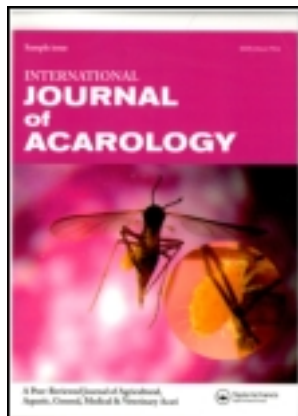


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New species of *Neoteneriffiola* (Acari: Trombidiformes: Teneriffiidae) from Brazilian caves: geographical distribution and ecological traits

Leopoldo Ferreira de Oliveira Bernardi^a, Thais Giovannini Pellegrini^a & Rodrigo Lopes Ferreira^b

^a PPG – Applied Ecology, Department of Biology (DBI), Federal University of Lavras (UFLA), Minas Gerais, Brazil

^b Laboratory of Underground Ecology, Department of Biology (DBI), Federal University of Lavras (UFLA), Minas Gerais, Brazil

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New species of *Neoteneriffiola* (Acari: Trombidiformes: Teneriffiidae) from Brazilian caves: geographical distribution and ecological traits

Leopoldo Ferreira de Oliveira Bernardi^a, Thais Giovannini Pellegrini^a and Rodrigo Lopes Ferreira^b

^aPPG – Applied Ecology, Department of Biology (DBI), Federal University of Lavras (UFLA), Minas Gerais, Brazil (emails: leopoldobernardi@yahoo.com.br and thais.g.pellegrini@gmail.com); ^bLaboratory of Underground Ecology, Department of Biology (DBI), Federal University of Lavras (UFLA), Minas Gerais, Brazil (email: drops@dbi.ufla.br)

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This work presents a description of a new species of the genus *Neoteneriffiola* Hirst found in the Brazilian caves. Individuals were collected in 22 caves located in Bahia, Goiás, Minas Gerais and Tocantins states.

Keywords: Anystoidea; Brazil; cave; Acariformes; taxonomy

Introduction

The family Teneriffiidae has only a few known species representing seven genera (*Austroteneriffia*, *Heteroteneriffia*, *Himalteneriffia*, *Mesoteneriffia*, *Neoteneriffiola*, *Parateneriffia*, *Teneriffiidae*) (Schmölzer, 2001). These species inhabit diverse habitats; they may be found in intertidal or arid regions, associated with trees, under small rocks in the soil and occasionally at altitudes exceeding 1000 m (e.g. the Himalayas) (Tibbetts 1958; Judson 1995; Schmölzer 2002).

The genus *Neoteneriffiola* was created by Hirst in 1924 and currently only three species belong to this genus: *N. luxoriensis* Hirst, 1924; *N. uta* Tibbetts, 1958; and *N. coineau* Judson, 1994. Up to now, the genus distribution was known only from the United States, Egypt and Namibia. There is little available information on the ecology, biology and distribution of *Neoteneriffiola*, as compared to most of the genera of the family Teneriffiidae (Tibbetts 1958; Eller and Strandtmann 1963; Ehara 1965; Shiba and Furukama 1975; Judson 1994).

The only record of a species of Teneriffiidae in South America was one for *Parateneriffia bipectinata* Thor, 1911. However, Bernardi et al. (2009) reported the occurrence of a teneriffiid mite (erroneously identified as belonging to the genus *Austroteneriffia*) in Brazilian caves. This work aims to describe the species observed by Bernardi et al. (2009), as well as to discuss its ecology and distribution in Brazilian caves.

Materials and methods

The specimens examined in this work came from collections made during the last 12 years by the Laboratory of Subterranean Ecology group of the Federal University of Lavras (Department of Biology/Zoology Sector). A total of 1100 caves were inventoried in the states of Alagoas, Bahia, Ceará, Espírito Santo, Goiás, Mato Grosso, Minas Gerais, Pará, Paraná, Pernambuco, Rio Grande do Norte, Rio Grande do Sul, Rio de Janeiro, Santa Catarina, São

Paulo, Sergipe and Tocantins, along with 110 artificial underground cavities in the state of Minas Gerais.

All the specimens were collected with the aid of a fine brush, after an extensive search throughout the soil, litter, under rocks, in the cave and then placed directly in vials with 70% alcohol. Mites were cleared in Nesbitt's solution, when necessary, and mounted on slides for microscopy using Hoyer's medium (Walter and Krantz 2009). The specimens were identified with a Leica MDLS phase-contrast microscope (Leica, Germany) using identification keys and morphological descriptions of Womersley (1935), Tibbetts (1958), Eller and Strandtmann (1963), Ehara (1965), Judson (1994, 1995) and Krantz and Walter (2009).

Measurements and drawings were made with the phase-contrast microscope. Measurements are given in micrometres (μm); values for the holotype measurements are followed by those of paratype I (male) and paratype II (female) in parentheses, respectively.

Body length was measured from the nasal base to the posterior margin of the idiosoma, and body width at the level of dorsal seta c_2 . Seta lengths were measured from their basis to the tip. Prodorsal shield length is the distance from the naso base to the posterior shield margin. Shield width was obtained at the level of seta c_1 . Each segment of legs and palp was measured separately, and the tarsus was measured from the articulation facer with the tibia to the ambulacra basis. Setal nomenclature follows Judson (1994, 1995).

The location of each organism collected was plotted on a schematic sketch of each cave, and some observations were noted *in situ*, such as the number of individuals, their position in the cave environment and in what kind of substratum they were found.

The live collection was made on 26 April 2011 in Gruta do Salitre (Saltpeter's Cave), municipality of Cordisburgo, Minas Gerais State. The specimens were collected with the aid of fine brushes and packed in a glass container, where humidity was maintained using a piece of tissue

moistened and fixed in the bottle. The individuals were taken to the laboratory and transferred to plastic pots (6.5 cm × 6 cm) with a 3 cm layer floor containing plaster of pairs mixed with activated charcoal powder (Walter and Krantz 2009). These containers were conditioned in the cultivation room of the Laboratório de Acarologia, EPAMIG EcoCentro – Lavras, where temperature ranged from 25°C to 27°C and relative humidity from 70% to 80%. Specimens were fed once a week. Observations lasted for 30 min and were made with the aid of a magnifying glass, always after the offer of a prey. Furthermore, random observations were made at least twice a week and any.

Family **Teneriffidae** Thor, 1911

Genus *Neoteneriffiola* Hirst, 1924

Neoteneriffiola xerophila sp. nov. (Bernardi *et al.*, 2011)
(Figures 1–8)

Description

The current species was wrongly identified by Bernardi *et al.* (2009) as belonging to the genus *Austroteneriffia*. However, the species belongs to the genus *Neoteneriffiola* because setae c_1 and c_2 are similar in size, leg I have four solenidia on tarsus, four on the tibia and only one on the genu and the peritremes which extend the margins of coxa I.

Female. Body – Length 880 (720–800), width 630 (585–615).

Gnathosoma – With two pairs of setae are present on fused coxal basis, and two pairs of small, strongly sclerotized denticles (setae or_{1-2}) on anterior portion of coxa (Figure 1).

Palp raptorial, with five segments, each with a thick cuticle. Palp femur bears long and barbed setae on inner-dorsal surface; palp genu with a nude, small seta on ventral surface; with a small barbed setae on ventral portion of tibia, in addition to a large, clearly visible oncophysis; palp tarsus greatly reduced, with a cluster of setae on its surface (Figure 2).

Chelicera with two setae; anterior seta often forked terminally, posterior seta long, strong and barbed (Figure 2B).

Dorsal podosoma – Naso in adult is broad, weakly projected from anterior margin of propodosoma in dorsal view (Figure 3).

Median eye absent; lateral eyes large and separate, posterior eyes are slightly larger than anterior eyes (Figure 3), which retain red pigmentation even after clarification with Nesbitt's solution. The sclerite is distinct, length 285 (280–240) and width 290 (290–250), presenting a vase-shape, finely striate and differing from surrounding striate cuticle (Figure 3). This sclerite bears two pairs of setae (na , np) and two pairs of trichobothria (sa , sp). Both trichobothria are finely barbed apically. Bothridium of sa is

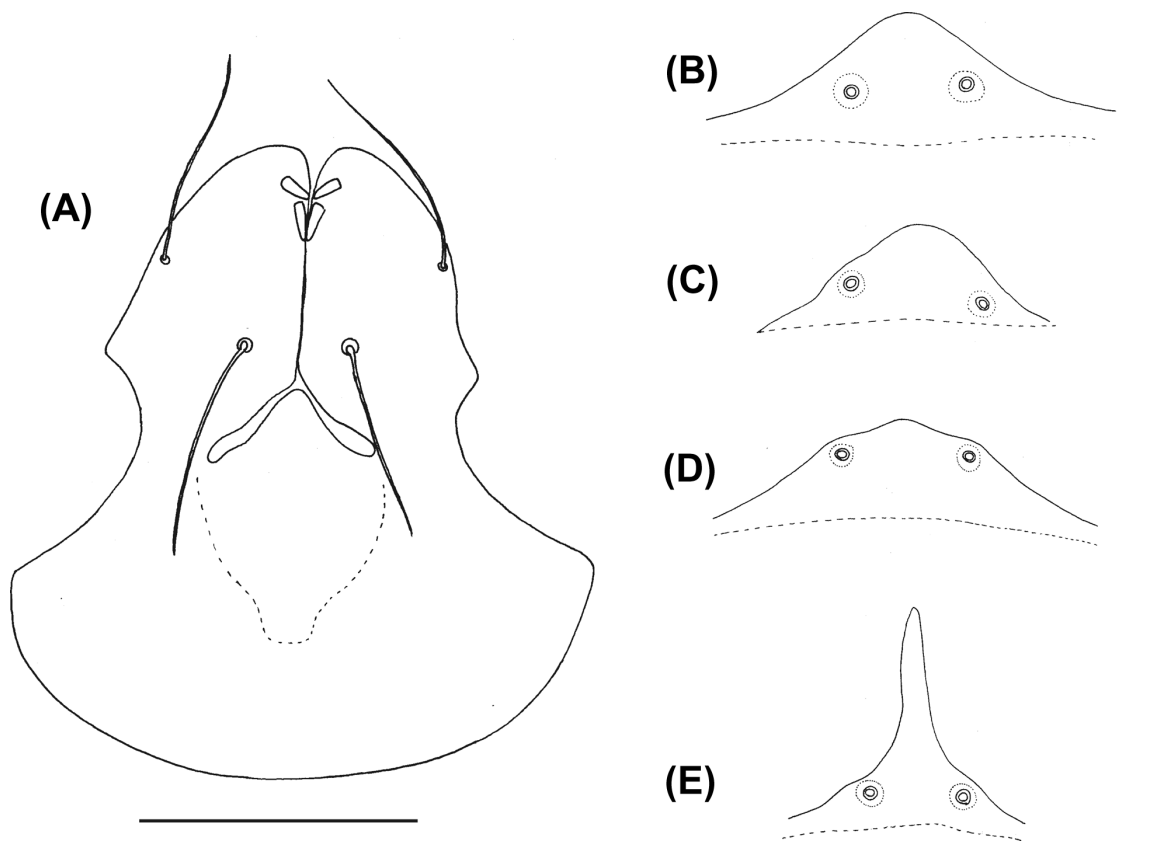


Figure 1. (A) Gnathogaster ventral view of the female holotype (scale bar 125 μ m). (B) naso of paratype II; (C)–(D) different naso shapes present on adult females; (E) naso shape of a juvenile (scale bar 125 μ m).

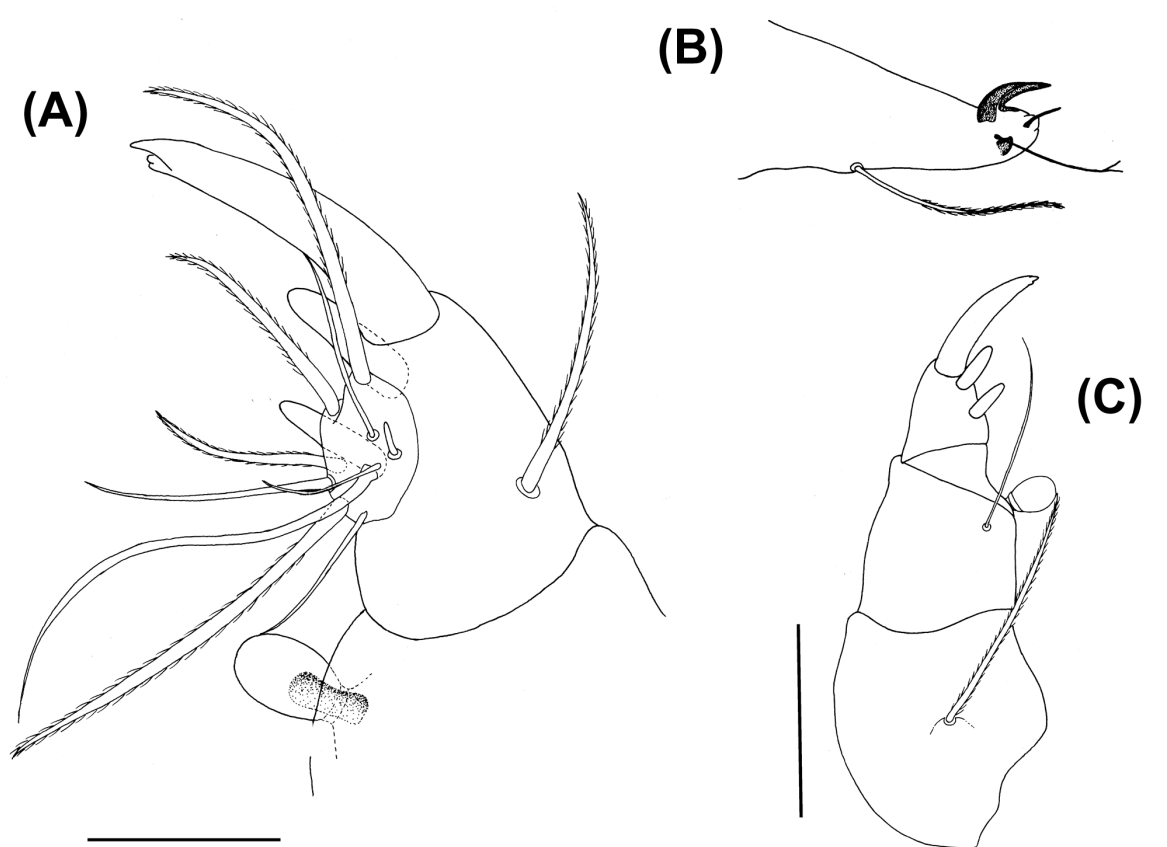


Figure 2. (A) Terminal portion of palp detailed (scale bar 50 μm), (B) Paraxial view of the chelicera (scale bar 125 μm), (C) Dorsal view of palp (scale bar 125 μm). All the drawings were made based on female holotype.

small and presents a typical form, *sp* which has 12–15 tubular vesicles in the base (forming a “rosette”) (Figure 4). Setae *na* located on a slight tubercle and *sa* located internally at the base of the sclerite (Figures 3 and 5).

Dorsal hysterosoma – Chaetotaxy holotrichous, dorsal setae long, decreasing in length caudally, setae *c*₁ and *c*₂ similar in length: 315 (280–260) and 325 (290–265), respectively.

Setae dark and bearing wedge-shaped barbs, each pair of setae (*c*₁, *d*₁, *e*₁, *f*₁ and *h*₁) almost reaches base of the setae next behind (e.g. *c*₁ transcends *d*₁ and reaches *e*₁). Dorsum covered with striae (Figures 3 and 5).

Venter – The genital area bears five pairs of sparsely barbed setae, without basal microsclerites; each genital valve display a great variation in number of nude setae, that is, the holotype has 10 setae on right valve and 8 on left, paratype I has 7 seta on right valve and 6 on left and paratype II has 7 seta on right valve and 7 on left (Figure 6) with three genital papillae.

Legs – Measurements of length of leg segments.

Leg I: trochanter 125 (115–125), basifemur 205 (205–175), telofemur 160 (150–140), genu 215 (205–205), tibia 325 (305–280), tarsus 325 (305–305).

Leg II: trochanter 105 (95–75), basifemur 200 (155–180), telofemur 160 (145–140), genu 210 (195–190), tibia 315 (305–280), tarsus 330 (310–285).

Leg III: trochanter 85 (90–125), basifemur 175 (175–150), telofemur 125 (135–125), genu 170 (180–165), tibia 355 (365–330), tarsu 425 (415–360).

Leg IV: trochanter 155 (150–160), basifemur 190 (200–195), telofemur 175 (165–155), genu 210 (200–205), tibia 440 (465–395), tarsu 510 (475–455).

Pectination of claws of anterior legs much stronger than on posterior legs, small median claws are present only on legs III–IV. Coxae I and II closely associated with coxae III and IV. Left and right coxae I–II join each other in the medial ventral region, next to the bases of coxae IV. Coxal chaetotaxy variable (3-4(6)-4-3), coxal setae slim and barbed. With four tarsal, four tibial and one genual solenidion on legs I (Figure 7).

Male. Similar to female, except for differences in internal genitalia.

Male genital region with five pairs of aggenital setae and ten pairs of eugenital setae externally. With three pairs of genital papillae, three pairs of setae *k*, four pairs of strongly branched setae, one pair of bifid and strongly

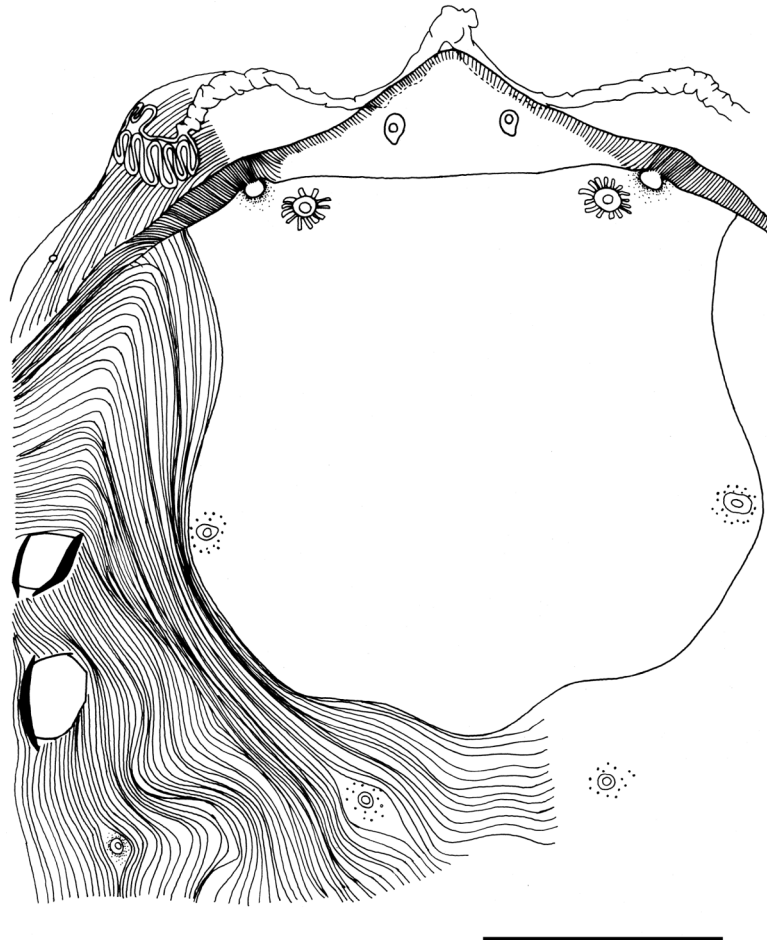


Figure 3. Dorsal view of holotype female prodorsum (scale bar 125 μ m).

branched, one pair of slightly barbed setae, two pairs of smooth setae and four pairs of small spines in the genital area (Figure 8).

Type specimens

Holotype. Female collected in Gruta do Sabiá (Thrush's Cave), municipality of Aurora do Tocantins, Tocantins, Brazil. coll. R.A. Zampaulo, July 2008, deposited at the Mite Reference Collection, Department of Entomology and Acarology, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba-SP, Brazil (MZLQ).

Paratype I. Female collected in Gruta do Birititi (Birititi's Cave), municipality of Aurora do Tocantins, Tocantins, Brazil; coll. R.A. Zampaulo, July 2008, deposited at Collection of Subterranean Invertebrates (ISLA), Section of Zoology, Department of Biology, Universidade Federal de Lavras, Lavras-MG, Brazil.

Paratype II. Male collected in Gruta do Birititi (Birititi's Cave), municipality of Aurora do Tocantins, Tocantins, Brazil; coll. R.A. Zampaulo, July 2008, deposited at the Mite Reference Collection, Department of Entomology and Acarology, Escola Superior de Agricultura "Luiz

de Queiroz", Universidade de São Paulo, Piracicaba-SP, Brazil.

Additional material examined

Two females and one male from Toca D'agua (Water's Cave), Patamutê, Bahia, Brazil, coll. R.L. Ferreira January 2008; one female, one male, one immature from Lapa do Convento (Convent's Cave), Campo Formoso, Bahia, Brazil, coll. R.L. Ferreira June 2008; three females, one male from Lapa do Catitú (Catitu's Cave), São Desidério, Bahia, Brazil. coll. R.L. Ferreira July 2008; one female from Lapa do Bode (Goat's Cave), Itaetê, Bahia, Brazil. coll. R.L. Ferreira 2 January 2010; one female from Poço Azul do Milú (Milu's Blue Well Cave), Nova Redenção, Bahia, Brazil. coll. R.L. Ferreira 4 January 2010; one male, one immature from Lapa do Córrego dos Porcos (Big's Cave Stream), Damianópolis, Goiás, Brazil. coll. M. Souza-Silva 5 October 2001; three females from Gruta do Salitre (Saltpeter's Cave), Cordisburgo, Minas Gerais, Brazil. coll. R.L. Ferreira 21 July 1999; one female, two males from Mina do Pico 01 (Peak's Cave 01), Itabirito, Minas Gerais, Brazil. coll. R.L. Ferreira 2 February 2002; two females from Mina da VMetals artificial mine (VMetals's Mine), Vazante, Minas Gerais, Brazil

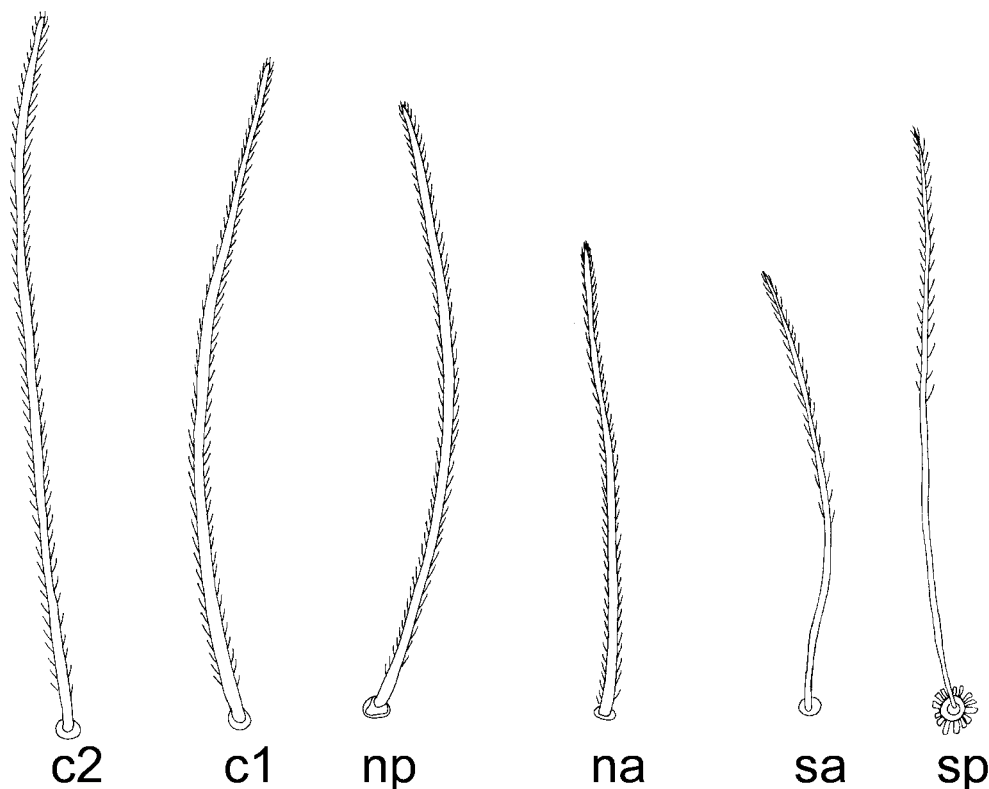


Figure 4. Different types of setae found on female holotype prodorsum (scale bar 125 μm).

Coll. Bernardi L.F.O., 8 April 2009; two females, one immature from Lapa Nova (Lapa Nova Cave), Vazante, Minas Gerais State, Brazil. coll. T.G. Pellegrini, 7 June 2009; two male, one immature from Lapa do Guardião Severino cave (Severino Guardian's Cave), Vazante, Minas Gerais, Brazil, coll. Bernardi L.F.O. 11 July 2010; three females, two immatures from Lapa da Santa Fé (Santa Fe's Cave), Paracatu, Minas Gerais, Brazil, coll. Bernardi L.F.O. 15 July 2010; three females from Lapinha do Atamis (Atamis' Cave), Cordisburgo, Minas Gerais, Brazil. coll. M.F.V.R. Souza 13 November 2010; Fazenda do Sr. Antônio Andrade (Cave of Atonio Andrade's Farm), Vazante, Minas Gerais, Brazil. coll. Simões M.H, December 2010; one female, three males and one immature from Gruta do Sabiá (Thrush's Cave), Aurora do Tocantins, Tocantins, Brazil. coll. R.A. Zampaulo July 2008; five females, two males and three immatures from Gruta Birititi (Birititi's Cave), Aurora do Tocantins, Tocantins, Brazil. coll. R.A. Zampaulo July 2008.

The specimens are deposited in the Invertebrate Collection of Lavras (ISLA) in the Zoology Sector/Department of Biology of the Federal University of Lavras (UFLA), Lavras, Minas Gerais state, Brazil (ISLA); The Mite Collection "Geraldo Calcagnolo" in the Instituto Biológico, Campinas, São Paulo state, Brazil; Mite Reference Collection, Department of Entomology and Acarology, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba-SP, Brazil (MZLQ).

Etymology

The epithet is given in designation to the preferences exhibited by the species for dry or xeric microhabitats. From Greek, *xero*: dry; *phila*: friend.

Behaviour

Six specimens were collected in the cave entrance zone (photic) of Gruta do Salitre, but only four of them survived the transportation to the laboratory and were kept alive. The food items offered were Collembola (Poduromorpha), *Tyrophagus* sp. (Sarcoptiforme: Acaridae) and *Tetranychus urticae* (Prostigmata: Tetranychidae). Only one individual of Collembola and *Tyrophagus* sp. were offered, and both were accepted as prey. However, because of its availability and its acceptability as prey, *T. urticae* was offered weekly to *N. xerophila* sp. nov. until the end of experiment.

A juvenile survived for 13 days, a female and a juvenile for 22 days, and the other individual (a female) survived for 35 days. All specimens showed the same behaviour during the days preceding their death: they became lethargic, when touched they moved slowly and were not observed feeding.

Neoteneriffiola xerophila sp. nov. was observed capturing prey only when the prey passed close to the gnathosoma, or when it touched some part of the mite's body. Prey was captured with the palpal claws, which typically contacted the prey organism in the lateral

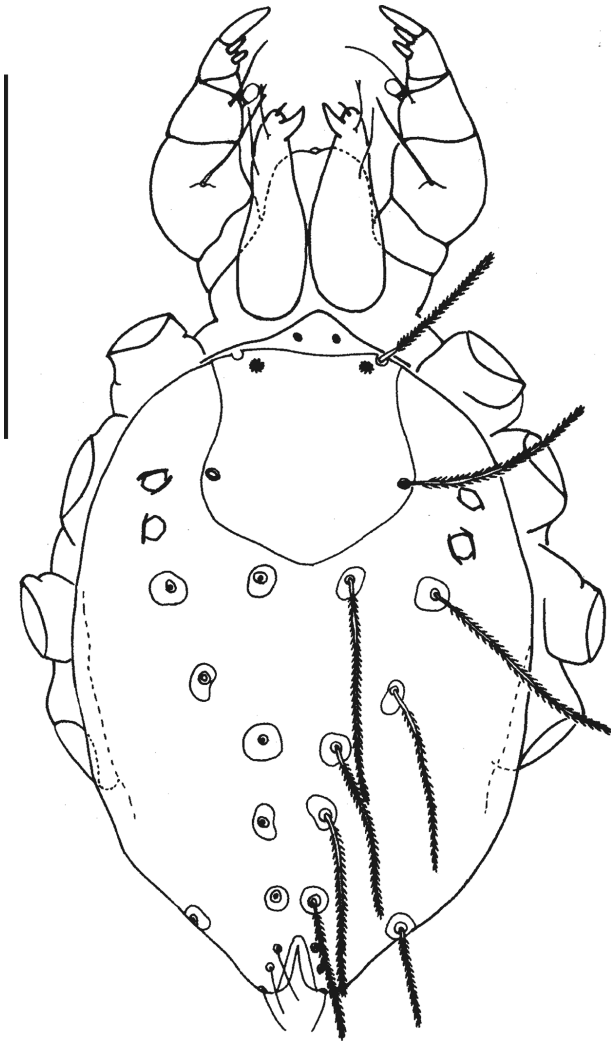


Figure 5. Dorsal view of female holotype (scale bar 500 μm).

or hind portion and pressed until the integument was pierced. The prey was then raised from the substratum and the integument torn by the chelicerae using fast movements of projection and retraction. Movement of the dark internal fluids of the prey could easily be observed through the integument of *N. xerophila* following ingestion. Throughout feeding the prey was kept raised and the chelicerae were observed being introduced into the prey's body in a continuous movement, one at a time. The process finished when only the external cuticle of the prey remained, and all the contents had already been ingested. The empty cuticle was then discarded on the substratum and the predator then moved to another for other part of container.

During these observations there was no record of antagonism or cannibalism for among specimens of *N. xerophila*. When direct contact occurred between mites, an immediate withdrawal was observed.

In addition to feeding, individuals of *N. xerophila* were also observed cleaning their legs by bending them under the idiosoma and passing them between the palpi. It was

not possible to observe what structure was used for cleaning, but we suspect that the mite uses the two pairs of teeth located on the end of the rostrum. The legs were placed individually between the palpi, held up to the portion of the rostrum where these structures are located, and moved slowly from the posterior portion of the leg to the tarsal claws. During leg cleaning it was noted that the gnathosomatic articulation with the idiosoma is highly flexible. The gnathosoma was observed to bend downward at an angle exceeding 45° while cleaning leg IV.

It was not possible to report events of moulting, coupling or oviposition in the laboratory.

Discussion

Differential diagnosis

Neoteneriffiola xerophila **sp. nov.** differs from other species of the genus in that the prodorsal shield is vase-shaped, as well as a particular disposal of setae np , which are on the shield margin. Setae c_1 and c_2 , as in *N. coineau* are of the same length. However, setae c_1 in *N. xerophila* **sp. nov.** are inserted off the dorsal shield, whereas in *N. coineau* the shield is expanded and seta c_1 is inserted on it, close to the margin.

Ecological traits

The fauna of cave mites from Brazil are still poorly studied. At present, 67 families of the orders Opilioacarida, Ixodida, Mesostigmata, Trombidiformes and Sarcoptiformes have been recorded (Bernardi et al. 2009). There is a high probability of new occurrences, because only a small part of the biospeleological potential of the country has been explored. Most studies conducted in Brazilian caves are concentrated in the southeast, the most economically developed region, while many limestone caves situated in the northern parts of the country are still unexplored. The lack of knowledge of cave mites in Brazil is illustrated in Bernardi et al. (2009), in which the occurrence of several previously unknown families is cited. The Opilioacarida is an example, and there were no records of these mites from Brazilian caves prior to the above study. The only occurrence of the order in Brazil was reported by Van der Hammen (1969) for an epigeal species from southern Brazil. However, as studies of cave fauna have increased, and opilioacarid sightings have he expanded to the states of Alagoas (one species), Minas Gerais (three species), Bahia (one species), Pará (one species) and Rio Grande do Norte (one species), and currently there are seven species to be described (Bernardi et al. 2009; Bernardi pers. comm.). Bernardi et al. (2009) recorded the first occurrence of Teneriffiidae in Brazil from eight caves. However, the present work expands the distribution of *N. xerophila* **sp. nov.** to 21 Brazilian caves and one artificial subterranean cavity, located in the states of Bahia, Goiás, Minas Gerais and Tocantins (Table 1, Figure 9).

Specimens of *N. xerophila* **sp. nov.** were observed on different substrates and in different portions of the caves. They were found on bat guano in aphotic portions of the

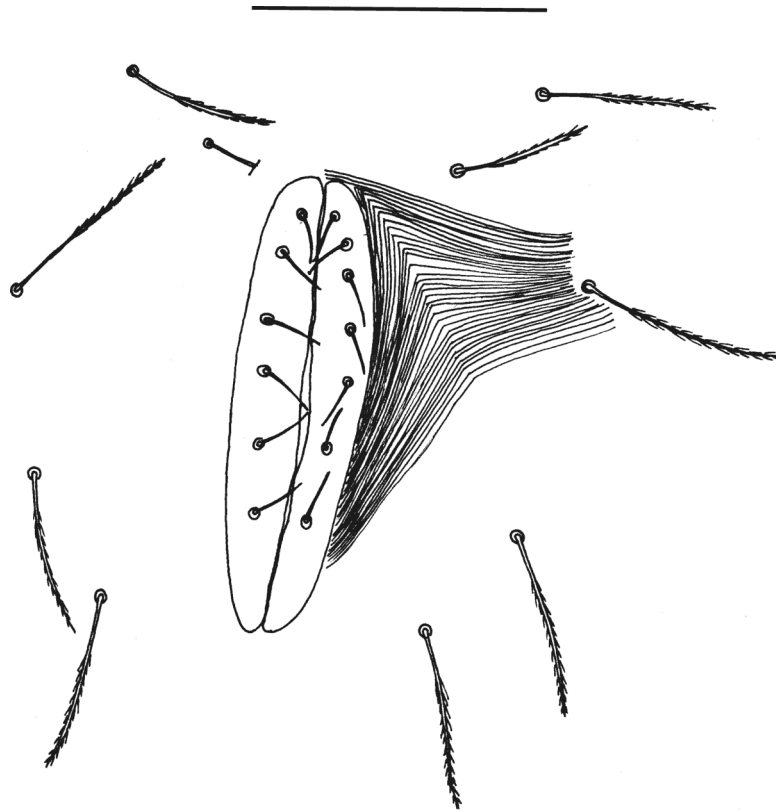


Figure 6. Genitalia of female paratype I (scale bar 125 μ m).

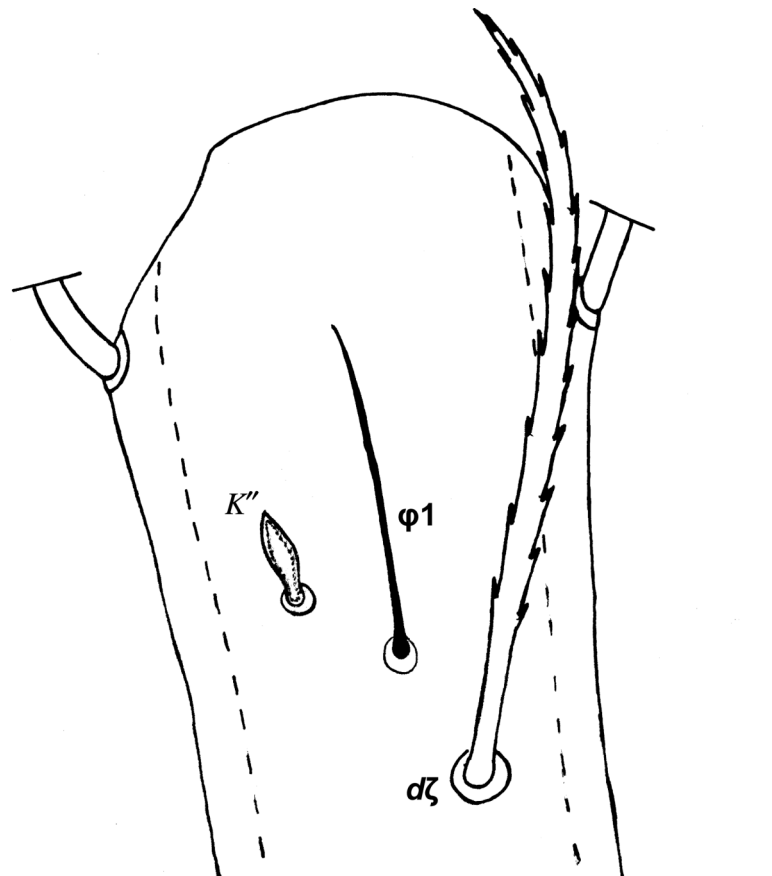


Figure 7. Setae k'' , $\phi 1$ and $d\zeta$ on genu I, holotype female (scale bar 50 μ m).

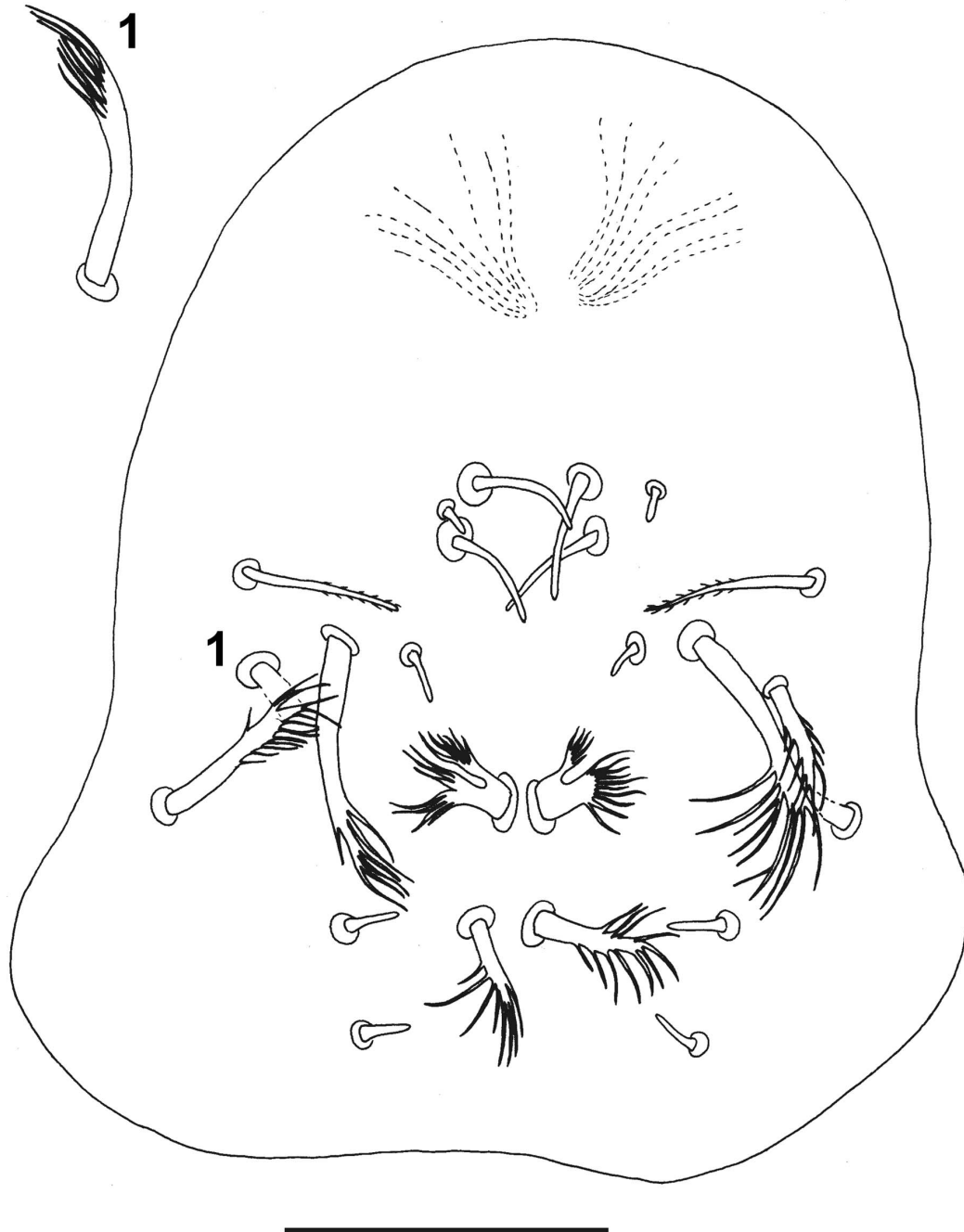


Figure 8. Genitalia of male paratype II (scale bar 50 μm).

caves, on litter overlying bedrocks and soil, and on bare rock, soil or speleothems close to or far from the cavity entrance. Most frequently, they were observed on rocks or soil on which there were plant fragments.

Two collections were made in Lapa Nova Cave in the municipality of Vazante, in different periods of the same year. In both collections, teneriffiids were found near the entrance, walking on the bedrock. Three individuals were found in the dry season (September), while in the rainy season (April) we observed 12 individuals. Two specimens of *N. xerophila* **sp. nov.** were collected

from the same municipality in an artificial underground cavity. They were found 500 m from cavity entrance, the deepest occurrence of the species observed in the current work.

The fauna of cave mites from Brazil remains poorly known, mainly because of few researchers are working in this area and few studies are under development. Moreover, there is difficulty in exploring the vast Brazilian territory. Certainly there is still much information that remain unknown to the scientific community and that should be studied.

Table 1. Records of *Neoteneriffiola xerophila* sp. nov. in Brazilian caves.

State	Municipality	Cave	Easting	Northing	Zone	Lithology	Biome
BA	Itaetê	Lapa do Bode	275894	8569218	24L	Li	Caa
BA	São Desidério	Lapa do Catitú	513053	8627112	23L	Li	Caa
BA	Campo Formoso	Lapa do Convento	310735	8888681	24L	Do	Caa
BA	Nova Redenção	Poço Azul do Milú	266719	8586036	24L	Li	Caa
BA	Patamutê	Toca D'água	444434	8970376	24L	Do	Caa
GO	Diaminópolis	Lapa do Córrego dos Porcos	374938	8400284	23K	Li	Ce
MG	Cordisburgo	Gruta do Salitre	555392	7885650	23K	Li	Ce
MG	Cordisburgo	Lapinha do Atamis	567749	7883332	23K	Li	Ce
MG	Cordisburgo	Caverna IV	568205	7885838	23K	Li	Ce
MG	Arinos	Lapa do Taquaril	369401	8295327	23L	Li	Ce
MG	Presidente Olegário	Lapa da Vereda da Palha	380964	7981211	23K	Li	Ce
MG	Itabirito	Gruta da Mina do Pico I	619251	7762602	23K	Ir	Ce/At
MG	Paracatu	Lapa da Santa Fé	297342	8133601	23K	Do	Ce
MG	Vazante	Lapa Nova	299855	8008865	23K	Do	Ce
MG	Vazante	Gruta do Guardião Severino	300039	8010088	23K	Do	Ce
MG	Vazante	Mina da VMetais ^a	306866	8013371	23K	Do	Ce
MG	Vazante	Gruta Sr. Antônio Andrade	299617	8007387	23K	Do	Ce
MG	Vazante	Abrigo da Escarpa	307964	8016809	23K	Do	Ce
MG	Vazante	Lapa da Escarpa	307917	8016809	23K	Do	Ce
MG	Vazante	Gruta das Urtigas	308181	8017673	23K	Do	Ce
TO	Aurora do Tocantins	Gruta do Sabiá	348241	8594672	23L	Li	Ce
TO	Aurora do Tocantins	Gruta Birititi	348562	8594292	23L	Li	Ce

Notes: Abbreviations of Brazilian States: BA, Bahia; MG, Minas Gerais; GO, Goiás; TO, Tocantins. Abbreviations of Biomes: Caa, Caatinga; Ce, Cerrado; At, Atlantic Forest. Abbreviations of cave lithology: Li, Limestone; Do, Dolomite; Ir, Iron ore.

^aThis locale corresponds to a disused artificial subterranean cave.

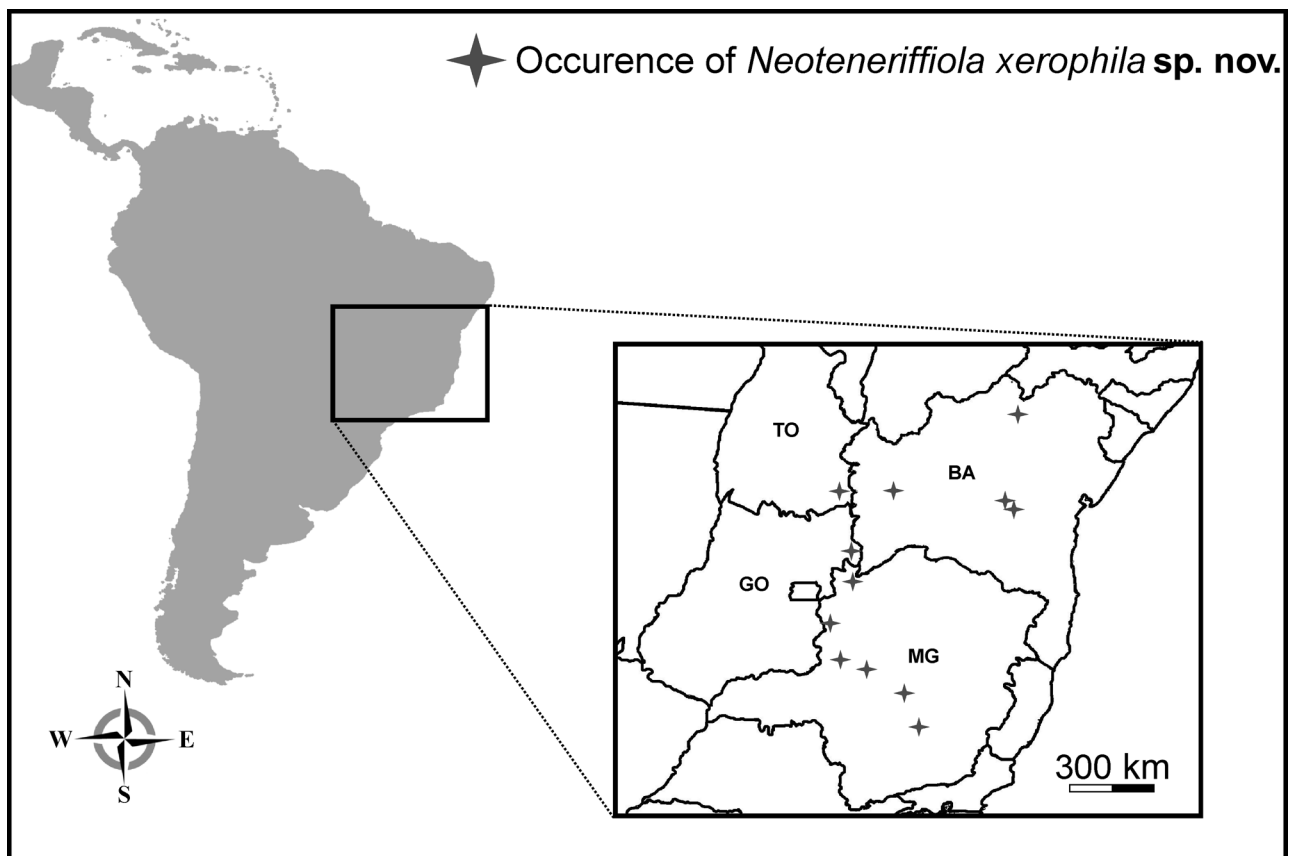


Figure 9. Brazil (abbreviations of Brazilian States: BA, Bahia; MG, Minas Gerais; GO, Goiás; TO, Tocantins).

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