

SYNOPSIS OF BRAZILIAN CAVE-DWELLING MILLIPEDES  
(DIPLOPODA)

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ABSTRACT

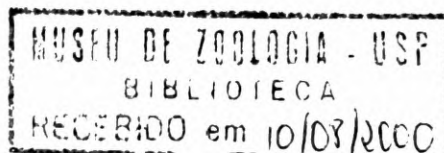
*A review of the Diplopoda currently known to occur in Brazilian caves is presented. More than 37 morphospecies (most of them undescribed) have been recorded, mainly belonging to the families Pseudonannonelidae (Spirostreptida), and Chelodesmidae, Oniscodesmidae and Cryptodesmidae (Polydesmida). Troglophilic and troglobitic species are mostly represented among the genera Pseudonannolene (Pseudonannolenidae), Crypturodesmus (Oniscodesmidae), Peridontodesmella and Cryptodesmus (Cryptodesmidae), Yporangiella (Pyrgodesmidae) and Leodesmus yporangae (Chelodesmidae). The distribution of cave millipedes in Brazil is outlined, with some taxonomic, ecological and biogeographical remarks.*

KEYWORDS: Diplopoda, Brazil, Biospeleology, Taxonomy, Distribution

Current title: Brazilian Cave Diplopoda

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## INTRODUCTION

Brazil has long been known to encompass hundreds of caves distributed through several karst areas (see map in Pinto-da-Rocha, 1995: 159). Many of these caves harbour millipedes (Diplopoda) as one of the dominant components of saprophagous soil meso- and macrofauna. A few of these species are presumed troglobites, i.e. exclusively hypogean organisms often displaying apomorphies related to the subterranean life (“troglomorphisms”) such as tegument depigmentation, elongation of the antennae and appendages, development of sensory organs and, for some of them, reduction to loss of eyes (Holsinger & Culver, 1988). Although recent synopses of Brazilian cave faunas (Trajano, 1987; Gnaspini & Trajano, 1994; Trajano & Sanchez, 1994; Pinto-da-Rocha, 1995) include a large number of references to diplopods, very little has been recorded at levels below order or family.

The history of diplopodological investigations in Brazil is dominated by two main papers by Brölemann (1902) and Schubart (1944) but the very beginning of exploration of Brazilian caves starts with the work by Schubart (1946a) who described *Alocodesmus yporangae* from Areias caves and *Yporangiella stygius* from Monjolinho cave, both in São Paulo State. Schubart (1956, 1957) described two other species, *Obiricodesmus rupestris* from Lapinha and Lapa Vermelha caves (Minas Gerais) and *Peridontodesmella alba* from Bethary de Baixo cave (São Paulo), respectively. Mauriès (1974) described *Pseudonannolene strinatii* from Areias de Cima cave. Additional cave species of *Pseudonannolene* have been described by Mauriès (1987) and Fontanetti (1996a, 1996b).

The Class Diplopoda is among the most poorly known groups of large soil/litter-dwelling organisms belonging to meso- or macrofauna and both its inventory and classification are still in progress (cf. Hoffman, 1980). If, in accordance with Golovatch *et al.* (1995), we assume that only about 10% of diplopod species richness has been assessed to date, this figure being even lower as regards tropical countries, one must admit that:

- (1) The about 300 diplopod species currently known to occur in Brazil, which is probably among the best studied territories in South America, represent only a minor part of its actual richness. However, this is bound to remain underestimated, not only because many forms are still underscribed or remain unsampled, but also because many natural habitats in Brazil have vanished completely or partially;
- (2) Caves, due to the better exploration in comparison to epigeal sites from the same regions, appear to yield a disproportionately high number of millipede species. The cave species are frequently better known than the local surface

ones, as it is the case for many invertebrate groups (Culver 1982) and the case for millipedes of other regions (Shear 1972).

The present paper provides a preliminary list of the diplopods collected in Brazilian caves. There are almost one hundred new records. Most of the material is included in the collection of the Museu de Zoologia da Universidade de São Paulo (MZUSP), some specimens are included in the collections of the Instituto de Biociências da UNESP/Rio Claro, Brazil, the Muséum national d'Histoire naturelle de Paris, France (MNHN), the Muséum d'Histoire naturelle de Genève, Switzerland (MHNG), and the Zoological Museum of Copenhagen, Denmark (ZMUC).

#### RESULTS: LIST OF BRAZILIAN CAVE DIPLOPODA

The following checklist is based on the material recently examined by two of us (S.I.G. and J.J.G.) and on data from the literature. References to diplopods included in the synopsis of Brazilian cave fauna by Pinto-da-Rocha (1995) but not listed here correspond to material that could not be taken into account (missing specimens or visual records). The classification and nomenclature are in accordance with Hoffman (1980) and more recent works (Hoffman, 1990a, 1990b, 1990c). Within families, genera and species are listed alphabetically without reference to subfamilies or tribes. The family Pseudonannonelidae has been included in the order Spirostreptida, but one must keep in mind that the classification dealing with spirostreptidan, julidan, cambalidean and pseudonannonelidean millipedes is still in progress (cf. Mauriès, 1983, 1987; Jeekel, 1985).

The localities have been listed within the correspondent karst areas. In order to favour comparisons, and in view of the huge extension of the Bambuí karst area, we decided to consider two distinct, main regions corresponding to the western (mainly Goiás State) and eastern (Minas Gerais and southwestern Bahia States) outcrops of the Bambuí Group. The Una karst, geologically distinct from the Bambuí (Auler & Farrant, 1996), corresponds to the limestone outcrops in central and northern Bahia (indicated as part of the Bambuí karst in Pinto-da-Rocha, 1995: 159).

Abbreviations: TM (= troglomorphic) species showing reduction of tegument depigmentation, not shared with related epigeal taxa. MZSP= Museu de Zoologia da Universidade de São Paulo. Brazilian States: BA - Bahia; CE - Ceará; GO - Goiás; MG - Minas Gerais; MS - Mato Grosso do Sul; MT - Mato Grosso; PR - Paraná; SC - Santa Catarina; SP - São Paulo.

Class Diplopoda Blainville-Gervais, 1844

ORDER SPIROSTREPTIDA Brandt, 1833

PSEUDONANNOLENIDAE Silvestri, 1895

*Pseudonannolene* Silvestri, 1895

***Pseudonannolene anapophysis* Fontanetti, 1996**

Type-locality: Caverna Lapão, Lençóis, BA.

Chapada Diamantina quartzitic area

Gruta do Lapão, Lençóis, BA, i.1987, leg. F. Chaimowicz, 2 males, 2 females [types, UNESP/Rio Claro] (Fontanetti 1996b); *ibidem*, 03.ix.1991, leg. E. Trajano, 1 male.

***Pseudonannolene chaimowiczi* Fontanetti, 1996**

Type-locality: Gruta Helictites, Lagoa Santa, Pedro Leopoldo, MG.

Una karst area

Toca do Gonçalves, Campo Formoso, BA, i.1987, leg. F. Chaimowicz, 2 males, 3 females;

Eastern Bambuí karst area

Caverna Helictites, Lagoa Santa, Pedro Leopoldo, MG, iii.1986 and v.1987, leg. F. Chaimowicz, 2 males, 3 females [types, UNESP/Rio Claro] (Fontanetti 1996b);

Lapa do Janelão, Itacarambi, MG, 07.vii.1993, leg. E. Trajano, 1 male;

Gruta Olhos d'Água, Itacarambi, MG, iv.1985, leg. F. Chaimowicz, 2 males, 2 females.

Gruta do Padre, Santana, BA, vi. 1987, leg. F. Chaimowicz, 1 male, 4 females.

***Pseudonannolene imbirensis* Fontanetti, 1996**

Type-locality: Caverna São Mateus-Imbira III, São Domingos, GO.

Western Bambuí karst area

Caverna São Mateus II, São Domingos, GO, ii.1985, leg. J. Allievi, 2 males, 1 female, 1 juv.;

Caverna São Mateus-Imbira III (*sic*), vii.1988, leg. GREGEO, 2 females; *ibidem*, 7.iv.1989, leg. GREGEO, 1 male, 1 juv. [types, UNESP/Rio Claro] (Fontanetti 1996b).

Caverna Passa Três, São Domingos, GO, 27.vii.1983, leg. E. Trajano, 7 ex..

***Pseudonannolene leucocephalus* Schubart, 1944**

Type-locality: Cachoeira de Cima, perto de Mogi-Guassu, na mata, Mogi-guassu, SP.

Vale do Ribeira karst area

Gruta do Rocha, Cerro Azul, PR, 02.iv.1991, leg. R. Pinto-da-Rocha, 1 male, 1 female (recorded in the same cave as *P. strinatii*).

***Pseudonannolene microzoporus* Mauriès, 1987**

Type-locality: Gruta Lapa Vermelha, Lagoa Santa, MG.

Eastern Bambuí karst area

Gruta Lapa Vermelha, Lagoa Santa, MG, leg. Reinhardt, 1 male, 1 female, 1 juv. male, 1 juv. female [types, ZMC] (Mauriès 1987).

***Pseudonannolene strinatii* Mauriès, 1974 (Fig. 1)**

Type-locality: Gruta Areias de Cima, Iporanga, SP.

Vale do Ribeira karst area

Gruta Areias de Cima, Iporanga, SP, 29-30.vii.1968, leg. P. Strinati, 2 males, 2 females, 2 juveniles [types, MHNG & MNHN] (Mauriès 1974); ibidem, 01.iii.1984, leg. E. Trajano, 1 juv.; ibidem, 18.vii.1991, leg. R. Pinto-da-Rocha, 4 females;

Ressurgencia da Areias, Iporanga, SP, iv.1984, leg. E. Trajano, 2 males, 4 females;  
Gruta do Jeremias, Iporanga, SP, vi.1981, leg. E. Trajano, 1 female, 2 juv.;  
18.viii.1991, leg. R. Pinto-da-Rocha, 2 females;

Toca do Tigre, Ribeira, SP, 09.iii.1991, leg. R. Pinto-da-Rocha, 1 female;

Gruta de Bonsucesso, Cerro Azul, PR, 03.iv.1991, leg. R. Pinto-da-Rocha, 1 male, 1 female, 1 juv.;

Gruta do Rocha, Cerro Azul, PR, 02.iv.1991, leg. R. Pinto-da-Rocha, 2 females, 3 juv.;

Gruta da Lancinha, Rio Branco do Sul, PR, 19.viii.1989, leg. R. Pinto-da-Rocha, 1 female, 2 juv.;

Gruta de Itacolombo, Rio Branco do Sul, PR, 28.iv.1990, leg. R. Pinto-da-Rocha, 1 female;

Gruta de Toca, Rio Branco do Sul, PR, 19.viii.1989, leg. R. Pinto-da-Rocha, 1 male;

Gruta de Terra Boa, Almirante Tamandaré, PR, 04.xi.1989, leg. R. Pinto-da-Rocha, 1 female;

Gruta do Pinheirinho, Campo Largo, PR, 07.ix.1988 and 01.ix.1990, leg. R. Pinto-da-Rocha, 3 females.

***Pseudonannolene tocaiensis* Fontanetti, 1996**

Type-locality: Fazenda da Toca, Toca Cave, Itirapina, SP.

Serra Geral sandstone karst areaa

Gruta da Toca, Itirapina, SP, 24.ii.1984, leg. A. Mesa, 1 male, 3 females, 2 juv. [Types, UNESP/Rio Claro]; ibidem, 24.ii.1985, 27.vii.1985, 27.viii.1985 and 18.vi.1986, leg. C. Fontanetti, A. Mesa, Mello F. A. G., Martins V. G. & Cella D. M., 21 males, 18 females, 8 juv. (Fontanetti 1996a).

***Pseudonannolene tricolor* Broelemann, 1902**

Type-localities: Alto da Serra, Santo André, SP (lectotype, Mauriès 1987).

Rio Pardo karst area, Ilhéus region

Gruta Califórnia, Pau Brasil, BA, 03.vi.1997, leg. E. Trajano, 1 male;

Western Bambuí karst area

Gruta Paineira, Formosa, GO, 01.v.1989, leg. GREGEO, 1 male, 1 female.

***Pseudonannolene* spp.**Rio Pardo karst area, Ilhéus region

Gruta Pedra do Sino, Santa Luzia, BA, (deep zone), 27.x.1997, leg. B.S. Santos, 1 male, 3 females;

Gruta São Gotardo (twilight zone), Camacá, BA, 25.x.1997, leg. B.S. Santos, 1 female;

Gruta São Gotardo (dark zone), Camacá, BA, 25.x.1997, leg. B.S. Santos, 1 female.

Eastern Bambuí karst area

Gruta da Ciminhas, Pedro Leopoldo, MG, 20.ix.1992, leg. E. Trajano, 1 female;

Gruta da Salmoura, Pedro Leopoldo, MG, 23.i.1991, leg. E. Trajano, 1 female;

Gruta da Cinco Bocas, Matozinhos, MG, 09.i.1992, leg. E. Trajano, 1 juv.;

Caverna Dente de Cão, Matozinhos, MG, 30.xi.1992, leg. E. Trajano, 1 female;

Gruta do Tombo, Matozinhos, MG, 29.xi.1992, leg. E. Trajano, 1 juv.;

Gruta do Meandro Abismante, Matozinhos, MG, 28.ix.1992, leg. L. Senna Horta, 1 juv., 1 female;

Gruta do Urubu, Lagoa Santa, Pedro Leopoldo, MG, 20.x.1990, leg. M. M. Argel-de-Oliveira, 3 females, 1 juv.;

Western Bambuí karst area

Gruta Suindara, Formosa, GO, 01.v.1985, leg. GREGEO, 1 juv.;

Caverna São Mateus II, São Domingos, GO, 23.vii.1978, leg. E. Trajano, 1 female;

Caverna São Vicente I, São Domingos, GO, 28.vii.1998, leg. E. Trajano, 1 male, 2 females;

Lapa do Bezerra, São Domingos, GO, 03.viii.93, leg. L. Sena Horta, 2 males, 4 females, 1 juv. female;

Gruta Jaboticaba, Formosa, GO, 30.iv.89, leg. GREGEO, 3 juv.;

Gruta Suindara, Formosa, GO, 01.v.1985, leg. GREGEO, 1 juv..

Serra da Bodoquena karst area

Gruta Pitangueiras, Bonito, MS, 16.vii.1992, leg. E. Trajano & P. Gnaspini, 1 male, 2 juv.

Vale do Ribeira karst area

Caverna Ouro Grosso, Iporanga, SP, 18.xi.1985, leg. E. Trajano, 1 female;  
Gruta do Alambari de Cima, Iporanga, SP, 08.ix.1991, leg. M.C. Chamani & J.P.M. Seino, 1 female;  
Gruta do Betari, Iporanga, SP, 06.xii.1981, leg. E. Trajano, 1 ex. (fragm.);  
Gruta dos Buenos I, Iporanga, SP, 02.xi.1997, all along the main gallery, on soil and banks (rocks, clay, detritic organic matter: leaves and wood), leg. J.J. Geoffroy & E. Trajano, 5 males, 3 females.

Central-eastern Santa Catarina

Gruta de Botuverá, Botuverá, SC, 05-06.ii.1998, leg. R. Pinto-da-Rocha & G. Sessegolo, 1 male;

Serra do Mar granitic caves

Gruta do Quarto Patamar, Paranapiacaba, SP, 20.viii.1992, leg. E. Trajano & P. Gnaspini, 1 male.

Serra Geral sandstone karst area

Caverna Sitio da Toca, Itirapina, SP, x.1996, in hematophagous bat guano, leg. E. B. da Silva, 2 males, 2 females, 1 juv. male, 1 juv. female

## SPIROSTREPTIDAE Brandt, 1833

Alto Paraguai karst area

Gruta do Sauá, Tangará da Serra, MT, i.1986, leg. J. Allievi, 1 juv.

Eastern Bambuí karst area

Gruta das Escadas, Matozinhos, MG, 26.ii.1992, leg. E. Trajano, 1 female;  
Gruta Vargem da Pedra, Matozinhos, MG, 25.i.1992, leg. E. Trajano, 1 juv. female.

Rio Pardo karst area, Ilhéus region

Gruta Pedra Suspensa, Pau Brasil, BA, 02.vii.1997, leg. E. Trajano, 1 female, 1 male juv.;  
Gruta Pedra do Sino (twilight zone), Santa Luzia, BA, 19.x.1997, leg. B.S. Santos, 1 female;  
Gruta Califórnia, Pau Brasil, BA, 03.vi.1997, E. Trajano, 1 juv.; ibidem, 22.iv.1997, leg. B. Soares-Santos, 1 juv.

Serra da Bodoquena karst area

Gruta Nossa Senhora Aparecida, Bonito, MS, 16.x.1990, leg. E. Trajano, 1 juv.;  
Gruta do Guaviral, Bonito, MS, 29.vii.1991, leg. E. Trajano, 1 female;  
Gruta João Arruda, Bonito, MS, 15.vii.1984, leg. N.M. Godoy, 6 juv.;  
Gruta Serradinho, Bonito, MS, 21.vii.1984, leg. N.M. Godoy, 1 female;  
Gruta Vale do Prata I, Bonito, MS, 26.vii.1991, leg. E. Trajano, 2 females;

Gruta Vale do Prata II, Bonito, MS, 26.vii.1991, leg. E. Trajano, 1 juv.;  
 Gruta Cantagalo, Bonito, MS, 14.iv.1998, leg. J.J.Geoffroy, 3 juv.;  
 Gruta Pitangueiras, Bonito, MS, 15.iv.1998, leg. J.J.Geoffroy, 5 juv.;  
 Toca do Tamanduá, Bonito, MS, 14.iv.1998, leg. J.J.Geoffroy, 14 juv.  
 N.B. — Some records from Serra da Bodoquena were erroneously cited as  
 Julida in Gnaspini & Trajano (1994).

*Gymnostreptus* Brolemann, 1902

**Gymnostreptus** sp.

Serra do Ibiapaba karst area

Gruta de Ubajara, Ubajara, CE, (entrance zone), 11.vii.1979, leg. R. Gonçalves.  
 - 1 male, 1 female, 2 juv.

*Orthoporus* Silvestri, 1897

**Orthoporus** sp.

Serra da Bodoquena karst area

Gruta São Miguel (= Carneiro), Bonito, MS, 6-8.iv.1998, leg. R. Pinto-da-Rocha  
 & G. Sessegolo, 1 male, 4 juv.

ORDER POLYDESMIDA Leach, 1815

**Suborder Chelodesmidea** Cook, 1895

CHELODESMIDAE Cook, 1895

Eastern Bambuí karst area

Gruta das Conchas, Matozinhos, MG, 8 & 13.x.1991, leg. L. Senna Horta, 1 female.

Vale do Ribeira karst area

Gruta do Betari, Iporanga, SP, 06.xii.1981, leg. E. Trajano, 1 female;  
 Gruta do Chapéu, Iporanga, SP, 10.iv.1990, leg. E. Trajano, 4 juv.;  
 Abismo da Chuva, Fazenda Intervalles, SP, 20.v.1989, leg. E. Trajano, 1 subadult  
 female, stadium 7;  
 Gruta dos Buenos I (near pit entrance, probably fallen from the above soil forest),  
 Iporanga, SP, 2.xi.1997, leg. J.J.Geoffroy, 1 female.

Serra do Mar granitic caves

Gruta do Quarto Patamar, Paranapiacaba, SP, 20.viii.1992, leg. E. Trajano &  
 P. Gnaspini, 1 subadult male, stadium 7.



*Arthrosolaenomeris* Schubart, 1943**Arthrosolaenomeris** sp.Serra da Bodoquena karst area

Gruta São Miguel (= Carneiro), Bonito, MS, 20.x.1990, leg. E. Trajano, 1 male.

*Gangugia* Schubart, 1947**?Gangugia** sp.Cocalzinho region

Caverna dos Ecos (Salão de Argila), Corumbá de Goiás, GO, xi.1985, leg. C. Lino, 1 male.

*Eurydesmus* de Saussure, 1860 [= *Chelodesmus*, Cook, 1895]**Eurydesmus** spp.Eastern Bambuí karst area

Gruta da Mangabeira, Ituaçu, BA, 29.iv.1984, leg. Gouveia, 1 male (fragm.);

Vale do Ribeira karst area

Gruta do Betari, Iporanga, SP, 17.xi.1984, leg. E. Trajano, 1 male.

*Leptodesmus* de Saussure, 1859**“Leptodesmus” gilvomelaena** Schubart, 1946

Type-locality: Bairro Casa Verde, chácara Morrinhos, SP.

Eastern Bambuí karst area

Gruta Olhos d’Água, Itacarambi, MG, 10.vii.1993, leg. E. Trajano, 2 males, 2 juv.; ibidem, 14.vii.1994, leg. E. Trajano, 4 males, 1 female; ibidem, 30.iii.02.iv.1994, leg. P. Gnaspini, 1 male.

N.B. — This species, described as a *Leptodesmus* by Schubart (1946b), probably does not belong to this genus and needs to be correctly placed within the chelodesmids. It probably belongs to a genus to be described.

**? Leptodesmus** sp.Serra da Bodoquena karst area

Gruta Cantagalo, MS, 14.iv.1998, leg. J.J.Geoffroy, 1 male in moulting chamber, several abandoned moulting chambers scattered in the cave.

*Camptomorpha* Silvestri, 1897**?Camptomorpha** spp.Una karst area

Toca do Gonçalo, Campo Formoso, BA, 05.i.1997, leg. E. Trajano, 1 male, 1 female;

Eastern Bambuí karst area

Gruta do Meandro Abismante, Matozinhos, MG, 28.ix.1992, leg. L. Senna Horta, 1 female.

Western Bambuí karst area

Gruta Qualquer Coisa, Padre Bernardo, GO, 08.iv.1989, leg. GREGEO, 1 subadult male, 1 subadult female (juv. stadium 7).

Vale do Ribeira karst area

Ermída Paiol do Alto, Adrianópolis, PR, 13.iii.1991, leg. R. Pinto-da-Rocha & N. Moracchioli, 4 juv.

*Brasilodesmus* Brolemann, 1929**Brasilodesmus** sp.Vale do Ribeira karst area

Gruta Temimina II, Iporanga, SP, 09.iv.1990, leg. E. Trajano, 1 female; ibidem, 26.xi.1988, leg. E. Trajano, 1 male;

Abismo da Chuva, Iporanga, SP, 20.v.1989, leg. E. Trajano, 1 male, 1 juv.;

Mina do Paqueiro, Adrianópolis, PR, 13.iii.1991, leg. R. Pinto-da-Rocha & N. Moracchioli, 1 male, 1 female;

Ermídia Paiol do Alto, Adrianópolis, PR, 13.iii.1991, leg. R. Pinto-da-Rocha & N. Moracchioli, 2 males, 3 females.

N.B. — Cited in previous papers as *Leptodesmus* (Schubart, 1946b; Trajano & Gnaspini-Netto, 1991).

*Obiricodesmus* Schubart, 1955**Obiricodesmus rupestris** Schubart, 1956

Type-locality: Gruta da Lapinha, Lagoa Santa, MG.

Eastern Bambuí karst area

Gruta da Lapinha, Lagoa Santa, MG, 21.x.1947, leg. O. Schubart, 1 male, 2 females, 1 juv. female (MZSP-3176); ibidem, leg. J. Schubart, 14 males (holotype, MZSP-3177), 52 females, 2 subadult males and 2 subadult females paratypes (MZSP-3177, 3184, and 3185) (Schubart 1956).

Gruta Lapa Vermelha and surroundings, Lagoa Santa, MG, 22.x.1947, leg. J. Schubart, 7 males, 13 females (Schubart, 1956).

N.B.— This troglophilic species shows interesting polychromatism between the specimens collected from cave and from soil populations.

*Leodesmus* Mauriès & Geoffroy, 2000***Leodesmus yporangae*** (Schubart, 1946) - TM (Fig. 2)

Type-locality: Gruta Areias de Baixo, Iporanga, SP.

Vale do Ribeira karst area

Gruta Areias de Cima (= Areias I), Iporanga, SP, 19.ii.1951, leg. O. Schubart, 6 males, 8 females; ibidem, 29-30.vii.1968, leg. P. Strinati, 11 males, 7 females, 3 fragments (food of large spiders); ibidem, 10.xi.1982, leg. E. Trajano, 1 female; ibidem, 24.viii.1983, leg. N.M. Godoy, 11 males;

Gruta Areias de Baixo (= Areias II), Iporanga, SP, 1942, leg. C. Pavan, 5 males [holotype + paratypes, MZUSP], 7 females [paratypes, MZUSP]; ibidem, 29.x.1997, leg. E.H. Santos, 4 males;

Gruta-Ressurgência das Areias da Água Quente, Iporanga, SP, 1979, leg. N.S. César Jr, 1 male; ibidem, 22.vii.1983, leg. N.M. Godoy, 1 male; ibidem, 22.x.1983, leg. N.M. Godoy, 2 males, 2 females; ibidem, 23.vii.1984, leg. N.M. Godoy, 1 fragment; ibidem, 29.x.1997, leg. E.H. Santos, 4 males;

Caverna Alambari de Cima, Iporanga, SP, 23.??1984, leg. E. Trajano, 1 male, 1 female; ibidem, 23.i.1985, leg. F. Gavioli, 2 males, 1 female; ibidem, 08.ix.1990, leg. M.C. Chamani & J.P.M. Seino, 3 males;

N.B. — Previously cited as *Alocodesmus* sp. or *Alocodesmus yporangae*, *Chelodesmus yporangae*, and *Leptodesmus yporangae* (Schubart, 1946a; Mauriès, 1974; Trajano, 1987; Trajano & Gnaspini-Netto, 1991a; Gnaspini & Trajano, 1994; Trajano & Sánchez, 1994; Pinto-da-Rocha, 1995; Thompson & Moracchioli, 1996). Only known from Areias and Alambari cave systems. Three morphological forms have been recognized for this species, a typical one from Gruta Areias de Baixo and Gruta Ressurgência das Areias da Água Quente, a second one from Gruta Areias de Cima and the third one from Caverna Alambari de Cima (Mauriès & Geoffroy, 2000). Epigeal relatives may exist in the surrounding soils.

*Strongylomorpha* Silvestri, 1897***Strongylomorpha* sp.**Serra da Bodoquena karst area

Gruta do Pindó, Bonito, MS, 21.vii.1984, leg. N.M. Godoy, 1 male.

**Suborder Paradoxosomatidea** Hoffman, 1967

## PARADOXOSOMATIDAE Daday, 1889

Eastern Bambuí karst area

Gruta Vargem da Pedra, Matozinhos, MG, 25.i.1992, leg. E. Trajano, 1 juv.

*Oxidus* Cook, 1911***Oxidus gracilis*** (C.L. Koch, 1847)

Introduced, pantropical species. Frequently found in the literature as *Orthomorpha* or *Fontaria*.

Eastern Bambuí karst area

Gruta Lapa Vermelha I, Pedro Leopoldo, MG, 08.x.1995, leg. L. Senna Horta, 2 males.

Vale do Ribeira karst area

Gruta da Tapagem, Eldorado, SP, 18.xi.1991, leg. E. Trajano, 1 male, 1 female.

Serra do Mar granitic caves

Gruta da Quarta Divisão (entrance & twilight zone, boulders, leaves and logs), Ribeirão Pires, SP, 31.x.1997, leg. J.J. Geoffroy. - 2 males, 1 female. Also found in soil and under wooden logs in the surroundings.

*Catharosoma* Silvestri, 1897***Catharosoma*** spp. (Fig. 3)Serra da Bodoquena karst area

Gruta Pitangueiras (entrance zone), Bonito, MS, 15.iv.1998, leg. J.J. Geoffroy, 7 juv. (6 stad. 7 and 1 stad. 6).

Vale do Ribeira karst area

Gruta do Moquem, Iporanga, SP, 28.ii.1990, leg. E. Trajano, 1 juv.;

Gruta Jane Mansfield, Iporanga, SP, 15.iv.1989, leg. E. Trajano, 4 juv.;

Gruta dos Buenos I (near pit entrance, probably fallen from the above soil forest), Iporanga, SP, 2.xi.1997, leg. J.J. Geoffroy, 1 subadult female, stadium 7;

Gruta Detrás, Iporanga, SP, 3.xi.1991, leg. P. Gnaspini, 1 male;

Gruta dos Paiva (entrance zone), Iporanga, SP, 22.viii.1998, leg. R. Pinto-da-Rocha, 1 female;

Gruta Colorida (entrance zone), Iporanga, SP, 23.viii.1998, leg. R. Pinto-da-Rocha, 1 female.

Serra do Mar granitic caves

Gruta da Quarta Divisão (entrance & twilight zone), Ribeirão Pires, SP, 31.x.1997, leg. J.J. Geoffroy. -1 female, 1 juv.

*Mestosoma* Silvestri, 1897**?*Mestosoma*** spp.Western Bambuí karst area

Gruta Jaboticaba, Formosa, GO, 18.vi.1989, leg. GREGEO, 1 female.

Serra da Bodoquena karst area

Gruta Pitangueiras, Bonito, MS, 15.iv.1998, leg. J.J. Geoffroy, 1 male, 2 females, 2 juv.

**Suborder Polydesmidea** Leach, 1815**CRYPTODESMIDAE** Karsch, 1879Vale do Ribeira karst area

Gruta de Queijo Suiço, Iporanga, SP, 27.ii.1990, leg. E. Trajano, 1 juv.;

Gruta do Alambari de Cima, Iporanga, SP, 08.ix.1991, leg. M.C. Chamani & J.P.M. Seino, 1 female (probably TM);

Gruta do Morro Preto (entrance), Iporanga, SP, 31.viii.1986, leg. P. Gnaspini, 1 female;

Toca dos Meninos, Capão Bonito, SP, 24.ii.1990, leg. E. Trajano, 1 juv.

N. B.— Some species have been recorded and described by Schubart (1957) from deep galleries in mines which are not known to occur in caves (*Peridotodesmoides umbrosus*, *Apomus vanzolinii*).

*Cryptodesmus* Peters, 1864**Cryptodesmus** sp. - TMVale do Ribeira karst area

Gruta das Águas Quentes, Iporanga, SP, 23.xii.1983, leg. N.M. Godoy, 1 female.

**?Cryptodesmus** sp. TMVale do Ribeira karst area

Ressurgencia da Aegla, Iporanga, SP, 02.iii.1990, leg. E. Trajano, 1 female;

Gruta Temimina II, Iporanga, SP, 09.iv.1990, leg. E. Trajano, 1 female.

*Peridotodesmella* Schubart, 1957**Peridotodesmella alba** Schubart, 1957 - TM (Fig. 4)

Type-locality: Gruta de Bethary, Iporanga, SP.

Vale do Ribeira karst area

Gruta Bethary de Baixo, Iporanga, SP, 11.xii.1952, leg. O. Schubart, 1 male, 1 female, 3 subadults [types, MZUSP] (Schubart, 1957);

Mina do Espírito Santo, Iporanga, SP, 12.iv.1990, leg. E. Trajano, 2 males, 3 females;

Caverna Areias de Baixo, Iporanga, SP, 06.i.1985, E. Trajano, 1 male;

Gruta dos Paiva, Iporanga, SP, 10.ii.1989, leg. E. Trajano, 2 juv.; *ibidem*, 26.xi.1993, leg. E. Trajano, 1 female; *ibidem*, 22.viii.1998, leg. E. Trajano et al., 1 male, 3 females, 5 subadult males, 3 subadult females, 1 juv. (stad. 6);

Ermida Paiol do Alto, Adrianópolis, PR, 13.iii.1991, leg. R. Pinto-da-Rocha & N. Moracchioli, 1 male, 1 female;

Mina do Paqueiro, Adrianópolis, PR, 13.iii.1991, leg. R. Pinto-da-Rocha & N. Moracchioli, 2 females.

N. B.— Troglomorphisms shown by this species, including tegumentary depigmentation, suggest that *P. alba* is a troglobite, thus unable to disperse via surface. Its record in discontinuous karst areas represented by Paraná and São Paulo portions of the Ribeira Valley karst area, which are separated by the Ribeira River, poses a problem of systematics: either the populations from Paraná actually belong to a closely related, cryptic species, probably as a result of parallel evolution from a common epigeal ancestor, or *P. alba* is not a true troglobite, probably living in the deep soil.

FUHRMANNODESMIDAE Brölemann, 1916

Una karst area

Buraco do Cão, Seabra, BA, 1993, leg. J.S. Cardoso, 1 ex. (fragm.);  
Gruta Azul, Iraquara, BA, 30.vii.1991, leg. E. Trajano, 2 females, 2 juv.;  
Lapa de Bode, Itaeté, BA, 04.ix.1991, leg. E. Trajano, 1 male, 3 females, 7 juv.;  
ibidem, 07.ix.1993, leg. E. Trajano, 3 females.

Western Bambuí karst area

Caverna São Mateus II, São Domingos, GO, vii.1986, leg. F. Chaimowicz, 1 male;  
Gruta Jaboticaba, Formosa, GO, 30.iv.89, leg. GRECEO (0116), 4 females;  
Gruta do Tamboril, Unai, MG, 10.ix.1988, leg. E. Trajano, 1 male, 2 females.

Serra da Bodoquena karst area

Gruta Pitangueiras, Bonito, MS, 15.iv.1998, J.J.Geoffroy, 1 juv.

Vale do Ribeira Karst Area

Caverna Arataca, Iporanga, SP, 28.06.1991, leg. E. Trajano, 1 juv.(subadult).  
N.B. — Cited erroneously in previous papers as cf. Cryptodesmidae or Oniscodesmidae (Gnaspini & Trajano, 1994; Pinto-da-Rocha, 1995).

PYRGODESMIDAE Silvestri, 1896 [= Stylodesmidae Cook, 1896, invalid]

Altamira-Itaituba arenitic area

Gruta do Piriá, PA, 06.ii.1988, leg. GEP, 1 male.

Una karst area

Gruta Azul, Iraquara, BA, 31.viii.1991, leg. E. Trajano, 2 males, 2 juv.

Eastern Bambuí karst area

Gruta Vargem da Pedra, Matozinhos, MG, 25.i.1992, leg. E. Trajano, 1 juv.

Western Bambuí karst area

Gruta Jaboticaba, Formosa, GO, 30.iv.1989, leg. GRECEO (0116), 3 juv.;

Vale do Ribeira karst area

Abismo da Chuva, Iporanga, SP, 20.v.1989, leg. E. Trajano, 2 females, 4 juv.; ibidem,  
25.vii.1991, leg. E. Trajano, 2 juv.; ibidem, 11.iv.1990, leg. E. Trajano, 1 juv.;  
Caverna Areias de Cima, Iporanga, SP, 01.iii.1984, leg. E. Trajano, 1 female;

Gruta d'Omorcegovaiomorcevem, Iporanga, SP, 26.xi.1989, leg. E. Trajano, 1 male;

Gruta da Cabeça de Paca, Iporanga, SP, 17.xi.1990, leg. E. Trajano, 1 male, 1 female;

Gruta da Figueira, Iporanga, SP, 01.iii.1990, leg. E. Trajano, 1 female, 1 juv.;

Gruta do Chapéu, Iporanga, SP, 10.iv.1990, leg. E. Trajano, 2 juv.;

Gruta do Jair, Iporanga, SP, 07.x.1990, leg. E. Trajano, 1 female;

Gruta do Minotauro, Iporanga, SP, 25.ii.1990, leg. E. Trajano, 1 juv.;

Gruta do Moquem, Iporanga, SP, 28.ii.1990, leg. E. Trajano, 1 male;

Caverna Arataca, Iporanga, SP, 11.04.1990, leg. E. Trajano, 1 juv.; *ibidem*, 25.vii.1991, leg. E. Trajano, 2 juv.

Serra do Mar granitic caves

Gruta da Quarta Divisão, Ribeirão Pires, SP, 20.viii.1992, leg. E. Trajano & P. Gnaspini, 1 juv.

*Yporangiella* Schubart, 1946

***Yporangiella stygius* Schubart, 1946 - TM**

Type-locality: Gruta do Monjolinho, Iporanga, SP.

Vale do Ribeira karst area

Gruta do Monjolinho, Iporanga, SP, xii.1909, leg. R. Krone, male [holotype, MZUSP] (Schubart 1946a).

ONISCODESMIDAE de Saussure, 1860

Serra da Bodoquena karst area

Gruta do Portal, Bonito, MS, 24.vii.1992, leg. E. Trajano & P. Gnaspini, 1 juv.;

Gruta Dona Matilde, Bonito, MS, 19.vii.1992, leg. E. Trajano & P. Gnaspini, 1 male, 3 females.

Vale do Ribeira karst area

Gruta da Tapagem (= Caverna do Diabo), Eldorado, SP, 14.v.1978, leg. C. Lino, 6 juv.; *ibidem*, 18.xi.1991, leg. E. Trajano, 3 juv.

N.B. — Also found in Grutas Jesuítas, Fadas and Bromados I, Paraná.

*Crypturodesmus* Silvestri, 1897 [= *Katantodesmus* Attems, 1899]

***Crypturodesmus* sp.**

Serra da Bodoquena karst area

Gruta do Ametista, Bonito, MS, 21.vii.1991, leg. E. Trajano, 1 female, 13 juv.;

Gruta Harmonia, Bonito, MS, 22.vii.1992, leg. E. Trajano & P. Gnaspini, 2 males, 1 juv.;

Caverna Santa Maria, Jardim, MS, 20.vii.1991, leg. E. Trajano, 2 males, 4 females;

- Gruta do Curvelinho, Porto Murtinho, MS, 21.vii.1992, leg. E. Trajano & P. Gnaspini, 2 juv.;
- Gruta Cantagalo, Bonito, MS, 14.iv.1998, leg. J.J.Geoffroy, 56 ex., males, females (mating adults) and several juvenile stadia;
- Gruta Pitangueiras, Bonito, MS, 15.iv.1998, leg. J.J.Geoffroy, 3 males, 7 females, 11 juv.;
- Toca do Tamanduá, Bonito, MS, 14.iv.1998, leg. J.J.Geoffroy, several ex.

### **Crypturodesmus** sp. - TM (Fig. 5)

#### Serra da Bodoquena karst area

- Gruta do Curé, Bonito, MS, 17.x.1990, leg. E. Trajano, 2 males, 1 female;
- Gruta João Arruda, Bonito, MS, 15.vii.1984, leg. N.M. Godoy, 2 males, 7 females; ibidem, 18.x.1990, leg. E. Trajano, 1 female;
- Gruta Nossa Senhora Aparecida, Bonito, MS, 17.vii.1984, leg. N.M. Godoy, 1 male, 3 females; ibidem, 16.x.1990, leg. E. Trajano, 1 male, 2 females;
- Gruta São Miguel (= Carneiro), Bonito, MS, 20.x.1990, leg. E. Trajano, 1 male; ibidem, 6-8.iv.1998, leg. R. Pinto-da-Rocha & G. Sessegolo, 2 males, 2 females;

### **Crypturodesmus** sp. -TM

#### Vale do Ribeira karst area

- Caverna Areias de Cima, Iporanga, SP, 23.x.1983, leg. E. Trajano, 1 male;
- Gruta Casa de Pedra, Iporanga, SP, 15.x.1988, leg. P. Gnaspini, 1 ex.; ibidem, 29.iv.1990, leg. E. Trajano, 1 male, 1 female; ibidem, 21.iv.1991, leg. P. Gnaspini & E. Trajano, 1 male, 1 female;
- Gruta do Couto, Iporanga, SP, 17.vi.1984, leg. E. Trajano, 2 females;
- Mina Espírito Santo, Iporanga, SP, 12.iv.1990, leg. E. Trajano, 5 ex.;
- Caverna do Grotão, Ribeira, SP, 09.iii.1991, leg. N. Moracchioli, 1 female;
- Mina do Paqueiro, Adrianópolis, PR, 13.iii.1991, leg. R. Pinto-da-Rocha, 6 males, 10 females; ibidem, 13.iii.1991, leg. R. Pinto-da-Rocha & N. Moracchioli, 4 males, 1 female, 2 juv.;
- Ermídia Paiol do Alto, Adrianópolis, PR, 13.iii.1991, leg. R. Pinto-da-Rocha & N. Moracchioli, 1 male, 5 females, 3 juv.;
- Gruta de Bonsucesso, Cerro Azul, PR, 03.iv.1991, leg. R. Pinto-da-Rocha, 3 males, 4 females, 2 juv.;
- Gruta do Rocha, Cerro Azul, PR, 02.iv.1991, leg. R. Pinto-da-Rocha, 2 females;
- Gruta Paiol de Capim, Cerro Azul, PR, 04.iv.1991, leg. R. Pinto-da-Rocha, 2 females.
- N.B. — This genus has been frequently cited as *Katantodesmus*, its junior synonym, in several previous papers (Trajano, 1987; Gnaspini & Trajano, 1994;



Pinto-da-Rocha, 1994, 1995; Trajano & Sánchez, 1994). Troglomorphic species were also recorded from the following caves in Vale do Ribeira: Gruta da Lancinha, Gruta de Terra Boa, Gruta Olhos d'Água, and Gruta do Tocão (Gnaspini & Trajano, 1994). The genus may include more than one troglobitic species in the area, as is the case with *P. alba* (see N.B.)

#### FAUNISTICS AND DISTRIBUTION

No less than 13 orders (among 15-16 in Diplopoda) and 46 families of diplopods are currently known to occur in the Neotropical Region south of central Mexico (Hoffman *et al.* 1996). Of these, at least nine orders and 27 families are found in Brazil. However, even a superficial look at the taxonomic composition of the Brazilian cave fauna (about 40 species, many of these still to be described) allows to trace several biases and peculiarities.

Representatives of only 2-3 orders and eight families have been recorded in Brazilian caves. A numerical account of the studied material is provided in Table I. Although they are clearly influenced by cave fauna sampling biases, these numbers allow a rough estimation of the relative abundance for the larger, most conspicuous taxa. Unfortunately, there are too many undescribed species to allow a more precise figure for the Brazilian diplopod cave fauna.

The best known Brazilian cave fauna (for the Diplopoda as well) is that from the Vale do Ribeira, followed by Serra da Bodoquena and Bambuí karst areas. Diplopod taxa recorded in these areas are summarized in Boxes 1 to 5. Other Brazilian cave areas have been sampled on few occasions only and are poorly known. Cave diplopods seem to become less frequent in the lower latitudes: there are few records from northern Bahia and Ceará, and no one from Pará (Trajano & Moreira, 1991; Pinto-da-Rocha, 1995).

A clear-cut dominance by *Pseudonannolene* species is striking. This genus is the most species-rich (up to 10 species, of a total of about 45 species in the genus) and widespread one in Brazilian caves, forming troglophilic populations (i.e., able to complete their life cycle both in the epigeal and in the subterranean habitats - Holsinger & Culver, 1988) throughout the country. Apparently, *Pseudonannolene* is among the genera best preadapted to subterranean life. However, it must be noted that *Pseudonannolene* diplopods are relatively large (at least for cave invertebrate standards), thus easily found and collected, in opposition to the members of "miniature" groups such as the Oniscodesmidae, Pyrgodesmidae and Cryptodesmidae.

A second dominant group in Brazilian caves is the family Oniscodesmidae, largely the genus *Crypturodesmus*, with probably 5-6 species from Serra da Bodoquena and Vale do Ribeira. There are some troglomorphic features (mainly pallid teguments), and at least three *Crypturodesmus* species

may well prove to be troglobites. The same generally concerns both *Peridontodesmella* and *Cryptodesmus* diplopods (Cryptodesmidae) in the Vale do Ribeira karst area, as some species (one and 2-3, respectively) display troglomorphic traits such as depigmentation of the tegument and hypertrophied metatergal trichome.

On the other hand, the proportion of species recorded in caves is surprisingly modest among the huge family Chelodesmidae, which dominates the entire Neotropical fauna. The only claimed troglobite is the polymorphic *Leodesmus yporangae*, with three morphological “forms” recently recognized: the typical one from Vale do Ribeira, Areias de Baixo and Ressurgência das Areias da Água Quente, and two other forms respectively from Areias de Cima and Alambari de Cima caves, possibly resulting from allopatric or peripatric differentiation (Mauriès & Geoffroy, 2000).

A low proportion of cave-dwelling species was also observed for the large families Spirostreptidae and Paradoxosomatidae, other very important components of the Neotropical diplopod fauna, but rarely found in Brazilian caves. None seems to contain troglobites, their representatives tending to be restricted to the entrance and twilight zones, rarely occurring at the deep zones (see, for instance, Pitangueiras cave in MS). Several orders and families seem also to be absent from Brazilian caves, e.g. Polyxenida, Glomeridesmida, Siphonophorida, Polyzoniida, Dalodesmidae (Polydesmida), Spirobolida (Rhinocricidae) etc.

It is difficult to say if there are true troglobites among Brazilian species belonging to the large families Fuhrmannodesmidae and Pyrgodesmidae, composed of small-sized individuals. Superficially, due to the pallid teguments and relatively long antennae and legs, some Fuhrmannodesmidae may be troglomorphic, especially if one keeps in mind that there are numerous troglobites among Central American fuhrmannodesmids. Cave Fuhrmannodesmidae diplopods were found in Bambuí, Vale do Ribeira and Serra da Bodoquena karst areas. Pyrgodesmidae diplopods have been recorded from Altamira-Itaiatuba, Bambuí, Vale do Ribeira and granitic areas. Some of them can be considered as troglobites (for instance *Yporangiella stygius*) despite the fact that most of the studied specimens show nicely colored teguments. Let us remember that many of the Central American caves are well known to harbor pyrgodesmid populations. Anyway, these two miniature families were certainly undercollected/underestimated.

To summarize, various diplopod groups are able to colonize caves into a very different extent, with some groups such as *Pseudonannolene* and *Crypturodesmus* being far more successful than others. Furthermore, several diplopod orders and families were never recorded in Brazilian caves, although

some of these taxa are very common and abundant in epigean Neotropical habitats. The colonization of a few Brazilian caves by the pantropical introduced *Oxidus gracilis* is a further evidence of its high ecological plasticity. Like *Orthomorpha coarctata* (de Saussure, 1860), this paradoxosomatid species belongs to the synanthropic and alien elements of the Brazilian cave and soil fauna, as already noticed by Schubart (1947).

The comparison between the best studied cave faunas (boxes 1 to 5) is hampered by the lack of more precise identifications. In the few cases in which species have been determined, as with *Pseudonnanolenne* diplopods, each karst area generally harbours its own set of species. Since these millipedes are probably trogliphilic, such specificities are probably due to regional differences in the epigean fauna. At the genus level, *Crypturodesmus* and *Catharosoma* are shared by Serra da Bodoquena and Vale do Ribeira. *Catharosoma* diplopods have only been found at the entrance of a few caves, but *Crypturodesmus* diplopods, comprising both trogliphilic and troglobitic species, are the commonest cave millipedes in Serra da Bodoquena and are also relatively frequent in the Vale do Ribeira, thus constituting important components of cave faunas in both areas. On the other hand, genera separately shared by each of these and other karst areas (e.g., *Eurydesmus* and ?*Camptomorpha*, occurring in the Vale do Ribeira and Bambuí; *Mestosoma*, occurring in Serra da Bodoquena and Bambuí) have been recorded in a few caves and probably do not represent important components of those faunas. Likewise, no special similarity was observed between the Una and Bambuí karst areas, situated in the semiarid Bahia, and the Rio Pardo area, at the coastal Atlantic rainforest in Bahia.

It is often difficult to decide whether a millipede species is strictly a troglobite or not, due to the fact that numerous soil representatives may also be found in caves and in the M.S.S. ("milieu souterrain superficiel" - Juberthie, 1983) and, besides that, associated epigean faunas are frequently too poorly known to be compared. Therefore, most of the time it is difficult to classify a millipede species as a troglaxene, a trogliphile or a troglobite, and almost impossible to provide an accurate estimation of the relative importance of these categories among diplopod faunas (cf. Mauriès, 1994). However, some estimates have been proposed for Palearctic and Nearctic faunas, where the percentage of cave-restricted species among the Diplopoda ranges from 5 to 25% (Mauriès, 1994, Geoffroy, 1997). A recent synopsis of the cave millipedes in France shows that the cave-related (*sensu lato*) forms represent 30% of the whole Diplopoda, while 13% are composed of troglobites, mainly represented among the orders Glomerida, Craspedosomatida, Polydesmida and Julida (Geoffroy, 1997).

For Brazil, among the 37 or more species listed herein, at least seven (20%) are troglomorphic, probably troglobitic, which is within the range for

temperate cave faunas. All recorded Brazilian troglomorphic diplopods are polydesmids, most of them living in caves from the Vale do Ribeira. The relatively high number of troglomorphic millipede species in the Vale do Ribeira is expected since this area harbours one of the richest and most diverse troglobitic faunas in Brazil (e.g., Gnaspini & Trajano, 1994). This points to the occurrence of major vicariant events affecting both terrestrial and aquatic faunas, probably related to paleoclimatic fluctuations, as suggested by Trajano (1995). The absence of troglomorphic populations of *Pseudonannolene*, which are the most widespread cave diplopods in the country, is noteworthy.

#### ECOLOGICAL NOTES

Ecological data are available for the commonest and most conspicuous cave diplopods, such as pseudonannolenids and chelodesmids. *Pseudonannolene* diplopods feed mainly on animal matter such as bat guano (specially from haematophagous bats) and carcasses. Population densities are usually low, except at bat guano deposits and around dead animals, where dozens of millipedes may concentrate.

Chelodesmids like *Leodesmus yporangae* are geophagues that may form large populations in sediment banks. Diplopods living in this kind of habitat frequently display accentuated population fluctuations probably due to periodical movements between the superficial and deeper sediment layers and small rocky crevices, apparently synchronized with the rainy cycles. The population ecology of *L. yporangae* from Ressurgência das Areias da Água Quente cave was studied by Thompson & Moracchioli (1996), who found higher population sizes during the dry season, with population densities varying from 0.10 (rainy season) to 0.20 individuals m<sup>-2</sup> (dry season).

Cryptodesmids and oniscodesmids also concentrate near or at guano deposits and may attain very high densities at some sites, as observed in *Crypturodesmus* sp. in Serra da Bodoquena (500-1,000 individuals m<sup>-2</sup> at vampire bat guano piles in Gruta do Cantagalo), and *Peridontodesmella alba* in the Vale do Ribeira - this species used to form very large populations at Gruta do Betari, Iporanga Co., but this population greatly declined after vampire bat control in the cave, and the original levels have never been re-established.

#### CONCLUSIONS

This is an up-to-date approach to the composition of the Brazilian cave diplopod fauna, representing a further step after the synopsis by Pinto-da-Rocha (1995). The emerging figure, that may be considered accurate for well-studied

Table I. Diplopoda from Brazilian caves: material collected and studied since Brölemann 1902 and Schubart 1944, 1946a.

Family	caves recorded	specimens recorded	species richness	trogomorphic
1. Pseudonannolenidae (= <i>Pseudonannolene</i> )	46	192	9-more	0
2. Oniscodesmidae (mainly <i>Crypturodesmus</i> )	27	187	4-more	2-more
3. Chelodesmidae	26	197	11-more	1
4. Spirostreptidae	18	51	3-more	0
5. Pyrgodesmidae	15	21	2-more	1
6. Cryptodesmidae	14	36	4-more	3-more
7. Paradoxosomatidae*	12	28	2-more	0
8. Fuhrmannodesmidae	8	29	1-more	0

\* Excluding the anthropogenic *Oxidus gracilis* occurring in three caves.

Box 1. Cave diplopods recorded from the Una karst area, northern and central Bahia State, northeastern Brazil.

Pseudonannolenidae:  
*Pseudonannolene chaimowiczi*  
Chelodesmidae  
? *Camptomorpha* sp.  
Fuhrmannodesmidae indet.  
Pyrgodesmidae indet.

Box 2. Cave diplopods recorded from the eastern outcrop of the Bambuí karst area, Minas Gerais and southern Bahia States, eastern Brazil.

Pseudonannolenidae:  
*Pseudonannolene chaimowiczi*  
*Pseudonannolene microzoporus*  
*Pseudonannolene* sp.  
Spirostreptidae indet.  
Chelodesmidae indet.  
*Eurydesmus* sp.  
“*Leptodesmus*” *gilvomelaena*  
? *Camptomorpha* sp.  
*Obiricodesmus rupestris*  
Paradoxomatidae indet.  
*Oxidus gracilis* (introduced)  
Pyrgodesmidae indet.

Box 3. Cave diplopods recorded from the western outcrop of the Bambuí karst area, Goiás State, central Brazil.

Pseudonannonelidae  
*Pseudonannolene ibirensis*  
*Pseudonannolene tricolor*  
*Pseudonannolene* sp.  
Chelodesmidae  
*?Camptomorpha* sp.  
Paradoxosomatidae  
*?Mestosoma* sp.  
Fuhrmannodesmidae indet.  
Pyrgodesmidae indet.

Box 4. Cave diplopods recorded from the Serra da Bodoquena karst area, Mato Grosso do Sul State, southwestern Brazil.

Pseudonannolenidae  
*Pseudonannolene* sp.  
Spirostreptidae indet.  
*Orthoporus* sp.  
Chelodesmidae  
*Arthrosolaenomeris* sp.  
*?Leptodesmus* sp.  
*Strongylomorpha* sp.  
Paradoxosomatidae  
*Catharosoma* sp.  
*?Mestosoma* sp.  
Fuhrmannodesmidae indet.  
Oniscodesmidae indet.  
*Crypturodesmus* sp.  
*Crypturodesmus* sp. (troglomorphic)

Box 5. Cave diplopods recorded from the Vale do Ribeira karst area, São Paulo and Paraná States, southeastern Brazil.

Pseudonannolenidae

*Pseudonannolene strinatii*

*Pseudonannolene leucocephalus*

*Pseudonannolene* sp.

Chelodesmidae indet.

*Eurydesmus* sp.

?*Camptomorpha* sp.

*Brasilodesmus* sp.

*Leodesmus yporangae* (troglomorphic)

Paradoxosomatidae

*Oxidus gracilis*

*Catharosoma* sp.

Cryptodesmidae indet.

*Cryptodesmus* sp. (troglomorphic)

?*Cryptodesmus* sp. (troglomorphic)

*Peridontodesmella alba* (troglomorphic)

Fuhrmannodesmidae indet.

Pyrgodesmidae indet.

*Yporangiella stygius* (troglomorphic)

Oniscodesmidae indet.

*Crypturodesmus* sp.

*Crypturodesmus* sp. (troglomorphic)



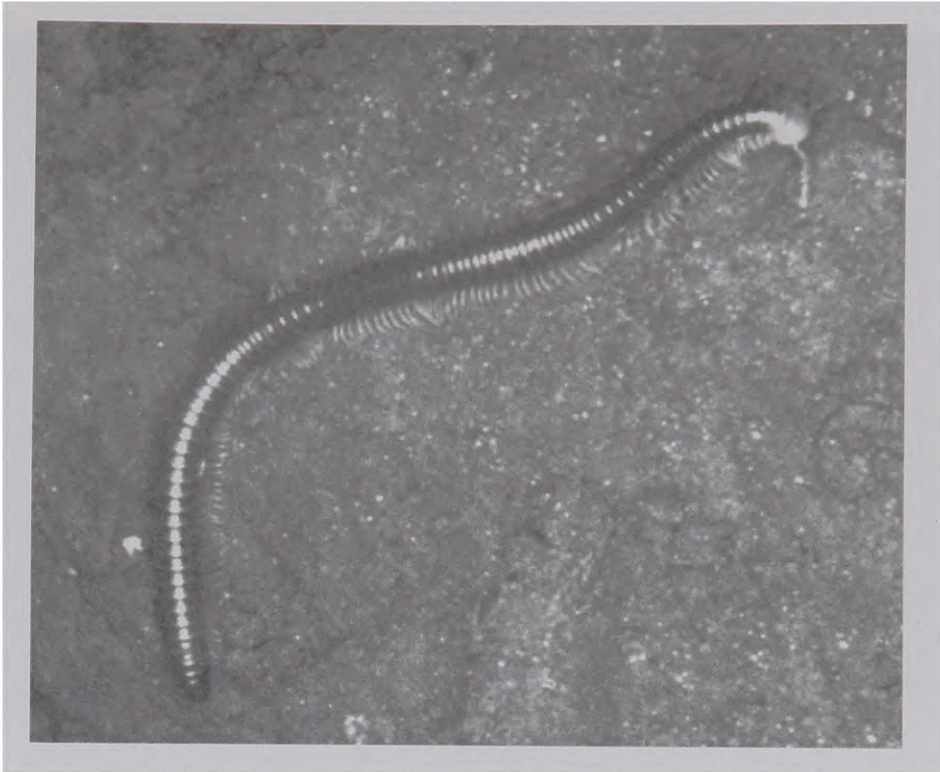


Figure 1. *Pseudonannolenne strinatii* (Pseudonannolenidae) from Areias de Cima Cave, Iporanga, SP. Photo: João Allievi.



Figure 2. *Leodesmus yporangae* (Chelodesmidae) from Areias de Cima Cave, Iporanga, SP. Photo: João Allievi.



Figure 3. *Catharosoma* sp. (Paradoxosomatidae) from Colorida Cave, Iporanga, SP. Photo: Ricardo Pinto da Rocha.



Figure 4. *Peridontodesmella alba* (Cryptodesmidae) from Paiva Cave, Iporanga, SP. Photo: Ricardo Pinto da Rocha.



Figure 5. *Crypturodesmus* sp. (Oniscodesmidae) from São Miguel Cave, MS. Photo: Ricardo Pinto da Rocha.

areas such as the Vale do Ribeira, Serra da Bodoquena and most Bambuí area, points to a few dominant groups, namely the widespread troglophilic *Pseudonannolenne* species and troglophilic and troglobitic polydesmidans, mainly Chelodesmidae, Oniscodesmidae and Cryptodesmidae, besides some less common taxa such as spirostreptids, pyrgodesmids and paradoxomatids. The composition of cave millipede communities results from differential “selection” of components of epigean communities living in karst areas both in the present and in the past, in accordance with their degree of preadaptation to subterranean life.

A relatively large number of troglobitic species has been found in the Vale do Ribeira, corroborating the hypothesis that this karst area was subject to accentuated palaeoclimatic fluctuations, providing opportunities for isolation of troglophilic populations and speciation in the hypogean biotope. On the other hand, millipedes seem to be less frequent in the caves situated to the north of the country.

The need is clear for more comprehensive surveying, specially so in poorly studied areas such as the Alto Paraguai, MT, Ubajara, CE, and part of the Bambuí karst area, associated with extensive taxonomic work, in order to assess the faunistic

and distributional patterns shown by the subterranean diplopod fauna in Brazil. Special effort should also be developed in areas with occurrence of troglobitic species in view of their scientific importance - cave millipedes seem to be good models to address questions about speciation modes - , and ecological vulnerability claiming for conservation measures.

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