.86±0.76		4.37±0.08		4.30±0.41		4.23±0.12	
Dissolved oxygen (mg/l)	0.36±0.07		0.32±0.08		0.41±0.05		0.74±0.33		0.47±0.07	

[1] samples from the soil surface organic layer; [2] samples from the soil mineral layer.

Appendix 1: Inventory of species, growth and life forms, and corresponding habitats.

Family	Genus and species	growth form	life form	habitat
Alismataceae	*Sagittaria lancifolia* subsp. *lancifolia*	geophyte	herb	Md
Amaranthaceae	*Amaranthus australis* (A. GRAY) J.D. SAUER	terophyte	herb	Mg, Sf, Mo
Amaranthaceae	*Blutaparon vermiculare* (L.) MEARS	microphanerophyte	herb	Md
Anacardiacaeae	*Tapirira guianensis* AUBL.	mesophanerophyte	tree	Mg, Sf, Mo, Shr, Md
Anacardiacaeae	*Tapirira* sp. AUBL.	mesophanerophyte	tree	Sf,Mo
Annonaceae	*Annona glabra* L.	microphanerophyte	tree	Mg, Sf, Shr
Apiaceae	*Hydrocotyle umbellata* L.	hydrophyte	herb	Mo
Apocynaceae	*Allamanda cathartica* L.	mesophanerophyte	liana	Sf, Mo, Shr
Apocynaceae	*Malouetia flavescens* (WILLD. EX ROEM. & SCHULT.) MÜLL. ARG.	mesophanerophyte	tree	Mg, Sf
Apocynaceae	*Odontadenia nitida* (VAHL.) MÜLL. ARG.	microphanerophyte	liana	Sf
Apocynaceae	*Rhabdadenia biflora* (JACQ.) MÜLL. ARG.	mesophanerophyte	liana	Mg
Aquifoliaceae	*Ilex guianensis* (AUBL.) KUNTZE	mesophanerophyte	tree	Mg, Sf, Shr
Aquifolicaeae	*Ilex martiniana* D. DON	mesophanerophyte	tree	Mg, Sf, Shr
Araceae	*Anthurium crassinervium* hort. ex ENGL.	microphanerophyte	herb	Mg
Araceae	*Heteropsis flexuosa* (KUNTH) BUNTING	microphanerophyte	semi-epiphyte	Sf
Araceae	*Monstera adansonii* var. *laniata* (SCHOTT) MADISON	microphanerophyte	semi-epiphyte	Mg
Araceae	*Montrichardia arborescens* (L.) SCHOTT	microphanerophyte	shrub	Mg, Sf, Mo, Md
Araceae	*Philodendron acutatum* SCHOTT	microphanerophyte	semi-epiphyte	Sf
Araceae	*Philodendron fragantissimum* (HOOK) G. DON	microphanerophyte	semi-epiphyte	Sf
Araceae	*Philodendron linnaei* KUNTH	microphanerophyte	semi-epiphyte	Sf
Araceae	*Philodendron grandifolium* (JACQ.) SCHOTT	microphanerophyte	semi-epiphyte	Mg

Family	Genus and species	growth form	life form	habitat
Araceae	*Philodendron muricatum* WILLD. ex SCHOTT	microphanerophyte	semi-epiphyte	Sf
Araceae	*Spathiphyllum cannifolium* (DRYAND.) SCHOTT	nanophanerophyte	herb	Sf
Araceae	*Urospatha sagittifolia* (RUDGE) SCHOTT	nanophanerophyte	herb	Md
Araliaceae	*Didymopanax morototoni* (AUBL.) DECNE et PLANCH	megaphanerophyte	tree	Sf
Arecaceae	*Bactris campestris* POEPP. ex MART.	microphanerophyte	multicaulis palm	Mg, Sf, Mo
Arecaceae	*Bactris major* JACQ.	microphanerophyte	multicaulis tree palm	Sf
Arecaceae	*Desmoncus orthacanthos* MART.	microphanerophyte	climbing palm	Mg, Sf
Arecaceae	*Desmoncus polyacanthos* MART.	mesophanerophyte	climbing palm	Sf
Arecaceae	*Euterpe precatoria* MART.	mesophanerophyte	monocaulis tree palm	Mg, Sf, Mo, Shr
Arecaceae	*Euterpe* sp. MART.	mesophanerophyte	monocaulis tree palm	Sf
Arecaceae	*Manicaria saccifera* GAERTN.	microphanerophyte	multicaulis tree palm	Sf
Arecaceae	*Mauritia flexuosa* L.f.	megaphanerophyte	monocaulis tree palm	Sf, Shr, Md
Asclepiadaceae	*Matelea stenopetala* SANDWITH	microphanerophyte	herb	Sf
Asclepiadaceae	*Sarcostemma clausum* (JACQ.) SHULT.	microphanerophyte	herb	Sf, Md
Asteraceae	*Mikania micrantha* KUNTH	microphanerophyte	herb	Mo, Sf, Shr
Bignoniaceae	*Cydista* sp.	mesophanerophyte	liana	Sf
Bignoniaceae	*Macfadyena uncata* (ANDREWS) SPRAGUE & SANDWITH	microphanerophyte	liana	Sf
Bignoniaceae	*Tabebuia aquatilis* (E. MEY.) SPRAGE & SANDWITH	mesophanerophyte	tree	Mg, Sf, Mo, Shr, Md
Bignoniaceae	*Tabebuia insignis* var. *monophylla* (MIQ.) SANDWITH	mesophanerophyte	tree	Mg, Sf, Mo, Shr, Md
Bombacaceaea	*Pachira insignis* (SW.) SW. ex SAVIGNY	megaphanerophyte	tree	Sf
Boraginaceae	*Heliotropium indicum* L.	nanophanerophyte	herb	Sf
Bromeliaceae	*Aechmea lingulata* (L.) BAKER	protohemicryptophyte	epiphyte	Mg, Shr

Family	Genus and species	growth form	life form	habitat
Bromeliaceae	*Aechmea aquilega* (SALISB.) GRISEB.	protohemicryptophyte	epiphyte	Mg, Shr
Bromeliaceae	*Aechmea mertensii* (G. MEY.) SCHULT. & SCHULT. f.	protohemicryptophyte	epiphyte	Sf
Bromeliaceae	*Aechmea nudicaulis* (L.) SALISB. var. *nudicaulis*	protohemicryptophyte	epiphyte	Mg
Bromeliaceae	*Catopsis sessiliflora* (RUIZ & PAVÓN) MEZ	protohemicryptophyte	epiphyte	Sf
Bromeliaceae	*Guzmania lingulata* (L.) MEZ	protohemicryptophyte	epiphyte	Mg
Bromeliaceae	*Guzmania monostachia* (L.) RUSBY ex MEZ	protohemicryptophyte	epiphyte	Sf
Bromeliaceae	*Tillandsia bulbosa* HOOK.	protohemicryptophyte	epiphyte	Mg
Bromeliaceae	*Tillandsia fasciculata* SW.	protohemicryptophyte	epiphyte	Mg, Sf
Bromeliaceae	*Tillandsia flexuosa* SW.	protohemicryptophyte	epiphyte	Sf
Bromeliaceae	*Tillandsia usneoides* (L.) L.	protohemicryptophyte	epiphyte	Mg,Sf
Cabombaceae	*Cabomba aquatica* AUBL.	helophyte	herb	Sf
Cactaceae	*Epiphyllum hookeri* (LINK & OTTO) HAWORTH	nanophanerophyte	epiphyte	Mg
Cactaceae	*Epiphyllum phyllanthus* (L.) HAW.	nanophanerophyte	epiphyte	Sf
Cactaceae	*Rhipsalis baccifera* (J.S. MÜLL.) STEARN	nanophanerophyte	epiphyte	Mg, Sf
Caesalpiniaceae	*Macrolobium acaciifolium* (BENTH.) BENTH.	mesophanerophyte	tree	Sf
Cecropiaceae	*Cecropia peltata* var. *lingua* MART.	mesophanerophyte	tree	Sf, Mo, Shr, Md
Cecropiaceae	*Cecropia sciadophylla* MART.	mesophanerophyte	tree	Sf
Chrysobalanaceae	*Chrysobalanus icaco* L.	microphanerophyte	tree	Mg, Sf, Mo, Shr, Md
Clusiaceae	*Calophyllum brasiliense* CAMBESS	mesophanerophyte	tree	Sf
Clusiaceae	*Clusia flavida* (BENTH.) PIPOLY	mesophanerophyte	shrub	Shr
Clusiaceae	*Clusia grandiflora* SPLITG.	mesophanerophyte	tree	Mg, Sf, Mo, Shr, Md
Clusiaceae	*Clusia myriandra* (BENTH.) PLANCH & TRIANA	mesophanerophyte	tree	Sf, Mo, Md
Clusiaceae	*Clusia nemorosa* G. MEY.	mesophanerophyte	tree	Sf, Shr
Clusiaceae	*Clusia panapanari* (AUBL.) CHOISY	mesophanerophyte	liana	Sf

Family	Genus and species	growth form	life form	habitat
Clusiaceae	*Clusia rosea* JACQ.	mesophanerophyte	tree	Sf, Mo
Clusiaceae	*Clusia* sp.	mesophanerophyte	tree	Sf, Shr
Clusiaceae	*Symphonia globulifera* L.f.	mesophanerophyte	tree	Mg, Sf, Mo, Shr
Combretaceae	*Laguncularia racemosa* (L.) C.F. GAERTN	mesophanerophyte	tree	Mg, Sf, Shr
Commelinaceae	*Tripogandra serrulata* (VAHL) HANDLOS	nanophanerophyte	herb	Mg, Sf
Costaceae	*Costus arabicus* L.	microphanerophyte	shrub	Sf
Costaceae	*Costus guanaiensis* RUSBY	microphanerophyte	herb	Sf
Costaceae	*Costus spiralis* (JACQ.) ROSCOE	microphanerophyte	shrub	Mg, Sf, Md, Mo
Cyperaceae	*Cyperus odoratus* L.	protohemicryptophyte	herb	Sf
Cyperaceae	*Fuirena umbellata* ROTTB.	protohemicryptophyte	herb	Md
Cyperaceae	*Lagenocarpus guianensis* (NESS)	protohemicryptophyte	herb	Mg, Sf, Shr, Md
Cyperaceae	*Rhynchospora gigantea* LINK	protohemicryptophyte	herb	Mo, Shr, Md
Cyperaceae	*Scleria stipularis* NEES	protohemicryptophyte	herb	Sf
Cyperaceae	*Torulinium odoratum* (L.) S.S. HOOPER	protohemicryptophyte	herb	Mg
Dioscoreaceae	*Dioscorea coriacea* HUMB. & BONPL. ex WILLD.	microphanerophyte	herb	Sf
Ebenaceae	*Diospyros lissocarpoides* SANDW.	microphanerophyte	tree	Mg, Sf, Mo, Shr
Elaeocarpaceae	*Sloaena durissima* SPRUCE ex BENTH.	mesophanerophyte	tree	Sf
Euphorbiaceae	*Omphalea diandra* L.	microphanerophyte	liana	Mg, Sf, Md
Fabaceae	*Andira inermis* (W.WRIGHT) KUNTH ex DC.	mesophanerophyte	tree	Sf, Mo
Fabaceae	*Dalbergia monetaria* L.f.	microphanerophyte	liana	Sf
Fabaceae	*Dioclea malacocarpa* DUCKE	microphanerophyte	liana	Sf
Fabaceae	*Machaerium lunatum* (L.f.) DUCKE	microphanerophyte	shrub	Mg
Fabaceae	*Muellera frutescens* (AUBL.) STANDL.	microphanerophyte	shrub	Mg
Fabaceae	*Pterocarpus officinalis* JACQ.	mesophanerophyte	tree	Mg, Sf, Mo, Shr, Md
Fabaceae	*Pterocarpus rohrii* VAHL	mesophanerophyte	tree	Mg, Sf, Mo

Family	**Genus and species**	**growth form**	**life form**	**habitat**
Fabaceae	*Pterocarpus santalinoides* L. HÉR. ex DC.	mesophanerophyte	tree	Mg, Sf
Fabaceae	*Vigna juruana* (HARMS) VERD.	microphanerophyte	liana	Sf
Gentianaceae	*Irlbachia alata* (AUBL.) MAAS ssp. *longistyla* PERSOON & MAAS	nanophanerophyte	bush	Mo, Shr, Md
Gesneriaceae	*Drymonia serrulata* (JACQ.) MART.	nanophanerophyte	herb	Sf
Heliconiaceae	*Heliconia psittacorum* L.f.	helophyte	herb	Mg, Shr, Md
Lauraceae	no determined	mesophanerophyte	tree	Sf
Lauraceae	no determined	mesophanerophyte	tree	Sf
Liliaceae	*Crinum erubescens* AITON	geophyte	herb	Mg, Sf
Liliaceae	*Crinum* sp.	geophyte	herb	Mo, Shr, Md, Md
Liliaceae	*Hymenocallis tubiflora* SALISBURY	geophyte	herb	Mg, Sf
Liliaceae	*Hymenocallis venezuelensis* TRAUB.	geophyte	herb	Sf, Mo
Loranthaceae	*Phthirusa pyrifolia* (KUNTH) EICHLER	microphanerophyte	parasite	Mg
Malpighiaceae	*Tetrapterys discolor* (G. MEY.) DC.	mesophanerophyte	liana	Sf
Malvaceae	*Hibiscus furcellatus* DESR.	microphanerophyte	shrub	Mg
Malvaceae	*Hibiscus pernambucensis* ARRUDA	microphanerophyte	shrub	Mg
Malvaceae	*Malvaviscus longifolius* (a. ST.-HIL.) SPACH	nanophanerophyte	shrub	Mg
Malvaceae	*Pavonia* sp.	nanophanerophyte	shrub	Sf, Shr
Marantaceae	*Ischnosiphon arouma* (AUBL.) KÖRN	geophyte	herb	Sf, Mg
Marcgraviaceae	*Marcgravia coriacea* VAHL	mesophanerophyte	liana	Sf
Marcgraviaceae	*Norantea guianensis* AUBL. ssp. *japurensis* (MART.) BEDELL	mesophanerophyte	liana	Mo, Sf
Marcgraviaceae	*Souroubea guainensis* AUBL.	mesophanerophyte	liana	Sf
Melastomataceae	*Miconia ciliata* (RICH.) DC.	microphanerophyte	bush	Md
Melastomataceae	*Miconia prasina* (SW.) DC.	microphanerophyte	bush	Mo, Shr, Md
Melastomataceae	*Nepsera aquatica* NAUDIN	helophyte	aquatic herb	Md

Family	Genus and species	growth form	life form	habitat
Melastomataceae	*Rhynchanthera dichotoma* (DESR.) DC.	microphanerophyte	bush	Mo, Md
Melastomataceae	*Rhynchanthera grandiflora* (AUBL.) DC.	microphanerophyte	bush	Mo, Shr, Md
Melastomataceae	*Tococa nitens* (BENTHh.) TRIANA	microphanerophyte	bush	Md
Menyanthaceae	*Nymphoides indica* (L.) KUNTZE	hydrophyte	herb	Mo
Mimosaceae	*Entada polystachya* (L.) DC.	microphanerophyte	bush	Mg, Sf
Mimosaceae	*Inga edulis* C. MART.	mesophanerophyte	tree	Mg, Sf, Shr
Mimosaceae	*Inga* sp.	mesophanerophyte	tree	Sf
Mimosaceae	*Inga spuria* HUMB. & BONPL. ex WILLD.	mesophanerophyte	tree	Sf
Mimosaceae	*Phitecellobium inaequale* HUMB. & BONPL. ex WILLD.	mesophanerophyte	tree	Mg, Sf
Mimosaceae	*Zygia cauliflora* (WILLD.) KILLIP ex RECORD	nanophanerophyte	tree	Sf
Moraceae	*Ficus caballina* STANDL.	mesophanerophyte	tree	Sf
Moraceae	*Ficus maxima* MILL.	mesophanerophyte	tree	Mg, Sf
Moraceae	*Ficus obtusifolia* KUNTH	mesophanerophyte	tree	Sf, Shr
Moraceae	*Ficus pertusa* L.f.	mesophanerophyte	epiphyte	Sf, Md, Shr
Moraceae	*Ficus schumacheri* (LIEBM.) GRISEB.	mesophanerophyte	tree	Sf
Moraceae	*Ficus* sp. 2	mesophanerophyte	tree	Sf, Shr, Md, Mo
Moraceae	*Ficus* sp. 1	mesophanerophyte	epiphyte	Mg, Mo, Shr
Myristicaceae	*Virola surinamensis* (ROL. ex ROTTB.) WARB.	mesophanerophyte	tree	Mg, Sf, Mo, Md
Myrsinaceae	*Cybianthus spicatus* (KUNTH) AGOSTINI	microphanerophyte	bush	Sf, Mo, Shr
Myrsinaceae	*Myrsine guianensis* (AUBL.) KUNTZE	microphanerophyte	tree	Sf
Myrtaceae	*Eugenia coffeifolia* D.C.	microphanerophyte	tree	Mg, Sf, Mo, Md
Nyctaginaceae	*Guapira olfersiana* (LINK, KLOTZSCH. & OTTO) LUNDELL	mesophanerophyte	tree	Sf, Mo, Shr
Ochnaceae	*Ouratea castaneifolia* (D.C.) ENGL.	mesophanerophyte	tree	Mg, Sf, Mo, Md, Shr
Onagraceae	*Ludwigia affinis* (DC) H. HARA	microphanerophyte	herb	Sf

Family	Genus and species	growth form	life form	habitat
Onagraceae	*Ludwigia nervosa* (POIR.) H. HARA	microphanerophyte	tree	Mo, Shr, Md
Orchidaceae	*Campylocentrum micranthum* (LINDL.) ROLFE	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Dimerandra* sp.	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Encyclia fragans* (SW.) LEMEE	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Encyclia leucantha* SCHLTR.	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Epidendrum ciliare* L ssp. *squamum* SCHNEE	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Epidendrum ibaguense* KUNTH	protohemicryptophyte	epiphyte	Mg
Orchidaceae	*Epidendrum nocturnum* JACQ.	protohemicryptophyte	epiphyte	Mg, Sf
Orchidaceae	*Epidendrum paniculatum* RUÍZ & PAVÓN	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Epidendrum rigidum* JACQ.	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Epidendrum secundum* JACQ.	protohemicryptophyte	epiphyte	Mg, Sf
Orchidaceae	*Lockhartia imbricata* (LAM.) HOEHNE	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Maxillaria camaradii* RCHB. f.	protohemicryptophyte	epiphyte	Mg
Orchidaceae	*Neolehmannia* sp.	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Oncidium cebolleta* (JACQ.) SW.	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Phragmorchis pusilla* (SW.) DOD. & DRES.	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Pleurothallis uniflora* LINDL.	protohemicryptophyte	herb	Sf
Orchidaceae	*Rodrigueiza lanceolata* RUÍZ & PAVÓN	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Sobralia* sp.	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Stanhopea grandiflora* (LOOD.) LINDL.	protohemicryptophyte	epiphyte	Sf
Orchidaceae	*Trizeuxis falcata* LINDL.	protohemicryptophyte	epiphyte	Sf
Piperaceae	*Peperomia glabella* (SW.) A. DIETR.	protohemicryptophyte	epiphyte	Sf
Piperaceae	*Peperomia magnoliaefolia* (JACQ.) A. DIETR.	protohemicryptophyte	herb	Sf
Poaceae	*Hymenachne amplexicaulis* (RUDGE) NEES	protohemicryptophyte	herb	Md
Poaceae	*Hymenachne amplexicaulis* (RUDGE) NEES	protohemicryptophyte	herb	Md
Poaceae	*Reimarochloa aberrans* (DÖLL) CHASE	protohemicryptophyte	herb	Md
Poaceae	*Sacciolepis myuras* (LAM) BEAV	protohemicryptophyte	herb	Mo

Family	Genus and species	growth form	life form	habitat
Poaceae	*Setaria vulpisieta* (LAMARK) ROEM. & SCHULT.	protohemicryptophyte	herb	Mo
Polygonaceae	*Coccoloba latifolia* LAM.	mesophanerophyte	tree	Sf, Shr, Md
Polygonaceae	*Coccoloba marginata* BENTH.	mesophanerophyte	tree	Sf
Polygonaceae	*Polygonum acuminatum* KUNTH	hydrophyte	herb	Mo
Rapataceae	*Rapatea paludosa* AUBL.	protohemicryptophyte	herb	Mg, Shr
Rhizophoraceae	*Cassipourea guianensis* AUBL.	mesophanerophyte	tree	Mg, Sf, Mo, Shr
Rhizophoraceae	*Rhizophora harrisonii* LEECHM.	mesophanerophyte	tree	Mg, Sf
Rhizophoraceae	*Rhizophora mangle* L.	mesophanerophyte	tree	Mg, Sf
Rhizophoraceae	*Rhizophora racemosa* G. MEY.	mesophanerophyte	tree	Mg, Sf
Rubiaceae	*Coccocypselum hirsutum* BARTL. ex DC.	microphanerophyte	shrub	Mo
Rubiaceae	*Duroia eriophyla* L.f.	mesophanerophyte	tree	Mo, Sf
Rubiaceae	*Genipa caruto* KUNTH.	mesophanerophyte	tree	Mg, Sf
Rubiaceae	*Malanea macrophylla* var. *bahiensis* (M. ARG.) STEYERM.	mesophanerophyte	tree	Sf
Sapindaceae	*Paullinia pinnata* L.	mesophanerophyte	liana	Mg, Sf, Shr, Md
Sapindaceae	*Toulicia guianensis* AUBL.	mesophanerophyte	tree	Sf
Sapotaceae	*Manilkara bidentata* (A.DC.) A. CHEV.	megaphanerophyte	tree	Shr
Smilaceae	*Smilax schomburgkiana* KUNTH.	mesophanerophyte	liana	Mg, Sf, Shr, Md
Solanaceae	*Solanum lanceifolium* JACQ.	nanophanerophyte	liana	Sf, Shr
Solanaceae	*Solanum stramonifolium* JACQ.	nanophanerophyte	shrub	Shr
Sterculiaceae	*Byttneria uaupensis* SPRUCE ex K. SCHUM.	mesophanerophyte	herb	Sf
Sterculiaceae	*Sterculia pruriens* (AUBL.) K. SCHUM. var. *pruriens*	megaphanerophyte	tree	Sf
Urticaceae	*Boehmeria ramiflora* JACQ.	microphanerophyte	shrub	Sf
Urticaceae	*Pilea pubescens* LIEBM	microphanerophyte	herb	Sf

Family	Genus and species	growth form	life form	habitat
Verbenaceae	*Avicennia germinans* (L.) STEARN	mesophanerophyte	tree	Mg
Viacaceae	*Phoradendron piperoides* (KUNTH) TREL.	microphanerophyte	parasite	Mg
Vitaceae	*Cissus sicyoides* L.	mesophanerophyte	liana	Mg
Cryptogames				
Pteridophyta				
Aspleniaceae	*Polybotrya caudata* KUNZE	protohemicryptophyte	epiphyte	
Blechnaceae	*Blechnum serrulatum* L.C. RICH.	protohemicryptophyte	fern	Sf, Mo, Shr, Md
Lycopodiacae	*Huperzia dichotoma* (JACQ.) TREVIS	microphanerophyte	epiphyte	Sf
Polypodaceae	*Campyloneurum phyllitidis* (L.) C. PRESL	protohemicryptophyte	fern	Mg
Polypodaceae	*Microgramma reptans* (CAV.) A.R. SM.	protohemicryptophyte	fern	Mg, Sf, Mo, Md, Shr
Polypodaceae	*Microgramma persicariifolia* (SCHRAD.) C. PRESL	protohemicryptophyte	fern	Sf
Polypodaceae	*Polypodium polypodioides* (L.) WATT.	protohemicryptophyte	epiphyte	Sf
Pteridaceae	*Acrostichum aureum* L.	protohemicryptophyte	fern	Mg, Sf, Shr
Vittariaceae	*Vittaria lineata* (L.) SM.	protohemicryptophyte	epiphyte	Mg
Fungi				
Dematiaceae	*Cercospora* sp.		fungus	Sf
Bryophyta				
Meteoriaceae	*Zelometeorium patulum* (HEDW.) MANUEL	protohemicryptophyte	mosses	Sf
Pterobryaceae	*Orthostichopsis tetragona* (Hedw.) Broth.	protohemicryptophyte	mosses	Sf
Lichens				
Usneaceae	*Ramalina* sp.	protohemicryptophyte	lichen	Sf

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New records of Pauropoda and Symphyla (Myriapoda) from Brazil with description of new species in *Allopauropus, Hanseniella* and *Ribautiella* from the northern Pantanal wetland and from Mato Grosso of Brazil

by

U. Scheller

Ulf Scheller, Häggeboholm, Häggesled, 53194 Järpås, Sweden;
e-mail: ulf.scheller@telia.com

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Abstract

Pauropoda and Symphyla are reported from Mato Grosso of Brazil and for the first time from the northern Pantanal wetland. Three species new to science were found, and are described: the pauropod *Allopauropus pantanalicus* n.sp. in the Pauropodidae; the symphylans *Hanseniella guimaraensis* n.sp. in the Scutigerellidae and *Ribautiella cathetus* n.sp. in the Scolopendrellidae.

Keywords: **Pauropoda, Symphyla, Myriapoda, Neotropical region, new species.**

Resumo

Pauropoda e Symphyla são relatados para Mato Grosso, Brasil e pela primeira vez para o Pantanal do norte. Três novas espécies para ciência foram encontradas e são descritas: o paurópodo *Allopauropus pantanalicus* n.sp. em Pauropodidae; os sínfilos *Hanseniella guimaraensis* n.sp. em Scutigerellidae e *Ribautiella cathetus* n.sp. em Scolopendrellidae.

Introduction

Thanks to many years of collecting in several ecosystems in Central Amazonia by Prof. Joachim ADIS, MPIL Plön/Germany and his collaborators, many species of Pauropoda and Symphyla from there have been described and investigated (SCHELLER 1979, 1992, 1994, 1997, 1999, 2002a, b; SCHELLER & ADIS 1984, 1996, 2002). These taxa are very poorly known from other parts of Brazil.

The Pantanal of Mato Grosso (JUNK et al. 2006) represents one of the largest wetlands of the world and is situated in the center of South America. It is formed in a large depression by the River Paraguay and its tributaries. The study area, situated on the right bank of Rio Cuiabá and the left bank of Rio Bento Gomes, is subjected to annual flooding of 0.6-1.5 m height, generally between December and March. To inhabit the floodplain forests and open grasslands of this environment, terricolous arthropods have to adapt to the unfavorable external conditions to enhance their ability of survival (ADIS et al. 2001). The five specimens of pauropods collected were obtained from emergence traps (ground photo-eclectors; ADIS 2002) in a monodominant

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inundation forest of *Vochysia divergens* (Vochysiaceae) on sandy soil during the rainy season. The symphylan specimens from Mato Grosso (*Hanseniella guimaraensis* n.sp. and *Ribautiella cathetus* n.sp.) were obtained during both rainy and dry seasons from litter (WINKLER extractors; CASTILHO et al. 2005) in a secondary upland forest on latosoil at Chapada dos Guimarães, a table mountain about 50 km NE Cuiabá. One specimen of *H. guimaraensis* also occurred in the Pantanal inundation forest during high-water in a trunk trap.

These studies represent a bilateral cooperation between the Federal University of Mato Grosso (UFMT) at Cuiabá (Prof. Marinêz M. MARQUES and students) and the Max-Planck-Institute for Limnology (MPIL) at Plön/Germany (Prof. Joachim ADIS and collaborators) (cf. MARQUES et al. 2006; PEREIRA et al. 2007).

The holotypes of the new pauropod and the two new symphylan species have been deposited in the Museu de Zoologia da Universidade de São Paulo (MZUSP), São Paulo, Brazil. Paratypes of *Hanseniella guimaraensis* have been deposited in the MZUSP (15 specimens), in the Natural History Museum of Geneva, Genève, Switzerland (3 specimens), and in the author's collections, with Ulf Scheller, Häggeboholm, Sweden (8 specimens) and with Joachim Adis, MPIL Plön, Germany (5+2 specimens).

Systematics with description of species

Notes

* Abbreviations: ad. = a specimen with the maximum number of legs; subad. ... and juv. ... = a subadult or a juvenile specimen with the number of pairs of legs indicated. These numbers include the rudimentary first pair of legs in *Ribautiella*.

** Length excludes antennae and cerci; the range of variation in the paratypes is given in parentheses.

Class Pauropoda
Order Tetramerocerata
Family Pauropodidae
Genus *Allopauropus* SILVESTRI, 1902
Subgenus *Allopauropus* s.str.
Allopauropus (A.) pantanalicus n.sp. (Figs. 1-9)

Type locality. - Brazil, Mato Grosso (MT), District of Pirizal, Pantanal of Poconé, 16°23'S, 56°18'W, inundation forest Cambarazal (*Vochysia divergens*, Vochysiaceae), ground photo-eclectors.

Type material. - Holotype: ad. 9* (female), 23.X.2004, leg. L.D. BATTIROLA. Paratypes: Same data as holotype: 4 subad. 8 (females). As holotype but 9.X.2004.

Total number. - 5 specimens.

Description

Length. - 0.89 mm**.

Head (Fig. 1). - Submedian setae of rows 2-4 lost. Setae thin, cylindrical, annulate. Relative lengths of setae, 1st row: $a_1=10$, $a_2=15$; 2nd row: $a_1=?$, $a_2=23$, $a_3=18$; 3rd row: $a_1=?$, $a_2=18$; 4th row: $a_1=?$, $a_2=20$, $a_3=25$, $a_4=30$; lateral group: $l_1=l_2=30$, $l_3=38$. Ratio a_1/a_1 -a_1 in 1st row 0.8. Temporal organs in tergal view narrow, as long as their shortest interdistance; no pistil in posterior part. Head cuticle glabrous.

Antennae (Fig. 2). - Segment 4 with setae *p*, *p'*, *p''* and *r*; *p'''* not identified. Setae annulate, *p* tapering distally, other setae cylindrical. Relative lengths of setae: $p=100$,

$p'=40$, $p''=29$, $r=48$. Tergal seta p 1.3 times as long as tergal branch t. The latter somewhat fusiform, 3 times longer than its greatest diameter and 1.3 times as long as sternal branch s, this 1.7 times as long as its greatest diameter and with its anterodistal corner distinctly truncate. Seta q thin, cylindrical, densely striate, almost 1.3 times as long as s. Relative lengths of flagella (basal segments included) and basal segments: $F_1=100$, $bs_1=9$; $F_2=43$, $bs_2=9$; $F_3=80$, $bs_3=10$. F_1 4.3 times as long as t, F_2 and F_3 2.3 and 4.3 times as long as s, respectively. Distal calyces of F_2 with small caps; distal part of flagella axes not widened. Globulus g proportionately small, about as wide as long, ∅ 0.8 of ∅ of t, capsule ∅=1.5 ηm. Antennae glabrous.

Trunk. - Setae of collum segment (Fig. 3) simple, thin, cylindrical, densely striate. Sublateral seta 1.8 times as long as submedian seta; sternite process triangular and without apical incision; appendages barrel-shaped, caps large. Process and appendages pubescent, caps glabrous.

Setae on tergites annulate, on anterior tergite blunt, on posterior ones pointed; 4+4 setae on tergite I, 6+6 on II-IV, 6+4 on V and 4+2 on VI. Posterior setae on tergite VI (Fig. 4) 0.3 of interdistance and 1.6 times as long as pygidial setae a_1.

Bothriotricha. - Relative lengths: $T_1=100$, $T_2=125$, $T_3=117$, $T_4=133$, $T_5=158$. All these with simple straight axis, very thin in T_1, T_2 and T_4, thin in T_5. T_3 (Fig. 5) with thicker axis, in distal 1/3 widening into a longish swelling. Pubescence of simple straight hairs, oblique on proximal half T_1-T_4 and on whole the T_5, almost erect on distal halves of T_1, T_2 and T_4.

Legs. - Setae on coxa (Fig. 6) and trochanter of leg 9 short, simple, thin, cylindrical, striate. Corresponding setae on more anterior legs similar but with rudiments of secondary branch. Tarsus of leg 9 (Fig. 7) 3.1 times as long as greatest diameter. Proximal seta curved, tapering, pointed, with short oblique pubescence, 0.2 of length of tarsus and somewhat shorter than distal seta; the latter straight, cylindrical, annulate, blunt. Cuticle of tarsus glabrous.

Pygidium (Fig. 8). - *Tergum*. Posterior margin rounded but with low bulge between st. Relative lengths of setae: $a_1=10$, $a_2=47$, $a_3=93$, $st=7$. Setae a_1 short. lanceolate, diverging; a_2 and a_3 long, tapering, directed posteriorly, somewhat curved inwards; st clavate, converging. Distance a_1-a_1 2.2 times as long as a_1, distance a_1-a_2 1.3 times as long as distance a_1-a_1 and about 4 times longer than a_2-a_3; distance st-st 5.7 times as long as st and 1.3 times as long as distance a_1-a_1. Surface of st and distal part of a_2 and a_3 not completely glabrous.

Sternum. Posterior margin between b_1 broadly indented but with low bulge with median incision below anal plate. Relative lengths of setae ($a_1=10$): $b_1=53$, $b_2=36$, $b_3=16$. b_1 and b_2 faintly striate, tapering, b_3 cylindrical, blunt, striate, somewhat diverging, b_2 curved inward, converging. b_1 0.9 of interdistance; b_2 1.7 times as long as distance b_1-b_2, b_3 0.5 of interdistance.

Anal plate (Fig. 9) subtriangular, narrowest anteriorly, lateral diverging margins ending posteriorly into short blunt appendages; posteriorly a median subquadrate lobe from the base of which two cylindrical, diverging, striate, blunt appendages protrude backward-downward; length of appendages 0.5 of length of plate.

Diagnosis. - The new species is close to *Allopauropus (A.) bicorniculus* SCHELLER (SCHELLER 1994) from Amazonas (shape of pygidial setae and anal plate) but there are good distinguishing characters in the length of the posterior row of setae on the tergite VI (submedian setae 1/4 of interdistance in *A. patanalicus*, 1.5-1.6 times as long as interdistance in *A. bicorniculus*), the shape of the bothriotricha T_3 (with long distal swelling in *A. patanalicus*, no swelling in *A. bicorniculus*), the shape of the tarsus of the last pair of legs (subcylindrical, tapering only distally in *A. patanalicus*, tapering whole the length in *A. bicorniculus*) and the length of the pygidial setae b_3 (0.5 of interdistance in *A. patanalicus*, 0.3 in *A.bicorniculus*).

Etymology. - A latinized adjective of the name Pantanal.

Class Symphyla

Family Scutigerellidae BAGNALL, 1913

Genus *Hanseniella* BAGNALL, 1913

Hanseniella orientalis (HANSEN, 1903)

Localities. - Manaus, Conj. Adrianapolis II, under plant pots in garden, 6 ad., 20.III.1983, leg. I. ADIS. - N of Manaus at 29 km on highway Manaus-Boa Vista (BR-174), grazed pasture (fucada), 4 ad., 18.IV.1997, leg. K. VOHLAND. - N of Manaus at 30 km on highway Manaus-Boa Vista (BR-174), grazed pasture (fucada), 5 ad., 2 subad., 7 juv., 26.IX.1994, leg. J. ADIS et al. - Lago Janauari, on a spit between the Rio Negro and the Rio Solimões 10 km E Manaus, 29 ad., 1 subad., 30 juv., 7.III.1996, leg. J. ADIS. - 20 km NW of Manaus, Tarumã Mirím, secondary forest (capoeira), 2 ad., 1 subad, 1 stad. ?, 16.III.1990, leg. J. ADIS et al. - Mato Grosso (MT), Pantanal, Porto Cercado, under plant pots, 5 ad., 24.VIII.2006, leg M.I. MARQUES.

Total number. - 93 specimens.

H. orientalis has been reported both from the Old World (Sri Lanka, Thailand, Sumatra, Java, Marquesas and Samoa Islands) and from the New World (Mexico, Brazil). Most collecting sites indicate spreading by human activities and it is unknown where the species is indigenous. The occurrence at Porto Cercado in a black organic soil probably from a terra firme site nearby may indicate an indigenous occurrence there.

Hanseniella guimaraensis n.sp. (Figs. 10-17)

Type locality. - Brazil, Mato Grosso (MT), Chapada dos Guimarães, 50 km N of Cuiabá, Centro de Treinamento AMI, 15°26’126"S, 55°47’236"W, alt. 2288 ft.(approx. 686 m a.s.l.), secondary forest on latosoil.

Type material. - Holotype: ad (female), 20.III.2004, leg. M.I. MARQUES, J. & I. ADIS, in litter (WINKLER extraction) (MZUSP). Paratypes: Same data as holotype: 12 ad., 3 juv. 10, 1 juv. 9, 2 juv. 8. As holotype but under stones: 12 ad, 1 subad. 11, 2 juv. 10.

Other material. - Same place as type material, forest litter, 1 ad., 23.V. 2004, and 1 ad., June 2004, forest litter, 23 ad., 1 subad., 1 juv. 10, 3 stad.?, 16.VII.2004, leg. L.D. BATTIROLA et al. (all WINKLER extraction). - Brazil, Mato Grosso (MT), District of Pirizal, Pantanal of Poconé, 16°23’S, 56°18’W, inundation forest Cambarazal, in trunk trap (arboreal photo-eclector downwards; cf. ADIS 2002), mounted in 5 m height on *Vochysia divergens* (Vochysiaceae), 1 ad. (desiccated), 29.II.2004 (high-water), leg. L.D. BATTIROLA.

Total number. - 35 specimens.

Description

Length. - (1.95-)2.55(-3.10) mm.

Head (Fig. 10). - Head short, broadest at the middle, (1.2-)1.3 times as broad as long, with indistinct lateral angle at point of articulation of mandible. Central rod with anterior and lateral branches invisible. Dorsal surface of head densely set with short straight thin setae. Longest setae just inside lateral head angles, these setae about 3 times longer than shortest setae and somewhat longer than longest inner seta at base of antenna. Posterior of antennal base a dense row of setae. Palp of first maxilla (Fig. 11) conical, pointed. Head cuticle smooth, glabrous.

Antennae (Figs. 12-14). - Antennae with (23-)28 and 30 segments; length 0.6 of length of body. Diameter of distal segments about 0.8 of diameter of most proximal segments. Setae decrease somewhat in length outwards. First segment (Fig. 12) short, twice as wide as long with a whorl of 6 setae: 3 thin depressed inner setae and 3 thicker ones, 2 sternal and one tergal. Tergal seta longest, 0.5 of diameter of segment. Second segment (Fig. 12) 1.2 times as long as wide with 9 setae, 3 thin depressed inner setae and 6 thicker ones; in a paratype 10 setae. 3rd segment (Fig. 12) 1.1 times as wide as long with 9 setae, arranged as on preceding segment, and a short spined organ on outer part of tergal side. The latter are on segments 3-17. 10th segment (Fig. 13) about as long as wide with 7 setae, one of them very short and thin; inner and outer setae of the same length. A second whorl of setae begins on outer side of 7th(-9th) segment and is complete on 17th-18th segments. 3rd whorl not found in holotype but is on ventral side of segments 20-27 in some paratypes. Apical segment (Fig. 14) (1.3-)1.4 times as long as its greatest diameter with about 20 setae and one large spined organ. The latter (0.4-)0.5 of the length of segment and with almost straight bracts. First segment glabrous, second segment with sparse pubescence which becomes more dense but thinner outwards.

Tergites (Fig. 10). - 1st tergite rudimentary with 2 very thin setae. 2nd tergite complete, 2.1(-2.2) times as broad as long; posterior margin straight in the middle; anterolateral angles distinct with macrochaetae directed outwards and backwards; the latter 1.2 times as long as diameter of first antennal segment; 20(-24) posteromarginal setae between anterolateral macrochaetae, a few of them about 0.5 of the length of anterolateral macrochaetae. Inner setae of tergite short, thin, subequal in length. Pubescence short, sparse, not reaching posterior margin. 3rd tergite 2.1 times as broad as long with straight posterior margin; anterolateral macrochaetae as on preceding tergite, 25 marginal setae between macrochaetae. Posteromarginal and inner setae and pubescence as on preceding tergite. 4th tergite distinctly broader than preceding one, 3.3 times as broad as long, posteriorly straight (or very indistinctly emarginate). Penultimate tergite with straight posterior margin, setae short, pubescence as on anterior tergites. Long anterolateral or lateral macrochaetae on tergites 2, 3, 4, 6, 7 and 9.

Legs. - Tarsus of first pair of legs (Fig. 15) 3.5(-4.8) times as long as greatest diameter, strongly tapering distally. Longest dorsal row with 5(-6) setae, longest ventral row with 3(-5) setae; distal setae somewhat longer than proximal ones; the longest one most distally on dorsal side, 0.5 of greatest diameter of tarsus. Both claws acuminate, anterior one almost straight, its length 0.1 of length of tarsus and 1.7 times as long as posterior claw. The latter and front seta subequal in length. Pubescence distinct. Trochanter with several short setae. Coxa with 3 short setae and one twice longer than them.

Tarsus of last pair of legs (Fig. 16) (3.6-)4.1(-4.4) times as long as greatest diameter, almost straight, slowly tapering distally. Setae arranged in rows lengthways, longest dorsal row with 5(-6) setae, longest ventral one with 4 setae. Dorsal setae somewhat longer than ventral ones, longest seta one (0.7-)0.8 of greatest diameter of tarsus. Tibia (2.0-)2.1 times as long as its greatest diameter, its length 0.9 of the length of tarsus; longest row on dorsal side with 4(-5) setae, the one on ventral side with 3(-4) setae; length of setae decreasing in length proximally but only inconsiderably; posterior side with a few setae only. Femur very short with a few setae on dorsal and anterior sides; neither ventral nor posterior setae. Trochanter setose on anterior and ventral sides only, one seta near base longer than the others. Anterior claw sickle-shaped, blunt, 0.2 of length of tarsus; posterior claw almost as long as anterior claw. Pubescence on tarsus, tibia and anterior and dorsal side of femur short but distinct; posterior side of femur and trochanter glabrous.

Styli of 12th pair of legs 3.8 times as long as wide, 0.3(-0.4) of length of tarsus and as long as greatest diameter of tarsus. No additional setae.

There are 7 pairs of fully developed coxal sacs at bases of legs 3-9. Posterior coxal plates of legs 11 and 12 with 2 setae, those of leg 10 with 3 setae.

Cerci (Fig. 17). - Cerci conical, 0.1 of the length of body and (3.3-)3.7(-4.2) times as long as greatest diameter. They are densely set with somewhat curved depressed setae, a few of the most distal ones longest; longest distal seta (0.3-)0.4 of greatest diameter of cercus. Longest dorsal row with 8 setae, longest ventral row has 7 setae. Pubescence dense and short. The longer of the two apical setae 3 times longer than shorter one.

Diagnosis. - *Hanseniella guimaraensis* n.sp. is closely related to *H. caldaria* (HANSEN), *H. orientalis* (HANSEN) (HANSEN 1903) and *Hanseniella indecisa* (ATTEMS) (ATTEMS 1911). It is distinguished from *H. caldaria* e.g. by the structure of the central part of the tergal side of the head (no central rod in *H. guimaraensis* n.sp., rod distinct in *H. caldaria*), by the number of setae on the first rudimentary tergite (2 setae in *H. guimaraensis* n.sp., generally 5 in *H. caldaria*) and by a proportionately shorter femur of the last pair of legs. The latter character distinguishes it readily also from *H. orientalis*. Other good characters separating the new species from *H. orientalis* are the pubescence of the tergites (sparse and minute in *H. guimaraensis* n.sp., coarse in *H. orientalis*), the chaetotaxy of the ventral side of the trochanter of leg 1 (no long setae in *H. guimaraensis* n.sp., several long setae in *H. orientalis*) and the length of the distal setae of the cerci (a few distal setae distinctly longer than the others in *H. guimaraensis* n.sp., proximal and distal setae of the same length in *H. orientalis*). The similarities with *H. indecisa* are fewer and the two species differs particularly by the shape of the setae in general (thin in *H. guimaraensis* n.sp., strong in *H. indecisa*), by the pubescence of the head and tergites (short minute in *H. guimaraensis* n.sp., coarse in *H. indecisa*), and the shape of the claws and the cerci (main claw bent strongly and cerci densely setose in *H. guimaraensis* n.sp., main claw bent only inconsiderably and cerci with fewer setae in *H. indecisa*. Moreover, the styli of the type specimens of *H. indecisa* have additional setae.

Etymology. - A latinized adjective of the name (Chapada dos) Guimarães.

Family Scolopendrellidae BAGNALL, 1913

Genus *Ribautiella* BRÖLEMANN, 1926

Ribautiella cathetus n.sp. (Figs. 19-25)

Type locality. - Brazil, Mato Grosso (MT), Chapada dos Guimarães, 50 km N of Cuiabá, Centro de Treinamento AMI, 15°26'126"S, 55°47'236"W, alt. 2288 ft. (approx. 686 m a.s.l.), secondary forest on latosoil, in litter.

Type material. - Holotype: ad (female), 20.III.2004, leg. M.I. MARQUES, J. & I. ADIS (MZUSP).

Total number. - 1 specimen.

Description

Length. - 2.98 mm.

Head (Fig. 18). - Head 1.1 times as long as broad with rounded lateral angles at points of articulation of the mandibles; broadest at the middle; posterolateral margins evenly rounded. Central rod thin but distinct, not broken; frontal and median branches lacking. Tergal side of head covered sparsely with thin short straight setae. Postantennal organ subglobular with narrow opening anteriorly. Palp of first maxilla (Fig. 19) bud-like, 2.8 times as long as broad and with 3 distal points, the median one longest; lateral points somewhat curved inwards, inner one longer than outer one. Cuticle of head granular.

Antennae (Figs. 20-21). - Right antenna with 16 segments (left broken outside 13th segment). Antenna 0.1 of length of the body. 1st segment (Fig. 20) shorter and thinner than following ones, 1.7 times as wide as long and with 6 very thin setae in a single whorl, 3 of them on inner side. The latter longest, 1.8 times as long as outer seta and 0.2 of greatest diameter of segment. Outer and inner setae on 10th segment of the same length. Longest setae of proximal segments 3.3 times as long as those of apical segment. 2nd segment with 9 setae, inner ones longest. Proximal part of antenna with one whorl of setae on each segment. Secondary whorl begins on sternal side of 9th segment behind the primary whorl but grows never complete and disappears distally. Circular (globular) sensory organs begin on the tergal side of segments 5-15. Other bladder-shaped organs on segments 13-15, the most, 9 ones, on segment 14. Small spined organs begin on inner tergal side of 2nd segment and occur on most segments the apical one included. Apical segment (Fig. 21) subglobular with short setae and 6 short spined organs in small depressions in the cuticle. All segments with distinct pubescence.

Tergites (Fig. 22). - There are 24 tergal plates, 12 of them with triangular posterior processes. The division of the tergites appear to be: tergites 1, 4, 5, 6, 8, 10, 12, 13, 16 undivided, tergites 2, 3, 7, 9, 11, 14, 15 divided. No setae on the triangular processes. 1st tergite rudimentary, short, with 6 short thin setae in an almost straight row. 2nd tergite complete; anterior part with 4 setae in one transversal row, posterior part with 4 setae in an anterior row and 6 in a posterior one; triangular processes small without end swellings and with straight inner margin. 3rd tergite with 6 and 10 setae on anterior and posterior part respectively. The ratio of the distance between the triangular processes to their length (measured from inner basal setae) is 2.1 on 2nd and 3rd tergites. There are two setae between inner basal setae on anterior tergites. All setae thin, insertion areas indistinct; no long anterolateral setae. Cuticle of tergites somewhat granular; triangular processes with short pubescence arranged in 3 rows lengthways.

Legs. - First pair of legs (Fig. 23) reduced to two small roundly conical pubescent knobs each with an apical seta; 8 setae between the leg rudiments. Last pair of legs (Fig. 24) with a subcylindrical tarsus, which narrows at both ends. It is 2.1 times as long as its greatest diameter and has 5 setae on distal half, 4 tergal and one sternal; 3 tergal setae are erect, rather long, straight, and one is depressed, somewhat curved; longest seta about 0.7 of greatest diameter of tarsus and about 0.4 of the length of tibia. Tibia and femur 1.4 and 1.0 times as long as its greatest diameter respectively and with two short and thin setae on distal part of tergal side. Trochanter with 4-5 very short and thin setae. Claws sickle-shaped, curved similarly. Styli at bases of legs 3-12, small, conical, pubescent with thin distal hair and about twice longer than their greatest diameter. Coxal sacs at bases of legs 3-10. Coxal plates of leg 11-12 with 2 setae.

Cerci (Fig. 25). - 2.5 times as long as greatest diameter, conical, all sides curved, 0.05 of the length of body. Setae thin, straight, longest on proximal part of tergal side; there are 5 setae on tergal side, 3 on outer and 2 on sternal and inner sides. Longest tergal row with 3 setae; longest seta almost 0.4 of greatest diameter of cercus. Terminal area with two striae at base. Apical setae lost. Pubescence of cerci sparse but distinct.

Diagnosis. - Two species in *Ribautiella* are known earlier from the Neotropics, both from Brazil, *R. amazonica* SCHELLER (SCHELLER & ADIS 1984) from near Manaus in Central Amazonia and *Ribautiella tuxeni* ALLEN (ALLEN 1998) from Santarém in Pará. The new species is easily distinguished from the former by the shape of the postantennal organs (subglobular in *R. cathetus* n.sp., longer than wide and generally two-parted in *R. amazonica* SCHELLER), the shape of the first pair of legs (simply conical in *R. cathetus* n.sp., two-parted in *R. amazonica* SCHELLER) and the shape of the claws of the last pair of legs (slowly tapering in *R. cathetus* n.sp., pointed in *R. amazonica* SCHELLER). A good distinguishing character in relation to both *R. amazonica* SCHELLER and *R. tuxeni* ALLEN is the chaetotaxy of the anterior tergites (two setae between the inner basal setae and inner margins of the posterior triangular appendages in *R. cathetus* n.sp., one seta in *R. amazonica* and *R. tuxeni*). Moreover are the inner margins of the posterior triangular appendages of anterior tergites parallel with the body in *R. cathetus* n.sp., converging anteriorly in *R. amazonica* and *R. tuxeni*. Other characters delimiting *R. cathetus* n.sp. from *R. tuxeni* are in the antennae (2nd whorl of setae occurs in the middle in *R. cathetus* n.sp., no 2nd whorl in *R. tuxeni*) and in the last pair of legs (tarsus 2.1 times as long as its greatest diameter in *R. cathetus* n.sp., almost 3 times in *R. tuxeni*; tibia with two short depressed thin setae on posterior part of tergal side in *R. cathetus* n.sp., with two long protruding setae in *R. tuxeni*).

Etymology. - From Latin cathetus = form a perpendicular line (the inner sides of the triangular appendages of the tergites).

Key to the species of *Ribautiella*

ALLEN (1998) presented a key to the species of *Ribautiella* but unfortunately he included neither *R. remyi* HINSCHBERGER nor *R. amazonica* SCHELLER. A new key is presented below including these species and the new one described above.

1. All tergites with straight posterior margin; bothriotrix fusiform .... *remyi* HINSCHBERGER
- 12 or 13 tergites with triangular processes; bothriotrix thin, threadlike 2
2. First tergite with 8 setae; terminal area of cerci with 7-8 striae .... *borbonica* JUPEAU
- First tergite with 6 setae; terminal area of cerci with 5 or less striae 3
3. 2nd tergite undivided; styli rounded .... *delphini* ROCHAIX
- 2nd tergite divided; styli conical 4
4. Anterior part of 2nd tergite with 6 or less setae 5
- Anterior part of 2nd tergite with 9 or more setae 6
5. Terminal area of cerci with 5 striae .... *schoutedeni* HINSCHBERGER
- Terminal area of cerci with at most 2 striae 7
6. Cerci sparsely setose .... *machadoi* HINSCHBERGER
- Cerci densely setose .... *zagnanadina* BRÖLEMANN
7. Styli very short; terminal area of cerci with 2 striae .... *cathetus* SCHELLER

- Styli well developed; terminal area of cerci without striae 8

8. Anterior part of 2nd tergite with 4 setae; tarsi of last pair of legs about twice longer than greatest diameter; cerci with about 20 setae .... *amazonica* SCHELLER

- Anterior part of 2nd tergite with 6 setae; tarsi of last pair of legs about 3 times longer than greatest diameter; cerci with less than 10 setae .... *tuxeni* ALLEN

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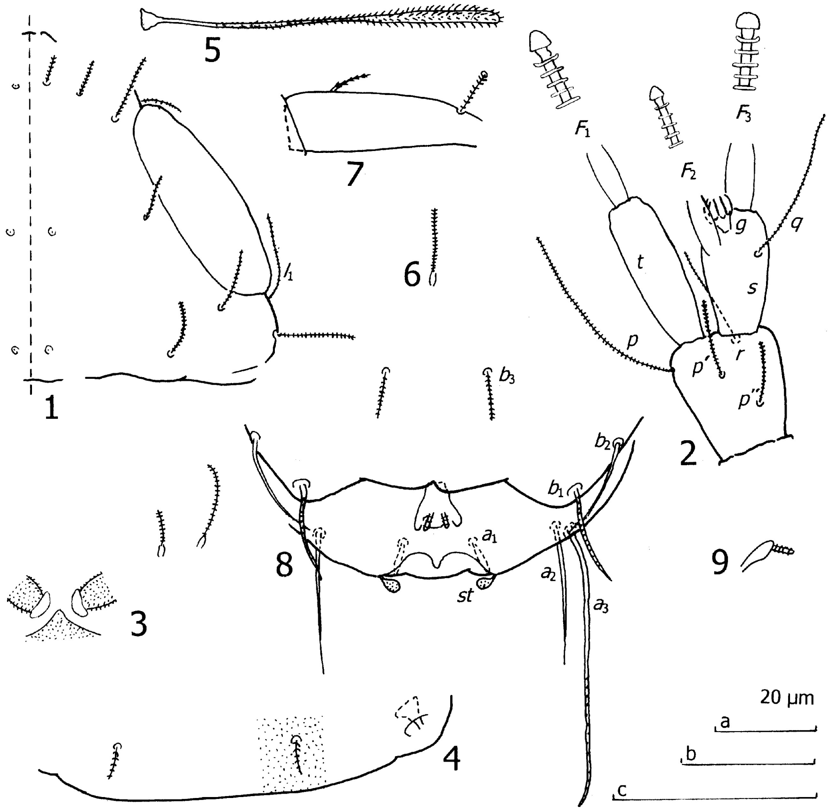
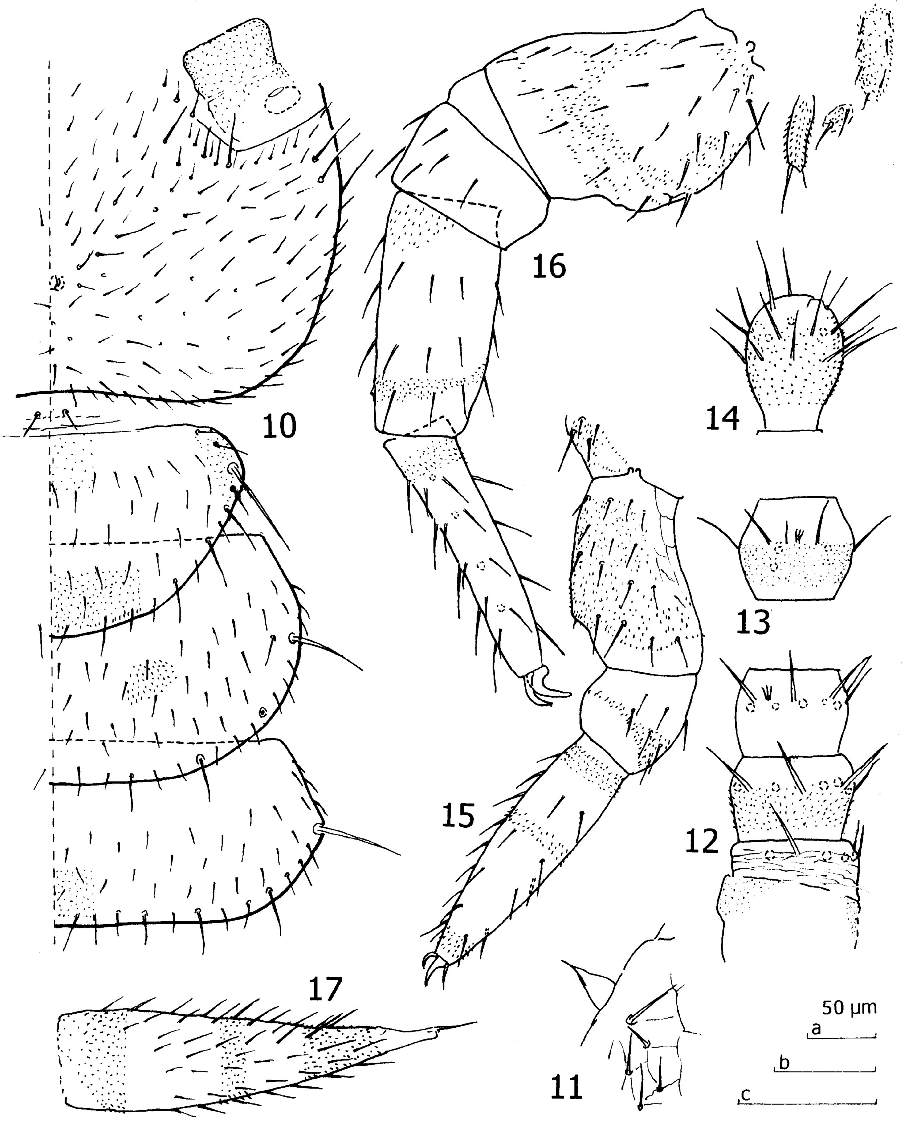
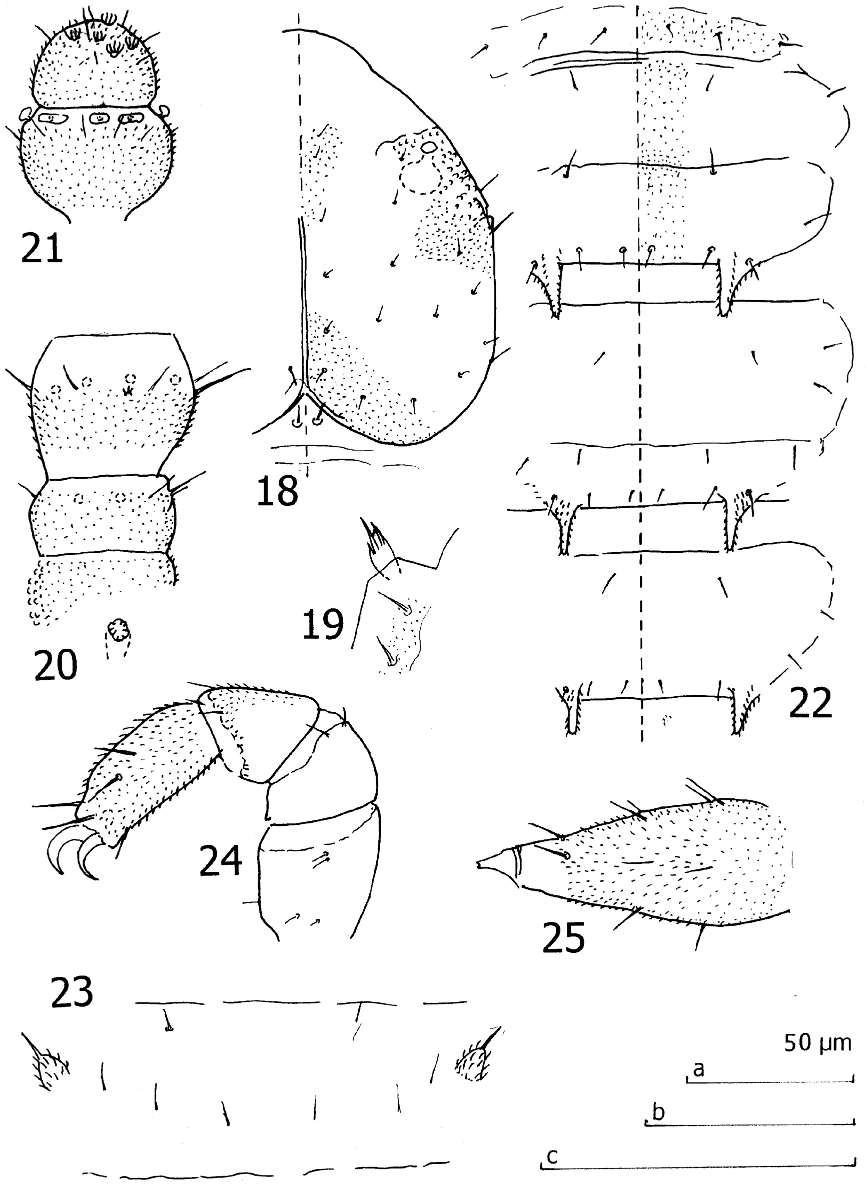


Figs. 1-9:
Allopauropus (Allopauropus) pantanalicus n.sp., holotype.
1: Head, median and right part, tergal view. **2**: Left antenna, sternal view. **3**: Collum segment, median and left part, sternal view. **4**: Tergite VI, posteromedian part and right posterior corner. **5**: T_3. **6**: Seta on coxa of leg 9. **7**: Tarsus of leg 9. **8**: Pygidium, posteromedian part, sternal view. **9**: Anal plate, lateral view. Scale a: 5; b: 1, 3, 4, 6-9; c: 2.



Figs. 10-17:
Hanseniella guimaraensis n.sp., holotype.
10: Head, right half, 1st rudimentary tergite and right half of tergites 2-4, tergal view. **11**: Palp of first maxilla, right side, sternal view. **12-14**: Antenna, right side, tergal view: **12**, first three segments; **13**, 10th segment; **14**, apical segment. **15**: First leg, right side. **16**: 12th leg, right side, anterior view. **17**: Right cercus, outer lateral view. Pubescence only partly drawn in 10, 15-17. Scale a: 10, 17; b: 11-14, 16 ; c: 15.



Figs. 18-25:
Ribautiella cathetus n.sp., holotype.
18: Head, right half, tergal view. **19**: Palp of first maxilla, right side, sternal view. **20-21**: Antenna, right side, tergal view: **20**, first two segments; **21**, apical and subapical segments. **22**: Tergites 1-4, tergite 1 complete, tergites 2-4 median and right part. **23**: First pair of legs. **24**: 12th leg, left side. **25**: Left cercus, outer lateral view. Pubescence only partly drawn in 18, 22, 24. Scale a: 18; b: 22; c: 19, 20-21, 23-25.

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New evidence for a disrupted distribution pattern of the 'Tityus confluens' complex, with the description of a new species from the State of Pará, Brazil (Scorpiones, Buthidae)

by

W.R. Lourenço & E. Aparecida da Silva

Dr. Wilson R. Lourenço, Département de Systématique et Evolution, USM 0602, Section Arthropodes (Arachnologie), Muséum national d'Histoire naturelle, CP 053, 61 rue Buffon 75005 Paris, France; e-mail: arachne@mnhn.fr
B.Sc. Elizângela Aparecida da Silva, Depto. De Biologia, Universidade do Estado de Mato Grosso, UNEMAT, Av. Tancredo Neves, 1095, Cavalhada 2, 78200-000 Cáceres, MT, Brazil

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Abstract

The existence of a possible scorpion complex known as the 'Tityus confluens' complex is discussed once again in the present paper. The species *Tityus confluens* BORELLI, 1899 is native to Bolivia, Paraguay and Argentina. It has also been found in the States of Mato Grosso and Mato Grosso do Sul in Brazil. Recent studies have confirmed the existence of several additional species associated with this 'Tityus confluens' complex. Most of these are distributed in savannah (cerrado) areas of central Brazil, but one, *Tityus sylviae* LOURENÇO, 2005, was recently described from the upper Rio Negro region, in Brazilian Amazonia. This species was the first indication of a disrupted pattern of distribution within the complex. In the present paper, another new species, *Tityus marajoensis* n.sp., is described from the State of Pará, Brazil. It provides further evidence of a disrupted pattern of distribution. Some biogeographic comments are also added.

Keywords: **Scorpion, 'Tityus confluens' complex, new species, Marajó Island, State of Pará, Brazil.**

Resumo

É discutida mais uma vez no presente artigo, a provavel existência de um complexo definido como 'Tityus confluens'. A espécie *Tityus confluens* BORELLI, 1899 é nativa da Bolivia, Paraguai e Argentina, tendo sido igualmente confirmada nos Estados de Mato Grosso e Mato Grosso do Sul no Brasil. Estudos recentes confirmaram a existência de diversas espécies adicionais igualmente associadas ao complexo 'Tityus confluens'. A maioria dessas espécies apresenta uma distribuição geográfica em áreas de vegetação aberta do tipo cerrado na região central do Brasil. Uma porém, *Tityus sylviae* LOURENÇO, 2005, descrita recentemente do alto Rio Negro aparece como uma excessão a essa regra. Esta espécie é o primeiro elemento indicador de um modelo de distribuição disjunta dentro do complexo. No presente artigo uma nova espécie, *Tityus marajoensis* n.sp., é descrita do Estado do Pará no Brasil. Ela confirma o modelo de distribuição disjunta do complexo. Alguns comentários biogeográficos são igualmente incluidos.

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Introduction

As pointed out in previous publications (MAURY 1974; LOURENÇO 1980; LOURENÇO & SILVA 2006), *Tityus confluens* was originally described by BORELLI (1899) under the name *Tityus trivittatus confluens*, on the basis of a single female holotype collected at Caiza in the Bolivian Chaco, Bolivia, as well as one female and one juvenile paratype collected at Misione di San Francisco, alto Pilcomayo, Bolivia. After its description, this subspecies failed to attract the attention of many authors. Indeed, only MAURY (1974) proposed a full redescription. He raised the subspecies to species rank, as *Tityus confluens*. The study by MAURY (1974) was the first to be based on re-analysis of the type material, and his opinion was later confirmed by LOURENÇO (1980). In his monograph on South American scorpions, MELLO-LEITÃO (1945) had published a redescription of this subspecies, based on specimens collected in Iguaçú, in the State of Paraná, Brazil. This redescription incorrectly indicated that the type locality was Chaco, Argentina. Moreover, the characters redescribed by MELLO-LEITÃO (1945) do not agree with those of Borelli's types. As suggested by MAURY (1974) and confirmed by LOURENÇO (1980), the specimens used by MELLO-LEITÃO in his study almost certainly correspond with some other species, possibly *Tityus trivittatus* KRAEPELIN 1898.

The controversy regarding the presence of *Tityus confluens* in Brazil has been the subject of several publications. It has recently been revised and, to some extent clarified (see LOURENÇO & SILVA 2006). In more recent years too, the presence of *T. confluens* has been confirmed in several localities of the States of Mato Grosso and Mato Grosso do Sul (SILVA, unpubl. data). Furthermore, as do some other species of *Tityus* (see LOURENÇO & CLOUDLSEY-THOMPSON 1996; LOURENÇO et al. 1996) this species appears to show the ecological capacity necessary for it readily to become adapted to modified urban environments. For this reason, *T. confluens* is now to be found in several cities and towns of these two States, especially Cuiabá, Cáceres, and Campo Grande. The presence of *T. confluens* in numerous localities in the States of Mato Grosso and Mato Grosso do Sul is unquestionable (LOURENÇO et al. 2004). Its range of distribution has also been extrapolated by BERTANI et al. (2005) to include several others States of Brazil. This claim has, however, been shown undoubtedly to be fallacious. It has doubtless been engendered by lack of knowledge of the existence of a considerable number of species closely associated with *T. confluens* (see LOURENÇO & SILVA 2006). In recent years, several additional species have been added what is evidently a 'T. confluens' complex. Several of these have been described in the last few years (LOURENÇO 2003; LOURENÇO & SILVA 2006), while others have only recently been associated with the complex (LOURENÇO et al. 1997). The most unexpected discovery has been that of *Tityus sylviae* LOURENÇO (LOURENÇO 2005), a species described on the basis of specimens collected in the upper Rio Negro of occidental Brazilian Amazonia. This species can also be associated with *Tityus confluens*, but shows a totally disrupted pattern of distribution with regard to the other species of the complex. Another new species, also associated with the 'T. confluens' complex, is described below from campos areas in the Island of Marajó in the State of Pará, confirming thereby the disrupted pattern of distribution of the 'T. confluens' complex of species.

Methods

Illustrations and measurements were produce using a Wild M5 stereo microscope with a drawing tube and an ocular micrometer. Measurements follow STAHNKE (1970) and are given in mm. Trichobothrial notations follow VACHON (1974) and the morphological terminology mostly follows VACHON (1952) and HJELLE (1990).

Species associated with the 'Tityus confluens' complex

As already pointed out (LOURENÇO et al. 1997; LOURENÇO & Silva 2006), the first attempt at a revision of the genus *Tityus* was proposed by MELLO-LEITÃO (1931) when he mentioned a new species, *Tityus blaseri* MELLO-LEITÃO, of which he provided only a short description and a single rather poor photo. According to MELLO-LEITÃO, the type specimen on which the description was based consisted of a small (35 mm) female collected at Veadeiros, in the State of Goiás on the Central Plateau of Brazil. MELLO-LEITÃO (1931) included *Tityus blaseri* in the group of small scorpions defined as 'A-Group *Tityus clathratus* (KOCH)'. In his later monograph on South American scorpions (MELLO-LEITÃO 1945), *Tityus blaseri* was redescribed and again placed in the 'Tityus clathratus' group. Only in recent years have LOURENÇO et al. (1997) proposed a redescription of *Tityus blaseri*. This was based on fresh material collected in the region of Niquelândia in the State of Goiás, from a locality geographically very close to Veadeiros, the type locality. Moreover, the type material of *Tityus blaseri* was located in the Museu Nacional in Rio de Janeiro. Close examination of the type material, together with the specimens collected in Niquelândia, confirmed the identification of *Tityus blaseri*. The study also showed that *Tityus blaseri* does not belong to the 'Tityus clathratus' group, but is associated with *Tityus confluens* and its related species. Another species, also associated with *T. confluens*, is *Tityus uniformis*, described by MELLO-LEITÃO (1931), again from the State of Goiás. The status of this species remains unclear, however, since the types have been lost and the type locality was not clearly defined. It may perhaps be a junior synonym of *Tityus blaseri*, but further collecting will be necessary before a final decision can be made. More recently yet two other new species, *Tityus adrianoi* LOURENÇO (2003) and *Tityus paulistorum* LOURENÇO & SILVA (2006) were described respectively from the regions of the Serra do Cipo in the State of Minas Gerais and from the cerrados of the State of São Paulo. These two species should also be included in the 'Tityus confluens' complex.

The most unexpected event concerning species associated with the 'T. confluens' complex has been the discovery and description of *Tityus sylviae* by LOURENÇO (2005) in the upper Rio Negro region. This is a typical case of a disrupted biogeographic distribution within the species of the 'T. confluens' complex. This biogeographic pattern is now confirmed by the description of another species, this time from the Marajó Island in oriental Amazon region in Brazil.

Description of a new species from the State of Pará

Taxonomic treatment

Tityus marajoensis n.sp. (Figs. 1-9, Table 1)

Brazil, State of Pará, Ilha de Marajo, X/1973 (collected by local Indians; J.-B. LACROIX leg.) 1 female holotype, 1 female paratype. Deposited in the Muséum national d'Histoire naturelle, Paris.

Etymology: the specific name makes reference to the locality in which the new species was collected.

Diagnosis. Scorpions of medium size, the female having a total length of 49 mm. Coloration yellowish, with carapace and tergites reddish-brown to brown, much darker than appendages. Granulation moderately marked throughout the body. Fixed and movable fingers with 15/17 rows of granules. All carinae moderately to strongly marked. Pectinal tooth count 19-20 in the female holotype and 19-19 in the female paratype; basal middle lamella not dilated; basal piece to the genital operculum strongly developed (Fig. 6). *T. marajoensis* n.sp. belongs to the subgenus *Tityus* (sensu LOURENÇO 2006) and to the 'Tityus confluens' complex of species.

Relationships

In its general morphology and pattern of coloration the new species shows affinities with *Tityus confluens* BORELLI from Argentina, Paraguay and Brazil and with *Tityus blaseri* MELLO-LEITÃO from Chapada dos Veadeiros in the State of Goiás. The distribution of the three species is, however, quite distinct. *T. blaseri* for example, inhabits a campo rupestre formation at altitudes ranging from 1000 to 2000 m, whereas the new species originated from a coastal campo formation, with an altitude averaging 0 to 100 m (EITEN 1978; MURÇA PIRES & PRANCE 1985). The following characters may be distinctive: (i) the chelicerae of the new species lack the variegated blackish spots which are present in both *T. confluens* and *T. blaseri* (Fig. 7), (ii) the tergites are divided by a yellow longitudinal strip, absent from the other two species, (iii) the basal piece to the genital operculum is remarkably developed in the new species, but reduced in the other two species (Fig. 6).

Description based on female holotype and female paratype

Coloration. Basically yellowish to slightly reddish-yellow. Carapace and tergites I to VI reddish-brown to brownish with a longitudinal yellowish strip over the tergites I to VI; tergite VII yellowish to reddish-yellow; eyes strongly marked with black pigment. Metasoma: segments I to V yellowish to reddish-yellow. Vesicle with the same colour as segment V; extremity of aculeus darker than vesicle. Venter yellowish-brown; genital operculum and pectines pale yellow. Chelicerae yellowish without any variegated dark pigmentation; fingers reddish; teeth reddish-brown. Pedipalps: yellowish; granulations on cutting edge of fingers reddish. Legs yellowish without any spots.

Morphology. Carapace moderately to strongly granular; anterior margin with a weakly marked median concavity. Anterior median superciliary and posterior median carinae moderate; all other carinae weak. All furrows moderately deep. Median ocular tubercle slightly anterior to the centre of the carapace. Three pairs of lateral eyes. Sternum triangular. Mesosoma: tergites moderately granular. Median carina strong in all tergites. Tergite VII pentacarinate. Venter: genital operculum larger than high; basal piece strongly developed. Pectines: pectinal tooth count 19-20 in female holotype, 19-19 in female paratype; basal middle lamellae of the pectines not dilated. Sternites with thin granulation and elongate stigmata; VI with vestigial carinae; VII with four carinae, moderate. Metasoma: segments I-II with ten carinae; lateral inframedian carinae on segment I complete, crenulate; on II represented by granules covering only the distal one fourth; segments III-IV with eight complete carinae; segment V with five carinae. Intercarinal spaces moderately granular. Telson, with some weakly marked granulations on ventral and lateral surfaces; aculeus long and strongly curved; subaculear tooth strong and spinoid with two dorsal teeth. Cheliceral dentition characteristic of the family Buthidae; ventral teeth on movable finger moderately marked; ventral aspect of both fingers and manus with long dense setae (VACHON 1963). Pedipalp: femur pentacarinate; patella with seven carinae; chela with nine carinae; all carinae moderate to strong; all faces weakly granular. Fixed and movable fingers with 15/17 oblique rows of granules. Trichobothriotaxy; orthobothriotaxy A-α (alpha) (VACHON 1974, 1975). Legs: tarsus with numerous short setae ventrally. Pedal spurs moderate.

Biogeographical comments

The pattern of geographic distribution presented by *Tityus marajoensis* n.sp. and its associated species, *Tityus confluens, Tityus blaseri* and *Tityus sylviae*, suggests that these are allopatric species. *T. confluens* and *T. blaseri* inhabitat similar landscape formations, respectively of the type Chaco / Pantanal-cerrado and campo rupestre which, however, belong to different categories according to EITEN (1978, 1982). Furthermore, their areas of distribution are separated by almost 1000 km of cerrado gradients which acts as a barrier. In contrast, *T. sylviae* inhabits forest formations in the upper Rio Negro possibly associated with Amazonian caatinga and campinarana. The present geographical pattern of disrupted distribution of the different species belonging to the 'T. confluens' complex suggests that in past times a contact zone probably existed between these today distinct populations. The present pattern of distribution is almost certainly the result of climatic vicissitudes in tropical South America during the late Cenozoic and Pleistocene (AB'SABER 1977a, b; PRANCE 1982; LOURENÇO 1986a, 1987, 1996).

Buthids show the widest distribution among the different scorpion families present in South America. They are present in almost all regions of the continent with the exception of the centre and South of Chile and Southern Argentina. Within the family Buthidae, the genus *Tityus* is the only one present in almost every geographical region and type of vegetation of South America. The genus *Ananteris* THORELL 1891, found mainly in South America but also in Africa, also presents quite a wide range, but most of the species are only present in small endemic patches between which there are many gaps. The genus *Rhopalurus* THORELL 1876 is typical of open vegetation formations in South America. Its core areas of distribution are the cerrados and caatinga formations of the central and North-eastern regions of Brazil. One species is known from a single enclave in a savanna formation inside oriental Amazonia, two others from the savannas of Roraima.

Several interesting examples of both genera and species presenting a discontinuous distribution can be observed among the scorpions exclusively adapted to savanna or rainforest. These examples have an important relationship with species endemic to present habitat islands of savanna in Amazonian enclaves and with forest islands inside xerophytic formations such as the Brazilian caatingas. These isolated endemic populations provide good evidence in support of the hypothesis of past connections between the savannas of central Brazil and the savanna enclaves in Amazonia and Gran-Sabana (Guayana region). When forest cover was reduced during past dry periods, open vegetation formations probably coalesced (AB'SABER 1977a, b; PRANCE 1982).

Scorpions provide strong evidence in support of this suggestion. Examples are provided by the genera *Rhopalurus* of the family Buthidae and *Opisthacanthus* of the family Liochelidae. *Rhopalurus*, a genus specifically adapted to open vegetation (savannas) in South America, is widely distributed from north-eastern and central Brazil to Guyana, Venezuela and Colombia, with some species present in the Greater-Antilles (LOURENÇO 1982). This genus probably exhibited a continuous distribution during Pleistocene dry periods and the present disrupted distribution is a possible consequence of the reestablishment of rainforest over the region. Evidence for this hypothetical paleodistribution is provided by the species *R. amazonicus* LOURENÇO, 1986, endemic to savanna enclaves in Alter do Chão, State of Pará, Brazil (LOURENÇO 1986b). An analysis of the species of *Rhopalurus* demonstrated that *R. amazonicus* is phylogenetically closely related to *R. acromelas* LUTZ & MELLO, 1922 from central Brazil, distributed in a region close to the area of transition between cerrados and Amazonia. A similar example is provided by two allopatric species of *Opisthacanthus* PETERS, 1861. *O. cayaporum* VELLARD, 1932 is distributed among enclaved cerrado formations in the South of Brazilian Amazonia, while its sibling species, *O. heurtaultae* LOURENÇO, 1980 is known only from the coastal savannas of French Guiana. It is quite possible that these two species experienced contacts in the past, when the forested formations knew extensive regressions during dry episodes of the Pleistocene. With the expansion of wet forest these two populations were again isolated (LOURENÇO 1986a, 1987, 1996). This biogeographical model seems to fit well with the pattern of distribution observed today among the species associated with the 'T. confluens' complex.

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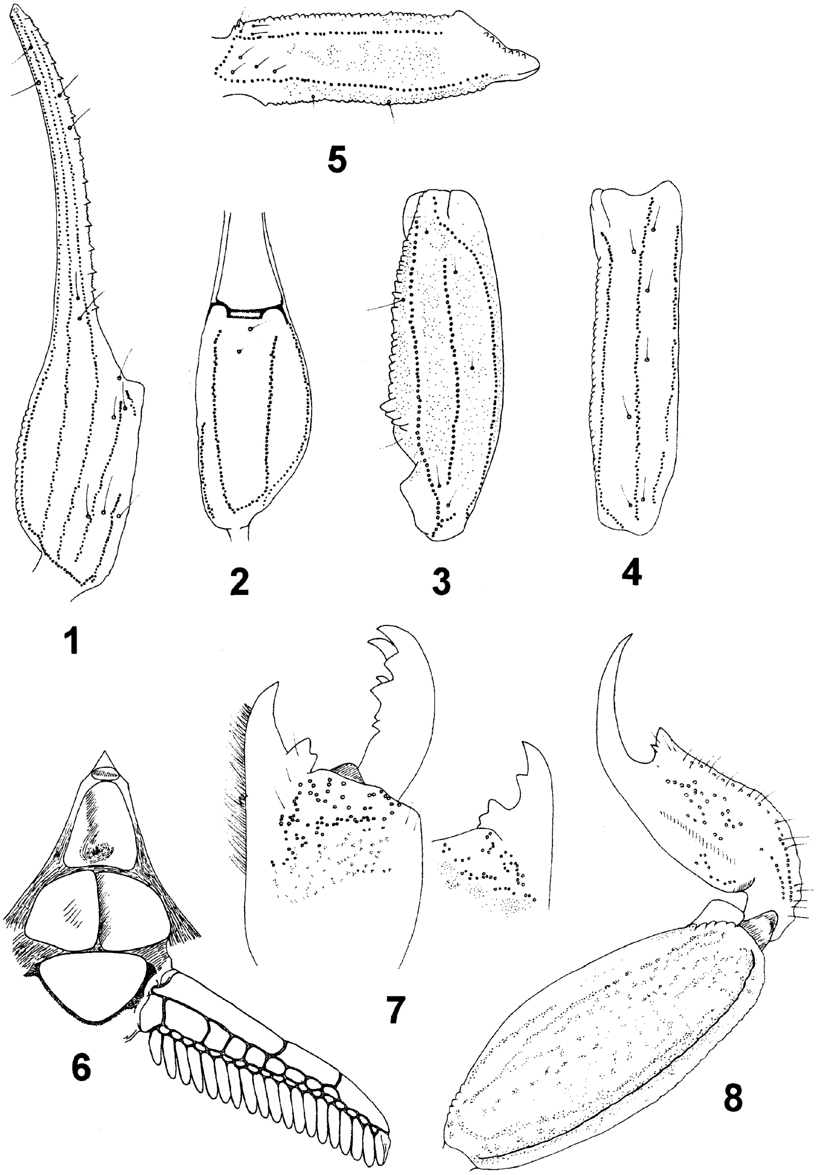
Table 1: Morphometric values (in mm) of the female holotype of *Tityus marajoensis* n.sp., male and female of *Tityus blaseri* from Niquelândia, State of Goiás and, male and female of *Tityus confluens* from Mato Grosso do Sul, Brazil.

	***Tityus marajoensis* n.sp.**	***Tityus blaseri***		***Tityus confluens***	
	♀	♂	♀	♂	♀
Total length	49.1	55.6	44.3	49.3	47.4
Carapace:					
- length	6.1	6.8	6.2	6.0	6.0
- anterior width	4.2	4.6	4.1	4.0	4.1
- posterior width	6.5	7.4	6.4	6.0	6.1
Metasomal segment I:					
- length	3.8	4.7	3.8	4.0	3.8
- width	3.2	3.7	3.4	3.2	2.8
Metasomal segment V:					
- length	6.8	8.9	6.8	7.3	6.6
- width	2.9	4.2	2.8	3.5	2.4
- depth	2.9	4.2	2.7	3.3	2.4
Vesicle:					
- width	2.1	2.7	2.1	2.2	2.0
- depth	2.0	2.8	2.1	2.1	2.2
Pedipalp:					
- Femur length	6.3	7.1	5.9	6.6	6.4
- Femur width	1.9	2.1	1.8	1.6	1.7
- Patella length	6.8	7.7	6.3	7.0	6.9
- Patella width	2.2	2.7	2.3	2.2	2.2
- Chela length	11.6	13.9	11.2	11.7	11.2
- Chela width	2.2	3.9	2.2	3.1	1.9
- Chela depth	2.1	3.7	2.1	2.8	1.8
Movable finger:					
- length	7.6	8.8	7.6	7.6	7.7



Figs. 1-8:
Tityus marajoensis n.sp. female holotype. **1-5**: Trichobothrial pattern. **1-2**: Chela, dorso-external and ventral aspects. **3-4**: Patella, dorsal and external aspects. **5**: Femur, dorsal aspect. **6**: Ventral aspect showing sternum, genital operculum, basal piece and pecten. **7**: Right chelicera and fixed finger of left chelicerae, dorsal aspect. **8**: Metasomal segment V and telson, lateral aspect.

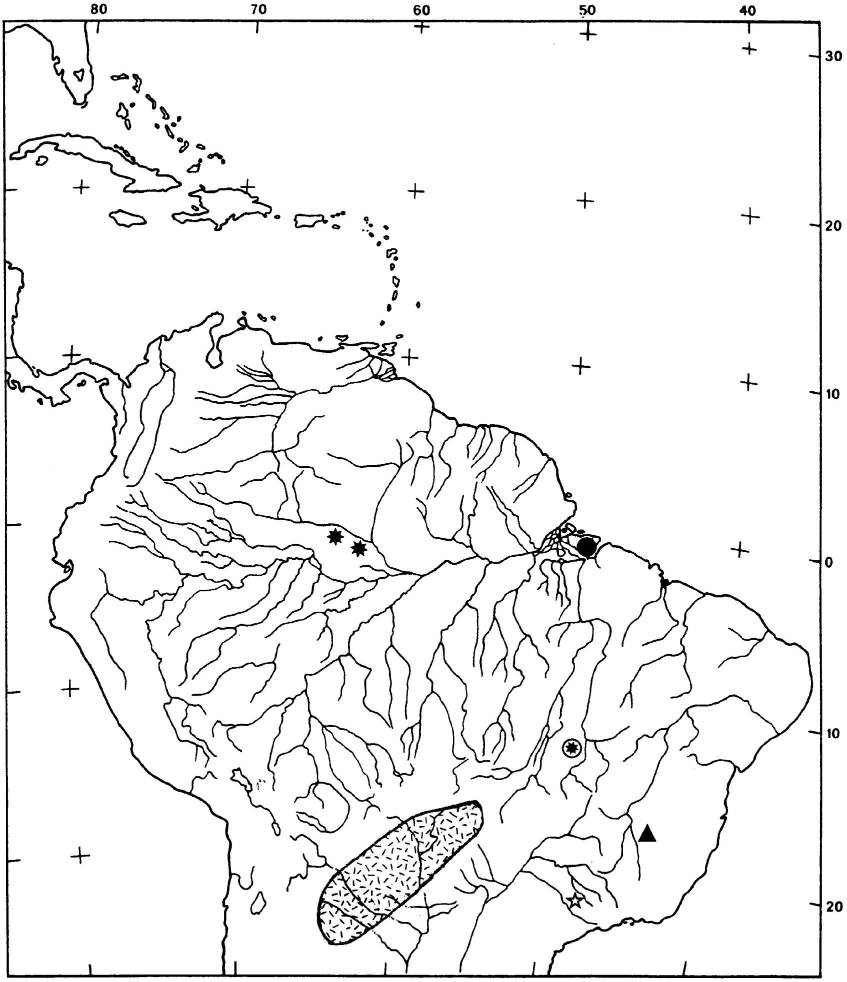


Fig. 9:
Map of Central South America and Brazil showing the areas of distribution of the species associated to the 'Tityus confluens' group. *Tityus confluens* (shaded area). *Tityus sylvia* (black star). *Tityus blaseri* (open circle with black star). *Tityus adrianoi* (black triangle). *Tityus paulistorum* (white star). *Tityus marajoensis* n.sp. (black circle).

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Neue *Stenus*-Arten, vorwiegend aus dem Amazonasgebiet (Coleoptera: Staphylinidae)*

von

V. Puthz

Dr. Volker Puthz, Seebergstr. 4, 36110 Schlitz; e-mail: stenus.puthz@t-online.de

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New *Stenus*, mainly from the Amazon region (Coleoptera: Staphylinidae)

Abstract

Six new species of the genus *Stenus* LATREILLE, predominantly from the Amazon region, are described and new records are presented: *Stenus (Hypostenus) adisi* n.sp. (Brazil), *S. (s. str.) calceolipes* n.sp. (Brazil), *S. (H.) flinti* n.sp. (Brazil, Bolivia), *S. (H.) fronto* n.sp. (Ecuador, Peru), *S. (H.) koerneri* n.sp. (Ecuador, Peru) and *S. (H.) mathani* n.sp. (Brazil).

Resumo

Seis novas espécies do gênero *Stenus* LATREILLE, predominante da região da Amazônia, são descritas e novos registros efetuados: *Stenus (Hypostenus) adisi* n.sp. (Brasil), *S. (s. str.) calceolipes* n.sp. (Brasil), *S. (H.) flinti* n.sp. (Brasil, Bolivia), *S. (H.) fronto* n.sp. (Ecuador, Perú), *S. (H.) koerneri* n.sp. (Ecuador, Perú) and *S. (H.) mathani* n.sp. (Brasil).

Zusammenfassung

Sechs neue Arten der Gattung *Stenus* LATREILLE, vorwiegend aus dem Amazonasgebiet, werden beschrieben und einige neue Funde mitgeteilt: *Stenus (Hypostenus) adisi* n.sp. (Brasilien), *S. (s. str.) calceolipes* n.sp. (Brasilien), *S. (H.) flinti* n.sp. (Brasilien, Bolivien), *S. (H.) fronto* n.sp. (Ekuador, Peru), *S. (H.) koerneri* n.sp. (Ekuador, Peru) und *S. (H.) mathani* n.sp. (Brasilien).

Keywords: **Coleoptera, South America, Staphylinidae, Steninae, Stenus, new species.**

Einleitung

Die weltweit verbreitete Gattung *Stenus* LATREILLE ist mit 439 beschriebenen Arten in der Neotropis vertreten. Längst aber sind noch nicht alle dort lebenden Spezies erfasst. Unter mir jüngst von Prof. J. Adis vorgelegtem Material aus der Umgebung von Manaus fand sich eine neue Art, die ich hier, zusammen mit fünf weiteren, beschreibe.

Material und Methoden

In den folgenden Beschreibungen gelten diese Abkürzungen: aE = average distance between eyes, mittlerer

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*298. Beitrag zur Kenntnis der Steninen.

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Augenabstand; cP = coll. PUTHZ; HT = Holotypus; lEl = greatest length of elytra, größte Elytrenlänge; lP = length of pronotum, Pronotumlänge; lS = length of suture, Nahtlänge PM = proportional measurements, Proportionsmaße (1 E = 0,025 mm); PT = Paratypus; wEl = greatest width of elytra, größte Elytrenbreite; wH = width of head, Kopfbreite; wP = width of pronotum, Halsschildbreite.

Taxonomischer Teil

Stenus (s. str.) calceolipes n.sp. (Abb. 1, 15)

Material: Holotypus (♂) und 1 ♂- Paratypus: "Brésil Prov. Rio de Janeiro Laguna de Sacuaresma Août, Sept. 1884, P. Germain". Paratypen: 1 ♀: "Rio de Janeiro, 1883, P. Germain"; 3 ♂♂, 3 ♀♀: "Rio de Janeiro". Die ersten drei Stücke (mit gedrucktem Etikett) aus coll. R. OBERTHÜR, die restlichen Exemplare mit handschriftlichen Etiketten von J. JARRIGE (ex coll. JARRIGE).- HT and PTT im Muséum National d'Histoire Naturelle, Paris, 3 PTT in cP.

Kurzdiagnose: Makropter, schwarz mit leichtem Messingschimmer, mäßig glänzend, sehr grob und sehr dicht punktiert, kurz beborstet. Fühler gelblich, die Keule gebräunt. Kiefertaster gelb. Beine rötlichgelb. Clypeus schwarz, Oberlippe dunkelbraun, beide dicht beborstet.

Beschreibung: Länge: 3,8-4,3 mm (Vorderkörperlänge 2,1-2,2 mm).

PM des HT: wH: 38; aE: 19; wP: 30: lP: 34; wEl: 40; lEl: 37,5; lS: 29.

Männchen: Schenkel stark gekeult, Hinterschienen leicht gebogen und in der Spitzenhälfte leicht nach innen verbreitert; Mittel- und Hinterschienen ohne Dornen; 1. Tarsenglied stark verbreitert, etwa doppelt so breit wie die folgenden Glieder. Metasternum breit eingedrückt, grob und dicht auf glänzendem Grund punktiert, Punktzwischenräume kleiner als die Punktradien. Vordersternite grob und dicht punktiert, 5. Sternit median feiner punktiert und in der hinteren Mitte leicht eingedrückt. 6. Sternit mit breitem Eindruck in der Hinterhälfte, im Eindruck sehr dicht punktiert und beborstet. 7. Sternit median breit eingedrückt und daselbst fein und sehr dicht punktiert und beborstet, Hinterrand sehr flach ausgerandet. 8. Sternit mit spitzwinkligem Ausschnitt etwa im hinteren Viertel. 9. Sternit (Abb. 15), apikolateral mit spitzem Zahn. 10. Tergit abgerundet. Aedoeagus (Abb. 1), Medianlobus apikal stempelförmig verbreitert; Parameren viel kürzer als der Medianlobus, zur Spitze lang-löffelförmig, mit je zwei apikalen Borsten.

Weibchen: Beine einfach. 8. Sternit kontinuierlich abgerundet. Valvifer mit spitzem Apikolateralzahn. 10. Tergit abgerundet.

Kopf etwas schmäler als die Elytren, Stirn ziemlich schmal mit zwei deutlichen Längsfurchen, Mittelteil fast halb so breit wie jedes der Seitenstücke, längsbeulig-glänzend erhoben, aber bei weitem nicht die Höhe der Augeninnenränder erreichend. Punktierung, bis auf den Mittelteil, grob, sehr dicht, tief eingestochen, mittlerer Punktdurchmesser etwa so groß wie der apikale Querschnitt des 2. Fühlergliedes, Punktzwischenräume viel kleiner als die Punktradien. Fühler schlank, vergleichsweise kurz, zurückgelegt bis ins hintere Pronotumdrittel reichend, vorletzte Glieder eineinhalb mal so lang wie breit. Das gleichmäßig gewölbte Pronotum ist deutlich länger als breit, etwa in der Mitte am breitesten, seitlich nach vorn fast gerade, nach hinten deutlich konkav-eingeschnürt verengt. Die Punktierung ist sehr grob und sehr dicht, in der Nähe von Vorder- und von Hinterrand kurz quer-zusammenfließend, die Punkte sind fast so groß wie der mittlere Querschnitt des 2. Fühlergliedes, die Punktabstände überall viel kleiner als die Punktradien. Die trapezoiden Elytren sind wenig breiter als der Kopf, etwas breiter als lang, die Seiten hinter den eckigen Schultern gerade erweitert, Hinterrand breit ausgerandet. Die völlig gleichmäßige Punktierung ist fast so grob und dicht wie am Pronotum, aber nicht ganz so tief eingestochen. Das Abdomen ist stark gewölbt, die Sternitseiten sind bei Dorsalansicht deutlich zu sehen, die Paratergite sind schmal, die des 4. Segments so breit wie das 2. Fühlerglied, sie tragen eine schüttere Reihe mäßig feiner Punkte. Die basalen Querfurchen der ersten Tergite sind tief und tragen drei Kiele, das 7. Tergit besitzt einen deutlichen apikalen Hautsaum. Die Punktierung ist vorn grob und dicht (auf dem 3. Tergit sind die Punkte größer als der apikale Querschnitt des 3. Fühlergliedes), nach hinten wird sie erheblich feiner, bleibt aber vergleichweise dicht (auf dem 7. Tergit sind die Punkte kleiner als eine Augeninnenrandfacette, ihre Abstände doppelt so groß) das 8. und das 10. Tergit sind wieder etwas gröber punktiert. An den Beinen sind die ungelappten Hintertarsen etwa vier Fünftel schienenlang, ihr 1. Glied ist etwa so lang wie die drei folgenden zusammengenommen, viel länger als das Klauenglied. Nur die Abdomenspitze (Tergit 6 mit

Spuren, Tergite 7-10 deutlich) ist flach genetzt.

Bemerkungen: *Stenus calceolipes* n.sp. gehört in die Gruppe des *S. agilis* ERICHSON (PUTHZ 2006: 663), aus der auch andere Arten mit beim Männchen verbreiterten Tarsen bekannt sind (*S. augur* ERICHSON (Kolumbien): hier aber weniger deutlich; *S. peculiaripes* PUTHZ (Brasilien): hier jedoch nur das 1. Vordertarsenglied verbreitert). Von den Gruppenvertretern mit gerandetem Abdomen lässt sich die neue Art, abgesehen von ihren Sexualcharakteren, leicht durch ihre vergleichsweise bedeutende Größe und die trapezoiden Elytren unterschieden, vom größten Vertreter, *S. augur* ERICHSON durch geringere Größe, längeres, ungefurchtes Pronotum und genetzte Abdomenspitze.

Etymologie: Wegen des beim Männchen verbreiterten 1. Tarsengliedes nenne ich die neue Art: den mit dem kleinen Schuh (lat. *calceolipes*).

Stenus (Hypostenus) adisi n.sp. (Abb. 2, 5, 11, 12)

Material: Holotypus (♂): Brasilien: Amazonas: Manaus, Ilha de Marchantaria (Rio Solimões), 59°58'W, 3°15'S, emergence trap with floats (photo-eclector; ADIS 2002) on aquatic macrophytes (*Eichhornia crassipes*), 28.7.1981, J. ADIS (no 11): im Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus.

Kurzdiagnose: Makropter, schwarz mit Messingschimmer und schwachem blaumetallischem Anflug, glänzend, Vorderkörper mäßig grob, ziemlich dicht punktiert, Abdomen vorn mäßig grob, hinten fein, mäßig dicht punktiert; Beborstung goldglänzend, kurz, länger und besonders dicht im vorderen Nahteindruck und an den Tergitbasen. Fühler, Kiefertaster und Beine gelblich bis bräunlichgelb, Tarsengliedspitzen gebräunt. Clypeus braun, Labrum braun-rötlich, dicht scheitelbärtig.

Beschreibung: Länge: 4,0-4,8 mm (Vorderkörperlänge 2,3 mm).

PM des HT: wH: 37; aE: 19; wP: 25,5; lP: 31; wEl: 37,5; lEl: 40; lS: 34.

Männchen: Beine ohne Auszeichnungen. 8. Sternit (Abb. 5). 9. Sternit (Abb. 11). 10. Tergit (Abb. 12) am abgerundeten Hinterrand sehr fein gekerbt. Aedoeagus (Abb. 2): die Apikalpartie des Medianlobus schiffchenförmig; Medianlobus distal mit inneren, seitlichen Versteifungen und eine Ausstülptube; Parameren viel länger als der Medianlobus, dünn, mit 21-22 apikalen Borsten.

Weibchen: unbekannt.

Kopf fast so breit wie die Elytren, Stirn mäßig breit, tief eingesenkt, ohne Längsfurchen, Mittelteil also nicht abgesetzt. Punktierung mäßig grob, seitlich ziemlich dicht (Punktabstände hier nur selten größer als die Punktradien), median weitläufig (Punktabstände hier bis doppelt so groß wie die Punkte; es entsteht aber keine abgesetzte Glättung), der mittlere Punktdurchmesser ist so groß wie der mittlere Querschnitt des 3. Fühlergliedes. Fühler schlank, den Pronotumhinterrand mit mindestens dem 11. Glied überragend, vorletzte Glieder nicht ganz zweieinhalb mal so lang wie breit. Pronotum gleichmäßig gewölbt, deutlich länger als breit, knapp hinter der Mitte am breitesten, die Seiten nach vorn fast gerade verengt, nach hinten mäßig konkav eingeschnürt. Punktierung ein wenig gröber als auf den Stirnseiten, dicht, die glänzenden Punktzwischenräume meist kleiner als die Punktradien, wenig größer in der hinteren Längsmitte (es entsteht hier aber keine deutliche Glättung) und auf einer kleinen Partie jederseits der Mitte in der Hinterhälfte. Elytren vergleichsweise klein, wenig breiter als der Kopf, etwas länger als breit, Schultern eckig, Seiten lang-konvex etwas erweitert, im hinteren Viertel deutlich eingezogen, der Hinterrand tief rund ausgerandet. Die Punktierung ist gut so grob wie am Pronotum, aber etwas weniger dicht, der mittlere Punktdurchmesser liegt knapp über dem apikalen Querschnitt des 3. Fühlergliedes, die Punktzwischenräume sind, zumindest in der Hinterhälfte, größer als die Punktradien, können hier sogar Punktgröße erreichen. Abdomen breit, basale Quereinschnürungen der Segmente tief, 7. Tergit mit deutlichem apikalem Hautsaum. Punktierung vorn etwa so grob wie neben den Augen, nach hinten deutlich feiner, auf dem 7. Tergit sind die Punkte gut so groß wie eine Augeninnenrandfacette, ihre Abstände größer (aber nicht doppelt so groß) wie die Punkte; 10. Tergit mäßig fein und wenig dicht punktiert. An den schlanken Beinen sind die ungelappten Hintertarsen mehr als einhalb schienenlang (26: 43), ihr 1. Glied ist etwa so lang wie die drei folgenden Glieder zusammengenommen, viel länger als das Klauenglied; schon das 3. Glied ist leicht gelappt. Die Oberseite des Vorderkörpers ist netzungsfrei, das Abdomen ist sehr flach, wenig deutlich genetzt.

Bemerkungen: *Stenus adisi* n.sp. gehört in die Gruppe des *S. ariolus* ERICHSON und hier in die Nähe des *S. chalybeus* BOHEMAN (wie die Gestalt des 9. Sternums zeigt, das apikal gesägt ist, also keine spitzen Apikolateralzähne aufweist). Von den Gruppenvertretern mit ähnlichem 9. Sternum unterscheidet sich die neue Art so: von *S. chalybeus* BOHEMAN (Kalifornien, Mexico, Guatemala, Belize, Honduras, Costa Rica, Panama, Trinidad, Kolumbien, Ekuador), *S. drechseli* PUTHZ (Paraguay) und *S. tricolor* SHARP (Brasilien, Venezuela, Peru, Bolivien, Paraguay) durch konkav eingesenkte Stirn, von *S. elongatiformis* L. BENICK (Brasilien) durch schmälere Stirn, von *S. cinereus* L. BENICK (Kolumbien) und *S. sagax* SHARP (Mexiko, Guatemala, Costa Rica, Panama, Trinidad, Venezuela, Guyana, Kolumbien, Ekuador) durch weitläufigere Punktierung des gesamten Körpers, von *S. anguinus* ERICHSON (Venezuela, Trinidad, Guyana, Brasilien, Kolumbien, Bolivien) durch dichter punktierte Stirn, von *S. flinti* n.sp. (schwer!) durch weitläufigere Punktierung von Pronotum und Elytren sowie durch die äußerst flache Netzung des Abdomens, von *S. excisus* SHARP (Brasilien) und *S. nigricans* SHARP (Brasilien, Französisch Guyana, Surinam, Peru, Ekuador) wie auch von allen vorher genannten Arten durch die Sexualchaktere des Männchens.

Stenus adisi wurde bei den ökologischen Untersuchungen des Max-Planck-Instituts für Limnologie (MPIL), Abt. Tropenökologie in Plön/Deutschland, im Überschwemmungsgebiet des Amazonas auf der Ilha de Marchantaria zusammen mit folgenden weiteren Arten (alle leg. J. ADIS) festgestellt: *S. collaris* SHARP, S. *gaucho* PUTHZ (zahlreich; bisher nur aus Argentinien - hier auf *Eichhornia crassipes* - und Paraguay bekannt), *S. nebulosus* L. BENICK (1 Exemplar), *S. parviceps* SHARP (zahlreich) und *S. tricolor* SHARP (sehr zahlreich).

Etymologie: Ich widme diese neue Art herzlich ihrem Entdecker, Herrn Prof. Dr. J. Adis (MPIL, Plön).

Stenus (Hypostenus) flinti n.sp. (Abb. 3, 13)

Material: Holotypus (♂): Brasilien: Para: Faz. Pirelli Belem, 24.-25.3.1970, J.M. & B.A. CAMPBELL. Paratypen: 1 ♀: Para: Rio Xingu Camp, ca. 61 km S Altamira, 52°22'W, 3°49'S, Igarape Jabuti, malaise trap, 8.-16.10.1986, P.J. SPANGLER & O. FLINT; 1 ♂: Bolivien: Bolivian Espiritu, 230 m, savanna with wood and floodplain forest, 18.10.1980, W. HANAGARTH.- HT in der Canadian National Collection (Ottawa), Paratypen im U. S. National Museum (Washington) und in cP.

Kurzdiagnose: In fast allen Punkten dem *S. adisi* zum Verwechseln ähnlich.

Beschreibung: Länge: 4,2-5,0 mm (Vorderkörperlänge 2,4 mm).

PM des HT: wH: 38,5; aE: 19; wP: 28; lP: 34,5; wEl: 39; lEl: 42; lS: 35.

Männchen: Beine ohne Auszeichnungen. 8. Sternit mit tiefem, im Grunde gerundetem Ausschnitt gut im hinteren Drittel (Sternitlänge: Ausschnitttiefe = 27,5: 10,5). 9. Sternit prinzipiell wie bei *S. adisi*, der Hinterrand aber mit anderer Kontur (Abb. 13). 10. Tergit am abgerundeten Hinterrand sehr fein gekerbt. Aedoeagus (Abb. 3), Medianlobus spitzwinklig verengt, im Innern mit einer stark sklerotisierten Ausstülpspange und einer flagelliformen Tube; Parameren deutlich länger als der Medianlobus, an ihren dreieckig nach innen erweiterten Spitzen mit 18-19 Borsten.

Weibchen: unbekannt.

Kopf ebenso wie bei *S. adisi* mit sehr großen Augen und schmaler, konkaver Stirn ohne abgesetzten Mittelteil. Fühler wie bei *S. adisi*. Pronotum etwas gröber und dichter punktiert, Punktdurchmesser etwas größer als die apikale Querschnitt des 3. Fühlergliedes, aber deutlich kleiner als der apikalen Querschnitt des 2. Fühlergliedes, Punktzwischenräume überall deutlich schmäler als die Punktradien. Auch die Elytren sind etwas dichter als bei *S. adisi* punktiert, die Punktzwischenräume sind nur im hinteren Drittel größer als die Punktradien. Abdomen wie bei der verglichenen Art, aber nur auf dem 8. Tergit sehr flach genetzt.

Bemerkungen: *Stenus flinti* n.sp. unterscheidet sich von den ihm ähnlichen Gruppenvertretern wie *S. adisi* von diesen (vgl. o.), von *S. excisus* SHARP und *S. nigricans* SHARP durch fehlende Netzung auf dem 7. Tergit und durch robusteren Bau, von allen durch die Sexualcharaktere des Männchens.

Etymologie: Ich dediziere diese Art Dr. Oliver Flint (Washington), einem ihrer Sammler.

Stenus (Hypostenus) koerneri n.sp. (Abb. 4, 7)

Material: Holotypus (♂): Ekuador: San Rafael, Sucumbios, 77°35'W, 0°06'W, 1300 m, Übergangszone Bergwald - Nebelwald, 1.5.2004, L. KOERNER. Paratypen: 1 ♀: Ekuador: Pastaza: 25 km N Puyo, 1000 m, 4.7.1976, S. & J. PECK; 1 ♀: Puyo, 10.2.1976, Malaise trap, P.J. SPANGLER et al.; 1 ♂: Napo: Napo, 30 km E Coca, 6.3.1993, L. HUGGERT; 1 ♀: Peru: Madre de Dios: Puerto Maldonado, 6.1.1984, L. HUGGERT; 1 ♀: Loreto: Iquitos, 90 m, 7.5.1992, J. DANOFF-BERG; 2 ♀♀: Tingo Maria: Monson Valley, 2.9.1954, R.I. SCHLINGER & E.S. ROSS.- HT in cP (im Muséum d'histoire naturelle, Genève), PTT in der California Academy of Sciences (San Francisco), in der Canadian National Collection (Ottawa), im Natural History Museum of the Kansas University (Lawrence), im U.S. National Museum (Washington), im Zoologischen Museum der Universität Lund und in cP.

Kurzdiagnose: Makropter, schwarz mit schwach bläulichem Metallschimmer, mäßig glänzend, Vorderkörper mäßig grob, sehr dicht punktiert, Abdomen vorn mäßig grob, hinten etwas feiner, überall sehr dicht punktiert; Beborstung goldglänzend, kurz, länger und auffällig dicht an der Elytrenbasis und an den Tergitbasen. Fühler, Kiefertaster und Beine gelb bis rötlichgelb, Tarsengliedspitzen leicht verdunkelt. Clypeus schwarz, Oberlippe braun bis rötlichbraun, dicht scheitelbärtig.

Beschreibung: Länge: 3,0-3,5 mm (Vorderkörperlänge 1,8-1,9 mm).

PM des HT: wH: 31,5; aE: 16; wP: 22,3; lP: 29,5; wEl: 30; lEl: 34; lS: 28.

Männchen: Beine ohne Auszeichnungen. 7. Sternit in der hinteren Mitte abgeflacht, feiner und dichter als an den Seiten punktiert und beborstet, Hinterrand flach und breit augerandet. 8. Sternit (Abb. 7). 9. Sternit apikal fast abgestutzt, sehr fein gekerbt. 10. Tergit kontinuierlich abgerundet, Hinterrand glatt. Aedeoagus (Abb. 4) mit lang-spitzwinklig verengtem Medianlobus. Apikalpartie desselben mit ventralen Seitenfalten und dorsal, in mittlerer Höhe, mit einem queren Versteifungsband, Innenkörper mit einem distalen Versteifungs-Ausstülpknopf und einem langen Flagellum; Parameren kaum länger als der Medianlobus, an ihren Spitzen innen kräftig dreieckig erweitert und daselbst mit 13-15 Borsten.

Weibchen: 8. Sternit abgerundet. Valvifer apikal abgerundet, fein gesägt. 10. Tergit abgerundet.

Kopf etwas breiter als die Elytren, Stirn mäßig breit, vollkommen flach, eingesenkt, Punktierung ziemlich grob und sehr dicht, mittlerer Punktdurchmesser so groß bis gut so groß wie der größte Querschnitt des 3. Fühlergliedes, Punktzwischenräume überall deutlich kleiner als die Punktradien. Fühler schlank, zurückgelegt überragt mindestens das 11. Glied den Pronotumhinterrand, die vorletzten Glieder sind doppelt so lang wie breit. Pronotum deutlich länger als breit, deutlich etwas hinter der Mitte am breitesten, von dort seitlich nach vorn fast gerade, nach hinten deutlich, aber schwach konkav verengt. Die gleichmäßig gewölbte Oberseite ist mäßig grob und sehr dicht punktiert, die Punkte sind so groß wie der mittlere Querschnitt des 3. Fühlergliedes, ihre Abstände überall kleiner als die Punktradien. Die Elytren sind wenig schmäler als der Kopf, deutlich etwas länger als breit, ihre Seiten hinter den eckigen Schultern wenig erweitert, im hinteren Viertel eingezogen, der Hinterrand ist tief rund ausgerandet. Die Punktierung ist kaum gröber als am Pronotum, aber nicht ganz so gedrängt, wenn auch immer noch sehr dicht, die Punktzwischenräume sind fast überall (ausgenommen in der Nähe des Hinterrandes) kleiner als die Punktradien. Das zylindrische Abdomen zeigt an den Segmentbasen tiefe Einschnürungen, das 7. Tergit trägt einen deutlichen apikalen Hautsaum. Die Punktierung ist vorn wenig feiner als neben den Augen, sehr dicht; nach hinten wird sie deutlich, aber nicht sehr viel feiner, auf dem 7. Tergit sind die Punkte noch etwas gröber als eine innere Augenfacette, ihre Abstände überall kleiner bis viel kleiner als die Punkte, das 10. Tergit ist fein und weitläufig punktiert. An den schlanken Beinen sind die gelappten Hintertarsen nicht ganz drei Fünftel schienenlang, ihr 1. Glied ist wenig kürzer als die drei folgenden Glieder zusammengenommen, viel länger als das Klauenglied. Die gesamte Oberseite ist netzungfrei.

Bemerkungen: *Stenus koerneri* n.sp. gehört ebenfalls in die *ariolus*-Gruppe; er unterscheidet sich von den ähnlichen Gattungsvertretern um *S. chalybeus* BOHEMAN wie folgt: von *S. chalybeus* BOHEMAN, *S. drechseli* PUTHZ und *S. tricolor* SHARP durch flache Stirnmitte, von *S. elongatiformis* L. BENICK durch schmälere Stirn und dichtere Punktierung, von *S. cinereus* L. BENICK durch geringere Größe, schlankere Gestalt und weniger dicht (nicht gedrängt-dicht) punktiertes Abdomen, von *S. anguinus* ERICHSON durch dichtere Punktierung, von *S. sagax* SHARP durch geringere Größe und feiner punktiertes Abdomen, von *S. excisus* SHARP und *S. nigricans* SHARP durch netzungsfreies Abdomen, von *S. adisi* n.sp. und *S. flinti* n.sp. durch geringere Größe und dichtere Punktierung, von allen durch die Sexualcharaktere.

Etymologie: Ich dediziere diesen neuen *Stenus* einem ihrer Sammler, Herrn Lars Koerner (Kiel) mit

Dank für die Überlassung des HT und für seine interessanten Untersuchungen an verschiedenen *Stenus*-Arten.

Stenus (Hypostenus) fronto n.sp. (Abb. 8, 9)

Material: Holotypus (♂): Ekuador: Napo: Misahualli, 19.2.1983, L. HUGGERT. Paratypen: 1 ♂: Napo: Tena, 18.2.1983, L. HUGGERT; 2 ♂♂: Peru: "Amazones Pebas", M. DE MATHAN [1886/89].- Holotypus im Zoologischen Museum der Universität Lund, Paratypen im Muséum National d'Histoire Naturelle, Paris und in cP.

Kurzdiagnose: Makropter, schwarz, schwach glänzend, grob und sehr dicht punktiert, kurz, unauffällig beborstet. Fühler, Kiefertaster und Beine gelblich, Tarsengliedspitzen wenig angedunkelt. Clypeus schwarz bis schwarzbraun, Obelippe rotbraun, dicht beborstet.

Beschreibung: Länge: 3,8-4,7 mm (Vorderkörperlänge 2,1-2,2 mm).

PM des HT: wH: 35; größter Abstand zwischen den Augen: 25; wP: 25; lP: 31,5; wEl: 37; lEl: 39; lS: 33.

Männchen: Beine ohne Auszeichnungen. 6. Sternit in der hinteren Mitte etwas dichter als an den Seiten punktiert und beborstet. 7. Sternit median abgeflacht und daselbst wenig fein und sehr dicht punktiert und beborstet, Hinterrand sehr flach ausgerandet. 8. Sternit mit schmalem, gewinkeltem, dreieckigem Ausschnitt fast im hinteren Viertel. 9. Sternit (Abb. 9). 10. Tergit abgerundet, Hinterrand glatt. Aedoeagus (Abb. 8), Medianlobus spitzwinklig verengt, Apikalpartie mit mehreren apikalen Borsten, Innenkörper mit dreieckigem, stark sklerotisiertem Ausstülphilfsmechanismus und einer langen Ausstülptube/-flagellum; Parameren wenig länger als der Medianlobus, an ihren Spitzen wenig erweitert, mit 19 apikalen Borsten.

Weibchen: 8. Sternit sehr flach abgerundet. Valvifer apikal gesägt. 10. Tergit abgerundet.

Kopf etwas schmäler als die Elytren, Stirn auffallend breit, Augeninnenränder stark konkav, die gesamte Stirn konkav eingesenkt. Punktierung grob und sehr dicht, nur in der Stirnmitte können die Punktzwischenräume die Punktgröße erreichen, sonst sind sie überall viel kleiner als die Punktradien, der mittlere Punktdurchmesser erreicht etwa den größten Querschnitt des 3. Fühlergliedes. Die schlanken Fühler überragen, zurückgelegt, mit ihren letzten beiden Gliedern den Pronotumhinterrand, die vorletzten Glieder sind etwas mehr als doppelt so lang wie breit. Pronotum deutlich länger als breit, hinter der Mitte am breitesten, die Seiten von dort nach vorn gerade bis flachkonvex verengt, nach hinten deutlich eingeschnürt. Punktierung etwa so grob wie auf der Stirn, sehr gleichmäßig, äußerst dicht. Elytren gewölbt, subquadratisch, kaum länger als breit, die Seiten hinter den eckigen Schultern flachkonvex, im hinteren Drittel eingezogen, der Hinterrand tief rund ausgerandet. Punktierung gut so grob wie am Pronotum, aber nicht ganz so gedrängt, obwohl die glänzenden Punktzwischenräume überwiegend kleiner als die Punktradien sind. Am Abdomen sind die basalen Einschnürungen der Segmente tief, das 7. Tergit trägt einen deutlichen apikalen Hautsaum. Die Punktierung ist vorn grob und sehr dicht, der mittlere Punktdurchmesser der Punkte auf dem 3. Tergit ist etwa so groß wie der mittlere Querschnitt des 3. Fühlergliedes; nach hinten wird die Punktierung nur wenig feiner, auf dem 7. Tergit sind die Punkte noch so groß wie der basale Querschnitt des 3. Fühlergliedes, ihre Abstände erheblich kleiner als die Punkte, das 10. Tergit ist wenig fein, immer noch ziemlich dicht punktiert. An den schlanken Beinen sind die gelappten Hintertarsen weniger als zwei Drittel schienenlang (19,5: 34), das 1. Glied ist etwas kürzer als die drei folgenden zusammengenommen, gut so lang wie das Klauenglied, schon das 3. Glied ist deutlich gelappt. Bis auf das 8. Tergit ist die gesamte Oberseite netzungsfrei.

Bemerkungen: Diese neue Art kann ich zur Zeit nicht eindeutig einer der von mir bisher unterschiedenen und (zum Teil vorläufig) benannten Artengruppen zuordnen: Es bestehen Ähnlichkeiten zu Vertretern der *aculeatus*-Gruppe (PUTHZ, 1977, wo eine ebenfalls sehr breite Stirn und konkave Augeninnenränder vorliegen bei *S. bierigi* PUTHZ (Costa Rica), *S. detector* SHARP (Panama, Guatemala) und *S. dybasi* PUTHZ (Panama): diese Arten besitzen jedoch apikolateral zugespitzte 9. Sterna sowie spezielle Auszeichnungen am 10. Tergit), der *cupreus*-Gruppe (z.B. *S. subcoeruleus* BERNHAUER (Venezuela, Panama, Guyana, Trinidad, Kolumbien, Ekuador, Peru), mit breiter Stirn, aber mit stark blaumetallischer Färbung) und zu Vertretern der *ariolus*-Gruppe (*S. traversifrons* PUTHZ (Argentinien, Brasilien): aber auch mit apikolateral spitzem 9. Sternum). Mehrere Arten (vorwiegend noch unbeschriebene) um *S. capillaceus* L. BENICK scheinen dem *S. fronto* n.sp. am nächsten zu stehen, zeigen aber weniger tief eingesenkte Stirnen und weniger konkave Augeninnenränder. Am ähnlichsten ist *S. fronto* dem *S. laticeps* SHARP (Brasilien) und dem *S. mathani* n.sp.: vom ersteren unterscheidet er sich (sehr schwer) durch dichtere Punktierung der Abdomenspitze (bei *S. laticeps* sind die Punktzwischenräume auf dem 7. Tergit bis punktgroß), von *S. mathani* durch kürzere Elytren, von beiden durch die Sexualcharaktere.

Etymologie: Ich nenne diese neue Art wegen ihrer auffällig breiten Stirn "*fronto*" = die Breitstirn.

Stenus (Hypostenus) mathani n.sp. (Abb. 6, 10, 14)

Material: Holotypus (♂): Brasilien: Amazonas: São Paulo de Olivença, M. DE MATHAN [1879/85] (ex coll. R. OBERTHÜR): im Muséum National d'Histoire Naturelle, Paris.

Kurzdiagnose: wie bei *S. fronto* n.sp.

Beschreibung: Länge: 3,8-4,7 mm (Vorderkörperlänge 2,2 mm).

PM des HT: wH: 37,5; größter Abstand zwischen den Augen: 25; wP: 25; lP. 34; wEl: 36; lEl: 41; lS: 34.

Männchen: Beine ohne Auszeichnungen. 5. Sternit in der hinteren Mitte abgeflacht und daselbst erheblich feiner und dichter als an den Seiten punktiert und beborstet, 6. Sternit mit flachem Mitteleindruck in der Hinterhälfte, darin sehr fein und dicht punktiert und beborstet, 7. Sternit mit breitem Mitteleindruck in den hinteren zwei Dritteln, darin sehr fein und dicht punktiert und beborstet, Hinterrand flach und breit ausgerandet. 8. Sternit (Abb. 6). 9. Sternit (Abb. 14). 10. Tergit breit abgerundet, Hinterrand glatt. Aedoeagus (Abb. 10), die Apikalpartie des Medianlobus spatenförmig, Innenkörper mit stark sklerotisierter, distaler Ausstülphilfe und einer Ausstülptube/-flagellum; Parameren deutlich länger als der Medianlobus, dünn, an ihren Spitzen mit 9 Borsten.

Weibchen: unbekannt.

In fast allen Punkten äußerlich dem *S. fronto* zum Verwechseln ähnlich, der Kopf jedoch wenig breiter als die Elytren, diese länger; die groben Stirnpunkte sind wiederholt etwas größer als der größte Querschnitt des 3. Fühlergliedes, die Punktzwischenräume auch in der Mitte deutlich kleiner als die Punktdurchmesser. Punktierung des übrigen Körpers wie bei der verglichenen Art, auf dem 7. Tergit aber weniger dicht, die Punktabstände hier überwiegend punktgroß, das 10. Tergit sehr weitläufig punktiert.

Bemerkungen: *Stenus mathani* n.sp. lässt sich von *S. laticeps* SHARP (schwer) durch dichter punktierte Stirnmitte und durch seine längeren Elytren, leicht durch seinen Aedoeagus unterscheiden.

Etymologie: Ich erinnere mit dem Namen dieser neuen Art an den französischen Sammler Marc de Mathan, der im 19. Jahrhundert mehrfach Aufsammlungen im Amazonasgebiet durchgeführt hat (HORN et al., 1990).

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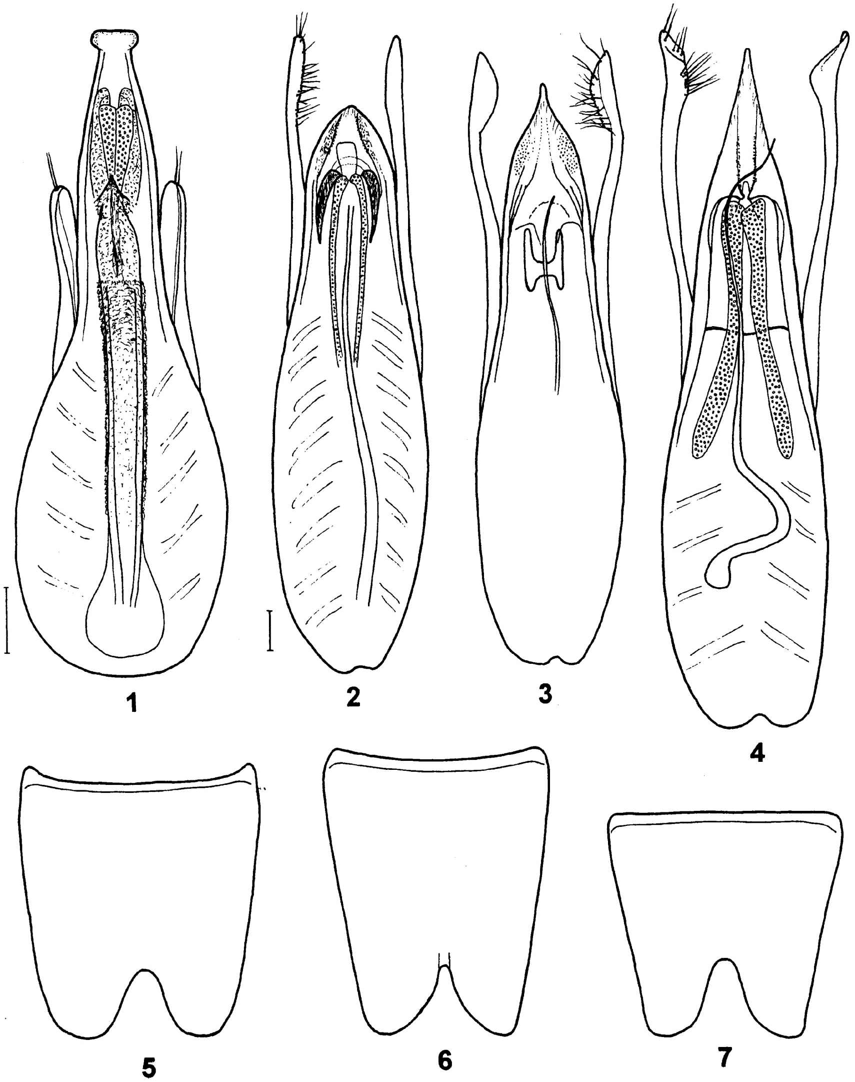

Abb. 1-7:
Ventralansichten der Aedoeagi (**1-4**) und 8. Sternit der Männchen (**5-7**) von *Stenus (s. str.) calceolipes* n.sp. (PT, **1**), *S. (Hypostenus) adisi* n.sp. (HT, **2**, **5**), *S. (H.) flinti* n.sp. (HT, Innenkörper, weil ausgestülpt, unvollständig, **3**), *S. (H.) koerneri* n.sp. (HT, **4**, 7), *S. (H.) mathani* n.sp. (HT, **6**).- Maßstab = 0,1 mm (1 = 4, 2 = 3, **5-7**).

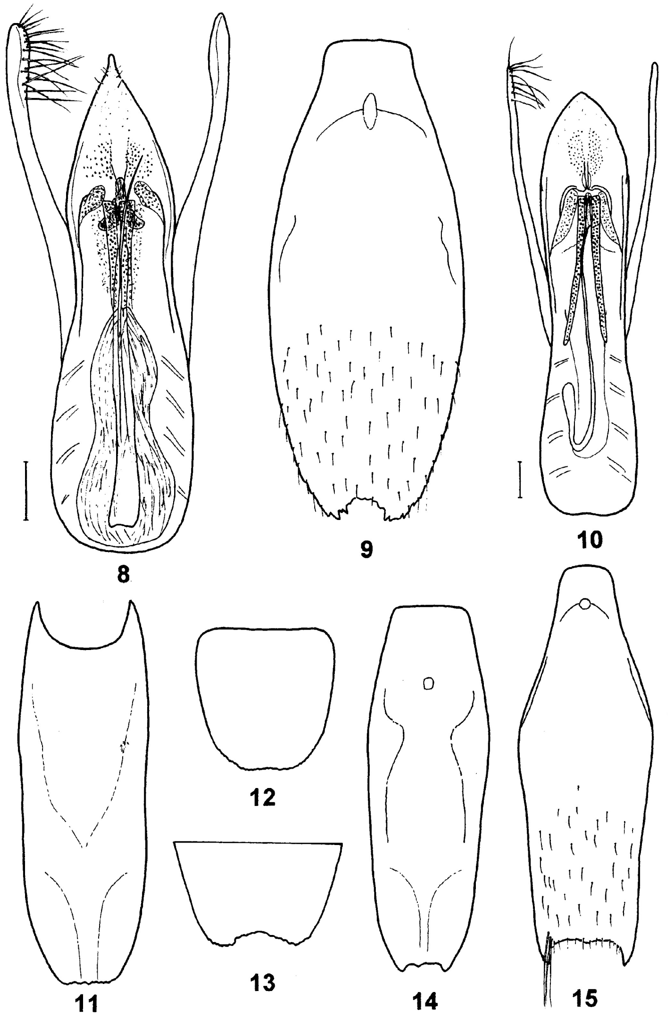

Abb. 8-15:
Ventralansicht der Aedoeagi (**8**, **10**), 9. Sternit des Männchens (**9**, **11**, **13** hintere Partie, **14**, **15**), 10. Tergit (**12**) von *Stenus (Hypostenus) fronto* n.sp. (HT, **8**, **9**), *S. (H.) mathani* n.sp. (HT, **10**, **14**), *S. (H.) adisi* n.sp. (HT, **11**, **12**), *S. (H.) flinti* n.sp. (HT, **14**) und *S. (s. str.) calceolipes* n.sp. (PT, **15**).- Maßstab = 0,1 mm (8 = 9, **15**; 10 = **11-14**).

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New Neotropical *Edaphus*-species (Coleoptera: Staphylinidae)*

by

V. Puthz

Dr. Volker Puthz, Seebergstr. 4, 36110 Schlitz; e-mail: stenus.puthz@t-online.de

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Abstract

26 new Neotropical species of the genus *Edaphus* MOTSCHULSKY are described: *Edaphus amigo* n.sp. (Costa Rica), *E. andersonianus* n.sp. (Panama, Costa Rica), *E. apo* n.sp. (Peru, Ecuador), *E. bierigi* n.sp. (Costa Rica), *E. bolivianus* n.sp. (Bolivia), *E. caballero* n.sp. (Panama), *E. chinan* n.sp. (Ecuador), *E. cinche* n.sp. (Peru), *E. david* n.sp. (Venezuela), *E. dybasi* n.sp. (Panama, Costa Rica), *E. eliab* n.sp. (Venezuela), *E. gallinaceus* n.sp. (Costa Rica, Panama), *E. goliath* n.sp. (Venezuela), *E. hidalgo* n.sp. (Panama, Costa Rica), *E. kapac* n.sp. (Ecuador), *E. kethleyi* n.sp. (Costa Rica), *E. limbipennis* n.sp. (Ecuador), *E. newtoni* n.sp. (Panama), *E. panamensis* n.sp. (Panama), *E. similifactus* n.sp. (Bolivia), *E. siphonifer* n.sp. (French Guyana, Peru), *E. subtilipunctatus* n.sp. (Venezuela), *E. sulcatipennis* n.sp. (Venezuela), *E. villac* n.sp. (Ecuador, Peru), *E. wagneri* n.sp. (Costa Rica), *E. wagnerianus* n.sp. (Costa Rica).

Keywords: **Coleoptera, Central America, South America, Staphylinidae, Euaesthetinae, *Edaphus*, new species.**

Resumo

26 novas espécies neotropicais do gênero *Edaphus* MOTSCHULSKY são descritas: *Edaphus amigo* n.sp. (Costa Rica), *E. andersonianus* n.sp. (Panama, Costa Rica), *E. apo* n.sp. (Peru, Ecuador), *E. bierigi* n.sp. (Costa Rica), *E. bolivianus* n.sp. (Bolivia), *E. caballero* n.sp. (Panama), *E. chinan* n.sp. (Ecuador), *E. cinche* n.sp. (Peru), *E. david* n.sp. (Venezuela), *E. dybasi* n.sp. (Panama, Costa Rica), *E. eliab* n.sp. (Venezuela), *E. gallinaceus* n.sp. (Costa Rica, Panama), *E. goliath* n.sp. (Venezuela), *E. hidalgo* n.sp. (Panama, Costa Rica), *E. kapac* n.sp. (Ecuador), *E. kethleyi* n.sp. (Costa Rica), *E. limbipennis* n.sp. (Ecuador), *E. newtoni* n.sp. (Panama), *E. panamensis* n.sp. (Panama), *E. similifactus* n.sp. (Bolivia), *E. siphonifer* n.sp. (French Guyana, Peru), *E. subtilipunctatus* n.sp. (Venezuela), *E. sulcatipennis* n.sp. (Venezuela), *E. villac* n.sp. (Ecuador, Peru), *E. wagneri* n.sp. (Costa Rica), *E. wagnerianus* n.sp. (Costa Rica).

Zusammenfassung

26 neue neotropische Arten der Gattung *Edaphus* MOTSCHULSKY werden beschrieben: *Edaphus amigo* n.sp. (Costa Rica), *E. andersonianus* n.sp. (Panama, Costa Rica), *E. apo* n.sp. (Peru, Ekuador), *E. bierigi* n.sp. (Costa Rica), *E. bolivianus* n.sp. (Bolivien), *E. caballero* n.sp. (Panama), *E. chinan* n.sp. (Ekuador), *E. cinche* n.sp. (Peru), *E. david* n.sp. (Venezuela), *E. dybasi* n.sp. (Panama, Costa Rica), *E. eliab* n.sp.

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[*] 94th contribution to the knowledge of Euaesthetinae.

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(Venezuela), *E. gallinaceus* n.sp. (Costa Rica, Panama), *E. goliath* n.sp. (Venezuela), *E. hidalgo* n.sp. (Panama, Costa Rica), *E. kapac* n.sp. (Ekuador), *E. kethleyi* n.sp. (Costa Rica), *E. limbipennis* n.sp. (Ekuador), *E. newtoni* n.sp. (Panama), *E. panamensis* n.sp. (Panama), *E. similifactus* n.sp. (Bolivien), *E. siphonifer* n.sp. (Französisch Guyana, Peru), *E. subtilipunctatus* n.sp. (Venezuela), *E. sulcatipennis* n.sp. (Venezuela); *E. villac* n.sp. (Ekuador, Peru), *E. wagneri* n.sp. (Costa Rica), *E. wagnerianus* n.sp. (Costa Rica).

Introduction

The genus *Edaphus* MOTSCHULSKY currently includes more than 350 species and has a worldwide distribution, with most species occurring in the Southern hemisphere. When I began to study Neotropical *Edaphus* in 1973, only 2 species were known from the Neotropics. In the meantime, species number increased to 39 and will further increase to 65 in this paper. This indicates that our knowledge of these minute insects is far from complete. Thanks to careful collecting using various methods, mainly by colleagues at the Field Museum of Natural History, Chicago, and the staff of the Natural History Museum of the Kansas University, a large amount of material is now available, which will be treated step by step.

At present, grouping species into tentative phylogenetic units is not possible, although one group (species with special abdominal atrium-structures) has already been defined (PUTHZ 1997). Based on the immense diversity of male genitalia in Neotropical *Edaphus*, numerous groups may have to be formed. The twofold sperm pump, described previously for the African group of *Edaphus franzi* PUTHZ (PUTHZ 1990: 216, 218), is also found in Neotropical species (Fig. 40). A new type of *vesica seminalis* was found in *Edaphus kethleyi* n.sp. (Fig. 23). A sexual dimorphism of wing length, as already known from African species, is also found in some Neotropical *Edaphus* (e.g. *E. wagnerianus* n.sp., *E. subtilipunctatus* n.sp.). Considerable differences in body size were observed in the treated material: *Edaphus goliath* n.sp. is the largest *Edaphus* of the world; compared to this variable species, *E. david* n.sp. is minute (see Figs. 2, 3).

Edaphus species are edaphic and mostly collected by sifting and in flight interception traps.

Material and methods

In the descriptions the following abbreviations are used (see Fig. 1): alfF = antero-lateral furrows of frons; alpF = antero-lateral portions of frons; ampF = antero-medial portion of frons; dE = distance between eyes; dlbc = distance of latero-basal carinae of pronotum; FIT = flight interception trap; HT = holotype; lbc = latero-basal carina of pronotum; lbf = latero-basal foveae of pronotum; lEl = maximal length of elytra; lE = length of eyes; lG = length of genae; lP= length of pronotum; lS = length of suture; lT = length of temples; mbc = medio-basal carina of pronotum; mbct3 = medio-basal carina on posterior part of tergite 3; mbf = medio-basal foveae of pronotum; PM = proportional measurements (1 unit = 0.0085 mm); PT= paratype; ptfF = postero-transverse furrow of frons; shC = special humeral characters; SpP = sperm pump; vs = vesica seminalis; wEl = maximal width of elytra; wH= width of head; wP = width of pronotum.

Acronyms for museums and private collections:

AMNH = American Museum of Natural History, New York
FMCh = Field Museum of Natural History, Chicago
MHNG = Muséum d'histoire naturelle, Geneva
NHMK = Natural History Museum University of Kansas, Lawrence, KS
cP = coll. PUTHZ

Taxonomic part

Edaphus goliath n.sp. (Figs. 2, 4-7)

Holotype (♂) and 1 ♂-paratype: Venezuela: Tachira: 10 km SE San Cristobal, P.N. Chorro El Indio, 1320 m, 7°44.03'N, 72°13.01'W, upper montane forest litter, 29.05.1998, R. ANDERSON. Paratypes: 1 ♂: Aragua: Rancho Grande Biological Station, Pico Periquitos, 1300 m, 10°21.0'N, 67°41.0'W, cloud forest litter, 13.05.1998, idem; 3 ♂♂, 4 ♀♀: Bolivia: Sucumbios: Sacha Lodge, 0°5'S, 76°5'W, 270 m, malaise trap, 24.05.-03.06.1994, HIBBS.- HT and PTT in NHMK, 3 PTT in cP.

Fully winged, chestnut-brown, shiny, almost impunctate (except insertions of pubescence); pubescence long, erect on pronotum, semi-erect on elytra. Antennae brown, maxillary palpi light brown, legs brownish, tarsi light brown.

Length: 2.5-5.1 mm (forebody 1.4-2.5 mm).

PM of HT: wH: 87; dE: 58; lE: 25; lT: 0; lG: 5; wP: 100; lP: 79; wEl: 154; lEl: 128; lS: 104.

Male: Segment 10 and 11 of antennae prolonged (Fig. 5). Sternite 7 very shallowly emarginate at posterior margin. Sternite 8 (Fig. 7). Sternite 9 (Fig. 6). SpP nearly 2/3 as long as the median lobe, vs small, about 1/4 as long as the median lobe. Aedeagus (Fig. 4), median lobe with two stout and two fine setae in anterior half; parameres shorter than median lobe, each with two short apical setae and one short medial seta.

Female: Antennae shorter than in the male, last segments less extended (Fig. 5).

Head narrower than pronotum, eyes large, prominent, temples absent, frons moderately broad, ptfF absent, ampF half as broad as the slightly convex alpF, clypeus simple, no punctation. Antennae as in Fig. 5. Pronotum much broader than long, anterior margin with a narrow edge laterally, base with strong lbc (distance: 77), mbc extending to base, with 6 basal foveae, the para-median ones very close, the lateral ones smaller than the other foveae, of which the intermedial fovea is the largest and mostly oval; without punctation, but with dense pubescence. Elytra much broader than long, humeral angles rectangular; with a deep humeral impression, which is delimited by a sharp ridge anteriorly and posteriorly; without punctation, but with dense pubescence. Mbct3 two thirds as long as the posterior tergite.

This is the largest *Edaphus* species. The size is highly variable: the smallest specimens (paratypes from Ecuador) are nearly half as long as the longest specimens (from Venezuela). Size and distance between mbf are variable, the distance is much smaller in the specimens from Ecuador than in those from Venezuela, but there are no significant differences in the male sexual characters. - The new species is easily distinguished by the size and the antennal dimorphism.

Named after Goliath, Philister of extraordinary body size (1. Sam, 14).

Edaphus sulcatipennis n.sp.

Holotype (♂): Venezuela: Trujillo: Paramo La Cristallina, Old Trujillo Road km 9.7, 2400 m, 9°21.21'N, 70°17.51'W, elfin forest litter, 30.05.1998, R. ANDERSON: in NHMK.

Brachypterous, castaneous, strongly shiny, elytra with a long curved sulcus; except for the frons and the humeral area of elytra almost impunctate (microscopically fine insertions of setae at 60 x barely noticeable); pubescence moderately dense, recumbent. Maxillary palpi yellowish, antennae and legs brown.

Length: 3.4-4.0 mm (forebody 2.0 mm).

PM of HT: wH: 87; dE: 61; lE: 23; lT: 0: lG: 10; wP: 116; lP: 96; wEl: 162; lEl: 118; lS: 88.

Male: Antennal segments 10 and 11 very long, segment 10 cylindrical, one third longer than broad, segment 11 slightly longer than segment 10. Sternite 4-7 with a narrow and shallow emargination apico-medially, posterior margin of sternite 7 slightly curved ventrad. Sternite 8 with a very deep emargination in apical half. Sternite 9 with a distinct apico-median tip. SpP nearly twice as long as the median lobe, double trumpet indistinctly developed, vs nearly 1/3 as long as the median lobe. Dorsal lobe of anterior median lobe narrowly triangular (axe-shaped in lateral view) with two moderately strong setae, ventral lobe broadly lanceolate with two lateral and one medial part; internal sac with a strongly sclerotized unguiculate injection piece; parameres shorter than the median lobe, each with one apical, one subapical (apically split !) setae and one seta in about longitudinal middle.

Head much narrower than pronotum, eyes moderately large, temples absent, ptfF incomplete, present only in lateral third, ampF less than 1.5 x as broad as each of the alfF, flat with a shallow depression postero-medially; punctation fine and dense, distinct. Antennae with a 2-segmented club. Pronotum markedly convex, much broader than long, strongly constricted behind, with 6 small mbf, the two medial ones close together, lbc and mbc absent; setae sparse. Elytra strongly trapezoid with a long curved sulcus (beginning shortly behind humeral angles, then curved inwards, extending to the posterior quarter of elytra); fine and moderately dense punctation near humeral angles, remaining surface only with sparse, microscopically fine insertions of setae. Mbct3 short, about 1/3 as long as the posterior tergite.

This new species is easily distinguished from all Neotropical *Edaphus* by the elytral sulcus.

The name refers to the distinctively modified elytra (Lat. *sulcatipennis* = with sulcate elytra).

Edaphus david n.sp. (Figs. 3, 8, 9)

Holotype (♂) and 1 ♀-paratype: Venezuela: Trujillo: Paramo La Cristallina, Old Trujillo Road km 9.7, 2400 m, 9°21.21'N, 70°17.51'W, elfin forest litter, 20.05.1998, R. ANDERSON; 1 ♀-paratype: Old Trujillo Road km 6.0, 2240 m, 9°21.03'N, 70°17.36'W, cloud forest litter, 20.05.1998, idem.- HT and 1 PT in NHMK, 1 PT in cP.

Brachypterous, light brown, finely and densely punctate; pubescence dense, recumbent. Antennae, maxillary palpi and legs yellowish brown.

Length: 1.0-1.4 mm (forebody 0.6-0.7 mm).

PM of HT: wH: 34; dE: 25; lE: 8; lT: 0; lG: 7; wP: 36; lP: 32; wEl: 54; lEl: 35; lS: 26.

Male: Antennal segment 10 about 1/4 longer than broad, distinctly bigger and larger than segment 11. Sternite 8 (Fig. 9). Sternite 9 with a minute apico-median tip, more distinctly delimited than in Fig. 12. SpP + vs about as long as the median lobe. Aedeagus (Fig. 8), apical part of median lobe with 4 minute setae; parameres shorter than median lobe, each with a long apical and a long subapical seta.

Female: Antennal segment 10 about as broad as long and distinctly shorter than segment 11.

Head slightly narrower than pronotum, eyes with moderately coarse ommatidia, moderately large, temples absent, ptfF distinct, ampF nearly twice as broad as alpF, flat, clypeus simple, punctation fine and dense. Antennae with a 2-segmented club. Pronotum distinctly broader than long, strongly constricted behind, with 4 small mbf; punctation fine and dense. Elytra strongly trapeziform, much broader than long, humeral angles unmodified, punctation fine and dense. Mbct3 absent.

Edaphus david n.sp. is very similar to *E. eliab* n.sp. from which it may be distinguished by the antennal and the male sexual characters (see below). From *E. cimicoides* PUTHZ (Venezuela) it may be distinguished by larger eyes and less densely punctate elytra.

The name refers to David, a hero of the Old Testament with a small body compared to Goliath as *Edaphus david* compared to *Edaphus goliath.*

Edaphus eliab n.sp. (Figs. 10-12)

Holotype (♂) and 3 ♂♂, 2 ♀♀-paratypes: Venezuela: Merida: Laguna Negra, Sierra Nevada National Park, 3.300 m, 8°47.14'N, 70°48.31'W, elfin forest litter, 23.05.1998, R. ANDERSON.- HT and PTT in NHMK, 2 PTT in cP.

Brachypterous, brown, finely and densely punctate; pubescence dense, semierect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs light brown.

Length: 1.3-1.7 mm (forebody 0.7-0.75 mm).

PM of HT: wH: 37.5; dE: 29; lE: 8; lT: 0; lG: 6; wP: 40; lP: 37; wEl: 53; lEl: 35; lS: 27.

Male: Antennal segment 10 about as long as broad, segment 11 slightly longer than segment 10. Sternite 8 (Fig. 11). Sternite 9 (Fig. 12). Aedeagus (Fig. 10), median lobe with 4 minute lateral setae approximately in middle; parameres bifid, each with two long setae.

Female: Antennal segment 10 slightly broader than long, segment 11 distinctly longer than segment 10.

In nearly all respects (except sexual characters) similar to *E. david* n.sp., but larger, ptfF indistinct or very shallow, head and pronotum more finely and less densely punctate.

Edaphus eliab n.sp. may be distinguished from *E. david* n.sp. by the antennal and the male sexual characters (despite similar body size the aedeagus of *E. eliab* is nearly twice as long as that of *E. david*); from *E. longepilosus* PUTHZ (Peru) it is easily distinguished by the distinct punctation.

The name refers to the similarity with *E. david* (Eliab = oldest brother of the Biblical David).

Edaphus apo n.sp. (Figs. 13, 15)

Holotype (♂): Peru: Cuzco Dept.: Consuelo, Manu road km 16.5, beating dead branches, 10.10.1982, L. E. WATROUS & G. MAZUREK, FMHD #82-364; 1 ♂-paratype: Ecuador: Napo: Yasumi Reseach Station in mid. Rio Tiputini, 8°40.05'S, 76°24'W, FIT #1, 11.-18.07.1999, A. TISHECHKIN.- HT in the FMCh, PT in NHMK.

Macropterous, reddish brown, shiny, head and pronotum impunctate, except for the microscopically fine insertions of setae, elytra very finely and densely punctate, abdomen with microscopically fine punctures; pubescence short, dense, semierect. Antennae, maxillary palpi and legs brownish.

Length: 1.8-2.1 mm (forebody 1.2 mm).

PM of HT: wH: 58; dE: 41; lE: 14; lT: 0; lG: 1.5; wP: 59; lP: 46; wEl: 85; lEl: 78; lS: 65.

Male: Antennal segment 9 of similar length as segment 11, but slightly broader, 1/4 longer than broad, segment 10 distinctly longer than segment 9 (15: 12) and 1/3 longer than broad. Sternite 8 (Fig. 15). Sternite 9 with a prominent apico-median tip. SpP twice as long as the median lobe, sclerotized double trumpet absent, vs strongly sclerotized, as long as the median lobe broad. Aedeagus (Fig. 13), parameres each with a thin apical seta.

Head slightly narrower than pronotum, eyes large, with coarse ommatidia, temples absent, ptfF distinct, ampF concave, more than two times as broad as each of the alpF, clypeus simple; alpf with two setiferous punctures. Antennae with a 3-segmented club. Pronotum much broader than long, moderately concave postero-laterally, lbc and mbc absent, but 8 small dorsal mbf and 1 small lateral fovea on each side distinct. Elytra very large, humeral angles unmodified, punctation very fine, interstices twice as large as punctures. Mbct3 absent.

Variability. In the paratype from Ecuador the antennal segment 10 is as long as segment 11.

This new species is closely related to *E. peruanus* PUTHZ, *E. bufo* PUTHZ and *E. kapac* n.sp. It may be distinguished from the former two by much broder head and longer elytra, from *E. kapac* by shorther length, less broad and nearly impunctate pronotum, from all by the male sexual characters.

Named after the Inka word for "Sir".

Edaphus kapac n.sp. (Figs. 14, 17)

Holotype (♂) (left elytron missing): Ecuador: Napo: 15 km S. Baeza on road to Tena, 1800 m, primary forest litter berlesate, 28.04.1990, C. CARLTON: in NHMK.

Macropterous, yellowish brown (somewhat immature), moderately shiny, very finely and densely punctate; pubescence moderately long, dense, semierect on pronotum, recumbent on the remaining surface. Antennae, palpi and legs yellowish.

Length: 2.2-2.6 mm (forebody 1.4 mm).

PM of HT: wH: 63; dE: 44; lE: 16; lT: 0; lG: 3; wP: 69; lP: 58; wEl: 104; lEl: 100; lS: 75.

Male: Antennal segment 10 much longer than segment 9 (17: 13) and much longer than broad (17: 11.5), segment 9 about 1/3 longer than broad, segment 11 slightly shorter than segment 10. Sternite 8 (Fig. 17). Sternite 9 with a prominent apico-median tip. SpP, double trumpet and vs as in *E. apo*. Aedeagus (Fig. 14), parameres only free at slightly swollen apex, with one minute apical seta and one longer seta in basal third.

In nearly all respects very close to *E. apo*, but the relations of body proportions different, the pronotum very finely,densely, and distinctly punctate, the pubescence and very fine punctation of the abdomen denser.

This new species is close to *E. apo* n.sp. and may be distinguished by larger body size and the male sexual characters.

Named after the Inka word for "pompous".

Edaphus hidalgo n.sp. (Fig. 16)

Holotype (♂) Panama: Chiriqui: 12 km W El Hato del Volcan, 4500 feet, berlese litter, cloud forest, 27.06.1976, A. NEWTON. Paratypes: 2 ♀♀: Chiriqui: 27.7 km W Volcan Hartmann's Finca, 1450 m, 8°51.48'N, 82°44.36'W, berlese forest litter, R. ANDERSON. Costa Rica: 1 ♂, 2 ♀♀-paratypes: Costa Rica: Puntarenas: OTS Sta. finca Las Cruces, 4000 feet: San Vito, 8°46'N, 82°58'W, Berlese banana root litter conc. 800 cc., West ravine, 16.03.1973, J. WAGNER & J. KETHLEY; 2 ♂♂, 1 ♀: Las Cruces Biol. Station, 1330 m, 8°47.14'N, 82°57.58'W, FIT, 28.-31.05.2004, J.S. ASHE et al.; 1 ♂: Las Alturas (Stanford Biological Station), 29 km NE San Vito, 1500 m, FIT, 27.05.1993, J.S. & A.K. ASHE; 1 ♀: Puntarenas: R.F. Golfo Dulce, 3 km SW Rincon, 10 m, 06. 1991, P. HANSON; 1 ♂: Rincon de Osa, 50 m, 8°41.141'N, 83°31.117'W, FIT, 23.-26.06.2001, S. & J. PECK; 1 ♂: Corcovado National Park, Sirena Station, Corcovado Trail, 150 m, 8°29.07'N, 83°34.39'W, FIT, 28.06. - 1.07.2000, Z.H. FALIN; 2 ♀♀: Altamira Biological Station, 1510-1600 m, 9°01.76'N, 83°00.49'W, FIT, 4.07.2004, J.S. ASHE et al.; 1 ♂: Monteverde: Estacion Biologica Monteverde, 1540 m, 10°19.40'N, 84°49.08'W, montane forest litter, 9.06.2001, R. ANDERSON; 1 ♀: Guanacaste: Cacao Biological Station, 1100-1200 m, 10°56.0'N, 85°27.0'W, berlese leaf litter, idem.- HT and 1 PT in FMCh, PTT also in NHMK and in cP.

Macropterous, reddish brown; shiny, extremely finely and densely punctate; pubescence dense, erect on pronotum, recumbent on the remaining surface. Base of antennae brown, club yellowish brown. Maxillary palpi and legs yellowish brown.

Length: 1.5-1.9 mm (forebody 0.95 mm).

PM of HT: wH: 44; dE: 30; lE: 12; lT: 0; lG: 4; wP: 46; lP: 37; dlbc: 33; wEl: 70; lEl: 621; lS: 50.

Male: Antennal segment 10 1/4 longer than broad, about as long as segment 11. Sternite 7 with a broad and shallow apical emargination. Sternite 8 (Fig. 16). Sternite 9 with a long apico-median tip. SpP about twice as long as the median lobe, double trumpet indistinct, vs very small. Aedeagus similar to that of *E. apo* (see Fig. 13), internal structures with a forked piece; parameres with a minute, short apical seta.

Female: Antennal segment 10 slightly longer than broad, segment 11 about 1/3 longer than segment 10.

In most respects similar to *E. apo* n.sp., but the pronotum with distinct (but very narrow) lbc and 6-8 mbf; microscopically fine punctation of the pronotum denser than in *E. apo*.

This new species is very similar to *E. caballero* n.sp., from which it may be distinguished by the narrow, distinctly (although very finely) punctate pronotum, from *E. apo* n.sp. and *E. kapac* n.sp. by the presence of lbc, from all by the male sexual characters.

Named after a Spanish nobleman.

Edaphus caballero n.sp. (Fig. 18)

Holotype (♂): Panama: Gativa, 09.-10.1938, A. BIERIG [The specimen was cleaned from mould, the pubescence therefore was partly rubbed off.]. Paratypes: 2 ♂♂: Coclé: 7.2 km NE El Coclé, 730 m, 8°37'N, 80°35'W, FIT, 20.05.-7.06.1995, J. ASHE; 2 ♂♂: ibidem, berlese forest litter, 7.06.1995, R. ANDERSON; 1 ♂: Darien: Estacion Ambiental Cana, Cerro Pirre, 1450 m, 7°45.20'N, 77°41.06'W, cloud forest litter, 6.06.1996, R. ANDERSON. HT in FMCh, PTT in NHMK and in cP.

Macropterous, castaneous, shiny, impunctate (except microscopically fine insertions of setae); pubescence moderately dense (rubbed off in the HT). Antennal base brownish, club yellowish brown. Maxillary palpi and legs yellowish brown.

Length: 1.5-1.9 mm (forebody 1.0 mm).

PM of HT: wH: 51; dE: 33; lE: 14; lT: 0; lG: 2; wP: 55; lP: 42; dlbc: 37; wEl: 77; lEl: 63; lS: 49.

Male: Antennae as in *E. hidalgo*, but segment 9 as long and as broad as segment 10. Sternite 8 (Fig. 18). Sternite 9 as in *E. hidalgo*. SpP and vs as in *E. hidalgo*. Aedeagus resembling that of *E. kapac* (see Fig. 14), apical part of parameres broad with an internal apophysis.

In most respects similar to *E. hidalgo*, pronotum also with very narrow, not very distinct lbc and with 8 small mbf, but broader, no distinct punctation at 60 x. Elytra also almost impunctate (insertions of setae sparser than in *E. hidalgo*).

This new species closely resembles *E. apo* n.sp. and *E. kapac* n.sp., but may be distinguished by the presence of lbc; from *E. hidalgo* n.sp. it may be distinguished by the almost impunctate forebody, from all by the male sexual characters.

Named after a Spanish knight horseman.

Edaphus panamensis n.sp. (Figs. 19, 20)

Holotype (♂): Panama: Cerro Campana, 3200 feet, berlese cloud forest leaf litter, 17.06.1976, A. NEWTON: in FMCh.

Macropterous, reddish brown, extremely finely, densely punctate (insertions of setae); pubescence dense, erect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs yellowish.

Length: 1.2-1.5 mm (forebody 0.8 mm).

PM of HT: wH: 36; dE: 25; lE: 11; lT: 0; lG: 5; wP: 36; lP: 33; wEl: 59; lEl: 52; lS: 43.

Male: Sternite 8 (Fig. 20). Sternite 9 with a distinct apico-median tip. SpP about as broad and as long as the median lobe, double trumpet strongly sclerotized, vs spindle-like, nearly as long as the median lobe. Aedeagus (Fig. 19), median lobe triangularly narrowed in apical part with some 6 minute setae, internal tube with a star-shaped piece; parameres bifid, nearly as long as the median lobe, each branch with one long seta.

Head as broad as pronotum, eyes with fine ommatidia, large, temples absent, genae about half as long as eyes, ptfF distinct, extending beyond the anterior margin of the eyes, ampF nearly twice as broad as each of the alpF, flat, alpF distinctly elevated with one setiferous puncture anteriorly, punctation on the remaining frons absent. Antennae with a 2-segmented club, segment 10 distinctly broader than long, segment 11 1.5 x as long as segment 10. Pronotum distinctly broader than long, strongly constricted behind, lbc absent (note: at first glance lbc seem to be present, but careful inspection by illumination from different angles reveals that no true lbc are present), 4 very small mbf on each side dorsally, placed in a transverse impression; punctation at 60 x indistinct. Elytra subquadrate, broader than long, humeral angles unmodified, punctation extremely fine but more distinct than on pronotum. Mbct3 short, about 1/3 as long as the posterior tergite.

This new species closely resembles *E. mexicanus* PUTHZ (Mexico) and *E. costaricensis* PUTHZ (Costa Rica); it may be distinguished from both by the larger eyes (in the compared species the genae are about as long as the eyes), 8 mbf and by the male sexual characters.

Named after the country where the type locality is situated.

Edaphus bierigi n.sp. (Figs. 21, 22)

Holotype (♂) and 1 ♀-paratype: Costa Rica: Cartago: 19 km S Tapanti, Rio Grande de Orosi, 1500 m, 9°42'N, 83°47'W, Berlese 3 liters concentrated moss on logs and loam, 14.04.1973, J. WAGNER & J. KETHLEY. Paratypes: 1 ♂: P.N. Tapanti, 1500 m, 9°45'N, 83°49'W, berlese forest litter, 04.06.1997, R. ANDERSON; 1 ♂: Cervantes, 27.04.1941, A. BIERIG; 1 ♂, 1 ♀: San Isidro-Le Estrella, 16.10.1941, idem; 1 ♀: Zarcaro, 04.1943, idem; 1 ♀: Vara Blanca, 1800-2000 m, 1936, idem; 5 ♂♂, 4 ♀♀: ibidem, 2000 m, 08.1938, idem; 1 ♂, 2 ♀♀. ibidem, 18.12.1940, idem; 1 ♀: ibidem 1800 m, 05.10.1941, idem; 1 ♀: San Jose/Cartago: km 45 Int. American Hwy, 6 km NE El Empalme, 1975 m, 9°45.0'N, 83°58.30'W, berlese forest litter, 08.06.1997, R. ANDERSON; 1 §: San José: La Hondura, Rio Claro, 10o03'N, 83o58'W, 1150 m, Berlese stream bed leaf litter, 05.04.1973, J. WAGNER & J. KETHLEY; 1 ♂: Puntarenas: Monteverde, 29.-31.06.1992, FIT, M.L. JAMESON; 1 ♂: ibidem, 1520 m, 24.05.1989, J. ASHE et al.; 1 ♂: Monteverde Reserve, FIT, 25.05.1993, C. MICHALSKI; 3 ♂♂: ibidem, trail near lab, FIT, 26.-28.05.1993, idem; 1 ♂: ibidem, 01.06.1993, idem; 1 ♂: Monte Verde Cerro Amigos, 1780 m, FIT, 24.05.1989, J. ASHE et al.; 1 ♂, 3 ♀♀: Monteverde, Estacion Biol. Monteverde, 1540 m, 10°19. 40'N, 84°49.08'W, montane forest litter, 15.05., 11., 14. & 16.06.2001, R. ANDERSON; 1 ♂: Heredia: La Selva, 3.2 km SE Puerto Viejo, 100 m, FIT, 01.03.1992, W. BELL; 2 ♂♂, 3 ♀♀: Guanacaste: Guanacaste Conservation Area, Cacao Field Station, 1200 m, wet montane forest litter, 12., 13., 20.02.1996, R. ANDERSON; 1 ♂: Alajuela: 14 km S Volcan Arenal, 1000 m, 10°20'N, 84°43'W, sifted leaf litter, 29.04.1988, J. LONGINO; 2 ♂♂: E.B. San Ramon, 27 km N & 8 km W San Ramon, 1120 m, 10°13.30'N, 84°35.30'W, wet montane forest, 29.06., 06.07.1999, R. ANDERSON; 1 ♀: ibidem, 950 m, berlese forest litter, 15.06.1997, idem.- HT and PTT in FMCh, PTT also in NHMK and in cP.

Macropterous, reddish brown, shoulders and a narrow posterior are of elytra yellowish brown, shiny, punctation microscopically fine and moderately dense (insertions of setae); pubescence dense, erect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs yellowish brown.

Length: 1.4-1.7 mm (forebody 0.9 mm).

PM of HT: wH: 39.5; dE: 29; lE: 11; lT: 1.5; lG: 5; wP: 39.5; lP: 36; wEl: 59; lEl: 54; lS: 44.

Male: Sternite 4 with a narrow triangular projection at base and a minute impression postero-medially, sternite 5 with a similar basal projection, posterior middle with a narrow and shallow excision, sternite 6 with a distinct impression and a distinct notch postero-medially, sides of the notch projecting ventro-posteriad, sternite 7 with a deep and narrow median impression and a shallow emargination at posterior margin. Sternite 8 (Fig. 21) very deeply emarginate. Sternite 9 with a distinct apico-median tip. SpP small, half as long and half as broad as the median lobe, double trumpet distinctly sclerotized, vs narrow and long, 1/3 as long as the median lobe. Aedeagus (Fig. 22), apical part of the median lobe spade-like with four minute setae; parameres slightly shorter than the median lobe, bifid, each with two long setae.

In nearly all respects similar to *E. panamensis* n.sp., but minute oblique temples present, base of pronotum with 6 mbf and the mbct3 longer, about half as long as tergite 3.

This new species is closely related to *E. andersoni* PUTHZ (Mexico), but may be distinguished by longer genae, shorter, nearly indistinct temples and the male sexual characters.

Named in honor of Alexander BIERIG (1884-1963), the famous specialist of Staphylinidae from Central America.

***Edaphus kethleyi* n.sp. (Figs. 23-25)**

Holotype (♂): Costa Rica: Cartago: 10 km S Tapanti, Rio Grande de Orosi, 1500 m, 9°42'N, 83°47'W, Berlese concentrated coarse leaf litter on floor, 14.04.1973, J. KETHLEY: in FMCh.

Macropterous, reddish brown, a narrow area at posterior margin of elytra yellowish brown, punctation barely noticable (insertions of setae); pubescence long and dense, erect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs yellowish brown.

Length: 1.2-1.5 mm (forebody 0.9 mm).

PM of HT: wH: 43.5; dE: 34; lE: 10; lT: 1.5; lG: 6; wP: 43.5; lP: 41; wEl: 62; lEl: 50; lS: 40.

Male: Sternite 3-7 simple. Sternite 8 (Fig. 24). Sternite 9 with a distinct apico-median tip. SpP 2/3 as long as the median lobe, double trumpet strongly sclerotized, vs (?) consisting of a multiply coiled strongly sclerotized tube (Fig. 23). Aedeagus (Fig. 25) large, median lobe anteriorly with short peg-like setae, apical part with 4 minute setae, internal structures complicated, clasp-like; parameres longer than the median lobe, bifid, each with two long setae.

Head as broad as the elytra, eyes moderately large, with moderately fine ommatidia, temples short but distinct, ptfF semicircular, ampF twice as broad as each of the alpF, flat, impunctate. Antennae with a 2-segmented club, segment 10 distinctly broader than long, about half as long as the last segment. Pronotum roader than long, with 6 minute mbf, distinct lbc absent. Elytra subtrapezoid, shoulders with a minute, nearly indistinct carina, the narrow yellowish brown posterior area very slightly elevated and with the pubescence directed mediad. Mbct3 about 1/3 as long as the posterior tergite.

Edaphus kethleyi n.sp. resembles *E. bierigi* n.sp., but may be distinguished by the absence of lbc, longer pubescence and the male sexual characters. The structure, which I regard to be the vesica seminalis is extraordinary in *Edaphus*. More material is required to confirm that it is a true vs.

Named in honour of the collector.

***Edaphus dybasi* n.sp. (Figs. 26-28)**

Holotype (♂) and 2 ♂♂, 2 ♀♀-paratypes: Panama: Chiriqui Prov.: Finca Lerida near Boquete "Casita Alta", 7800 feet, Berlese 524 conc. forest floor litter, 17.03.1959, H.S. DYBAS. Paratypes: 3 ♂♂, 1 ♀: ibidem 7750 feet, Berlese 526, idem; 1 ♂, 1 ♀: ibidem, Berlese 525, conc. forest floor litter under palms etc., idem; 1 ♂: ibidem 6900 feet, Berlese 543, conc. floor debris in dump ravine, 18.03.1959, idem; 1 ♀:

Coclé: El Valle, La Mesa Trail to Las Minas, 2500 feet, Berlese 349, ground debris from steep dry stream bed, 23.02.1959, idem; 1 ♂: Darien: Estacion Ambiental Cana, Cerro Pirre, 1450 m, 7°45.20'N, 77°41.06'W, cloud forest litter, 06.06.1006, R. ANDERSON. Costa Rica: 2 ♂♂: Tapanti, 22.-28.01.1941, A. BIERIG; 1 ♂: Vara Blanca, 2000 m, 08.1938, idem; 1 ♂, 2 ♀♀: Heredia: 6 km ENE Vara Blanca, 10°11'N, 84°07'W, 2000 m, montane forst leaf litter, 15.-22.04.2002, R. ANDERSON; 1 ♀: ibidem 2100 m, idem; 3 ♀♀: Puntarenas: Monte Verde, 1550 m, 10°18'N, 84°42'W, ground litter, 08.04.1909, J. LONGINO; 7 ♂♂, 2 ♀♀: San José/Cartago: km 45 Int. American Hwy 6 km NE El Empalme, 1975 m, 9°45'N, 83°58.30'W, FIT, 08.-26.06.1997, S. & J. PECK.- HT and PTT in FMCh, PTT also in NHMK and in cP.

Macropterous, reddish brown, shiny, punctation microscopically fine (insertions of setae), at 60 x barely noticable; pubescence dense, semierect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs yellowish brown.

Length: 1.2-1.6 mm (forebody 0.8 mm).

PM of HT: wH: 37; dE: 27; lE: 11; lT: 0; lG: 4; wP: 37; lP: 35; wEl: 61; lEl: 53; lS: 42.

Male: Antennal segment 10 nearly as long as broad, segment 11 slightly longer than segment 10. Sternites 3-7 simple, sternite 8 (Fig. 27). Sternite 9 with a distinct apicomedian tip. SpP (Fig. 28) consisting of two parts, the proximate part about half as long as the median lobe, double trumpet distinctly sclerotized, the distal part egg-shaped, half as long as the SpP, vs narrow and indistinct, weakly sclerotized. Aedeagus (Fig. 26), median lobe with two ventro-lateral branches, each with one stout and one thin apical seta, apical part with several setae; parameres shorter than the median lobe, shortly bifid, each with two long setae.

Female: Antennal segment 10 distinctly broader than long, segment 11 distinctly longer than segment 10.

In nearly all respects similar to *E. panamensis* n.sp., but the eyes with coarse ommatidia and the base of pronotum with 6-8 more or less distinctly delimited small foveae.

Variability: In some paratypes the frons is finely, distinctly punctate, in other type specimens the punctation is indistinct; in some PTT the elytra are distinctly longer than in the HT (e. g. Cerro Pirre: wEl: lEl = 57:50).

This new species resembles closely *E. mexicanus* PUTHZ and *E. costaricensis* PUTHZ, from which it may be distinguished by longer eyes and the male sexual characters.

Named in honor of the famous collector and specialist of Trichopterygidae Henry S. DYBAS, who guided me, when I visited the FMCh in 1970.

***Edaphus gallinaceus* n.sp. (Figs. 29-31)**

Holotype (♂): Costa Rica: San José: km 117 Pan-American Hwy 19 km N San Isidro, 1800 m, 9°28.00'N, 83°42.20'W, FIT, 20.-25.06.1997, S. & J. PECK. Paratypes: San José: 2 ♂♂, 2 ♀♀: Cerro de Escazu, 2 km S San Antonio, 1650 m, 9°53.30'N, 84°09.00'W, berlese forest litter, 13.06.1997, R. ANDERSON. Panama: 1 ♂, 2 ♀♀: Darien: Estacion Ambiental Cana, Cerro Pirre, 1450 m, 7°45.20'N, 77°41.06'W, cloud forest litter, 06.06.1996, R. ANDERSON; 1 ♂, 1 ♀: Chiriqui: 6 km NE Boquete, 1620 m, 8°48'N, 82°26'W, oak forest litter, 14.06.1996, idem; 1 ♂: Chiriqui: 27.7 km W Volcan Hartmann's Finca, 1800 m, 8°45'N, 82°48'W, oak forest litter, 16.06.1996, idem; 1 ♀: Chiriqui: 5.9 km N Cerro Punta, Parque Nacional Volcan Paru, 2400 m, 8°22'N, 82°34'W, bamboo forest litter, 14.06.1996, idem. 1 ♀ (cf. det.): Costa Rica: Puntarenas: OTS Sta. finca las Cruces, 4800 feet: San Vito, 8°46'N, 82°58'W, Berlese leaf litter in stream bed away from flowing water steep banks, Virgin forest cover, 18.03.1973, J. WAGNER & J. KETHLEY (FMCh).- HT and PTT in NHMK, PTT also in cP.

Macropterous, reddish brown, shiny, very finely punctate; pubescence dense, erect on pronotum, semierect on the remaining surface. Antennae, maxillary palpi and legs yellowish.

Length: 1.1-1.3 mm (forebody 0.7-0.8 mm).

PM of HT: wH: 34; dE: 24; lE: 9; lT: 0; lG: 4; wP: 33; lP: 31; dlbc: 22; wEL: 51; lEl: 48; lS: 40.

Male: Sternite 8 (Fig. 31). Sternite 9 with a distinct apico-median tip. SpP 2/3 as long as the median lobe, double trumpet weakly sclerotized, vs long and slender, also weakly sclerotized. Aedeagus (Figs. 29, 30), internal structures of the median lobe which guide the injection tube with narrow triangular acute tufts (which look like a cock's comb when extruded); parameres slightly shorter than median lobe, each with two long setae, the subapical one inserted on a very small protuberance (not a distinct extra-branch).

Head about as broad as the pronotum, eyes large, with moderately coarse ommatidia, distinct temples absent, ptfF distinct, ampF twice as broad as each of the alpF, flat, clypeus simple; punctation very fine, sparse. Antennae with a 2-segmented club, segment 10 as broad as long, segment 11 about 1.5 x as long as segment 10. Pronotum slightly broader than long, with distinct lbc and 4-6 moderately large mbf; punctation extremely fine, dense. Elytra subquadrate, slightly broader than long, shoulders with a minute carina; punctation very fine and very dense. Mbct3 nearly half as long as the posterior tergite 3.

Edaphus gallinaceus n.sp. may be distinguished from its relatives by the broad head, large elytra with a short humeral carina, very fine punctation, the pronotal characters and the male genitalia.

Named after the shape of the extruded structures of the aedeagus, which resemble a cock's comb (Lat. *gallinaceus* = belonging to chickens).

Edaphus wagneri n.sp. (Figs. 32, 33)

Holotype (♂) and 1 ♂-paratype: Costa Rica: Puntarenas: OTS Sta. finca Las Cruces, 4000 feet: San Vito, 8°46'N, 82°58'W, Berlese concentrated floor litter on slope above stream-good forest cover, 16.03.1973, J. WAGNER & J. KETHLEY. Paratypes: 1 ♂: ibidem, Berlese banana root litter, West Ravine, 16.03.1973, idem; 1 ♂, 1 ♀: ibidem, Berlese leaf litter in stream bed, away from flowing water steep banks, Virgin forest cover, 18.03.1973, idem; 3 ♂♂ (brachypterous): OTS Sta., 5 km SW finca Las Cruces, 4700 feet: La Fila, Berlese mixed floor litter leaf, palm fibers, logmold, 21.03.1973, idem; 1 ♂: Altamira Biological Station, 1510-1600 m, 9°01.76'N, 83°00.49'W, FIT, 04.-07.06.2004, J. ASHE et al.; 1 ♂: San Rafael-Sabanilla, 09.08.1941, A. BIERIG; 1 ♂: Wilson Botanical Garden (Las Cruces Biol. Sta.), 1200 m, FIT, 27.03.1993, J. & A. ASHE.- HT and PTT in FMCh, PTT also in NHMK and in cP.

Macropterous or brachypterous, reddish brown, pronotum and elytra very finely punctate; pubescence dense, erect on pronotum, semierect on elytra. Antennae, maxillary palpi and legs yellowish brown.

Length: 1.0-1.2 mm (forebody 0.7 mm).

PM of HT: wH: 32.5; dE: 24; lE: 8; lT: 1: lG: 5: wP: 33; lP: 32; wEl: 49; lEl: 43; lS: 38.

Male: Sternite 8 (fig. 32). Sternite 9 with a distinct apico-median tip. SpP as long as the median lobe, double trumpet strongly sclerotized, vs slender, weakly sclerotized, 1/3 as long as the median lobe. Aedeagus (Fig. 33) in principle very close to that of *E. gallinaceus*, but the apical part of the median lobe more slender and the parameres slightly but distinctly bifid.

Macropterous specimens are in most respects similar to *E. gallinaceus*, but the head slightly narrower and without fine punctation. Pronotum with very long, distinct lbc, feebly depressed postero-laterally, with 4-6 small mbf, punctation fine (less fine than in *E. gallinaceus*). Elytra very finely punctate.

Variability: 3 paratypes, which were collected at 4700 feet are brachypterous, but their genitalia are identical to those of the macropterous morph.

Edaphus wagneri n.sp. may be distinguished from *E. gallinaceus* n.sp. by longer lbc, smooth ampf and the male genitalia.

Named in honor of the collector J. WAGNER.

Edaphus amigo n.sp. (Figs. 34, 35)

Holotype (♂) and 1 ♂, 3 ♀♀-paratypes: Costa Rica: Puntarenas-Guanacaste border: Monte Verde, Cerro Amigos, 1780 m, Berlese, sifted leaf litter, 09.05.1989, J. ASHE, R. BROOKS & R. LESCHEN (Snow Ent. Mus. C. R. Exped. # 89). Paratypes: 1 ♀ (abdomen missing): Monteverde, 1570 m, FIT, 15.05.1989, idem; 1 ♂: Guanacaste: 8 km NE Sta. Elena, Santa Elena Forest Reserve, 10°20.701'N, 84°47.899'W, FIT, 11.-17.06.2001, S. & J. PECK. 1 ♀ (cf. det.): Heredia: Las Vueltas, upper Rio Patria SE slope Volcan Barba, 1900 m, 84°05'N, 10°06'W, conc. mixed floor litter, 01.04.1973, J. WAGNER & J. KETHLEY (FMCh).- HT and PTT in NHMK, 1 PT in cP.

This new species is in nearly all respects similar to *E. dybasi* n.sp., but the male genitalia are distinctive.

Length: 1.3-1.5 mm (forebody 0.85-0.9 mm).

PM of HT: wH: 37.5; dE: 27; lE: 12; lT: 0; lG: 5; wP: 38; lP: 36; wEl: 63; lEl: 57; lS: 48.

Male: Sternite 8 (Fig. 35). Sternite 9 and two-part SpP about as in *E. dybasi*. Aedeagus (Fig. 34) different: the ventro-lateral parts of the median lobe longer, internal structures different; parameres about as long as ventro-lateral parts of the median lobe, shortly bifid.

A reliable identification of *Edaphus amigo* n.sp. is possible only based on a study of the aedeagus.

Named after the type locality.

Edaphus andersonianus n.sp. (Figs. 36, 37)

Holotype (♂) and 2 ♂♂, 5 ♀♀-paratypes: Panama: Darien: Estacion Ambiental Cana, Cerro Pirre, 1450 m, 7°45.20'N, 77°41.06'W, cloud forest litter, 06.06.1006, R. ANDERSON. Paratypes: 1 ♂: Coclé: 1 Valle, La Mesa Trail to Las Minas, 2500 feet, ground debris from steep dry stream bead, 23.02.1959, H. S. DYBAS; 2 ♂♂. Costa Rica: Puntarenas: 11 km SW Est. Biol. Las Cruces, 1450 m, 8°46.43'N, 83°01.50'W, wet cloud forest litter, 09.07.1999, R. ANDERSON.- HT and PTT in NHMK, PTT also in FMCh and in cP.

General description: same as in *E. gallinaceus* n.sp.

Length: 1.2-1.4 mm (forebody 0.8 mm).

PM of HT: wH: 34; dE: 24; lE: 10; lT: 0; lG: 4; wP: 35; lP: 31; dlbc: 24; wEl: 58; lEl: 52; lS: 45.

Male: Sternite 8 (Fig. 36). Sternite 9 with a distinct apico-median tip. SpP consisting of two parts (about as in Fig. 28), proximal part 3/4 as long as the median lobe, double trumpet distinctly sclerotized, distal part oval, slightly less than half as long as the median lobe, vs weakly sclerotized, narrow, inconspicuous. Aedeagus (Fig. 37), ventral lobe of median lobe with two apical setae, shorter than the parameres; internal structures with a short, strongly sclerotized injection tube, acute tufts as in *E. gallinaceus* absent; parameres longer than the ventral lobes of the median lobe, with a small setiferous protuberance in about anterior third, apical seta shorter than subapical seta.

In nearly all respects similar to *E. gallinaceus*, but humeral angles unmodified.

Edaphus andersonianus n.sp. may be distinguished from *E. gallinaceus* n.sp. and *E. wagneri* n.sp. by simple shoulders and the male genitalia.

Named after R. ANDERSON, the successful collector of neotropical *Edaphus*.

Edaphus dybasianus n.sp. (Figs. 38, 39, 41)

Holotype (♂) and 1 ♀-paratype: Panama: Chiriqui: Cerro Punta, 7000 feet, Berlese floor debris on steep wooded slope, 07.03.1959, H.S. DYBAS. Paratypes: 2 ♀: Finca Lerida near Boquete "Casita Alta", 6900 feet, Berlese 543: conc. floor debris in damp ravine, 17.03.1959, idem; 3 ♂♂, 2 ♀♀: Chiriqui: 12 km NE Santa Clara, Cerro Pando, 2000 m, 8°54.44'N, 82°43.30'W, cloud forest litter, 17.06.1996, R. ANDERSON; 1 ♂, 2 ♀♀: 5.9 km N Cerro Punta, Parque Nac.Volcan Baru, 2150 m, 8°22'N, 82°34'W, alder forest litter, 14.06.1995, idem; 1 ♀: 6.7 km N Cerro Punta, Parque Nac. La Amistad, Las Nubes, 2150 m, 8°22'N, 82°34'W, berlese forest litter, 15.06.1995, idem; 1 ♂: 20 km N Gualaca, Finca La Suiza, 1450 m, 8°39'N, 82°12'W, oak forest litter, 12.06.1995, idem. Costa Rica: 1 ♂: Cartago: Sendero a Cerro Chirripo, Llano Bonito, 2450 m, 9°27.16'N, 83°32.22'W, cloud forest litter, 27.06.1999, idem; 1 ♀: ibidem 2800 m, 9°26.47'N, 83°32.12'W, mixed oak forest litter, 27.06.1999, idem; 1 ♀: Guanacaste: Guanacaste Conservacion Area, Patilla Field Station, 1000 m, cloud-wet montane forest trans. litter, 14.02.1996, idem.- HT and PTT in FMCh, PTT also in NHMK and in cP.

Brachypterous, castaneous, shiny, very finely, densely punctate; pubescence dense, semierect on forebody. Antennae, maxillary palpi and legs light brown.

Length: 1.2-1.4 mm (forebody 0.7 mm).

PM of HT: wH: 36; dE: 28; lE: 8; lT: 1.5; lG: 5; wP: 35; lP: 33; wEl: 50; lEl: 35; lS: 25.

Male: Sternite 8 with a very broad apical emargination (about as in Fig. 35). Sternite 9 with a prominent apico-median tip. SpP (Fig. 38) broad, 2/3 as long as the aedeagus, double trumpet distinctly sclerotized, vs spindle like, nearly half as long as the median lobe. Aedeagus (Fig,. 41), apical part of median lobe triangular with 2 (4?) minute setae; parameres slightly shorter than median lobe, shortly bifid, each with two long setae.

Head slightly broader than pronotum, eyes with moderately coarse ommatidia, prominent, temples short, oblique, distinct, ptfF distinct, ampF nearly twice as broad as the indistinctly delimited alpF, flat; punctation absent. Antennae with 2-segmented club, segment 10 about as long as broad (♂) or slightly broader than long (♀), segment 11 distinctly longer than segment 10. Pronotum broader than long, strongly constricted behind, with 4 (-6) small mbf, lbc and mbc absent; punctation very fine, dense. Elytra strongly trapezoid, humeral angles unmodified, punctation very fine, dense. Mbct3 absent.

This new species resembles closely *E. david* n.sp., *E. eliab* n.sp. and *E. cimicoides* PUTHZ, from which it may be distinguished by the broader head, impunctate frons and the male sexual characters.

Named in honor of the late Henry S. DYBAS, collector of the holotype.

Edaphus wagnerianus n.sp. (Figs. 42, 43)

Holotype (♂) and 2 ♀♀-paratypes: Costa Rica: Cartago: 10 km S Tapanti, Rio Grande de Orosi, 1500 m, 9°42'N, 83°47'W, Berlese concentrated coarse leaf litter on floor, 14.04.1973, J. WAGNER & J. KETHLEY. 3 ♀♀ (cf. det.): San José: La Hondura, Rio Claro, 1150 m, 10°03'N, 83°58'W, Berlese stream bed leaf litter, 05.04.1973, idem (FMCh); 4 ♀♀ (cf. det.): Panama: Chiriqui: La Fortuna, 1200 m, Continental Divide Trail, 8°48'N, 82°12'W, berlese forest litter, 09.06.1995, R. ANDERSON (NHMK and cP).- HT and 1 PT in FMCh, 1 PT in cP.

Brachypterous, reddish brown, shiny, extremely finely punctate; pubescence dense, semierect on pronotum, semirecumbent on elytra. Antennae, maxillary palpi and legs yellowish.

Length. 1.0-1.2 mm (forebody 0.7 mm).

PM of HT: wH: 33.5; dE: 25; lT: 1; lG: 5; wP: 33; lP: 32; dlbc: 24; wEl: 49 (♀: 46); lEl: 40 (♀: 36); lS: 32.

Male: Sternite 8 (Fig. 43). Sternite 9 with a distinct apico-median tip. SpP consisting of two parts, the proximate part about as long and as broad as the median lobe, double trumpet strongly sclerotized, the distal part slender-oval, vs narrow, nearly as long as the median lobe, weakly sclerotized. Aedeagus (Fig. 42), parameres distinctly shorter than the median lobe, shortly bifid, each with two moderately long setae.

In nearly all respects similar to *E. dybasianus* n.sp., but ptfF angulate (semicircular in *E. dybasianus*), ampF very finely punctate. Elytra less trapezoid (in the female distinctly shorter than in the male), shoulders slightly but distinctly prominent with a minute carina.

Named after one of its collectors.

Edaphus subtilipunctatus n.sp. (Figs. 40, 45, 46)

Holotype (♂) and 2 ♂♂, 1 ♀-paratypes: Venezuela: Aragua: Rancho Grande Biological Station, 1350 m, 10°21'N, 67°41'W, berlese leaf litter, 28.02.1995, R.W. BROOKS. Paratypes: 3 ♂♂, 2 ♀♀ ibidem, 1450 m, "La Cumbre", 28.02.1995, idem; 2 ♂♂, 3 ♀♀: ibidem, 1390-1420 m, 27.02.1995, idem; 2 ♂♂: ibidem, 1150 m, montane forest litter, 12.05.1995, R. ANDERSON; 1 ♂: Rancho Grande, sendero a la Toma de Agua, 3850 feet, litter near stream, 22.03.1992, L. HERMAN; 1 ♂, 2 ♀♀: Maracay, Rancho Grande, 1200 m, cloud forest, FIT, 1.-10.07.1987, BORDON & PECK; 2 ♂, 1 ♀: Rancho Grance, La Cumbre, 1500 m, Neurolepis pittieri-bamboo litter, 9.08.1987, S. & J. PECK.- HT and PTT in NHMK, PTT also in AMNH, MHNG and in cP.

Macropterous, reddish brown, shiny, pronotum and elytra very finely, densely, distinctly punctate; pubescence dense, erect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs yellowish.

Length: 1.1-1.4 mm (forebody 0.80-0.85 mm).

PM of HT: wH: 35; dE: 25; lE: 9; lT: 0; lG: 5; wP: 35; lP: 33; wEl: 55 (♀: 50); lEl: 48 (♀: 39); lS: 39.

Male: Sternite 8 (Fig. 46). Sternite 9 with a long prominent apico-median tip. SpP consisting of two parts (Fig. 40), the proximal part nearly as long as the median lobe, double trumpet strongly sclerotized, vs strongly sclerotized, suboval, about half as long as the median lobe. Aedeagus (Fig. 45), median lobe with a triangular apical part, which has 4 minute setae; parameres simple, as long as the median lobe, each with two long apical setae.

Head as broad as pronotum, eyes large, with fine ommatidia, temples absent, ptfF distinct, semicircular, ampF 1.5 x as broad as each of the alpF, flat, clypeus simple; punctation very fine, sparse. Antennae with 2-segmented club, segment 10 about as long as broad, segment 11 1.5 x as long as segment 10. Pronotum slightly broader than long, strongly constricted behind, with 6 small mbf, lbc and mbc absent; punctation very fine, dense. Elytra distinctly broader than long (in the female distinctly shorter than in the male), shoulders prominent, simple; punctation very fine and dense. Mbct3 absent.

Edaphus subtilipunctatus n.sp. resembles closely *E. dybasianus* n.sp. and *E. wagnerianus* n.sp.; from the former it may be distinguished by macroptery and the absence of distinct temples, from the latter by the semicircular ptfF and the recumbent elytral pubescence, from both by the male sexual characters.

Named after the very fine punctation (Lat. *subtilis* = fine; *punctatus* = punctate).

Edaphus siphonifer n.sp. (Figs. 44, 47)

Holotype (♂) and 1 ♂-paratype: French Guyana: Roura, 39.4 km SSE, 270 m, 4°32.43'N, 52°08.26'W, FIT, 25.-29.05.1997, J. ASHE & R. BROOKS. Paratypes: 1 ♂, 1 ♀: 18.4 km SSE Roura, 240 m, 4°36.38'N, 52°13.25'W, FIT, 25.-29.05.1997, idem; 5 ♂♂, 3 ♀♀: ibidem, FIT, 29.05.-10.06.1997, idem; 1 ♂, 1 ♀: Cayenne: 33.5 km S and 8.4 km NW of Hwy N2 on Hwy D5, 30 m, 4°48.18'N, 52°28.41'W, FIT, 29.05.-09.06.1997, idem; 3 ♂♂: Matoury: 41.5 km SSW on Hwy N2, 50 m, 4°37.22'N, 52°22.35'W, FIT, 26.-18.05.1997, idem; 1 ♂; Saül: Mt. Galbao summit, 740 m, 3°37.18'N, 53°16.42'W, FIT, 05.-07.06.1997, idem. Peru: 1 ♂: Madre de Dios: Pantiacolla Lodge, 2-7 km NW El Mirador Trail, Alto Madre de Dios River, 450-700 m, 12°39.10'S, 71°15.28'W, FIT, 23.-26.10.2000, R. BROOKS; 1 ♂: Loreto: Campamento San Jacinto, 2°18.75'S, 75°51.77'W, 175-215 m, 3.07.1997, R. LESCHEN; 2 ♂♂: Loreto: Teniente Lopez, 2°35.66'S, 76°06.92'W, 210-240 m, FIT, 23. & 28.07.1993, idem; 1 ♂: Ucayali Dept.;: Tingo Maria-Pucallpa Road, Puente Chino, km 205, 1300 m, 9°8.12'S, 75°47.20'W, FIT, 11.-14.10.1999, R. ANDERSON.- HT and PTT in NHMK, PTT also in cP.

Macropterous, light brown, shiny, very finely, densely punctate; pubescence dense, erect on pronotum, semierect on elytra. Antennae, maxillary palpi and legs yellowish.

Length: 1.1-1.3 mm (forebody 0.7-0.8 mm).

PM of HT: wH: 32; dE: 21; lE: 10.5; lT: 0; lG: 3; wP: 32; lP: 29; dlbc: 22; wEl: 54; lEl: 44; lS: 37.

Male: Sternite 8 (Fig. 47). Sternite 9 with a distinct apico-median tip. SpP about 3/4 as long as the median lobe, double trumpet distinctly sclerotized, vs weakly sclerotized, narrow, less than 1/5 as long as the median lobe. Aedeagus (Fig. 44) with a slender median lobe, which has a long, proximately more distinctly sclerotized extruding tube ("sipho"); parameres simple, much shorter than the median lobe, each with two moderately long setae.

Head as broad as pronotum, eyes very large, with moderately fine ommatidia, temples absent, ptfF deep, ampF nearly twice as broad as each of the alpF, flat, impunctate, clypeus simple. Antennae with 2-segmented club, segment 10 slightly broader than long, segment 11 1.5 x as long as segment 10. Pronotum distinctly broader than long, with distinct lbc (4-) 6 mbf and a narrow fold between the medial mbf (which is not a complete mbc and does not extend to base); punctation extremely fine, dense. Elytra subquadrate, distinctly broader than long, humeral angles unmodified; punctation very fine, dense. Mbct3 half as long as the posterior tergite.

Variability: The PT from Peru has only 4 mbf and the pronotum is nearly impunctate, but the genitalia are identical.

Edaphus siphonifer n.sp. may be distinguished from its relatives by the large eyes, the medio-basal fold of the pronotum and the male sexual characters.

Named after the long internal tube of the median lobe.

Edaphus newtoni n.sp. (Figs. 48, 50)

Holotype (♂): Panama: Canal Zone, Barro Colorado Island, litter under old tree and vine fall, 12.02.1976, A. NEWTON. Paratypes: 1 ♂: ibidem, litter under rotting logs, 13.02.1976, idem; 1 ♂: ibidem, 06.02.1976, idem; 1 ♂: Veraguas, 6.1 km N of Santa Fé, Cerro Tute, 1220 m, 8°30.30'N, 81°07.06'W, cloud forest litter, 13.06.1996, R. ANDERSON.- HT and 1 PT in FMCh, 1 PT in NHMK and 1 PT in cP.

Macropterous, reddish brown, shiny, at 60 x impunctate (insertions of setae barely noticable); pubescence dense, semierect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs yellowish.

Length: 0.8-1.1 mm (forebody 0.55-0.6 mm).

PM of HT: wH: 23.5; dE: 16; lE: 7; lT: 0; lG: 2; wP: 27; lP: 24; dlbc: 19; wEl: 40; lEl: 35; lS: 28.

Male: Sternite 8 (Fig. 50). Sternite 9 with a minute projecting apico-median tip. SpP about twice as long as the median lobe, double trumpet indistinct, vs small, 1/5 as long as the median lobe. Aedeagus (Fig. 48), median lobe triangularly narrowed; parameres simple, shorter than median lobe, each with two short apical setae.

Head distinctly narrower than pronotum, eyes with moderately coarse ommatidia, much longer than genae, temples absent, ptfF distinct, ampF about as broad as each of the strongly elevated alpF, deeply concave, clypeus somewhat delimited from ampF; punctation absent. Antennae with 2-segmented club, segment 10 distinctly broader than long, half as long as segment 11. Pronotum distinctly broader than long, strongly constricted behind, with distinct lbc, mbc and 4 comparatively large (+ 1 or 2 minute foveae near lbc) mbf. Elytra distinctly broader than long, humeral angles unmodified. Mbct3 nearly as long as the posterior tergite.

This new species seems to be the sister species of *E. plaumanni* PUTHZ (which was described from Brazil, Sta Catharina, but has been also found in Cuba: 1 ♂: Yaya, Oriente, VII.1941, JAUME (ex coll. A. BIERIG) (FMCh)It may be distinguished from this species by the more triangular ampF, which is more distinctly delimited laterally and anteriorly, and by the narrower aedeagus with shorter parameres.

This minute new species is dedicated to Dr. Alfred F. NEWTON (Chicago), the distinguished staphylinidologist, who collected the holotype.

Edaphus cinche n.sp. (Figs. 49, 56)

Holotype (♂): Peru: Ucayali Dept.: Tingo Maria-Pucallpa Road Puente Chino km 205, 1300 m, 9°08.12'S, 75°47.20'W, FIT, 11.-14.10.1999, R. BROOKS: in NHMK.

Macropterous, reddish brown, shiny, very finely, densely punctate; pubescence dense, erect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs yellowish brown.

Length: 1.0-1.2 mm (forebody 0.7 mm).

PM of HT: wH: 30.5; dE: 22; lE: 8.5; lT: 0; lG: 4; wP: 30; lP: 30; wEl: 47; lEl: 46; lS: 38.

Male: Sternite 8 (Fig. 56). Sternite 9 with a short apico-median projection. SpP about as long as the median lobe, double trumpet distinctly sclerotized, vs not found. Aedeagus (Fig. 49) stout, median lobe with two short apical setae; parameres very broad, each with two strong setae.

Head about as broad as pronotum, eyes moderately large, with fine ommatidia, distinct temples absent, ptfF distinct, angulate, ampF less than twice as broad as each of the alpF, flat, clypeus simple; punctation very fine, distinct. Antennae with a 2-segmented club, segment 10 nearly as long as broad, segment 11 1.5 x as long as segment 10. Pronotum about as long as broad, strongly constricted behind, with 4 moderately large mbf; distinct lbc absent (note: inspection has to be made using illumination from different angles); punctation very fine, dense. Elytra subquadrate, humeral angles unmodified, punctation indistinct (microscopically fine insertions of setae). Mbct3 half as long as the posterior tergite.

This new species resembles several neotropical *Edaphus* with a broad head, it may be distinguished from *E. irenae* PUTHZ (Panama) by the less distinctly, more finely punctate pronotum and the punctate frons, from *E. panamensis* n.sp. by smaller size and punctate frons, from both (and all other *Edaphus*) by the male sexual characters.

The name is the Inka word for a leader of a noble family.

Edaphus villac n.sp. (Figs. 51, 52)

Holotype (♂) and 1 ♀-paratype: Ecuador: Napo: El Chaco, 4.8 km NW on road to Oyacachi, 1750 m, 0°18.22'S, 77°50.38'W, montane evergreen forest litter, 7.11.1999, R. ANDERSON. Paratypes: 1 ♀: Sucumbios: Sacha Lodge, 0°05'S, 76°05'W, malaise trap, 13.-25.07.1994, HIBBS; 1 ♂: Peru: Ucayali

Dept.: Tingo Maria-Pucallpa Road Puente Chino, km 205, 1300 m, 9°08.12'S, 75°47.20'W, FIT, 11.-14.10.1999, R. ANDERSON.- HT and 1 PT in NHMK, 1 PT in cP.

Macropterous, reddish brown, shiny, punctation indistinct, microscopically fine (insertions of setae); pubescence dense, semierect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs yellowish.

Length: 1.0-1.4 mm (forebody 0.7-0.8 mm).

PM of HT: wH: 34; dE: 25; lE: 9; lT: 0; lG: 4; wP: 36; lP: 33; wEl: 56; lEl: 49; lS: 39.

Male: Sternite 8 (Fig. 51). Sternite 9 with a long apico-median tip. SpP as long as the median lobe, double trumpet distinctly sclerotized, vs ?. Aedeagus (Fig. 52), median lobe with a broadly rounded dorsal lobe and a bifid ventral part, each branch with a short subapical seta medially; parameres deeply split into two branches, the external branch longer than the internal one, each with a very strong and long apical seta.

In nearly all respects similar to *E. cinche* n.sp., but slightly longer, pronotum broader with 4-6 mbf, punctation even finer, at 60 x indistinct.

This new species also strongly resembles *E. panamensis* n.sp., from which it may be distinguished by the narrower head and the male sexual characters.

The name is the Inka word for priest.

Edaphus bolivianus n.sp. (Figs. 53, 54)

Holotype (♂) and 3 ♂♂, 2 ♀♀-paratypes: Bolivia: Santa Cruz: Mirana, 16.0 km NE Yungas de Mirana, 2300 m, 18°03.35'S, 63°54.38'W, litter, 29.01.1999, R. ANDERSON. Paratypes: 1 ♀: La Paz: Coroico, Cerro Uchumachi, 2150 m, 16°12.16'S, 67°43.33'W, 2nd growth cloud forest litter, idem.- HT and PTT in NHMK, 2 PTT in cP.

General description as in *E. villac* n.sp.

Length: 1.2-1.5 mm (forebody 0.8-0.85 mm).

PM of HT: wH: 38.5; dE: 28; lE: 9.5; lT:1; lG: 5; wP: 40; lP: 36; wEl: 61; lEl: 58; lS: 45.

Male: Sternite 8 (Fig. 54). Sternite 9 with a distinctly prominent apico-median tip. SpP twofold, proximate part 2/5 as long as the median lobe, double trumpet distinctly sclerotized, distal part weakly sclerotized, narrow, slightly shorter than the proximal part, vs weakly sclerotized, very narrow, nearly half as long as the median lobe. Aedeagus (Fig. 53) large, median lobe with an anteriorly broadly rounded dorsal lobe which has four minute setae; parameres bifid, shorter than the median lobe, each with 2 long setae.

In nearly all respects very similar to *E. villac* n.sp. and to *E. chinche* n.sp., but the pronotum with more or less distinct lbc: at first glance the lbc seem to be distinctly pronounced, inspection and illumination from different angles shows that there are no true, sharp, elevated carinae, but sharp folds which have a striking resemblance to carinae. *E. bolivianus* n.sp. may be distinguished from both species by these characters, as well as by the minute temples, from the second also by the 6 mbf, from all by the male genitalia.

Named after the country where the type localities are situated.

Edaphus similifactus n.sp. (Figs. 55, 57)

Holotype (♂) and 2 ♀♀-paratypes: Bolivia: La Paz: 9 km E Chulumani, Apa-Apa, 2100 m, 16°20.99'S, 67°30.30'W, lower yungas litter, 21.01.2001, R. ANDERSON; 1 ♀- 9.1 km E of Chulumani, 2100-2400 m, 16°20.59'S, 67°30.18'W, FIT, 17.-19.01.2001, J.S. ASHE & R.S. HANNLEY. HT and PTT, 1 PT in cP.

In nearly all respects similar to *E. bolivianus* but the very fine punctation slightly more distinct. The male genitalia also very similar.

Length: 1.3-1.7 mm (forebody 0.9 mm).

PM of HT and PT: wH: 38.5 (38); dE: 28.5; lE: 10; lT: 1.5; lG: 6; wP: 38.5 (39); lP: 39 (38); wEl: 60 (60); lEl: 55 (50); lS: 45.

Male: Sternite 8 (Fig. 55). Sternite 9 with a distinctly prominent apico-median tip. SpP and vs as in

E. bolivianus. Aedeagus (Fig. 57), ventro-lateral lobes of the anterior median lobe shorter than in *E. bolivianus*, dorsal lobe more triangular with four minute setae; parameres bifid, internal branch deeper separate from the external branch than in *E. bolivianus*.

The name refers to the similarity of the new species to *E. bolivianus* (Lat. *similifactus* = made similar).

Edaphus limbipennis n.sp.

Holotype (♂): Ecuador: Carchi: San Gabriel, approx. 15 km E R.B. Guandera, 3300 m, 0°35.11'N, 77°34.37'W, mixed riparian forest litter, 11.11.1999, R. ANDERSON: in NHMK.

Apterous, dark brown, shiny, head impunctate, pronotum and elytra finely, moderately densely punctate, abdomen finely, densely punctate; pubescence moderately dense, semierect on pronotum, recumbent on the remaining surface. Antennae, maxillary palpi and legs brownish.

Length: 2.2-2.5 mm (forebody 1.1 mm).

PM of HT: wH: 48; dE: 39; lE: 10; lT: 5; lG: 8; wP: 66; lP: 57; wEl: 88; lEl: 50; lS: 35.

Male: Sternite 7 with a broad apical emargination. Sternite 8 with a deep apical emargination nearly in apical half. Sternite 9 with a prominent apico-median tip. SpP long and narrow, slightly longer than twice as long as the median lobe, spindle-shaped with an internal distinctly sclerotized spiral, double trumpet absent, vs small, strongly sclerotized. Aedeagus large, median lobe with a triangular apical part; parameres much shorter than the median lobe, each with 2 long apical setae, the internal one thin, the external one very stout.

Head very small, much narrower than pronotum, eyes small with coarse ommatidia, temples prominent, genae nearly as long as eyes; ptfF distinct, ampF slightly broader than each of the strongly elevated alpF, concave and impunctate, clypeus simple. Antennae with 3-segmented club, segment 10 about 1.5 x as long and as broad as segment 9, segment 11 nearly twice as long as segment 10. Pronotum distinctly broader than long, moderately constricted behind, lateral margin narrowly prominent in posterior half, visible only in dorsal aspect; base with 4-6 mbf, lbc and mbc absent; punctation fine and dense. Elytra strongly trapezoid, sides rounded with an elevated narrow border and numerous fine granules nearby; punctation fine varying from sparse (near suture) to moderately dense (in lateral half). Mbct3 absent but tergite 3 with a shallow median impression basally.

This new species is separated from all its relatives by the distinctive elytral border.

The name refers to the distinctive elytral morphology of the species (Lat. *limbipennis* = with bordered elytra).

Edaphus chinan n.sp.

Holotype (♀): Ecuador: Pichincha: Bellavista Reserve, Ridge Trail 12 km S Nanegalito, 2250 m, 0°0.54'S, 78°40.56'W, cloud forest litter, 28.10.1999, R. ANDERSON: in NHMK.

Brachypterous, reddish brown, moderately shiny, very finely and densely punctate; pubescence dense, erect on pronotum, recumbent and very long on the remaining surface. Antennae, maxillary palpi and legs reddish brown.

Length: 1.5-1.7 mm (forebody 0.8 mm).

PM of HT: wH: 38; dE: 29; lE: 10; lT: 0; lG: 6; wP: 48; lP: 40; wEl: 72; lEl: 45; lS: 34.

Male: unknown.

Head much narrower than elytra, eyes with coarse ommatidia, moderately small, temples absent, ptfF distinct, ampF as broad as each of the strongly elevated alpF, concave, impunctate, clypeus simple. Antennae with 2-segmented club, segment 10 about as broad as long, segment 11 about 1.5 x as long as segment 10. Pronotum distinctly broader than long, strongly constricted behind, with 2 large transverse mbf, lbc and mbc absent; punctation very fine, dense. Elytra strongly trapezoid, much broader than long, with a deep transverse humeral and a circular parascutellar impression; punctation very fine and very dense. Mbct3 absent.

This new species is easily distinguished from other brachypterous species by the peculiar basal impression of the elytra.

The name refers to an Inka word for a maid.

Acknowledgments

For the loan of material from collections under their care I am indebted to all colleagues involved. For taking REM- and habitus-photographs I thank very much Prof. Dr. Oliver Betz and Karl-Heinz Hellmer (University of Tübingen) and Monsieur Marc Tronquet (Molitg-les-Bains).

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Supplementary note

Edaphus asheianus nom. nov.

Edaphus ashei PUTHZ, 2006: 79 f. (nec PUTHZ, 1971)

Through a regrettable lapsus the species name *ashei* has been published twice: 2001 in Dugesiana 8: 25 (Three new *Edaphus*-species from Mexico (Coleoptera: Staphylinidae), Dugesiana 8: 23-27) and 2006. *E. ashei* PUTHZ, 2006 therefore is a junior homonym of *E. asheianus* nom. nov.

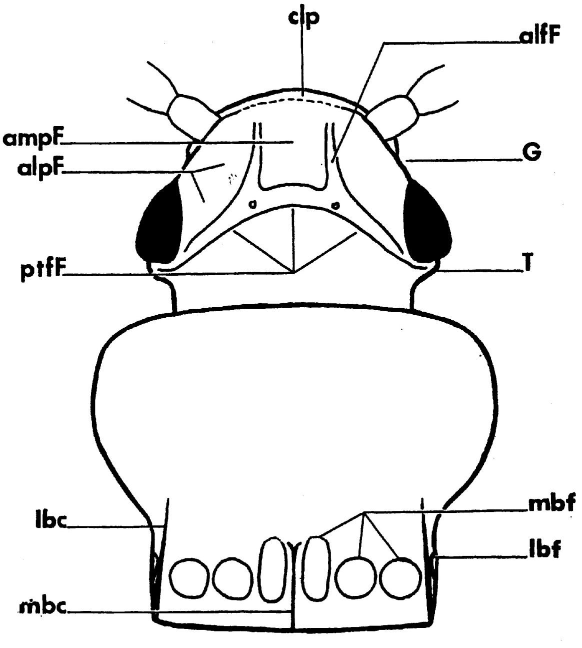

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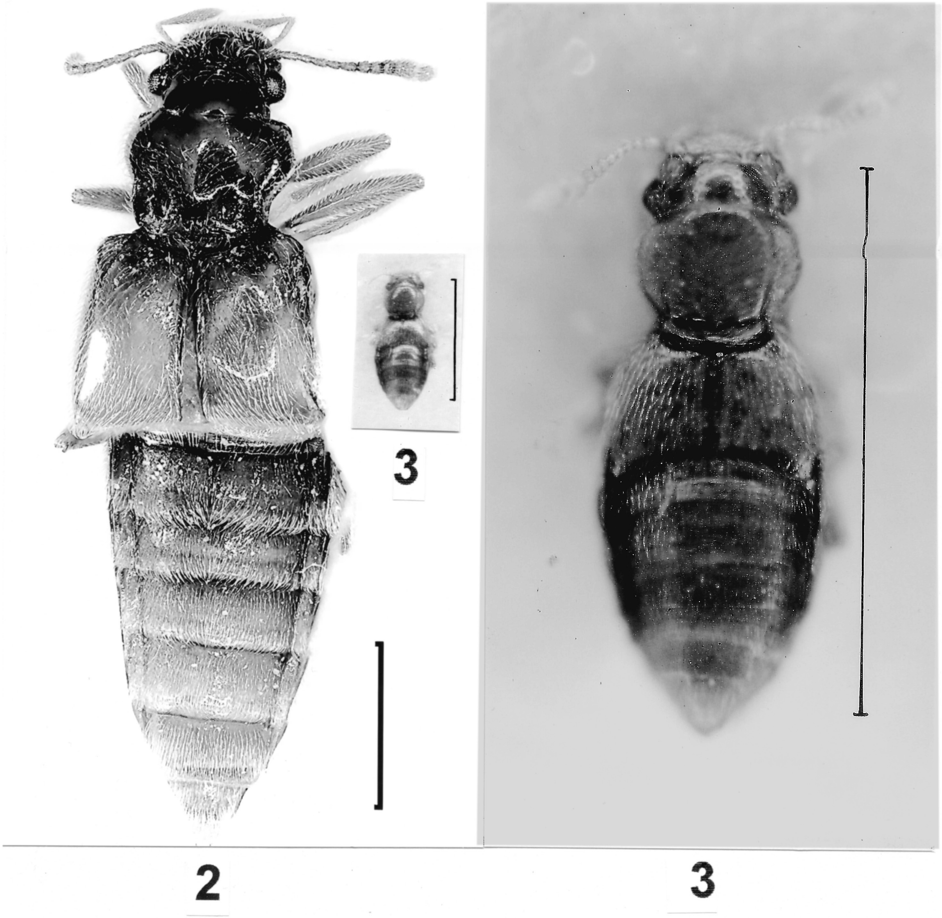
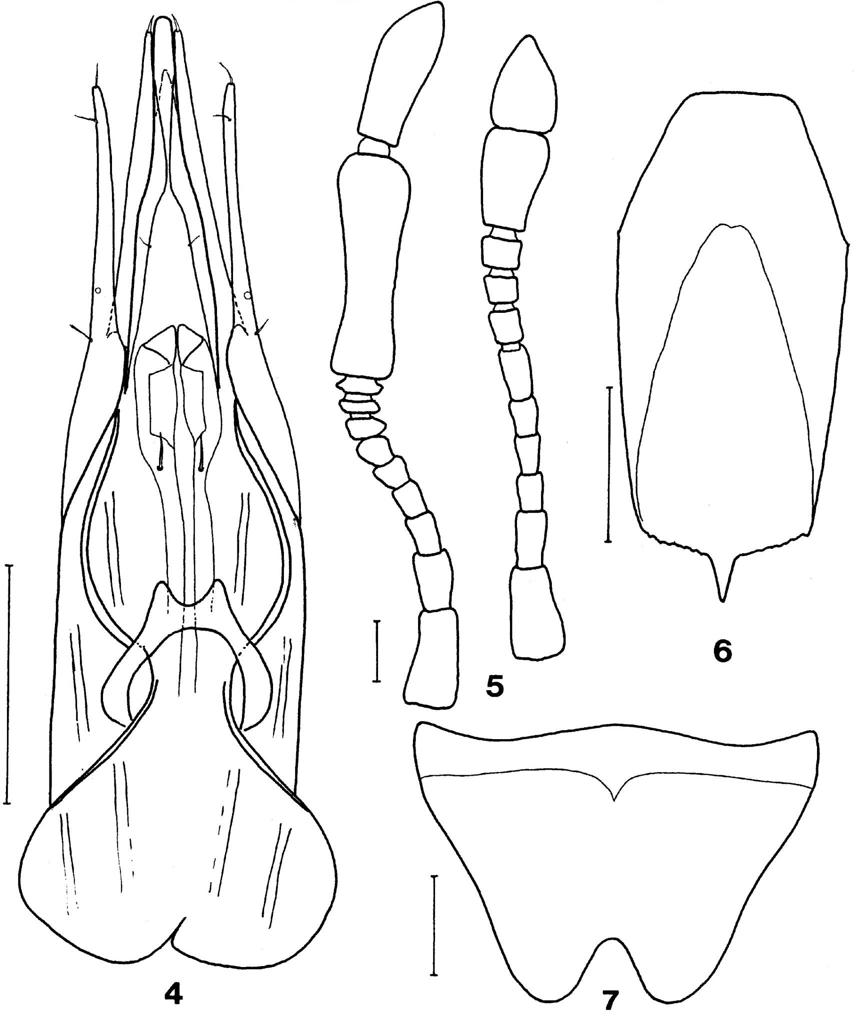
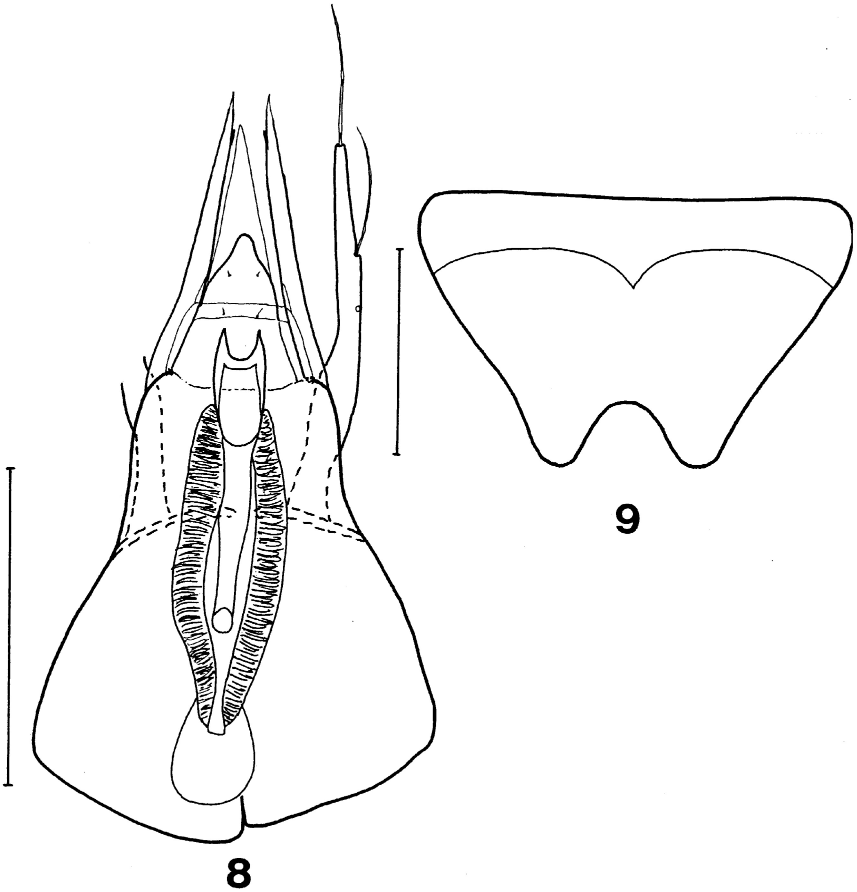
Fig. 1:
Head and pronotum of *Edaphus* spec., explanation of abbreviations see introduction.



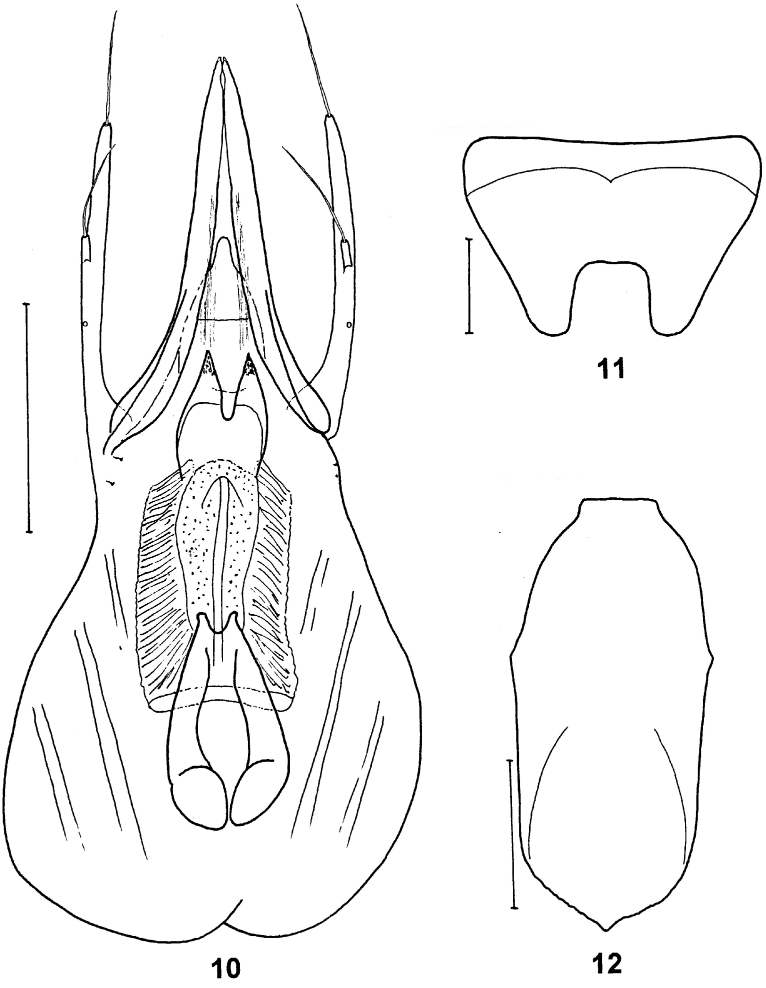
Figs. 2 & 3:
Habitus of *Edaphus goliath* n.sp. (**2**, PT) and *E. david* n.sp. (**3**, PT).- Scale bar = 0.1 mm.



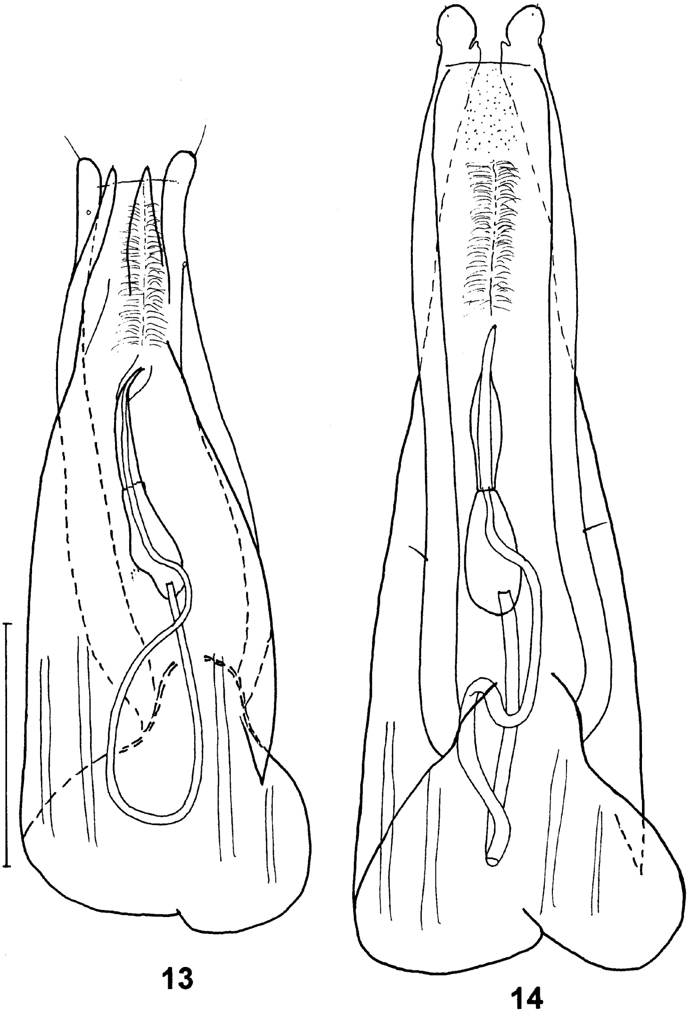
Figs. 4-7:
Edaphus goliath n.sp. (PTT): **4**: ventral aspect of aedeagus. **5**: antenna of the male (left) and the female (right). **6**: sternite 9 of male. **7**: sternite 8 of male.- Scale bar = 0.1 mm.



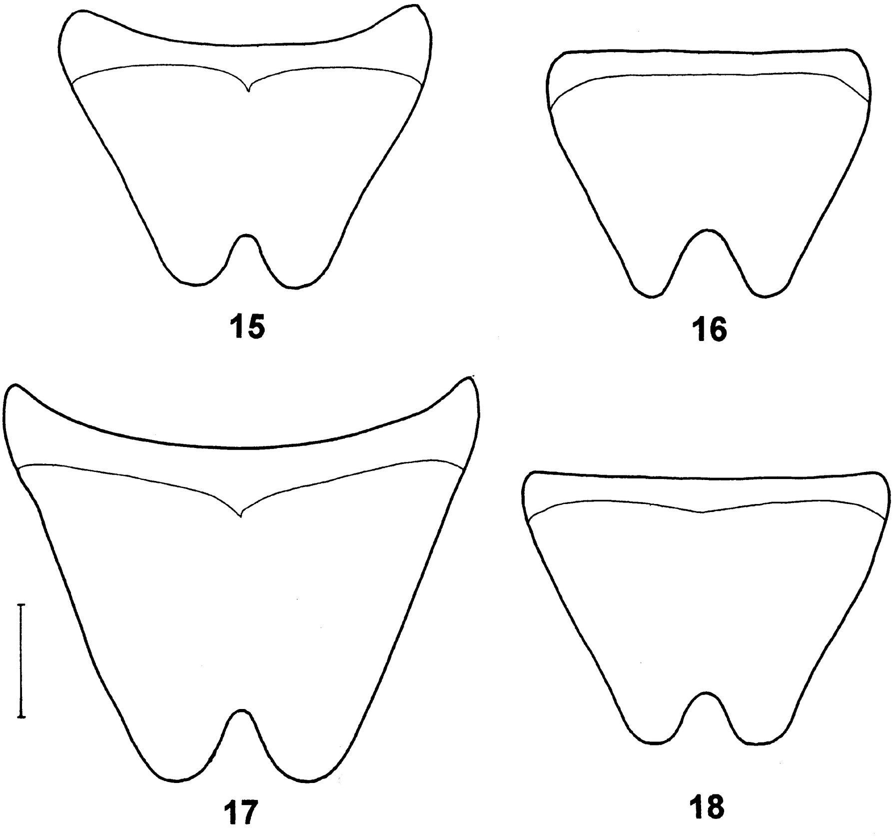
Figs. 8 & 9:
Edaphus david n.sp. (HT): Ventral aspect of aedeagus (**8**) and sternite 8 of male (**9**).- Scale bar = 0.1 mm.



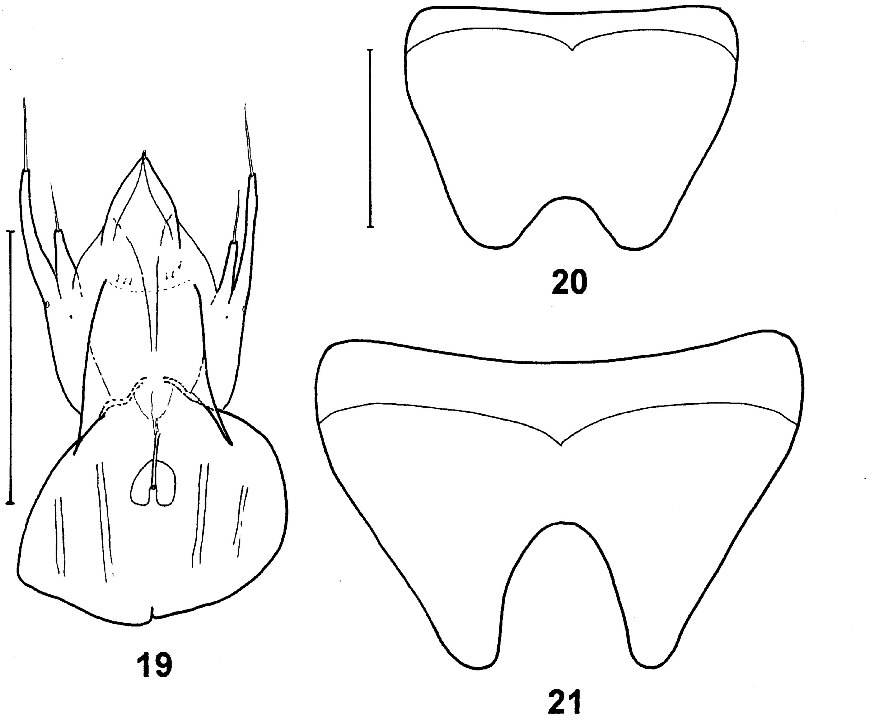
Figs. 10-12:
Edaphus eliab n.sp. (PT): ventral aspect of aedeagus (**10**), sternite 8 (**11**) and 9 (**12**) of male.- Scale bar = 0.1 mm.



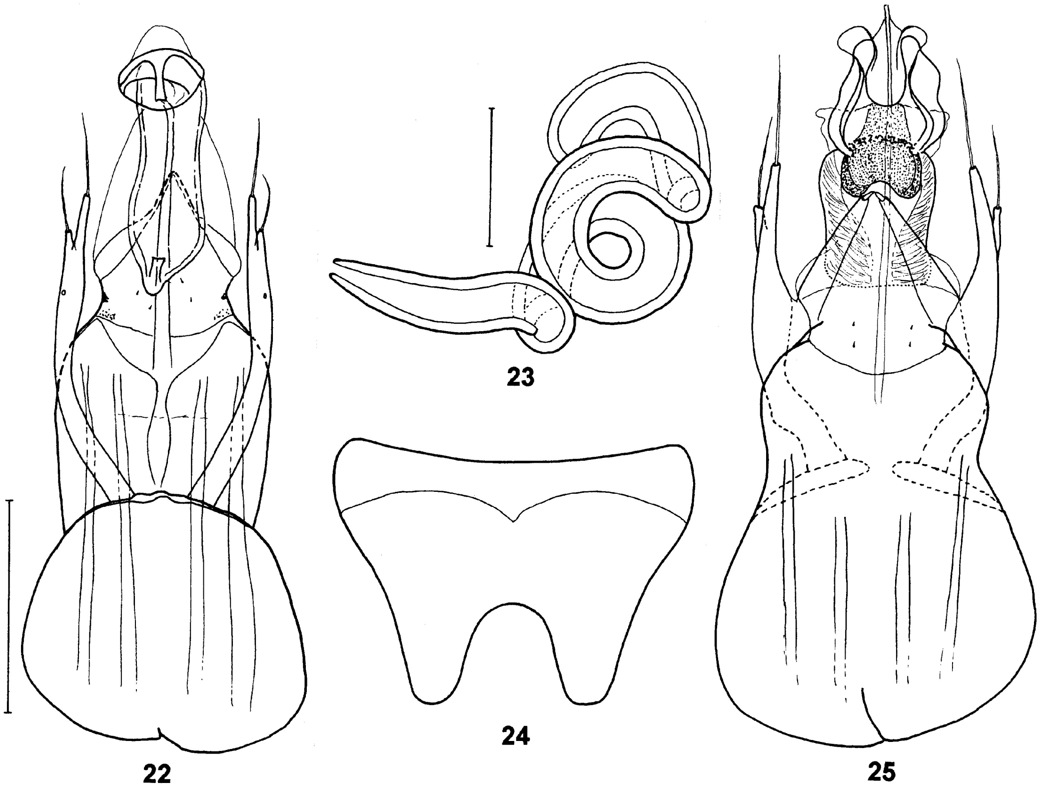
Figs. 13 & 14:
Aedeagus in ventral (**13**) and in dorsal aspect (**14**) of *Edaphus apo* n.sp. (**13**, HT) and *E. kapac* n.sp. (**14**, HT).- Scale bar = 0.1 mm.



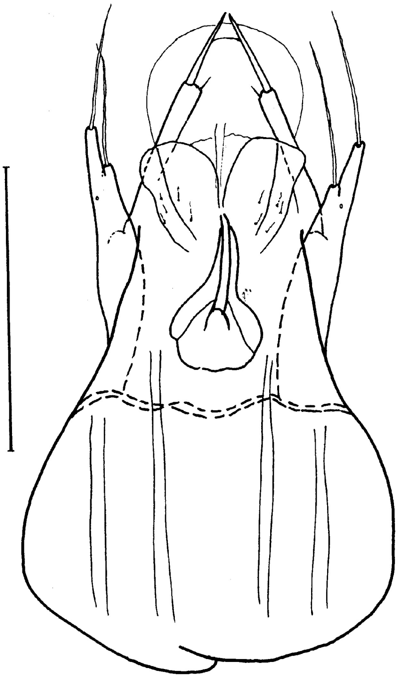
Figs. 15-18:
Sternite 8 of males: *Edaphus apo* n.sp. (**15**, HT), *E. hidalgo* n.sp. (**16**, HT), *E. kapac* n.sp. (**17**, HT) and *E. caballero* n.sp. (**18**, HT).- Scale bar = 0.1 mm.



Figs. 19-21:
Edaphus panamensis n.sp. (HT): ventral aspect of aedeagus (**19**), sternite 8 of male (**20**).- *E. bierigi* n.sp. (HT): sternite 8 of male (**21**).- Scale bar = 0.1 mm.



Figs. 22-25:
Edaphus bierigi n.sp. (PT): dorsal aspect of aedeagus (**22**).- *E. kethleyi* n.sp. (HT): vesica seminalis (**23**), sternite 8 (**24**), ventral aspect of aedeagus (**25**).- Scale bar = 0.1 mm (22 = 25; 23 = 24).



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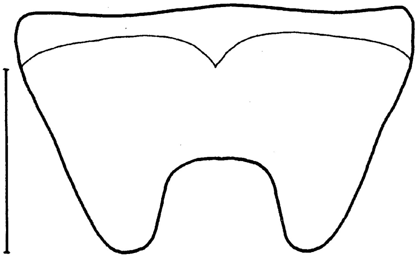

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Figs. 26 & 27:
Edaphus dybasi n.sp. (PT): ventral aspect of aedeagus (**26**) and sternite 8 of male (**27**).- Scale bar = 0.1 mm.

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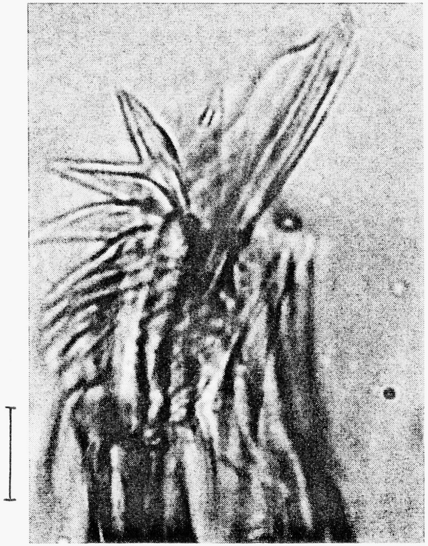
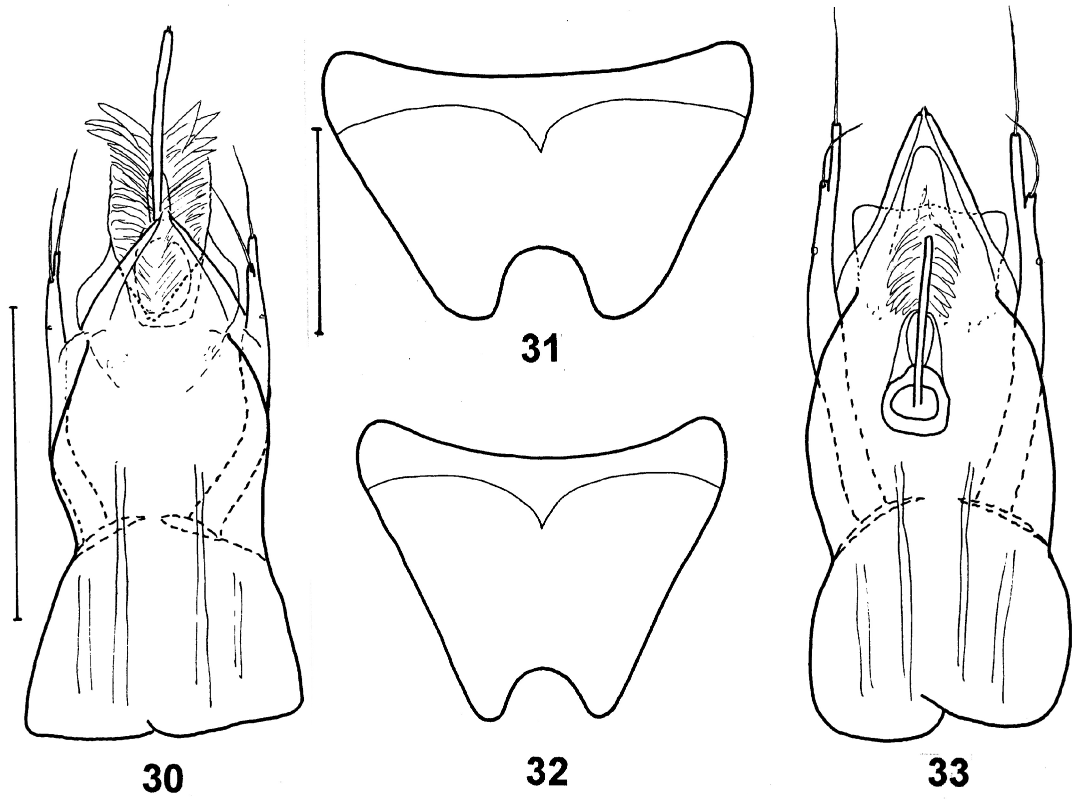
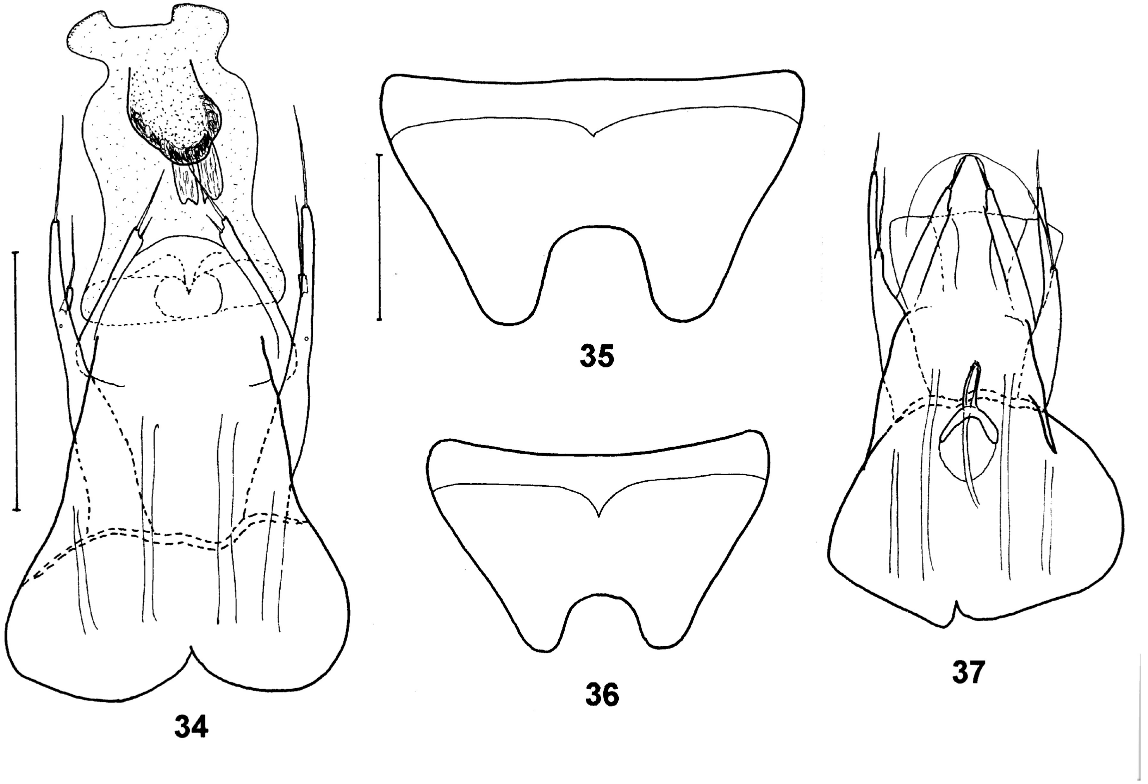


29

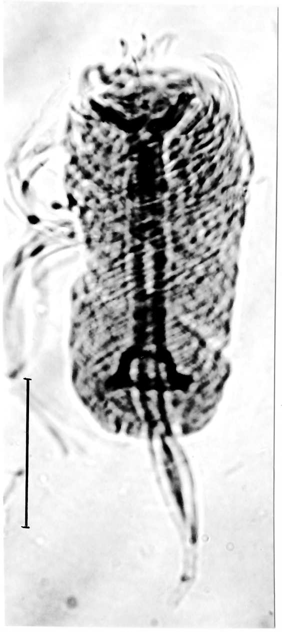
Figs. 28 & 29:
Edaphus dybasi n.sp. (PT): twofold sperm pump (**28**).- *E. gallinaceus* n.sp. (PT): apical part of the extruded aedeagus in lateral aspect (**29**).- Scale bar = 0.1 mm (**28**), 0.01 mm (**29**).



Figs. 30-33:
Ventral aspect of aedeagus (**30**, **33**) and sternite 8 of males (**31**, **32**): *Edaphus gallinaceus* n.sp. (**30**, **31**, PT), *E. wagneri* n.sp. (**32**, **33**, PT).- Scale bar = 0.1 mm (**30** = **33**; **31** = **32**).



Figs. 34-37:
Ventral aspect of aedeagus (**34**, **37**) and sternite 8 of male (**35**, **36**): *Edaphus amigo* n.sp. (**34**, **35**, PT), *E. andersonianus* n.sp. (**36**, **37**, HT).- Scale bar = 0.1 mm (**34** = **37**; **35** = **36**).



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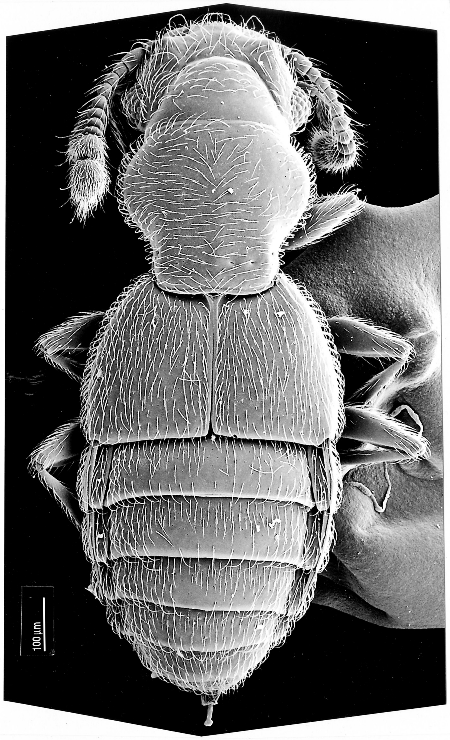

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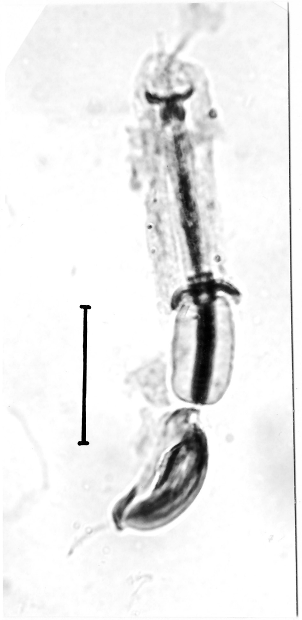
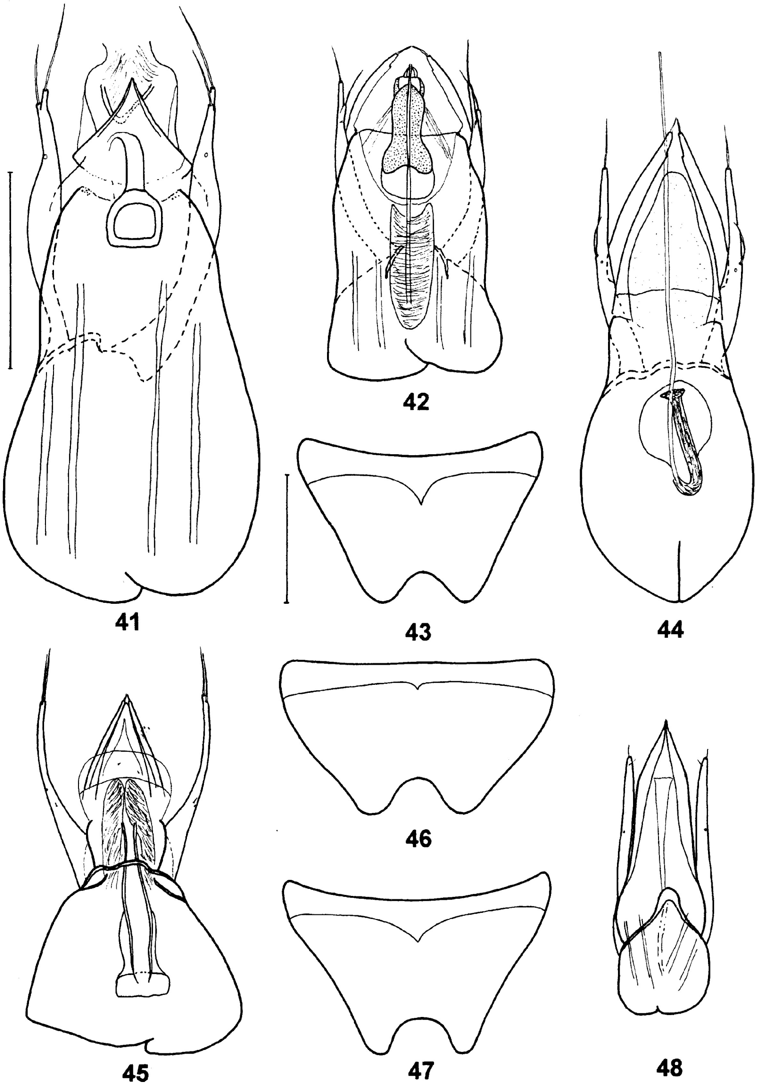
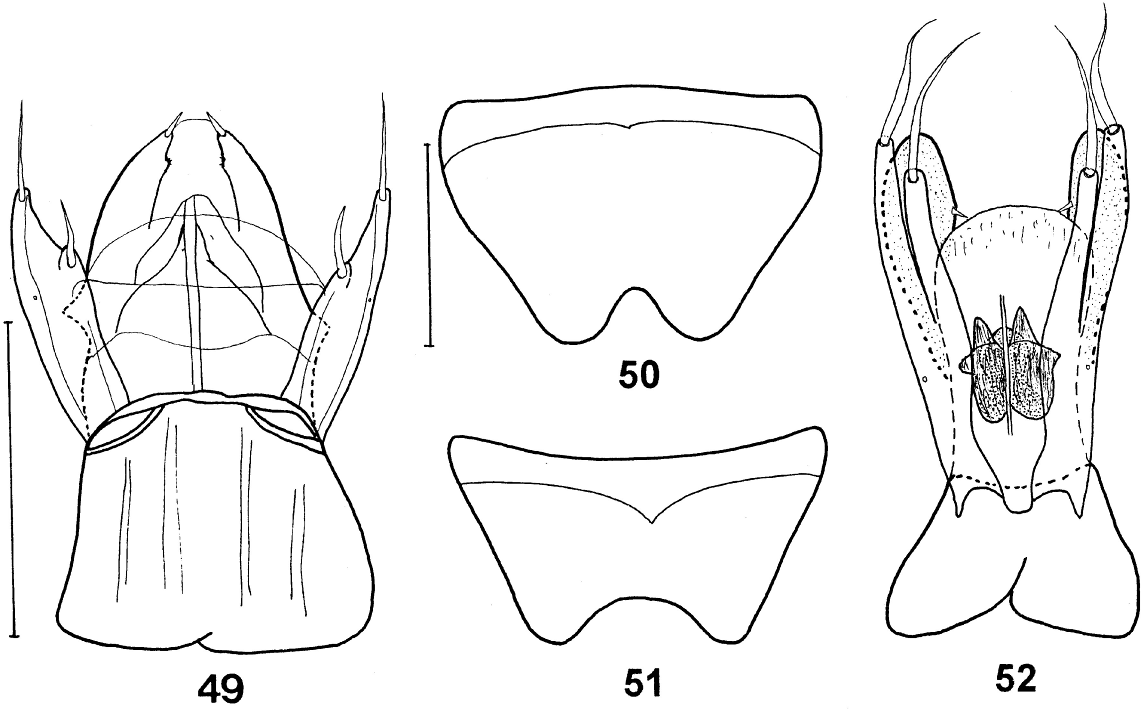


40

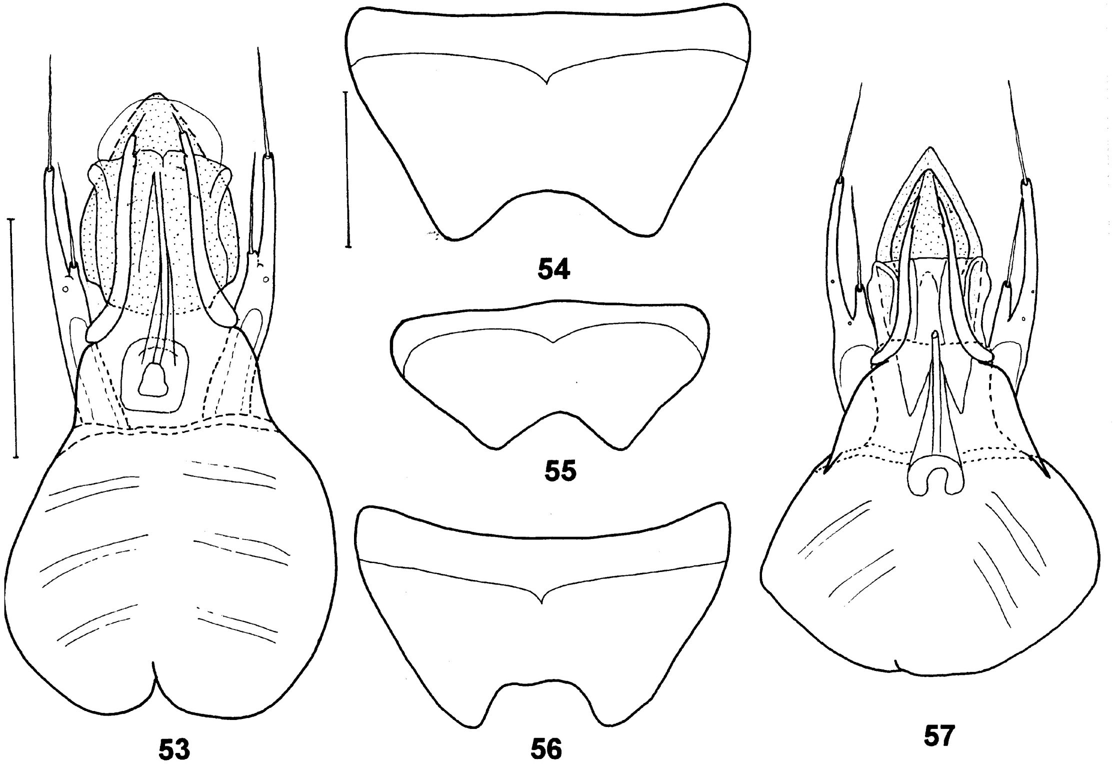
Figs. 38-40:
Edaphus dybasianus n.sp.: Sperm pump (**38**, HT), habitus (**39**, PT).- *E. subtilipunctatus* n.sp.: twofold sperm pump and vesica seminalis (**40**, PT).- Scale bar = 0.1 mm.



Figs. 41-48:
Aedeagus in ventral (**41**, **42**, **44**) and in dorsal aspect (**45**, **48**) and sternite 8 of males (**43**, **46**, **47**): *Edaphus dybasianus* n.sp. (**41**, HT), *E. wagnerianus* n.sp. (**42**, **43**, HT), *E. siphonifer* n.sp. (**44**, **47**, PT), *E. subtilipunctatus* n.sp. (**45**, **46**, PT), *E. newtoni* n.sp. (**48**, PT).- Scale bar = 0.1 mm (**41** = **42**, **44**, **45**, **48**; **43** = **46**, **47**).



Figs. 49-52:
Aedeagus in dorsal (4) and in ventral aspect (**49**, **52**) and sternite 8 of males (**50**, **51**): *Edaphus cinche* n.sp. (**49**, HT), *E. newtoni* (**50**, HT), *E. villac* n.sp. (**51**, **52**, HT).- Scale bar = 0.1 mm (**49** = **52**; **50** = **51**).



Figs. 53-57:
Ventral aspect of aedeagus (**53**, **57**) and sternite 8 of males (**54-56**): *Edaphus bolivianus* (**53**, **54**, PT), *E. similifactus* n.sp. (**55**, **57**, HT), *E. cinche* n.sp. (**56**, HT).- Scale bar = 0.1 mm (**53** = **57**; **54** = **55**, **56**).

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Composição da comunidade de artrópodes associada à copa de *Calophyllum brasiliense* (Guttiferae) no Pantanal, Mato Grosso, Brasil

by

M.I. Marques, J. Adis, L.D. Battirola, A.D. Brescovit, F.H.O. Silva & J.L. Silva

Prof. Dr. Marinêz Isaac Marques (Departamento de Biologia e Zoologia - IB), B.Sc. Biol. Fábio Henrique Oliveira Silva & M.Sc. Jorge Luiz Silva (Programa de Pós-Graduação em Ecologia e Conservação da Biodiversidade - IB), Universidade Federal de Mato Grosso, Av. Fernando Correa da Costa, s/n, Coxipó, 78060-900 Cuiabá/MT, Brasil; e-mails: m.marque@terra.com.br; cuiabant@yahoo.com.br; jluizsilva@yahoo.com.br
Prof. Dr. Joachim Adis, Max-Planck-Institute for Limnology, Tropical Ecology Working Group, Postfach 165, D-24302 Plön, Alemanha; e-mail: adis@mpil-ploen.mpg.de
M.Sc. Leandro Dênis Battirola, Departamento de Zoologia, Universidade Federal do Paraná, Programa de Pós-Graduação em Ciências Biológicas (Entomologia), Caixa Postal 19030, 81531-980 Curitiba/PR, Brasil; e-mail: ldbattirola@uol.com.br
Prof. Dr. Antonio Domingos Brescovit, Laboratório de Artrópodes Peçonhentos, Instituto Butantan. Av. Vital Brasil 1500, 05503-900 São Paulo/SP, Brasil; e-mail: adbresc@terra.com.br

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Composition of the arthropod community associated with the canopy of *Calophyllum brasiliense* (Guttiferae), in the Pantanal, Mato Grosso, Brazil

Abstract

One tree each of *Calophyllum brasiliense* CAMBESS. (Guttiferae) was surveyed during low water (October 2000) and high water (February 2001) to analyze the seasonal variation in composition and structure of the associated arthropod communities. The study was performed at Pirizal, municipality Nossa Senhora do Livramento, Fazenda Retiro Novo, Pantanal of Poconé - Mato Grosso, using canopy fogging. Fogging took place at 6 a.m., the arthropods being collected in nylon funnels of 1 m in diameter, placed under the canopy and containing plastic jars filled with 92 % alcohol. The collecting procedure was divided into two steps: two hours after canopy fogging and thereafter, by thoroughly shaking the arthropods off the foliage where they might have remained. Altogether, 11,307 arthropods from 32 m^2 (353.3 ind./m^2) were obtained, of which 10,852 ind. (95.9 %; 339.1 ind./m^2) belonged to Insecta and 455 ind. (4.1 %; 14.2 ind./m^2) to Arachnida, representing 17 orders. Of this total, 9,213 ind. (81.5 %; 575.8 ind./m^2) were obtained during low water and 2,094 (18.5 %; 130.8 ind./m^2) during high water. Thysanoptera (5,406 ind.; 58.7 %; 337.8 ind./m^2), Hymenoptera (2,429 ind.; 26.4 %; 151,8 ind./m^2), Collembola (447 ind.; 4.8 %; 27.9 ind./m^2) and Coleoptera (250 ind.; 2.7 %; 15.6 ind./m^2) dominated during low water. Hymenoptera (757 ind.; 36.3 %; 47.3 ind./m^2), Diptera (348 ind.; 16.7 %; 21.8 ind./m^2), Collembola (289 ind.; 13.8 %; 18 ind./m^2) and

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Coleoptera (247 ind.; 12.2 %; 15.9 ind./m^2) dominated during high water. In beetles (Coleoptera), the families Nitidulidae, Curculionidae, Staphylinidae and Corylophidae dominated, and the trophic guild of herbivores was most abundant. In the spider community, Salticidae, Anyphaenidae, Araneidae, Corinnidae and Pisauridae represented the most abundant families, and the guild of hunters prevailed over web-builders.

Keywords: **Arthropods, *Calophyllum brasiliense*, canopy, canopy fogging, Pantanal, Mato Grosso.**

Resumo

Dois indivíduos de *Calophyllum brasiliense* CAMBESS. (Guttiferae) foram amostrados, um no período de seca (outubro/2000) e outro na cheia (fevereiro/2001), para analisar a variação sazonal na composição e estrutura da comunidade de artrópodes associada à copa dessa espécie. Este estudo foi realizado na localidade de Pirizal, município de Nossa Senhora do Livramento, fazenda Retiro Novo, Pantanal de Poconé - Mato Grosso, empregando-se como método termonebulização de copas. A nebulização ocorreu às 6:00 horas da manhã e os artrópodes foram coletados em funis de náilon de 1m de diâmetro posicionados debaixo das copas, contendo coletores de plástico com álcool a 92 %. Após este procedimento efetuaram-se duas etapas de coleta. A primeira, duas horas após a nebulização, e a segunda, após a copa ter sido fortemente sacudida para a queda dos artrópodes que ainda permanecessem presos às folhas. Foram obtidos 11.307 artrópodes em 32m^2 de área (353,3 ind./m^2), sendo 10.852 ind.(95,9 %; 339,1 ind./m^2) pertencentes à Insecta e 455 ind. (4,1 %; 14,2 ind./m^2) à Arachnida, distribuídos em 17 ordens taxonômicas. Deste total, 9.213 indivíduos (81,5 %; 575,8 ind./m^2) correspondem ao período de seca e 2.094 (18,5 %; 130,8 ind./m^2) à cheia. Durante a seca, Thysanoptera (5.406 ind.; 58,7 %; 337,8 ind./m^2), Hymenoptera (2.429 ind.; 26,4 %; 151,8 ind./m^2), Collembola (447 ind.; 4,8 %; 27,9 ind./m^2) e Coleoptera (250 ind.; 2,7 %; 15,6 ind./m^2) predominaram. E no período de cheia, Hymenoptera (757 ind.; 36,3 %; 47,3 ind./m^2), Diptera (348 ind.; 16,7 %; 21,8 ind./m^2), Collembola (289 ind.; 13,8 %; 18 ind./m^2) e Coleoptera (255 ind.; 12,2 %; 15,9 ind./m^2) foram as mais representativas. Dentre os Coleoptera destacam-se as famílias Nitidulidae, Curculionidae, Staphylinidae e Corylophidae, e como guilda trófica mais abundante, os herbívoros. Com relação à comunidade de aranhas, Salticidae, Anyphaenidae, Araneidae, Corinnidae e Pisauridae representaram as famílias mais abundantes e a guilda comportamental das caçadoras prevaleceu sobre as tecelãs.

Introdução

As copas das florestas tropicais são consideradas importantes habitats para um grande número de organismos, bem como, fonte de produção primária da biosfera influenciando diretamente o ciclo da água e carbono e apesar disso, constituem um dos biótopos menos estudados (FARREL & ERWIN 1988; HURTADO-GUERREIRO et al. 2003).

Dentre os organismos que ocupam estes habitats, os artrópodes destacam-se pela abundância e diversidade, sendo considerados os principais componentes da fauna arbórea em florestas tropicais (BASSET et al. 2002; NOVOTNY et al. 2002; LUCKY et al. 2002; STORK & HAMMOND 1997), influenciando a estrutura da copa e respondendo sensivelmente às mudanças nas condições florestais (HIJJI et al. 2001).

No Pantanal mato-grossense, estudos em copas de árvores vêm progredindo ao longo dos anos, podendo-se citar aqueles realizados por MARQUES et al. (2001, 2006), que avaliaram a composição da comunidade de artrópodes em copas de *Vochysia divergens* POHL. (Vochysiaceae) em cambarazais, SANTOS et al. (2003) e BATTIROLA et al. (2004a) que estudaram a composição e estrutura da comunidade de artrópodes associados à copa de *Attalea phalerata* MART. (Arecaceae) durante os períodos de seca e cheia, respectivamente.

Além destes, aspectos ecológicos da comunidade de Araneae e composição da comunidade de Formicidae, ambos em copas de *A. phalerata* foram discutidos por

BATTIROLA et al. (2004b, 2005), respectivamente. BATTIROLA et al. (2006) discutem a importância da matéria orgânica encontrada em bainhas desta espécie vegetal como habitat e local de reprodução para os artrópodes. Em solo, destaca-se CASTILHO et al. (2005) que abordaram a distribuição sazonal e vertical de Araneae em área com predomínio de *A. phalerata* (Arecaceae).

Considerando a relevância de estudos ecológicos sobre os artrópodes em ambientes inundáveis e a importância do fortalecimento das pesquisas em copas de florestas tropicais, este estudo objetivou avaliar a composição dessa comunidade associada à copa de *Calophyllum brasiliense* CAMBESS. (Guttiferae) durante os períodos de seca e cheia do Pantanal mato-grossense.

Área de estudo

Este estudo foi realizado no Pantanal de Cuiabá-Bento Gomes-Paraguaizinho, denominado Pantanal de Poconé, mais especificamente na localidade de Pirizal, entre os paralelos 16°15'24" e 17°54'32" de latitude sul e 56°36'24" e 57°56'23" de longitude oeste, município de Nossa Senhora do Livramento, Mato Grosso. Essa região é caracterizada por apresentar estações bem definidas, com período chuvoso de outubro a abril, e a inundação entre dezembro e março (0,6-1,5 m de altura), caracterizando a fase aquática deste ecossistema (HECKMANN 1998). Destaca-se que excepcionalmente no ano de 2000 o período de chuvas iniciou-se tardiamente, e outubro manteve características da fase seca.

O Pantanal mato-grossense apresenta uma complexa condição paisagística, onde cada unidade fitofisionômica caracteriza-se por uma associação de diferentes espécies ou pela predominância de uma delas. Dentre estas unidades, são comuns os landis, sistemas inundáveis com um fluxo d'água corrente durante o período de cheia que funcionam como canais de escoamento durante a vazante. As características definidoras dos landis como a sua forma, tamanho e predomínio de *C. brasiliense*, tornam essas florestas inundáveis distintas das demais encontradas nessa região (GIRARD & NUNES DA CUNHA 1999).

Metodologia

Duas copas de *C. brasiliense* foram nebulizadas empregando-se o termonebulizador durante os períodos de seca (outubro/2000) e cheia (fevereiro/2001) utilizando-se um piretróide sintético, Lambdacialotrina a 0,5 %.

A seleção das árvores amostradas seguiu os critérios estabelecidos por ADIS et al. (1998), e os procedimentos de coleta e nebulização os apresentados por BATTIROLA et al. (2004b), que compreendem duas coletas, a primeira duas horas após a nebulização e a segunda após os galhos serem sacudidos a fim de coletar aqueles artrópodes que ainda permanecessem aderidos às folhas. Neste estudo, a terceira coleta não foi realizada devido à arquitetura de copa da espécie avaliada. Embora a metodologia estabeleça que as árvores selecionadas não devam possuir frutos e flores, os períodos sazonais de seca e cheia, coincidem com as fases de floração e frutificação desta espécie, respectivamente sendo inevitável a sua amostragem.

Para efetuar as coletas, as árvores selecionadas tiveram todo seu diâmetro na base circundado por 16 funis de náilon (1 m diâmetro cada), contendo em suas bases frascos de plástico com álcool a 92 %, numerados e mapeados, possibilitando a localização do ponto de coleta e a análise de distribuição espacial.

Os artrópodes coletados, exceto Araneae, estão acondicionados no Laboratório de Entomologia 21A do Instituto de Biociências da Universidade Federal de Mato Grosso, onde foram triados em nível de ordem. Para Coleoptera procedeu-se a identificação ao nível de família e morfoespécies e posterior avaliação de seus agrupamentos em guildas tróficas de acordo com ARNETT (1963), ERWIN (1983) e

HAMMOND et al. (1996), embora a prioridade para classificação dos grupos tenha sido a proposta por ERWIN (1983).

Os indivíduos de Araneae foram identificados ao nível taxonômico de família, gênero e/ou espécie e depositados na coleção do Laboratório de Artrópodes Peçonhentos do Instituto Butatan, em São Paulo - SP. Para o agrupamento em guildas comportamentais seguiu-se UETZ et al. (1999) e HÖFER & BRESCOVIT (2001).

Resultados e discussão

Composição taxonômica da comunidade de artrópodes

Nas duas copas de *C. brasiliense* foram obtidos 11.307 artrópodes em 32m^2 de área (353,3 ind./m^2), sendo 10.852 indivíduos (96,0 %; 339,1 ind./m^2) pertencentes a Insecta e 455 ind. (4,2 %; 14,2 ind./m^2) à Arachnida, distribuídos em 17 ordens taxonômicas. Deste total, 9.213 indivíduos (81,5 %; 575,8 ind./m^2) correspondem ao período de seca e 2.094 (18,5 %; 130,8 ind./m^2) à cheia (Tabela 1; Figuras 1A e B).

Durante o período de seca houve predominância das ordens Thysanoptera (5.406 ind.; 58,7 %; 337,8 ind./m^2), Hymenoptera (2.429 ind.; 26,4 %; 151,8 ind./m^2) na sua maioria Formicidae (2.110 ind.; 86,8 %; 131,8 ind./m^2), Collembola (447 ind.; 4,8 %; 27,9 ind./m^2) e Coleoptera (288 ind.; 3,1 %; 18,0 ind./m^2). No período de cheia Hymenoptera (757 ind.; 36,1 %; 47,3 ind./m^2) em sua maioria Formicidae (667 ind.; 88,1 %; 41,7 ind./m^2), Diptera (348 ind.; 16,6 %; 21,8 ind./m^2), Collembola (289 ind.; 13,8 %; 18,0 ind./m^2) e Coleoptera (255 ind.; 12,2 %; 15,9 ind./m^2) foram os táxons mais representativos (Tabela 1; Figuras 1A e B).

Thysanoptera (5.541 ind.; 49,0 %; 173,1 ind./m^2) foi o táxon mais abundante na amostragem geral cuja predominância na seca pode estar associada à floração desta espécie vegetal que ocorre somente durante este período, ocasionando uma grande oferta alimentar para estes insetos. Ao contrário destes resultados, BATTIROLA et al. (2004a) e MARQUES et al. (2006), obtiveram em copas de *A. phalerata* e *V. divergens* uma maior abundância destes organismos durante a cheia e vazante, respectivamente, não coincidindo com os períodos de floração, demonstrando que Thysanoptera pode explorar outros recursos além das flores. WOLDA & FISK (1981) consideraram que as condições climáticas nos trópicos são variadas afetando a distribuição sazonal dos insetos, envolvendo principalmente a distinção entre as fases seca e chuvosa. Segundo BASSET (2001), embora este táxon seja comumente amostrado em copas de árvores, pode ser subestimado devido a forte influência da sazonalidade.

Dentre os Hymenoptera (3.186 ind.; 28,2 %; 99,5 ind./m^2), Formicidae (2.777 ind.; 87,1 %; 86,8 ind./m^2) foi o mais representativo. Este táxon é considerado dominante em número e biomassa em ambientes tropicais (FLOREN & LINSENMAIR 1997, 2000; HARADA & ADIS 1997, 1998), provavelmente devido as diversas funções ecológicas que exercem (HOLLDOBLER & WILSON 1990; DELABIE 2001). Além disso, as espécies de formigas arborícolas possuem uma grande variedade de estratégias de forrageamento, hábitos de colonização e padrões de organização das colônias (TOBIN 1995) que as possibilitam explorar acentuadamente estes habitats.

No Pantanal estudos demonstraram que Formicidae é um dos táxons dominantes em comunidades de artrópodes em copas de diferentes espécies vegetais (MARQUES et al. 2001, 2006; SANTOS et al. 2003 e BATTIROLA et al. 2005). Nesta região algumas espécies foram observadas realizando migrações verticais para os troncos e copas de árvores durante as inundações periódicas (ADIS et al. 2001). Esse comportamento pode influenciar temporariamente a composição das comunidades arborícolas durante a fase aquática.

Os Collembola (736 ind.; 6,5 %; 23,0 ind./m^2) que também foram representativos nestas amostragens, correspondem a um táxon geralmente associado a matéria orgânica existente em copas (NADKARNI 1994; NADKARNI & LONGINO 1990).

Diptera correspondeu ao segundo grupo mais abundante durante o período de cheia (348 ind.; 16,6 %; 21,8 ind./m^2). Apesar desta abundância, comum em amostragens de comunidades arbóreas, este táxon é sub-utilizado em estudos taxonômicos (DIDHAM 1997). Diptera apresenta, interações significativas neste habitat, contribuindo em vários níveis tróficos, atuando como predadores, parasitóides e fitófagos, embora não se alimentem somente neste habitat (MORAN & SOUTHWOOD 1982; STORK 1991). Nos estudos de MARQUES et al. (2001, 2006) em copas de *V. divergens* realizados nesta mesma região, Diptera correspondeu a 7,4 % e 5,4 % do total amostrado, representando o quarto e quinto grupo, respectivamente, em abundância. Para SANTOS et al. (2003) e BATTIROLA et al. (2004a), este táxon também foi o quarto mais abundante em copas de *A. phalerata*, com 9,1 % e 8,4 %, respectivamente.

De maneira geral, a resposta à sazonalidade difere entre os grupos que compõem esta comunidade, pois a maioria ou apresentou uma maior densidade em suas populações ou foi restrita ao período de seca a exemplo de Isoptera e Trichoptera (Insecta) e Pseudoscorpiones (Arachnida), provavelmente devido a maior disponibilidade de recursos alimentares neste habitat, principalmente devido a floração de *C. brasiliense*. Todos os Pseudoscorpiones representavam *Parachernes* sp. (Chernetidae).

Do total de indivíduos amostrados durante a seca, 7.540 artrópodes (81,8 %; 471,2 ind./m^2) foram capturados na primeira coleta e 1.673 indivíduos (18,2 %; 104,5 ind./m^2) na segunda. Durante a cheia, 1.348 indivíduos (64,4 %; 84,2 ind./m^2) ocorreram na primeira coleta e 746 indivíduos (35,6 %; 46,6 ind./m^2) na segunda (Figura 2).

Estes resultados corroboram aos de SANTOS et al. (2003) e BATTIROLA et al. (2004a), pois cerca de 40 % do total de artrópodes obtidos nestes estudos permaneceram presos às folhas e galhos após a primeira coleta, demonstrando a necessidade da execução da segunda etapa de coleta. Evidencia-se assim, a funcionalidade e necessidade da segunda coleta para uma maior eficácia da metodologia empregada neste estudo.

Composição taxonômica da comunidade de Coleoptera

Foram amostrados 502 indivíduos adultos (15,7 ind./m^2) distribuídos em 18 famílias. Deste total, 250 indivíduos (49,8 %) foram obtidos no período de seca, sendo Nitidulidae (81 ind.; 32,4 %; 5,1 ind./m^2), Curculionidae (52 ind.; 20,8 %; 3,3 ind./m^2) e Staphylinidae (28 ind.; 11,2 %; 1,8 ind./m^2) as famílias mais abundantes. Lathridiidae (12 ind.; 4,8 %; 0,8 ind./m^2), Scarabaeidae (2 ind.; 0,8 %; 0,1 ind./m^2), Aderidae, Meloidae, Melyridae (1 ind.; 0,4 %; 0,1 ind./m^2 cada) ocorreram somente neste período (Tabela 2; Figura 3).

Dentre os 252 indivíduos (50,2 %; 15,7 ind./m^2) amostrados durante a cheia, destacam-se Nitidulidae (95 ind.; 37,7 %; 5,9 ind./m^2), Curculionidae (80 ind.; 31,7 %; 5,0 ind./m^2) e Staphylinidae (21 ind.; 8,3 %; 1,3 ind./m^2) como famílias dominantes. Diante destes resultados, verifica-se que não houve uma alteração na predominância das famílias de Coleoptera ao longo dos dois períodos avaliados, embora cinco táxons sejam restritos à fase de seca (Tabela 2; Figura 3).

A dominância de Curculionidae e Staphylinidae coincide com as pesquisas já desenvolvidas com outras espécies vegetais nesta mesma região do Pantanal (MAR-

QUES et al. 2006; SANTOS et al. 2003). Estudos realizados em copas de árvores na Amazônia peruana (FARREL & ERWIN 1988) e na Venezuela (DAVIES et al. 1997), indicaram dominância de Curculionidae. De acordo com FARREL & ERWIN (1988), a arquitetura das copas em florestas tropicais exerce um forte efeito sobre a riqueza e abundância de alguns grupos como Staphylinidae e a classificação de copa é um fator determinante na diversidade deste táxon, bem como de outros predadores, exercendo mais influência que a composição florística.

KIRMSE et al. (2003) avaliando a relação entre a diversidade de Coleoptera e os eventos de floração de duas espécies arbóreas na Venezuela, verificaram a predominância de Curculionidae, Cerambycidae e Chrysomelidae, assim como ØDEGAARD (2003) no Panamá em que Curculionidae e Chrysomelidae também foram predominantes. Estudos realizados por ALLISON et al. (1993 e 1997) em Nova Guiné e Papua Nova Guiné, respectivamente demonstraram que Staphylinidae, Chrysomelidae e Curculionidae apresentaram maior riqueza. Estes resultados coincidem com os apresentados por ERWIN (1983) na Amazônia, STORK (1991) em Bornéo e FLOREN & LINSEMAIR (1998) na Malásia.

Durante a seca Curculionidae (15 spp.) foi o táxon mais representativo dentre os herbívoros. Entre os predadores, Staphylinidae (9 spp.) destacou-se como grupo dominante. Nitidulidae e Anthicidae, ambas com 2 morfoespécies, como os táxons de maior riqueza dentre os saprófagos (39,6 %) e Lathridiidae (2 spp.) dentre os fungívoros (Tabela 2). Verificou-se também que durante o período de cheia houve predominância dos herbívoros, representados na sua maioria por Curculionidae (18 spp.). Dentre os predadores, Staphylinidae (7 spp.) foi o táxon dominante, e Nitidulidae (7 spp.) o de maior riqueza dentre os saprófagos (Tabela 2; Figura 4).

Guildas tróficas de Coleoptera

Em *C. brasiliense* observou-se a dominância de saprófagos (191 ind.; 38,0 %; 5,9 ind./m^2) e herbívoros (188 ind.; 37,5 %; 5,9 ind./m^2) sobre predadores (109 ind.; 21,7 %; 3,4 ind./m^2) e fungívoros (13 ind.; 2,6 %; 0,4 ind./m^2) na amostragem geral (Tabela 2; Figura 4). Durante a seca verificou-se a predominância dos herbívoros (92 ind.; 36,8 %; 5,7 ind./m^2), enquanto na cheia os saprófagos (106 ind.; 42,1 %; 6,6 ind./m^2) foram mais representativos.

Nitidulidae foi o táxon mais abundante dentre os saprófagos durante a seca (81 ind.; 95,2 %) e cheia (95 ind.; 89,6 %). Da mesma maneira Curculionidae predominou na seca (51 ind.; 56,5 %) e na cheia (80 ind.; 83,3 %) entre os herbívoros (excluindo-se Platypodinae), e dentre os predadores, Staphylinidae foi o mais representativo tanto na seca (28 ind.; 47,5 %), quanto na cheia (21 ind.; 42,0 %). Com relação aos fungívoros amostrados somente durante a seca, observa-se a dominância de Lathridiidae (12 ind.; 92,3 %) (Tabela 2; Figura 4).

SANTOS et al. (2003) avaliando copas de *A. phalerata* obtiveram herbívoros como grupo dominante devido ao grande número de indivíduos das famílias Curculionidae, Phalacridae, Scarabaeidae e Anobiidae que, somados, corresponderam a 35,8 % dos besouros coletados. Os predadores foram representados por Carabidae (10,9 %) e Staphylinidae (7,9 %), os fungívoros por Lathridiidae (3,3 %), Pselaphinae (1,2 %) e Biphyllidae (1,0 %) e os saprófagos, em sua maioria, por Tenebrionidae (22,9 %).

Estudos realizados em copas de *V. divergens* demonstraram a maior abundância de herbívoros (37,8 %) e predadores (35,2 %) em relação aos saprófagos (16,2 %) e fungívoros (10.8 %) (MARQUES et al. 2006). Dentre os herbívoros destacaram-se Anobiidae, Meloidae, Curculionidae e Chrysomelidae, para os predadores Colydiidae, Staphylinidae e Coccinelidae. Assim como em *C. brasiliense*, Nitidulidae foi mais abundante dentre os saprófagos e Lathridiidae dentre os fungívoros.

Outros estudos realizados em regiões tropicais apontam os herbívoros como o principal grupo nas comunidades de Coleoptera em copas (DAVIES et al. 1997; ERWIN 1983; HAMMOND 1990; HAMMOND et al. 1996, 1997; WAGNER 1997).

Composição taxonômica da comunidade de Araneae

Foram obtidos 224 indivíduos em duas copas de *C. brasiliense*, correspondendo a uma densidade de 7 ind./m^2, distribuídos em 20 famílias e 15 gêneros. Salticidae (63 ind.; 28,1%; 1,9 ind./m^2), Anyphaenidae (32 ind.; 14,3 %; 1,0 ind./m^2), Araneidae (27 ind.; 12,1 %; 0,8 ind./m^2), Corinnidae (25 ind.; 11,2 %; 0,8 ind./m^2) e Pisauridae (24 ind.; 10,7 %; 0,7 ind./m^2) corresponderam as famílias mais representativas. O baixo número de espécies identificadas deve-se ao grande número de indivíduos imaturos coletados (167 ind.; 74,6 %; 5,2 ind./m^2), que devido à ausência de órgãos reprodutivos desenvolvidos impossibilitaram a identificação a níveis mais específicos (Tabela 3; Figura 5).

Foram amostrados 139 indivíduos (62,1 %; 8,7 ind./m^2) durante o período de seca, distribuídos em 17 famílias, 9 gêneros e 2 espécies, sendo Salticidae (45 ind.; 32,4 %; 2,8 ind./m^2) e Anyphaenidae (21 ind.; 15,1 %; 1,3 ind./m^2) as famílias predominantes. No período de cheia foram coletados 85 indivíduos (37,9 %; 5,3 ind./m^2), representantes de 15 famílias, 8 gêneros, 1 espécie identificada e os demais indivíduos identificados em morfoespécies. Salticidae (18 ind.; 21,2 %; 1,1 ind./m^2), Corinnidae (12 ind.; 14,1 %; 0,7 ind./m^2) e Anyphaenidae (11 ind.; 12,9 %; 0,7 ind./m^2) foram às famílias mais representativas (Tabelas 3 e 4; Figura 5).

Comparando-se a freqüência dos representantes de algumas das famílias obtidas durante os períodos avaliados, observa-se que os de Gnaphosidae, Symphytognathidae e Oxyopidae são restritas ao período de cheia, enquanto os de Miturgidae, Selenopidae, Sparassidae, Tetragnathidae e Trechaleidae ao de seca (Tabelas 3 e 4; Figura 5).

Dentre os representantes das 18 famílias coletadas nas copas de *A. phalerata* por SANTOS et al. (2003) durante a seca, apenas aqueles de Amaurobiidae, Caponiidae, Ctenidae, Pholcidae e Prodidomidae não foram amostrados em copas de *C. brasiliense* neste período. Além desta pesquisa, BATTIROLA et al. (2004b) obtiveram Lycosidae, Philodromidae e Titanoecidae em *A. phalerata* durante a cheia, que também não foram coletados em copas de *C. brasiliense* durante este período. Estes resultados demonstram de maneira geral, que *A. phalerata* possui uma comunidade relativamente diferenciada em relação à obtida em copas de *C. brasiliense*.

Na Amazônia HÖFER et al. (1994), obtiveram como dominantes as famílias Salticidae e Araneidae, coincidindo em parte com os resultados obtidos nesta pesquisa e nas demais realizadas em copas no Pantanal.

Guildas comportamentais de Araneae

A comunidade de aranhas foi representada por 8 agrupamentos comportamentais compreendidas entre as caçadoras e tecelãs. As caçadoras subdividiram-se em 5 agrupamentos tais como corredoras aéreas noturnas de folhagens (Anyphaenidae, Corinnidae, Thomisidae, Oxyopidae e Miturgidae), corredoras aéreas diurnas de folhagens (Salticidae), emboscadeiras noturnas de folhagens (Pisauridae, Senoculidae, Sparassidae, Selenopidae e Trechaleidae), corredoras noturnas de solo (Gnaphosidae) e emboscadeiras de solo (Oonopidae). Aranhas tecelãs subdividiram-se em 3 grupos, orbiculares aéreas (Araneidae, Uloboridae e Tetragnathidae), construtoras de teias tridimensionais aéreas (Dictynidae, Linyphiidae e Theridiidae) e tecelãs diurnas de solo (Symphytognathidae). As caçadoras foram dominantes destacando-se Salticidae, Anyphaenidae, Corinnidae e Pisauridae, e dentre as tecelãs, Araneidae, Uloboridae e Dictynidae (Tabela 4).

Embora as aranhas caçadoras tenham prevalecido na captura total durante os dois períodos avaliados tanto em *A. phalerata* quanto em *C. brasiliense*, a estrutura geral de guildas comportamentais avaliadas em copas de *C. brasiliense* foi distinta daquela obervada por BATTIROLA et al. (2004b) ainda que o padrão de ocorrência de guildas seja similar.

Pesquisas realizadas na Amazônia Central demonstraram resultados semelhantes aos de *C. brasiliense* quando analisadas comunidades amostradas por diferentes metodologias. Foi verificado o predomínio de aranhas caçadoras sobre as tecelãs tanto em solo quanto em copas de árvores, sendo Salticidae uma das famílias predominantes (HÖFER & BRESCOVIT 2001; HÖFER et al. 1994).

CASTILHO et al. (2005) demonstraram que o solo foi menos diversificado em relação as guildas comportamentais quando comparado as copas em acurizal no Pantanal mato-grossense. Dentre os grupos dominantes, destacam-se Salticidae, Araneidae e Oonopidae, com predomínio de caçadoras sobre tecelãs, tanto em solo quanto em copas.

FLÓREZ (2000) analisou diferentes habitats de bosques tropicais na Colômbia e obteve como guilda dominante as tecelãs, e dentre essas, as orbiculares aéreas, representando mais da metade do total amostrado, diferindo dos dados aqui obtidos.

Conclusões

Através destes resultados verificam-se diferenças na composição e estrutura da comunidade de artrópodes associados à copa de *C. brasiliense*, entre os períodos sazonais, principalmente em relação à densidade dos táxons dominantes, evidenciando possivelmente, o papel controlador do regime hídrico sobre este habitat.

Os táxons que compõem esta comunidade correspondem aos mesmos verificados em estudos realizados com copas de outras espécies vegetais nesta mesma região, entretanto com padrão de ocorrência diferenciado. Tal fato pode estar relacionado às características peculiares propiciadas pelo habitat e a espécie vegetal analisada.

A predominância das famílias de Coleoptera em copas de *C. brasiliense* apresentou pouca variação entre os dois períodos sazonais avaliados, porém evidenciaram-se mudanças na composição desta comunidade e na estrutura de guildas tróficas, provavelmente devido a diferente disponibilidade de recursos encontrada nestas fases.

Os grupos predominantes de Araneae obtidos coincidem com aqueles amostrados em copas de outras espécies vegetais no Pantanal mato-grossense. Os grupos mais abundantes nestes habitats foram Salticidae, Araneidae e Anyphaenidae e podem ser caracterizados como os principais componentes da araneofauna em copas nesta região.

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Tabela 1: Artrópodes obtidos em duas copas de *C. brasiliense* durante os períodos de seca e cheia no Pantanal de Poconé - MT (A = Adulto; L = Larva; N = Ninfa).

	Seca			**Cheia**			**Geral**		
Ordem	**N**	**%**	**Ind./m^2**	**N**	**%**	**Ind./m^2**	**Σ**	**%**	**Ind./m^2**
Thysanoptera	5.406	58,7	337,8	135	6,4	8,4	5.541	49,0	173,1
Hymenoptera$^{(A+L)}$	2.429	26,4	151,8	757	36,1	47,3	3.186	28,2	99,5
(Formicidae)	(2.110)	(86,8)	(131,8)	(667)	(88,1)	(41,7)	(2.777)	(87,1)	(86,8)
Collembola	447	4,8	27,9	289	13,8	18,0	736	6,5	23,0
Coleoptera$^{(A+L)}$	288	3,1	18,0	255	12,2	15,9	543	4,8	17,0
Diptera$^{(A+L)}$	68	0,7	4,2	348	16,6	21,8	416	3,7	13,0
Hemiptera$^{(A+N)}$	226	2,5	14,1	103	4,9	6,4	329	2,9	10,2
Acari	167	1,8	10,4	62	2,9	3,9	229	2,0	7,2
Araneae	139	1,5	8,7	85	4,1	5,3	224	2,0	7,0
Psocoptera	19	0,2	1,2	50	2,4	3,1	69	0,6	2,2
Orthoptera$^{(A+N)}$	7	<0,1	0,4	6	0,3	0,4	13	0,1	0,4
Isoptera	6	<0,1	0,4	0	0	0	6	<0,1	0,2
Lepidoptera$^{(A+L)}$	5	<0,1	0,3	1	<0,1	<0,1	6	<0,1	0,2
Blattodea$^{(N)}$	1	<0,1	<0,1	1	<0,1	<0,1	2	<0,1	<0,1
Neuroptera$^{(A)}$	1	<0,1	<0,1	1	<0,1	<0,1	2	<0,1	<0,1
Pseudoscorpiones	2	<0,1	0,1	0	0	0	2	<0,1	<0,1
Trichoptera	2	<0,1	0,1	0	0	0	2	<0,1	<0,1
Mantodea$^{(N)}$	0	0	0	1	<0,1	<0,1	1	<0,1	<0,1
Total	9.213	100,0	575,8	2.094	100,0	130,8	11.307	100,0	353,3

Tabela 2: Indivíduos das famílias de Coleoptera obtidos em duas copas de *C. brasiliense* durante os períodos de seca e cheia no Pantanal de Poconé - MT. S = número de morfoespécies.

P = predadores, H = herbívoros, S = saprófagos, F = fungívoros, D = decompositores; ( ) = hábito de nutrição considerado secundário.

Famílias	**Seca**				**Cheia**				**Total**				**Guilda trófica**
	N	**%**	**Ind./m²**	**S**	**N**	**%**	**Ind./m²**	**S**	**N**	**%**	**Ind./m²**	**S**	
Nitidulidae	81	32,4	5,1	2	95	37,7	5,9	7	176	35,0	5,5	8	S
Curculionidae	52	20,8	3,3	16	80	31,7	5,0	18	132	26,3	4,1	25	H
Scolytinae	(4)	(7,7)	(0,3)	(3)	(14)	(17,5)	(0,8)	(4)	(18)	(13,6)	(0,5)	(6)	H (X, F)
Platypodinae	(1)	(1,9)	(0,1)	(1)	-	-	-	-	(1)	(0,7)	(<1,0)	(1)	F
Staphylinidae	28	11,2	1,8	9	21	8,3	1,3	7	49	9,7	1,5	10	P (S, F)
Corylophidae	9	3,6	0,6	2	18	7,1	1,1	4	27	5,4	0,8	6	P (S, F)
Colydiidae	16	6,4	1,0	5	9	2,4	0,6	6	25	5,0	0,8	5	P (F)
Anobiidae	16	6,4	1,0	2	4	1,6	0,3	1	20	4,0	0,6	2	H
Chrysomelidae	18	6,4	1,1	5	4	1,6	0,3	1	22	4,4	0,7	5	H
Bruchinae	(2)	(11,1)	(0,1)	(2)	-	-	-	-	(2)	(0,4)	(<0,1)	(2)	H
Lathridiidae	12	4,8	0,8	2	-	-	-	-	12	2,4	0,4	2	F
Anthicidae	3	1,2	0,2	2	8	3,2	0,5	2	11	2,2	0,3	2	S
Tenebrionidae	1	0,4	0,1	1	7	2,7	0,4	2	8	1,6	0,3	2	S (F)
Alleculinae	-	-	-	-	(4)	(57,1)	(0,2)	(1)	(4)	(50,0)	(0,1)	(1)	H
Coccinelidae	4	1,6	0,3	3	1	0,4	0,1	1	5	1,0	0,2	4	P
Cerambycidae	3	1,2	0,2	2	1	0,4	0,1	1	4	0,8	0,1	2	H
Buprestidae	1	0,4	0,1	1	3	1,2	0,2	1	4	0,8	0,1	2	H
Scarabaeidae	2	0,8	0,1	2	-	-	-	-	2	0,4	0,1	2	H (S)
Scydmaenidae	1	0,4	0,1	1	1	0,4	0,1	1	2	0,4	0,1	1	P
Aderidae	1	0,4	0,1	1	-	-	-	-	1	0,2	<0,1	1	?
Meloidae	1	0,4	0,1	1	-	-	-	-	1	0,2	<0,1	1	H
Melyridae	1	0,4	0,1	1	-	-	-	-	1	0,2	<0,1	1	P
Σ	250	100,0	15,6	56	252	100	15,7	52	502	100,0	15,7	81	-

Tabela 3: Indivíduos de Araneae obtidos em duas copas de *C. brasiliense* durante os períodos de seca e cheia no Pantanal de Poconé - MT. I = Imaturos.

	Táxons	**Seca**				**Cheia**				**Σ**			
Famílias	**Gênero e/ou espécie**	♂	♀	**I**	Σ	♂	♀	**I**	Σ	♂	♀	**I**	Σ
Anyphaenidae	*Italaman santamaria* BRESCOVIT, 1997	-	2	-	2	-	-	-	0	-	2	-	2
	Jessica erithrostoma MELLO-LEITÃO, 1939	2	2	-	4	-	1	-	1	2	3	-	5
	Outras	-	-	15	15	1	-	9	10	1	-	24	25
Araneidae	*Hypognatha* sp.	2	-	-	2	-	-	-	0	2	-	-	2
	Metazygia sp.	-	-	-	0	-	1	-	1	-	1	-	1
	Outras	-	-	16	16	-	-	8	8	-	-	24	24
Corinnidae	*Castianeira* sp. 1	3	5	-	8	3	2	-	5	6	7	-	13
	Castianeira sp. 2	-	-	-	0	-	1	-	1	-	1	-	1
	Outras	-	-	5	5	-	-	6	6	-	-	11	11
Dictynidae	*Dictyna* sp.	1	-	-	1	-	-	-	0	1	-	-	1
	Outras	-	-	2	2	-	-	1	1	-	-	3	3
Gnaphosidae	*Cesonia* sp.	-	-	-	0	-	1	-	1	-	1	-	1
	Outras	-	-	-	0	-	-	2	2	-	-	2	2
Linyphiidae	Outras	-	-	1	1	-	-	1	1	-	-	2	2
Miturgidae	Outras	-	-	1	1	-	-	-	0	-	-	1	1
Oonopidae	*Gamasomorpha* sp.	-	1	-	1	-	-	-	0	-	1	-	1
	Outras	-	-	-	0	-	-	1	1	-	-	1	1
Oxyopidae	*Hamataliwa* sp.	-	-	-	0	-	1	-	1	-	1	-	1
	Outras	-	-	-	0	-	-	3	3	-	-	3	3
Pisauridae	Outras	-	-	16	16	-	-	8	8	-	-	24	24
Salticidae	*Chirothecia* sp.	2	-	-	2	-	-	-	0	2	-	-	2
	Sp. 1	2	-	-	2	-	-	-	0	2	-	-	2
	Sp. 2	1	1	-	2	-	-	-	0	1	1	-	2
	Outras	4	1	34	39	3	3	12	18	7	4	46	57
Selenopidae	Outras	-	-	1	1	-	-	-	0	-	-	1	1
Senoculidae	Outras	-	-	1	1	-	-	5	5	-	-	6	6
Sparassidae	Outras	-	-	4	4	-	-	-	0	-	-	4	4
Symphytognathidae	*Anapistula* sp.	-	-	-	0	1	1	1	3	1	1	1	3
Tetragnathidae	Outras	-	-	1	1	-	-	-	0	-	-	1	1
Theridiidae	*Thwaitesia* sp.	-	-	-	0	-	1	-	1	-	1	-	1
	Outras	-	-	1	1	-	-	-	0	-	-	1	1
Thomisidae	*Tmarus* sp.	-	-	-	0	2	1	-	3	2	1	-	3
	Outras	-	-	6	6	-	1	3	4	-	1	9	10
Trechaleidae	Outras	-	-	1	1	-	-	-	0	-	-	1	1
Uloboridae	*Miagrammopes* sp.	2	-	-	2	-	-	-	0	2	-	-	2
	Uloburus sp.	1	-	-	1	-	-	-	0	1	-	-	1
	Outras	-	-	2	2	1	-	-	1	1	-	2	3
Σ		20	12	107	139	11	14	60	85	31	26	167	224

Tabela 4: Guildas comportamentais dos indivíduos de Araneae obtidos em duas copas de *C. brasiliense* durante os períodos de seca e cheia no Pantanal de Poconé - MT.

Guilda		**Seca**			**Cheia**			**Σ**		
comportamental	**Famílias**	**N**	**%**	**Ind./m^2**	**N**	**%**	**Ind./m^2**	**Σ**	**%**	**Ind./m^2**
CAÇADORAS										
Corredoras aéreas noturnas de folhagens	Anyphaenidae	21	15,1	1,3	11	12,9	0,7	32	14,3	1,0
	Corinnidae	13	9,4	0,8	12	14,1	0,7	25	11,2	0,8
	Thomisidae	6	4,3	0,4	7	8,2	0,4	13	5,8	0,4
	Oxyopidae	-	-	-	4	4,7	0,2	4	1,8	0,1
	Miturgidae	1	0,7	0,1	-	-	-	1	0,4	0,1
Corredoras aéreas diurnas de folhagens	Salticidae	45	32,4	2,8	18	21,2	1,1	63	28,1	1,9
Emboscadeiras noturnas de folhagens	Pisauridae	16	11,5	1	8	9,4	0,5	24	10,7	0,7
	Senoculidae	1	0,7	<0,1	5	5,9	0,3	6	2,7	0,2
	Sparassidae	4	2,9	0,2	-	-	-	4	1,8	0,1
	Selenopidae	1	0,7	<0,1	-	-	-	1	0,4	<0,1
	Trechaleidae	1	0,7	<0,1	-	-	-	1	0,4	<0,1
Corredoras noturnas de solo	Gnaphosidae	-	-	-	3	3,5	0,2	3	1,3	<0,1
Emboscadeiras de solo	Oonopidae	1	0,7	<0,1	1	1,2	<0,1	2	0,9	<0,1
TECELÃS										
Orbiculares aéreas	Araneidae	18	12,9	1,1	9	10,6	0,5	27	12,1	0,8
	Uloboridae	5	3,6	0,3	1	1,2	<0,1	6	2,7	0,2
	Tetragnathidae	1	0,7	<0,1	-	-	-	1	0,4	<0,1
Teias tridimensionais aéreas	Dictynidae	3	2,2	0,2	1	1,2	<0,1	4	1,8	0,1
	Linyphiidae	1	0,7	<0,1	1	1,2	<0,1	2	0,9	<0,1
	Theridiidae	1	0,7	<0,1	1	1,2	<0,1	2	0,9	<0,1
Orbiculares diurnas do solo	Symphytognathidae	-	-	-	3	3,5	<0,1	3	1,3	<0,1
Σ	-	139	100	8,6	85	100	5,1	224	100	7,0

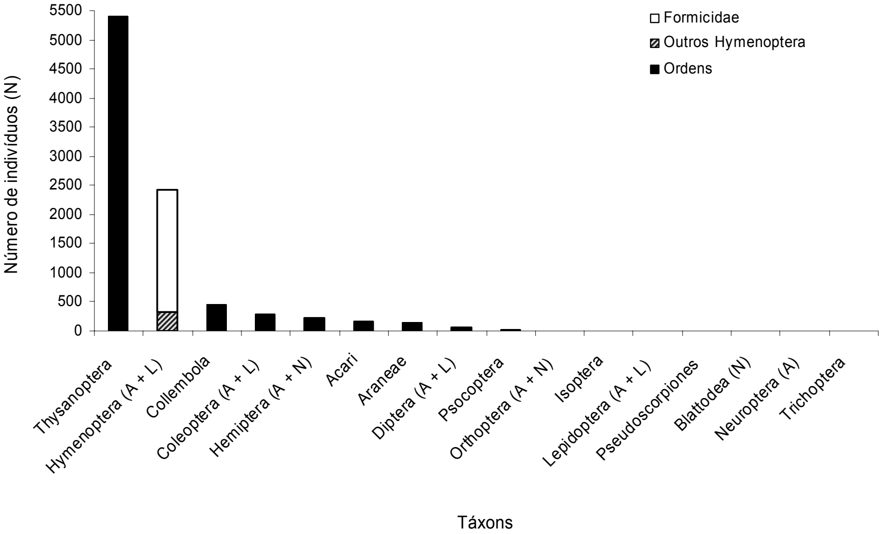

Fig. 1A:
Artrópodes obtidos em copa de 1 indivíduo de *C. brasiliense* durante o período de seca no Pantanal de Poconé - MT (A = adultos; L = larvas; N = ninfas).

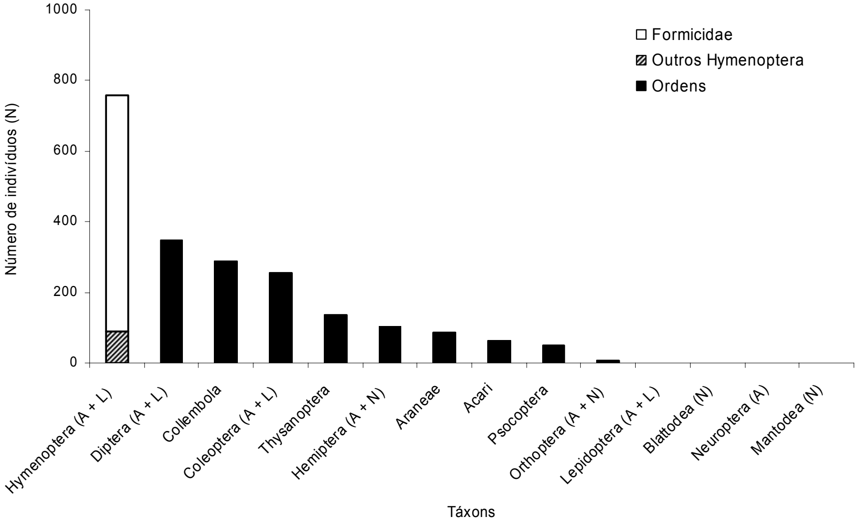

Fig. 1B:
Artrópodes obtidos em copa de 1 indivíduo de *C. brasiliense* durante o período de cheia no Pantanal de Poconé - MT (A = adultos; L = larvas; N = ninfas).

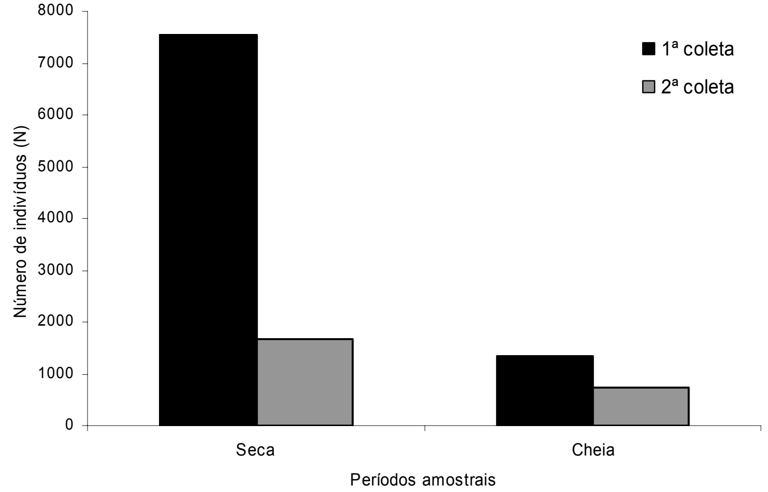

Fig. 2:
Artrópodes obtidos durante a primeira e segunda etapas de coleta em copas de *C. brasiliense* nos períodos de seca e cheia no Pantanal de Poconé - MT.

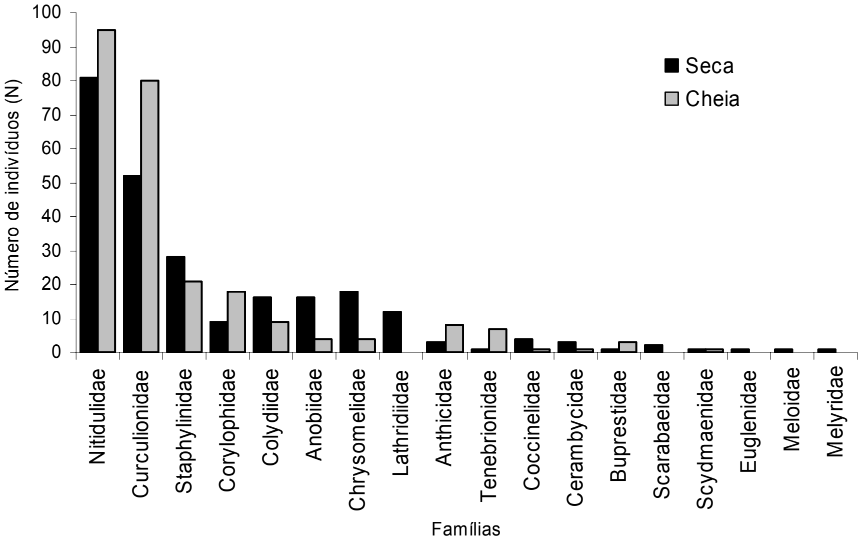

Fig. 3:
Indivíduos de Coleoptera obtidos em duas copas de *C. brasiliense* durante os períodos de seca e cheia no Pantanal de Poconé - MT.

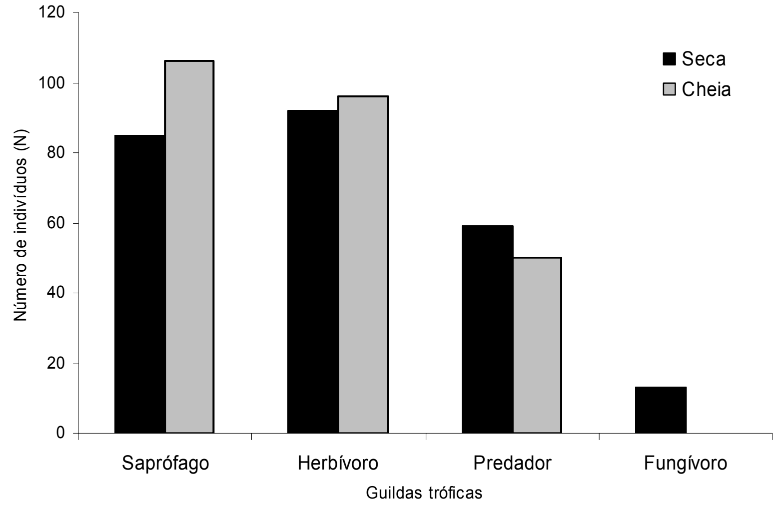

Fig. 4:
Guildas tróficas de Coleoptera obtidas em duas copas de *C. brasiliense* durante os períodos de seca e cheia no Pantanal de Poconé - MT.

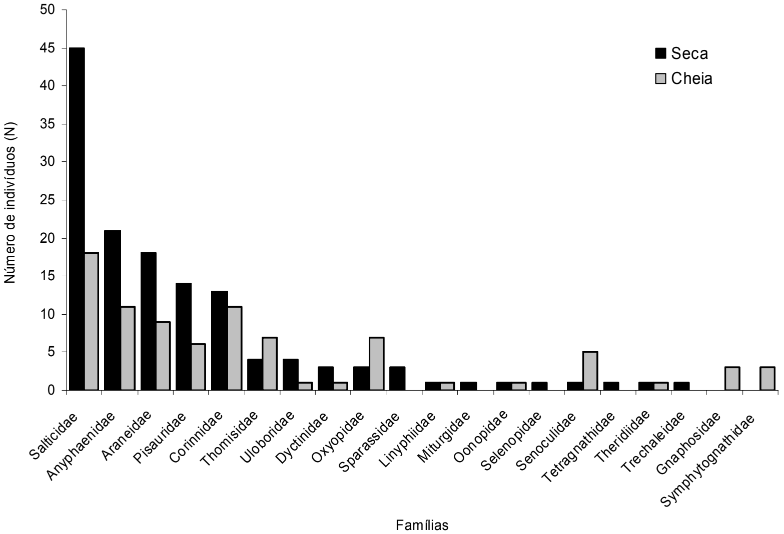

Fig. 5:
Indivíduos de Araneae obtidos em duas copas de *C. brasiliense* durante os períodos de seca e cheia no Pantanal de Poconé - MT.

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Fenología de *Cornops aquaticum* (Orthoptera: Acrididae) en un camalotal de *Eichhornia azurea* (Pontederiaceae) en Argentina

by

M.C. Franceschini, J. Adis, A. Poi de Neiff & M.L. De Wysiecki

Lic. María Celeste Franceschini, Cátedra de Limnología, FACENA-UNNE y Centro de Ecología Aplicada del Litoral (CECOAL-CONICET), Ruta 5, km 2.5 - cc 291, 3400 Corrientes, Argentina; e-mail: celestefranceschini@ yahoo.com.ar
Prof. Dr. Joachim Adis, Instituto Max-Planck para Limnología (Ecología Tropical), Plön, Alemania; e-mail: adis@mpil-ploen.mpg.de
Dr. Alicia Poi de Neiff, Cátedra de Limnología, FACENA-UNNE y Centro de Ecología Aplicada del Litoral, Ruta 5, km 2.5, (3400) Corrientes, Argentina;
e-mail: apoi@cecoal.com.ar
Dr. María Laura De Wysiecki, Centro de Estudios Parasitológicos y de Vectores (CEPAVE), Calle 2 n° 584, 1900 La Plata, Argentina; e-mail: mlw@cepave.edu.ar
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Phenology of *Cornops aquaticum* (Orthoptera: Acrididae) on a floating meadow of *Eichhornia azurea* (Pontederiaceae) in Argentina

Abstract

Cornops aquaticum BRUNER is a native Latin-American grasshopper frequently associated with *Eichhornia* spp., a characteristic macrophyte of lakes in Argentina and southern Brazil. The aim of this research was to determine the age structure of *C. aquaticum* populations in a permanent lake at Corrientes (Argentina), where *E. azurea* represented the host plant. Between February 2004 and April 2006 monthly samples were taken with a net of 70 cm of diameter. We separated adults, minor nymphs (stage I and II) and major nymphs (III to VI) and registered ovary maturation stages. Adults were found in all sampling dates whereas minor nymphs were absent during the coldest months. The results suggest that *C. aquaticum* shows different reproduction periods within the lake studied.

Keywords: **Grasshopper, water hyacinth, macrophyte, floodplain, Argentina.**

Resumen

Cornops aquaticum BRUNER es una tucura nativa de Latinoamérica que vive frecuentemente asociada a *Eichhornia* spp., una macrófita característica de las lagunas de Argentina y sur de Brasil. El objetivo de este trabajo fue determinar la estructura de edades de la población de *C. aquaticum* en una laguna permanente de Corrientes (Argentina), que presenta a *E. azurea* como planta hospedera. Los muestreos fueron realizados mensualmente entre febrero de 2004 y abril de 2006, con una red de 70 cm de diámetro. Se separaron adultos, ninfas menores (estadio I y II) y ninfas mayores (III al VI) y se registró además el estado de maduración de los ovarios. Los adultos fueron encontrados en todos los meses del año, mientras que las ninfas menores estuvieron ausentes en los meses más fríos. Estos resultados sugieren que *C.*

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aquaticum podría presentar diferentes periodos de reproducción en la laguna estudiada.

Introduccíon

Cornops aquaticum BRUNER es una especie que habita desde el sudeste de México hasta el centro de Argentina y Uruguay (ROBERTS & CARBONELL 1979). Este acridio vive asociado a algunas especies de la Familia Pontederiaceae, entre las que se incluye *Eichhornia azurea* (SW.) KUNTH, una macrófita característica de las lagunas de la provincia de Corrientes. Numerosos estudios han demostrado la estrecha asociación de *C. aquaticum* con *E. azurea* y *E. crassipes* (MART.) SOLMS para la alimentación y para la reproducción (ADIS & JUNK 2003; FERREIRA & VASCONCELLOS-NETO 2001; SILVEIRA-GUIDO & PERKINS 1975; ZOLESSI 1956).

En el marco de un estudio biológico y ecológico que se viene llevando a cabo en Sudamérica y África (ADIS et al. 2004, 2006; BREDE & BEEBEE 2005; FERREIRA & VASCONCELLOS-NETO 2001; FRANCESCHINI et al. 2005a, b; LHANO et al. 2005; MEDEIROS 1984; OBERHOLZER & HILL 2001; VIEIRA & SANTOS 2003), este trabajo tiene como objetivo estudiar la estructura de edades de la población de *C. aquaticum* en una laguna sin conexión fluvial y con dominancia de *E. azurea.*

Material y métodos

Los muestreos se realizaron en la Laguna Pampín (27°30'S, 58°45'W), localizada en las proximidades de la ciudad de Corrientes, la qual pertenece a la cuenca del Riachuelo, un afluente del Río Paraná (Figura 1). Sin embargo, esta laguna no se encuentra conectada al río, por lo cual el nivel del agua depende básicamente de las lluvias. *E. azurea* (Pontederiaceae), llamada camalote, es la planta huésped de *C. aquaticum* presente en la laguna, y junto con *Oxycaryum cubense* (POEPP. & KUNTH) LYE var. *paraguayense* (MAURY) PEDERSEN (Cyperaceae) constituyen las macrófitas más abundantes de la zona litoral, con una cobertura cercana al 40 %.

El clima de Corrientes fue clasificado como subtropical, con temperaturas mayores a 16,5 °C en verano y 7,25 °C al final del otoño; los veranos son cálidos y prolongados y los inviernos cortos y benignos, con presencia de muy pocos días con heladas (BRUNIARD 1981, 1996). Las precipitaciones superan los 1100 mm anuales, con siete meses del año que son perhúmedos (febrero-abril y septiembre-diciembre), dos meses húmedos (enero y agosto) y tres meses subáridos (mayo-julio); las lluvias ocurren principalmente en los meses de primavera (septiembre-noviembre), verano (diciembre-febrero) y otoño (marzo-mayo), disminuyendo notablemente en el invierno (junio-agosto), que es predominante subárido (ESKUCHE 1982).

Se realizaron muestreos mensuales entre febrero de 2004 y abril de 2006. Los ejemplares de *C. aquaticum* fueron capturados desde una embarcación agitando varias veces sobre la vegetación una red entomológica de 70 cm de diámetro, con un tejido de 1 m de profundidad hasta capturar 50 individuos; cuando el número de individuos no llegaba a 50 (febrero, abril a septiembre de 2004, marzo y abril de 2006) se consideró el número de individuos capturados en 30 minutos. Se determinó el número de individuos y el peso fresco de machos y hembras (adultos), ninfas menores (estadio I al II) y ninfas mayores (estadio III al VI). Se comparó la relación entre machos y hembras en adultos y en ninfas mayores con un test de X^2 de heterogeneidad (ZAR 1996), considerando que la proporción teórica de sexos en esta especie es 1:1, de acuerdo a lo obtenido por MEDEIROS (1984) en crías de laboratorio.

Se realizaron disecciones en las hembras para determinar el estado de maduración de los ovarios (I: inmaduros; II: en maduración; y III: completamente maduros). También se registró el estado de las valvas del ovipositor: abiertas y cerradas (Figura 2).

Los distintos tipos de ovarios y valvas del ovipositor fueron observados y fotografiados con microscopía electrónica de barrido utilizando un equipo Jeol 5800LV, secando previamente el material a punto crítico y metalizando con oro paladio.

Los datos de temperatura fueron registrados con una estación micrometeorológica de registro continuo LiCor (LI- 1200S) y los de insolación fueron obtenidos del Boletín Agrometeorológico del Instituto Nacional de Tecnología Agropecuario de Colonia Benitez (Chaco).

Resultados

La temperatura media mensual más alta se registró en el verano (enero y febrero), con valores de 25,20 °C a 27,74 °C; en el invierno (junio-agosto) los valores fluctuaron entre 14,97 °C y 18,66 °C. Las temperaturas más bajas se registraron durante el año 2004, con el mínimo valor promedio en el mes de mayo (8,62 °C). El otoño y el invierno del año 2005 fueron más benignos, registrándose la temperatura mínima más baja en julio (8,97 °C). La temperatura máxima promedio más alta llegó a 36,30 °C, si bien se registraron valores absolutos de hasta 43,42 °C. Los valores de insolación fluctuaron entre 304,4 horas de sol por mes en diciembre de 2004 y 118,2 horas de sol por mes en junio de 2005 (Figura 3).

Los adultos fueron encontrados durante todo el periodo de muestreo excepto en junio-julio de 2004. La proporción de adultos con respecto a ninfas fue mayor durante mayo, agosto y septiembre de 2004, desde abril a septiembre de 2005, y desde febrero a abril de 2006 (Figura 4). La proporción de ninfas menores fue mayor en marzo y octubre de 2004 y desde octubre a noviembre de 2005.

Se constató la presencia de adultos de *C. aquaticum* en el embalsado de *O. cubense* durante los meses más fríos de ambos ciclos anuales.

En el verano de 2006 la tendencia observada en las proporciones de cada categoría se modificó en la población, con un incremento notable de los adultos con respecto a las ninfas.

El peso fresco de la población tuvo valores altos desde diciembre de 2004 a septiembre de 2005, período en el cual hubo mayor proporción de adultos (Figura 5).

No se obtuvieron diferencias significativas al comparar el número de hembras con respecto al de machos en adultos ($X^2_{\text{Hetero}} = 34{,}87$; $p < 0{,}05$; g = 24) y ninfas mayores ($X^2_{\text{Hetero}} = 17{,}50$; $p < 0{,}05$; gl = 19) mes a mes y durante todo el período de muestreo.

Las hembras con ovarios maduros fueron dominantes en la población hacia fines de invierno y principio de primavera (Figura 6). Se encontraron hembras con valvas del ovipositor abiertas la mayor parte del periodo de muestreo, con mayor proporción que las hembras con valvas cerradas desde septiembre a noviembre de 2004 y desde junio a diciembre de 2005 (Figura 7).

Discusión

En las lagunas de la planicie del Paraná, las poblaciones de *C. aquaticum* están siempre asociadas a las épocas de aguas bajas o sequía (POI DE NEIFF & BRUQUETAS 1983; POI DE NEIFF & CASCO 2003). La población de *C. aquaticum* en la Laguna Pampín (Corrientes), presentó adultos durante todo el año, con ninfas menores que estuvieron ausentes sólo en los meses más fríos, lo que estaría indicando la ocurrencia de diferentes períodos de reproducción. Esta misma tendencia en la estructura poblacional se observó en una población de *C. aquaticum* en una laguna del Chaco, que a diferencia de la Laguna Pampín, está conectada al río Paraná y presenta a *E. crassipes* como planta hospedera (FRANCESCHINI et al. 2005b).

El análisis del período en el cual se colectaron 50 individuos (octubre 2004 - febrero 2006), indica que las variaciones en el peso fresco estuvieron influenciadas por la clase de edades de los individuos colectados, obteniéndose los valores más altos cuando la población estuvo dominada por adultos.

La presencia de adultos de *C. aquaticum* en el embalsado de *O. cubense* durante los meses más fríos indicaría que esta planta es utilizada como refugio; la arquitectura tridimensional relativamente cerrada de esta macrófita y la alta densidad de hojas por metro cuadrado determinaría que la población encuentre un refugio con un microclima más adecuado comparado con el camalotal bidimensional y relativamente abierto de *E. azurea*. Esta elección no respondería a necesidades alimentarias ya que en la laguna estudiada no se registraron signos de ataque de las tucuras en las plantas de *O. cubense*, a pesar de los altos valores de aceptación a esta macrófita que se obtuvieron en condiciones de laboratorio (FRANCESCHINI et al., no publicado).

A principios del 2006, hubo una disminución marcada de las lluvias y del nivel del agua de la laguna, lo que provocó una disminución drástica en la cobertura del camalotal de *E. azurea*. Esta reducción en la cobertura pudo haber incidido en la estructura poblacional de *C. aquaticum*, ya que esta especie depende de *E. azurea* para la oviposición (ZOLESSI 1956).

El número de machos fue igual al número de hembras tanto en adultos como en ninfas mayores, coincidiendo esto con lo mencionado por SILVEIRA-GUIDO & PERKINS (1975) para poblaciones naturales de *C. aquaticum* de Argentina y Uruguay.

En la primavera de los dos ciclos anuales, la mayor proporción de ninfas menores coincidió con la mayor proporción de hembras con ovarios de tipo III y valvas abiertas del ovipositor. El estado de las valvas ha sido descripto en detalle para algunos Acrididae sólo para el momento cuando está ocurriendo la oviposición; sin embargo estas descripciones están referidas a las especies que oviponen en el suelo, que representan un 85 %, en comparación con las de oviposición endófita que alcanzan sólo el 5 % (STAUFFER & WHITMAN 1997).

MEDEIROS (1984) encontró un mayor número de plantas de *E. crassipes* con posturas y un mayor número de huevos por postura en primavera y verano en poblaciones de *C. aquaticum* asociadas a la planicie de los ríos Guaraguaçu y Pery, en Brasil. Las oviposiciones endofíticas primaverales-estivales y los adultos invernales fueron encontrados también en la especie *Cornops paraguayense* (BR.), la cual tiene como especie hospedera a plantas del género *Typha* sp. (TURK & AQUINO 1996).

Agradecimientos

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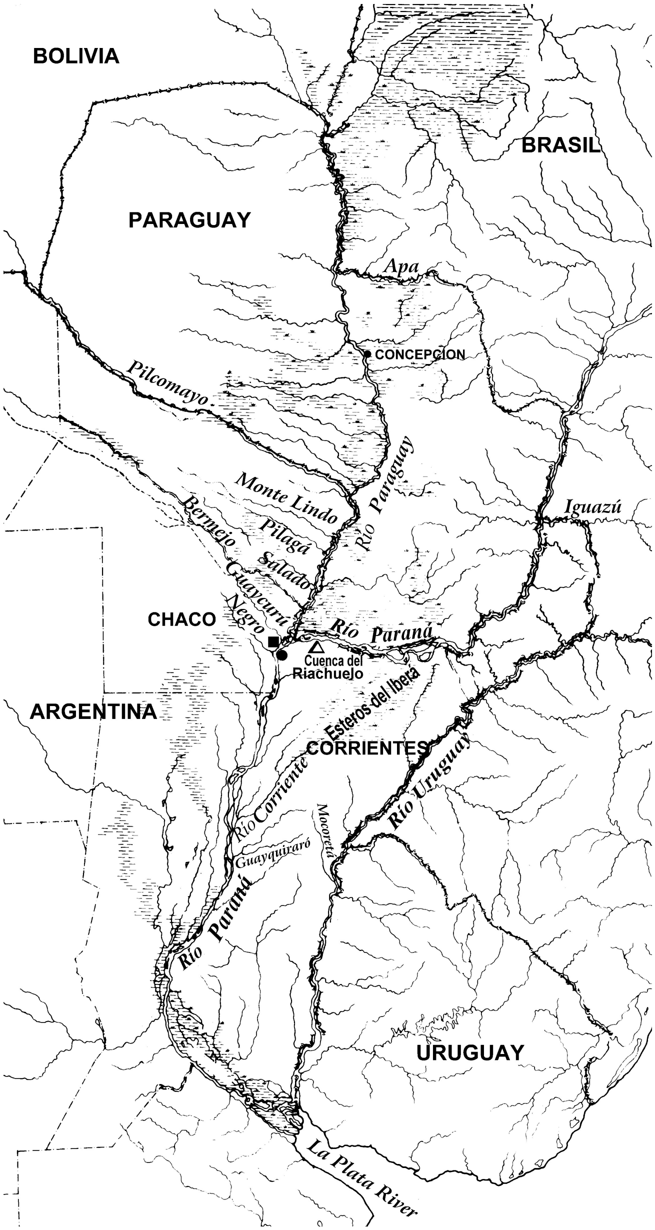

Fig. 1:
Area de estudio; la localización de la Laguna Pampín está indicada con un triángulo (△).

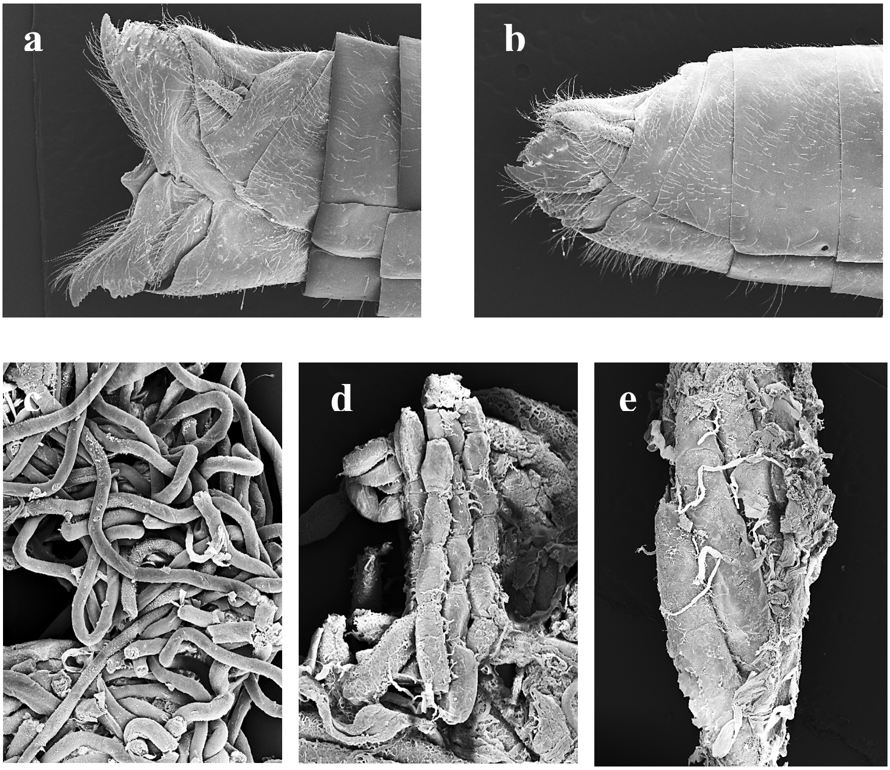

Fig. 2:
Valvas del ovipositor y ovarios en hembras adultas de *Cornops aquaticum*. **a**: Ovipositor con valvas abiertas; **b**: Ovipositor con valvas cerradas; **c**: Ovario de tipo I (inmaduro; x 140); **d**: Ovario de tipo II (en maduración; x 100); **e**: Ovario de tipo III (maduro; x 23).

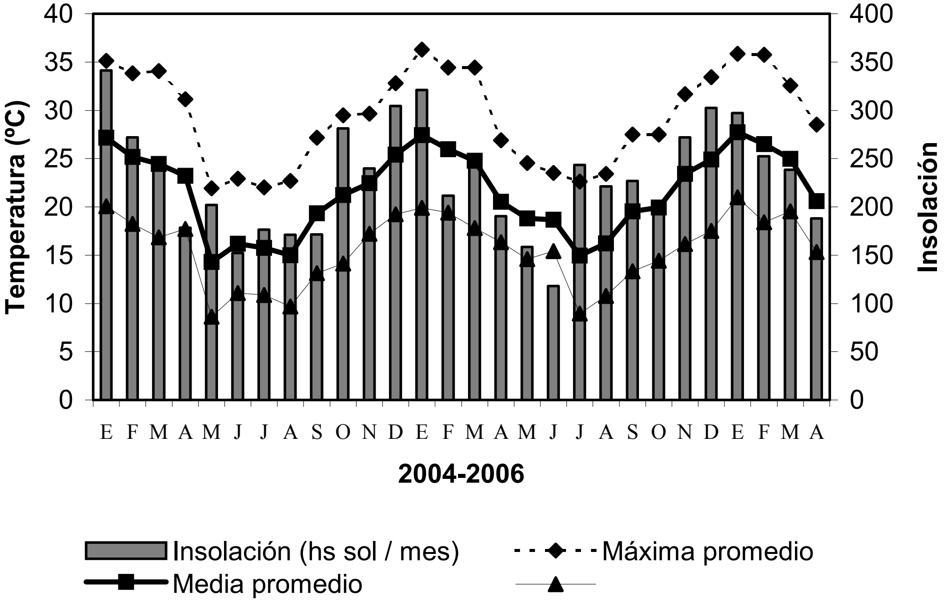

Fig. 3:
Temperatura media mensual, mínima promedio, máxima promedio e insolación en Corrientes.

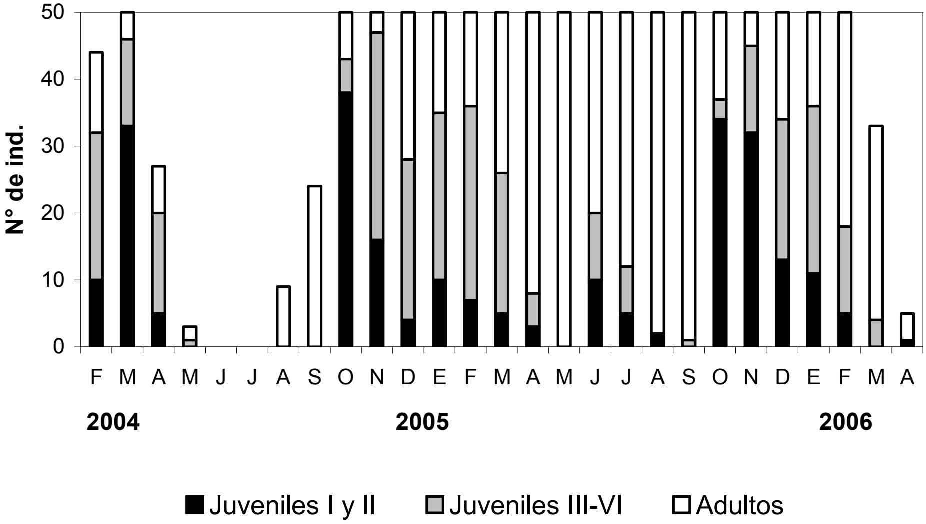

Fig. 4:
Estructura de edades de la población de *Cornops aquaticum* en la Laguna Pampín, expresado en número de individuos por categoría sobre un total de 50 (excepto en febrero, abril a septiembre de 2004, marzo a abril de 2006).

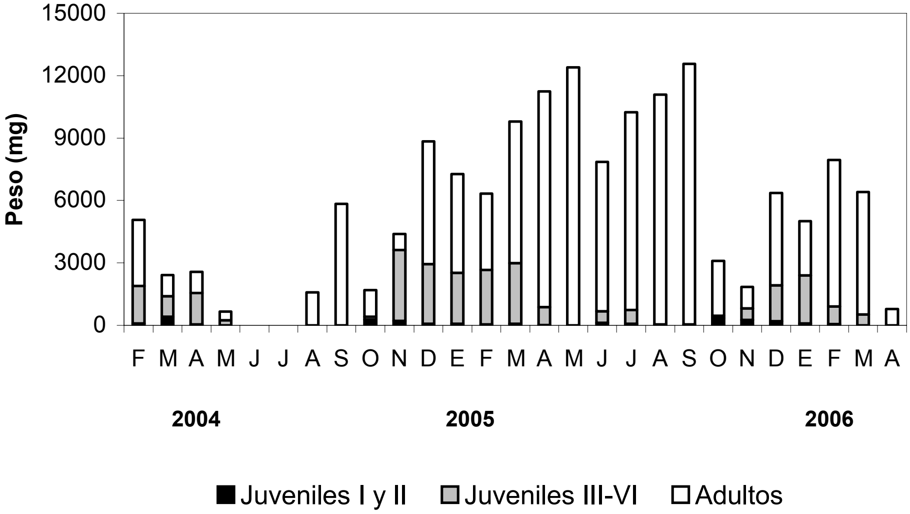

Fig. 5:
Peso fresco de cada categoría de individuos de *Cornops aquaticum* en la Laguna Pampín.

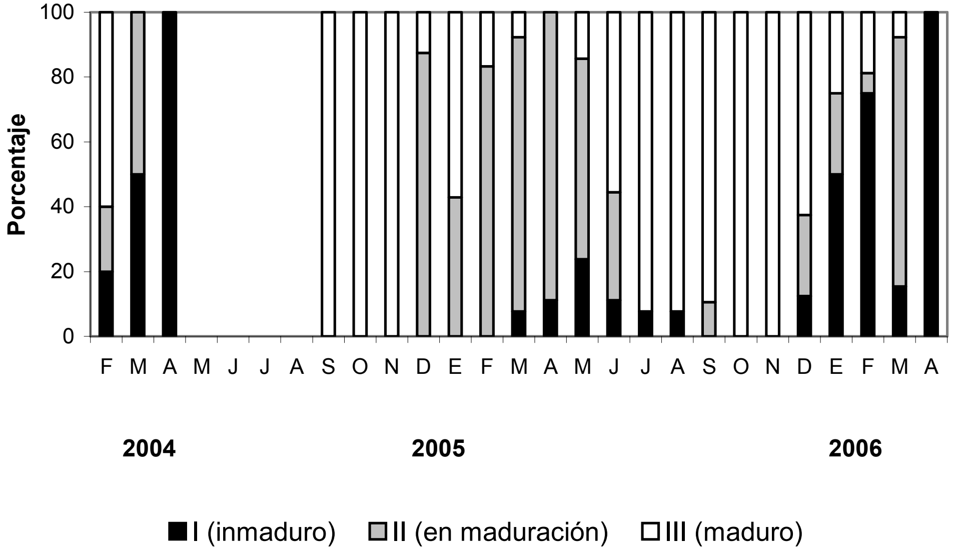

Fig. 6:
Tipos de ovarios de hembras adultas de *Cornops aquaticum* en la Laguna Pampín.

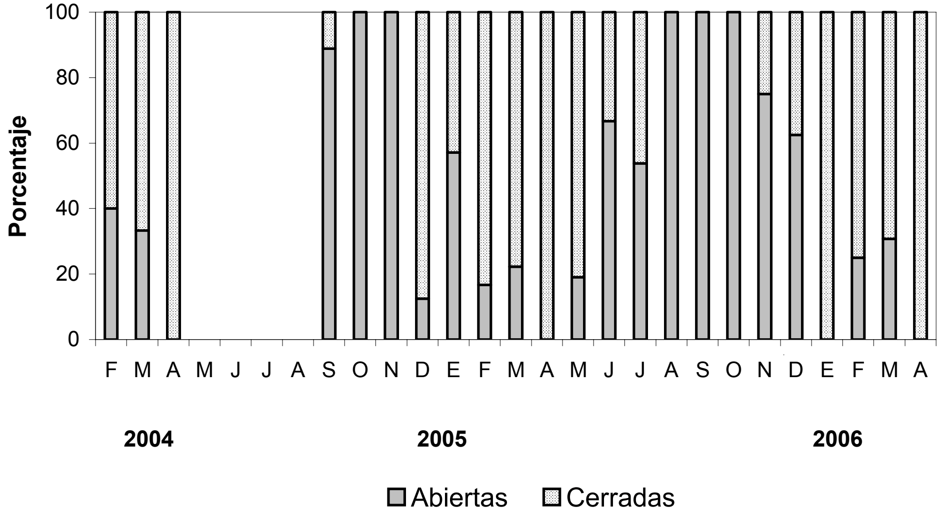

Fig. 7:
Tipos de valvas del ovipositor de las hembras adultas de *Cornops aquaticum* en la Laguna Pampín.

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Woody vegetation in the Pantanal of Mato Grosso, Brazil: a preliminary typology

by

C. Nunes da Cunha, W.J. Junk & H.F. Leitão-Filho

Prof. Dr. Catia Nunes da Cunha, Dept. of Botany and Ecology, NEPA, IB/UFMT, Av. Fernando Correia s/n, Coxipó, 78060-900 Cuiabá/MT, Brazil; e-mail: catianc@ufmt.br
Prof. Dr. Wolfgang J. Junk, Max-Planck-Institute for Limnology, Tropical Ecology Working Group, August-Thienemann Strasse 2, 24306 Ploen, Germany; e-mail: wjj@mpil-ploen.mpg.de
Prof. Hermógenes Freitas Leitão-Filho, Dept of Botany, IB-Unicamp, Campinas-SP, Brazil. In memoriam.

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Abstract

The ecological conditions of the Pantanal of Mato Grosso change during yearly and multi-years cycles because of pronounced water-level fluctuations. Differences in topography and related hydrological conditions allow the coexistence of specific vegetation units. This paper presents an analysis of the flora and vegetation types described in the scientific literature and based on our own observations in the Pantanal. It offers a unifying characterization of the vegetation of the Pantanal of Mato Grosso with respect to the characteristics of woody plants of the region. Grasslands and aquatic communities were not considered. Three floristic types with 19 units were distinguished: savannas (5 units), forests (2 sub-types and 10 units), and scrublands (4 units). The environmental parameters used to define these types, sub-types, and units are described, and information on species composition is given.

Keywords: **Pantanal, semi-deciduous and dry forest, savanna and *cerrado* vegetation, periodically flooded forests, typology.**

Resumo

As condições ecológicas do Pantanal de Mato Grosso mudam anualmente e em ciclos pluri-anuais devido às pronunciadas flutuações do nível das águas. Diferenças na topografia e nas condições hidrológicas relacionadas permitem a coexistência de unidades específicas de vegetação. Este artigo apresenta uma análise da flora e tipos de vegetação apresentada na literatura científica e em nossa experiência e oferece uma caracterização unificada da vegetação lenhosa do Pantanal de Mato Grosso. Campos e comunidades de plantas aquáticas não foram consideradas. Diferenciamos 3 tipos florísticos com 19 unidades: savanas (5 unidades), florestas (2 sub-tipos e 10 unidades) e *arbustal* (4 unidades). Os parâmetros ambientais que levam à formação dos tipos, dos sub-tipos e das unidades são descritos e a composição das espécies é apresentada.

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Introduction

The Pantanal is situated in a depression of the upper Paraguay River catchment area that developed as a consequence of the formation of the Andes. During the Pleistocene, at least four climate changes alternating between arid and semi-humid occurred. Torrential rains transported large amounts of sediments into the depression and formed a sediment layer called the Pantanal Formation (DEL'ARCO et al. 1982). Based on the region's evolution, the Pantanal Formation can be subdivided into three sub-units, representing the Pleistocene alluvial plain, sub-recent sediments, and recent sediments. During the Holocene, the Pantanal passed through different climatic episodes that are not yet fully understood (ASSINE & SOARES 2004). Nonetheless, the following climatic episodes have been distinguished: 40,000-8,000 BP, cool and dry; 8,000-3,500 BP, warm and wet; 3,500-1,500 BP, warm and dry; and 1,500-Present, warm and wet (IRIONDO & GARCIA 1993; STEVAUX 2000).

In the first article of the Ramsar Convention, wetlands are defined as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water the depth of which at low tide does not exceed six meters" (NAVID 2002). According to this definition, the Pantanal is a wetland, but the term "Pantanal" suggests an area of swamps. In fact, the Pantanal is a large floodplain that is periodically inundated during the rainy season by rainwater and transbording rivers but which is dry during the dry season (JUNK et al. 1989). Permanent lakes and swamps represent permanent aquatic or moist habitats inside the vast floodplain, which covers an area of 160,000 km^2. Elevated paleo-levees of former rivers serve as permanent terrestrial habitats.

Associated with the numerous types of habitats is a large variety of different vegetation types. These have been given specific local names and they are also used in the scientific literature. However, the local names are often not adequately defined, a fact that leads to confusion in comparative studies.

LUGO (1990) pointed out that inadequate characterization of forested wetlands hinders comparative studies but also the development of sustainable management and protection measures. The present study shows that a major portion of the woody vegetation of the Pantanal of Mato Grosso does not belong to the category of floodplain forests but colonizes small permanent dry areas inside the floodplain. These little or non-flooded forested habitats increase habitat and species diversity and play an important role as periodic refuge for terrestrial animal species during the flood season.

PRANCE (1989) proposed a classification of Amazonian wetland forests and differentiated between three major groups: permanent swamp forest (2 sub-groups), periodically flooded forest (5 sub-groups), and gallery forest. The applicability of this classification to the forested wetlands of the Pantanal remains to be tested. All flooded forests of the Pantanal of Mato Grosso belong to those categories describing seasonally flooded forests with the exception of the swampy woodland savanna, in which *Mauritia flexuosa* is found.

An analysis of 86 tree species that occur along the inundation gradient indicated that 26 species are restricted to terrestrial habitats and only four to habitats that are subject to long-term flooding. The other 56 species show a large ecological amplitude and occur under dry as well as flood conditions. This has been interpreted as an adaptation of the woody plants to the strongly varying hydrological conditions in the Pantanal, which have favored the occurrence of these species under recent climatic conditions (NUNES DA CUNHA & JUNK 1999). A similar overlap of species occurs between deciduous and semi-deciduous forests.

The aim of the present study is the floristic and physiognomic characterization of the principal woody plant communities associated with specific habitats of the Pantanal, based on information in the literature and data from our own studies. While our knowledge of plant communities of the Pantanal is still insufficient to propose a phytosociologically correct classification according to international rules (BARKMAN et al. 1986), preliminary characterizations are urgently required to support sustainable management and ecological research. This article provides the basis for deriving a classification of wetland habitats of the Pantanal.

Study area

ADAMOLI (1982) divided the Pantanal of Mato Grosso into different sub-regions according to their ecological characteristics (Fig. 1). Large areas in the northern part are situated more than 130 m asl and are shallowly flooded. Near the Cuiabá River, flooding is intermediate. To the south, the altitude decreases to 100-110 m asl.), with annual rainfall reaching about 1,300 mm. The southern Pantanal is strongly inundated (HAMILTON et al. 1996). There is a pronounced dry season from June to August (winter), when the monthly rainfall is less than 10 mm, and a rainy season from December to February (summer), when the maximum monthly rainfall is 250-300 mm. The climate is Köppen's "savanna" subtype (AW).

In the northern Pantanal, flooding coincides with the rainy season (Fig. 2). During low-water periods, the Pantanal is dry and many of the floodplain lakes are decoupled from the rivers. Floodwater needs about 3 months to reach the southern end of the Pantanal. In addition to the annual flood cycle, there are multi-year periods of high floods and strong droughts.

The research area of this study was subdivided into the following geomorphologic units: elevations that reach 1-2 m above mean flood level (*murunduns, capões, cordilheiras*, and levees), flat plains periodically flooded to a depth ranging from a few decimeters to up to 3 m (*campos*), shallow natural channels that drain the *campos* but fall dry during low-water periods (*landis, vazantes*), depressions that continue to be swampy even during normal low-water periods, and permanent lakes and river channels. Woody vegetation grows mostly on elevations, in shallowly flooded areas, in the drying drainage channels, and along river and lake shores.

State of the art

Different denominations for the Pantanal vegetation are found in the literature. HOEHNE (1936) differentiated between xerophilous vegetation on dry and calcareous soils and hydrophilous vegetation on periodically flooded non-calcareous soils. The vegetation was described as a mixture of species from the Amazonian rain forest and the xerophilous vegetation (*caatinga*) of Ceará (NE Brazil). "The xerophilous flora is represented by the following species: *Cereus peruvianus, Opuntia stenarthra, Pereskia sacharosa, Cereus bonplandii, Novillea cavendishii, Jatropha urens, Cnidoscolus phyllanthus, Loasa* sp, *Ceiba pentandra, Ceiba pubiflora* and others".

Because of the extension of the climatic region of the boreal Chaco into the southern Pantanal, typical species of the flora of the eastern Chaco occur as far as Corumbá, such as *Chorisia ventricosa, Schinopsis balansae*, and *S. lorentzi, Aspidosperma* sp. (WILHELMY 1958; RIZZINI 1963). Only a few species of the Chaco enter the entire Pantanal, such as *Jacaranda mimosifolia, Tecoma ocracea*, and *Piptadenia macrocarpa*.

AGUIRRE (1945) emphasized the existence of gallery forests along rivers and water bodies. KUHLMAN (1954) complemented this analysis with the observation that along the Paraguay River these formations are irregular and often very narrow. Resident species included "*Inga edulis, Inga nobilis, Tecoma caraiba, Attalea princeps, Triplaris formicosa*, and *Genipa americana*". HOEHNE (1936) referred to this as a hydrophilous formation on non-flooded ground (*terra firme*) when "*Desmoncus, Bactris*, and *Astrocarium*" were present. For WILHELMY (1958), these were not gallery forests, but river bank forests, in the sense of TROLL (1936), that grew on the highest levees.

Humid semi-deciduous forests that were green in summer (wet season) were found, according to WILHELMY (1958), "in every non flooded area in the Pantanal with species that occur in the Chaco: *Tecoma caraiba, Tecoma ipe, Tecoma ochracea, Jacaranda mimosifolia, Caryocar brasiliense, Attalea phalerata, A. princeps, Vochysia tucanorum, Curatella americana, Hancornia speciosa, Piptadenia macrocarpa, Hymenaea stignocarpa*, and *Acrocomia aculeata*".

Flooding savannas were mentioned by PAFFEN (1957). WILHELMY (1958) confirmed the authenticity of the flooding savannas for the Gran Pantanal, commenting that sometimes they were interspersed with islands of humid semi-deciduous forests. He mentioned a special savanna type, the termite savanna, which was first denominated by TROLL (1936) in Africa. Termite savanna is blanketed by small forested islands that cover termite mounds (*murunduns*).

Several authors, among them COLE (1960), KUHLMAN (1953, 1954), and RIZZINI (1979), considered the Pantanal as one vegetational complex because of the environmental variations resulting from alternating dry and flood periods. For COLE (1960), this complex included several not-specified types of savannas and forests. RIZZINI (1979) denominated the mosaic of hydrophilous, mesophilous, and xerophilous communities as the Pantanal Complex, a term that was dismissed by ADAMOLI (1982).

The first vegetation classification was elaborated by LOUREIRO et al. (1982), who defined five phytoecological sub-regions for the Pantanal: (1) savanna (*cerrado*), (2) savanna steppe (*chaquenha*), (3) semi-deciduous seasonal forest, (4) deciduous seasonal forest, and (5) areas of ecological tension, i.e., subject to anthropogenic modification.

PRANCE & SCHALLER (1982) described different floristic types in the Fazenda Acurizal, which covers an area at the border of the Pantanal. The authors characterized *cerrado*, semi-deciduous forest, swamp vegetation types, and xeric vegetation types. RATTER et al. (1988) carried out a phytosociological study of the *cerrado* and semi-deciduous forests of the region. An area near Poconé was found to contain many of the indicator species of the mesotrophic facies *cerradão*. The phytosociological studies of NASCIMENTO & NUNES DA CUNHA (1989) included stands of *Vochysia divergens* POHL in the Pantanal of Mato Grosso. In 1999, NUNES DA CUNHA & JUNK quantified the floristic composition of forests on termite mounds (*murunduns*) and paleo-levees (*capões* and *cordilheiras*); these authors related tree distribution to flooding patterns.

Further information on the vegetation of the Pantanal is found in POTT & POTT (1994), PRADO et al. (1994), DUBS (1994), NUNES DA CUNHA (1990, 1998), GUARIM-NETO et al. (1996), SCHESSL (1999), ZEILHOFER & SCHESSL (1999),

NUNES DA CUNHA. & JUNK (1999), POTT & POTT (2000), SALIS (2000), SILVA et al. (2000), NUNES DA CUNHA & JUNK (2001), NUNES DA CUNHA & JUNK (2004), DAMASCENO-JUNIOR et al. (2004), and DAMASCENO-JUNIOR et al. (2005).

NUNES DA CUNHA et al. (1996) elaborated a physiognomic vegetation map at a scale of 1:100,000 for the area north of Poconé, based on a modified classification of the results of VELOSO et al. (1991). Using satellite images, they delineated for the Pantanal: (1) one type of seasonal semi-deciduous forest; (2) four types of savanna (*cerrado*): (a) forested savanna (*cerradão*), (b) seasonally flooded low-tree and scrub woodland (*cerrado aberto*), (c) seasonally flooded savanna parkland, including *campos de murunduns, paratudal, piuval,* and *campos* with *capões*, and (d) seasonally flooded grass-wood savannas, including fields of *Thalia geniculata, Ipomoea carnea, Combretum lanceolatum*; (3) transition systems or ecological tension areas of two types: seasonally flooded evergreen forests, including *cambarazais* and floating aquatic vegetation (*batumes*); (4) secondary systems including deforested areas and bare soil.

SILVA et al. (2000) constructed maps of the vegetation of the Pantanal following an aerial survey. They used the management and protection of large animals, such as caimans, capybaras, jaguars, and swamp deer, as the basis for separating 16 vegetation classes and one class with miscellaneous structures.

Methodology

We characterized the woody vegetation in terms of three types: savanna, forests, and scrublands. These were further classified in different sub-types and units according to flooding regime, physiognomic aspects (e.g., degree of deciduousness), and the dominant species found in each one. The units were communities or groups of communities with similar characteristics.

There are several unresolved questions with respect to the definition of deciduous, semi-deciduous, and evergreen forests. In many species, leaf change is subject to a certain seasonality that may be intensified or weakened during very dry or wet years, respectively. Many species of the flooded forest are considered evergreen, for instance, *Calophyllum brasiliense* CAMBESS., and *Vochysia divergens* POHL., but may lose most of their leaves during very dry years (facultative deciduous). This behavior has also been described for trees of semi-evergreen lowland rain forests (RICHARDS 1996). Some flooded forest species are also deciduous, such as *Vitex cymosa* and *Cassia grandis*. While *Callistene fasciculata* and *Astronium fraxinifolium* of the semi-deciduous forest type are deciduous, they may retain some of their leaves in wet years. Due to the large multi-year variation in rainfall in the Pantanal, the behavior of the different forest types with respect to leaf fall and flush can also vary considerably.

The term semi-evergreen was defined by WALTER (1971) and was used to refer to those species in which the "upper tree layer is defoliated for some of the year (during drought), while the lower tree layer retains its foliage". Semi-evergreen forests have been described in non-flooded areas of Trinidad (RICHARDS 1996) and Sri Lanka (DITTUS 1977). In the Pantanal, semi-evergreen forests occur in areas that become inundated during the high-water period from December to April and are dry during the period of low water from June to November. The soil is in part denuded or covered by a dense litter layer, with few tree seedlings and very few herbaceous plants and shrubs. The upper story consists of both facultative deciduous and deciduous species. In wet years, most of the trees lose few leaves, while in very dry years the entire canopy may appear leafless.

Here, regional terms for habitats and vegetation have been used for the characterization of vegetation units. Botanical collections were carried out for the purpose of taxonomic characterization, and quantitative analyses were performed to describe community structure, as published in NUNES DA CUNHA & JUNK (1999) and NUNES DA CUNHA (1990). The data of BRAZIL MINTER (1979) and RADAMBRASIL (1982) were also included in this analysis. However, the scale and vegetation units used in the maps of those authors were too small to be useful in the present context. In this study, we have used the term "savanna" according to the definition of the IBGE (1992), which positions the Brazilian *cerrado* in an international context.

Botanical names correspond to those listed at http://mobot.org/W3T/Search/vast.html and in POTT & POTT (1994, 1996).

Results

The Pantanal of Mato Grosso presents, in terms of its woody plants, three basic types of vegetation: savanna, forest, and scrubland. This vegetation grows on characteristic landscape units, some of which have local names. These are defined as follows:

Cordilheiras are sinuous remains of paleo-levees several kilometers in length and about 100 m wide, reaching 1-2 m above the surrounding seasonally inundated plains. These elevations are not subject to inundation (Fig. 3).

Capões are elevated remnants of eroded paleo-levees. They are elongated or round in shape and occur in seasonally flooded plains (the term *capão* comes from the aborigine Tupi word Káa pu'ã, round woods).

Murunduns are earth mounds up to 1.20 m high that reach above the mean high-water level and cover an area between 1 and 15 m^2. The mounds are built by termites to escape flooding during periods of high water (Fig. 3).

Levees are the highest recent sediment depositions along river channels. They become flooded only in years of exceptionally high water. Lower river terraces and low-lying areas opposite the levees are periodically flooded to varying extents, depending on their elevations (Fig. 4).

Morrarias are groups of hills a few hundred meters high that are located at the border or isolated inside the Pantanal. They are not discussed here further.

Aterros de bugre are artificial earth mounds of anthropogenic, often of pre-Columbian origin. They were constructed by the indigenous population for flood protection.

Inundated plains are defined as the flat areas between elevations and depressions in the floodplain that become periodically flooded by rain water or transbording rivers. The depth of inundation varies from a few decimeters to several meters, depending on the elevation of the plain.

Landis are continuous and sinuous depressions covered by trees in high-lying parts of the Pantanal. They provide drainage during the flood period but fall dry during low-water periods, while maintaining a rather high groundwater level (Fig. 3). When they are covered with grasses and herbaceous vegetation, they are called *vazantes*.

1. Type: Treeless vegetation (not characterized in this article)

(a) Treeless, periodically flooded savanna and grassland (*campo limpo*)
(b) Treeless vegetation on low-lying levees and river terraces
(c) Depressions with waterlogged soils that are covered with perennial herbaceous palustric vegetation even during dry periods (swamps)
(d) Extended belts of floating and submersed aquatic macrophytes along river and lake shores
(e) Dense floating islands (*batumes*) that drift on the lakes

2. Type: Savannas (*cerrado, chaco*)

"*Cerrado*" is the Brazilian term given to the xeromorphic woodland scrub savanna and grass-field vegetation of central Brazil (EITEN 1978). According to COUTINHO (1982), "*cerrado* sensu lato" is formed by *campo limpo* (a grassland formation), *campo sujo, campo cerrado, cerrado* "sensu stricto" (intermediate savanna formations), and *cerradão* (a scleromorphic forest formation). The savanna formations may be considered ecotones between *campo limpo* and *cerradão*. The different phytophysiognomies and the floristic heterogeneity are determined by the mosaic pattern of fire action and hydrologic and edaphic factors (EITEN 1972; GOODLAND & POLLARD 1973; COUTINHO 1982; OLIVEIRA-FILHO et al. 1989; RATTER et al. 1997). The Pantanal, together with Mato Grosso, Goias, and Mato Grosso do Sul, is included in the central-western geographic region of the *cerrado* vegetation (RATTER & DARGIE 1992; CASTRO 1994; RATTER et al. 1996; RATTER et al. 1997).

According to EITEN (1990), the flat periodically inundated plains of the Pantanal are "hyper-seasonal savannas", the *cerrado*-covered non-inundated elevations are "seasonal savannas". Hyper-seasonal savannas occur on heavy, ill-drained soils and are characterized by alternating dry and very wet conditions. In the dry season, the vegetation dries out and is often burnt but in the wet season the ground becomes waterlogged or flooded (RICHARDS 1996). We include in this vegetation type a sub-type that, based on its floristic composition, belongs to the chaco (*carandazal*).

The savannas of the Pantanal of Mato Grosso include the vegetation that occurs mainly in the peripheral areas of the northern part, with the Pinxaim River as the southern border. Savanna vegetation in the southern end of the Pinxaim River occurs sporadically and the floristic richness of arboreal species is less. Some *cerrado* species form dense, almost homogeneous stands, which determine the physiognomies of the vegetation of some localities, for instance, *Curatella americana* L., *Callisthene fasciculata* MART., and *Tabebuia aurea* (MANSO) B. & H. ex S. MOORE, locally called *lixeiro*, *carvoal*, and *paratudal*, respectively. The great majority of the registered species has a wide geographic distribution.

2.1 Seasonally flooded termite savanna with *Curatella americana* (*campo de murunduns, lixeiral*)

The termite savanna, regionally known as *lixeiro or campo de murunduns*, is a seasonally inundated savanna covered by termite mounds (micromounds according to PONCE & NUNES DA CUNHA 1993). The density of the mounds may be more than 100 ha^{-1} (CASTRO 1999). They are covered with trees and their floristic composition is closely related to that of the *cerrado* flora. The characteristic tree species are *Curatella americana* L., *Andira cuyabensis* BENTH., *Simarouba versicolor* ST. HIL., *Vatairea macrocarpa* (BENTH.) DUCKE, *Tabebuia aurea* (MANSO) B. & H. ex S. MOORE, and *Sclerolobium aureum* (TUL.) BENTH, among others (NUNES DA CUNHA 1990). The plain between the termite mounds is covered by grasses and herbaceous plants.

2.2 Seasonally flooded woodland savanna with *Tabebuia aurea* (*paratudal*)

The *paratudal* designates a woodland savanna covered mainly with single trees of *Tabebuia aurea* (MANSO) B. & H. ex S. MOORE (Fig. 3). It occurs mainly on flat land that is shallowly flooded during the rainy season, mostly in the region of the Cassanges River, and in large extensions in the region of the Paraguaizinho River (NUNES DA CUNHA et al. 2006). Abundant herbaceous vegetation and grasses grow between the trees. Large areas of *paratudal* have also been described for the southern

Pantanal (OLIVEIRA 1993).

2.3 Seasonally flooded woodland savanna with *Copernicia alba* (*carandazal*)

The *carandazal* is a monodominant community of the palm tree *Copernicia alba* MORONG ex MORONG & BRITTON, which is present at varying densities. The palm reaches a height of about 10 m. The understory consists of a dense scrub layer, including *Celtis spinosa* SPRENG., *Mimosa hexandra* MICHELI, *Croton urucurana* BAILL., *Manihot carthaginensis*, (JACQ.) MÜLL. ARG., *Thevetia amazonica* DUCKE, and the grass *Panicum laxum* SWARTZ. (ALLEM & VALLS 1987). PRADO (1993) considered this community to be edaphic. *Carandazal* occurs in the humid Chaco (HUECK 1972; LEWIS 1991; PRADO 1993) and extends into the Pantanal on periodically flooded habitats of high salinity.

2.4 Open low-tree savanna with *Curatella americana* and *Tabebuia aurea* (*cerrado ss*)

SILVA et al. (1998) described this unit as comprising little-inundated plains in the region of the Miranda River. The vegetation of open, low-tree savanna is less dense than that of the *cerradão* (see Sect. 3.1.1) and consists of a continuous grass stratum that is frequently affected by fire. The trees are small, with thin and tortuous stems, and mixed with shrubs. In the area of Nhecolândia, ABDON et al. (1998) described this unit as *cerrado denso* or *savanna arborizada* (woody savanna), with a tree coverage of <70 %, a tree height of up to 12 m, and a herbaceous stratum. Frequent tree species are *Curatella americana* L., *Tabebuia aurea* (MANSO) B. & H., *Alibertia sessilis* (VELL.) SCHUM., *Andira cuyabensis* BENTH., *Byrsonima orbignyana* A. JUSS., *Casearia sylvestris* SW., *Hymenaea stigonocarpa* (MART.) HAYNE, *Caryocar brasiliense* CAMB., and *Tocoyena formosa* (CHAM. & SCHL.) SCHUM. In the Pantanal of Poconé, this vegetation is considered to be the result of *cerradificação* (savannization), which is the invasion of savanna tree species in the floodplain because of man-made or naturally reduced flooding.

2.5 Swampy woodland savanna with *Mauritia flexuosa*

In depressions at the edge of the Pantanal there are wetlands covered by grasses, sedges, and herbaceous plants (Poaceae, Cyperaceae, Xyridaceae, Eriocaulaceae). In higher-lying areas, a few shrub and tree species dominated by the palm *Mauritia flexuosa* L.F. are found. Soils are waterlogged or flooded over long periods and may contain high amounts of organic material. Similar formations occur in depressions in the *cerrado* of central Brazil, where they are called *veredas*. Frequently, streams rise from theses depressions (EITEN 1983, 1994).

3. Type: Seasonal forests

Seasonal forests can be divided into semi-deciduous and deciduous forests (PRADO 2000). They are related to climatic seasonality and undergo a well-defined dry season of variable length. Many species of deciduous forests also occur in semi-deciduous forests and vice versa. Here, seasonal forests also include seasonally flooded forests. Seasonality is induced by inundation with rain/river water and can coincide with the rainy season, for instance in the northern Pantanal. It may also be delayed, as in the southern Pantanal, where the flood curve follows the precipitation curve with a time difference of about 3 months (hydrologically induced seasonality). While many species of this forest type are facultative evergreen, they lose most of their leaves during extremely dry periods. Some species are deciduous.

3.1 Sub-type: Seasonal semi-deciduous forests on dry ground

3.1.1 Semi-deciduous forest with *Curatella americana* and *Magonia pubescens*

This unit is the forested form of the *cerrado*, called *cerradão*, which is defined as a scleromorphic forest formation. Many authors consider it as a transition between savanna and forest. We have included it as a forest type, as did COUTINHO (1982). The floristic composition is influenced by different factors, such as surface area, topography, soil conditions, and grazing and trampling by cattle. This leads to a large heterogeneity between *cerradões* of the Pantanal with respect to floristic composition and vegetation structure. For the Pantanal of Poconé, COSTA (2002) described *Curatella americana* L. and *Magonia pubescens* A. ST.-HIL. as the characteristic species; in Nhecolândia, SALIS (2004) reported *Protium heptaphyllum* (AUBL.) MARCHAND and *Diptychandra aurantiaca* TUL. The *cerradão* normally shows two distinct tree strata. The upper stratum reaches a maximum height of 18 m, sometimes with emergent trees of 20 m. The lower stratum has a height of up to 7 m. The occurrence of *Bromelia balansae* MEZ, locally called *gravatá*, in the herbaceous stratum characterizes the beginning of the non-flooded area. Other common tree species in the Poconé region are *Qualea parviflora* MART., *Qualea grandiflora* MART., *Apidosperma macrocarpa* MART., *Tabebuia aurea* (MANSO) B. & H. ex S. MOORE, *Connarus suberosus* PLANCH., and *Kielmeyera coriacea* MART. In the Pantanal, the *cerradão* represents about 22 % of the vegetation cover (SILVA 2000). It is frequent on sandy soils in the sub-regions of Cáceres, Barão de Melgaço, Nhecolândia, Aquidauana, and Miranda.

3.1.2 Semi-deciduous forest with *Tabebuia* spp. and *Scheelea phalerata* (*Cordilheira de mata, capão de mata*)

Semi-deciduous forests occur in the central parts of *capões* and *cordilheiras* and on high levees along the rivers (Fig. 3). These dense forests consist of lianas and are without a layer of grasses, herbaceous plants, and shrubs. The first stratum, between 2 and 8 m, is closed and composed of *Trichilia stellato-tomentosa* KUNTZE, *Combretum leprosum* MART., *Cordia glabrata* (C. MARTIUS) A. DC., *Dilodendron bipinnatum* RADLK., and *Dipteryx alata* VOG. The upper stratum is open and contains specimens with heights up to 25 m. The typical species are *Scheelea phalerata* (MART. ex SPRENGEL) BURRET, *Tabebuia heptaphylla* (VELL.) TOLEDO, *Tabebuia impetiginosa* (MART. ex DC.) STANDL., *Tabebuia roseo-alba* (RIDL.) SANDWITH, *Enterolobium contortisiliquum* (VELL.) MORONG, *Anadenanthera colubrina* var. *cebil* (GRISEB.) REIS., *Anadenanthera falcata* (BENTH.), *Hymenaea courbaril* L., *Sclerolobium aureum* (TUL.) BENTH, *Terminalia argentea* (CAMB.) MART., *Vitex cymosa* BERTERO ex SPRENG., *Aspidosperma cylindrocarpon* MÜLL. ARG., *Casearia sylvestris* SW., *Acacia paniculata* WILLD., and *Inga marginata* WILLD., among others. Individuals of the palm tree *Scheelea phalerata* (MART. ex SPRENGEL) BURRET normally occur in larger numbers at the edges of these forests or in groups or as single specimen in the inner part. An increased density of palms inside the stands points to human impact.

3.1.3 Semi-deciduous forests on *aterros* de indio

Aterros de indio, also called *aterros de bugre* and *capão de aterro*, are artificial earth mounds with sizes up to 1 ha. They were constructed by pre-colonial indigenous settlers to provide protection against flooding. Excavations have revealed fragments of pottery and other archeological remnants, but also large deposits of mollusk shells (PONCE & NUNES DA CUNHA 1993). Soil fertility in the mounds is higher than in the surroundings. Most of the trees are useful for humans, suggesting former plantations of *Acrocomia aculeate* (JACQ.) LODD. ex MART., *Genipa americana* L., *Rheedia brasiliensis* (MART.) PLANCH. & TRIANA, *Sapindus saponaria* L., *Cassia grandis* L., *Unonopsis lindmannii* R.E. FR., and *Ficus* sp.

3.1.4 Deciduous forest with *Callisthene fasciculata* (*carvoal*)

The name *carvoal* refers to deciduous vegetation, with *Callisthene fasciculata* MART., locally called *carvoeiro*, as the dominant or even exclusive tree species. The soil is covered by a sparse vegetation of grasses and herbaceous plants, with dense stands of *Bromelia balansae* MEZ. and *Ananas ananassoides* (BAKER) L.B. SM. Some communities form dense canopies 8-14 m in height, with emerging specimen 15-18 m high. Other communities are lower, with canopies 2-8 m in height and emerging specimen 13-15 m high. RATTER et al. (1973, 1977) denominated this type of vegetation mesotrophic facies *cerradão*. The authors noted several frequent indicator species, such as *Callisthene fasciculata* MART., *Magonia pubescens* A. ST. HIL., *Lafoensia pacari* ST. HILAIRE., *Jacaranda cuspidifolia* MART., *Tabebuia aurea* (MANSO) B. et H. ex S. MOORE, *Terminalia argentea* (CAMB.) MART., *Pseudobombax longiflorum* (MART. et ZUCC.) ROB., *Bowdichia virgilioides* H.B.K., *Luehea paniculata* MART., *Dilodendron bipinnatum* RADLK., *Terminalia argentea* (CAMB.) MART., *Astronium fraxinifolium* SCHOTT. ex SPRENG., *Dipteryx alata* VOG., and *Myracodruon urudeuva* (ENGl.) FR. ALL. The carvoal occurs on *cordilheiras* and levees common in the regions of the Pinxaim, Claro, and Novo Rivers and less frequent in the region of the Cassanges River (NUNES DA CUNHA et al. 2006). Trees are slightly flood-resistant and drought-adapted. This vegetation type features the physiognomy of a forest and the floristic elements of a savanna (*cerrado* domain).

3.1.5 Deciduous forest with *Sebastiana brasiliensis* and *Seguieria paraguayensis* (*Cordilheira de mata, capão de mata*)

On the highest levels of these forests, which are flooded, if at all, only during extreme floods, the floristic composition is made up of deciduous species (Fig. 3). The herbaceous stratum is heterogeneous and shows, between areas of denuded soil, dense stands of *Bromelia balansae* MEZ up to 2 m high, patches of *Petiveria alliacea* L., and sparse shrubs of *Sebastiana brasiliensis* SPRENG. The first canopy stratum, which has a height of 5-6 m, is characterized by *Adelia membranifolia* (MÜLL. ARG.) CHODAT & HASSL. and *Trichilia pallida* SWARTZ. Large trees form the upper canopy, which reaches a height of up to ~30 m. The species found in this stratum are *Swartzia jorori* HARMS, *Sweetia fruticosa* SPRENG., *Pterogyne nitens* TUL., *Seguieria paraguayensis* MORONG, *Sideroxylon obtusifolium* (HUMB. ex ROEM. & SCHULT.) T.D. PENN., *Calycophyllum multiflorum* GRISEB., *Aspidosperma australe* MÜLL. ARG., and *Aspidosperma cuspa* (KUNTH) S.F. BLAKE ex PITTIER.

The deciduous forests of the Pantanal also contain many species found by RATTER et al. (1988) on the hills (*morrarias*) of the Corumbá region, such as *Acacia paniculata* WILLD., *Anadenanthera colubrina* var. *cebil* (GRISEB.) REIS., *Myracodruon urundeuva* (ENGL.) FR. ALL., *Sideroxylon obtusifolium* (HUMB. ex ROEM. & SCHULT.) T.D. PENN., *Calycophyllum multiflorum* GRISEB., *Cereus peruvianus* MILL., *Combretum leprosum* MART., *Cordia glabrata* (MART.) A. DC., *Albizia samam* (JACQ.) F. MUELL., *Sebastiana brasiliensis* SPRENG., *Tabebuia heptaphylla* (VELL) TOLEDO, *Tabebuia aurea* (MANSO) B. & H. ex S. MOORE, and *Vitex cymosa* BERTERO ex SPRENG.

Typical species from forests of the central Brazilian highlands and southeast Brazil also occur in deciduous forest in cordilheiras, capões, and levees, such as *Pterogyne nitens* TUL., *Trichilia catigua* A. JUSS., *Astronium fraxinifolium* SCHOTT. ex SPRENG., *Trichilia pallida* SWARTZ., *Seguieria paraguayensis* MORONG, and *Vitex cymosa* BERTERO ex SPRENG, (HUECK & SEIBERT 1981).

Deciduous and semi-deciduous forests are frequent on soils of intermediate to high fertility and are located in peripheral areas that connect the Cerrado and Caatinga Provinces in the east to the Chaco Province at the western boundaries of the Pantanal (OLIVEIRA-FILHO & RATTER 1995). The indicator species are *Sterculia striata, Anadenanthera colubrina, Tabebuia impetiginoa, Myracrodruon urundeuva, Dilodendron bipinnatum, Maclura tinctoria, Cordia glabrata* and *Enterolobium contortisiliquum*.

3.2 Sub-type: Seasonally flooded semi-evergreen forests

3.2.1 Seasonally flooded semi-evergreen forests with *Calyptranthes eugenoides* and *Mouriri guianensis*

These forests occur in all areas subjected to flooding over several months. Normally, the soil is covered by a litter layer that lacks herbaceous plants. There exist several varieties of seasonally flooded semi-evergreen forests (NUNES DA CUNHA 1998). In the Pantanal of Poconé, the forests established in sandy soils are characterized by a sparse understory about 2 m in height, with *Unonopsis lindmanii* R.E. FRIES. and *Psychotria carthagenensis* JACQ. as the characteristic species. This is followed by a middle stratum, 4-7 m in height, containing *Calyptranthes eugenioides* CAMBESS., *Mouriri guianensis* AUBL., and *Thieleodoxa lanceolata* CHAM. The upper stratum, up to 13 m high, is occupied by *Calophyllum brasiliense* CAMBESS. and *Vochysia divergens* POHL. On soils with a higher clay content, *Zygia cauliflora* (WILD.) KILLIP ex RECORD, *Trichilia catigua* A. JUSS., *Salacia elliptica* (MART.) PEYR, *Aptandra liriosmoides* SPRUCE, *Buchenavia oxycarpa* (MART.) EICHLER, *Homalium guianense* (AUBL.) OKEN, *Inga vera* ssp. *affinis* (DC) T.D. PENN., *Crataeva tapia* L., and *Pouteria glomerata* (MIQ.) RADLK. are frequent in the middle stratum, and *Ceiba samauma* (MART.) K. SCHUM., *Cassia grandis* L.F. and *Tabebuia heptaphylla* (VELL.) TOLEDO in the upper stratum.

3.2.2 Seasonally flooded semi-evergreen forest with *Calophyllum brasiliense* (*landizal*)

Elongated and sinuous stretches of semi-evergreen forest in high-lying plains covered by *cerrado* vegetation point to the presence of *landizal*. This can be explained by the fact that, in periodically drying drainage systems, floods last longer and water availability during low-water periods is better because of a high groundwater level. *Landi* refers to the regional name of *Calophyllum brasiliense* CAMBESS. The following species, which are also common in other seasonally flooded forests, are characteristic of this sub-type of forest: *Licania parvifolia* HUBER, *Erythroxylum anguifugum* MART., *Alchornea discolor* POEPP., *Calophyllum brasiliense* CAMBESS., *Mouriri guianensis* AUBL., *Ficus pertusa* L.F., *Sorocea sprucei* (BAILL.) MACBR., *Eugenia florida* DC., *Coccoloba ochereolata* WEED., and *Triplaris gardneriana* WEDD.

3.2.3 Seasonally flooded semi-evergreen forests with *Licania parvifolia* (*pimenteiral*)

This unit is characterized by *Licania parvifolia* HUBER. These trees, which are 5-8 m in height, grow in periodically flooded areas with a preference for drainage channels with intermittent water flow. The sandy soil is normally not covered with an herbaceous stratum (GUARIM NETO 1984; LORENZZI 1992; BRASIL 1997). According to POTT & POTT (1994), this species was favored during the multi-annual wet period lasting from 1974 until the middle of the 1990s, and invaded pasture areas. It has been described in the Pantanal de Poconé and in the Pantanal de Barão de Melgaço.

3.2.4 Seasonally flooded semi-evergreen forests with *Vochysia divergens* (*cambarazal*)

Cambarazais are dense forest formations in which *Vochysia divergens* POHL (*cambará*), sometimes occurring in monospecific stands, predominates. According to NASCIMENO & NUNES DA CUNHA (1989), *V. divergens* is a characteristic species of the Pantanal. Dense stands develop in low-lying humid areas. This species is flood-tolerant (ARIEIRA & NUNES DA CUNHA 2006) and in multi-year wet periods spreads into surrounding savannas, creating serious problems for ranchers. The expansion of *cambarazais* is counteracted by the wild fires of extremely dry years. Stands of *V. divergens* are also found in periodically flooded areas along the Rio das Mortes and the Araguaia River in the Amazon basin (MARIMON et al. 2001).

3.2.5 Seasonally flooded semi-evergreen forests with *Erythrina fusca* (*abobral*)

Along some river stretches, for instance the Paraguay River near Taiamã Island and the Caracará River in Pantanal National Park, the sediment load is low. Shores show no or little developed levees and are flooded for several months every year to a depth of 2 m and more. These shores are covered by old monospecific stands of *Erythrina fusca* LOURT. (*abobreiro*) that develop impressive stilt roots.

4. Type: Scrubland (*arbustal*)

Arbustal is a common plant community in the Pantanal and refers to the domination by shrubs (*arbusto* = shrub). Scrublands occur in periodically flooded areas and may be either naturally occurring or the result of human activity. In some regions, they remain stable over decades, while in others they are transitional communities that occur temporarily as the result of a disturbance, such as major fire events or deforestation. The shrub density can be very high, making some parts of the *arbustal* nearly impenetrable for humans.

4.1 Seasonally flooded scrubland with *Mimosa pellita* (*espinheiral*)

Scrubland with *Mimosa pellita* KUNTH ex WILLD. reaches a height of about 1.50 m. It dominates the large areas of the Cuiabá River floodplain that become flooded during several months. Sparsely scattered individuals of *Bonafousia siphilitica* (L.F.) L.

ALLORGE. rise above the canopy to a height of about 2.5 m. Mainly during the flood period, the *arbustal* is rich in annual and perennial vines, which cover the scrubs. During the dry period *Cissus* sp. dominates the upper stratum.

4.2 Seasonally flooded scrubland with *Combretum lanceolatum* (*pombeiral*)

Scrubland with *Combretum lanceolatum* POHL ex EICHLER, which reaches a height of about 4 m, is often monospecific. It is widespread in the Pantanal and occurs near permanent water bodies in areas subject to several months of inundation. Ranchers have tried to eradicate the vegetation because it invades natural and artificial pastures and reduces the carrying capacity for cattle.

4.3 Seasonally flooded scrubland with *Byrsonima orbignyana* (*canjiqueiral*)

Below the stratum of *Byrsonima orbignyana* (A. JUSS.), which is about 1-5 m high, there is a stratum of grasses, sedges, and herbaceous plants (SILVA et al. 2000). *Canjiqueiral* grows on sandy, little-flooded soils and expands during multi-annual dry periods into low lying areas, where it becomes problematic for ranchers because it occupies pasture. However, it is naturally eradicated in prolonged wet periods (POTT & POTT 1994). SILVA et al. (1998) denominated *canjiqueiral* as open scrubland or scrub savanna, depending on its density.

4.4 Seasonally flooded scrubland with *Byttneria filipes* and *Bauhinia bauhinioides* (*espinheiral*)

This type of scrubland, which is impenetrable for humans and cattle, was described by SILVA et al. (1998) as a scrub community dominated by *Byttneria filipes* MART. ex K. SCHUM., *Bauhinia bauhinioides* (MART.) J.F. MACBR., and *Cissus spinosa* CAMBESS. It occurs in areas of different levels of flooding.

Distribution of the units along the inundation gradient

Most woody species of the Pantanal have a broad ecological amplitude (NUNES DA CUNHA & JUNK 2001). This enables them to colonize a substantial portion of the inundation gradient and to adapt their ranges to multi-annual wet and dry periods. The geographical positions of the units listed in Table 1 therefore indicate only the core areas of distribution. The gradient comprises the entire aquatic terrestrial transition zone (ATTZ; JUNK et al. 1989) and varies from permanently terrestrial conditions on the one end to permanently aquatic conditions on the other. Inundation of the Pantanal is the result of flooding by transbording rivers, local rainfall, and geomorphology. Due to the Pantanal's characteristic flat relief, the hydrological conditions are very complex.

Woody vegetation colonizes the upper and middle parts of the gradient but is absent from the lowest part, which is instead colonized at low-water levels by grasses and herbaceous plants (natural *campos limpos*). The permanent terrestrial habitats that were part of the present study belong to the ATTZ because the vegetation is affected during extreme flood events, either by direct short-term flooding or an increase in the groundwater level to the rhizosphere, which eliminates those species sensitive to waterlogging of the soil. The length of the inundation period is often correlated with the depth of inundation, but depressions may be shallowly flooded and their soils can remain waterlogged over long periods of time, independent of the level of the parent river or the amount of rainfall. Some species, such as *Copernicia alba* and *Mauritia flexuosa*, tolerate long-term waterlogging of the soil but not very deep flooding.

Tab. 1: Characterization of the vegetation units according to the depth of flooding. Types with a broad distribution are mentioned several times. Occurs, respectively, frequently or exclusively in permanently waterlogged soils.

Permanently dry or shortly flooded in extreme flood periods	
3.1.1	Semi-deciduous forest with *Curatella americana* and *Magonia pubescens*
3.1.2	Semi-deciduous forest with *Tabebuia* spp and *Scheelea phalerata* (*Cordilheira de mata, capão de mata*).
3.1.3	Semi-deciduous forests on *aterros de indio*
3.1.4	Deciduous forest with *Callisthene fasciculata* (*carvoal*)
3.1.5	Deciduous forest with *Sebastiana brasiliensis* and *Seguieria paraguayensis* (*Cordilheira de mata, capão de mata*)
Little flooded habitats	
2.1	Seasonally flooded termite savanna with *Curatella americana* (*campo de murunduns, lixeiral*)
2.4	Open low-tree savanna with *Curatella americana* and *Tabebuia aurea* (*cerrado ss*)
4.3	Seasonally flooded scrubland with *Byrsonima orbignyana* (*canjiqueiral*)
Intermediate flooded habitats	
2.2	Seasonally flooded woodland savanna with *Tabebuia aurea* (*paratudal*)
2.3	Seasonally flooded woodland savanna with *Copernicia alba* (*carandazal*)
2.5	Swampy woodland savanna with *Mauritia flexuosa*
3.2.1	Seasonally flooded semi-evergreen forests with *Calyptranthes eugenoides* and *Mouriri guianensis*
3.2.2	Seasonally flooded semi-evergreen forest with *Calophyllum brasiliense* (*landizal*)
3.2.3	Seasonally flooded semi-evergreen forests with *Licania parvifolia* (*pimenteiral*)
3.2.4	Seasonally flooded semi-evergreen forests with *Vochysia divergens* (*cambarazal*)
4.2	Seasonally flooded scrubland with *Combretum lanceolatum* (*pombeiral*)
4.4	Seasonally flooded scrubland with *Byttneria filipes* and *Bauhinia bauhinioides* (*espinheiral*)
Deep flooded habitats	
2.3	Seasonally flooded woodland savanna with *Copernicia alba* (*carandazal*)
3.2.4	Seasonally flooded semi-evergreen forests with *Vochysia divergens* (*cambarazal*)
3.2.5	Seasonally flooded semi-evergreen forests with *Erythrina fusca* (*abobral*)
4.1	Seasonally flooded scrubland with *Mimosa pellita* (*espinheiral*)
4.4	Seasonally flooded scrubland with *Byttneria filipes* and *Bauhinia bauhinioides* (*espinheiral*)

Discussion

All ecological classification systems are inherently artificial, as they depend on the aim of the study and the parameters used by the respective authors. The typology proposed herein is based mostly on woody vegetation, physiognomic aspects (e.g., level of deciduousness), and hydrological parameters. Water is the driving force in floodplain ecosystems. Plant and animal species are distributed in floodplains according to the length and depth of the flooding, as postulated by the flood pulse concept (JUNK et al. 1989). Climate clearly affects the level of deciduousness, whereas the impact of edaphic factors is still poorly understood. *Pantaneiros* (people living inside the Pantanal) have denominated certain landscape features, habitats, and plant communities with local names that refer to the respective environmental characteristics. We have adopted these local names as much as possible because one of the aims of our typology is to assist sustainable management and protection measures in the Pantanal. The inclusion of local terms facilitates discussions between *pantaneiros*, scientists, and politicians as well as the implementation of protective measures. The second aim of this typology is of a scientific nature, i.e., to provide a better overview of habitat diversity, support comparative studies, and offer a scientifically based framework in which further scientific information can be incorporated, such as edaphic parameters, the occurrence of animals, and management aspects.

Nevertheless, our typology is still preliminary because the Pantanal has not been studied sufficiently to allow the characterization of all its vegetation types. As already stated in the introduction, the names given to the units are informal and do not follow the strict international syntaxonomic rules described by BARKMAN et al. (1986). However, this allows terms to be used more flexibly without interfering with the international classification system. We have not considered herbaceous communities and aquatic habitats. Furthermore, classification in general is difficult, because: (1) there are no fixed boundaries separating the many vegetation types, (2) the flood pulse changes the habitat conditions in the aquatic-terrestrial transition zone throughout the year, and (3) multi-annual climate changes lead to large-scale changes in habitat conditions and related changes in vegetation cover. For instance, *carvoal* occurs in a dense formation with high trees, and this physiognomic feature was the basis for its classification as unit 3.1.4, i.e., "Deciduous forest with *Callisthene fasciculata* (*carvoal*)", corresponding to the forest-ecotone-grassland concept of the *cerrado* (COUTINHO 1978). However, according to RATTER et al. (1973, 1977), the floristic composition of *carvoal* suggests its assignment to the mesotrophic facies *cerradão*. In some areas of the Pantanal, the properties of the *carandazal* support its listing as unit 2.3 (seasonally flooded woodland savanna with *Copernicia alba*), but in others the soil may be permanently waterlogged. If this is ultimately found to occur over major areas, a new unit should be established (e.g., 2.6 Swampy woodland savanna with *Copernicia alba*).

The problem of typifying vegetation is also demonstrated by plant communities growing on levees. Along the main river channels and oxbow lakes there are levees of different height and extension that support different plant communities. A difference of a few decimeters in the height of the topography alters the flood and drought stresses as well as the sedimentation pattern and may therefore change the structure of the community.

Levees in the Pantanal show a longitudinal and a transversal height gradient (Fig. 4). The longitudinal gradient is detectable over long distances, from shallowly to deeply flooded parts of the Pantanal. Well-developed large levees are found, for instance, in the little flooded northern part of the Pantanal, whereas small levees at the beginning stages of development are frequent in the deeply flooded southern Pantanal. Transversal gradients are present anywhere along the levees. Moreover, in some areas, the rivers do not form levees. Instead, the shores are rather flat and flooded for long periods of time at high water levels and covered by a species-poor forest (unit 3.2.5, *abobral*). In addition to changes in species composition according to flood intensity, there are changes in the floristic composition along the north-south gradient, e.g., due to the entrance of species from the southern humid Chaco.

In the Cassangue River, a medium-sized tributary of the Cuiabá River, NUNES DA CUNHA & JUNK (1999) differentiated eight communities and 50 woody species along the transversal transect of a levee, according to the flood gradient. Two sub-types were distinguished: forests growing on the highest part of the levee that is rarely flooded and forests growing in frequently flooded areas (Fig. 4). Units of the rarely flooded areas are semi-deciduous and deciduous while those of the periodically flooded areas are semi-evergreen. The transversal gradient shows differences in species composition between low-lying areas on the channel side, where there is running water, and on the campo side, where there is standing water. *Sloanea garckeana* K. SCHUM., *Coccolobas mollis* CASAR, *Crataeva tapia* L., and *Campomanesia eugenioides* (CAMB.) LEGR. are characteristic species of the channel side, whereas *Salacia elliptica* (MART) PEYR, *Byrsonima cydoniifolia* ADR. JUSS., *Guarea macrophila* VALL, *Eugenia tapacumensis* O. BERG., *Eugenia inundata* DC., *Rheedia brasilienses* (MART.) PI. & TR., and *Triplaris americana* L. show a preference for the campo side.

At the highest parts of the levees of the Paraguay River, DAMASCENO-JUNIOR et al. (2005) identified *Tabebuia heptaphylla* (VELL.) TOL., *Hymenaea courbaril* L. var. *stilbocarpa* (HAYNE) Y.T. LEE & LANGENH and *Guazuma tomentosa* H.B.K.; *Albizzia inundata* (MART.) BARNEBY & J.W. GRIMES. At the lower parts, flood--tolerant species, such as *Crataeva tapia* L., *Alchornea castaneifolia* (WILLD.) A. JUSS., *Inga vera* WILLD. ssp. *affinis* (DC.) PENNINGTON, *Zygia inaequalis* (H.B.K.) PITT., and *Mouriri guianensis* AUBL. were observed.

Low-lying parts of the levees that extend above the water level only during the low-water period are covered by dense monospecific stands of semi-aquatic grasses, e.g., *Panicum elephantipes*, and robust herbs, such as *Polygonum ferrugineum* WEDD. *Ludwigia* spp., and *Aspilia latissima* MALME (Fig. 4). Levees of intermediate height are covered by different successional stages of the forests on well-developed levees (Fig. 4). Succession begins with several species, including *Alchornea castaneifolia, Mimosa pellita* HUMB. & BONPL. ex WILLD., *Crataeva tapia* L., and *Bactris glaucescens* DRUDE. With increasing height of the levee, these species become denser and finally eliminate herbaceous species due to shading. Monospecific stands of *Inga vera, I. uruguensis, Sapium obovatum,* and *Alchornea castaneifolia* (HUMB. & BONPL. ex WILLD.) A. JUSS. may also be found. *Inga* spp. occur mostly in the northern part of the Pantanal and are replaced in the middle and southern part by *Sapium*. When the levee becomes more pronounced, all species of the semi-evergreen forest are present. Spatial zonation of the levees represents successional stages that change when sediment deposition has increased the height of the levee, which diminishes flood duration.

The phytogeographic analysis of the woody vegetation of the Pantanal has demonstrated the mosaic of species from different regions. No endemic species were found and the overwhelming majority of tree species has a wide distribution. Most species originate from the Cerrado Province or the Central-Western Province (BRIDGEWATER et al. 2004) but there are also many species of deciduous forests in the eastern Pantanal as well as the mesophytic deciduous forest of the Chiquitos hills (*morrarias*), which features rocky outcrops of limestone and quartz, and the subtropical deciduous and mesophytic forests of western and central Brazil (SEIBERT 1996, KILLEEN et al. 1998).

PRADO (2000) postulated floristic links between the deciduous and semi-deciduous forests of Gran Chaco and Brazilian Caatingas and speculated as to the influence of earlier wet-dry climatic fluctuations on the present-day disjunctions of the seasonal forests on the continent. Some of the characteristic species of these biogeographic formations (PRADO & GIBBS 1993) are also common in the two types of deciduous forests on *cordilleiras, capoes*, and levees in the Pantanal. Although the participation of species from the Amazon Basin is less significant, several species that occur in Amazonia are frequently found in the Pantanal.

The absence of endemic species of arboreal plants is coherent with observations regarding other species groups, including butterflies, mammals, reptiles, amphibians, and birds (PRANCE & SCHALLER 1982; BROWN 1986; JUNK et al. 2006a; BROWN 1986). JUNK et al. (2006b) concluded that the Pantanal is not a center of endemic species, but instead absorbs species from flooded and non-flooded habitats of the borders. The same affirmation can be made for the arboreal vegetation of the Pantanal.

Conclusion

The Pantanal of Mato Grosso is a vast floodplain covered by different vegetation types, such as savanna, seasonal forest, scrubland, and grassland. The vegetation in this region is associated with different landscape units and influenced by different factors, such as length and depth of the flooding, climate, soil quality, fire, competition, animal grazing, and human impact. Annual and multi-annual wet and dry periods result in large-scale changes in the vegetation cover.

Ecologists, farmers, and policy-makers require a vegetation typology to serve as a framework for organizing the increasing amount of scientific information concerning the Pantanal, quantifying changes in its vegetation cover, and establishing management and protection measures. Woody vegetation is especially appropriate as the basis for a typology because it is a prominent feature of the landscape. Furthermore, woody species have long life spans and thus represent the environmental conditions of their habitats over decades or even centuries. For this reason, woody vegetation guided the typology constructed in this study. Three types were identified: savannas (5 units), forests, with two sub-types: seasonal forests on dry ground (5 units) and seasonally flooded semi-evergreen forests (5 units), and scrublands (4 units). The units are characterized by typical tree species previously identified in phytosociological studies, but our knowledge of the vegetation of the Pantanal is still insufficient to allow a comprehensive classification following strict international syntaxonomic rules. Many of the vegetation and landscape units are derived from the local population's perception of their environment. These names have been incorporated into the present study.

While the typology presented in this study is preliminary, it should nonetheless encourage scientists and people living in the Pantanal (*pantaneiros*) to propose and characterize further units, which can be incorporated into our framework. The results of our analysis can also contribute to the comprehensive classification system of wetland habitats that is required for the sustainable management and protection of the Pantanal.

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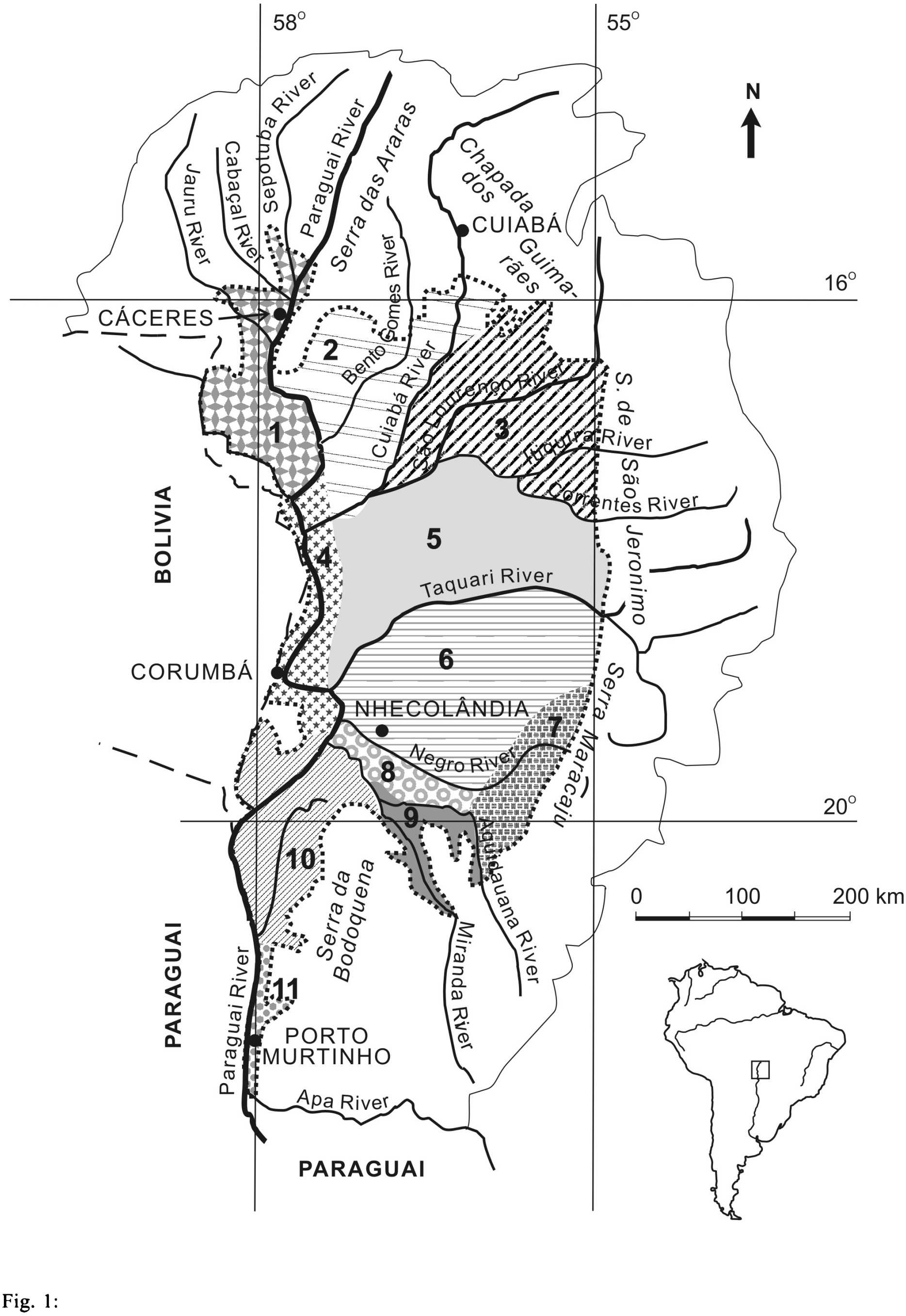

Fig. 1:

Map of the Brazilian part of the Pantanal, with subdivisions according to ADAMOLI (1982). **1** = Cáceres; **2** = Poconé; **3** = Barão de Melgaço; **4** = Paraguai; **5** = Paiaguás; **6** = Nhecolândia; **7** = Aquidauana; **8** = Abobral; **9** = Miranda; **10** = Nabileque; **11** = Porto Murtinho.

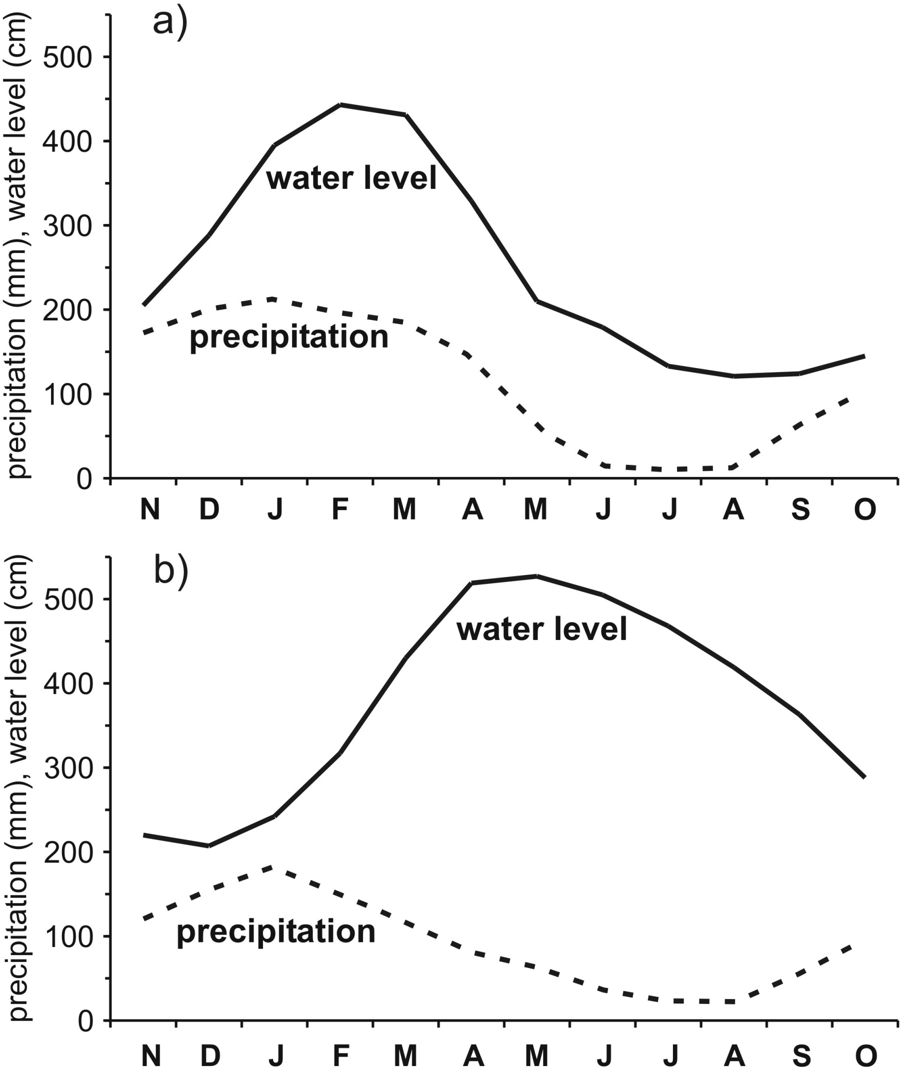

Fig. 2:
a: Mean monthly precipitation near Cuiabá (1933-1993) and mean water level of the Cuiabá River at Cuiabá (1971-1988), northern Pantanal, (data according to ZEILHOFER 1996); **b**: mean monthly precipitation near Corumbá (1912-1971) and mean water level of the Paraguay River at Ladário (1979-1987), southern Pantanal (data according to HAMILTON et al. 1999).

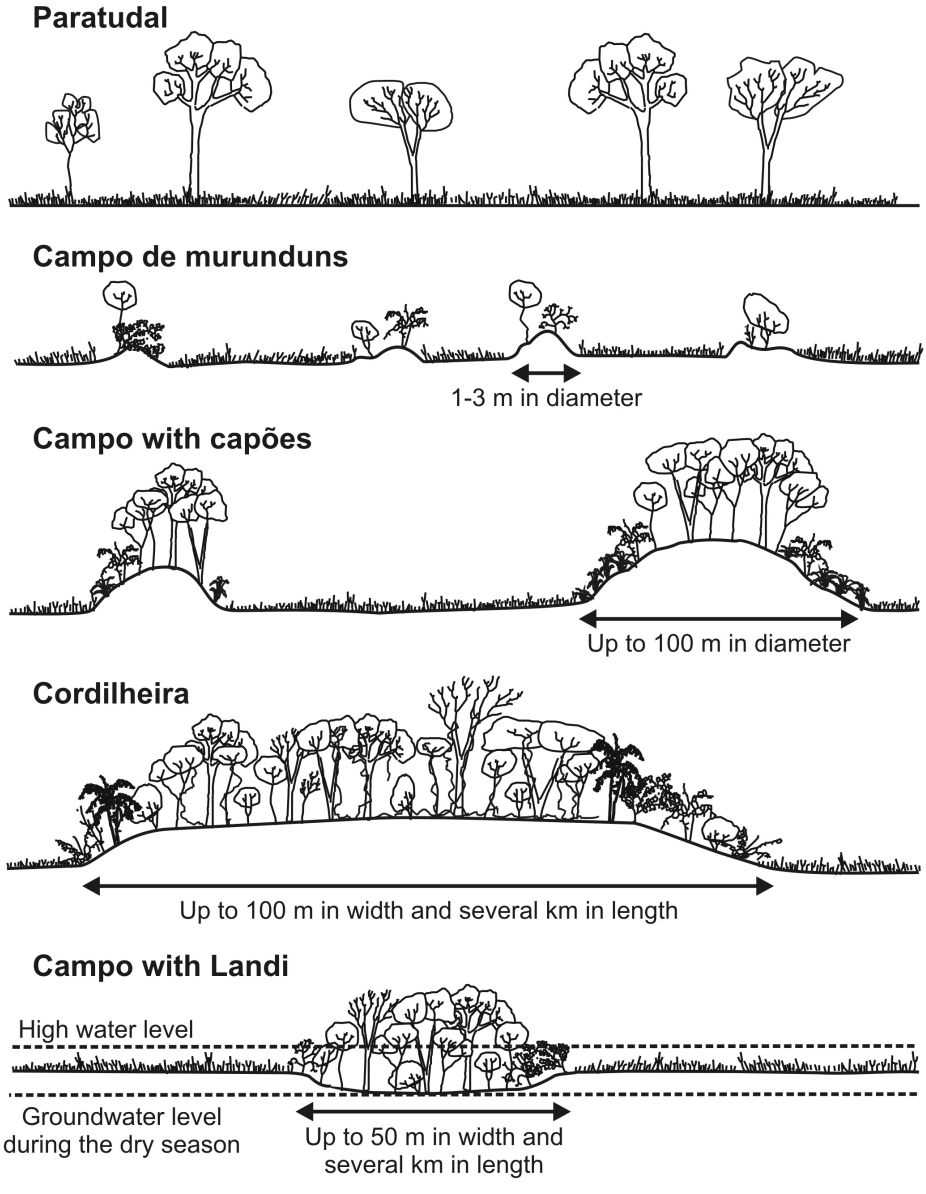

Fig. 3:
Forested landscape units of the Pantanal.

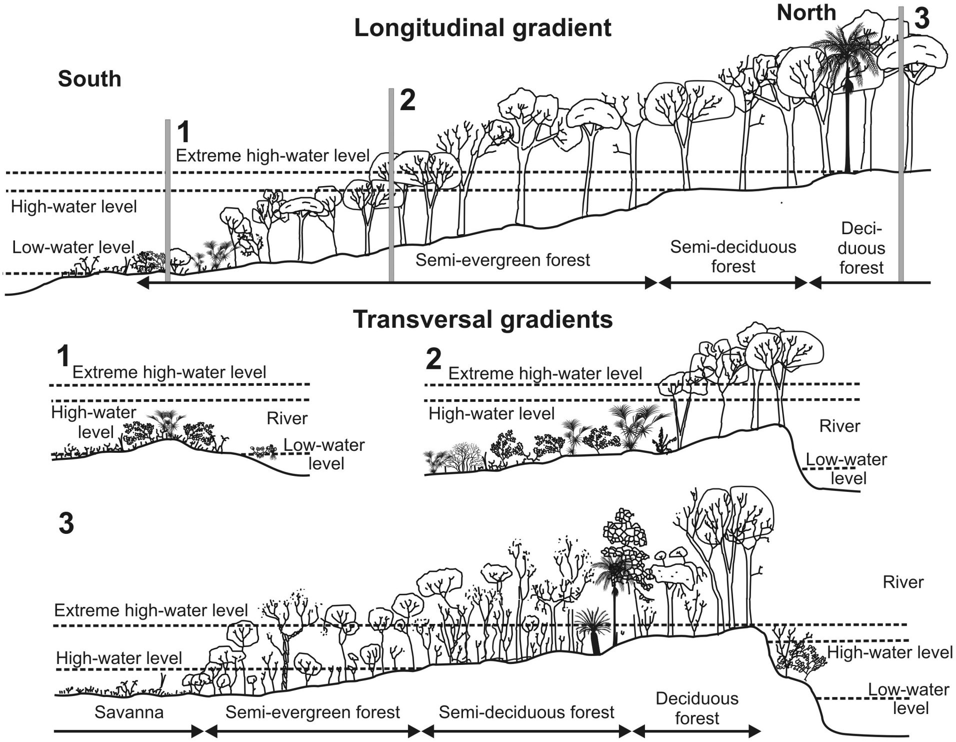

Fig. 4:
Distribution of woody vegetation along a schematic longitudinal gradient and three transversal gradients on a levee. Different forest types occur according to the length of the inundation period. The longitudinal gradient can extend over hundreds of kilometers, from higher lying to lower lying parts of the Pantanal. Transversal gradients cover distances of tens of meters in weakly developed parts (**1**), and up to 500 m in well-developed parts (**3**) of the levee.

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Anatomic prerequisites for internal root aeration of three tree species of the Amazonian inundation forest

by

G. Rätsch & K. Haase

Dr. Gudrun Rätsch & Dr. Karen Haase, Tropical Ecology Working Group, Max-Planck Institute for Limnology, Postfach 165, 24302 Plön, Germany; e-mail: raetsch@mpil-ploen.mpg.de & haase@mpil-ploen.mpg.de

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Abstract

Many tree species of the Amazonian inundation forest not only survive long periods of flooding, they are also able to continue shoot and root growth, flowering, and fruiting despite the unfavorable conditions of the oxygen-depleted soil. Internal root aeration is an effective adaptation mechanism that maintains the high-energy status required by root cells - to support growth and development. In the present study, internal root aeration was investigated in three Amazonian species by using oxygen microelectrodes to measure oxygen concentrations in the root cortex and rhizosphere, and light and fluorescence microscopy to analyze lacunar shape, extent, and distribution, as well as suberin incrustations in the exodermis. A highly porous gas transport system from the shoot to the roots is the prerequisite for an effective internal oxygenation. The results showed that the roots of *Nectandra amazonum* were not oxygenated, although large, regularly distributed intercellular spaces were observed in the root cortex. The roots of *Triplaris pyramidalis* were moderately supplied with oxygen via irregularly distributed, developing cavities in the cortex. Internal oxygen transport within regularly distributed lacunae (aerenchyma) in the root cortex of *Pseudobombax munguba* was reflected by the high concentration of oxygen measured in this species. In the roots of *Triplaris pyramidalis*, internal oxygen was conserved due to the formation of a hypodermal suberin barrier. By contrast, in *Pseudobombax munguba*, the absence of a suberized layer resulted in the diffusion of oxygen into the rhizosphere. The tree species display three different strategies, although they grow in the same habitat: no internal aeration at all, internal aeration without loss of oxygen to the rhizosphere, and internal aeration with massive loss of oxygen to the rhizosphere.

Keywords: **Anoxia, aerenchyma, flood adaptation, radial oxygen loss, root aeration.**

Resumo

Muitas espécies arbóreas das florestas alagáveis da Amazônia não somente conseguem sobreviver longos períodos de inundação, as espécies também são capazes de manter o crescimento de brotos e raízes, floração e frutificação apesar das condições desfavoráveis de um solo esvaziado por oxigênio. Aeração das raízes internas é um mecanismo eficaz de adaptação para manter o estado de energia necessitada pelas células da raiz - para suportar o crescimento e desenvolvimento. No estudo presente, aeração das raízes internas foi analisada para três espécies amazônicas usando microelectrodos de oxigênio para medir a concentração de oxigênio no córtex da raiz e na rizosfera, e microscopia de luz e florescência para analisar a forma do aerênquima, extensão, e distribuição, também como incorporação de suberina na exodermis. Um sistema com muitos poros é pré-requisito para o transporte de gás dos brotos para as raízes para uma

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oxigenação interna com eficiência. Os resultados indicam que as raízes da *Nectandra amazonum* não foram oxigenadas, mesmo largas, espaços intercelulares com uma distribuição regular foram observados no córtex da raiz. As raízes da *Triplaris pyramidalis* foram moderadamente suportadas com oxigênio através de cavidades com uma distribuição irregular no córtex. O transporte interno de oxigênio dentro de um aerênquima regularmente distribuído no cortes da raiz do *Pseudobombax munguba* foi refletido pela concentração mais alta de oxigênio medido nesta espécie. Nas raízes da *Triplaris pyramidalis*, oxigênio interno foi conservado através da formação de uma barreira hypodermal de suberina. Em contraste, no *Pseudobombax munguba*, a ausência de um estrato com suberina resultou na difusão de oxigênio para a rizosfera. As três espécies representam três estratégias diferentes, mesmo que elas crescem no mesmo habitat: nenhuma aeração interna, aeração interna sem perda de oxigênio para a rizosfera, e aeração interna com perda massiva de oxigênio para a rizosfera.

Introduction

Morphologic, anatomic, metabolic, and functional adaptations of plants to permanent or periodic hypoxic or anoxic growth conditions as a result of flooding have been studied intensively, and the results reviewed in several publications (ARMSTRONG 1979; CRAWFORD & BRAENDLE 1996; JACKSON & COLMER 2005; KOZLOWSKI 1997; LÖSCH & BUSCH 2000; PAROLIN et al. 2004; PEZESHKI 2001; VISSER et al. 2003). Most of those studies focused on the plants' above-ground organs, since although plant roots are strongly affected by anoxic soil conditions, they are more difficult to examine. Studies of the specific adaptations of tree roots are even less numerous than those evaluating aquatic and graminaceous species. Intensively studied woody species include *Alnus* species, *Salix* species, *Fraxinus excelsior*, other tree species in temperate regions (ARMSTRONG 1968; DITTERT et al. 2006; EWING 1996; HARRINGTON 1987; IREMONGER & KELLY 1988; JACKSON & ATTWOOD 1996; KOZLOWSKI 1997; SIEBEL et al. 1998), mangroves at different sites (ALLAWAY et al. 2001), and a few tropical tree species (DE SIMONE et al. 2002, 2003; JOLY 1996; LOBO & JOLY 1998; LOPEZ & KURSAR 1999; PAROLIN 2001; PAROLIN et al. 2002; WALDHOFF et al. 1998). The results of those investigations revealed species-specific differences in adaptations to waterlogging and flooding. Some trees avoid oxygen deficits in their roots by internal aeration, which is an important survival strategy during unfavorable growth conditions. In contrast to anaerobic metabolism, root aeration, as a prerequisite for root respiration and radial loss of internally transported oxygen, is of particular importance for energy supply, nutrition uptake, and protection against reduced phytotoxic ions, and thus for plant survival (JANIESCH 1991). The production of new roots, leaves, flowers, and fruits by numerous species of the Amazonian inundation forest during the aquatic phase (SCHÖNGART et al. 2002) points to their optimal energy supply and suggests internal aeration processes.

Internal oxygen transport has been detected through measurements of the redox potential of the rhizosphere (DITTERT et al. 2006), the reduced-dye technique (ARMSTRONG & ARMSTRONG 1988), and cylindrical polarographic electrodes (ARMSTRONG 1994), but these methods require the loss of oxygen into the rhizosphere. Oxygenation in the root tissue has been shown by means of oxygen microelectrode measurements (ARMSTRONG et al. 2000). DE SIMONE et al. (2002) investigated root aeration in three tree species of the Amazonian inundation forest by this *in vivo* technique. Differences in aeration were shown in a comparison of the species, *Salix martiana, Tabernaemontana juruana*, and *Laetia corymbulosa*, growing in the same environment (DE SIMONE et al. 2002, 2003). The aims of the present study were: (1) to broaden the set of described Amazonian tree species, (2) to confirm known aeration strategies, and (3) to demonstrate further differences in aeration mechanisms. Therefore, the root morphology and anatomy of three other common Amazonian tree species growing in the same habitat were examined under simulated flooding conditions. Particular attention was given to the capacity for internal root oxygenation, the nature of the oxygenated roots, and the occurrence of radial oxygen loss to the oxygen-depleted rhizosphere.

Material and methods

Plant material

Experiments were carried out with young tree cuttings: the brevi-deciduous species *Triplaris pyramidalis* JACQ. (Polygonaceae), the evergreen species *Nectandra amazonum* NEES (LAURACEAE), and the stem succulent *Pseudobombax munguba* (MART. & ZUCC.) DUGAND (Bombaceae). *T. pyramidalis* mainly grows in the high várzea (Amazonian white-water forest) although individual trees are established at lower flood levels. The trees are inundated at least 50-100 days per year. *N. amazonum* grows in the low várzea, with an inundation period of at least 100-150 days per year. *P. munguba* is distributed along the entire flood-level gradient, but most of the trees are located in the low várzea (WITTMANN et al. 2004). All species are subject to long-term flooding in their natural habitats.

Cuttings were derived from 2-year-old trees grown from seeds collected in Central Amazonia in a climate-controlled greenhouse. The cuttings were rooted in standard potting soil and transferred after 8-12 weeks to a climate chamber. The plants grew under stable climate conditions resembling those of Central Amazonia: 70-80 % relative humidity, day/night regime of 12/12 h (PAR 50 µmol m^{-2} s^{-1}), 32/28 °C day/night temperature. In addition, the cuttings were illuminated with 100 µmol m^{-2} s^{-1} by four high-pressure mercury lamps (HQL-R, 80 W, OSRAM, Germany) for the middle 8 h of the day.

To simulate stagnant water and anoxic growth conditions in the rhizosphere, the roots of the cuttings were washed carefully under lukewarm tap water and planted into agar medium in a glass basin. The solid agar (0.5 % w/v) was dissolved in a nutrient solution containing (mmol l^{-1}): NH_4NO_3 (3.0), $MgSO_4$ (0.5), $CaCl_2$ (1.5), K_2SO_4 (1.5), NaH_2PO_4 (1.5), and the following trace elements (µmol l^{-1}): H_3BO_3 (25), $MnSO_4$ (1), $ZnSO_4$ (0.5), $(NH_4)_6Mo_7O_{24}$ (0.05), Cu SO_4 (0.3), and FeEDTA (40). The pH was between 5.5 and 6. The cuttings were transferred to fresh medium at least once a week. The plants grew in the agar medium for at least 10 weeks and oxygen concentrations in the cortex of several roots were repeatedly measured (Tab. 1). The glass basin was completely wrapped in black paper to prevent illumination of the roots and agar medium.

Oxygen measurements

Oxygen was measured with highly sensitive and specific microelectrodes (Ox 25, tip diameter 25 µm, Unisense, Aarhus, Denmark). Details on the operating mode of these miniaturized Clark-type electrodes (REVSBECH 1989) and on the measuring technique were provided in DE SIMONE et al. (2002).

For oxygen measurements, the cuttings were planted into agar medium consisting of a solid layer (2 %, w/v) as a lay-on for the roots and an upper layer (0.5 %, w/v) surrounding the roots. The latter allowed the simulation of water-filled soil pores and the establishment of oxygen profiles. Selected roots were positioned 0.5 cm from the wall of the glass basin (250-500 ml depending on the root ball) to optimize observation by means of a magnifying glass. A water layer of 1-2 cm covered the agar surface to prevent shrinkage of the agar and to simulate flooding conditions. The microelectrode was gradually driven by means of a mechanical micromanipulator through an agar layer of 2.5-3.5 cm before it touched the root surface. Oxygen profiles were recorded 20 h after the cutting had been inserted in fresh agar. Even though the microfloral content of a stagnant solution is less than in most soils (WIENGWEERA et al. 1997), at the time of measurement oxygen was completely consumed in the basin due to root respiration and developing microbial activity beneath the top centimeter of agar. Both the respiration rate of the roots and the growth rate of microorganisms introduced into the agar by the roots were high because of the high temperature (28-32 °C) in the climate chamber. Oxygen profiles obtained from around the root ball verified the anoxic conditions; consequently, oxygen liberated near the roots was exclusively derived from root oxygen. The microelectrode was inserted into the root tissue (100-200 µm) until a constant cortical oxygen value was obtained. To the extent possible, the electrode was positioned at right angles to the root surface. Radial profiles in the rhizosphere and concentrations in the cortex were recorded leastwise at two measuring points, i.e., 1 cm behind the root tip and 2-3 cm from the root origin.

Microscopy

The roots in which oxygen had been assayed using microelectrodes were subsequently harvested for microscopy. The lacunae in the root cortex were visualized by light-field microscopy. Presumed suberin incrustations, which may act as a selective barrier for gas transport in the epidermal and subepidermal cell walls, were observed by fluorescence microscopy (Leitz, Laborlux, Germany). Photos were taken with a digital camera (DFC 320, Leica, Germany).

Light microscopy

Tissues of the root segments were fixed in 4 % paraformaldehyde in 100 mM phosphate-buffered saline (PBS), pH 7.0, for at least 24 h. The root segments were washed three times with PBS (100 mM) and transferred into liquid agar (2 % w/v), which was then allowed to solidify. The resulting agar cuboids containing the roots were cut and the segments placed in Histoform S embedding mold (Kulzer, Germany) for fixation as follows: The samples were dehydrated in a graded ethanol series of 20, 40, 60, 80, and 100 % (30-min/step), pre-infiltrated in an ethanol/glycolmethacrylate mixture (1:1) for 24 h, and embedded in pure glycolmethacrylate (Technovit 7100, Kulzer, Germany), as described by RUETZE & SCHMITT (1986). The carrier plates were then glued to the histology blocks (Technovit 3040, Kulzer, Germany). Sections of 3-4 µm thickness were cut with a rotation microtome (RM 2165, Leica, Germany) with disposable 45°-knives (Histoknife, Kulzer, Germany), floated on a water surface at room temperature, and transferred to microscope slides. The polymerized sections stuck to the glass surface after drying on a warming tray (50 °C). Root cross-sections were stained in 0.05 % toluidine blue O (w/w) for at least 1 min. Glycerin-gelatin was used to seal the cover slips. Cross-sections were viewed by light-field microscopy.

Fluorescence microscopy

Transverse free-hand sections, cut using a razor blade (Wilkinson, Sword Classic, Germany), were stained for suberin and then incubated in 0.05 % toluidine blue O (w/w) in 100 mM PBS, pH 6.0, to quench lignin and suberin autofluorescence. The sections were stained with 0.1 % neutral red (w/w) in 100 mM PBS, pH 6.0, for 1 min and washed with tap water. This procedure yielded suberin-specific fluorescent probes (LULAI & MORGAN 1992). The cross-sections were transferred to a drop of tap water on microscope slides, and cover slips were placed over the samples. Blue-violet excitation (Leitz I 2/3, Germany; excitation filter 450-490, dichromatic beam splitter 510, and barrier filter 515) was used in all investigations of suberin deposition.

Results

Triplaris pyramidalis

After immersion of the young roots in agar, the young trees did not show symptoms of impaired growth. Roots that had been developed during aerobic conditions grew slowly under anoxic conditions until elongation ceased, at a length of about 6 cm. The formation of single lateral roots and of new roots under the latter conditions was observed. Between 0.8 and 2.5 mg oxygen l^{-1} (mean value: 1.5 mg l^{-1}, Tab. 1) was measured in the cortex of all roots originating from the portion of the stem at least 4-5 cm below the water and agar layers (measuring point: 2-3 cm from the root base, length of the roots: 4-6 cm). Oxygen was detected at the outer root surface only along the 0.5-0.8 cm of the white apex and did not exceed 0.4 mg l^{-1} (Fig. 1a). This slight radial diffusion of oxygen occurring around the root apex was most likely not enough to create a detectable oxygen profile in the rhizosphere, which was populated with microorganisms. Oxygen profiles in the remaining, brownish part of the root (2-3 cm from the root origin) showed a very steep slope at the site of penetration of the root exodermis, suggesting that oxygen transport from the oxygenated root cortex to the rhizosphere was greatly restricted (Fig. 1a).

The anatomy of the cortex of *T. pyramidalis* roots was characterized by a large number of intercellular spaces, degeneration of the parenchymatic cortical cell walls, and numerous irregularly arranged, developing air lacunae. The latter are a prerequisite for oxygen transport (Fig. 2a).

Figure 2b shows the strongly fluorescent suberin deposits found in the radial and inner tangential cell walls of the hypodermis. In the apical region, there was a slight diffusion of radial oxygen (≤1 cm beyond the tip) but no suberin incrustations were seen (photo not shown). Suberin staining did not differ between deposits in the aerobically grown parts of the root (brownish part) and those in the anoxically grown fresh regions (whitish part).

Pseudobombax munguba

Immersion of the young roots in agar not only allowed the growth of aerobically grown roots to continue, it also promoted the development of new, adventitious roots. Under the experimental conditions, roots of *P. munguba* reached a length of 10-12 cm. Oxygen microelectrode measurements in the proximity of these vital original roots and of the new roots demonstrated oxygenated layers along their entire lengths. Oxygen concentrations in the root cortex were around 3.5 mg l^{-1} (measuring point 2-3 cm from the root basis, length of the roots: 5-12 cm; Tab. 1). The oxygen gradient between the cortex and the outer surface was very much less step, both in the white apex region and in the brownish part near the root origin, indicating massive radial oxygen diffusion from the well-oxygenated cortex to the rhizosphere (Fig. 1b).

Light microscopy examinations of the cortical tissue of *P. munguba* showed regularly arranged air lacunae (aerenchyma) of different shapes (Fig. 2c). In the aerenchyma, numerous ligaments remained. The most expanded lacuna, seen in cross-section, occupied nearly a quarter of the cortex (photo not shown).

Suberin deposits were not found at any site along the entire root in the rhizodermis, as determined by fluorescence microscopy (Fig. 2d). The lack of suberin incrustations corresponded well to the pronounced oxygen profiles in the agar surrounding the roots.

Nectandra amazonum

Aerobically grown roots of *N. amazonum* did not elongate under anoxic conditions in oxygen-free agar medium and there was no development of new roots. Oxygen was not detected either outside or inside the roots (Tab. 1, Fig. 1c).

Anatomic examination of the cortical root tissue of *N. amazonum* showed regularly distributed, large, intercellular spaces but no extended lacunae (Fig. 2e).

Fluorescence microscopy demonstrated moderate suberin deposits in the cell walls of the hypodermis of *N. amazonum* (Fig. 2f). A weak fluorescence signal was visible in the radial and inner tangential cell walls. Portions of the hypodermis contained fewer suberin incrustations, suggesting pore formation in the hypodermal layer.

Discussion

In wetlands, soil flooding restricts soil-atmospheric gas exchange leading to rapid depletion of soil oxygen by roots, microorganisms, and soil reductants (PEZESHKI 2001). External supply of root cells with oxygen stops. Generally, internal oxygen transport is an important trait for both herbaceous (ARMSTRONG et al. 1994; COLMER 2003; COLMER et al. 2006) and woody (ANDERSEN & KRISTENSEN 1988; ARMSTRONG & ARMSTRONG 2005; DITTERT et al. 2006; JACKSON & ATTWOOD 1996, LI et al. 2006) plants, in that it compensates for local anoxic conditions. Root respiration that is restored by internal oxygen supply maintains the plant's high-energy status. It is thus essential for root growth, nutrient and water uptake, and the synthesis of structural substances as well as various secondary metabolites. A fraction of the root oxygen derived from internal transport can be lost by radial oxygen diffusion to the rhizosphere. This oxygen is of great importance for the well-being of the plant; for instance, it is used in the oxidative detoxification of reduced ions or gases in the rhizosphere (ARMSTRONG & ARMSTRONG 2001; JACKSON & ARMSTRONG 1999). Concurrently, the loss of oxygen into the anoxic surroundings means that there is less available for root metabolism. According to several authors, the restriction or control of radial oxygen loss by the formation of an anatomic barrier in the root exodermis along most of the root system is the predominant adaptive process (COLMER et al. 1998; KONČALOVA 1990; McDONALD et al. 2002).

The results of this study showed that different types of cortical root tissues carry out internal gas transport for root oxygenation via an interconnected lacunae system that extends from the aboveground organs to the roots. Microscopy of the root cortex revealed the common intercellular spaces in all species and the air lacunae. The latter varied in shape as well as extent in *T. pyramidalis* and *P. munguba*. Previous studies found that an increase in root porosity due to the development of aerenchyma leads to a reduction in both resistance to diffusive and pressurized gas transport and the number of cells, resulting in a decrease in metabolic oxygen consumption (JACKSON & ARMSTRONG 1999; COLMER et al. 2006; LI et al. 2006; WALDHOFF et al. 1998). Together, these processes imply that cortex oxygen concentrations increase with increasing root porosity. This was verified by measuring cortex oxygen concentrations with microelectrodes. High oxygen concentrations were found in the cortex of *P. munguba*. In this species, the root cortex contained many regularly distributed lacunae that appeared to be fully developed aerenchyma of lysigenous origin. By contrast, lower oxygen concentrations were found in *T. pyramidalis* roots. The irregularly arranged developing lacunae of this species lacked a complete aerenchyma; instead, single enlarged cavities and widened intercellular spaces were present. Oxygen was not detected in the root cortex of *N. amazonum*. In this species, lacunae were not observed; instead, only usual, but large intercellular spaces, which are able to mediate gas transport, were seen. Possibly, the root-shoot junction blocks oxygen transport from the atmosphere via the shoot to the roots. In *N. amazonum*, GRAFFMANN (2000) found a very low rate of transport of a tracer gas from the stem basis to the roots - only one fourth of the rate measured in *P. munguba*. Small trees of *N. amazonum* developed adventitious roots after 5 weeks during a flooding experiment carried out in that study. In the present study, oxygen could not be measured in adventitious roots, which possibly can be oxygenated, because the young cuttings in our experiments did not form such roots during stagnant cultivation.

It should be noted that in this study only small cuttings with very young roots were examined. Older roots, after prolonged growth in anoxic medium, as well as newly developed adventitious roots may exhibit better-developed aerenchyma, resulting in measurable or better oxygenation. Cortex oxygen concentrations in adventitious roots of *S. martiana* that exhibit mature aerenchyma tissue that can be compared with four tubes, exceeded those in *P. munguba* roots (DE SIMONE et al. 2002). The moderate oxygenation of *T. pyramidalis* roots was comparable to that of the adventitious roots of *T. juruana*, the cortex of which lacks aerenchyma but has similar widened intercellular spaces (DE SIMONE et al. 2002). In this context, it must be emphasized that the roots of *T. pyramidalis* and some roots of *P. munguba* had been aerobically grown but nonetheless remained vital in anoxic medium and were able to transport oxygen. This finding suggests that atmospheric oxygen can diffuse both in newly formed adventitious roots and in porous original roots. DE SIMONE et al. (2002) exclusively investigated porous adventitious roots that had been grown in agar under anoxic conditions. Since the original roots of *S. martiana* die, they cannot provide a long-term pathway for oxygen transport (JUNK personal communication). Lacunae are constitutively formed in *T. pyramidalis* and *P. munguba* and may quickly enlarge in response to anoxia. In both species, aerenchyma formation seems to require the death of parenchymatic cells (lysigenous aerenchyma) (JACKSON & ARMSTRONG 1999; VOESENEK et al. 2006). In *P. munguba*; the remaining ligaments of the cell walls may act as stabilizing elements in the root cortex.

Suberin incrustations in the hypodermal cell layer constitute an apoplastic barrier to water uptake (ZIMMERMANN et al. 2000) and to oxygen diffusion from the root to the rhizosphere (DE SIMONE et al. 2003). ARMSTRONG et al. (2000) proposed that lignification is the anatomic basis of those barriers, but suberin deposits could also contribute to the low permeability of the hypodermal layers. Knowledge regarding the specific contribution of lignin and suberin to barrier function is scant. Oxygen measurements in and around agar-embedded roots together with the visualization of suberin deposits in the hypodermis by fluorescence microscopy indicated that suberin plays the most important role in limiting gas diffusion (DE SIMONE et al. 2002). In the present study, oxygen measurements and fluorescence microscopy together provided information about oxygen transport to the roots, its maintenance in the roots and its loss to the rhizosphere. In *T. pyramidalis*, the suberin barrier maintains cortical oxygen derived from internal transport for metabolism, as evidenced by root elongation. For *T. pyramidalis* the barrier seems to be of particular importance since the irregularly arranged lacunae do not permit highly effective transport. COLMER et al. (1998) and MCDONALD et al. (2001) proposed enhanced longitudinal oxygen diffusion, which would allow greater penetration of the roots into the soil, in response to a hypodermal barrier that reduced oxygen loss as well. Another benefit of the apoplastic barrier may be the decreased influx of potentially toxic substances, for instance, Fe^{2+}, Mn^{2+}, and sulfide, and pathogens (COLMER et al. 1998). Clearly, the moderate amounts of suberin incrustations present in the non-oxygenated roots of *N. amazonum* suit this purpose.

The lack of suberin incrustations in the hypodermis of the roots of *P. munguba* allowed massive radial oxygen diffusion from the well-oxygenated cortex to the anoxic rhizosphere along the entire lengths of the roots. In spite of this massive loss, cortex oxygen concentrations were high and enabled fast elongation and deep penetration of the roots. The oxidation of reduced toxic compounds by lost oxygen creates a protective layer around the roots. This survival strategy was even more pronounced in *S. martiana*. Previous laboratory experiments showed oxygenated layers of up to 1.5 cm wide around the roots of this Amazonian species (DE SIMONE et al. 2002). Microelectrode measurements also showed oxygen in the layers outside the roots that contributed to the oxygen profiles in the rhizosphere of maize (ARMSTRONG et al. 1994), rice (REVSBECH et al. 1999), and *Phragmites australis* (ARMSTRONG et al. 2000). However, most wetland species have a strong barrier to radial oxygen loss in their basal regions and thus release oxygen only in the vicinity of the root apex as *T. pyramidalis* (ARMSTRONG et al. 2000; COLMER 2003; CONNELL et al. 1999; DITTERT et al. 2006; McDONALD et al. 2002). The only exception seems to be the wetland species *Phalaris aquatica*, in which the adventitious roots exhibit radial oxygen loss (McDONALD et al. 2002). To our knowledge, the only woody species that lacks a barrier to radial oxygen loss in its adventitious roots is the Amazonian tree species *S. martiana* (DE SIMONE et al. 2003, 2002). Examinations of several tree species inhabiting the Amazonian inundation forest suggested that only those plants with very high amounts of oxygen in their root cortices (≥ 3 mg l^{-1}, *S. martiana* and *P. munguba*), such as accumulate by massive internal oxygen transport, afford the lack of apoplastic barriers in their hypodermis and thus have a positive influence on the redox potential of their rhizosphere.

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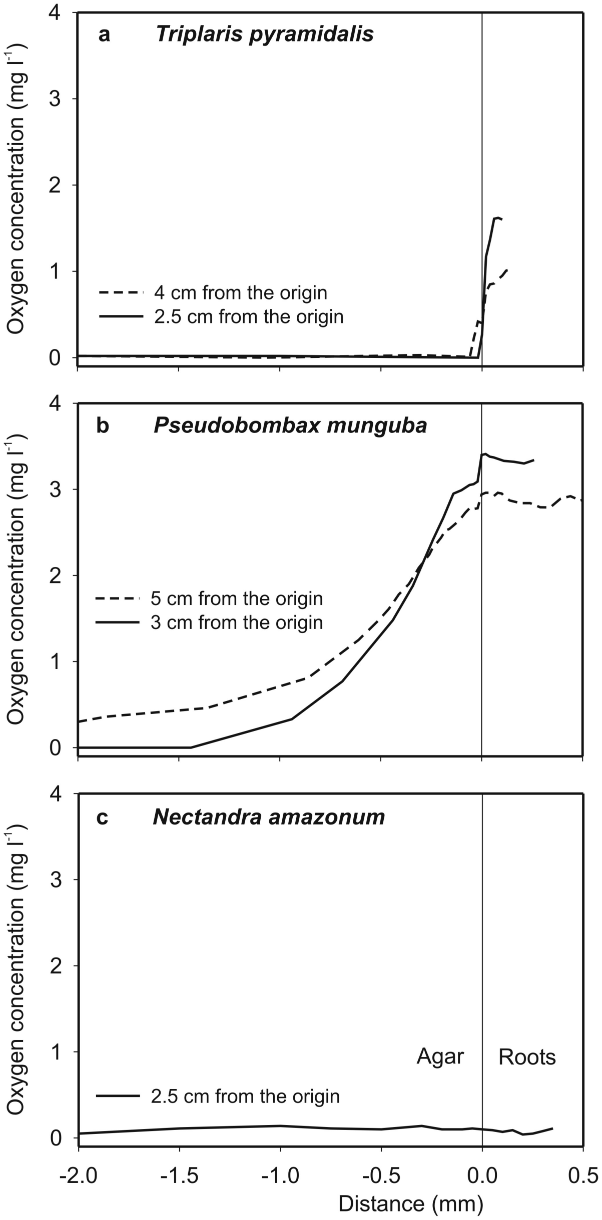

Fig. 1:

Typical oxygen profiles in the rhizosphere, exodermis, and outer cortex of the roots of the examined tree species. The vertical axis (distance 0 mm) indicates the root surface. (a) 5-cm-long original root of *T. pyramidales*. (b) 6-cm-long new root of *P. munguba*. (c) 6- to 7-cm-long original root of *N. amazonum*.

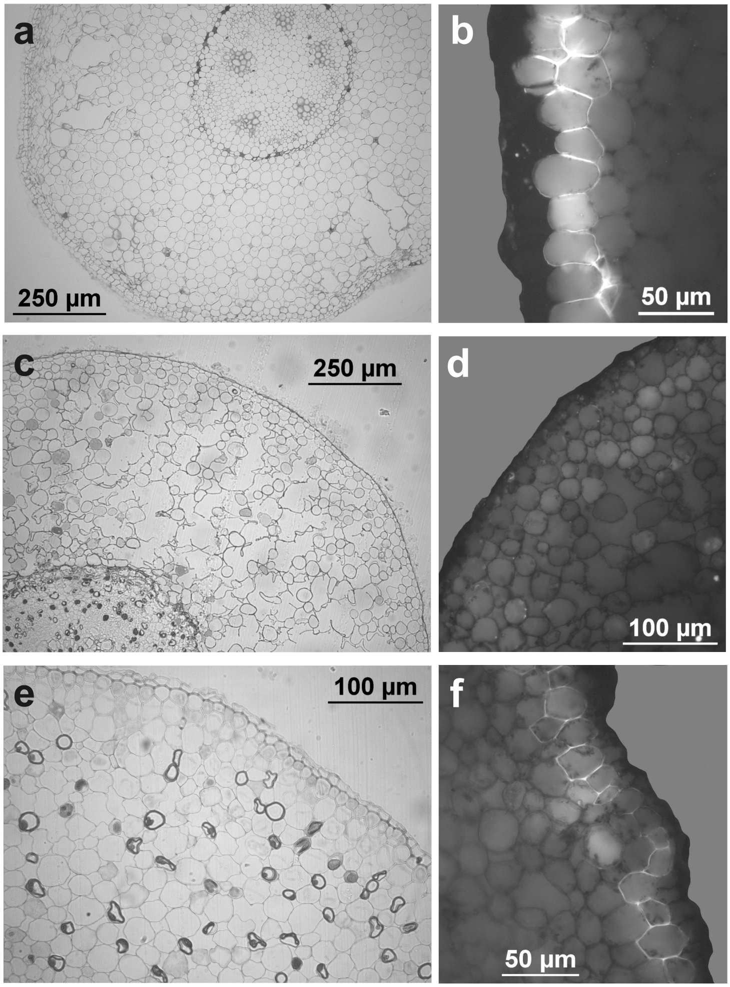

Fig. 2:

Typical transverse sections of roots harvested after 10 weeks of cultivation in stagnant agar nutrient solution. Cross-sections were taken ~1 cm behind the root apex. (**a**) Microtome-cut cross-section of a slowly growing original root of *T. pyramidalis* (5 cm long) stained with toluidine blue and viewed with light-field microscopy. (**b**) Free-hand-cut section of the same root of *T. pyramidalis*. Suberin staining revealed a strongly suberized hypodermis. (**c**) Microtome-cut cross-section of a new root of *P. munguba* (6-7 cm long) stained with toluidine blue and viewed with light-field microscopy. (**d**) Free-hand-cut section of the same root of *P. munguba*. Suberin staining revealed no suberization of the hypodermis. (**e**) Microtome-cut cross-section of an original root of *N. amazonum* (6-7 cm long) stained with toluidine blue and viewed with light-field microscopy. (**f**) Free-hand-cut section of an original root of *N. amazonum*. Suberin staining revealed a moderately suberized hypodermis.

Table 1: Growth rate, cortex oxygen concentration (mean value, measured 2-3 cm from the root origin), and number of comparable measurements and examined roots.

Species	**Growth rate (mm/d)**		**Cortex oxygen concentration**		**Number of of oxygen measurements***	**Number of examined roots**
	Original roots	**Adventitious roots**	**(mg/l)**	**(hPa)**		
T. pyramidalis	2	n.d.	1.5	3.8	8	4
P. munguba	5	5-10	3.4	8.6	8	4
N. amazonum	0	n.d.	0	0	10	5

*Comparable measuring points in each case 2-3 cm from the root origin.

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Anatomia de cinco espécies de macrófitas aquáticas e sua importância para *Cornops aquaticum* (Orthoptera, Acrididae, Leptysminae)

by

M.R.T. Boeger & J. Adis

Prof. Dr. Maria Regina Torres Boeger, Departamento de Botânica, Setor de Ciências Biológicas, Universidade Federal do Paraná, Caixa Postal 19031, Centro Politécnico, 81.531-990 Curitiba/PR, Brasil; e-mail: rboeger@ufpr.br
Prof. Dr. Joachim Adis, Tropical Ecology Working Group, Max-Planck-Institute for Limnology, Postfach 165, 24302 Plön, Alemanha; e-mail: adis@mpil-ploen.mpg.de
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Anatomy of five aquatic macrophytes and its influence on *Cornops aquaticum* (Orthoptera, Acrididae, Leptysminae)

Abstract

The anatomy of leaves, petioles and/or stems in five species of aquatic macrophytes (*Eichhornia crassipes, E. azurea, Pontederia cordata* (Pontederiaceae), *Sagittaria montevidensis* (Alismataceae) and *Ludwigia peploides* (Onagraceae)) were evaluated in respect to alimentation and oviposition of the grasshopper *C. aquaticum*. Plants were collected at Curitiba, Brazil and Corrientes, Argentina. Leaves and petioles, previously fixed in FAA 70, were prepared according to standard techniques of Scanning Electron Microscopy. Except for *L. peploides*, leaves and petioles of the studied species presented well developed aerenchyma. The stoloniferous stem of *L. peploides* had an aerenchymatous cortex but the medulla was compact. The petioles were poorly developed. Based on plant morphology, the species studied can potentially serve for alimentation and, except *L. peploides*, for oviposition of *C. aquaticum*. However, the preference of this grasshopper for Pontederiaceae species appears to involve other factors than anatomical characteristics, which need further investigation.

Keywords: **Leaf, petiole, anatomy, grasshopper, macrophytes, water hyacinth.**

Resumo

A anatomia das folhas, pecíolos e/ou caule de cinco macrófitas aquáticas (*Eichhornia crassipes, E. azurea, Pontederia cordata* (Pontederiaceae), *Sagittaria montevidensis* (Alismataceae) and *Ludwigia peploides* (Onagraceae)) foram avaliadas em relação à alimentação e oviposição do gafanhoto *C. aquaticum*. As plantas foram coletadas em Curitiba, Brasil e Corrientes, Argentina. Folhas e pecíolos, previamente fixados em FAA 70, foram preparadas de acordo com as técnicas usuais para Microscopia Eletrônica de Varredura. Exceto para *L. peploides*, as folhas e pecíolos das espécies estudadas apresentam aerênquima bem desenvolvido. O caule estolonífero de *L. peploides* possui cortex aerenquimático, mas a medula é compacta. Os pecíolos são pobremente desenvolvidos. Baseado na morfologia das plantas, as espécies estudadas potencialmente podem servir de alimentação e, exceto *L. peploides*, para a oviposição de *C. aquaticum*.

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Entretanto, a preferência deste acidídeo por espécies de Pontederiaceae, aparentemente, envolve outros fatores além das características anatômicas que necessitam de investigações futuras.

Introdução

Cornops aquaticum (BRUNER) (Acrididae: Orthoptera) é uma espécie neotropical, associada às populações de macrófitas aquáticas flutuantes, principalmente *Eichhornia crassipes, E. azurea* e *Pontederia cordata*, as quais têm alta dominância em corpos d'água naturais e artificiais (ADIS & JUNK 2003; ADIS et al. 2004). A especificidade deste inseto sobre estas plantas poderá ser relacionada com a presença do tecido aerenquimático que proporciona ótimas condições de oviposição e desenvolvimento dos ovos (HILL & OBERHOLZER 1999; FRANCESCHINI et al. 2005).

A distribuição destas macrófitas aquáticas na America do Sul é variável. *E. crassipes* domina a região norte e propaga-se principalmente por reprodução assexuada (clonal). *E. azurea* domina a região sul e sudeste e propaga-se principalmente por sementes (ADIS et al. 2004). No entanto, outras macrófitas aquáticas ocorrem juntamente com as espécies de *Eichhornia*. *Pontederia cordata*, na América do Sul, ocorre na Argentina, Colômbia e no Brasil desde a região norte até o norte da Região Sul (Paraná) (SANCHES et al. 2000) e propaga-se por meio de sementes e vegetativamente (LORENZI 2000). *Sagittaria montevidensis* ocorre nas regiões subtropicais da América do Sul, sendo que no Brasil é encontrada na Amazônia e Centro-Sul. Propaga-se por sementes e touceiras e é indicadora de ambientes eutrofizados (POTT & POTT 2000). *Ludwigia peploides* apresenta distribuição pantropical, ocorrendo em toda a América Central e do Sul. Propaga-se facilmente por propágulos e por sementes. Considerada espécie invasora, formando tapetes flutuantes que podem bloquear margens dos cursos d'água (POTT & POTT 2000).

Vários estudos indicam que *C. aquaticum* em *E. crassipes* ou *E. azurea* exibem plasticidade fenotípica a respeito de ciclos reprodutivos. Essa variação poderá ser associada ao tipo de reprodução da planta hospedeira e as condições abióticas diferenciadas onde estas plantas ocorrem (ADIS et al. 2004). Em *E. crassipes*, as fêmeas de *C. aquaticum* preferem realizar suas posturas nos pecíolos longilíneos das plantas flutuantes do que nos pecíolos globosos (BISCAIA DE MEDEIROS 1984).

Apesar de se encontrar na literatura descrições detalhadas dos órgãos vegetativos de algumas destas espécies de macrófitas aquáticas (SCULTHORPE 1985; BOEGER 1997; GONZALEZ 2002), pouco se sabe da influência da anatomia das plantas a respeito de oviposição e alimentação de *C. aquaticum*. Assim, este trabalho teve como objetivo comparar a estrutura do limbo foliar e do pecíolo de quatro espécies de macrófitas aquáticas (*Eichhornia crassipes, E. azurea, Pontederia cordata, Sagittaria montevidensis*) e o limbo foliar e o caule de *Ludwigia peploides*, para avaliar a potencialidade destas espécies nas atividades reprodutivas e alimentares deste acridídeo.

Material e métodos

Pecíolos e folhas de *Eichhornia crassipes* (MART.) SOLMS-LAUBACH foram coletadas no Complexo do Rio Iguaçu, Curitiba/PR, Brasil (25°31'49"S, 49°13'23"O). *Eichhornia azurea* (SW.) KUNTH e *Ludwigia peploides* (KUNTH) P.H. RAVEN (Onagraceae) foram coletadas na Lagoa Pampín, Corrientes, Argentina (27°30'S, 58°45'O) e *Pontederia cordata* L. (Pontederiaceae), e *Sagittaria montevidensis* CHAM. & SCHLTDL. (Alismataceae) nas proximidades da Ilha Brasileira, Dep. San Fernando, Chaco, Argentina (27°19'S, 58°46'O), áreas de ocorrência de *C. aquaticum*. Os segmentos dos limbos foliares, pecíolos e caule foram fixados em FAA 70. Posteriormente, o material vegetal foi desidratado em série etílica crescente até etanol absoluto e seco, via ponto crítico, com CO2, em equipamento Bal-Tec CPD 030. As amostras foram montadas em suporte metálico, fixadas com uma mistura de esmalte incolor e grafite e metalizadas com ouro, a vácuo, em equipamento Balzers Union FL 9496 SCD 030. As observações e fotografias foram realizadas em Microscópio Eletrônico de Varredura Jeol (JSM 6360 LV), no Centro de Microscopia Eletrônica da UFPR. Para a análise em microscopia óptica, o material vegetal, após fixação, foi seccionado transversalmente com lâmina de barbear, clarificado em hipoclorito de sódio 10 %, corado com azul de toluidina 1 % solução aquosa, montado em gelatina glicerinada (KRAUS & ARDUIM 1997) e vedado com esmalte de unha incolor.

Resultados

A morfologia das folhas e dos pecíolos de *E. crassipes, E. azurea* e *P. cordata* é bastante semelhante. As folhas são revestidas por epiderme uniestratificada, onde ocorrem estômatos tanto na face adaxial como na abaxial (Fig. 2). O mesofilo é isobilateral, com a ocorrência de parênquima paliçádico em ambas as faces. As lacunas concentram-se na região mediana da folha, assim como os feixes vasculares, que são envolvidos por uma endoderme. As folhas não apresentam tecido esclerenquimático.

O pecíolo também possui uma epiderme uniestratificada, cujas células são revestidas por uma cutícula, que se torna levemente estriada em torno dos estômatos (Fig. 3), quando observada em vista frontal. Os estômatos são escassos, mas estão presentes tanto no pecíolo quanto no limbo.

As lacunas que compõem o aerênquima da folha e do pecíolo, nas duas espécies de *Eichhornia*, variam de tamanho e forma, no mesmo órgão (Fig. 7). Os feixes vasculares apresentam padrão de distribuição disperso. As lacunas são delimitadas nas suas duas extremidades por diafragmas (Figs. 11, 15, 16) que, por sua vez, são compostos por células braciformes (Figs. 15, 17) e comunicam as lacunas. Os diafragmas apresentam uma grande quantidade de cristais de oxalato de cálcio longos e pontiagudos (Figs. 12, 16, 18), denominados de estilóides, sendo estes parcialmente expostos em ambas as faces do diafragma. Células globosas também são freqüentemente encontradas nos diafragmas (Figs. 13, 16-18) das folhas dos pecíolos.

O pecíolo de *P. cordata* apresenta uma organização interna diferente das demais espécies de Pontederiaceae. Este órgão é limitado por uma epiderme uniestratificada. Internamente à epiderme ocorre aerênquima, composto por grandes lacunas, e feixes vasculares dispersos. As lacunas são delimitadas nas suas extremidades por diafragmas. A região cortical delimita uma grande lacuna central que também apresenta diafragma (Fig. 9). Nesse diafragma é possível observar células globosas entre as células braciformes (Fig. 13), semelhantes às encontradas em *E. crassipes* e *E. azurea*.

Sagittaria montevidensis possui limbo com epiderme uniestratificada, com estômatos nas duas faces (Fig. 6) e mesofilo isobilateral com um maior número de camadas do parênquima paliçádico voltado para a face adaxial (Fig. 4). Em função da organização do mesofilo, as folhas são espessas e macias, como as folhas de pontederiáceas. Ocupando a porção mediana inferior da lâmina foliar, ocorrem grandes lacunas delimitadas por diafragmas e os feixes vasculares. As lacunas não são tão pronunciadas como nas espécies de Pontederiaceae. O pecíolo é semelhante, em organização, aos pecíolos de *E. azurea* e *E. crassipes* (Fig. 8). Este órgão, em secção transversal, é formado por epiderme uniestratificada e aerênquima, onde ocorrem os feixes vasculares dispersos. As lacunas são grandes e delimitadas por diafragmas.

O limbo das folhas de *L. peploides* são mais finas quando comparadas com as demais espécies, revestidas por epiderme uniestratificada, com estômatos nas duas faces

(Fig. 5). O mesofilo dorsiventral não mostra lacunas e é formado por duas a três camadas de parênquima paliçádico que ocupam cerca de dois terços da lâmina foliar em secção transversal (Fig. 1). O parênquima lacunoso restringe-se a poucas camadas celulares e é voltado para a face abaxial. Os feixes vasculares localizam-se entre os dois parênquimas clorofilianos. Os pecíolos são bastante curtos e diminutos. Devido a pouca ocorrência de tecidos de sustentação, as folhas não são coriáceas.

O caule estolonífero de *L. peploides* é revestido por uma epiderme uniestratificada, com cutícula pouco espessa que delimita um córtex aerenquimático. As camadas mais externas do córtex são compactas, com poucos espaços intercelulares. As lacunas mais internas são maiores, mas não tão desenvolvidas como as lacunas que ocorrem nos pecíolos das demais espécies. As lacunas não apresentam diafragmas. Internamente ao córtex, ocorre o tecido vascular em crescimento secundário. O tecido cambial é formado por poucas séries de células. Tanto o xilema como o floema são pouco conspícuos, com poucos elementos de condução. A faixa contínua de tecido vascular delimita a medula parenquimática compacta, formada de células isodiamétricas e poucos espaços intercelulares (Fig. 10).

Discussão

Entre as cinco espécies analisadas, quatro espécies (*E. crassipes, E. azurea, P. cordata* e *S. montevidensis*) apresentam folhas com morfologia interna semelhante devido à presença de grandes lacunas, delimitadas por diafragmas. Embora o diafragma varie na forma das células, entre as espécies, a continuidade do sistema vascular é preservada, pela presença dos espaços intercelulares (BLAYLOCK & SEYMOUR 2000).

Outras características comuns entre as folhas das pontederiáceas, são presença de células globosas entre as células do diafragma que GONZALEZ (2002) descreve como células com compostos fenólicos (tanino) e os estilóides pontiagudos que atravessam os diafragmas. Em *S. montevidensis* e *L. peploides* não ocorrem células com compostos fenólicos e/ou estilóides. Entre as espécies estudadas, a folha de *L. peploides* é a única que não possui pecíolo desenvolvido e os tecidos clorofilianos são mais compactos, sem lacunas desenvolvidas. Apesar da diferença de organização do mesofilo, todas as espécies possuem folhas macias (não coriáceas), característica importante no processo de herbivoria do acridídeo.

Os pecíolos das quatro espécies (*E. crassipes, E. azurea, P. cordata* e *S. montevidensis*) também se assemelham em estrutura com a presença marcante do aerênquima. Os diafragmas com estilóides e células com compostos fenólicos também são comuns entre as espécies, com exceção de *S. montevidensis*. Diferente das demais espécies, o caule estolonífero de *L. peploides* possui a maior parte deste órgão ocupado por uma medula parenquimática compacta e o sistema lacunar não é tão desenvolvido como nas demais espécies.

Todas as lacunas observadas nas espécies estudadas devem ser de origem esquizógena, resultado da separação da lamela média entre as células (RAVEN 1996). Apesar da semelhança na estrutura do sistema lacunar, o padrão exato das lacunas pode variar entre espécies do mesmo gênero, podendo servir como critério de identificação (SCULTHORPE 1985). Isto parece mais evidente entre os pecíolos de *P. cordata* e as espécies de *Eichhornia*.

A ocorrência do sistema lacunar em macrófitas tem sido relacionada por vários autores como mecanismo de flutuação e transporte interno de gases. No entanto, RAVEN (1996) indica outras funções dos espaços lacunares como difusão da luz e associação com organismos (domácias).

Os cristais, assim como os compostos fenólicos, são interpretados como uma estratégia de defesa que as folhas das plantas dispõem contra a herbivoria (TURNER 2001; VOLK et al. 2002). Tais estruturas não parecem, no entanto, ser eficazes em defender as pontederiáceas contra a herbivoria causada por *C. aquaticum*. Os cristais e compostos fenólicos são comumente encontrados em macrófitas aquáticas, juntamente com esclereides e células amilíferas (SCULTHORPE 1985; GONZALEZ 2002).

Vários estudos realizados sobre a especificidade de *C. aquaticum* com diferentes espécies de plantas (HILL & OBERHOLZER 1999; FERREIRA & VASCONCELLOS-NETO 2001; VIEIRA & SANTOS 2003) em condições artificiais indicam que o acridídeo tem preferência por espécies de Pontederiaceae, mais precisamente pelas espécies de *Eichhornia*. No entanto, em condições artificiais e utilizando as espécies separadamente, várias espécies vegetais e não relacionadas filogeneticamente com Pontederiaceae proporcionaram substrato adequado para oviposição e desenvolvimento de *C. aquaticum*, tal como a *Canna indica* (HILL & OBERHOLZER 1999). Em algumas espécies vegetais, o desenvolvimento larval não foi completo. Para indivíduos maduros e com capacidade de vôo, a seletividade alimentar é menos restrita, com preferência por pontederiáceas (FERREIRA & VASCONCELLOS-NETO 2001).

A oviposição em Orthoptera está estreitamente relacionada com a dieta do inseto e a utilização de plantas como substrato de oviposição se dá por gafanhotos que se alimentam de poucas espécies de plantas (STAUFFER & WHITMAN 1997). *Cornops aquaticum* é um inseto oligófago, devido à sua preferência por algumas espécies vegetais. Entretanto, a oviposição de fêmeas e a alimentação de ninfas sobre a vegetação aquática requerem algumas exigências como folhas emergentes e presença de tecido aerenquimático no pecíolo (HILL & OBERHOLZER 1999). *C. aquaticum* alimenta-se de tecidos macios com sua mandíbula específica do tipo parênquima-forvíboro. As ninfas raspam sobre a epiderme foliar e os adultos roem o parênquima (GANGWERE & RONDEROS 1975).

Com base apenas na estrutura anatômica das folhas e dos pecíolos (que são muito semelhantes entre as quatro espécies *E. crassipes, E. azurea, P. cordata* e *S. montevidensis* no que diz respeito à presença de um extensivo sistema lacunar e a ocorrência de folhas emergentes) é possível afirmar que *C. aquaticum* pode utilizar estas espécies como hospedeiras para alimentação e oviposição. A presença de células com compostos fenólicos e cristais de oxalato de cálcio (estilóides) não parece ser impedimento para as atividades reprodutivas e alimentares do acridídeo. As características morfológicas da folha de *L. peploides*, como a ausência de um sistema lacunar bem desenvolvido na folha e no caule estolonífero, assim como a ausência de pecíolos longos, aparentemente não favorecem as atividades reprodutivas do acridídeo, porém, devido à ausência de tecidos de sustentação, as folhas são macias, o que pode favorecer os hábitos alimentares de *C. aquaticum*.

Entretanto, os experimentos em condições artificiais demonstraram que várias espécies com ausência de um sistema lacunar bem desenvolvido também podem servir de substrato para oviposição e alimentação (HILL & & OBERHOLZER 1999; LHANO et al. 2005; VIEIRA & SANTOS 2003). Em algumas das espécies utilizadas come fonte alimentar nestes experimentos (p.ex. *Saccharum officinarum, Oryza sativa*) foi observado o desenvolvimento de ninfas até o 3° e 4° estádio, que danificaram fortemente estas espécies (LHANO et al. 2005). Isto indica que a presença do sistema lacunar bem desenvolvido não é condição exclusiva para a alimentação, em experimentos de laboratório.

Assim, baseado na anatomia, as espécies vegetais estudadas apresentam potencial para servirem para alimentação e, exceto *L. peploides*, para oviposição de *C. aquaticum*. Porém, sua preferência por pontederiáceas parece envolver diversos fatores além das características anatômicas os quais necessitam de maior investigação. Por exemplo, a composição química das plantas tem sido mencionada como um dos fatores que determinam significativamente a especificidade dos insetos fitófagos, especialmente no processo de oviposição (BERNAYS & CHAPMAN 1994).

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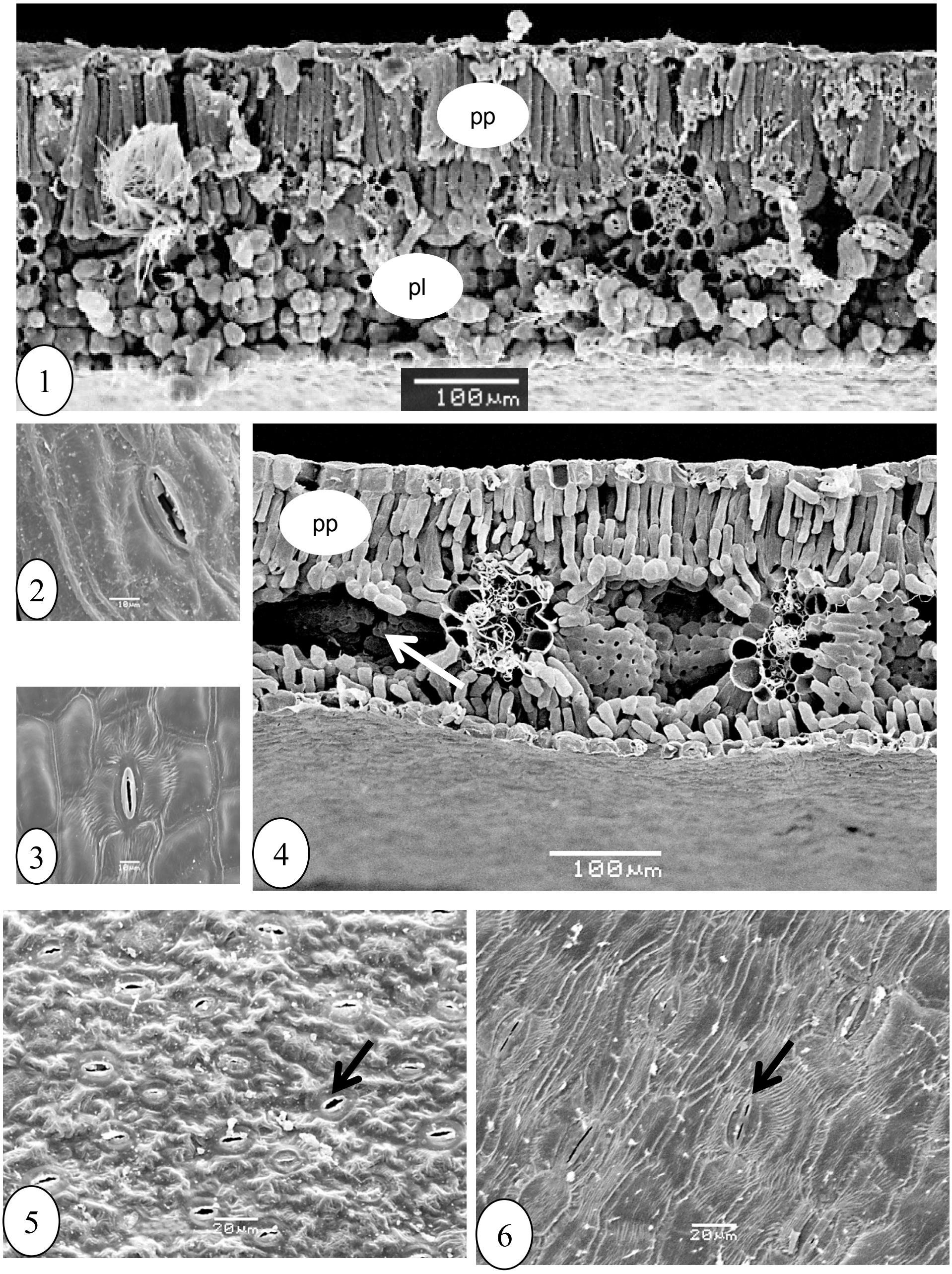
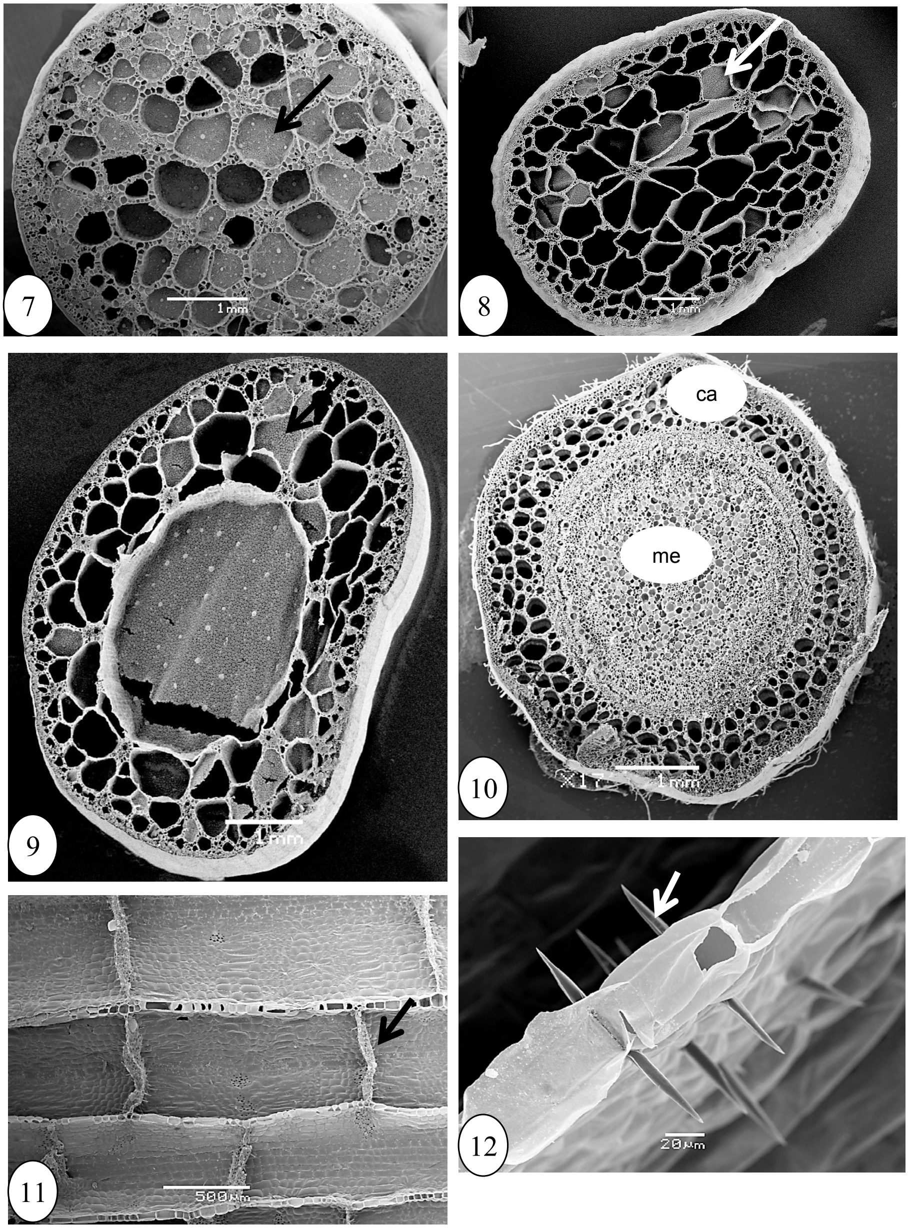


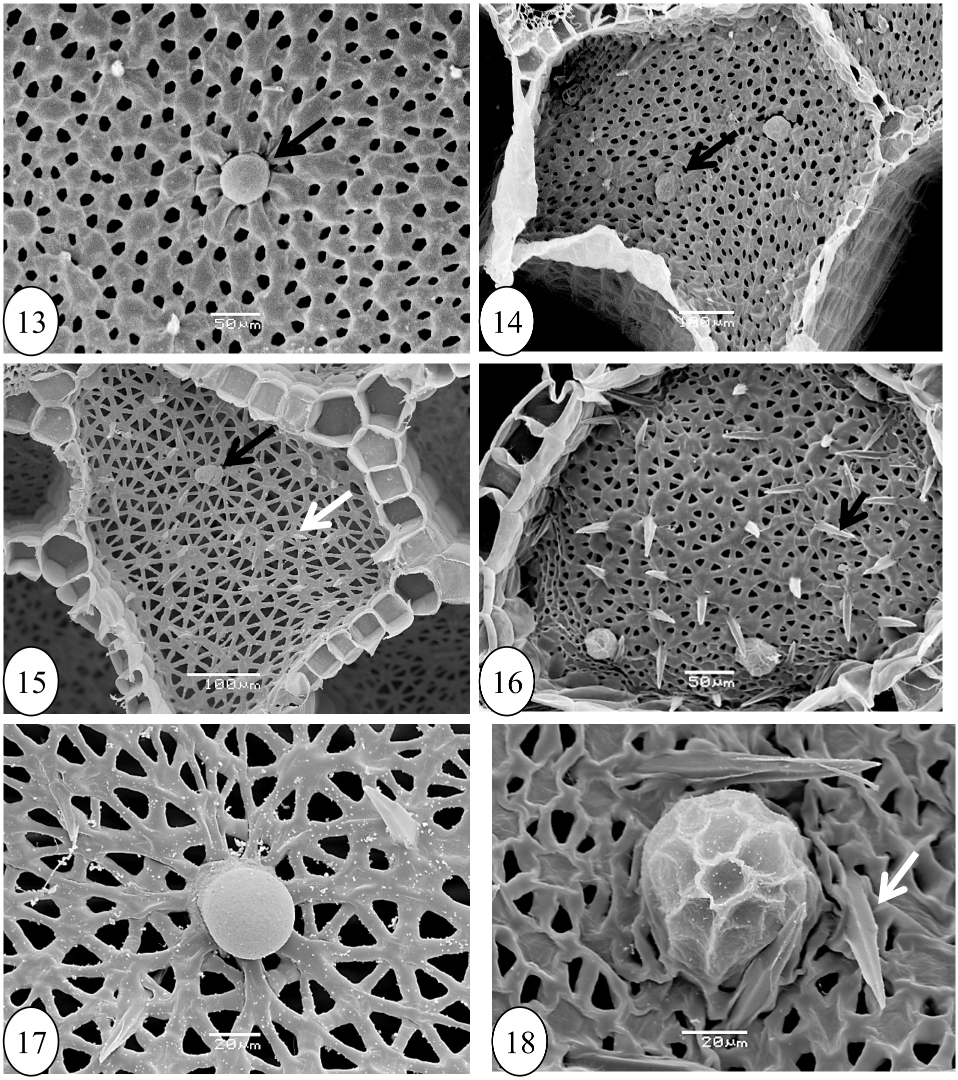
Figs. 1-6:

1: Secção transversal da folha de *Ludwigia peploides* (pp - parênquima paliçádico; pl - parênquima lacunoso); **2**: Detalhe do estômato da epiderme foliar de *Eichhornia azurea*; **3**: Detalhe do estômato da epiderme foliar de *Eichhornia crassipes*; **4**: Secção transversal de folha *Sagittaria montevidensis* (pp - parênquima paliçádico, seta branca indica lacuna); **5**: Superfície foliar da face adaxial da folha de *Ludwigia peploides* (seta preta indica estômato); **6**: Superfície foliar da face adaxial da folha de *Sagitaria montevidensis* (seta preta indica estômato).



Figs. 7-12:

7: Secção transversal do pecíolo de *Eichhornia azurea* (seta preta indica lacuna com diafragma); **8**: Secção transversal do pecíolo de *Sagittaria montevidensis* (seta branca indica lacuna com diafragma); **9**: Secção transversal do pecíolo de *Pontederia cordata* (seta preta indica lacuna com diafragma); **10**: Secção transversal do caule de *Ludwigia peploides* (ca - córtex aerenquimático, me - medula); **11**: Secção longitudinal do pecíolo de *Eichhornia crassipes*, evidenciando as lacunas (seta preta indica diafragma); **12**: Detalhe dos cristais de oxalato de cálcio (estilóides - indicado pela seta branca) cruzando as células do diafragma, em *Eichhornia crassipes*.



Figs. 13-18:
13: Detalhe do diafragma do pecíolo de *Pontederia cordata*, evidenciando célula globosa com tanino (indicada por seta preta); **14**: Detalhe da lacuna do pecíolo de *Pontederia cordata*, evidenciando o diafragma (seta preta indica célula com compostos fenólicos); **15**: Detalhe da lacuna do pecíolo de *Eichhornia crassipes* evidenciando células braciformes (seta preta indica células com compostos fenólicos, seta branca indica estilóide); **16**: Detalhe da lacuna do pecíolo de *Eichhornia azurea* evidenciado as células braciformes do diafragma e cristais de oxalato de cálcio (indicado pela seta preta); **17**: Detalhe do diafragma do pecíolo de *Eichhornia crassipes* com célula globosa com tanino; **18**: Detalhe do diafragma do pecíolo de *Eichhornia azurea* com célula globosa com tanino (seta branca indica estilóide).

AMAZONIANA XIX (3/4): 209-216 Kiel, June 2007

Temperatura y fotoperíodo: qué influencia ejercen en el desarrollo ninfal de *Cornops aquaticum* (Orthoptera: Acrididae)?

by

S. Capello, J. Adis & M.L. de Wysiecki

Lic. Soledad Capello, Instituto Nacional de Limnología (INALI-CONICET-UNL), José Maciá 1933, 3016 Santo Tomé, Santa Fe, Argentina; e-mail: solecapello1@yahoo.com.ar
Prof. Dr. Joachim Adis, Instituto Max-Planck para Limnología (Ecologia Tropical), Plön, Alemania; e-mail: adis@mpil-ploen.mpg.de
Dr. María Laura de Wysiecki, Centro de Estudios Parasitológicos y de Vectores (CEPAVE), Calle 2 nº 584, 1900 La Plata, Argentina; e-mail: mlw@cepave.edu.ar
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Temperature and photoperiod: what affects the nymphal development of *Cornops aquaticum* (Orthoptera: Acrididae)?

Abstract

Development of the semi-aquatic acridid *Cornops aquaticum* on *Eichhornia crassipes* (Pontederiaceae) was investigated in the laboratory. Influence of constant (12 and 27 °C) and variable (36/3 °C and 36/4.5 °C) temperatures as well as constant (24 h day) and variable (14 h day/10 h night) photoperiods were analysed. The highest survival of nymphs (69 %) was obtained under an extreme photoperiod (24 h day) and constant temperature (27 °C). Both temperature and photoperiod were important for the development and number of nymphal stages, indicating a synergic effect.
Keywords: **temperature, photoperiod, nymph, development, Acrididae, *Cornops*.**

Resumen

El desarrollo del acrídido semi-acuático *Cornops aquaticum* sobre *Eichhornia crassipes* (Pontederiaceae) fue investigado en laboratorio. Se analizó la influencia de temperaturas constantes (21 y 27 °C) y variables (36/3 °C, y 36/4,5 °C) y de fotoperíodos constantes (24 h día) y variables (14 h día/10 h noche). La mayor supervivencia de ninfas (69 %) se obtuvo con el fotoperíodo extremo (24 h día) y temperatura constante (27 °C). Tanto la temperatura como el fotoperíodo resultaron importantes para el tiempo de desarrollo y el número de estadios ninfales, indicando un efecto sinérgico.

Introducción

Cornops aquaticum (BRUNER, 1906) es un acrídido que habita desde el sudeste de México hasta el centro de Argentina y Uruguay, desarrollando su ciclo de vida sobre diferentes especies de *Eichhornia* spp. (Pontederiaceae), especialmente *Eichhornia crassipes* y *E. azurea* (ADIS et al. 2007).

Eichhornia crassipes es considerada de origen sudamericano y ha sido introducida

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en África, Asia, Australia y América del Norte como especie ornamental donde, por su rápida dispersión y adaptabilidad, se ha extendido en una proporción alarmante, causando serios problemas económicos que la han llevado a ser considerada la peor maleza tanto en los cuerpos de agua leníticos como lóticos (GOPAL 1987; JULIEN & GRIFFITHS 1998).

Diversos estudios acerca del ciclo biológico e impacto alimentario de *C. aquaticum* están siendo llevados a cabo por la posibilidad de que este acrídido sea utilizado como controlador biológico de *Eichhornia* spp. (ADIS & JUNK 2003; FERREIRA & VASCONCELLOS-NETO 2001; OBERHOLZER & HILL 2001; SILVEIRA GUIDO & PERKINS 1975; VIEIRA & SANTOS 2003; FRANCESCHINI et al. 2005).

Existen varios factores externos que pueden influenciar el tiempo de desarrollo y el número de estadios ninfales en los artrópodos. Entre los principales se encuentran la insolación anual, el fotoperíodo, la temperatura, la alimentación y el parasitismo, entre otros. Distintos trabajos mencionan que el fotoperíodo sería el factor que mayor incidencia tiene en los ciclos vitales estacionales (NYLIN & GOTTHARD 1998; DAVID et al. 2003; TANIGUCHI & TOMIOKA 2003). Sin embargo, para otros autores (OMKAR 2002; ROY et al. 2002, PIESIK 2006), la temperatura es el principal factor que influencia la tasa de desarrollo en los insectos y determina todas las funciones biológicas (SAMIETZ et al. 2005). Con respecto a *C. aquaticum*, ADIS et al. (2004) mostraron que existe variación en la cantidad de estadios y tiempo de desarrollo según la temperatura y/o fotoperíodo a las que son expuestas las ninfas.

Teniendo en cuenta lo anteriormente expuesto, el objetivo del presente trabajo es analizar la influencia de distintas temperaturas y fotoperíodos en el ciclo de vida de *C. aquaticum*, así como evaluar posibles efectos sinérgicos.

Material y métodos

Se realizaron crías de *C. aquaticum* a distintas temperaturas y fotoperíodo (luz día de 60W): Cría I - 36/3 °C y 14/10 h día/noche (condiciones naturales); Cría II - 27 °C y 14/10 h luz/noche; Cría III - 27 °C y 24 h luz; Cría IV - 36/4,5 °C y 24 h luz; Cría V - 21 °C y 14/10 h luz/noche.

Las ninfas del primer estadio fueron recolectadas sobre plantas de *Eichhornia crassipes* durante enero y febrero de 2005 en lagunas ubicadas en la llanura aluvial del Río Paraná Medio (Santa Fe, Argentina). Para identificarlas se utilizó la medida del fémur posterior (de 3-4 mm de longitud) de acuerdo a FRANCESCHINI et al. (2005). Las ninfas fueron colocadas individualmente en recipientes de aproximadamente 250 ml, con algodón humedecido en la base junto con hojas de *E. crassipes* y tapados con film transparente.

En las Crías I y III se utilizaron 26 individuos, respectivamente; mientras que las Crías II, IV y V se realizaron con 25 individuos cada una. Cada dos días se renovaron las hojas de *E. crassipes* y se registraron los datos para obtener la supervivencia, la duración de cada estadio y el número de estadios por sexo.

Solamente fueron considerados los datos de las ninfas que alcanzaron el estado adulto. Para efectuar las mediciones los individuos fueron manipulados con tul, a fin de no dañarlos; las exuvias fueron etiquetadas y conservadas en alcohol al 90 %.

Para determinar si había diferencias significativas entre los atributos medidos de las diferentes crías, se aplicó GLM (General Lineal Model) con ANOVA ($\alpha = 0,05$) y homogeneidad avalada por el Test de LEVENE utilizando el programa SPSS 7.5, previa transformación de los datos a log10. Se utilizó la prueba de KRUSKAL-WALLIS para comparar crías y la prueba de MANN-WHITNEY para comparar pares de crías, del programa estadístico XLSTAT 7.5.3

Resultados

La mayor supervivencia de las ninfas (69,2 %), se registró en la Cría III con temperatura (27 ˚C) y fotoperíodo (24h luz) constantes. En la Cría V (21 ˚C, 14/10 h luz/-noche), sólo 2 ninfas llegaron hasta el tercer estadio (Fig. 1, Tabla 1).

En la Cría I (condiciones naturales: 36/3 ˚C, 14/10 día/noche), 16 individuos (5 machos y 11 hembras), alcanzaron el estado adulto. La duración media fue de 43,0 ± 13,2 días (Tabla 1). Los machos representaron el 31,3 % del total de ninfas y tuvieron 5 estadios ninfales. De las hembras (68,7 %), seis (37,5 %) tuvieron 5 estadios ninfales y cinco (31,2 %) 6 estadios ninfales (Figs. 2, 3).

En la Cría II (27 ˚C, 14/10 h luz/noche), 14 individuos (6 machos y 8 hembras) alcanzaron el estado adulto, con una duración media de 36,1 ± 5,3 días (Tabla 1). Los machos representaron el 42,9 % del total de ninfas y tuvieron 5 estadios ninfales. De las hembras (57,1 %), siete (50,0 %) tuvieron 5 estadios ninfales y una (7,1 %) tuvo 6 estadios ninfales (Figs. 2, 3).

En la Cría III (27 ˚C, 24 h luz), 18 individuos (8 machos y 10 hembras) llegaron a adultos en 32,7 ± 4,9 días (Tabla 1). Los machos representaron el 44,4 % del total de ninfas, siete (38,8 %) tuvieron 5 estadios ninfales y uno (5,6 %) tuvo 6 estadios. De las hembras (55,6 %), cuatro (22,3 %) tuvieron 5 estadios ninfales y seis (33,3 %) 6 estadios ninfales (Figs. 2, 3).

En la Cría IV (36/4,5 ˚C, 24 h luz), 13 individuos (7 machos y 6 hembras) llegaron a adultos en 74,9 ± 14,6 días (Tabla 1). Los machos representaron el 53,8 % y tuvieron 5 estadios ninfales. Las hembras (46,2 %) tuvieron 5 estadios ninfales (Figs. 2, 3). En este tratamiento se registró el estado ninfal más largo, ya que, aunque se observaron 5 estadios tanto en hembras como en machos, el tiempo promedio de cada estadio fue el mayor en las restantes crías (Tabla 1).

Comparando el tiempo promedio de duración de cada estadio entre las diferentes crías, hubo diferencias significativas entre las cuatro crías (KRUSKAL-WALLIS: p <0,0001), por siendo la cría IV, donde se observó la mayor duración del ciclo (Tabla 1).

Analizando los resultados de las crías con igual temperatura (Cría II y Cría III), no existieron diferencias significativas en la duración del estadio ninfal (KRUSKAL-WALLIS: p = 0,098). En la Cría III se registró 1 macho con 6 estadios ninfales y la proporción de hembras con 6 estadios fue mayor que en la Cría II (33,3 % y 7,1 % respectivamente), registrándose diferencias significativas en la cantidad de estadios ninfales (MANN-WHITNEY: p = 0,043).

Los resultados de las crías con igual fotoperíodo se dividieron en dos grupos para el análisis: las Crías I y II con un fotoperíodo de 14 horas de luz y las Crías III y IV con 24 horas de luz. En el primer grupo las ninfas fueron sometidas 14 horas de luz y 10 horas de noche. Se observó que las ninfas de la Cría II tardaron, en promedio, menos tiempo en llegar al estado adulto que la Cría I, pero la cantidad de estadios ninfales fue similar (MANN-WHITNEY: p = 0,105). En cambio, cuando la luz fue constante (Cría III y IV), se observaron diferencias significativas tanto en la cantidad de estadios ninfales (p = 0,012) como en el tiempo de desarrollo de las ninfas (p <0.001) (Tabla 1). La cantidad de días que tardaron las ninfas en llegar al estado adulto no fue significativamente diferente para el sexo (F = 0,03; p = 0.866) pero sí para las diferentes crías realizadas (F = 47,2; p <0,001).

Discusión

La mayor supervivencia (69,2 %) se observó cuando la temperatura y fotoperíodo fueron constantes (Cría III: 27 ˚C, 24 h luz), coincidiendo con lo obtenido por AMO-

RIM & ADIS (1995) para *Stenacris f. fissicauda* (Orthoptera: Acrididae) en Amazonia Central. Una temperatura constante más baja (21 °C) junto con la luz oscilante (Cría V: 21 °C, 14 h luz, 10 h noche), aparentemente representa una situación desfavorable para las ninfas jóvenes resultando en una mortalidad total.

Los resultados demostraron que, ante una temperatura óptima (Cría II y III: 27 °C) hay una influencia del fotoperíodo sobre el desarrollo de *C. aquaticum*. Cuando el fotoperíodo fue constante y extremo (Cría III: 24 h), apareció un estadio ninfal adicional (6° estadio) en los machos, aunque en muy bajo porcentaje (7,1 %) y aumentó la proporción de hembras con 6 estadios (Fig. 3). Además, en esta cría se registró la mayor supervivencia y el menor tiempo de desarrollo. ADIS et al. (2004), encontraron un efecto del fotoperíodo sobre la cantidad de estadios en *C. aquaticum* en Amazonia Central sólo en hembras.

En las Crías III y IV se observó que la diferencia de estadios fue consecuencia de la temperatura, ya que ambas crías fueron sometidas al mismo fotoperíodo (Fig. 3, Tabla 1). Estos resultados contradicen la idea tradicional de que la temperatura afecta principalmente al tiempo de desarrollo, mientras que el fotoperíodo influye en la cantidad de estadios.

Se pude concluir que, para el desarrollo de ninfas de *C. aquaticum* es fundamental el efecto de la temperatura para completar exitosamente toda la fase. Si la temperatura de cría es óptima, el fotoperíodo comienza a cobrar importancia dependiendo si éste es variable o constante, pero no siempre actúa sobre la cantidad de estadios, demostrando que las variables ambientales actúan sinérgicamente.

Agradecimientos

Esta contribución forma parte de los proyectos Host-Insect Co-evolution on Waterhyacinth (HICWA) del Instituto Max-Planck para Limnología en Plön, Alemania (www.mpil-ploen.mpg.de).

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Tabla 1: Tiempo mínimo y máximo (A) y tiempo medio con desvío estándar (B) de días por estadio para el desarrollo ninfal completo en las distintas crías.

		Cria I	**Cría II**	**Cria III**	**Cria IV**	**Cria V**
Temperatura		36/3 ºC	27 °C	27 °C	36/4,5 °C	21 °C
Fotoperíodo		14/10 h	14/10 h	24 h	24 h	14/10 h
Supervivencia (%)		61,5	56,0	72,0	54,2	0
Estadio 2	A	6 - 10	6 - 10	4 - 11	6 - 16	-
	B	7,6 ± 1,4	7,3 ± 1,3	6,3 ± 2,5	8,2 ± 3,0	-
Estadio 3	A	4 - 17	4 - 9	4 - 7	9 -18	-
	B	9,0 ± 3,0	7,3 ± 1,5	6,1 ± 1,5	13,2 ± 2,7	-
Estadio 4	A	5 - 14	7 - 13	3 - 12	14 - 23	-
	B	11,0 ± 2,5	8,9 ± 1,8	7,1 ± 1,9	13,3 ± 2,7	-
Estadio 5	A	9 - 20	8 - 16	6 - 14	25 - 58	-
	B	15,0 ± 2,9	11,8 ± 2,1	8,5 ± 1,0	37,6 ± 9,7	-
Estadio 6	A	13 - 33	12	8 - 11	-	-
	B	22,0 ± 9,1	12,0	9,8 ± 1,1	-	-
TOTAL	A	28 - 71	28 - 47	25 - 41	58 - 107	-
	B	43,0 ± 13,2	36,1 ± 5,3	32,7 ± 4,9	74,9 ± 14,6	-

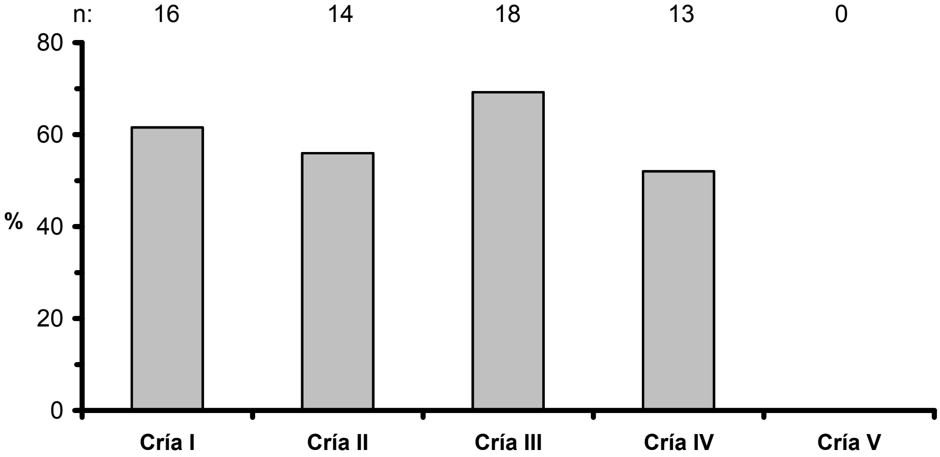

Fig. 1:
Supervivencia (porcentaje y número total) de ninfas que alcanzaron la etapa adulta en cada cría.

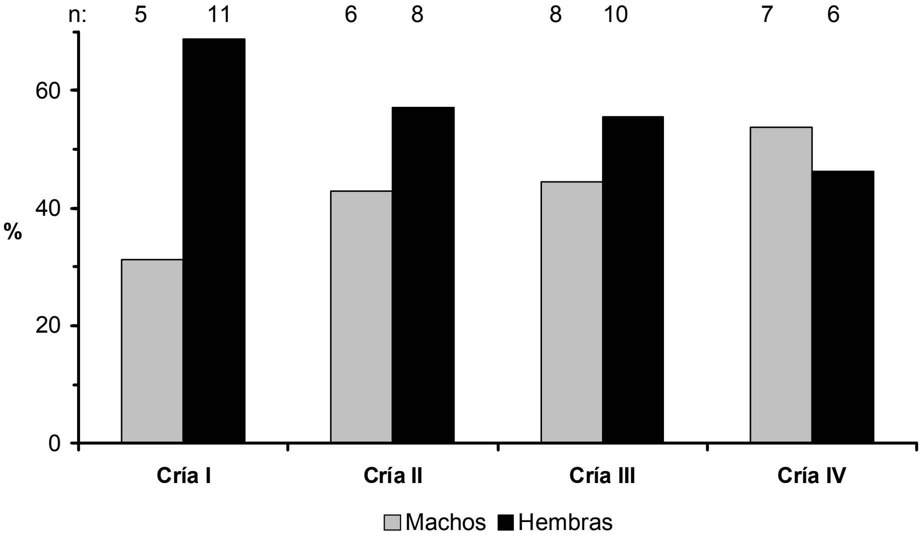

Fig. 2:
Porcentaje y número total de machos y hembras de cada cría. Se excluyó la cría 5 debido a que no hubo adultos.

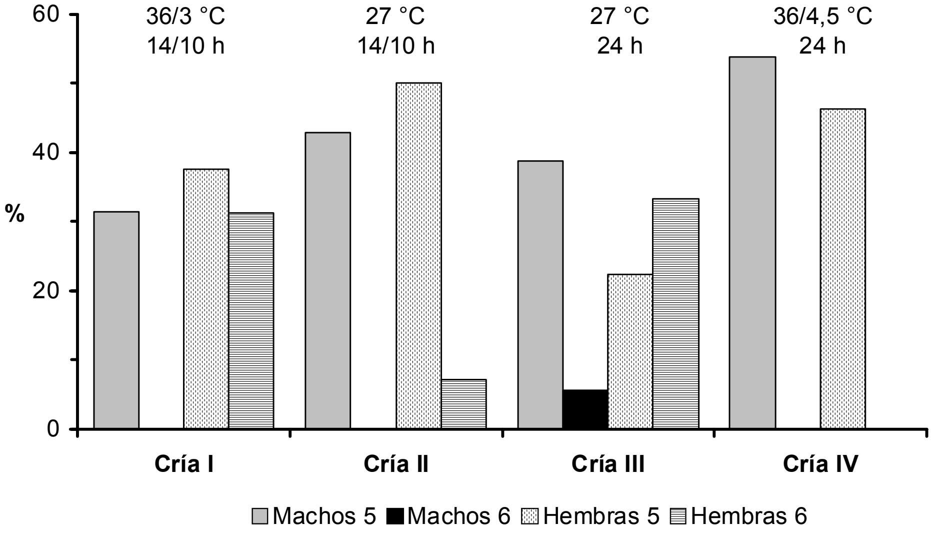

Fig. 3:
Porcentaje total de machos y hembras (con 5 y 6 estadios ninfales, respectivamente) en cada cría. Se excluyó la cría 5 debido a que no hubo supervivencia.

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Book review

POR, F.D., IMPERATRIZ-FONSECA, V.L. & F. LENCIONI NETO: Biomes of Brazil: An Illustrated Natural History. PENSOFT Publishers, Sofia-Moscow. First published: 2005, 207 pp. English and Portuguese, ISBN 954-642-237-1; 39.50 Euro.

Purpose of the book:

The purpose of the book is primarily didactic and popular-science. The amount of information and the way of presenting it to the reader makes it a very valuable textbook for interested laymen, students and scientists. The text is written in English and Portuguese, thus making the information accessible also for Brazilian and other Portuguese and Spanish speaking readers.

Contents:

After an introduction, the book describes in eight chapters the following biomes: Atlantic rain forest, Araucaria forests, Cerrado Savannas, Pantanal of Mato Grosso, Campos Rupestres and Tepuis, Caatingas Dry Forests, Amazonia, and the Mangrove Forests.

The chapters present a general overview of the major aspects of the biomes, such as extension, geography, geology, soil cover, recent climate and paleoclimate, floristic physiognomy, floristic diversity, animals and animal diversity (invertebrates, fishes, amphibians, reptiles, birds and mammals), types of water bodies and the hydrochemical conditions, aquatic flora and fauna therein. Some paragraphs deal with specific driving forces in the different biomes, e.g., fire in the cerrado, floods and droughts in the Pantanal, and tides in the mangrove forests. Several paragraphs are devoted to the use of the different biomes by man. Case studies show the potential and threats of different management methods and efforts of protection.

The book is nicely illustrated. All figures are didactically well conceived drawings and schemes of high artistic value. A short list of selected references provides additional information for the interested reader. The paper, binding and printing quality of this hard-cover book are high. The mongraph is an excellent synthesis of knowledge of the eight most important biomes of Brazil and can be recommended to anyone interested in the natural history and ecology of South America in general and of the country in particular.

Prof. Dr. Wolfgang J. Junk
Tropical Ecology Working Group
Max-Planck-Institute for Limnology
Postfach 165
24302 Plön, Germany

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Book review

TUDORANCEA, C. & M.M. TUDORANCEA: Danube Delta: Genesis and Biodiversity: 2006, xvi and 444 pp., with 89 figures and 66 tables, hardbound; Backhuys, Leiden; ISBN 90-5782-165-6; (Biology of Inland Waters Series); 156.00 Euro.

My first international congress, organized by the Association of Aquatic Vascular Plants, led me in 1969 to Bucharest. My memory of many of the certainly interesting lectures read at the conference fails after so many years elapsed since, but I clearly remember an excursion to the Danube Delta. I had just returned from 20 months of field-work in the central Amazon floodplain with the conviction that European wetlands could no longer impress me. To my great surprise, I immediately changed my mind when I saw the vast delta, the incredible complexity of the habitats, the tremendous biodiversity, the large flocks of herons and pelicans, and the "plaurs" of *Phragmites* recalling the floating islands in the Amazon. At present, the status of the Danube Delta as a biosphere reserve, Ramsar site, and World Natural Heritage emphasizes its importance in an international context.

One of the memories left by the conference was that many of the reprints distributed there were in Rumanian, so unfortunately of little use to me and most of my colleagues. Therefore, I welcome with great pleasure and satisfaction the publication of this book in English, which now makes comprehensive information available worldwide.

The book is divided into a preface, written by eminent Professor H.B.N. HYNES, and 16 chapters. Each chapter provides an ample list of references that allow specialists to obtain more information if required. The introduction (Chapter 1) provides general information about the delta and the objectives of the book. Chapter 2, on Danube Delta geology, geomorphology, and geochemistry, outlines the dramatic changes the delta underwent during the post-glacial era through the interaction of the sea, wind, Danube River and, finally, human activities.

Chapters 3 and 4 introduce the physiography, climate and hydrological regime. On the macro-scale, the hydrological system is simple. As the water level rises, the delta receives water from the channels, while as the water level falls, the delta devolves it to the channels. However, on smaller scales, the hydrology becomes very complex because the channels transport different amounts of water, fluxes vary between different parts of the delta, sediment deposition and aquatic macrophytes may temporarily or permanently block channels, and man-made channels and dikes interfere with the natural flood regime. Unfortunately, little importance is attributed to the impact of the Black Sea on the hydrology of the delta.

The complex hydrological conditions are reflected by changes in water chemistry. This is illustrated in Chapter 5, which deals with the chemistry of the Danube Delta. Four different classes are distinguished: (1) fluvial waters, (2) fluvial-deltaic waters, (3) deltaic waters, and (4) maritime-deltaic waters. Since the 1980s, increasing eutrophication has been observed as the consequence of an increased nutrient input from the entire Danube River basin. In the beginning of the 1960s, the input of pesticides and, in the 1980s, that of heavy metals rose. Their distribution patterns within the delta follows the sedimentation pattern. Different levels of retention capacity of the different ecosystems in the delta are demonstrated. Bioaccumulation of heavy metals in organisms within the delta is shown.

Chapter 6 provides information on the ecosystems of the Danube Delta. The authors delimit 10 units: Danube branches, shallow ponds and channels, lakes, lagoons, river banks, marshes, marine sand banks, land plains, marine shore, and calcareous islands, with many habitat types and subtypes. Emphasis is placed on description of palustrine and aquatic macrophyte communities, including the reed island

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community ("plaur") and the related aquatic invertebrate fauna.

Chapter 7 focuses on phytoplankton and its primary production. An impressive number of 1098 algal species have been identified to date. This large number is attributed to habitat diversity. Algal biomass and primary production increased with increasing nutrient input from the watershed in the beginning of the 1980s, and blooms of cyanobacteria now occur frequently in some lakes. Special reference is made to the phytoplankton in the contact zone of the delta with Black Sea waters.

In Chapter 8, aquatic macrophyte communities are characterised according to their growth forms. Despite *Phragmites australis* being the dominant species, covering almost 160,000 ha, species diversity is high. Examples of changes in species composition of macrophyte communities are given, and their reasons discussed. Biomass and primary production values are provided that show the importance of macrophytes for carbon fixation in the delta. Special emphasis is placed on nutrient cycling and feed-back mechanisms.

Chapter 9 focuses on zooplankton structure and productivity. The taxonomic spectrum of the delta's lacustrine environment over a 20-year study period includes 562 species or subspecies. Rotifers and copepods play determinant roles in the diversity of the plankton community. The abundance is relatively low. Cladocerans, copepods and rotifers are dominant in zooplankton productivity. Examples show that large habitat diversity and intra-annual and inter-annual changes in environmental conditions lead to profound spacio-temporal variation and dynamics. Emphasis is placed on the complex interactions between aquatic macrophytes, phytoplankton and zooplankton. Anthropogenic eutrophication in the 1980s increased the phytoplankton production but decreased the number of aquatic macrophytes, the diversity, abundance, biomass and productivity of the zooplankton community.

Chapter 10 summarises the knowledge of the benthic fauna. The latter currently comprises 296 species, including palaearctic and holarctic forms introduced to the Danube River, Pontoazov-Caspian relicts, Mediterranean species, and a gastropod species from the southern hemisphere. The benthic communities vary between habitats, as shown by descriptions of the communities of the mainstream, lakes, ponds and new marine lagoons. Increasing eutrophication leads to a decrease in species diversity.

A special chapter (Chapter 11) is devoted to the Oligochaeta communities because they are nice indicators of changes in the environmental conditions and they also play important roles in food webs and in the recycling of nutrients. Increasing eutrophication led to an increase in the numbers and biomass of Oligochaeta in the impoverished benthic community. Special emphasis is placed on the impact of Oligochaeta populations on the recycling of nitrogen and phosphorus.

Aquatic macrophytes are well-known as representing an important habitat for aquatic invertebrates. However, methodological problems have limited the number of studies compared to those on zooplankton and benthos. Chapter 12 covers the weed-bed fauna and provides valuable information on this group. With 353 species, the weed-bed fauna is highly diverse. Temporal and spacial variation in species composition and abundance is large. Phytophile chironomids, gastropods, oligochaetes, gammarids and caddisflies are dominant groups. Of special interest is the migration of weed-bed species between bottom and macrophyte beds triggered off by the disappearance of macrophytes during the winter.

Books on wetland ecosystems only rarely provide information on microbial communities. Therefore, Chapter 13, which encompasses benthic microbial communities, is most welcome. The temporal and spatial evolution of heterotrophic microorganisms is shown to depend on seasonality and sediment type. A decrease in microbial numbers from the sediment surface to deeper sediment layers is documented. Organic matter decomposition in sediments take place mostly under anoxic conditions. Accumulation of organic matter exceeds decomposition.

There has always been a lot of interest in the ichthyofauna of the Danube Delta because of its importance for fishery. With 69 species known in the region and 47 species registered in 1992, fish diversity is very high by European standards. Natural interspecific hybridisation occurs. Several exotic species have been introduced, and about 10 have established permanent populations. The presence of 23 species of marine origins point to an interaction between the delta and the Black Sea. Different migrating behaviours of the species correspond to those in other large river deltas. Information is given on the age structure of the fish populations, individual growth rates, reproduction, as well as food and feeding behaviour. Fish yield decreased dramatically from the 1970s to the end of the 20th century not only because of Danube regulation, industrial impoundments in the delta, and changes in its trophic status, but also because of overfishing, intentional reduction of predatory species, and changes in the composition of fish stocks. Some species face extinction.

The species-rich and abundant avifauna is most attractive for visitors to the delta. Of the more than 300 species present there, more than half breed in the delta. Furthermore, the delta is an important stepping stone for migrating species. After a description of important representatives of the breeding avifauna, the migrating species are characterised. An ample paragraph deals with biogeographical aspects, another with the bird fauna of different habitats. The latter part shows a link between habitat diversity and species diversity. During the 20th century, the delta lost 11 breeding species but gained 18 species which extended their ranges.

Of special interest is interpreting the data over a period of about a century by authors of most of the chapters, showing not only a decline but sometimes also recovery of plant and animal populations and linking them to natural and human-induced environmental changes. Chapter 16 discusses the human presence and activities in the delta since the first reports about 2500 years ago. Fishery has lost importance because of stock reduction. Agriculture has dramatically increased in the Danube floodplain and, to a minor extent, in the delta, being, together with other factors, a reason for the severe environmental changes. Reed harvesting has been a tradition for one century in the delta and is considered as an ecologically sound activity when properly managed. Ecotourism may become a future activity of economic interest and may help protect the Danube Delta. The international value of the delta has called attention to its protection. Plans to restore some modified parts of the delta are described. However, a considerable part of the problems derive from the impact of the large human population in the catchment area. The political challenge for the protection of the Danube Delta is to achieve international cooperation of the nine countries participating in the catchment area and to efficiently combine protection measures of the entire Danube River, its major tributaries, and their floodplains with national efforts to protect and restore the delta itself in Rumania and the Ukraine. The book illustrates the complex human impacts on wetland ecosystems and the need for long-term over-regional strategies to protect them.

This book provides an important contribution to the understanding of large European wetlands, and I enjoyed reading it. I recommend it not only to all students and scientists interested in the subject, but also to environmental managers and planners.

Prof. Dr. Wolfgang J. Junk
Tropical Ecology Working Group
Max-Planck-Institut for Limnology
Postfach 165
24302 Plön, Germany

AMAZONIANA XIX (3/4): 223-224 Kiel, June 2007

Book review

WALKER, I.: The evolution of biological organization as a function of information. 319 pp, paperback. Manaus: Editora INPA, 2005. ISBN 85-211-0021-3; 35.- Reais, about 15.- Euro.

This relatively small book (290 pages, excluding the list of references) can serve as a marvelous introduction to modern biology by summarizing the latest progress achieved in virtually all branches of this science. This book's core is rooted in numerous, relevant publications (331 references), and well thought-out by the author who shows the rich background both of an academic and of a field explorer. It is noteworthy that in contrast to a standard textbook, this publication is distinguished by a wide range of specific facts presented from a broad philosophical and methodological viewpoint. The entire material is thereby arranged in a highly logical order.

The book consists of 17 chapters, each subdivided into 2 to 9 paragraphs with their own subtitles. Rubrication within each of the paragraphs is very strict, each new topic being preluded with its notion and shown italicized. Such an exhaustive division is highly rational, and allows the reader to be confidently guided in the sea of abundant factual material by following the author's cross-references to previous and subsequent chapters. Most of the chapters are concluded with a brief summary that emphasizes the problems requiring further insights.

Chapter 1 (Introduction) states "The objective in writing this book is to present a synthesis of thirty years of research into basic biological and biophysical patterns of structure and functions on cellular and supra-cellular levels of organization". Ilse Walker addresses the concepts and methodologies of biophysics, this being specifically accentuated in this chapter, with the following declaration. The ways of analysis and interpretation are consciously reductionist, since "all principles and processes should be explained in terms of the three classical, physical parameters of *Mass* in *Space* and *Time*, mass being quantified in terms of *Force* (for example weight) in *four-dimensional phase-space*" (emphasis original).

However, as this becomes increasingly clear while reading the book, its true pathos lies in that, in the biological systems, the category of information is admitted analogous to the category of force. Chapter 4 states that "In analogy to *force* in classical physics, *information* can be measured as the effect it imposes on respective target systems". Here, this being generally characteristic of the author, she refers to a simple example taken from our everyday life: a red traffic light affects all participants of road traffic as directly and immediately as if the transport were blocked by an insurmountable barrier.

The first 8 chapters are devoted to the problems of epistemology and methodology. Such overall scientific categories as system complexity, information code, chance, entropy, symmetry of space and time etc. are treated therein. The essence, as well as the explanatory forces of our cognition of biological systems are discussed, in particular the different levels of their organization. Mathematical theories of information are denoted as being of limited applicability to biological system analysis.

Analogy methods are treated in due detail, these being repeatedly applied further on by emphasizing the similarities of the organizational principles controlling biological systems, that range from subcellular to biocoenotic. The analogy methodology is also widely used as a highly efficient didactic instrument. This part of the book gives clear-cut and strict analytical concepts to the main notions, many of which such as order, complexity, information, redundancy etc., appear to be considerably devalued by their commonplace usage. As a rule, these notions are reinforced due to simple and popular examples like the above concerning traffic light.

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The following 7 chapters provide a detailed analysis of the informational processes leading, in the course of evolution, to progressive sophistications of organization (Chapters 9 and 10) and further, to a maintenance of the integrity and functional efficacy of biological systems at all hierarchical levels i.e. from subcellular (Chapters 11 and 12) to populational (Chapter 13) and biocoenotic (Chapters 14 and 15). Chapters 16 (Conclusion and Discussion) and 17 (Epilogue) summarize the main ideas expressed earlier.

Among the numerous topics dealt with in the book we wish to pay special attention to the way the author presents the latest research data concerning the "editorship" of errors in various stages of translation of genetic information into morphogenetic processes, i.e. DNA and mRNK repair, somatic repair mechanisms (Chapter 11). The much-debated problem of competition is considered at a new, original angle (Chapter 14). This topic is continued in Chapter 15, stipulating that the traditional views of competition cannot be applied to tropical ecosystems so characteristically rich in closely related symbiotic species. The validity of the theoretical statements formulated in the beginning of this chapter are illustrated by the original studies the author conducted using as model, the benthal communities of small rivers in Central Amazonia.

Ilse Walker's great learning allows her to confidently cope with any branch of modern biology, from molecular genetics to population ecology and community organization. The examples she quotes concern the entire range of living organisms, from bacteria and unicells to the higher mammals and *Homo sapiens*. Due to her truly encyclopaedic knowledge, combined with an analytical mentality, the author can present well-known facts at new, unexpected angles. Such is her original "necklace principle" to clearly show a deep biological meaning of genetic code redundancy.

This book and its clear style can be recommended both to professional and specialist biologists alike, in order to broaden their philosophy, whilst allowing the non-specialists to become acquainted with the basics of life sciences, especially the great progress achieved there over the past few decades.

The only serious reproach to be addressed to the author lies in lack of a glossary. A generalist publication like the reviewed one with so many complex topics, terms and ideas revised or revisited, would certainly gain a lot if it had a glossary. In addition, the book could have been hardbound, thus extending its life over that of the loose paperback edition currently available.

Dr. Evgeny N. Panov and Dr. Sergei I. Golovatch
Institute for Problems of Ecology and Evolution
Russian Academy of Sciences
Leninsky pr. 33
Moscow 119071, Russia

AMAZONIANA XIX (3/4): 225 Kiel, June 2007

Scientific note

Pontederia rotundifolia (Pontederiaceae): host plant of *Cornops brevipenne* (Leptysminae: Acrididae: Orthoptera)

by

C.E. Braga & J. Adis

B.Sc. Carlos Elias de Souza Braga, Projeto INPA/Max-Planck, Caixa Postal 478, 69011-970 Manaus/AM, Brazil; e-mail: bragaelias@yahoo.com.br
Prof. Dr. Joachim Adis, Tropical Ecology Working Group, Postfach 165, 24302 Plön, Germany; e-mail: adis@mpil-ploen.mpg.de
(Accepted for publication: February, 2007).

According to ADIS et al. (2007), the native host plant of the Neotropical grasshopper *Cornops brevipenne* ROBERTS & CARBONELL, 1979 is unknown.

During an excursion in August, 2006 to the mixedwater floodplains in the vicinity of Manaus, Central Amazonia, the authors observed occurrence of six nymphs (early and late instars), six males and three females feeding intensively on leaves of the macrophyte *Pontederia rotundifolia* L. (Pontederiaceae). It was the only Pontederiaceae species present in the surroundings. Occurrence of early instar nymphs together with adults and one copulating couple on top of a plant leaf indicate reproduction of *C. brevipenne* on this macrophyte species.

Material examined and deposited at Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil: Amazonas, Manaus, Lago Janauarí (03°20'S, 60°17'W), 10 August 2006 (C.E. BRAGA), 1 male, 1 female.

As to the distribution, additional material was located from Leticia, Colombia, representing a new country record. *C. brevipenne* is now known from Bolivia, Brazil, Colombia, Ecuador and Peru.

Material examined by C. AMEDEGNATO and deposited at the Muséum national d'Histoire naturelle, Paris, France: Colombia: Leticia (04°09'S, 69°57'W), August 1975, (C.H.F. ROWELL), 1 male.

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AMAZONIANA XIX (3/4): 227-231 Kiel, June 2007

Nota Científica

Cornops frenatum frenatum (MARSCHALL, 1836) (Orthoptera, Acrididae, Leptysminae): Ocorrência e oviposição em quatro espécies de *Heliconia* (Heliconiaceae) na Amazônia Central, Brasil

by

C.E. Braga, A.L. Nunes & J. Adis

M.Sc. Carlos Elias de Souza Braga, Bolsista de Pós-graduação, Projeto INPA/Max-Planck, Caixa Postal 478, 69011-970 Manaus/AM, Brasil; e-mail: bragaelias@yahoo.com.br
Dra. Ana Lúcia Nunes Gutjahr, Pesquisadora colaboradora do Museu Paraense Emílio Goeldi/MPEG, 66077-530 Belém/PA, Brasil; e-mail: alnunes@museu-goeldi.br
Prof. Dr. Joachim Ulrich Adis, Tropical Ecology Working Group, Postfach 165, 24302 Plön, Germany; e-mail: adis@mpil-ploen.mpg.de

(Accepted for publication: March, 2007).

Scientific Note

Cornops frenatum frenatum (MARSCHALL, 1836) (Orthoptera, Acrididae, Leptysminae): Occurrence and oviposition on four species of *Heliconia* (Heliconiaceae) in Central Amazonia, Brazil

Introdução

Cornops frenatum frenatum (MARSCHALL, 1836) é um gafanhoto de distribuição Neotropical, que pode ser encontrado desde Trinidad, Colômbia, Venezuela, Guiana Francesa, Suriname, Brasil, Peru e até na Bolívia e Paraguai (ROBERTS & CARBONELL 1979; ADIS et al. 2007). Possui hábito semi-aquático ou terrestre e que segundo TURK & AQUINO (1996) desenvolve seu ciclo de vida preferencialmente em *Eichhornia crassipes* (Pontederiaceae) e *Canna* spp. (Cannaceae), mostrando-se ocasional em *Heliconia* spp. (Heliconiaceae) (ADIS et al. 2007). Contudo, informações sobre *C. f. frenatum* na Região Amazônica ainda são praticamente inexistentes. Os dados contidos nesta nota científica, visam contribuir para o conhecimento de aspectos biológicos dessa espécie de gafanhoto.

Ocorrência

Observou-se nos meses de abril, maio, agosto, dezembro de 2006 e março de 2007 a ocorrência de adultos e ninfas de *C. f. frenatum* nas seguintes espécies de *Heliconia*: *H. stricta* HUBER, *H. psittacorum* L.F., *H. tarumaensis* HUBER e *H. hirsuta* L.F. no

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Bosque da Ciência (02°59'S, 60°00'W), que é um fragmento florestal localizado no município de Manaus, Amazonas, Brasil, que pertence ao Instituto Nacional de Pesquisas da Amazônia (INPA). Para confirmação da espécie do gafanhoto, coletou-se adultos com rede entomológica, que foram transportados e examinados no laboratório em estereomicroscópio (WILD M3C), auxiliado por chave dicotômica e descrição segundo ROBERTS & CARBONELL (1979). A identificação das espécies de *Heliconia* citadas foi realizada por um pesquisador especialista da Coordenação de Pesquisas em Botânica (CPBO/INPA). Também, observou-se, durante uma excursão em agosto de 2006, ao Rio Tarumã-Mirim, Manaus (03°02'S, 60°17'W) a ocorrência de *C. f. frenatum* em *Heliconia tarumaensis* numa floresta secundária de terra firme. Na ocasião se coletou cinco adultos (2 machos e 3 fêmeas) e uma ninfa do gafanhoto, a identificação foi confirmada no laboratório (Figura 1).

Oviposição

Em dezembro de 2006, no início do período chuvoso na Região Amazônica, e em março de 2007, foi observado no Campus de Pesquisa I do INPA (02°59'S, 60°00'W) um grande número de ninfas em estádios iniciais, algumas em estádios mais avançados e adultos de *C. f. frenatum*, além de inúmeras marcas de oviposição endofítica de gafanhotos Leptysminae (NUNES & ADIS 1992) em *H. stricta, H. hirsuta, H. psittacorum* e *H. tarumaensis*. Algumas plantas com características semelhantes foram coletadas. No laboratório as plantas foram examinadas, constatando-se a presença, no pecíolo foliar, de oviposições endofíticas que seguramente eram de *C. f. frenatum* (Figura 2). Essa afirmação é baseada na realização de uma análise minuciosa na vegetação de entorno e nas próprias plantas de Heliconia da área mencionada, onde se constatou apenas a presença de espécies de gafanhotos da subfamília Ommatolampinae que realizam oviposições no solo, com exceção de *C. f. frenatum* que realiza oviposição endofítica (PFROMMER 1990). Os pecíolos foliares foram dissecados e no interior das plantas, observou-se a presença de ovos que comprovam a oviposição desse gafanhoto nessas espécies de Heliconia (Figura 2). A disposição dos ovos no interior das plantas obedeciam ao padrão já observado para outros Leptysminae (NUNES & ADIS 1992).

Dessa forma, as observações citadas neste trabalho, confirmam as afirmações feitas por PFROMMER (1990) que verificou o desenvolvimento de *C. f. frenatum* em diferentes espécies de *Heliconia*. Embora *C. f. frenatum* apresente hábitos de alimentação (fitófago) e de oviposição (endofítica), que podem prejudicar o desenvolvimento das helicônias, mesmo quando em grandes populações, esse gafanhoto ainda não é considerado uma praga dessas plantas. Segundo ASSIS et al. (2002), são reconhecidos como insetos pragas em plantações de grande escala de helicônias, voltadas ao comércio de plantas ornamentais, as espécies dos gêneros: *Atta* (Hymenoptera: Formicidae), *Antichloris* (Lepidoptera: Amatidae), *Calligo* e *Opsiphanes* (Lepidoptera: Brassolidae), *Castnia* (Lepidoptera: Castniidae) e *Dysmicoccus* (Hemiptera: Aphididae). Por isso, estudos que visem à confirmação de que o gafanhoto *C. f. frenatum* seja potencialmente praga de cultivares de helicônias são extremamente necessários.

Agradecimentos

Os autores agradecem a Dra. Ieda Leão do Amaral da Coordenação de Pesquisas em Botânica do INPA pela identificação das espécies de *Heliconia* mencionadas neste trabalho. Agradecem também ao Projeto INPA/MAX-PLANCK pela organização da excursão ao Rio Tarumã-Mirim, que possibilitou observações

valiosas, contidas neste trabalho.

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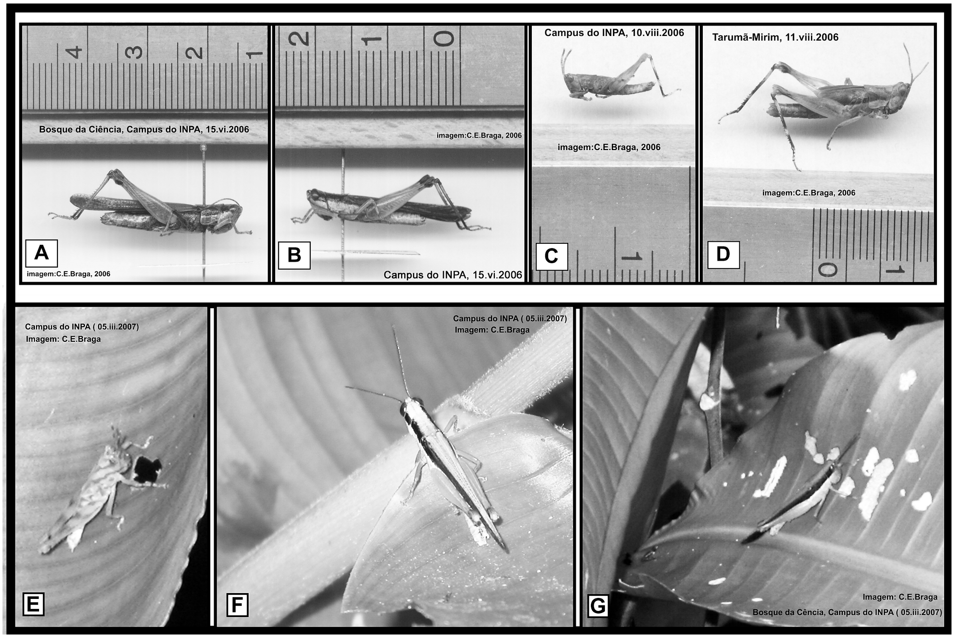
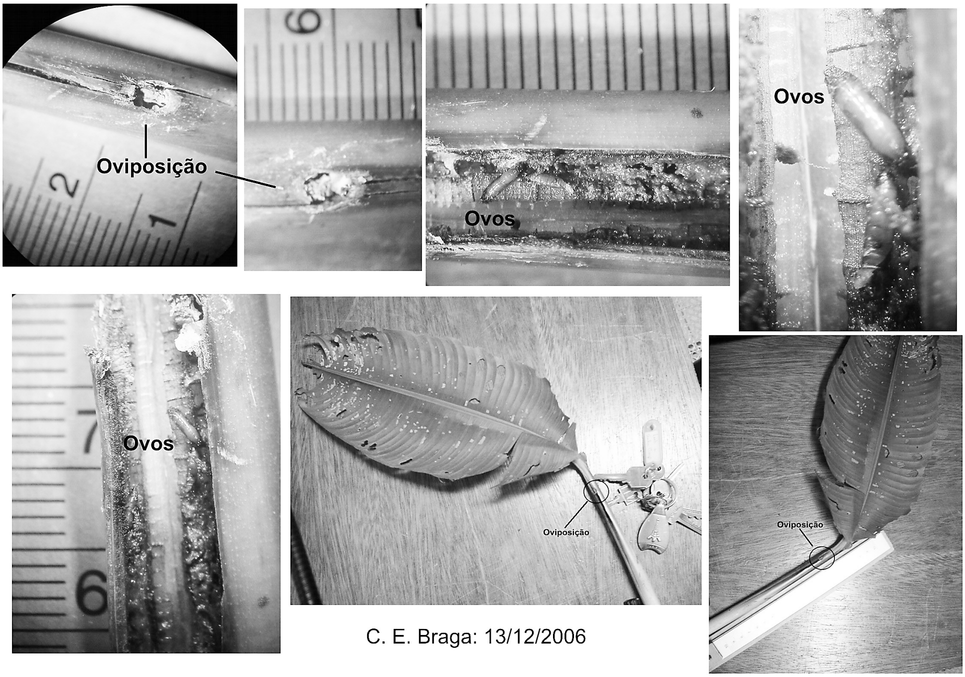


Fig. 1:

Cornops frenatum frenatum coletados em *Heliconia* spp.: Adultos coletados no Bosque da Ciência (INPA - Manaus/AM): **A**: fêmea; **B**: macho. Ninfas: **C**: coletada no Campus I do INPA; **D**: coletada no Tarumã-Mirím-AM. *C. f. frenatum* em habitat natural: **E**: Ninfa se alimentando em *H. psittacorum* (Campus I do INPA); **F**: Adulto (macho) em *H. hirsuta* (Campus I do INPA); **G**: Adulto (fêmea) se alimentando em *H. stricta* (Bosque da Ciência).



C. E. Braga: 13/12/2006

Fig. 2:
Oviposição de *Cornops frenatum frenatum* em *Heliconia*. Material coletado no Campus do INPA I em Dezembro 2006.

AMAZONIANA XIX (3/4): 233-234 Kiel, June 2007

Buchbesprechung

SIOLI, H.: Gelebtes, geliebtes Amazonien: Forschungsreisen im brasilianischen Regenwald zwischen 1940 und 1962: 2007, 228 Seiten, 2 Farb- und 61 Schwarzweißabbildungen, 1 Expeditionskarte. Herausgegeben und bearbeitet von Gerd Kohlhepp. Hardcover, 24,5 x 17,3 cm; Verlag Dr. Friedrich Pfeil; ISBN 978-3-89937-071-3; Euro 38,00.

Nach einem einfühlsamen Vorwort des Herausgebers und langjährigen Lateinamerika--Forschers Prof. Gerd Kohlhepp beschreibt Harald Sioli kurz seinen Weg nach Amazonien und danach sein Leben und Forschen am Amazonas in 7 Kapiteln mit jeweils 3-6 reich bebilderten Unterkapiteln. Die Kapitel umfassen unterschiedliche Zeitabschnitte, die von seiner Reise- und Forschungstätigkeit aber auch von politischen Ereignissen bestimmt wurden. Sie geben ein eindrucksvolles Zeugnis von der faszinierenden Flusslandschaft des Amazonas und seinen Nebenflüssen, seiner Menschen und seiner Städte. Neben den Reisebeschreibungen gibt er dem Leser Einblicke in seine Forschungstätigkeit, die ein Gebiet der Wissenschaft erschloss, das vor ihm in Amazonien noch niemand detailliert behandelt hatte, der Gewässerkunde auch Limnologie genannt. Er erweiterte die vorwiegend deskriptive Naturbeschreibung früherer Reisender durch Methoden der modernen Naturwissenschaften. Er erfasste Amazonien als Einheit von Wasser, Wald, Boden und Klima und verfolgte damit einen landschaftsökologischen Forschungsansatz, der erst einige Jahrzehnte später von der Ökologie im großen Rahmen aufgegriffen wurde. Seine wissenschaftlichen Einsichten vermittelt er dem Leser beiläufig ohne ihn zu ermüden.

Harald Sioli kam nach Amazonien vor dem Zweiten Weltkrieg und lernte das Gebiet in einer Phase des Umbruchs kennen. Die "goldene Gummizeit" war lange vorbei, und das Gebiet wieder weitgehend in Vergessenheit geraten. Die Menschen entlang der Flüsse lebten in Armut von Subsistenzwirtschaft, hatten aber ihr Auskommen, da die Ansprüche gering, und die Natur großzügig war. Das Gefühl der Hilflosigkeit, das er häufig bei seinen Besuchen im Landesinneren empfand, so z.B. am Urariá Anfang 1941 gegenüber der von einer Malaria-Epidemie heimgesuchten Bevölkerung oder 1942 am Cururú (Masern-Epidemie), verstärkte seinen Respekt vor der Natur aber auch vor dem Lebenswillen der lokalen Bevölkerung. Zugleich förderten diese Reisen aber auch sein Misstrauen gegenüber europäisch-amerikanischen Kolonisationsformen, die er schon damals häufig als nicht an die lokalen Bedingungen angepasst empfand. Wegen dieser kritischen Einstellung, die sich mit zunehmendem Alter und wachsender Lebenserfahrung verstärkte, wurde Sioli schon in den 70er Jahren zum unermüdlichen und unbequemen Mahner gegen die Umweltzerstörung in Amazonien.

Dann kam der Zweite Weltkrieg dessen Auswirkungen in Amazonien die wenigen Ausländer verspätet erreichten. Es zeugt von der lockeren Lebenseinstellung der Brasilianer, dass die Internierung der Deutschen und Japaner erst verspätet und dann relativ

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lax gehandhabt wurde. Für Sioli brachten die 3 Jahre Internierung in Tomé-Açú insofern eine Erweiterung seiner Lebenserfahrungen, als er im Hospital aus Mangel an Ärzten als Krankenbetreuer arbeiten musste, eine Arbeit, für die er nicht ausgebildet war, die er aber mit großem Engagement übernahm. Ähnlich zwanglos ergab sich Sioli's Rückkehr in das normale Leben nach dem Kriege. Er erhielt sofort eine Anstellung am Landwirtschaftlichen Institut in Belem, und konnte seine Studien in Amazonien weiterführen.

In den folgenden Jahren begründete er mit seinen Untersuchungen die Gewässertypen Amazoniens und verband sie mit den geologischen Gegebenheiten ihrer Einzugsgebiete. Dabei musste er sich einfachster chemischer Untersuchungen bedienen. Er schloss von der Elektrolytarmut der Gewässer auf Nährstoffarmut in den Böden und postulierte eine geringe landwirtschaftliche Produktionskapazität der Region. Wie ihm das Beispiel seines Freundes Rettelbusch in Belem zeigte, kann diese zum Teil durch geschlossene Nährstoffkreisläufe überwunden werden, zum Beispiel bei der Kombination von Intensivhaltung von Rindern und Hühnern und der Pflanzung von hochwertigem Pfeffer auf an sich armen Böden, deren Fruchtbarkeit durch Düngung mit dem Mist aus der Tierhaltung weitgehend erhalten werden konnte.

1955 wechselte Sioli an das Nationale Amazonasforschungsinstitut (INPA) in Manaus, das erst provisorisch in wenigen Räumlichkeiten im Zentrum von Manaus untergebracht war, sich in den 70er Jahren jedoch zu einem modernen Forschungsinstitut wandelte. Seine Tätigkeit am INPA wurde zwar 1957 durch seine Berufung an das Max-Planck-Institut für Limnologie unterbrochen, aber nicht beendet. Seine Liebe zu Amazonien führte dazu, dass er das Plöner Institut in zwei Abteilungen teilte und mit seiner Abteilung Tropenökologie die Amazonasforschung in modernem Stil weiterführte, wobei ihm das INPA als Partnerinstitut diente. Damit gab er der deutschen Tropenökologie eine institutionelle Basis und verschaffte ihr internationale Anerkennung.

Ich war der erste Doktorand, den Prof. Sioli 1967 nach Manaus schickte. Manche der Persönlichkeiten, die er in seinen Memoiren beschreibt habe ich noch kennengelernt, einige der Flüsse, die er bereist hat habe auch ich bereist, wenn auch unter weit weniger abenteuerlichen Bedingungen. Die Faszination Amazoniens hat auch mich gepackt und deshalb kann ich sagen, dass Sioli's Memoiren eine eindrucksvolle, authentische Beschreibung Amazoniens in der Übergangszeit zur Moderne darstellen. Mit bewunderungswürdiger Akribie hat er über lange Jahre konsequent Tagebuch geführt. Diese Aufzeichnungen bilden die Basis dieses einmaligen Werkes. In einem kurzen, sehr informativen Nachwort hat der Herausgeber, Herr Prof. Kohlhepp, die weitere Entwicklung Amazoniens zusammengefasst. Es zeigt wie rasend schnell sich das Gebiet verändert. Herr Prof. Sioli würde "sein" Amazonien heute kaum wiedererkennen. Umso lesenswerter sind seine Memoiren, die ich allen an dem Gebiet interessierten Lesern nur wärmstens empfehlen kann.

Prof. Dr. Wolfgang J. Junk
Tropical Ecology Working Group
Max-Planck-Institute for Limnology
Postfach 165
24302 Plön, Germany

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