

## DESCRIPTION AND ECOLOGY OF A NEW SOLIFUGE FROM BRAZILIAN AMAZONIA (ARACHNIDA, SOLIFUGAE, MUMMUCIIDAE)

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**ABSTRACT.** Three regions of Brazilian Amazonia within the state of Rondônia were searched for the presence of solifuges by means of pitfall traps. A new solifuge, *Mummucia taiete*, was found at two sites inside Vilhena region, which are “Cerrado” enclaves surrounded by Amazonian forest. This new species is described here and is the seventh from Brazil. Populations of *M. taiete* from these two sites were compared regarding some autoecological parameters. Results showed populations from the two sites are similarly diurnal and male biased, as observed in *M. mauryi* and *M. coaraciandu*. On the other hand, these populations differ in density and juvenile/adult ratio.

**RESUMO.** Três regiões da Amazônia brasileira pertencentes ao Estado de Rondônia foram investigadas quanto à presença de Solifugae por meio de armadilhas “pitfall”. Um novo solífugo, *Mummucia taiete*, foi encontrado dois locais no município de Vilhena, que são enclaves de Cerrado circundados por floresta Amazônica. Esta nova espécie de Solifugae é descrita aqui e é a sétima do território brasileiro. Populações de *Mummucia taiete* desses dois locais foram comparadas quanto a alguns parâmetros autoecológicos. Resultados indicam que as populações se assemelham pelos hábitos diurnos e pelo maior número de machos, como observado para outras espécies como *Mummucia mauryi* and *Mummucia coaraciandu*. Por outro lado, essas populações diferem em densidade e na razão jovens/adultos.

**Keywords:** Solpugida, sun-spiders, camel-spiders, taxonomy

The arachnid order Solifugae is distributed over the Americas, Africa and Eurasia, currently comprising about 1,100 species (Harvey 2002). However, South American distributional maps exhibit the presence of only six species in Brazil with large empty areas (Rocha & Cancellato 2002b). That is mostly due to the lack of studies as shown by recent novel species descriptions (Xavier & Rocha 2001; Martins et al. 2004). We hereby describe a new species from “Cerrado” enclaves, surrounded by Amazonian forest, in Vilhena region, situated in southwestern Brazilian Amazonia and provide notes on the habitat and abundance of this species.

“Cerrado” is the Brazilian savannah-like vegetation, the largest domain after Amazon forest (Silva & Bates 2002). This vegetation occupies a large continuous area in central Brazil and many isolated remnants or “islands” in the Atlantic and Amazon forests bi-

omes (Silva & Bates 2002; Prance 1996). The Cerrado comprises mainly open vegetation types such as grasslands, open-scrublands and woodlands. Cerrado has been nominated as an important world biodiversity hotspot due to its diversity and high incidence of endemism (Myers et al. 2000). Solifuges are arthropod predators common in arid and semi-arid lands (Muma 1967). Besides the functional similarity between solifuges and spiders, the former resemble scorpions in relation to thermal tolerance (Cloudsley-Thompson 1962), which enable them to be typical desert inhabitants (Cloudsley-Thompson 1977). They present an extreme wide foraging mode (*sensu* Pianka 1966) differentiating them from other arachnids, including wandering spiders. Solifuges are also prodigal excavators in order to meet various needs (Muma 1966a), and the role played by them in trophic webs of drier ecosystems should not be underestimated.

## METHODS

We surveyed nine Cerrado enclaves in the state of Rondônia, northwestern Brazil, with three study sites in each region: Vilhena, Pimenta Bueno and Guajará-Mirim. We used 50 pitfall traps set 100 cm apart from each other at three sites. These traps were 500 ml plastic cups sunk in the soil so that the top of the cup remains at the soil level, with 9 cm diameter, filled with a 200 ml mixture of 9 parts of 80% G.L. alcohol and 1 part of 0.8% formaldehyde. The traps were provided with a protective cover consisting of a 20 cm diameter white plastic plate fixed with sticks 5–8 cm height above the traps. The traps were opened for seven days.

On all nine study sites we searched both during morning and night hours for arachnids. We also inspected 20 liter pitfall traps (used for herpetological surveys) at all three Vilhena sites plus two P. Bueno sites. Night collecting was a one hour search per collector over each of 12 quadrats (30 × 5 meters) set up on each site. The surveys were conducted on the following dates: Vilhena (30 August–14 September 1999) and P. Bueno (11–29 July 2000) during the dry season and (southern hemisphere) winter, whereas the G.-Mirim surveys were conducted during summer (wet season, 12–21 January 2001). The material studied is deposited in the Instituto Butantã, São Paulo, Brazil (IBSP) and the Universidade Nacional de Brasília, Brasília-DF, Brazil (UNB).

Cheliceral teeth are named according to Muma (1951), where sizes of cheliceral teeth are ordered with Roman numerals, such that I is larger than II, etc. The telotarsal spination formulae are used as in Maury (1982). The nomenclature of podomeres is in accordance with Shultz (1989).

## TAXONOMY

Family Mummuciidae Roewer 1934

Genus *Mummucia* Simon 1879

*Mummucia taiete* new species

Figs. 1–8

**Types.**—Holotype male, Vilhena (12° 41'39"S, 60°05'53"W), State of Rondônia, Brazil, 30 August–14 September 1999, M.C. Carvalho (IBSP). Paratypes: 4 males and 5 females, same data as holotype (IBSP); 1 male and 1 female, same data as holotype (UNB).

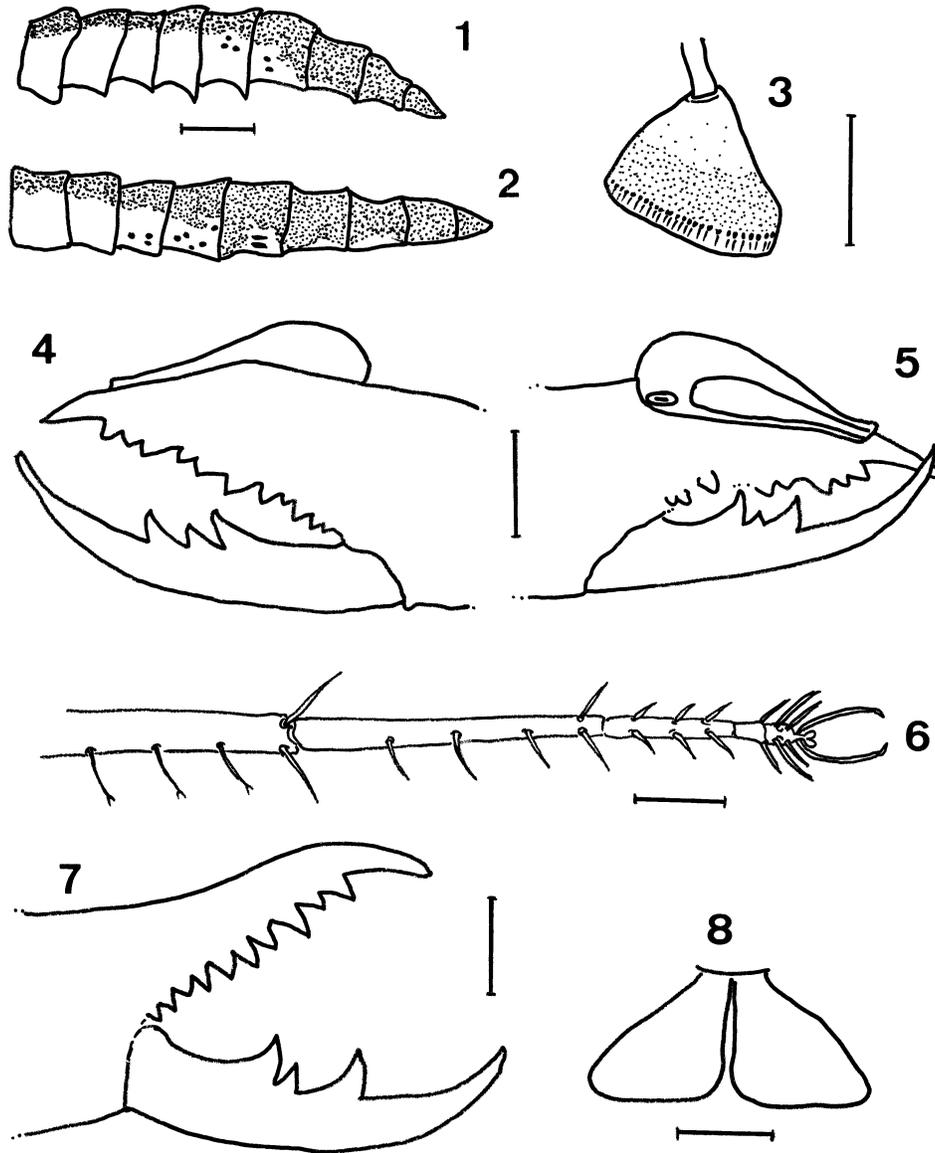
**Etymology.**—The specific name “taiete” is

from Tupi, ancient South American Indian language, and means “very good teeth”, and is to be treated as a noun in apposition.

**Diagnosis.**—*Mummucia taiete* is the only species of Mummuciidae with the last three distal pleurites almost totally dark-brown (Figs. 1, 2).

**Description.**—*Male*: Coloration in 80% ethanol: Prosoma. Propeltidium white, with a central brown blotch, with the dorsal grooves between propeltidium and lateral lobes dark-brown. Ocular tubercle dark-brown. Peltidium white. Parapeltidium, mesopeltidium and metapeltidium similar to opisthosomal tergites. Chelicerae pale-brown, three longitudinal white stripes on ectal face joined dorsally above the fonal teeth. Pedipalps and legs brown, with slightly darker ends. Malleoli as in Fig. 3. Opisthosoma: Lateral borders of tergites white, with wide dark-brown stripe on the central half, which is darker near the posterior border of the tergites. Brown bifid setae with brown sockets when they are in white area of the tergites, and white sockets when in the dark-brown area. Pleurites (Figs. 1, 2) with dark-brown and pale-brown areas, being the three last distal almost entirely dark-brown. Sternites pale-brown, lateral borders slightly darker. First and second post-spiracular sternites with about 15 brown spots which include the sockets of some bifid bristles. All vestitural bristles and bifid bristles are translucent pale-brown.

**Morphology and chaetotaxy:** Prosoma. Propeltidium with some scattered bifid setae, slightly wider than long (Table 1) and separated from lateral lobes by dorsal grooves. Ocular tubercle prominent with bifid setae anteriorly oriented. Distance between the two eyes slightly more than one eye diameter. Peltidium narrow, with a transverse row of bifid setae. Parapeltidium smooth. Mesopeltidium wider than long, semicircle-shaped, with several bifid setae on posterior border. Metapeltidium wider than long, with several bifid setae. Chelicerae (Figs. 4, 5): stridulatory apparatus on mesal face with six parallel narrow grooves; ectal face with several short bristles and several setae, bifid or acuminate; movable finger with one anterior, one intermediate and one principal tooth, graded in size from distal to proximal II, III, I. Fixed finger with three anterior teeth, one intermediate and one principal tooth, graded in size from distal to prox-



Figures 1–8.—*Mummucia taiete* new species, holotype male unless stated otherwise: 1. Left pleurites; 2. Left pleurites of male paratype; 3. Left malleolus V; 4. Left chelicera, mesal view; 5. Left chelicera, ectal view; 6. Left leg IV; 7. Right chelicera, ectal view, of female paratype; 8. Genital operculum of female paratype.

imal III, V, II, IV, I. The three anterior teeth placed in a slightly prominent projection so that they are not completely aligned with other teeth. Six ectal fondal teeth graded in size from distal to proximal I, II, V, III, IV, VI, being third and sixth ectal teeth from distal to proximal occasionally vestigial or absent. Three mesal fondal teeth graded I, II, III, the first distal separated from the others by a di-

astema; flagellum (Figs. 4, 5) thin, translucent drop-shaped vesicle, laterally flattened and with a longitudinal ectal opening. Pedipalp: tarsi immovable, without spines, densely covered by differentially sized bifid bristles, with some very long setae on basitarsi and tibiae (about twice the length of pedipalpal tibia). Legs: with several differentially sized bifid bristles and some bifid setae. Some very long

Table 1.—Morphometric characters of *Mummucia taiete*, in millimeters (except propeltidium length/width ratio).

| Morphometric character          | Holotype | Males<br>( <i>n</i> = 5) | Female<br>paratype | Females<br>( <i>n</i> = 5) |
|---------------------------------|----------|--------------------------|--------------------|----------------------------|
| Total length                    | 9.20     | 8.00–9.20                | 12.00              | 10.00–12.00                |
| Cheliceral length               | 2.50     | 1.80–2.50                | 2.80               | 2.50–2.80                  |
| Cheliceral width                | 0.90     | 0.70–0.90                | 1.00               | 0.84–1.00                  |
| Propeltidium length             | 1.72     | 1.30–1.72                | 1.63               | 1.56–1.63                  |
| Propeltidium width              | 2.03     | 1.60–2.03                | 2.25               | 2.19–2.25                  |
| Propeltidium length/width ratio | 0.85     | 0.81–0.85                | 0.72               | 0.71–0.72                  |
| Pedipalpus length               | 6.88     | 6.50–6.88                | 6.40               | 5.84–6.40                  |
| Leg I                           | 5.75     | 5.75–6.00                | 5.50               | 5.20–5.50                  |
| Leg IV                          | 11.88    | 9.20–11.88               | 8.96               | 8.00–8.96                  |

dorsal setae (about twice the length of basitarsus IV). Leg I thin, without claws and spines. Legs II and III: tibiae with a distal pair of ventral spines; basitarsus with three retro-lateral spines and 1.1.2 ventral spines; telotarsi two-segmented with 2.2.2/2.2 ventral spines. Leg IV (Fig. 6): tibia with an anterior row of 1.1.1 ventral bifid spines and a distal pair of ventral spines; basitarsus with 1.1.1.2 ventral spines; telotarsi three-segmented, with 2.2.2/2.2 ventral spines. Opisthosoma. Tergites with rounded borders, covered by bifid setae and bifid bristles. Sternites densely covered by bifid bristles. Posterior border of second post-spiracular sternite with a row of about 50 ctenidia. Morphometric dimensions in Table 1.

*Female*: Similar to male, but with the following particular features. Morphology and chaetotaxy: Prosoma. Eyes separated by twice their diameter. Chelicerae (Fig. 7): stridulatory apparatus with 8 parallel narrow grooves. Movable finger with 1 anterior, 1 intermediate and 1 principal teeth graded in size from distal to proximal I, III, II. Fixed finger with three anterior teeth, one intermediate and one principal tooth, graded in size from distal to proximal III, V, I, IV, II. Five ectal fondal teeth graded in size from distal to proximal I, II, IV, III, V. Genital operculum prominent, fan-shaped, round-bordered, with central longitudinal opening (Fig. 8). Morphometric characters in Table 1.

**Remarks.**—According to Maury (1998), it is impossible to reliably distinguish the genera of Mummuciidae, so the most conservative decision is to consider the new species described here as belonging to the typical genus

*Mummucia* until more precise information about the taxonomy and phylogeny of the group become available. The same decision was adopted in the description of *Mummucia mauryi* Rocha 2001 (Xavier & Rocha 2001) and *M. coaraciandu* Pinto-da-Rocha & Rocha 2004 (Martins et al. 2004).

The cheliceral dentition of *M. taiete* and *M. coaraciandu* are quite similar; remarkably this feature is generally species-specific in Solifugae (Maury 1984; Rocha 2002). These two species can only be distinguished by the coloration of the posterior three pleurites, which are almost totally dark-brown in *M. taiete* whereas they are predominantly pale-brown in *M. coaraciandu*.

The color pattern of the pleurites are known for four species of Mummuciidae and may be considered as species-specific. The mummuciids *Metacleobis fulvipes* Rower 1934 (Rocha & Canello 2002a), *Mummucia mauryi* (Xavier & Rocha 2001), *Mummucia coaraciandu* (Martins et al. 2004), *Gaucha fasciata* Mello-Leitão 1924 (Maury 1970; Rocha, unpub. data) present distinct patterns of pleurite coloration, with slight intraspecific variation. Unfortunately, pleurite coloration has not been studied in the remaining 15 species of Mummuciidae.

It is not known if the coloration difference between *M. coaraciandu* and *M. taiete* suggests that they are two actual and reproductively isolated species. Alternatively, this distinction could be merely a geographical polymorphism due to low gene flow between the populations (putative species), since they are isolated by about 1300 km and by several rivers, ecosystems and other barriers. Any-

Table 2.—Characteristics of two Cerrado enclaves near Vilhena, Rondônia state, Brazil where *M. taiete* was collected (data from Colli, G.R. in prep.). Cerrado “stricto sensu” = a woodland; Cerrado field = open scrubland.

|        | Area (Km <sup>2</sup> ) | Cerrado “stricto sensu” | Antropic field | Cerrado field | Cerrado “forest” |
|--------|-------------------------|-------------------------|----------------|---------------|------------------|
| Site 1 | 73.15                   | 83.9%                   | 8.2%           | 7.6%          | 0.3%             |
| Site 2 | 10.06                   | 85.2%                   | 9.4%           | 5.4%          | 0%               |

how, pleurite coloration is indeed diagnostic for *M. coaraciandu* and *M. taiete* and fits at least the definition of the typological concept of a species.

#### ECOLOGICAL RESULTS AND DISCUSSION

We recorded the occurrence of *M. taiete* at only two study sites in the Vilhena region with densities of 29.65 individuals/m<sup>2</sup>/day at site 1 and 17.52 individuals/m<sup>2</sup>/day at site 2. Both sites are Cerrado enclaves with similar vegetation cover (Table 2). Total number of individuals captured:  $n_{\text{site 1}} = 66$ ;  $n_{\text{site 2}} = 39$ . These figures show both the high density and mobility of this species. The observed frequency distributions of the number of *M. taiete* caught in 50 pitfall traps fit the Poisson distribution in both areas (Kolmogorov-Smirnov one-sample test,  $K = 0.368$ ,  $P < 0.01$ ,  $n = 50$ ) showing a random distribution pattern of *M. taiete* movements. We found no solifuges in the other seven study sites. Data from other arachnids will appear elsewhere (Carvalho et al. in prep.).

We found a decreasing activity in *M. taiete* in the early morning hours when we arrived at the sites between 7:30–8:30 a.m., when many live individuals were found in the 20 1 pitfall traps. This suggests that activity may begin at dawn (no individuals were seen during the night surveys) (Maury 1984; Xavier & Rocha 2001; Martins et al. 2004). The sex-ratio (operational) was biased toward males ( $\chi^2 = 4.694$ , d.f. = 1,  $P < 0.05$ ; with Yates correction; data from both areas were pooled after perform heterogeneity chi-square analysis:  $\chi^2 = 0.29$ , d.f. = 1, N.S.; Chi-square analysis with Yates correction  $H_0 = 1:1$ ; site #1:  $\chi^2 = 3.368$ , d.f. = 1, N.S.; site #2:  $\chi^2 = 0.941$ , d.f. = 1, N.S.), probably due to higher male

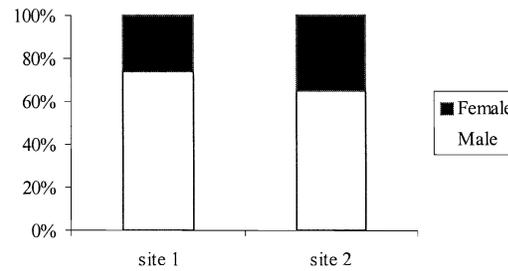


Figure 9.—Operational sex-ratio of *M. taiete* is male biased ( $\chi^2$  with Yates correction = 4.694, d.f. = 1,  $P < 0.05$ ,  $n = 36$ ; data from both areas were pooled after perform heterogeneity chi-square analysis). Mature individuals were captured in two Cerrado enclaves near Vilhena, Rondônia state, Brazil. ( $n_{\text{site 1}} = 19$ ,  $n_{\text{site 2}} = 17$ ). Capture effort: 50 pitfall traps (9 cm diameter, 1 meter apart) were exposed for one week.

activity (Muma 1975, 1980; Xavier & Rocha 2001; Martins et al. 2004) or to early male maturity (Muma 1966b). The occurrence of one or both of these factors could explain the male biased sex-ratio we found in the pitfall trap data (Fig. 9). We tested the null hypothesis of an 1:1 juvenile/adult ratio and Site 1 seems to have a young, rapidly expanding population ( $\chi^2$  with Yates correction test:  $\chi^2 = 11.045$ , d.f. = 1,  $P < 0.001$ ,  $n = 66$ ) and site 2 a relatively slow growth population ( $\chi^2 = 0.41$ , d.f. = 1, N.S.,  $N = 39$ ) (Fig. 10). This difference in the dynamic of these populations may reflect constraints due to the smaller size of Site 2. This survey was conducted at the end of the dry season, thus juveniles would

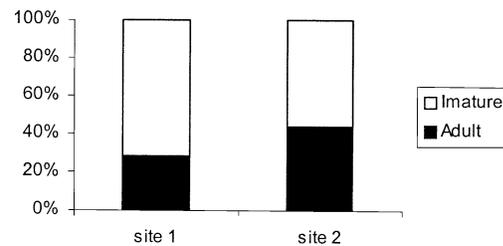


Figure 10.—Proportion of juveniles in *M. taiete* populations from two Cerrado enclaves near Vilhena, Rondônia state, Brazil. Individuals were caught by 50 pitfall traps (9 cm diameter, 1 meter apart) exposed for one week in each site. ( $\chi^2$  with Yates correction test  $H_0 = 1:1$ , site 1:  $\chi^2 = 11.045$ , d.f. = 1,  $P < 0.001$ ,  $n_{\text{site 1}} = 66$ ; site 2:  $\chi^2 = 0.41$ , d.f. = 1, N.S.,  $n_{\text{site 2}} = 39$ ).

reach maturity after the onset of the rainy season.

Both sites have white sandy soil and this may facilitate colonization by *M. taiete* due to the excavation behavior of Solifugae. Similar soil features appear to be favorable for *M. coaraciandu*, another solifuge from Brazilian Cerrado, which is more abundant in sites with sandy soils (Martins et al. 2004). Accordingly to these observations, Dean & Griffin (1993) suggest that sandy soils are a key factor determining the occurrence of many solifuge species. However, two other P. Bueno sites (Sites 12 & 12A) also have white sandy soils and may potentially be colonized by *M. taiete*. Prance (1996) observes that savannahs on white sandy soil have a high incidence of endemism among plant species. All three G. Mirim sites are rock outcrops and seem unlikely to be colonized by *M. taiete* (Colli unpub. data, for details of vegetation structure and physical characteristics for all nine sites; we use here the same site labels as Colli). *Mum-mucia taiete* may be a distribution-restricted species with high density populations in Cerrados of white sandy soils with a particular combination of Cerrado types allowing direct incidence of solar radiation in patches of bare soil surface. It is worth noting that these two sites are the most similar regarding vegetation cover compared to the other seven sites surveyed (Colli et al. unpub. data).

The data presented here coupled with the above-mentioned characteristics derived from the literature suggest that Solifugae deserve further investigation as a key predator of arthropod fauna in the Brazilian Cerrados, a poorly known biodiversity hotspot.

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#### LITERATURE CITED

- Cloudsley-Thompson, J.L. 1962. Lethal temperatures of some desert arthropods and the mechanism of heat death. *Entomologia Experimentalis et Applicata* 5:270–280.
- Cloudsley-Thompson, J.L. 1977. Adaptational biology of Solifugae (Solpugida). *Bulletin of the British Arachnological Society* 4:61–71.
- Dean, W.R.J. & E. Griffin. 1993. Seasonal activity patterns and habitats in Solifugae (Arachnida) in the southern Karoo, South Africa. *South African Journal of Zoology* 28:91–94.
- Harvey, M.S. 2002. The neglected cousins: what do we know about the smaller arachnid orders? *Journal of Arachnology* 30:357–372.
- Martins, E.G., V. Bonato, G. Machado, R. Pinto-Da-Rocha & L. S. Rocha. 2004. Description and ecology of a new species of sun spider (Arachnida: Solifugae) from the Brazilian cerrado. *Journal of Natural History* 38:2361–2375.
- Maury, E.A. 1970. Sobre la presencia de *Gaucho fasciata* Mello-Leitao 1924 en la Argentina. *Physis* 79(29):357–362.
- Maury, E.A. 1982. Solifugos de Colombia y Venezuela (Solifugae, Ammotrechidae). *Journal of Arachnology* 10:123–143.
- Maury, E.A. 1984. Las familias de Solifugos Americanos y su distribución geográfica (Arachnida, Solifugae). *Physis, Buenos Aires* 42:73–80.
- Maury, E.A. 1998. Solifugae. Pp. 560–568. *In* Biodiversidad de Artropodos Argentinos. (J.J. Morrone & S. Coscarón, eds). Ediciones SUR. La Plata.
- Muma, M.H. 1951. The arachnid order Solpugida in the United States. *Bulletin of the American Museum of Natural History* 97:35–141.
- Muma, M.H. 1966a. Burrowing habits of North American Solpugida (Arachnida). *Psyche, Cambridge* 73:251–260.
- Muma, M.H. 1966b. The life cycle of *Eremobates durangonus* (Arachnida: Solpugida). *Florida Entomologist* 49:233–242.
- Muma, M.H. 1967. Basic behavior of North American Solpugida. *Florida Entomologist* 50:115–123.
- Muma, M.H. 1975. Long term can trapping for population analyses of ground-surface, arid-land arachnids. *Florida Entomologist* 58:257–270.
- Muma, M.H. 1980. Comparison of three methods for estimating solpugid (Arachnida) populations. *Journal of Arachnology* 8:267–270.
- Myers, N., R.A. Mittermeier, G.C. Mittermeier, G.A.B. Fonseca & J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403:853–859.
- Pianka, E.R. 1966. Convexity, desert lizards, and spatial heterogeneity. *Ecology* 47:1055–1059.
- Prance, G.T. 1996. Islands in Amazonia. *Philosophy*

- ical Transactions of the Royal Society of London B 351:823–833.
- Rocha, L.S. 2002. Solifugae. Pp. 439–448. *In* Amazonian Arachnida and Myriapoda (Adis, J. ed). Sofia. Pensoft Publishers.
- Rocha, L.S. & E.M. Canello. 2002. Redescription of *Metacleobis fulvipes* Roewer from Brazil (Solifugae, Mummuciidae). *Journal of Arachnology* 30:104–109.
- Rocha, L.S. & E.M. Canello. 2002b. South American Solifugae: New records, occurrence in humid forests and concurrence with termites. *Newsletter of the British Arachnological Society* 93:4–5.
- Shultz, J.W. 1989. Morphology of locomotor appendages in Arachnida: evolutionary trends and phylogenetic implications. *Zoological Journal of the Linnean Society* 97:1–56.
- Silva, J.M.C. & J.M. Bates. 2002. The Cerrado: a tropical savannah hotspot. *Bioscience* 52:225–233.
- Xavier, E. & L.S. Rocha. 2001. Autoecology and description of *Mummucia mauryi*, a new species from Brazilian semi-arid caatinga. *Journal of Arachnology* 29:127–134.
- Manuscript received 11 May 2004, revised 1 February 2005.*