



Land Flatworms (Platyhelminthes: Tricladida) in Remnants of Deciduous Forest in the Northeast Region Of Southern Brazil

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AMARAL, S.V., HACK, I.R., ITURRALDE, G.G., LEAL-ZANCHET, A.M. Land Flatworms (Platyhelminthes: Tricladida) in Remnants of Deciduous Forest in the Northeast Region Of Southern Brazil. Biota Neotropica. 14(1): e20130045. <http://www.biotaneotropica.org.br/v14n1/en/abstract?inventory+bn00714012014>

Abstract: Land flatworms show high endemism due to their restricted mobility. In southern Brazil, land flatworm communities have been found mainly in areas of ombrophilous forests. Thus, this study documents land planarian species composition in remnants of deciduous seasonal forest in the northeast region of southern Brazil. Direct, diurnal samplings reveal the occurrence of 26 species of land flatworms, of which one belongs to the subfamily Rhynchodeminae and the others to the subfamily Geoplaninae. The Rhynchodeminae genus *Rhynchodemus* Leidy 1851 and the following Geoplaninae genera occurred: *Cephaloflexa* Carbayo & Leal-Zanchet, 2003, *Choeradoplana* Graff, 1896, *Imbira* Carbayo et al., 2013, *Issoca* Froehlich, 1955, *Luteostriata* Carbayo, 2010, *Obama* Carbayo et al., 2013, *Paraba* Carbayo et al., 2013, *Pasipha* Ogren & Kawakatsu, 1990 and *Xerapoa* Froehlich, 1955, besides the collective group *Pseudogeoplana* Ogren & Kawakatsu, 1990. The genus *Obama* had the highest species richness (S=6), followed by *Paraba* (S=4) and *Pasipha* (S=3). Eighteen species were recorded exclusively in one of the two study areas, and eight species occurred in both sites. The known distribution of *Luteostriata abundans* (Graff, 1899), *Choeradoplana iheringi* Graff, 1899, *Obama ficki* (Amaral & Leal-Zanchet, 2012), *Imbira guaiana* (Leal-Zanchet & Carbayo, 2001) and *Pasipha hauseri* (Froehlich, 1959) is increased. Results emphasize the relevance of expanding taxonomic studies on land flatworms and including more study areas in southern Brazil.

Keywords: biodiversity inventory, planarians, community composition, Neotropical Region.

AMARAL, S.V., HACK, I.R., ITURRALDE, G.G., LEAL-ZANCHET, A.M. Planárias Terrestres (Platyhelminthes: Tricladida) Em Remanescentes De Floresta Decidual Do Nordeste Do Rio Grande Do Sul, Brasil. Biota Neotropica. 14(1): e20130045. <http://www.biotaneotropica.org.br/v14n1/PT/abstract?inventory+bn00714012014>

Resumo: Os tricladidos terrestres apresentam alto grau de endemismo, devido especialmente à sua capacidade de locomoção reduzida. No Rio Grande do Sul, dados sobre as comunidades de planárias terrestres são principalmente conhecidos de áreas de floresta ombrófila mista. O presente estudo teve como objetivo analisar a composição das espécies de planárias terrestres em remanescentes de floresta estacional decidual, situados na região nordeste do Rio Grande do Sul. Com base em coletas diurnas diretas foram registradas 26 espécies, pertencentes às subfamílias Geoplaninae e Rhynchodeminae. Foram registrados os seguintes gêneros de Geoplaninae: *Cephaloflexa* Carbayo & Leal-Zanchet, 2003, *Choeradoplana* Graff, 1896, *Imbira* Carbayo et al., 2013, *Issoca* Froehlich, 1955, *Luteostriata* Carbayo, 2010, *Obama* Carbayo et al., 2013, *Paraba* Carbayo et al., 2013, *Pasipha* Ogren & Kawakatsu, 1990 e *Xerapoa* Froehlich, 1955, além do grupo coletivo *Pseudogeoplana* Ogren & Kawakatsu, 1990 e do gênero de Rhynchodeminae *Rhynchodemus* Leidy 1851. O gênero *Obama* apresentou a maior riqueza de espécies (S=6), seguido por *Paraba* (S=4) e *Pasipha* (S=3). Dezoito espécies foram registradas exclusivamente em uma das áreas de estudo, enquanto oito espécies ocorreram em ambas localidades. Amplia-se a distribuição conhecida de *Luteostriata abundans* (Graff, 1899), *Choeradoplana iheringi* Graff, 1899, *Obama ficki* (Amaral & Leal-Zanchet, 2012), *Imbira guaiana* (Leal-Zanchet & Carbayo, 2001) e *Pasipha hauseri* (Froehlich, 1959). Além disso, os resultados enfatizam a importância de ampliação dos estudos taxonômicos de planárias terrestres, bem como das áreas de estudo no sul do Brasil.

Palavras-chave: inventário de biodiversidade, planárias, composição de comunidades, Região Neotropical.

Introduction

Land flatworms are susceptible to microclimatic changes since they live in humid, non-flooded habitats (Sluys 1998, 1999). Their restricted motility leads to high endemism (Sluys 1995, Ogren et al. 1997, Winsor et al. 1998). Land triclads are carnivorous and prey on other invertebrates such as snails, insect larvae, small arthropods and other land flatworms (Du Bois-Reymond Marcus 1951, Froehlich 1955, Jones & Cumming 1998, Ogren 1995, Sluys 1999, Carbayo & Leal-Zanchet 2003, Prasniski & Leal-Zanchet 2009). Thus, flatworm diversity may reflect the diversity of other invertebrates that constitute their prey. There are records of about 170 species of land flatworms in Brazil, which has the highest species richness in the Neotropical Region (Carbayo & Froehlich 2008, 2012, Amaral et al. 2012, Leal-Zanchet et al. 2012). Recent inventories and studies on flatworm communities reveal the occurrence of at least 90 morphospecies of land flatworms, most of which are unknown to science, in forests of southern Brazil (Antunes et al. 2008, Baptista et al. 2010). Most of these studies occurred in ombrophilous forests (Leal-Zanchet & Carbayo 2000, Carbayo et al. 2002, Fick et al. 2003, 2006, Leal-Zanchet et al. 2011, Antunes et al. 2012). Two inventories have been performed in deciduous forest, one in the central region and the other in the northwest region of southern Brazil (Castro & Leal-Zanchet 2005, Baptista et al. 2010).

Deciduous forest was the greatest forest cover in southern Brazil before colonization. About 24% of the original area now remains in the southern Brazilian state Rio Grande do Sul. The

northeastern region has been highly impacted by human colonization (Teixeira & Coura-Neto 1986). This study offers the first inventory of land flatworms in the northeastern deciduous forest of Rio Grande do Sul and expands our knowledge of flatworm diversity and distribution in southern Brazil.

Material and methods

The study areas are located in two cities (Salvador do Sul and São Pedro da Serra) of the northeast hillside of Rio Grande do Sul (Figure 1), between 29°26'S - 51°30'W and 29°25'S - 51°28'W, respectively. The climate is warm temperate (sub-tropical) and humid, without any marked dry periods (Nimer 1989). The region experiences a long cold period with a mean temperature of 15°C and a warm period with mean temperature of 20°C (Quadros & Pillar 2002). The annual rainfall is 1,200-1,750 mm year⁻¹ with the heaviest rains occurring in the summer (Oliveira & Ribeiro 1986). The rough relief has a maximum altitude of 556 m a.s.l. (Leite 2002). The coverage consists of seasonal deciduous forest defined by a canopy dominated by caducifolious species and a dominance of *Pachystroma longifolium* (Nees) I.M.Johnst. and *Eugenia rostrifolia* D.Legrand (Teixeira & Coura-Neto 1986). Both study areas have suffered intense anthropogenic influence, with high level of deforestation to prepare sites for agriculture and cattle farming (Teixeira & Coura-Neto 1986), and have undergone consequent structural and physiognomic changes (A. Backes, personal communication).

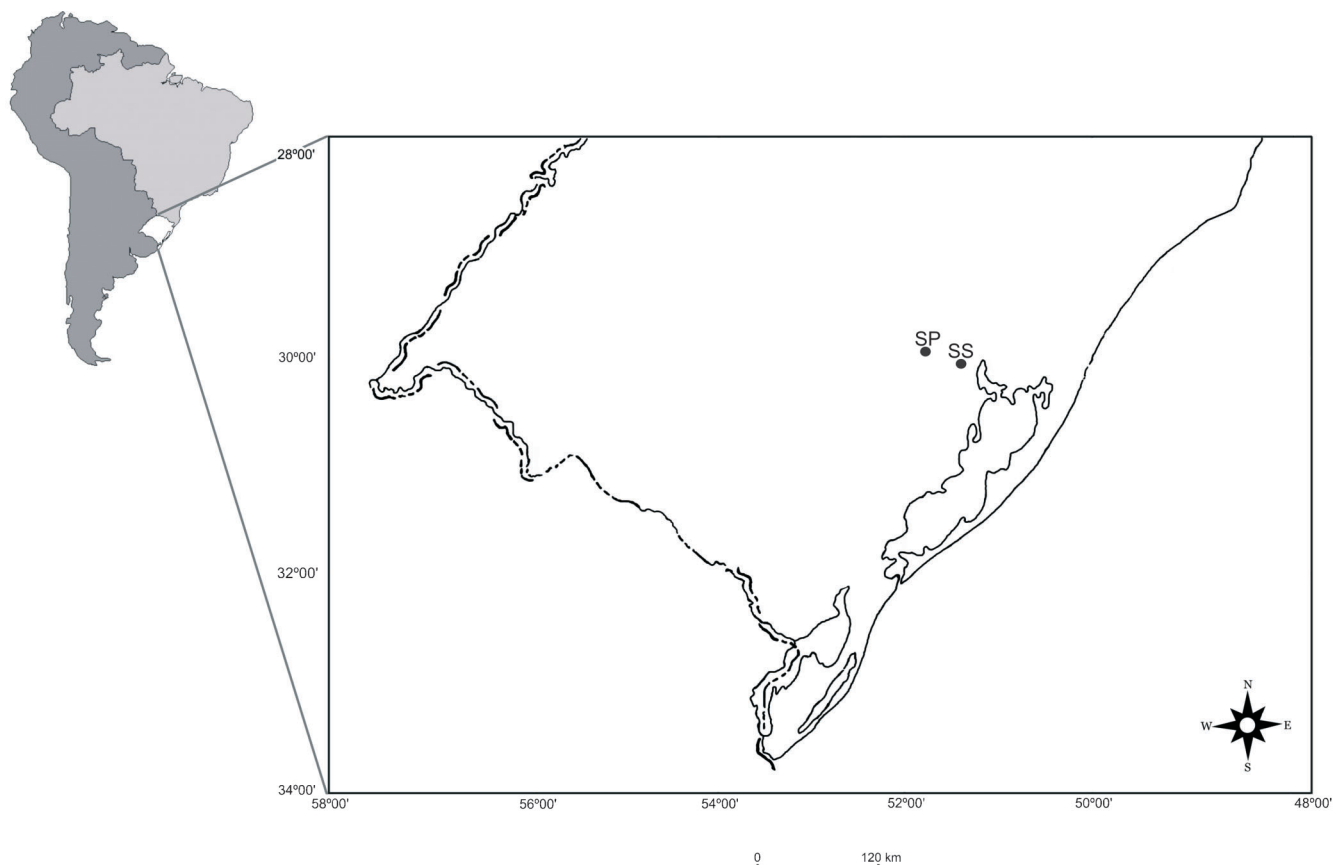


Figure 1. Study areas of the northeastern deciduous forest of Southern Brazil. SP: São Pedro da Serra, SS: Salvador do Sul.

Sixteen diurnal samplings were performed with random and non-random methods from June 1996 to March 2007. Land flatworms were directly sampled under fallen logs and branches, rocks and leaf litter, which, after inspection, were returned to their original positions in order to avoid altering soil microhabitats (Ball & Reynoldson 1981, Winsor 1997).

In the field, specimens were identified as morphospecies. Their external morphology was studied under a stereomicroscope. Body fragments of the pre-pharyngeal region, pharynx, and copulatory apparatus were histologically processed to be studied under optical microscopy according to techniques described by Baptista & Leal-Zanchet (2005). Adult specimens without all the necessary morphological characteristics required for identification at the genus level, which could be differentiated from specimens of other species occurring in the study areas, were placed in the collective group *Pseudogeoplana* Ogren & Kawakatsu, 1990.

The sampled specimens were placed in the scientific collection of the Planarian Research Institute, Universidade do Vale do Rio dos Sinos (UNISINOS).

Results

In the two study areas, we found 26 species of land flatworms (Table 1). Twenty-five of these species belong to the subfamily Geoplaninae and one to Rhynchodeminae, of which at least 13 are unknown to science. Species of the genus *Obama* Carbayo et al., 2013 represented 23% of the species found (S=6), followed by *Paraba* Carbayo et al., 2013 (S=4) (Figures

2-4) and *Pasipha* Ogren & Kawakatsu, 1990 (S=3). Another seven Geoplaninae genera were also documented: *Cephaloflexa* Carbayo & Leal-Zanchet, 2003, *Choeradoplana* Graff, 1896, *Cratera* Carbayo et al., 2013, *Luteostriata* Carbayo, 2010, *Imbira* Carbayo et al., 2013, *Issoca* Froehlich, 1955 and *Xerapoa* Froehlich, 1955. Five morphospecies were included into the collective group *Pseudogeoplana* Ogren & Kawakatsu, 1990. The genus *Rhynchodemus* Leidy, 1851 (Rhynchodeminae) was also documented.

Four species had a high number of records, with 16 or more sampled specimens (Table 1). Two of these species, *Paraba* sp.1 (Figure 2) and *Obama* sp.1, are still undescribed (Table 1). *Luteostriata abundans* (Graff, 1899) (Figure 3) and *Obama carrierei* (Graff, 1897) (Figure 4) had the third and fourth highest records, respectively. Two species, *Obama* sp.2 and *Choeradoplana iheringi* Graff, 1899, had a moderate number of occurrences at the study sites (Table 1). The other 12 species had few occurrences (less than five specimens), and five of these are formally described taxa. Eighteen species were recorded exclusively in one of the two study areas, and eight species occurred in both sites (Table 1).

Discussion

The flatworm species richness recorded in the areas of deciduous forest of this study was similar to the richness of other areas of deciduous forest in southern Brazil where land flatworms inventories have been performed (Castro & Leal-Zanchet 2005, Baptista et al. 2010). Two of these locations are

Table 1. Land planarians recorded in areas of the northeastern deciduous forest of southern Brazil.

| Species | Salvador do Sul | São Pedro da Serra | Total |
|--|-----------------|--------------------|-------|
| <i>Paraba</i> sp.1 | 21 | 6 | 27 |
| <i>Obama</i> sp.1 | 14 | 4 | 18 |
| <i>Luteostriata abundans</i> (Graff, 1899) | 17 | – | 17 |
| <i>Obama carrierei</i> (Graff, 1897) | 14 | 2 | 16 |
| <i>Obama</i> sp.2 | 7 | 1 | 8 |
| <i>Choeradoplana iheringi</i> Graff, 1899 | 1 | 6 | 7 |
| <i>Obama ficki</i> (Amaral & Leal-Zanchet, 2012) | 4 | – | 4 |
| <i>Cratera</i> sp. | 4 | – | 4 |
| <i>Cephaloflexa</i> sp. | – | 4 | 4 |
| <i>Paraba gaucha</i> (Froehlich, 1959) | 3 | – | 3 |
| <i>Obama</i> sp.3 | 1 | 2 | 3 |
| <i>Obama ladislavii</i> (Graff, 1899) | 2 | – | 2 |
| <i>Paraba</i> sp.2 | 1 | 1 | 2 |
| <i>Paraba</i> sp.3 | – | 2 | 2 |
| <i>Pasipha</i> sp.1 | 2 | – | 2 |
| <i>Pasipha</i> sp.2 | 1 | – | 1 |
| <i>Pasipha hauseri</i> (Froehlich, 1959) | 1 | – | 1 |
| <i>Imbira guaiana</i> (Leal-Zanchet & Carbayo, 2001) | 1 | – | 1 |
| <i>Issoca</i> sp. | 1 | – | 1 |
| <i>Xerapoa</i> sp. | 1 | – | 1 |
| <i>Pseudogeoplana</i> sp.35 | 3 | – | 3 |
| <i>Pseudogeoplana</i> sp.36 | 2 | 1 | 3 |
| <i>Pseudogeoplana</i> sp.37 | 2 | – | 2 |
| <i>Pseudogeoplana</i> sp.38 | – | 1 | 1 |
| <i>Pseudogeoplana</i> sp.39 | 1 | – | 1 |
| <i>Rhynchodemus</i> sp. | 1 | – | 1 |
| Abundance | 105 | 30 | 135 |
| Species richness | 23 | 11 | 26 |



Figures 2-7. Land flatworms occurring in the northeastern deciduous forest of Southern Brazil. (2) *Paraba* sp.1; (3) *Luteostriata abundans*; (4) *Obama carrierei*; (5) *Obama ficki*; (6) *Paraba gaucha*; (7) *Obama ladislavii*. Scale bar: 5 mm.

Turvo State Park and Santa Maria, in northwest and central Rio Grande do Sul, respectively. The species composition, however, differs among the three areas. A single species recorded in Turvo State Park (*Geoplana* sp.2 = *Obama* sp.2) and two species in Santa Maria, *Obama* sp.2 and *O. ladislavii* (Graff, 1899), were also found in our study areas. In addition, both dominant species in the study areas, *Paraba* sp.1 and *Obama* sp.1, were not yet recorded in other sites of southern Brazil where land flatworms have been studied (Leal-Zanchet & Carbayo 2000, Carbayo et al. 2002, Fick et al. 2003, 2006, Castro & Leal-Zanchet 2005, Leal-Zanchet et al. 2012, Baptista et al. 2010).

Luteostriata abundans that is dominant in areas of semideciduous forest (Antunes et al. 2008), was recorded for the first time in a deciduous forest. The present record may be explained by the proximity between the northeastern part of the deciduous forest and semideciduous forest range. Furthermore, anthropogenic impacts in the prospected area may favour occupation by *L. abundans*, which is tolerant to such impacts (Antunes et al. 2008, Prasniski & Leal-Zanchet 2009). The

distribution of this species is restricted to northeastern Rio Grande do Sul (Antunes et al. 2008, Carbayo 2010). *Obama carrierei* was previously recorded in Argentina and Bolivia (Graff 1899) and in areas of semideciduous forest (Hauser & Maurmann 1959).

Obama sp.2 has frequently been observed on the border of different types of forests and around man-made buildings (Leal-Zanchet & Carbayo 2000, Carbayo et al. 2002, Fick et al. 2003, 2006, Castro & Leal-Zanchet 2005, Antunes et al. 2008, Leal-Zanchet et al. 2012). It has been considered a generalist species regarding habitat use and tolerance (Castro & Leal-Zanchet 2005, Antunes et al. 2008). *Choeradoplana iheringi* has not yet been recorded in areas of seasonal forests from southern Brazil (Castro & Leal-Zanchet 2005, Baptista et al. 2010, Antunes et al. 2008) despite its ample distribution in Minas Gerais, Rio de Janeiro, São Paulo, Santa Catarina and Rio Grande do Sul (Graff 1899, Riester 1938, Marcus 1951, Froehlich 1956, 1959, Leal-Zanchet & Souza 2003, Baptista et al. 2006). Until now, its distribution in southern Brazil included areas of ombrophilous forest (Leal-Zanchet & Souza 2003,

Baptista et al. 2006, Antunes et al. 2012).

Obama ficki (Amaral & Leal-Zanchet, 2012) (Figure 5) has been documented in ombrophilous forest areas of Rio Grande do Sul and Santa Catarina (Leal-Zanchet & Carbayo 2000, Fick et al. 2003, 2006, Baptista et al. 2006, Amaral et al. 2012). The type-locality of *Paraba gaucha* (Froehlich, 1959) (Figure 6) is Salvador do Sul. It has also been found in areas of semideciduous forest (Froehlich 1959, Antunes et al. 2008). *Obama ladislavii* (Graff 1899) (Figure 7) was recorded in all four main types of forest formations in southern Brazil (Graff 1899, Carbayo et al. 2002, Fick et al. 2003, 2006, Castro & Leal-Zanchet 2005, Baptista et al. 2006, Leal-Zanchet & Baptista 2009, Antunes et al. 2008, 2012). Its known distribution includes locations in Rio Grande do Sul and Santa Catarina. *Imbira guaiana* (Leal-Zanchet & Carbayo, 2001) was only recorded in São Francisco de Paula, Rio Grande do Sul (type-locality), in areas of ombrophilous forest and plantations of *Araucaria angustifolia* (Carbayo et al. 2001, 2002). *Pasipha hauseri* (Froehlich, 1959) was previously recorded in the distribution range of the semideciduous forest, but also in the Amazon Forest (Froehlich & Froehlich 1972).

Deciduous forest remnants in northeastern southern Brazil suffer a greater amount of anthropogenic impacts than remnants in the northwest and central regions. Nevertheless, Geoplaninae species richness is high in this region. The occurrence of at least 13 species of land planarians that are probably new to science emphasises the importance of increasing taxonomic studies of the group, as was suggested by Antunes et al. (2008). These results, as well as differences in species composition among areas, also indicate the need to further develop studies of land planarian communities in other areas of southern Brazil.

Acknowledgements

We are grateful to the Brazilian Research Council (CNPq), the Fundação de Amparo à Pesquisa do Rio Grande do Sul (FAPERGS) and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for grants and fellowships in support of this study. We thank Prof. Dr. A. Backes (*in memoriam*) for his generosity and for sharing his deep knowledge of the forests of southern Brazil over many years. We acknowledge A.L. Seitenfus, C. Palacios, D. Rocha, E. Benya, I. Fick, L. Teixeira, M. Fontoura, M. Cardoso, M. Antunes, M. Gallon, N. Rodrigues, R. Murowaniecki, R. Castro, S. Souza, S.M. Oliveira, S.T. Souza, S. Schneider, V. Baptista and W. Santos for their help in sampling flatworms. Dr. L. Negrete is thanked for photographs of live specimens of flatworms in the figures 2, 3 and 7. We also thank MSc. E. Toriani for the English review of the manuscript. Three anonymous reviewers are acknowledged for their suggestions.

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Received 08/10/2013

Revised 14/01/2014

Accepted 24/01/2014