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# Population dynamics of *Loxosceles similis* (Moenkhaus, 1898) in a brazilian dry cave: a new method for evaluation of population size

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**ABSTRACT:** Variation in population size, distribution and displacement in the cave, age structure and sex ratio of a cave population of *Loxosceles similis* (Moenklaus, 1898) was studied in a southeastern limestone Brazilian cave. Spider abundance was smaller in July, 1998 (n=863) and higher in January, 1999 (n=1420), fact that can be related with an eventual increase of prey number in the rainy season. The abundance of spiders decreases from the entrance to the cave deep. Some individuals had dislocated at least 40 meters in one week. Some authors consider the mobility of 2 meters as expressive for species in this genera. The operational sex ratio was 1:6, but it changed during the study period. The population sizes were estimated by a new method here proposed.

**Key Words**: *Loxosceles similis*, population dynamics, caves, population size estimation, neotropics

## INTRODUCTION

Cave habitats are characterized by a tendency towards environmental stability and permanent darkness (POULSON & WHITE, 1969). In the absence of primary producers (phototrophics), the cave organisms must find other sources of energy, generally rare. Such resources are, mainly, organic matter brought from the exterior by the water or by animals that use the cave.

Just about 1,000 out of 40,000 spider species known in the world are capable of colonizing and stablishing populations inside caves (Ribera & Juberthie, 1994).

In Brazil, 44 spider families have already been registered into caves (PINTO-DA-ROCHA, 1995; FERREIRA, 2004), from which 36 occur in caves in Minas Gerais state (FERREIRA, 2004). Species of Pholcidae, Ctenidae, Theridiosomatidae, Scytodidae,

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Theridiidae, Oonopidae, Araneidae, and Sicariidae are relatively common, but Actinopodidae, Anyphaenidae, Amaurobiidae, Caponiidae, Corinnidae, Ctenizidae, Dipluridae, Deinopidae, Filistatidae, Gnaphosidae, Heteropodidae, Lycosidae, Lyniphiidae, Nemesiidae, Nesticidae, Ochyroceratidae, Palpimanidae, Phylodromidae, Pisauridae, Segestridae, Symphytognathidae, Tetrablemmidae, Tetragnathidae, Theraphosidae, Thomisidae, Trechaleidae, Uloboridae and Zodaridae occur in only few caves.

The genus *Loxosceles* Heineken & Lowe, 1832 (Sicariidae) is broadly distributed in the Americas and is considered of medical importance, as it causes a high number of accidents in humans by poisoning with its punctures (FUTRELL, 1992; MARQUES DA SILVA, 2002; GONÇALVES-DE-ANDRADE *et al*., 2003). The *Loxosceles* spiders are nocturnal, living usually in white silk sheet webs covering the substrate (BUCHERL, 1961). Although all spiders are predators, SANDIDGE (2003) decribed the scavenger behaviour of *L. reclusa* Gertoch & Mulaih 1940, preferring dead over live preys, what is an advantage because their food are more easily met. There are nine species of *Loxosceles* in Brazil, three of which have already been found into caves: *L. similis* (Moenkhaus, 1898) *L. gaucho* Gertsch,1967 and *L. adelaida* Gertsch,1967 (PINTO-DA-ROCHA, 1995). Such spiders are troglophile predators (FERREIRA & MARTINS, 1998) common in Brazilian caves.

Notwithstanding the potential importance of these top predators in the structure of cave communities (FERREIRA & MARTINS, 1998) there are no studies on the behavior and population dynamics of cave spiders in Brazil. The studies concerning *Loxosceles* spp. in Brazilian caves focus only on their presence on the different caves (DESSEN *et al*. 1980; TRAJANO & GNASPINI-NETO, 1990; TRAJANO & MOREIRA, 1991; GNASPINI & TRAJANO, 1994; GNASPINI *et al.* 1994; GONÇALVES-DE-ANDRADE *et al*., 2001).

The aim of this work was to study the dynamics of a *similis* population in its natural habitat (Lavoura cave), in order to answer the following questions:

1. Are there variations in population size of *similis* into the cave during the year?
2. How is the distribution of individuals within the cave?

3. Is there frequent migration of individuals through the conduct of the cave?

4. Does the age structure of the population vary during the year?

5. Does the sexual rate of the population vary through time?



# METHODOLOGY

## Study Site:

The study was conducted in the Lavoura Cave (S19º31'2700" W44º02'1400"; CNC – MG-221) (Sociedade Brasileira de Espeleologia, 1989), in Matozinhos municipality, Minas Gerais, Brazil, from May 1998 to March 1999, with bimestrial visits to the cave. The cave entrance is located in the base of a limestone outcrop with tumbled slabs of rock at its base. The outcrop and immediate vicinity have small shrubby vegetation, modified by anthropogenic action. On the top of the outcrop there is a cattle pen. The cave presents a horizontal projection of 290 meters and descends only 16 meters. Its entrance is at an altitude of 700 meters, and is initiated in a chamber of rock with a relatively low, flat ceiling. At the center of this, a skylight allows the entrance of sediments and organic material into the chamber from the cattle pen located above. Cattle and human inhabitants of the region occasionally use this chamber. Several hematophagous bat, *Desmodus rotundus,* (Geoffroy,1810), guano deposits are distributed along the floor of the main conduit of the cave (nearly 140 meters). A few deposits are found in lateral conduits or on higher levels in the main conduit. Detailed geological and ecological information about the cave system can be found in FERREIRA (1998).

## Spiders sampling:

The spiders were identified L. as *similis* by Adalberto J. Santos, from Laboratório de Artrópodes of Instituto Butantan, São Paulo.

The main conduit of the cave was divided, from the cave entrance, in seven linear sections, each one 20 meters long. The spiders were put, for some seconds, in glass pots inserted in ice, being temporarily paralyzed. The individuals were marked in the dorsal portion of the abdomen with a dot of acrylic fast dying ink. The color marked on the spider corresponded to the section where it was found. In the following week, after marking, spiders were counted to obtain the estimate of population size and the distribution of individuals among the sections of the cave. Since many spiders (especially immature individuals) are too small, individual marks were not possible. So, a new method to evaluate population size was proposed here, and will be described forward.

The bimestrial distribution of the individuals in the seven sections of the cave results from the total number of individuals in the first sampling and in the recapture. The variation in abundance of individuals by section in relation to the distance from the cave entrance was tested with simple linear regression (ZAR, 1996). Data lacking normal distribution were log transformed ($\log_{10}$).

The movement of spiders through the conduit of the cave was registered verifying the correspondence of marked colors of the dots on the abdomen of each individual and the corresponding color of the section where capture took place.

The maximum width of the cephalothorax was measured, between the second and the third leg pairs, aiming to group the spiders in size classes. Age pyramids were built grouping the individuals in size classes regarding cephalothorax width.

The presence or absence of modified pedipalps allowed the differentiation of sexually mature males and females. Only individuals with cephalothorax equal or wider than 3.0 mm were included in the calculation of the sexual rate. Since 3.0 mm was the measurement of the smallest mature male identified, all individuals with cephalothorax equal or wider than 3.0 mm were considered adults, and those without modified pedipalps were considered females.

## Estimation of the population oscillation:

Bimestrial variations in population size were detected using a new methodology, described herein for the first time. Since it was impossible to have a specific mark for each captured individual, mainly due to the small size of the youngest ones, the survivorship rates (whose estimates depend on specific individual marks) could not be estimated through conventional methods (see FERNANDEZ, 1995). Then, the estimates of survivorship rates were done as follows (Fig. 1):

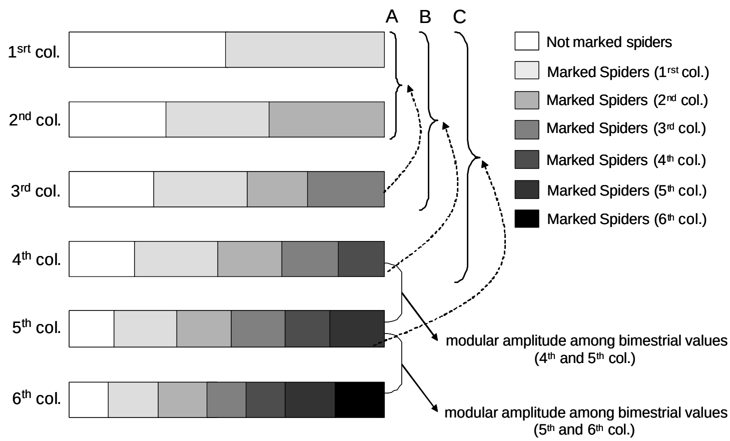


**Figure. 1.** Method proposed here to evaluate the oscillation in population size when individual marks are impossible. Each bar represents a bimestrial collection. Different colors indicate spiders that were marked in each collection, but that are no distinguishable, since the marks are not individual. The population size in the first sampling (first to second) was estimated through the method of capture and recapture of Lincoln-Petersen. From the second month on, the total number of marked spiders was the sum of all individuals marked during the whole sampling period. At the end of the study, the number of individuals marked and recaptured in each bimestrial were obtained. So, the proportion of marked individuals recaptured in relation to the total number of individuals marked previously (spiders marked in the second collection in relation to A, in the third collection in relation to B, in the fourth collection in relation to C) was calculated. The modular amplitude was calculated among bimestrial values, reflecting the rate of "variation" in the population in each bimestrial. These values were summed and divided by five (number of samplings), obtaining the mean modular amplitude during the sampling period (bimestrial rate of population variation). The complementary value of this "rate" corresponds to the rate of "bimestrial permanence of individuals in the population", that expresses the survivorship and the bimestrial variations in immigration, emigration, births and mortality.

The population size in the first sampling was estimated through the method of capture and recapture of Lincoln-Petersen (FERNANDEZ, 1995). Though, besides the individuals marked in the second sampling, there were also marked individuals that survived from the first sampling. As the individuals had not been marked individually (since it was impossible, as mentioned before), it was impossible to estimate population size through the method of Lincoln-Petersen in the second sampling, since recaptures could include individuals marked in both the first and the second samplings. Then, from the second month on, the total number of marked spiders was the sum of all individuals marked during the whole sampling period. At the end of the study, the number of individuals marked and recaptured in each bimestrial were obtained. The proportion of marked individuals recaptured in relation to the total number of individuals marked previously (all the spiders marked to that moment) was estimated as follows: as the estimate of population size in the first sampling was of more than 1000 individuals, the proportions were estimated by 1000 ($\%_o$), and not percentages (%). Following, the modular amplitude was calculated among bimestrial values, reflecting the rate of "gain" and "loss" in the population in each bimestrial. These values were summed and divided by five (number of samplings), obtaining the mean modular amplitude during the sampling period (bimestrial rate of population variation). The complementary value of this "rate" corresponds to the rate of "bimestrial permanence of individuals in the population", that expresses the survivorship and the bimestrial variations in immigration, emigration, births and mortality. The rate of bimestrial permanence of individuals in the population was used for the calculation of the estimates of population sizes in the remaining bimestrials, (instead of survivorship rates) by the conventional method (Lincoln-Petersen).

## RESULTS

The estimate of initial population size of *L. similis* in May 1998 was of 1038 individuals. The rate of population permanency for this month was 0.722. The estimates of population sizes varied in the following months: 836 individuals in July 1998; 1166 individuals in September 1998; 1370 individuals in November 1998; 1420 individuals in January 1999, and 1200 individuals in March 1999 (Fig. 2).

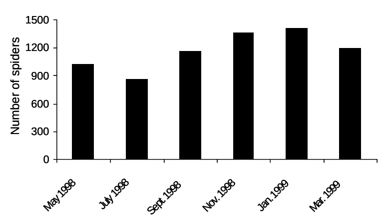


Figure. 2. Population size of *Loxosceles similis* in the Lavoura cave during the sampling months.

Simple regressions between the distributions of abundances of spiders (Fig. 3) and the distance from the entrance of the cave indicate a decrease in the abundance of *L. similis* as it becomes farther from the entrance in the months of May, July, and September 1998 ($r^2$=0.605; $r^2$=0.923 e $r^2$=0.699, $p<0.05$ respectively). However, these relationships were not significant for November 1998 nor January and February 1999.

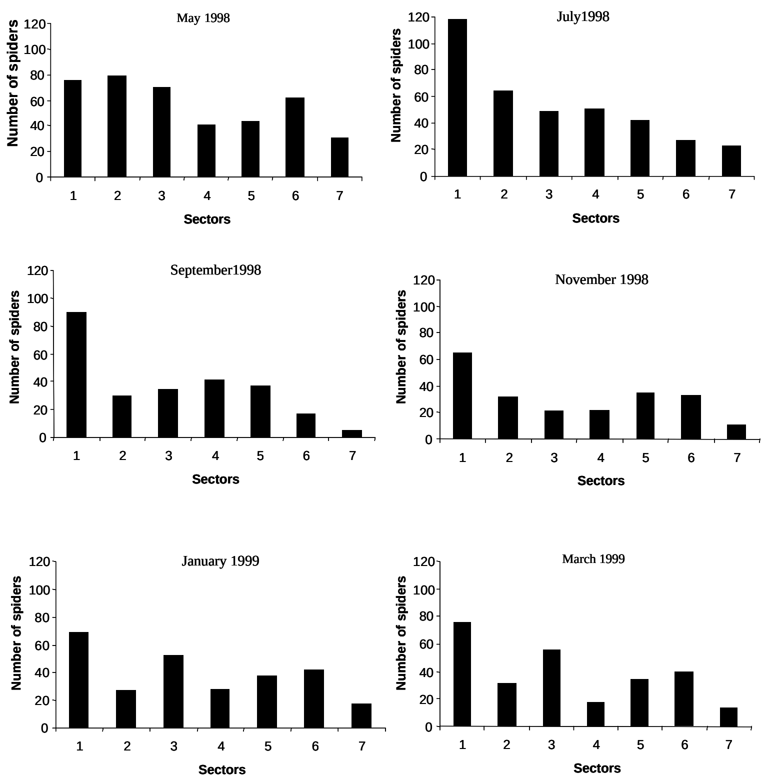


Figure. 3. Distribution of individuals of *Loxosceles similis* captured in the different sections of the Lavoura cave during the sampling months.

The dispersion of the spiders among the sections of the cave was frequent. A mean of 48% of the spiders was recaptured in sections different from those where they were first caught. However, most spiders were found in sections adjacent to the original ones. Only few individuals moved two, three and, more rarely, four sections (Tab. 1).

**Table 1.** Movement of the spiders of the Lavoura cave at different sampling periods.

| Sampling period | Spiders Spiders recaptured in a different section | Movement of the spiders | | | |
|---|---|---|---|---|---|
| | | 1 Section | 2 Sections | 3 Sections | 4 Sections |
| July 1998 | 55% (n=37) | 37,5% | 15% | 2,5% | 0% |
| September 1998 | 52% (n=10) | 36,75% | 5,25% | 5,25% | 5,25% |
| November 1998 | 58% (n=7) | 24,9% | 24,9% | 8,2% | 0% |
| January 1999 | 50% (n=5) | 20% | 20% | 10% | 0% |
| March 1999 | 54% (n=12) | 54% | 0% | 0% | 0% |

The pyramids of size classes showed variations along time during the study. The intermediate size classes prevailed in the first three months, after which there was an increase in the abundance of adults, in November 1998. In January and March 1999, on the contrary, the proportion of young individuals increased and there was a decrease in the number of adults (Fig. 4).

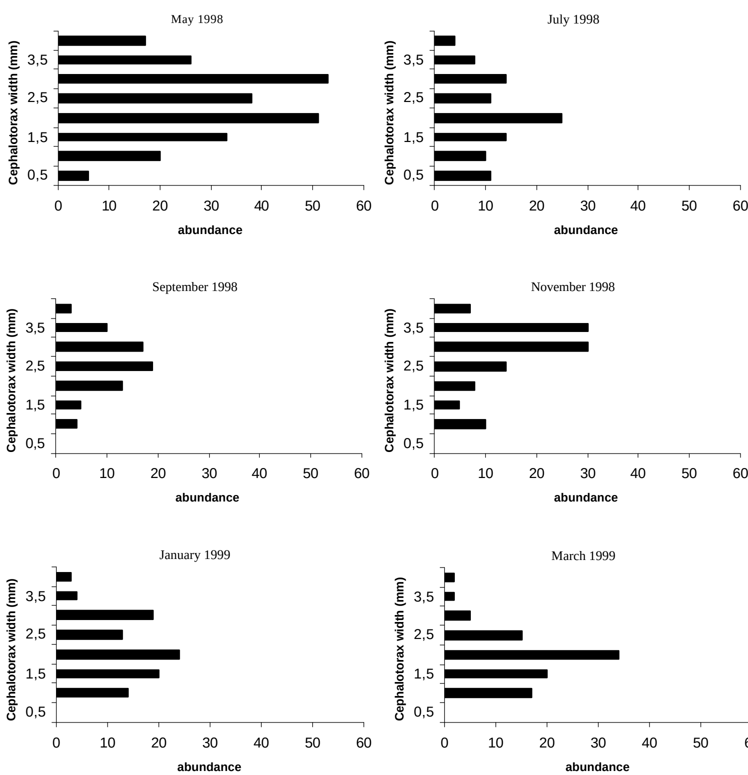


Figure 4. Age pyramids based on captured individuals of *Loxosceles similis* in different months at the Lavoura cave.

The operational sexual rates varied among the sampling months: 1:2.2 in July 1998; 1:3 in September 1998; 1:2.7 in November 1998; 1:6.25 in January 1999, and 1:10 in March 1999. The mean rate remained 1.0:6.03 during the study.

## DISCUSSION

The development of spiders of the genus *Loxosceles* depends on specific temperatures, and is damaged when the spiders are exposed to extreme temperatures (Fischer, 1996). Besides, spiders are markedly photophobic, and then they prefer sites with low light intensity (Bücherl, 1961). Although the temperatures were not measured during the study, cave environments are known to be extremely stable, possessing high humidity, stable temperatures and permanent lack of light, favoring the colonization and permanency of populations of these spiders, since there is enough food.

The population of *L. similis* showed a cycle that can suggest some seasonality, since the climatic conditions and food availability are maintained. The population was larger during the rainy period (November 1998 to January 1999), when there is an increase in the input of food resources as vegetal debris and cattle feces, brought by the water (percolation or floods). The increase of food resources contributes to elevate the number of detritivorous species, which are potential preys for *L. similis* (see FERREIRA & MARTINS, 1999).

*Loxosceles* species are considered sedentary, having a life area restricted to the vicinities of their webs (BÜCHERL, 1961; FOELIX, 1987). However, in this study, a great mobility was detected in relation to what was expected previously. Many individuals of *L. similis* were recaptured at distances from 20 to 80 m from the place where they were marked (a movement of 40 m was registered in only one week). These distances are much longer then those registered for *L. rufipes* (Lucas, 1834) and *L. intermedia* Mello-Leitão, 1934, which moved up to 2m in one week, what have been considered a significant mobility (DELGADO 1966; FISCHER 1996).

Nevertheless, the cave environment offers conditions different from those found in the external or anthropogenic environments. The lack or irregular distribution of food resources in a cave result in lower prey availability, what may lead the spiders to move longer distances searching for prey.

FISCHER (1996) observed the movements of *L. intermedia* in an urban environment. The reduced movement detected by Fischer then could be an altered behavior due to the features of habitats very altered by man, the behavior in natural conditions being that of higher mobility.

The distribution of *L. similis* was heterogeneous and variable. In all sampling months there was a decrease in the number of individuals from the entrance to the interior of the cave. This fact may be associated to the low resource availability in the inner sections of the cave. In this region, the main food sources are very old guano deposits that have a low nutritive value (FERREIRA *et al*, 2000). The potential preys of *Loxosceles* species are heteropterans, coleopterans, lepidopterans, diplopods, and orthopterans (HITE *et al.* 1966; LEVI & SPIELMAN, 1961; FISCHER, 1996). Invertebrates from these orders have been registered in guano deposits in the Lavoura cave (FERREIRA *et al,* 2000). These authors also observed a decrease in the abundance of these invertebrates as the deposits became older. So, since the main food sources in the inner region of the cave are old guano deposits, there is a reduction of potential prey availability, what may cause a decrease in the abundance of *L. similis*.

At the entrance of the cave, besides the organic matter brought by floods, there is an opening on the roof through which farmers throw calf carcasses. This nutrient availability promotes the development of a fauna rich in potential preys for *L. similis* in the first meters of the cave, where *L. similis* have been more abundant.

The duration of the sexual maturation period is variable for the different species of *Loxosceles*: 315 days for *L. laeta* (GALIANO, 1967), 336 days for *L. reclusa* (HITE *et al.,* 1966), 357 days for *L. rufipes* (Delgado, 1966), 370 to 610 days for *L. gaucho* (RINALDI *et al.* 1997). The pyramids of size classes of *L. similis* showed an increase in the number of young individuals in January and March, what indicates better conditions for reproduction during the rainy period. However, the reproduction occurs during the whole year, as it happens in *L. rufipes* (DELGADO, 1966), since specimens from all size classes were registered in all sampling months. These data also indicate the superposition of generations, as it was observed in *L. rufipes* (DELGADO, 1966).

All the size pyramids of *L. similis* always show a low number of individuals smaller than 1mm. However, the number of individuals in this size class was underestimated due to the difficulty of locating them in an irregular substratum as that of the cave.

The mean operational sexual rate of 1:6.03 is similar to that found by BÜCHERL (1961) in populations of *L. gaucho* in the field (1:6). In laboratory studies the sexual rate for *L. gaucho* and *L. intermedia* are 1.0:1.7 (RINALDI *et al.,* 1997) and 1.0:1.0 (FISCHER, 1996) respectively. According to RINALDI *et al.,* (1997), the difference in sexual rates between populations reared in the laboratory and natural populations reflect the evasive behavior of males and nymphs in the field. A minimum disturbance leads males, more evasive than females, to hide themselves promptly.

Population studies on spiders of the genus *Loxosceles* in cave environments are very important, as they aid to the understanding of population dynamics in natural habitats, very different from those found under human influence. Since these spiders are top predators in cave food webs, the study of their population dynamics aid to the understanding of the functioning of this ecosystem as a whole. Besides, as noted by GONÇALVES-DE-ANDRADE (2001), the medical importance associated to the increasing touristic interests in caves, make studies about *Loxosceles* biology strongly pertinent.

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## REFERENCES

BÜCHERL, W. 1961. Aranhas do gênero *Loxosceles* e o Loxoscelismo na América. **Ciência e Cultura 13**(4):213-224.

CULVER, D.C. 1982. **Cave Life**. Harvard University Press. Cambridge, Massachusetts and London, England. 189pp.

DECU, V. 1986. Some considerations on the bat guano synusia. **Trav. Inst. Spéol. "Emile Racovitza" 25**:41-51.

DELGADO, A. 1966. Investigacion ecológica sobre *Loxosceles rufipes* (Lucas) en la region costera del Perú. **Mem. Inst. Butantan** 33(3):683-688

DESSEN, B.E.M.; ESTON, V.R.; SILVA, M.S.; TEMPERINI-BECK, M.T. & TRAJANO E. 1980. Levantamento preliminar da fauna de cavernas de algumas regiões do Brasil. **Ciência e Cultura 32**: 714-725.

FERNANDEZ, F.A.S. 1995. Métodos para estimativa de parâmetros populacionais por captura, marcação e recaptura. **Oecologia Brasiliensis** 2: 01-26.

FERREIRA, R.L. & P.S. POMPEU. 1997. Fatores que influenciam a riqueza e a diversidade da fauna associada a depósitos de guano na gruta Taboa, Sete Lagoas, Minas Gerais, Brasil. **O Carste 2**(9):30-33.

FERREIRA, R.L. 1998. **Ecologia de comunidades cavernícolas associadas a depósitos de guano de morcegos.** Dissertação de mestrado do curso de Ecologia, Conservação e Manejo da Vida Silvestre, Universidade Federal de Minas Gerais, Belo Horizonte, Brasil, 86p.

FERREIRA, R.L.; MARTINS, R.P. & D. YANEGA. 2000. Ecology of bat guano arthropod communities in a brazilian dry cave. **Ecotropica** 6(2):105-116.

FERREIRA, R.L. 2004. **A medida da complexidade ecológica e suas aplicações na conservação e manejo de ecossistemas subterrâneos** Tese de doutorado do curso de Ecologia, Conservação e Manejo da Vida Silvestre, Universidade Federal de Minas Gerais, Belo Horizonte, Brasil, 152p.

FISCHER, M.L. 1996. **Biologia e ecologia de *Loxosceles intermedia* (Mello-Leitão, 1934) (Aranae, Sicariidae), no município de Curitiba, PR.** Dissertação de Mestrado em Ciências Biológicas – Zoologia, Universidade Federal do Paraná. 137pp.

FOELIX, R.F. 1987. **Biology of spiders**. Harvard University Press, Cambridge. 316pp.

FUTRELL, J.M. 1992. Loxoscelism. **Jour. Med. Science.** 304(4): 261–267.

GALIANO, M.E. 1967. Ciclo biologico e desarollo de *Loxosceles laeta* (Nicolet, 1849). **Acta Zool. Lilloana 23**:431-464.

GNASPINI, P. & E. TRAJANO. 1994. Brazilian cave invertebrates with a checklist of troglomorphic taxa. **Rev. Bras. Entomologia 38**: 549-584.

GNASPINI, P.; E. TRAJANO & L.H. SÁNCHEZ. 1994. Província espeleológica da Serra da Bodoquena, MS: exploração, topografia e biologia. **Espeleo-Tema 17**: 19-44.

GONÇALVES-DE-ANDRADE, R.M.; E.A.B. GALATI & D.V.TAMBOURGI. 2001. Presença de *Loxosceles similis* Moenkhaus, 1898 (Araneae, Sicariidae) na Serra da Bodoquena, Estado de Mato Grosso do Sul, Brasil. **Rev. Soc. Bras. Med. Tropical 34**(3): 275-277.

GONÇALVES-DE-ANDRADE, R.M. & D.V. TAMBOURGI. 2003. First record on *Loxosceles laeta* (Nicolet, 1849) (Araneae, Sicariidae) in the West Zone of São Paulo City, São Paulo, Brazil, and considerations regarding its geographic distribution. **Rev. Soc. Bras. Med. Tropical 36**(3):425-426.

HARRIS, J.A. 1970. Bat-Guano Cave Environment. **Science** 169:1342-1343.

HERRERA, F.F. 1995. Las comunidades de artropodos del guano del guácharos en la cueva del guacharo, Venezuela. **Bol. Soc. Venezoelana Espel. 29**:39-46.

HITE, M.J.; W.J. GLADNEY; J.L. LANCASTER JR & W.H. WHITCOMB. 1996. Biology of brown recluse spider. **Arkansas Agric. Exp. St. Bull.** 711:2-26.

LEVI, H.W. & A. SPIELMAN. 1961. The biology and control of the South American brown spider, *Loxosceles laeta* (Nicolet), in North American focus. **Am. Trop. Med. Hyg. 131**:132-136.

MARQUES da SILVA, E. 2002. **Loxoscelismo no Estado do Paraná: análise epidemiológica dos acidentes causados por *Loxosceles* Heinecken &**

**Lowe, 1832, no período de 1993 a 2000**. Dissertação de Mestrado em Ciências de Saúde Pública, Fundação Oswaldo Cruz, Escola Nacional de Saúde Pública, Rio de Janeiro. 58p.

PECK, S.B. 1976. The Effect of Cave Entrances on the Distribution of Cave-Inhabiting Terrestrial Arthropods. **Int. Jour. of Speleol. 8**:309-321.

POULSON, T.L. 1972. Bat Guano Ecossystems. **Bull. Nat. Speleol. Soc**. **34**(2):55-59.

POULSON, T.L. & W.B. WHITE. 1969. The Cave Environment. **Science** 165:971.

PINTO-DA-ROCHA, R. 1995. Sinopse da fauna caverícola do Brasil (1907 - 1994). **Pap. Av. Zool. Mus. Zool. Univ. São Paulo 39**(6):61-163.

RIBERA, C. & C. JUBERTHIE. 1993. Aranae. Pp. 197-214, in **Encyclopaedia Biospeologica** vol. I (C. JUBERTHIE & V. DECU, eds.). Imprimerie Fabbro, Saint-Girons, France. 834 p.

RINALDI, M.P.; L.C. FORTI, & A.A. STROPA. 1997. On the development of the Brown Spider *Loxosceles gaucho* Gertsch (Aranae, Sicariidae): The nynpho-imaginal period. **Revta bras. Zool. 14**(3):697-706.

SANDIDGE, J.S. 2003. Scavenging by Brown recluse spiders. **Nature** 426: 30.

SOCIEDADE BRASILEIRA DE ESPELEOLOGIA. 1989. **Cadastro Nacional de Cavidades Naturais**. Índice de dados sobre as cavernas do Brasil. São Paulo. www.sbe.com.br

TRAJANO, E. & P. GNASPINI-NETO. 1990. Composição da fauna cavernícola brasileira, com uma análise preliminar dos táxons. **Revta bras. Zoologia** 7: 383-407.

TRAJANO, E. & J.R.A. MOREIRA. 1991. Estudo da fauna de cavernas da Província Espeleológica Arenítica Altamira-Itaituba. **Rev. Brasil. Biol.** 51: 13-29.

ZAR, J.H. 1996. **Biostatistical Analysis**, 3rd edition . Prentice Hall, New Jersey. 929pp.

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