The Brazilian Goblin Spiders of the New Genus Guaraguaoonops (Araneae: Oonopidae)

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The Brazilian goblin spiders of the new genus *Guaraguaoonops* (Araneae: Oonopidae)

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ABSTRACT

A new endemic goblin spider genus *Guaraguaoonops* is erected to include two new soft-bodied oonopid species from Brazil: the type species, *G. hemhem*, distributed in the states of Maranhão, Piauí, and Ceará, and *G. humbom*, known only from Piauí. These spiders are unique among oonopids and easily diagnosed by the flattened carapace with a porrect clypeus, modified lateral setae on the carapace in both sexes, and male with a sinuous, flattened distal cheliceral projection and palp with ventral conical tegular projection. These species probably occupy a soil cryptic habit and are found in dry sand of "cerrado" areas in northeastern Brazil.

INTRODUCTION

The recent increase in knowledge of Oonopidae systematics from the Goblin Spider Planetary Biodiversity Inventory (PBI) project has shown that oonopids are probably more diverse in morphological structures than previously expected (Ubick and Griswold, in press). Recent

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publications show oonopids with a great number of exclusive morphological characteristics, such as sternal modifications (Baehr et al., 2010), distal processes in chelicerae (Brescovit et al., in press), clypeal horns (Platnick and Brescovit, 1995), oddly enlarged palpal patellae (Platnick and Dupérré, 2009; Baehr and Ubick, 2010; Ubick and Griswold, in press), and myrmecomorphism (Fannes and Jocqué, 2008. Nevertheless, these morphological modifications are more conspicuous in or even exclusive to males, and females generally show a more conservative morphology, except for the complex internal genitalia (Burger, 2009, 2010).

Recently, while sorting oonopids collected in dry areas of northeastern Brazil, we discovered two species with interesting body modifications. Since these species could not be assigned to any of the existing oonopid genera, a new genus, *Guaraguaoonops*, is here proposed to accommodate them. The unusual morphology of these species deserves some comments since it includes several potential synapomorphies, such as the very large, horizontal, and porrect clypeus (figs. 1, 2), lateral setae on the carapace with large bases in both sexes (figs. 3, 4), and males with a sinuous and flattened distal cheliceral projection (figs. 8–10). These two new species are recorded from the states of Maranhão, Piauí, and Ceará. Both occur in a Brazilian biome known as "cerrado," composed of large dry areas of very old and deep soil, covered with fine sand (Oliveira and Marquis, 2002), characterized by a regular and moderate dry season with temperatures ranging from 22° to 25° C (Rizzini, 1997).

Although *Guaraguaoonops* specimens were not observed in the field, some hypotheses may be proposed to link its odd morphology and the harsh environment in which these spiders occur. The shape of the body resembles that of species with cryptic adaptations that inhabit sandy soils in dry areas and could be related to a behavioral trait such as self-burying. Many examples of this trait in the araneomorph spiders are known: *Sicarius* Walckenaer (Sicariidae), *Bradystichus* Simon (Pisauridae), *Cryptothele* L. Koch (Zodariidae), *Borboropactus* Simon (Thomisidae), *Homalonychus* Marx (Homalonychidae) and *Leucorchestris* Lawrence (Sparassidae) (Reiskind, 1965; Platnick and Forster, 1993; Henschel, 2002). However, these are all relatively large spiders for which this behavior is easily observed. Species of *Guaraguaoonops* might also show this behavior since the flattened body, with its robust and inflated clypeus, could be used to open burrows in the sand. The modified carapace setae could protrude out of the sand and serve as sensory structures to perceive the external activities at soil level. Additionally, the eyes are on the flattened part of the carapace, which might enable the perception of external stimuli or even microclimatic changes at the soil level. These hypotheses are obviously speculative since they are based solely on morphology, and future studies should be conducted to test these assumptions.

MATERIAL AND METHODS

The format of descriptions follows that of Platnick and Dupérré (2009) and the terminology of genitalic structures follows Burger (2009). Only differences from the males are mentioned in the descriptions of females. Female genitalia were examined after digestion with Ultrazyme®, Enzymatic Cleaner, from Advanced Medical Optics, Inc. (AMO) at room temperature for 24 hours. Scales of drawings are 1.0 mm. All measurements are in mm. Abbre-

viations used throughout text and figures are as follows: ALE = anterior lateral eyes; ap = apodeme plate process of female epigynum; asr = anterior seminal receptaculum of female epigynum; bp = basal plate of anterior seminal receptaculum of female epigynum; ef = epigastric furrow; pb = basal projection of apodeme plate process of female epigynum; PLE = posterior lateral eyes; PME = posterior median eyes; psr = posterior seminal receptaculum of female epigynum; t = trachea.

Morphological observations and illustrations were made using a Leica MZ12 stereomicroscope with a camera lucida. Photographs were taken with a Leica DFC 500 digital camera mounted on a Leica MZ16A stereomicroscope. Extended focal range images were composed with Leica Application Suite version 2.5.0. Scanning electron micrographs were taken under high vacuum with a LEO 1450VP scanning electron microscope after critical point drying and gold-palladium coating, at the Laboratório de Microscopia Eletrônica do Museu Paraense Emílio Goeldi. Full-color, high-resolution versions of the images will be available on the Planetary Biodiversity Inventory project's website (http://research.amnh.org/oonopidae).

The examined specimens are deposited in the following collections (abbreviation and curator in parenthesis): Instituto Butantan, São Paulo (IBSP, D. Barros Battesti); Museu Paraense Emilio Goeldi, Belém (MPEG, A.B. Bonaldo).

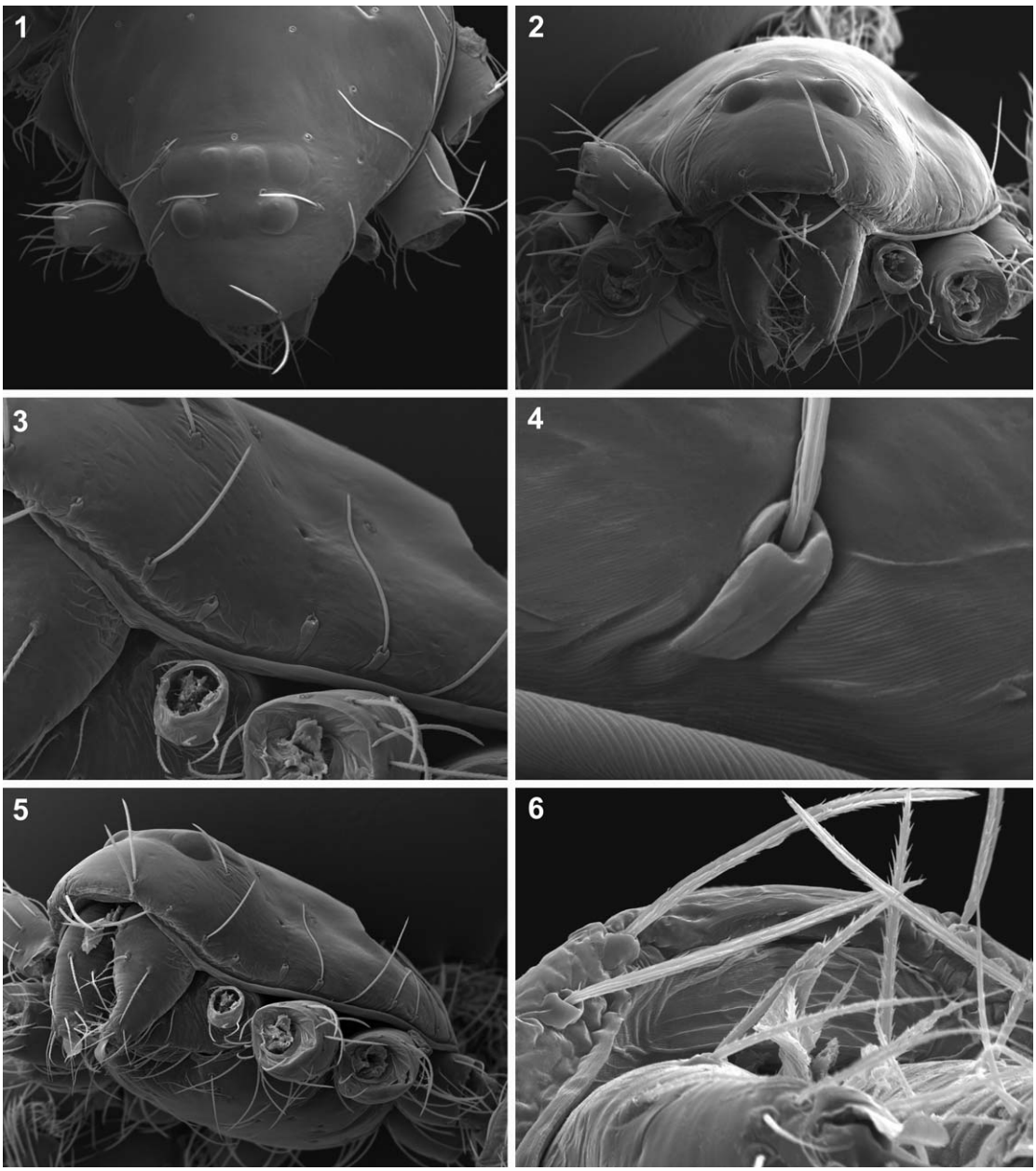
Guaraguaoonops Brescovit, Rheims and Bonaldo, new genus

Type Species: *Guaraguaoonops hemhem* Brescovit, Rheims and Bonaldo, new species.

Etymology: The generic name is a contraction of *guaragua*, which means "manatee" in the Brazilian Indian Tupi language (= peixe-boi in Portuguese) and *Oonops*. The gender is masculine.

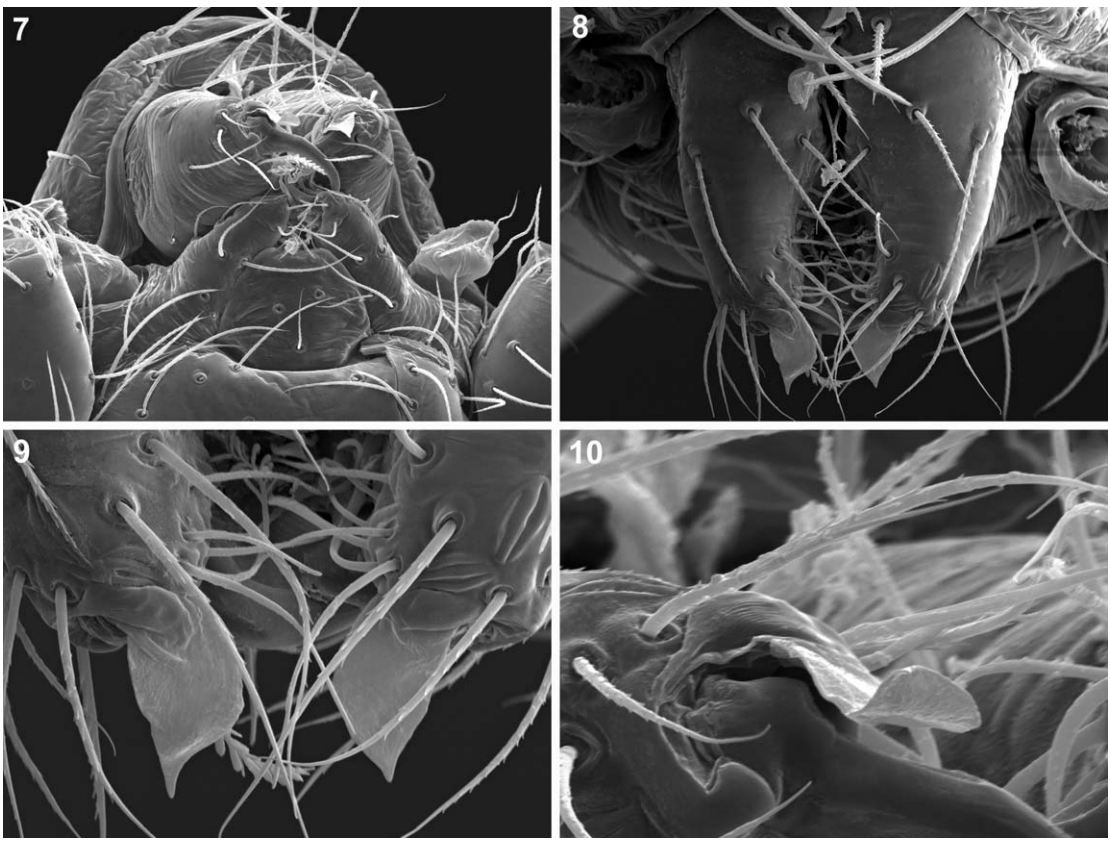
Diagnosis: *Guaraguaoonops* can be distinguished from all other oonopid genera by the following combination of characters: flattened carapace with porrect clypeus in both sexes (figs. 1–2); modified lateral setae, with large elongate bases, on the carapace of both sexes (figs. 3–4); male with a sinuous and flattened distal cheliceral projection (figs. 8–10) and palp with a ventral conical tegular projection (figs. 20–23).

Description: Total length of males 1.12, of females 0.93–.15. Carapace (figs. 1, 2, 24–26, 28, 29, 33) without color pattern, broadly oval in dorsal view, pars cephalica flat in lateral view, anteriorly narrowed to between 0.5 and 0.75 times its maximum width, with rounded posterolateral corners, posterolateral edge without pits, posterior margin not bulging below posterior rim, anterolateral corners without extension or projections, posterolateral surface without spikes, surface of elevated portion of pars cephalica smooth, sides smooth, thorax without depressions, fovea absent, without radiating rows of pits; lateral margin straight, smooth, without denticles; plumose setae near posterior margin of pars thoracica absent; nonmarginal pars cephalica setae absent; nonmarginal pars thoracica setae absent; 8–10 lateral marginal setae with large and elongated basis, light, needlelike (figs. 3–5, 15, 24, 30). Clypeus margin unmodified, curved ventrally in front view, sloping forward in lateral view, high; ALE separated from edge of carapace by five times their radius or more, median projection absent (figs. 1–2); two pairs of long setae on each side (figs. 2, 5). Chilum large, striated, undivided, without hairs (fig. 6). Six eyes, well developed (fig. 26), ALE



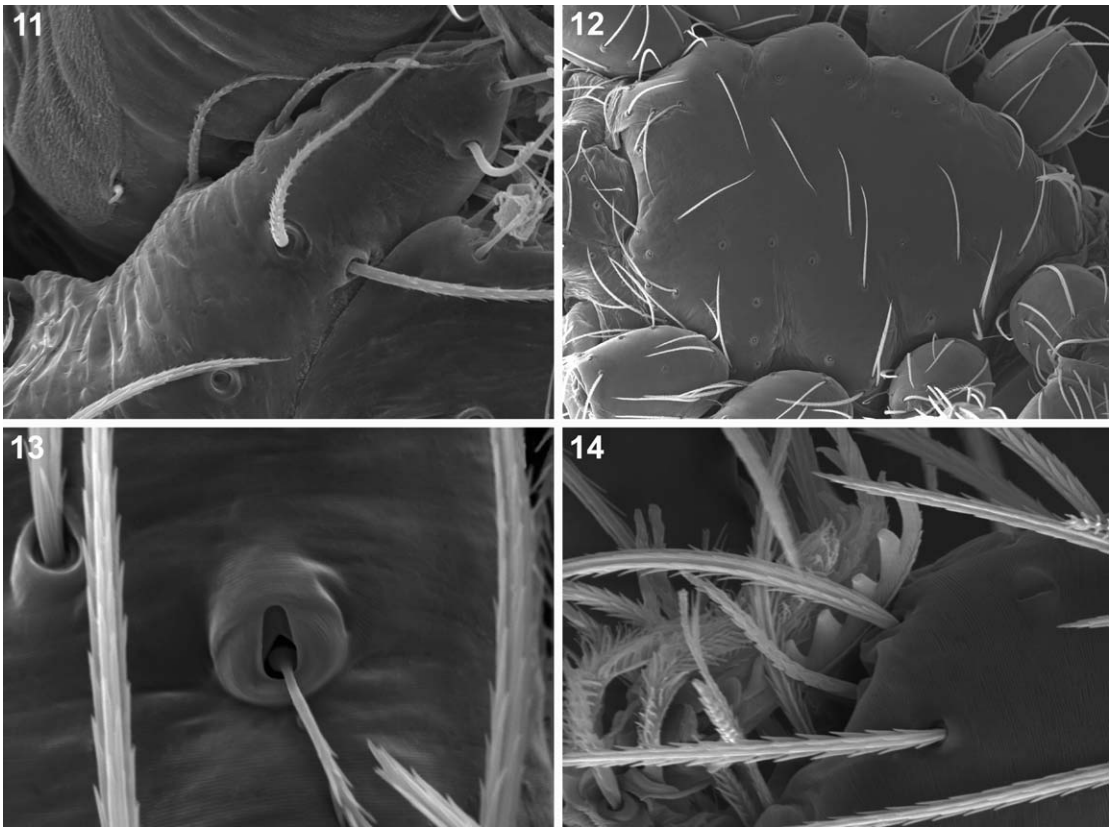
FIGS 1–6. *Guaraguaoonops hemhem,* new species, male, carapace. 1. Dorsal view. 2. Frontal view. 3. Lateral view. 4. Detail of lateral spine. 5. Lateroventral view. 6. Chilum, ventral view.

largest, circular, PME oval, PLE circular; posterior eye row straight from both above and front; ALE touching, ALE-PLE touching, PME touching throughout most of their length, PLE-PME touching, in a row with PME, ALE advanced (figs. 1, 15, 26). Sternum longer than wide, pale orange, uniform, not fused to carapace, median concavity absent, without radial furrows between coxae I–II, II–III, III–IV, radial furrow opposite coxae III absent, surface smooth, without pits,



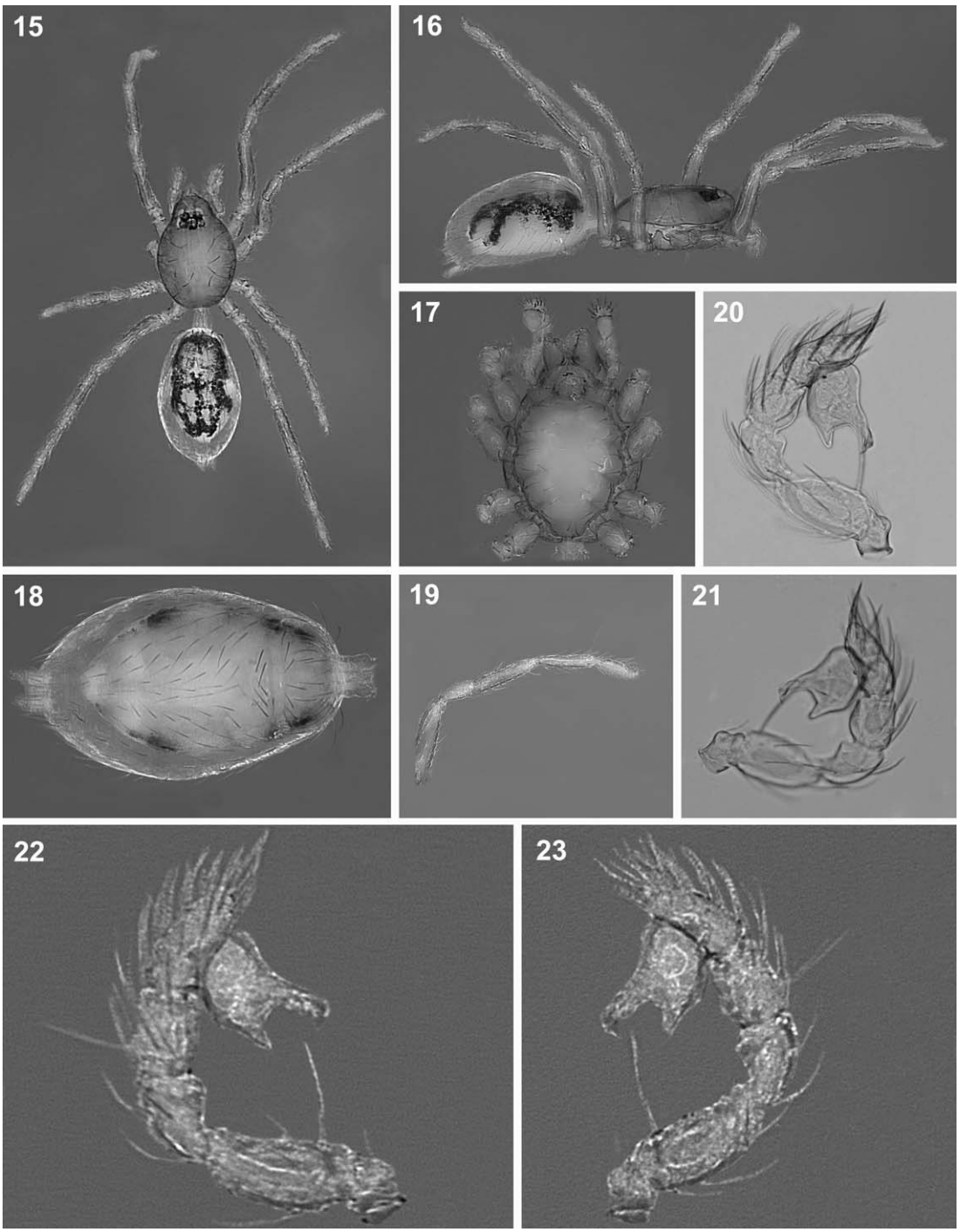
FIGS **7–10.** *Guaraguaoonops hemhem*, new species, male, chelicerae. **7.** Ventro-frontal view. **8–9.** Frontal view. **10.** Detail of distal area, lateral view.

microsculpture absent, sickle-shaped structures absent, anterior margin unmodified, posterior margin subtriangular, truncated, extending posteriorly beyond anterior edges of coxae IV as single extension, anterior corner unmodified, lateral margin without infracoxal grooves, distance between coxae approximately equal, extensions of precoxal triangles present, lateral margins with rounded extensions between coxae (fig. 12), without posterior hump; setae sparse, light, needlelike, evenly scattered, originating from small pits, without hair tufts. Chelicerae, endites, and labium pale orange. Chelicerae straight, anterior basal face unmodified; distal frontal area presenting a pair of slit sensillae (fig. 9) and an enlarged, sinuous and flattened laminar process with conical apex (figs. 7–10), shaggy hair at fang base (fig. 9), without teeth on both promargin and retromargin; without toothlike projections, directed medially, shape normal, without prominent basal process, tip unmodified; setae light, needlelike, evenly scattered; paturon inner margin with short interdigitating setae, distal region unmodified, posterior surface unmodified, promargin unmodified, inner margin unmodified, laminate groove absent. Labium triangular, not fused to sternum, anterior margin not indented at middle, same as sternum in sclerotization; with 3–5 setae on anterior margin, three median setae (figs. 11, 17, 27), subdistal portion with unmodified setae. Endites distally not excavated, serrula absent, anteromedian tip unmodified, posteromedian part unmodi-

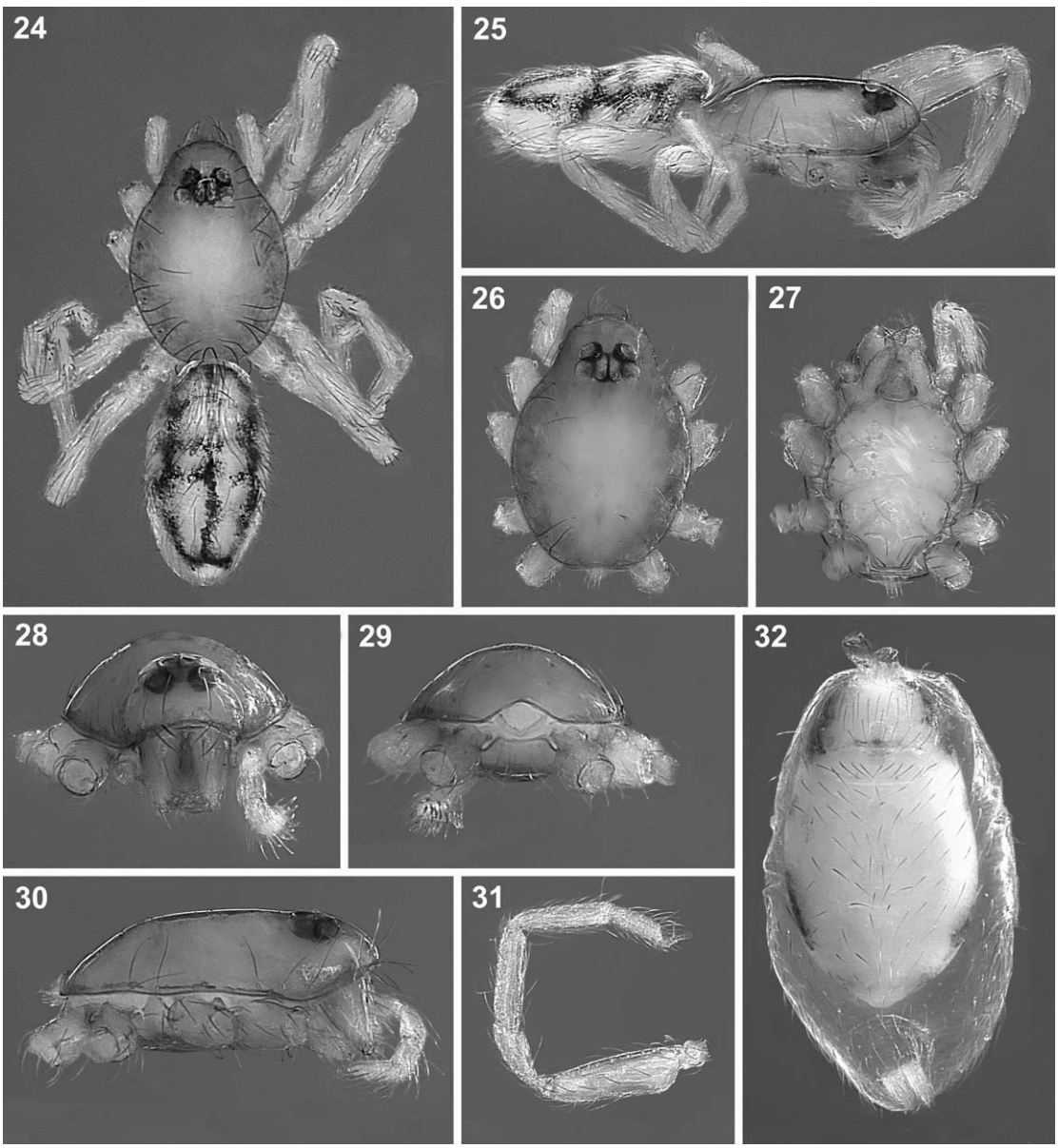


FIGS **11–14**. *Guaraguaoonops hemhem*, new species, male. **11.** Endite, ventral view. **12.** Sternum, ventral view. **13.** Trichobothria, leg I, dorsal view. **14.** Leg I, claw, lateral view.

fied, same as sternum in sclerotization (fig. 11). Abdomen ovoid, without long posterior extension, rounded posteriorly, interscutal membrane rows of small sclerotized platelets absent posteriorly (figs. 15, 18, 24, 25). Book lung covers small, round, without setae, anterolateral edge unmodified. Posterior spiracles not connected by groove (fig. 32). Pedicel tube short, unmodified, scuto-pedicel region unmodified, scutum absent, but abdomen not extending anterior of pedicel, plumose hairs absent, matted setae on anterior ventral abdomen in pedicel area absent, cuticular outgrowths near pedicel absent. Dorsal epigastric, postepigastric, and spinneret scuta absent. Supraanal scutum absent. Dorsum setae absent. Epigastric area setae uniform, light, needlelike. Postepigastric area setae absent. Spinneret scutum without fringe of setae. Dense patch of setae anterior to spinnerets absent. Colulus absent (fig. 39). Legs pale orange, without color pattern (figs.15, 16, 19, 31); femur IV not thickened, same size as femora I–III, patella plus tibia I near as long as carapace, tibia I unmodified, tibia I Emerit's glands absent, tibia IV specialized hairs on ventral apex absent, tibia IV ventral scopula absent, metatarsi I and II mesoapical comb absent, metatarsi III and IV weak ventral scopula absent. Leg spines absent. Tarsal proclaws and retroclaws inner face striate; tarsus I–IV superior claws with six teeth on lateral surface of proclaw, six teeth on median surface of proclaw, six teeth on lateral surface of retroclaw, six teeth on median surface of retroclaw, striated

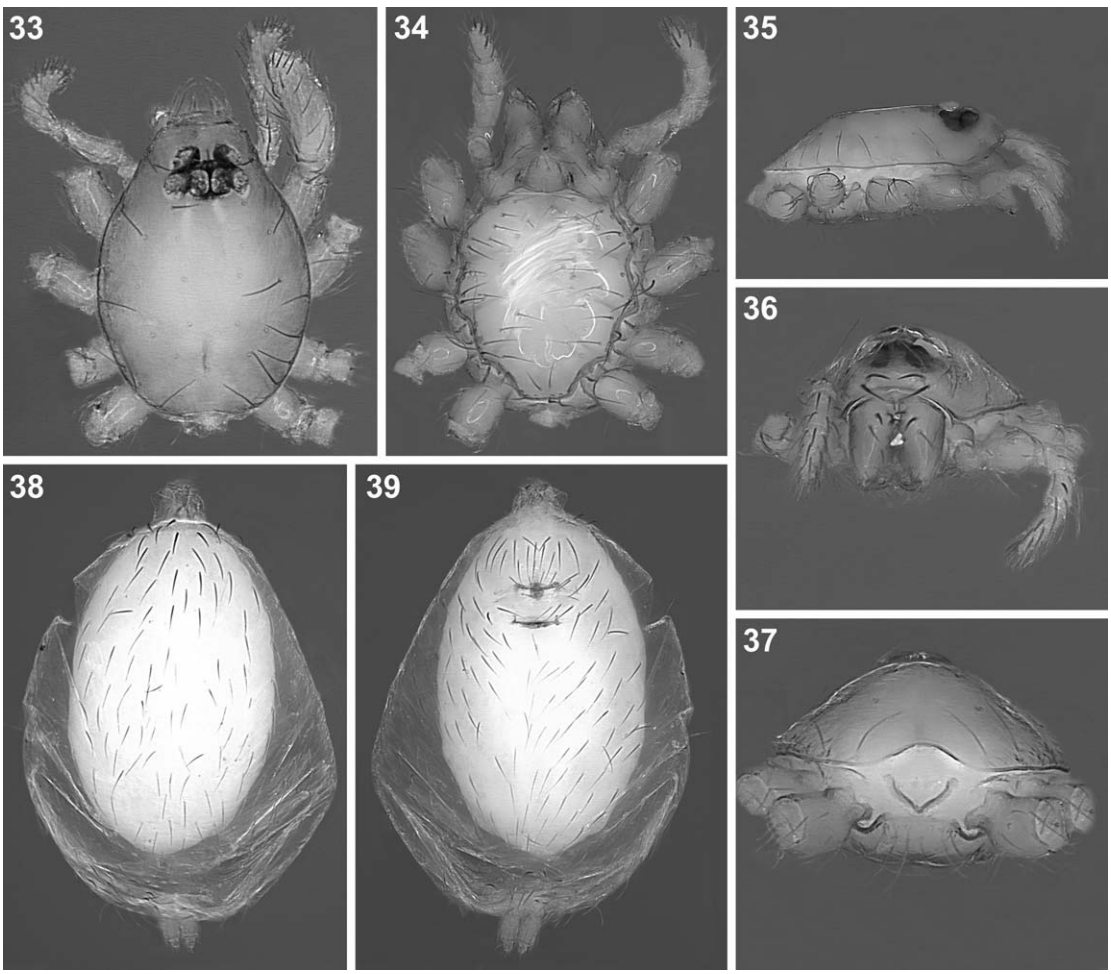


FIGS. **15–23.** *Guaraguaoonops hemhem*, new species, male. **15.** Body, dorsal. **16.** Lateral view. **17**. Carapace, ventral view. **18.** Abdomen, ventral view. **19.** Leg I, lateral view. **20–23.** Male palp. **20–21.** Under microscope. **20.** Prolateral view. **21.** Retrolateral view. **22–23.** Under stereomicroscope. **22**. Prolateral view. **23.** Retrolateral view.



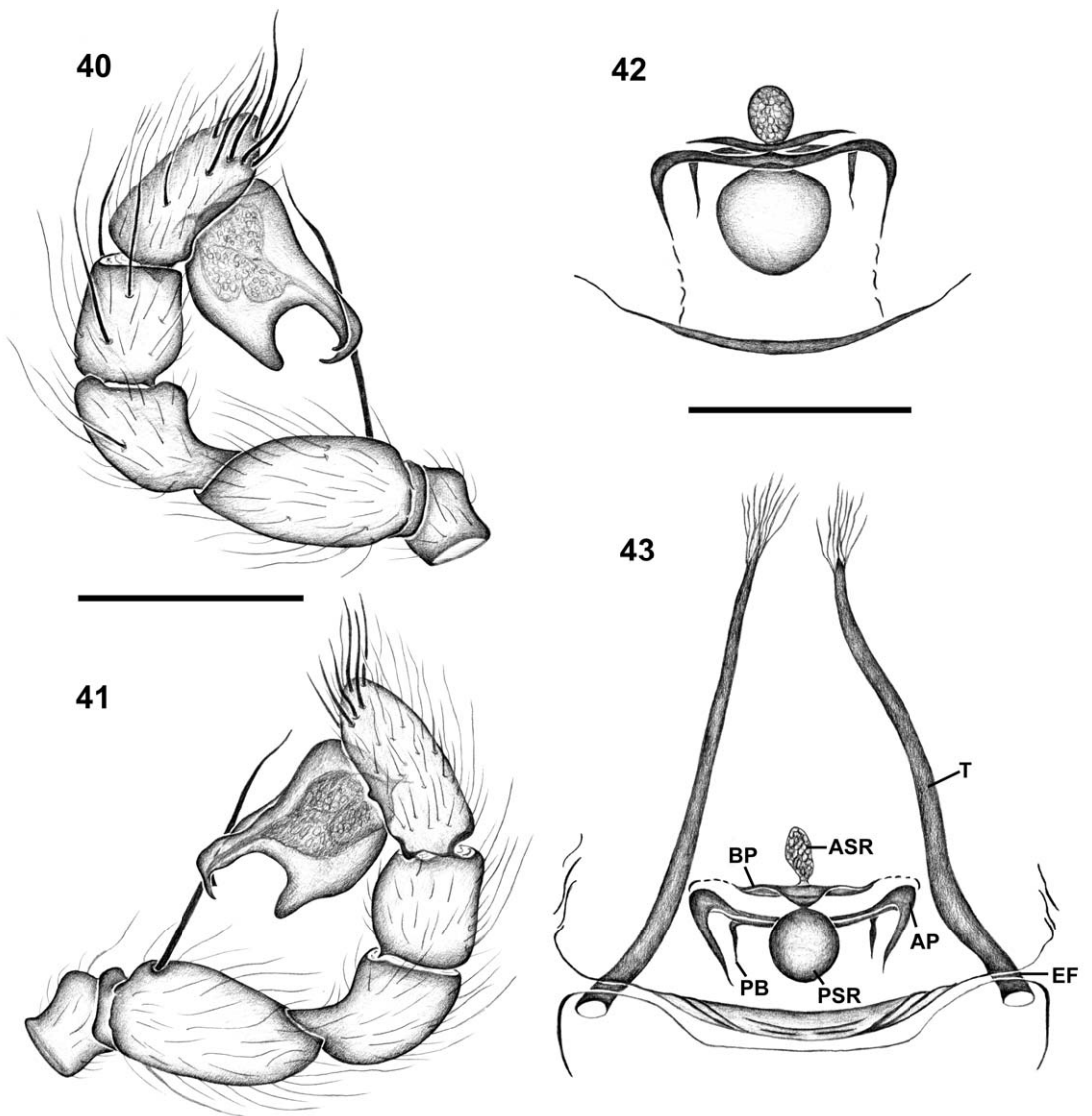
FIGS. **24–32.** *Guaraguaoonops hemhem*, new species, female. **24–25.** Body. **24.** Dorsal view. **25.** Lateral view. **26–30.** Carapace. **26.** Dorsal view. **27.** Ventral view. **28.** Frontal view. **29.** Posterior view. **30.** Lateral view. **31.** Leg I, lateral view. **32.** Abdomen, ventral view.

(fig. 14). Tarsi I–IV without inferior claw, with conspicuous onychium and plumose hairs (fig. 31). Trichobothria: tibia: each with one; metatarsus: each with two; base longitudinally narrowed, aperture internal texture not gratelike, hood smooth (fig. 13), no tricobothria on tarsus, tarsal organ not observed. Male genitalia: epigastric region with sperm pore not visible; furrow without Ω-shaped insertions, without setae (fig. 18). Male palp normal size, not strongly sclerotized, right



FIGS. **33–39.** *Guaraguaoonops humbom*, new species, female. **33–37.** Carapace, **33.** Dorsal view. **34.** Ventral view. **35.** Lateral view. **36.** Frontal view. **37.** Posterior view. **38–39.** Abdomen. **38.** Dorsal view. **39.** Ventral view.

and left palps symmetrical, proximal segments yellow; embolus light, prolateral excavation absent; trochanter normal size, unmodified; femur normal size, two or more times longer than trochanter, without posteriorly rounded lateral dilation, attaching to patella basally; patella shorter than femur, not enlarged, without prolateral row of ridges, setae unmodified; tibia with two trichobothria; cymbium pale orange, ovoid in dorsal view, not fused to bulb, not extending beyond distal tip of bulb, plumose setae absent, without tarsal organ and stout setae, without distal patch of setae; bulb yellow, 1 to 1.5 times as long as cymbium, stout, with basal projection (figs. 20–23; 40–41). Female palp claws absent; spines absent; tarsus unmodified, patella without prolateral row of ridges, tarsi covered with long hairs (figs. 27, 34). Epyginum between parallel and long tracheal spiracles connected by epigastric furrow (fig. 43). Internal genitalia with anterior seminal receptaculum, with a middle basal plate, a sclerotized apodeme plate, with median basal short projections and posterior seminal receptaculum globose (figs. 42, 43).

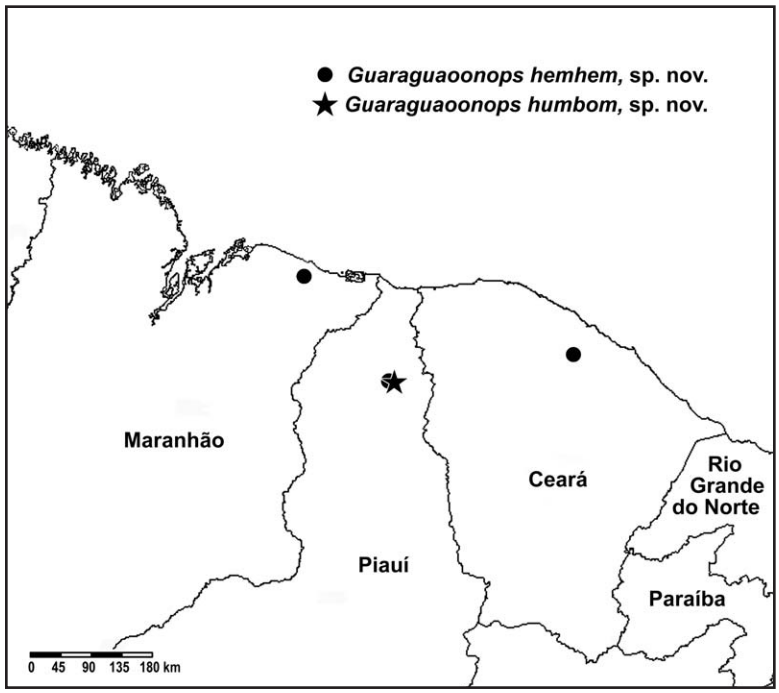


FIGS. **40–43. 40–42.** *Guaraguaoonops hemhem*, new species. **40–41.** Male palp. **40.** Prolateral view. **41.** Retrolateral view. **42.** Female genitalia, dorsal view. **43.** *G. humbom*, new species, female genitalia, dorsal view.

Remarks. *Guaraguaoonops* presently includes only the two new species: *G. hemhem* and *G. humbom*.

Guaraguaoonops hemhem Brescovit, Rheims and Bonaldo, new species
Figures 1–32, 40–42, map 1

Types: Male holotype from Parque Nacional dos Lençóis Maranhenses, 02°44′49″S, 42°49′39″W, Barreirinhas, Maranhão, Brazil, pitfall (Oct. 12–18, 2001, Equipe Biota), deposited in IBSP 67970 (PBI_OON 11044). Paratypes: two females from Parque Nacional de Sete Cidades,



MAP 1. Northeastern Brazil, with distribution records of *Guaraguaoonops* species.

04°06′44.2″S, 41°41′47.7″W, Brasileira/Piracuruca, Piauí, Brazil, PN7C0277 (Nov. 11, 2006, L.S. Carvalho, D.F. Candiani, and N.F. Lo Man Hung), deposited in MPEG 12255 (PBI_OON 11046) and IBSP 160919 (PBI_OON 11045); one male from same locality, MSC657 (Dec.13, 2006, L.S. Carvalho, M.P. Albuquerque, and M.T. Avelino), deposited in MPEG 18701 (PBI_OON 40627).

Etymology: The specific name is a slang interjection used by people who live in the Brazilian state of Piauí, meaning "yes, indeed."

Diagnosis: Males of *Guaraguaoonops hemhem* are diagnosed by the bifid embolar area, with curved embolus and conspicuous basal tegular projection (figs. 20–23, 40–41). The female is distinguished from that of *G. humbom* by the ornate dorsal abdomen (fig. 24), the straight apodeme plate, and by the posterior receptaculum, larger than that of *G. humbom* (fig. 42).

Male (PBI_OON_11044). Total length 1.12. Carapace 0.46 long, 0.34 wide. Eyes: ALE 0.06, PLE 0.06, PME 0.06. Carapace orange. Abdomen dorsum white with irregular and sinuous black fine lines, ventrally white (figs. 15, 18). Legs: femur I 0.24 long. Palpal embolus elongated, enlarged at basis and slender at tip, with two projections, a short one and a long one, the latter bearing the spermatic opening (figs. 20–23, 40–41); femur with a long ventral hair (22–23); bulb distal part with a large and basal conical projection (figs. 22–23, 40).

Female (PBI_OON_11045). Total length 1.15. Carapace 0.52 long, 0.36 wide. Eyes: ALE 0.06, PLE 0.06, PME 0.06. Carapace pale orange, broadly oval in dorsal view (figs. 24, 26). Abdomen dorsum white with black chevrons as in male, ventrally white (figs. 24, 32). Legs: femur I 0.26. Genitalia with short and sclerotized area in the anterior plate. Posterior plate not sclerotized. Internally with anterior seminal receptaculum oval, with a narrow basal plate,

curved at middle; straight apodeme plate, posterior seminal receptaculum four times larger than anterior seminal receptaculum (fig. 42).

Other Material Examined: BRAZIL. **Piauí**: Parque Nacional de Sete Cidades, 04°06′44, 2″S, 41°41′47, 7″W, Brasileira/Piracuruca, pitfall PN7C1518, Nov. 11, 2006, L.S. Carvalho, D.F. Candiani and N.F. Lo Man Hung (MPEG 12250, PBI_OON 11043), 1♂, SEM; **Ceará**: Pentecoste, 03°47′27″S, 39°15′56″W, Nov. 08, 2005, R. Azevedo (IBSP 160497, PBI_OON 11607), 1♂.

Distribution: Known from the states of Maranhão, Piauí, and Ceará, Brazil (map 1).

Guaraguaoonops humbom, Brescovit, Rheims, and Bonaldo
Figures 33–39, 43, map 1

Types: Female holotype from Parque Nacional de Sete Cidades, 04°06′44, 2″S, 41°41′47, 7″W, Brasileira/Piracuruca, Piauí, Brazil, pitfall PN7C1629 (Jul. 01, 2007, L.S. Carvalho, D.F. Candiani, and N.F. Lo Man Hung), deposited in MPEG 12255 (PBI_OON 11046). Paratype: one female from same locality, MSC(2)1011 (Jan. 29, 2007, L.S. Carvalho, M.P. Albuquerque, and M.T. Avelino), deposited in MPEG 18702 (PBI_OON 40628).

Etymology: The specific name is a slang interjection used by people who live in the Brazilian state of Piauí meaning "yes, it's possible."

Diagnosis: Females of *Guaraguaoonops humbom* are distinguished from those of *G. hemhem* by the dorsum of the abdomen white, without color pattern (fig. 38), the apodeme plate enlarged in the curved lateral area and smaller posterior seminal receptaculum (fig. 43).

Male: Unknown.

Female (PBI_OON_11042). Total length 0.93. Carapace 0.48 long, 0.36 wide. Eyes: ALE 0.06, PLE 0.06, PME 0.06. Carapace pale orange, broadly oval in dorsal view (fig. 33). Abdomen dorsally and ventrally without pattern (figs. 38–39) Legs: femur I 0.23. Genitalia with short and sclerotized area in the anterior plate. Posterior plate sclerotized elongated and narrow. Internally with anterior, oval seminal receptaculum, middle basal plate enlarged medially; with apodeme plate enlarged at the curved lateral area, posterior seminal receptaculum two times larger than anterior seminal receptaculum (fig. 43).

Other Material Examined: None.

Distribution. Known only from the state of Piauí, Brazil (map 1).

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REFERENCES

Baehr, B.C., and D. Ubick. 2010. A review of the Asian goblin spider genus *Camptoscaphiella* (Araneae: Oonopidae). American Museum Novitates 3697: 1–65.

Baehr, B.C., M.S. Harvey, and H.M. Smith. 2010. The goblin spiders of the new endemic Australian genus *Cavisternum* (Araneae: Oonopidae). American Museum Novitates 3684: 1–40.

Brescovit, A.D., C.A. Rheims, A.B. Bonaldo, A J. Santos, and R. Ott. In press. The Brazilian goblin spiders of the new genus *Predatoroonops* (Araneae: Oonopidae). American Museum Novitates.

Burger, M. 2009. Female genitalia of goblin spiders (Arachnida: Araneae: Oonopidae): a morphological study with functional implications. Invertebrate Biology 128: 340–358.

Burger, M. 2010. Complex female genitalia indicate sperm dumping in armored goblin spiders (Arachnida, Araneae, Oonopidae). Zoology 113: 19–32.

Fannes, W., and R. Jocqué. 2008. Ultrastructure of *Antoonops*, a new, ant-mimicking genus of Afrotropical Oonopidae (Araneae) with complex internal genitalia. American Museum Novitates 3614: 1–30.

Henschel, J.R. 2002. Long-distance wandering and mating by the dancing white lady spider (*Leucorchestris arenicola*) (Araneae, Sparassidae) across Namib dunes. Journal of Arachnology 30: 321–330.

Oliveira, P.S., and R.J. Marquis. 2002. The Cerrados of Brazil. Ecology and Natural History of a Neotropical Savanna. New York: Columbia University Press. 398 pp.

Platnick, N.I., and A.D. Brescovit. 1995. On *Unicorn*, a new genus of the spider family Oonopidae (Araneae, Dysderoidea). American Museum Novitates 3152: 1–12.

Platnick, N.I., and N. Dupérré. 2009. The goblin spider genera *Opopaea* and *Epectris* (Araneae, Oonopidae) in the New World. American Museum Novitates 3649: 1–43.

Platnick, N.I., and R.R. Forster. 1993. A revision of the New Caledonian spider genus *Bradystichus* (Araneae, Lycosoidea). American Museum Novitates 3075: 1–14.

Reiskind, J. 1965. Self-burying behavior in the genus *Sicarius* (Araneae, Sicariidae). Psyche 72: 218–224.

Rizzini, C.T. 1997. Tratado de Fitogeografia do Brasil: aspectos ecológicos, sociológicos e florísticos. Rio de Janeiro: Âmbito Cultural Edições Ltda., 747 pp.

Roth, V. D. 1984. The spider family Homalonychidae (Arachnida, Araneae). American Museum Novitates 2790: 1–11.

Ubick, D., and C.E. Griswold. 2011. The Malagasy goblin spiders of the new genus *Malagiella* (Araneae, Oonopidae). Bulletin of the American Museum of Natural History 356: 1–86.

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♾ This paper meets the requirements of ANSI/NISO Z39.48-1992 (permanence of paper).