

## TAXONOMY AND NOMENCLATURE

# On the enigmatic troglobitic scorpion *Trogloorhopalurus translucidus*: distribution, description of adult females, life history and comments on *Rhopalurus lacrau* (Scorpiones: Buthidae)

Jonas Eduardo Gallão<sup>1\*</sup> & Maria Elina Bichuette<sup>1</sup>

<sup>1</sup>Laboratório de Estudos Subterrâneos, Departamento de Ecologia e Biologia Evolutiva, Universidade Federal de São Carlos. Rodovia Washington Luís, km 235, 13565-905 São Carlos, SP, Brazil.

\*Corresponding author. E-mail: [jonasgallao@usp.br](mailto:jonasgallao@usp.br)

**ABSTRACT.** We describe for the first time the adult female of the troglobitic scorpion *Trogloorhopalurus translucidus* Lourenço Baptista & Giupponi, 2004, and broaden its known distribution to other sandstone caves at Chapada Diamantina's region. The life history of *T. translucidus* is reconstructed through morphometric measurements, with a multivariate analysis applied on a set of 16 specimens in all stages (including the holotype) and biological notes. The ontogeny of *T. translucidus* has seven stages and the litter size is 43 (n = 1). We discuss the isolation of *T. translucidus* and *Rhopalurus lacrau* Lourenço & Pinto-da-Rocha, 1997 in caves of Chapada Diamantina, and discuss their troglomorphisms (autapomorphies) among other species related with *Rhopalurus*. Both species must be considered fragile due their restricted endemism at Chapada Diamantina.

**KEY WORDS.** Endemism, Bahia, Chapada Diamantina, sandstone, troglomorphisms.

Troglobitic (exclusively subterranean species sensu HOLSINGER & CULVER 1988) scorpions are relatively rare, in contrast with troglobitic spiders, opilionids and pseudoscorpions, of which there are many (CULVER & PIPAN 2009, REDELL 2012). Even though there are about 38 troglomorphic (species that feature some kind of troglomorphisms) scorpions, only about 25 are considered true troglobites (VOLSCHENK & PRENDINI 2008, FRANCKE 2009, LOURENÇO & PHAM 2012, SANTIBÁÑEZ-LÓPEZ et al. 2014). Other troglomorphic scorpions (but not troglobitic) are endogean and/or leaf litter species.

Anophthalmy, absence or reduction of the median and/or lateral eyes, depigmentation, and reduction in sclerotization, are considered classical morphological troglomorphisms (POULSON 1963, BARR 1968, BARR & HOLSINGER 1985). The absence of a pectinal fulcra, reduction in the number of pectinal teeth, enlargement of the telson, absence of carapacial sutures and metasomal carinae, in addition to the shape and setation of the tarsi can be considered troglomorphisms in scorpions (PRENDINI 2001, VOLSCHENK & PRENDINI 2008).

The monotypic genus *Trogloorhopalurus* Lourenço, Baptista & Giupponi, 2004, was created to describe a new troglobitic scorpion based on a single male that lacks pigmentation, from Lapão Cave, central Bahia, Brazil, a sandstone cave inside the Chapada Diamantina National Park, at altitude near 900 m. According to LOURENÇO et al. (2004), this new genus features

some phylogenetic affinities with *Rhopalurus* Thorell, 1876, mainly the presence and disposition of granulation on the fingers of the pedipalp. The most notorious divergence between these two genera is the absence of an stridulatory apparatus in *Trogloorhopalurus* (LOURENÇO et al. 2004).

*Trogloorhopalurus translucidus* Lourenço Baptista & Giupponi, 2004 was the first troglobitic scorpion described from Brazil and the second for the family Buthidae, together with *Troglotityobuthus gracilis* (Fage, 1946) from Madagascar (LOURENÇO et al. 2004, LOURENÇO & DUHEM 2010, but see VOLSCHENK & PRENDINI 2008 that may not consider *T. gracilis* as a troglobitic species). However, there are other two species in Buthidae that have been recorded only inside caves: *Rhopalurus lacrau* Lourenço & Pinto-da-Rocha, 1997 from Brazil and *Alayotityus delacruzii* Armas, 1973 from Cuba.

In this paper we describe the adult female of *T. translucidus*, broaden its known distribution, give notes on the life history and biology of the species, and discuss troglomorphisms and troglobitism with respect to the family Buthidae.

## MATERIAL AND METHODS

Chapada Diamantina region (Fig. 1), in the central portion of the state of Bahia, eastern Brazil, belongs to Serra do Espinhaço Plateau and comprises an area of ca. 38,000 km<sup>2</sup>. Its landscape is

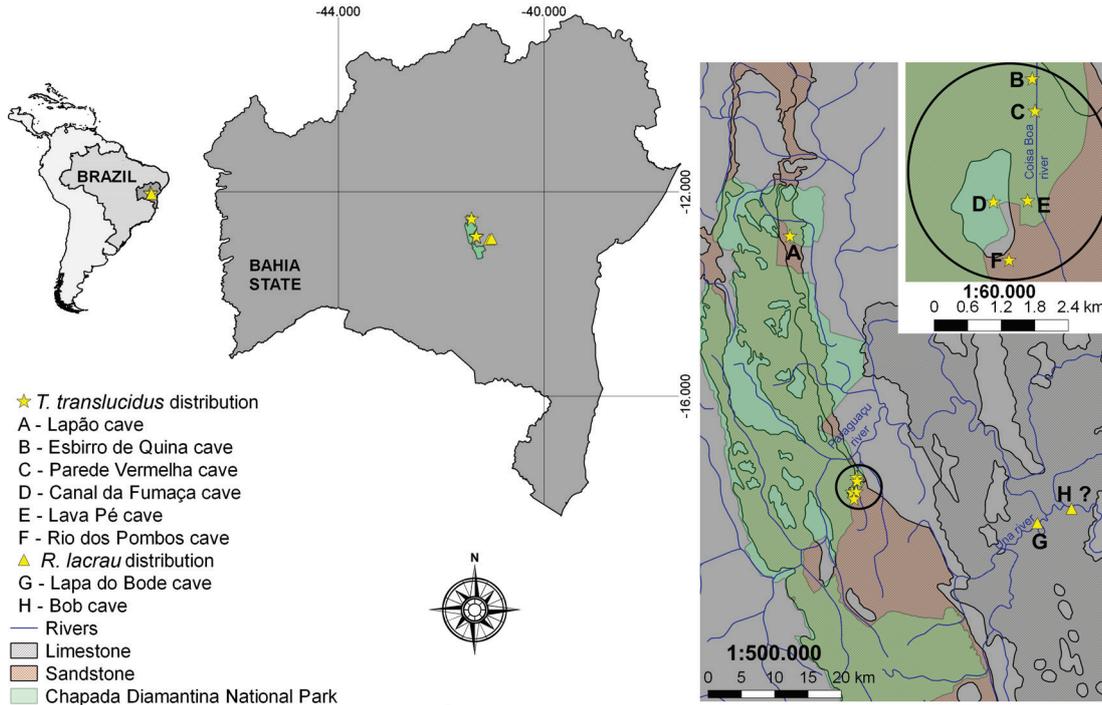


Figure 1. Distribution of *Troglorhopalurus translucidus* and *Rhopalurus lacrau* with type-locality and new records for both species. Question mark (?) indicates a new possible record in cave for *R. lacrau*, see text for explanation.

dominated by karst landforms due to the dissolution of carbonatic rocks and, to a lesser extent, at its central portion, siliclastic rocks. The caves in the region, consequently, are formed by limestone and sandstone. Lapa do Bode Cave, the type-locality of *R. lacrau*, and Bob Cave (a new locality for the referred species) are limestone caves on the eastern border of Chapada Diamantina, and are located below 350 m (Fig. 1). These caves are inserted in Caatinga formation, and the climate there is semi-arid (BSHW), according to KÖPPEN (1948). The sandstone caves of Chapada Diamantina are located at higher altitudes than the limestone caves (above 500 m), and encompass the type-locality of *T. translucidus* (Lapão cave) and its new distribution record. The vegetation around those sandstone caves is formed by Campos de Altitude and Atlantic Forest remnants, with tropical semi-arid climate (Aw – tropical wet and dry), according to KÖPPEN (1948). The limestone caves are warmer (temperature ca. 28°C and relative humidity ca. 95%) than the sandstone caves (temperature ca. 20°C and relative humidity ca. 95%), which may be related to their higher altitude. As mentioned above, the limestone caves are formed by rock dissolution, mainly carbonatic rocks, whereas sandstone caves are mainly formed by mechanical erosion of rock (FORD & WILLIAMS 2007); in the case of Chapada Diamantina, mainly by rivers.

Scorpions were hand collected, with the aid of UV light, and fixed in 70% ethanol. Some individuals were brought alive to the laboratory and were reared in terraria for further

observations. Specimens of *T. translucidus* in different stages of development were collected from sandstone caves at Igatu, municipality of Andaraí, state of Bahia; *R. lacrau* were collected from Lapa do Bode Cave, Itaetê, Bahia; A total of 17 specimens of *T. translucidus*, five female adults, two female subadults and ten juveniles (of all stages) were collected from five sandstone caves at Chapada Diamantina, Andaraí, from 2010 to 2014.

The acronyms of the collections where specimens are deposited are as follows: MNRJ – Museu Nacional, Rio de Janeiro, Rio de Janeiro, Brazil; UFSCar – Universidade Federal de São Carlos, São Carlos, Brazil; LES – Laboratório de Estudos Subterrâneos.

The following material was examined: *Rhopalurus lacrau* from BRAZIL, Bahia: Itaetê (Lapa do Bode cave), adult female, 19.vi.2005, S.V. Nascimento leg. (LES/UFSCar4158). *Rhopalurus* cf *lacrau* from BRAZIL, Bahia: Itaetê (Bob cave), adult, 19.iv.2015, J.E. Gallão and B.G.O. do Monte leg., one dead specimen (LES/UFSCar7089).

Trichobothrial terminology followed VACHON (1974) and morphological terminology followed VACHON (1952) and HJELLE (1990). Measurements were taken point-to-point with a digital caliper under the stereomicroscope, and expressed to the nearest 0.1 mm. Measurements of (given in mm) and notes on the carinae follow STAHNKE (1970), except for the metasomal carinae, which follows OCHOA et al. (2010) and the chela carinae, which follows ACOSTA et al. (2008).

Morphology and description – images of *T. translucidus* were taken with a Leica DFC 295 video camera attached to a Leica M205. Figures were produced from stacks of images using LAS (Leica Application Suite) v3.7. The ultraviolet images and photographs of live specimens were taken with 18.1 Megapixels resolution. The uncoated pectines of *T. translucidus* and *R. lacrau* were illustrated and analyzed through a Scanning Electron Microscope (SEM, FEI Quanta 250) in low-vacuum mode.

A multivariate analysis was performed to describe the ontogeny of *T. translucidus*, using Principal Components Analysis (PCA), since all data are quantitative (morphometric). Variables were tested by Shapiro-Wilk ( $p < 0.05$ ) normality test and then log-transformed. We only used normally distributed variables and the PCA graphics were generated showing the dispersion of the operational taxonomic units (OTUs) on the sampling space. A matrix with 17 characters for 16 specimens, including the holotype, was constructed (Appendix 1). The characters used for the multivariate analyses were selected on the basis of structures that are relevant to scorpions and sum measurements were discarded. Shapiro-Wilk test and PCA were performed with the program PAST version 3.09 (HAMMER et al. 2001).

## TAXONOMY

Buthidae C.L. Koch, 1837

*Troglophalurus* Lourenço Baptista & Giupponi, 2004

*Troglophalurus translucidus*

Lourenço Baptista & Giupponi, 2004

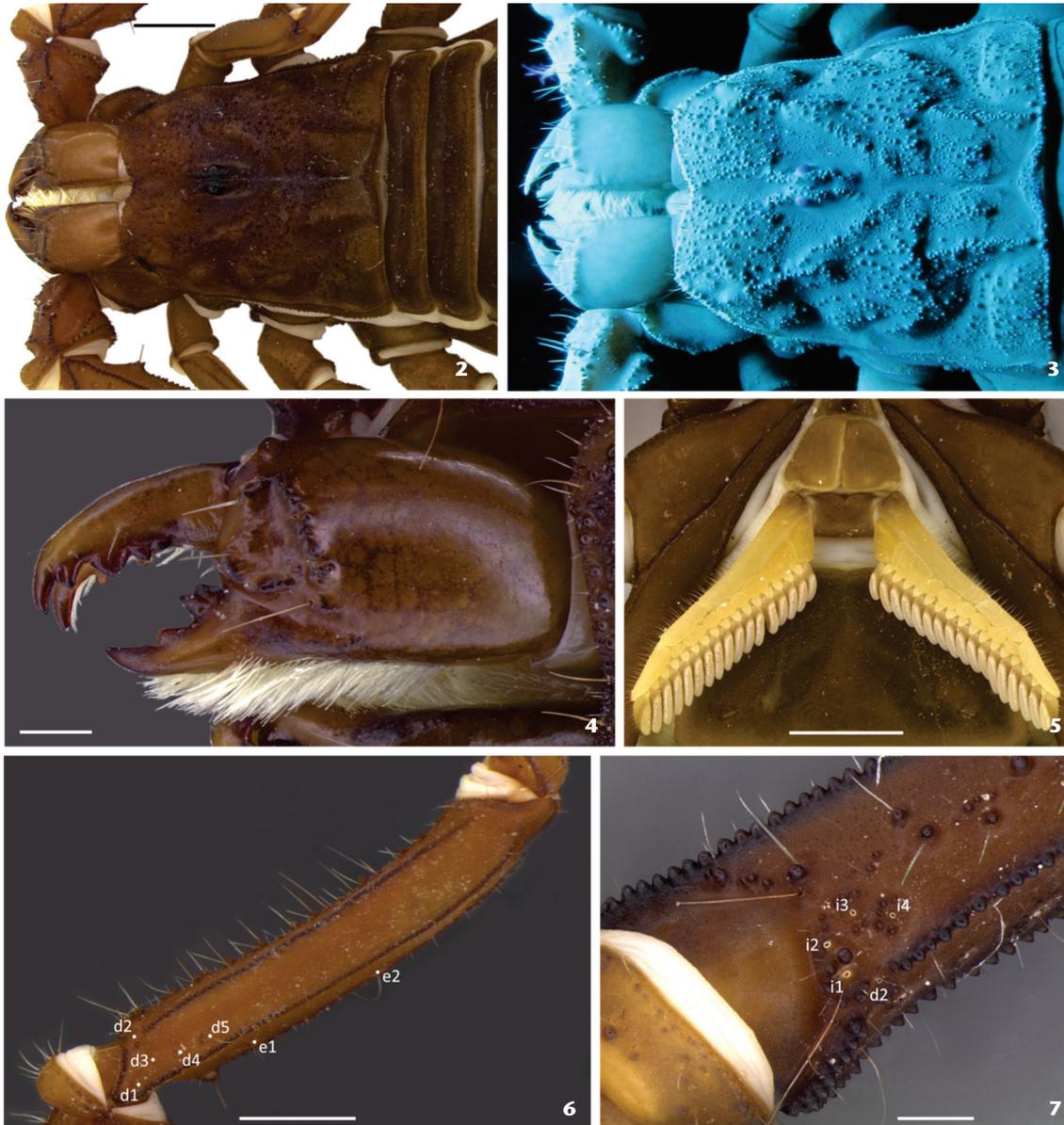
Figs. 1, 2-17, 19, 20-25, Tables 1-2

[urn:lsid:zoobank.org:pub:5C056290-E2FE-4247-B441-35C34F8B8930](http://urn:lsid:zoobank.org:pub:5C056290-E2FE-4247-B441-35C34F8B8930)

Diagnosis. Obligatory cave-dwelling scorpions. Large, 63-66 mm in total length. Body flattened dorso-ventrally. Median eyes reduced. Pedipalps long and slender, with very long and slender, fixed and movable fingers. Eight rows of granules in fixed and movable finger. Chela manus flattened laterally. Pectinal tooth count 17-17. Peg sensilla elongated and sharp. Pedal spurs reduced.

Description (based on females and juveniles). Morphology: Scorpions 63-66 mm long: all measurements of the holotype and four female adults specimens of *T. translucidus* are recorded in Table 1. **Prosoma** (Figs. 2, 3): carapace slightly flattened dorso-ventrally; anterior margin with moderate median concavity with row of granulations; carapace with moderately marked granulation between anterior margin, lateral eyes and median eyes, lateral and posterior portions of carapace; portion between anterior median carina and between median eyes and central lateral carina with fine granulation; anterior median carina weak to moderately marked, lateral ocular, central lateral and posterior median carinae moderately to strongly granulated; central lateral carina starting almost at middle of lateral ocular carina; anterior median furrow moderately marked and central median and pos-

terior median furrows strongly marked; median ocular tubercle slightly anterior to center of carapace, median eyes reduced and separated by little more than one ocular diameter; three pairs of lateral eyes. **Chelicerae** (Fig. 4): chelicera dentition characteristic of the family Buthidae (VACHON 1963); dorsal granulation in one row; fixed finger with basal and medial teeth forming strong bicuspid; movable finger with two weak basal teeth, distal internal tooth slightly larger than distal external; ventral surface of fixed and movable fingers with long and dense setae. **Mesosoma**: tergites with weak to moderately marked granulation, with some larger granules at lateral-posterior region; presence of median carina on all tergites, weak to moderately marked; tergite I with median carina restricted to posterior area; tergites II-IV with median carina occupying distal half; tergites V-VI with median carina occupying more than distal half and almost complete on tergite VI; tergite VII pentacarinata with median carina occupying anterior region and moderately marked, submedian and lateral carinae strongly marked and submedian carinae complete and lateral carinae almost complete. Sternum subpentagonal; genital operculum divided longitudinally, each plate more or less suboval. **Pectines** (Fig. 5): pectinal tooth count 17-17 ( $n = 17$  specimens, including the holotype); peg sensillae of pectinal tooth elongated and sharp (Figs. 16, 17); fulcra present; basal middle lamellae of pectines not dilated; basal piece of pectines with two depressions. Sternites weakly granular; sternite III with two oval areas with weakly granulation without stridulatory apparatus (Fig. 5); in the sternites IV-VI granulation on lateral areas; sternite VII with complete weakly granulation; sternites IV-VI with two little depressions on central anterior region; setation moderate to strong; spiracles moderately elongate, width about twice length; sternites IV-V with very weak carinae; sternite VI with four moderately marked carinae occupying 3/4 of distal region; sternite VII with four strongly marked carinae, lateral carinae occupying central region and submedian carinae almost complete. **Pedipalps**: elongated; femur (Figs. 6, 7) with five carinae – dorsointernal, dorsoexternal, externomedian and ventrointernal continuous and crenulate and internomedian carina discontinuous with a row of spiniform granules; internal surface of femur with long setae, intercarinal surfaces finely and uniformly granular. Patella (Figs. 8, 9) with seven carinae – dorsointernal, dorsomedian, dorsoexternal, externomedian, ventroexternal and ventrointernal continuous and crenulate and internomedian discontinuous, comprising six moderately well spaced spiniform granules, becoming smaller in size distally; proximal tubercle moderately strong; internal surface of patella with moderately number of long setae; intercarinal surfaces very weakly granular, almost smooth. Chela (Figs. 10-13): with four complete or almost complete carinae (dorsal secondary, dorsal marginal, ventrointernal and ventroexternal), two vestigial carinae (digital and ventromedian) and three absent (dorso-internal, internomedian and subdigital); dorsal secondary and dorso marginal with thin granulation; ventroexternal complete with thin granulation; ventrointernal with thin granulation at



Figures 2-7. Female *Troglorhopalurus translucidus*: (2-3) carapace; (2) prosoma and chelicerae under white light; (3) prosoma and chelicerae under ultraviolet light; (4) right chelicerae in detail; (5) ventral aspect showing genital operculum, pectines and sternite III; (6-7) right pedipalp femur showing trichobothrial pattern; (6) dorsal view; (7) internal view. Scale bars: 2, 5, 6 = 2 mm, 4, 7 = 0.5 mm.

proximal two-thirds and distal one-third without granulation; digital with few granules (about nine) at proximal region of chela manus, absent in the remaining chela manus; ventromedian with very few and thin granules (about five) at proximal region of chela manus, absent from the remaining chela manus; intercarinal surfaces almost smooth with very weak and thin granulation. Fixed and movable fingers (Figs. 10, 11, 13) very long and slender, weakly curved; internal and external surfaces

of fingers with conspicuous setae; fixed and movable fingers with slightly oblique rows of granules, presence of internal and external accessory granules as well as presence of internal and external supernumerary granules; three granules at distal area of movable fingers, do not count as a oblique row of granules; fixed and movable fingers with moderately enlarged terminal denticle. **Trichobothriotaxy**: ortobothriotaxy A- $\alpha$  (VACHON 1974, 1975); trichobothrial counts: femur 11 (5 dorsal, 4 internal



Figures 8-13. Female *Troglorhopalurus translucidus*: (8-9) right pedipalp patella showing trichobothrial pattern; (8) dorsal view; (9) external view; (10-13) right chela manus and fingers showing trichobothrial pattern and carinae; (10) dorso-external view in white light; ventro-internal view in white light; (12) above – dorsal view, underneath – ventral view; both in ultraviolet light; (13) above – external view, underneath – internal view, both in ultraviolet light. Scale bars: 2 mm.

and 2 external), patella 13 (5 dorsal, 1 internal and 7 external) and chela 15 (8 chela manus and 7 fixed finger); trichobothria *db* of fixed finger almost halfway between *et* and *est* (Fig. 10). **Metasoma** (Fig. 14): metasomal segments increasing in length and almost equal in width and height; segment I with ten complete paired carinae (dorsolateral, lateral suprmedian, median lateral, lateral inframedian and ventrosupmedian), crenulate; segment II-IV each with eight paired carinae, crenulate, pair of

median lateral carinae absent; segment V with five carinae, a pair of very weak dorsolateral carinae, a pair of crenulate lateral inframedian carinae and one crenulate ventromedian carina; intercarinal spaces weakly granular. **Telson** (Fig. 15): vesicle moderately slender and almost smooth with a very feebly ventral carina; aculeus long and strongly curved; subaculear tooth strong and spinoid in shape. **Legs**: tarsus with two rows of long and acuminate macrosetae ventrally; tibial spur absent in all

Table 1. Morfometric data of holotype and four adult females of *Troglophalurus translucidus*. The total length measure includes the telson.

		MNRJ07493	MNRJ58733	MNRJ58734	LES4153	LES7078
Total length		40.98	66.85	66.21	63.45	65.59
Prosoma	anterior width	2.80	4.10	4.33	4.07	4.31
	posterior width	4.28	5.85	6.25	5.93	6.39
	length	4.59	6.78	6.97	6.50	6.84
Mesosoma	length	8.83	16.90	18.19	17.03	16.26
Pedipalp	total length	24.95	35.87	36.42	33.87	36.25
Femur	length	6.31	9.41	9.39	8.88	9.19
	width	0.96	1.44	1.52	1.42	1.51
	height	0.72	0.98	1.05	0.96	1.05
Patella	length	7.38	10.69	11.01	10.02	11.10
	width	1.02	1.87	1.75	1.89	1.80
	height	0.85	1.64	1.54	1.59	1.55
Chela	length of chela	11.26	15.77	16.02	14.97	15.96
	length of fixed finger	7.28	10.2	10.38	9.85	9.58
	length of movable finger	8.13	10.91	11.32	10.27	11.25
	width of chela manus	0.95	2.20	2.22	2.06	2.28
	height of chela manus	1.10	2.34	2.28	2.15	2.32
Metasoma I	length	3.53	5.86	5.33	5.32	5.88
	width	2.02	2.96	2.84	2.79	3.05
	height	1.86	2.68	2.67	2.59	2.81
Metasoma II	length	4.23	6.90	6.39	6.42	6.64
	width	1.84	2.69	2.77	2.59	2.72
	height	1.68	2.56	2.51	2.41	2.45
Metasoma III	length	4.69	7.28	7.08	6.70	7.23
	width	1.66	2.84	2.82	2.65	2.71
	height	1.70	2.54	2.54	2.43	2.54
Metasoma IV	length	4.95	7.64	7.37	7.14	7.49
	width	1.68	2.65	2.69	2.47	2.60
	height	1.63	2.43	2.46	2.34	2.48
Metasoma V	length	5.80	9.12	8.89	8.50	8.75
	width	1.17	2.43	2.32	2.26	2.44
	height	1.44	2.48	2.37	2.27	2.41
Telson	length of vesicle	2.85	4.22	4.02	3.79	4.15
	width of vesicle	1.29	2.05	2.06	1.89	2.11
	height of vesicle	1.50	2.24	2.30	2.01	2.27
	length of telson	4.36	6.37	5.99	5.84	6.50

legs; prolateral and retrolateral spurs slight reduced on legs I and II and normally on legs III and IV; unguis long and curved and equal length.

**Coloration.** Adults generally reddish-brown (Figs. 19-25), with chela manus and vesicle light reddish-brown, pedipalps reddish-brown and legs yellowish-brown. Juveniles and subadults depigmented. **Prosoma** (Fig. 2): carapace brown with dark brown spots surrounding median eyes region; reddish-brown on the anterior region of carapace and on the posterior edge; granulation of the anterior region reddish-brown and granulation of median and posterior region of carapace brownish; eyes with black pigment. **Chelicerae** (Fig. 4): reddish-brown with dark reddish-brown variegated spots over the entire surface; fingers reddish-brown; teeth dark reddish-brown. **Mesosoma**: dark brown zones on the anterior edge of tergites I to VI and light reddish-brown on the posterior edge of the same segments;

tergite VII reddish-brown; granulation of tergite VII brownish. Coxosternal region reddish-brown. Sternites reddish-brown and sternites III-VI with light reddish-brown strip on the posterior edge. **Pedipalps** (Figs. 6-11): femur and patella homogeneous reddish-brown, chela hand light reddish-brown, chela fingers reddish-brown at the base and light reddish-brown at the apex of chela fingers, granulation of pedipalps reddish to brownish. **Metasoma** (Fig. 14): segments I and II reddish-brown and segments III-V brown; granulation of all segments brown. **Telson** (Fig. 15): vesicle light reddish without spots; aculeus with light reddish at the base, reddish-brown medially and dark reddish distally. **Legs**: yellowish-brown with the tarsus of the legs whitish, unguis reddish.

**Material examined.** Holotype: BRAZIL, Bahia: Lençóis (Lapão Cave), male, 12.xi.2002, R. Baptista and A.P.L. Giupponi leg., MNRJ07493.



Figures 14-15. Female *Troglorhopalurus translucidus*: metasoma. (14) dorso-lateral view of metasomal segments and telson; (15) telson in detail showing vesicle, subaculear tooth and aculeus. Scale bars: 14 = 5 mm, 15 = 2 mm.

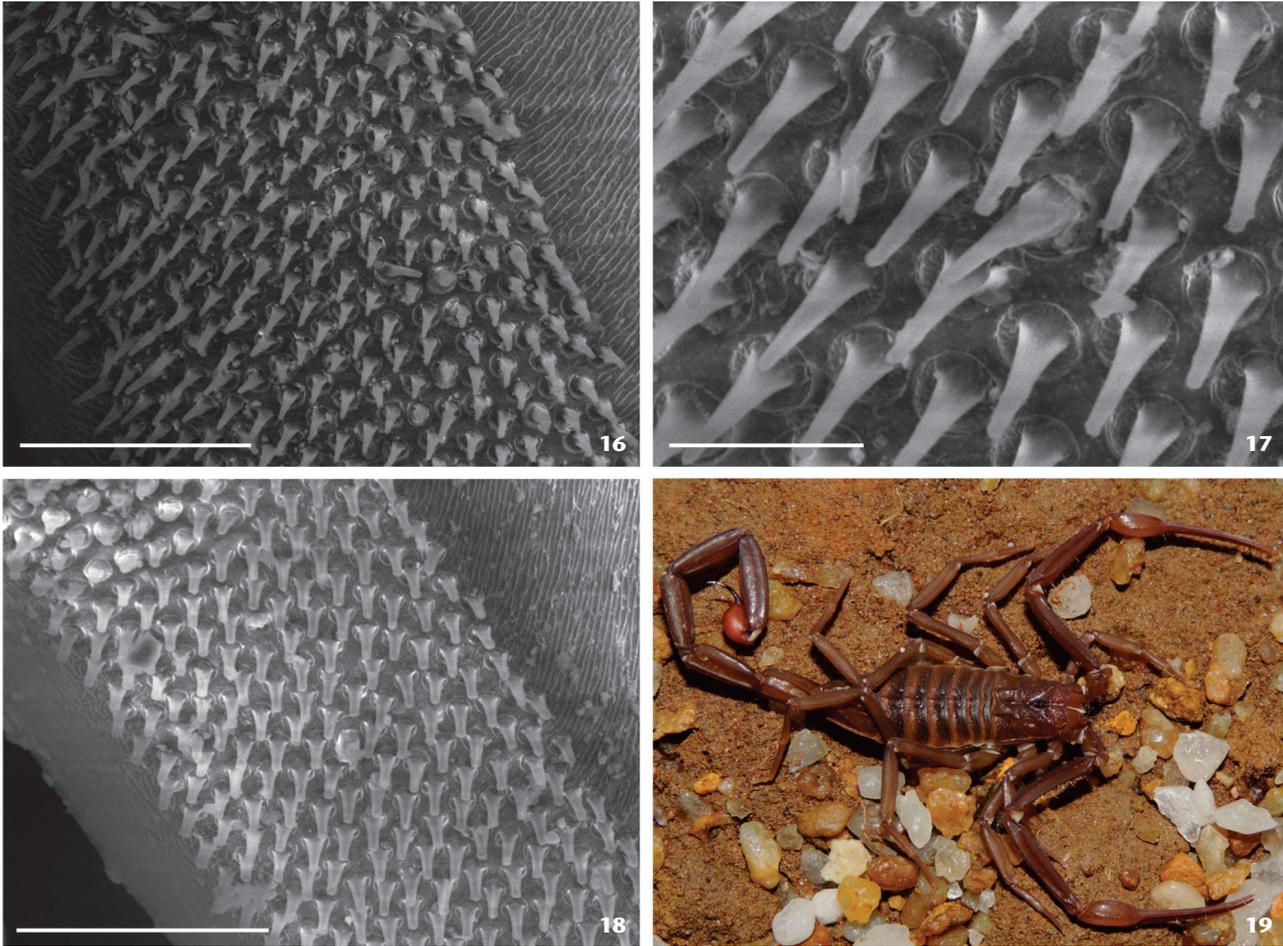
New Records. BRAZIL, Bahia: Andaraí (Igatú, Lava Pé cave), one adult female, 10.iii.2012, M.E. Bichuette, A.P.L. Giupponi, G. Miranda and J.E. Gallão leg., MNRJ58733. Canal da Fumaça cave, one adult female, 10.iii.2012, M. E. Bichuette, A.P.L. Giupponi, G. Miranda and J.E. Gallão leg., MNRJ58734. Gruna Lava Pé cave, one adult female, 30.iii.2013, M.E. Bichuette, D.M. von Schimonsky and J.E. Gallão leg., LES/UFSCar4153. Canal da Fumaça cave, one adult female, 14.iv.2014, J.E. Gallão and C.S. Fernandes leg., LES/UFSCar7078. Canal da Fumaça cave, one adult female, 03.iv.2013, M.E. Bichuette, D.M. von Schimonsky and J.E. Gallão leg., LES/UFSCar4786. Parede Vermelha cave, juvenile, 15.ii.2010, M. E. Bichuette and J.E. Gallão leg., MNRJ58736. Parede Vermelha cave, juvenile, 01.viii.2010, M.E. Bichuette, B. Rantin and J.E. Gallão leg., MNRJ58735. Lava Pé cave, juvenile, 10.iii.2012, M.E. Bichuette, A.P.L. Giupponi, G. Miranda and J. E. Gallão leg., LES/UFSCar7079. Rio dos Pombos cave, one subadult female, 12.iii.2012, M.E. Bichuette, A.P.L. Giupponi, G. Miranda and J. E. Gallão leg., LES/UFSCar7080. Canal da Fumaça cave, juvenile, 11.iv.2014, J.E. Gallão and C.S. Fernandes leg., LES/UFSCar7081. Canal da Fumaça cave, juvenile, 12.iv.2014, J.E. Gallão and C.S. Fernandes leg., LES/UFSCar7082. Canal da Fumaça cave, juvenile, 14.iv.2014, J.E. Gallão and C.S. Fernandes leg., LES/UFSCar7083. Esbirro de Quina cave, juvenile, 20.x.2014, J.E. Gallão and D.M. von Schimonsky leg., LES/UFSCar7084. Parede Vermelha cave, juvenile, 22.x.2014, J.E. Gallão and D.M. von Schimonsky leg., LES/UFSCar7085. Parede Vermelha cave, juvenile, 22.x.2014, J.E. Gallão and D.M. von Schimonsky leg., LES/UFSCar7086. Canal da Fumaça cave, one subadult female, 23.x.2014, J.E. Gallão and D. M. von Schimonsky leg., LES/UFSCar7087. Canal da Fumaça cave, juvenile, 23.x.2014, J.E. Gallão and D.M. von Schimonsky leg., LES/UFSCar7088.

Distribution. *Troglorhopalurus translucidus* is known from the type-locality, Lapão Cave (municipality of Lençóis), and from five other caves (Esbirro de Quina Cave – altitude 500 m, Parede Vermelha Cave – 595 m, Lava Pé Cave – 695 m, Rio dos Pombos Cave – 730 m and Canal da Fumaça Cave – 750 m and) all from the municipality of Andaraí, Igatú. All localities are sandstone caves and belong to the Chapada Diamantina's region, central portion of the state Bahia and are inside Chapada Diamantina National Park (Fig. 1).

### Life history of *Troglorhopalurus translucidus*

A total of 17 specimens of *T. translucidus* were collected from five sandstone caves at Chapada Diamantina, broadening the distribution of the species to 40 km to the south (Fig. 1). LOURENÇO et al. (2004) stated that this species was possibly an endemic element of caves from Lençóis, state of Bahia. Our new findings have revealed a wider distribution, with *T. translucidus* being apparently endemic to the central-north sandstone caves of Chapada Diamantina (Andaraí/Igatú in southern limit and Lençóis in northern limit). The sandstone of Chapada Diamantina is fractured, a result of having been formed by collapse/tectonism, erosion by streams and chemical dissolution (R.F. PEREIRA, pers. comm.). The connectivity between these spaces probably allows the dispersion of *T. translucidus* among different caves.

The ontogeny of females of *T. translucidus* has seven stages: the litter (not presented in PCA), stages 2 to 5 (juveniles), stage 6 (subadult) and stage 7 (mature) (Figs. 20-26). *Troglorhopalurus translucidus* molts six times during its life, a common pattern for the family Buthidae (from four to seven) (POLIS & SISSOM 1990). The stages of *T. translucidus* females can be easily recognized by quite distinct morphometric measurement and by the point dispersion in the PCA (Fig. 26).



Figures 16-19. (16-18) SEM of pectinal tooth showing peg sensilla: (16-17) female *Troglophopalus translucidus*: (14) peg sensilla shape; (15) detail of peg sensilla; (18) female *Rhopalurus lacrau* peg sensilla shape; (19) *Troglophopalus translucidus* live female adult specimen from Lava Pé cave. Scale bars: 16, 18 = 40  $\mu\text{m}$ , 17 = 10  $\mu\text{m}$ .

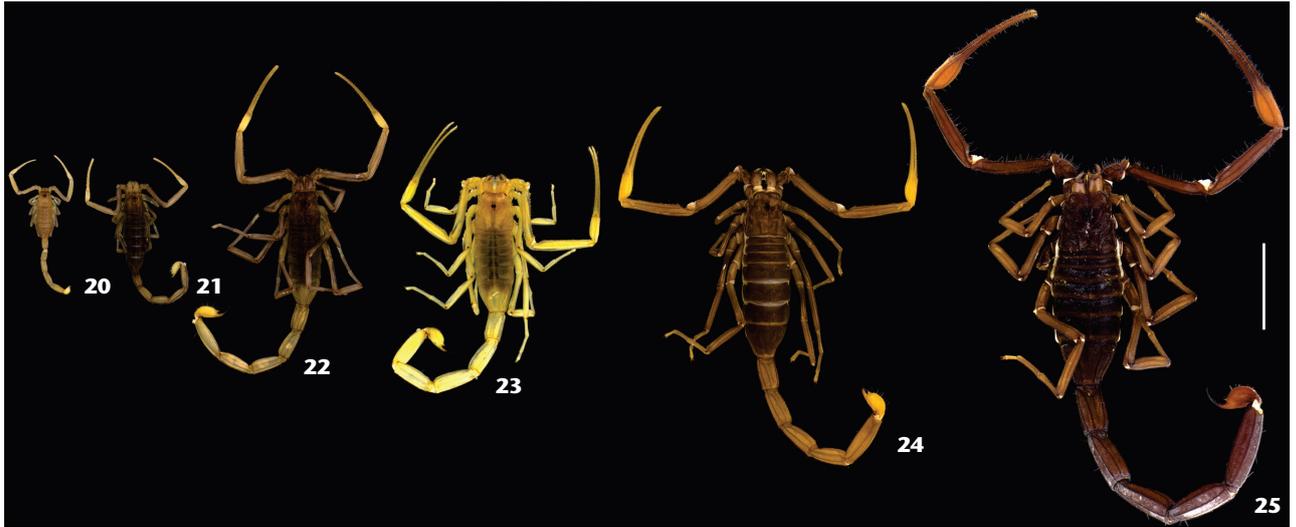
The most interesting fact concerning the ontogeny of females of *T. translucidus* is that the first axis is responsible for more than 98% of the variance in the PCA and the variables that most contribute in this first axis are length of metasoma I, II, III and IV, respectively (Table 2). Adding the second axis, almost 99.5% of the variance is explained and the variables that most contribute to this second axis are length of mesosoma, width of vesicle, posterior width of prosoma and length of metasoma I (Table 2).

Five adult females were examined, but only one male is known. Since it is known that sex ratio in Buthidae scorpions does conform to the 50:50 proportion and females are often oversampled (POLIS 1990).

Comparing with the original description (LOURENÇO et al. 2004) and with other examined juveniles, part of the morphological characters used to diagnose the male also apply to the females: body flattened dorsally, appendices long and slender, carapace flattened dorsally, median eyes reduced, pedipalps long

and slender, fixed and movable fingers very long and slender, with eight oblique rows of granules, pectinal tooth count 17-17 and pedal spurs reduced. Females differ from the male type specimen in size (females adults are bigger, at least 23 mm) and pigmentation (female adults present pigmentation).

There is a great deal of homoplasy in troglomorphic organisms, for instance reduction of the eyes and melanistic pigmentation, and behavioral traits (TRAJANO & BOCKMANN 1999). Troglomorphisms are not necessarily adaptive, unless pleiotropic effects have been demonstrated (JEFFERY 2010). *Troglophopalus translucidus* presents several morphological troglomorphisms, the most conspicuous being elongation of the appendages, mainly the pedipalps. Other morphological troglomorphic traits are the very long and slender fixed and movable fingers, attenuation of the carinae of the chela manus, reduction of the median eyes, attenuation of carapace granulation, reduction of pedal spur and shape of peg sensilla. The adult females of *T. translucidus*



Figures 20-25. *Troglophalurus translucidus* at different stages, except litter: (20) stage 2; (21) stage 3; (22) stage 4; (23) male holotype; (24) female subadult; (25) female adult. The stage 5 female is not represented. Scale bar: 10 mm.

Table 2. Results from the PCA for *Troglophalurus translucidus* collected in caves from Igatu, Bahia state. Eigenvalues on the left and eigenvectors on the right-hand columns, respectively. Bold type indicates characters that contributed for the most variation in PCA analyses.

Eigenvalues		#	Characters	Eigenvectors	
Eigenvalue	Percentage			PC 1	PC 2
0.804479000	98.96900000	1	length of chela	0.24493	0.023782
0.003751660	0.46154000	2	length of fixed finger	0.23897	0.011738
0.001778800	0.21883000	3	length of movable finger	0.23840	0.047340
0.000985208	0.12120000	4	length of pedipalp femur	0.23922	-0.143100
0.000768502	0.09454300	5	length of pedipalp patella	0.23374	-0.062558
0.000335332	0.04125300	6	length of metasoma I	0.28231	-0.255490
0.000261687	0.03219300	7	length of metasoma II	0.27862	-0.199920
0.000217862	0.02680200	8	length of metasoma III	0.27372	-0.107390
0.000119828	0.01474200	9	length of metasoma IV	0.25342	-0.014573
6.85347E-05	0.00843130	10	length of metasoma V	0.24567	-0.119020
5.10361E-05	0.00627860	11	length of vesicle	0.20108	0.145080
2.11041E-05	0.00259630	12	width of vesicle	0.22942	0.538620
1.37057E-05	0.00168610	13	height of vesicle	0.24725	0.225420
5.90701E-06	0.00072669	14	anterior width of prosoma	0.23374	0.215440
1.49244E-06	0.00018360	15	posterior width of prosoma	0.21747	0.311570
0	0	16	length of prosoma	0.21851	0.110460
0	0	17	length of mesosoma	0.23130	-0.569070

present pigmentation but the juveniles do not. Depigmentation is therefore not a troglomorphic trait of *T. translucidus*. It is important to document when juveniles are depigmented and adults are pigmented in studies that try to detect troglomorphisms, to avoid equivocal classifications, as discussed for troglolithic centipedes by CHAGAS-JR & BICHUETTE (2015).

Under laboratory conditions, one female of *T. translucidus* (LES/UFSCar4153) gave birth to a litter size of 43. This is the greatest number documented for epigeal and troglolithic South American Buthidae. Some examples of litter size in South Amer-

ican scorpions are *Rhopalurus amazonicus* Lourenço, 1986 (19) *R. lacrau* (30), *Rhopalurus rochai* Borelli, 1910 (11-47), *Ananteris balzanii* Thorell, 1891 (10-34), *Tityus serrulatus* Lutz & Mello, 1922 (8-36), *Tityus kuryi* Lourenço, 1997 (4-16) (OUTEDA-JORGE et al. 2009). Despite the uniqueness of our record, it contrasts with accepted evidence that troglolithic species, have a smaller litter size when compared to epigeal relatives (CULVER 1982). In Buthidae, the duration of the first instar ranges from 1 to 15 days (POLIS & SISSOM 1990) and *T. translucidus*, newborns begin to molt to stage two after 18 days. This suggests that the inter-

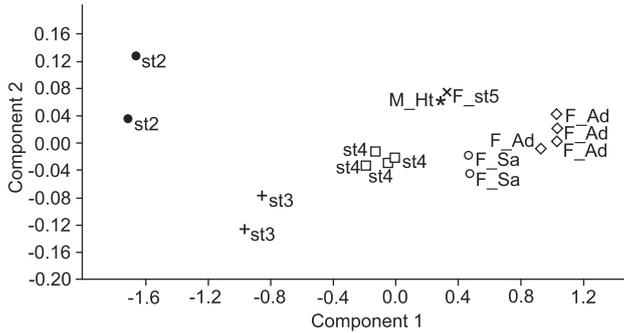


Figure 26. Ontogeny of females of *Troglorhopalurus translucidus*. Graphical representation of PCA showing separation by age classes. (st2) Stage 2, (st3) stage 3, (st4) stage 4, (M\_Ht) male holotype, (F\_st5) female stage 5, (F\_Sa) female subadult, (F\_Ad) female adults.

vals between molts in *T. translucidus* are longer than in other species, indicating greater longevity, a typical characteristic of many troglitic species (CULVER 1982, CULVER & PIPAN 2009). Slow growth and longevity, as observed in several troglitic species, can be interpreted as an adaptation to survive in scarce food conditions, characteristic of many caves (CULVER 1982).

### Troglitic species in Buthidae and comments on *Rhopalurus lacrau*

Since the discovery of the first cave animals, there have been many attempts to classify them into ecological-evolutionary categories (see TRAJANO 2012 for review purposes). TRAJANO (2012), proposed an alternative to the most accepted classification, as follows: **trogloxenes** – source population primarily in epigeal environments; hypogean environment is used as part of the species' habitat, but the entire life cycle cannot be completed in it (hypogean); **troglophiles** – source populations in both hypogean and epigeal habitats and generally maintaining the gene flow between them; **troglobites** – source population exclusively in hypogean environments, even when having sink populations in epigeal habitats. Thus, cavernicolous species cannot be regarded as synonymous with troglitic species, since the term cavernicolous encompasses these three. Although troglitic species can exhibit some troglomorphisms, this is not obligatory and exclusive.

The only known species of *Rhopalurus* that occur at the Chapada Diamantina region and its surroundings are *R. lacrau*, *R. rochai* and *Rhopalurus guanambiensis* Lenarducci, Pinto-da-Rocha & Lucas, 2005 (LENARDUCCI et al. 2005, PORTO et al. 2010). Only *R. lacrau* shares some morphological characteristics with *T. translucidus* – metasomal carination (10-8-8-8-5), number of pectinal tooth (17), peg sensillae shape (Figs. 16-18) and the absence of stridulatory apparatus, in addition to the obligatory cave-dwelling life habitat. *Rhopalurus rochai* possesses 10-10-10-8-5 metasomal carinae and 21-27 pectinal teeth and *R. guanambiensis* possesses 27 pectinal teeth and 10-10-8-8-5

metasomal carinae besides both are epigeal scorpions and have a stridulatory apparatus (LOURENÇO & CLOUDSLEY-THOMPSON 1995, LENARDUCCI et al. 2005). The other scorpions in Buthidae recorded for Chapada Diamantina belong to genera *Ananteris* – *A. balzanii* Thorell, 1891 and *Tityus* – *T. serrulatus*, *T. stigmurus* (Thorell, 1876), *T. kuryi* Lourenço, 1997 and *T. aba*, Candido, Lucas, Souza, Diaz and Lira-da-Silva, 2005 (PORTO et al. 2010).

Despite the absence of conspicuous troglomorphic traits in *R. lacrau*, this species seems to be no longer capable to colonize (or recolonize) the epigeal habitat. Searching for this species revealed no population or even solitary individuals outside the Lapa do Bode cave and a dead and dry specimen that probably belongs to *R. lacrau* was found inside Bob cave, about 20 km away on a straight line from Lapa do Bode cave (the hard parts of this specimen remain unaltered but the soft parts like pectin do not), which suggests that *R. lacrau* is vulnerable to desiccation (this hypothesis is under study). Caves are humid habitats and troglitic arthropods in general have reduced cuticle (BARR 1968). The current epigeal habitat of the Itaeté region is composed of Caatinga formation with semi-arid climate (BSHW), and relative humidity around 50% (pers. obs.). *Alayotityus delacruzi* is endemic to only one wet limestone cave in a semidesert coastal area in Cuba, and represents a troglitic non-troglomorphic scorpion subjected to lower selection pressure, with regards to food, which is readily available (TERUEL 2001, TERUEL et al. 2006). The same applies to *R. lacrau*, since Lapa do Bode and Bob are wet caves inserted into Caatinga formation near epigeal rivers of the Paraguaçu River Basin (Una and Paraguaçu rivers, Fig. 1). Lapa do Bode cave is frequently flooded by its epigeal river (Nascimento pers. comm.). Whether this happens at Bob cave, we do not know.

An interesting question to answer is “how were the two species isolated in the caves? According to the reconstruction of H. Yamaguti, unpublished data, *T. translucidus* and *R. lacrau* share a common ancestor. As already mentioned, these two species share at least four morphological traits, including the shape of the peg sensilla, which could represent a shared troglomorphic feature (Figs. 14-17).

The changes in the geomorphology and climate observed in the region in the last 30 Mya (Oligocene), including uplifting (tectonism phenomena) the sandstone over the limestone, 15 Mya (Miocene) evolution of the karstic system of Chapada Diamantina and, in the last 2 Mya (Pleistocene to nowadays), lowering of the base level, landslides, carving of Rio Una valley and capture of epigeal rivers by subterranean drainages (R.F. Pereira, unpublished data), probably led to the isolation of the two species by vicariance. Greater selection pressure, including the scarcity of food in sandstone caves (GALLÃO & BICHUETTE 2015) and an older isolation, which allowed for a greater accumulation of neutral mutations, could explain the presence of conspicuous troglomorphisms in *T. translucidus* compared with *R. lacrau*. It is noteworthy that none of the two species can be as old as the Oligocene/Miocene periods, and consequently, the geomorphological changes in these periods are not relevant.

Although the phylogenetic relationship between *T. translucidus* and *Rhopalurus* species remains unclear, *T. translucidus* and *R. lacrau* share, besides some morphological traits, the obligatory cave-dwelling life habitat. Thus, the number of troglobitic Buthidae is four species, *Troglopholurus translucidus*, *Rhopalurus lacrau*, *Alayotityus delacruzi* and *Troglotityobuthus gracilis* (since we agree with LOURENÇO 2000 about this species). The number of troglobitic species in Buthidae is low, only four species among more than 1,000 species (REIN 2015).

### Conservation remarks

The troglobitic fauna of Chapada Diamantina is remarkable. There are at least 23 troglobitic species in the sandstone caves, and more than 10 troglobitic species in the limestone caves of the same region, including beetles, centipedes, collembolans, scorpions, spiders, gastropods, fish etc (GALLÃO & BICHUETTE 2015, M.E. Bichuette unpubl. data). In this region some relict taxa are isolated, for instance *T. translucidus*, as well as the only troglobitic tarantula from Brazil, *Tmesiphantes hypogeus* Bertani, Bichuette & Pedroso, 2013 and the recently described centipede *Scolopocryptops troglodaudatus* Chagas-Junior & Bichuette, 2015 in the sandstone caves of Chapada Diamantina. The same happens to the limestone caves such as Lapa do Bode Cave (the same with *R. lacrau*), where the highly specialized carabid *Coarazuphium cessaïma* Gnaspin, Vanin & Godoy, 1998 and the ancient troglobitic catfish *Rhamdiopsis krugi* Bockmann & Castro, 2010 occur, plus some undescribed species.

Most sandstone caves of Chapada Diamantina were heavily impacted by diamond mining in the past, an activity that goes back to the early 1990's and, in a clandestine and residual way, continues to take place (BICHUETTE et al. 2008, M.E. Bichuette, pers. obs.). However, the sandstone caves where *T. translucidus* occurs are inside the Chapada Diamantina National Park and are, to some extent, protected. On the other hand, the limestone caves (Lapa do Bode and Bob Caves, locality of *R. lacrau*) are totally unprotected and can only count on the local population to protect them, with no support from environmental agencies. Currently, the problems concerning the limestone caves are deforestation of the surrounding areas for pastures, causing sedimentation of the Lapa do Bode Cave, lowering the water table due to agricultural irrigation, uncontrolled tourist visitation and pressure for limestone mining. Both species are listed as Endangered (EN), the second worst threat category, according to the last revision of the International Union for Conservation of Nature (IUCN). Studies such as this, on the distribution and life history of species, give support to the need for the effective protection of endangered species.

### ACKNOWLEDGEMENTS

We are very grateful to our guides at Chapada Diamantina, Raimundo C. dos Santos "Xiquinho" and Sinaldo V. Nascimento. We are grateful to several colleagues who helped us with fieldwork A. Giupponi, B. Rantin, B.O. Monte, C.S. Fernandes, D.M.V. Schimonsky, G. Miranda. JEG thanks CAPES for financial support in

the first trips and CNPq (142276/2013-8) for the doctoral scholarship. MEB thanks CNPq (fellowship 303715/2011-1) and FAPESP (processes numbers 2008/08910-8 and 2008/05678-7). We also thanks to Angélica Maria Penteadó Martins Dias (INCT Hympar Sudeste – Process FAPESP 2008/57949-4 e CNPq 573802/2008-4) for the availability of the stereomicroscopy and SEM. We kindly thank Luciana Bueno dos Reis Fernandes, for taking the SEM and stereomicroscope images and for preparing the plates for publication. Instituto Chico Mendes de Conservação da Biodiversidade (ICMBIO) and Sistema de Autorização e Informação em Biodiversidade (SISBio) provided the licenses for the collection of specimens. We are very grateful to Camilo Mattoni, José A. Ochoa, Adriano Chiarello and two anonymous reviewers for their helpful comments and careful review of the manuscript and to Alessandro Giupponi and Adriano Kury for the loan of specimens of Museu Nacional do Rio de Janeiro (MNRJ).

### LITERATURE CITED

- ACOSTA LE, CANDIDO DM, BUCKUP EH, BRESCOVIT AD (2008) Description of *Zabius gaucho* (Scorpiones: Buthidae), a new species from southern Brazil, with an update about the generic diagnosis. **The Journal of Arachnology** 36: 491-501.
- BARR TC (1968) Cave ecology and the evolution of troglobites. **Evolutionary Biology** 2: 35-102.
- BARR TC, HOLSINGER JR (1985) Speciation in cave faunas. **Annual Review of Ecology and Systematics** 16: 313-337. doi: 10.1146/annurev.es.16.110185.001525
- BICHUETTE ME, PINNA MCC, TRAJANO E (2008) A new species of *Glaephyropoma*: the first subterranean copionodontine catfish and the first occurrence of opercular odontodes in the subfamily (Siluriformes: Trichomycteridae). **Neotropical Ichthyology** 6: 301-306. doi: 10.1590/S1679-62252008000300002
- CHAGAS-JR A, BICHUETTE ME (2015) A new species of *Scolopocryptops* Newport: a troglobitic scolopocryptopine centipede from a remarkable siliciclastic area of eastern Brazil (Scolopendromorpha, Scolopocryptopidae, Scolopocryptopinae). **ZooKeys** 487: 97-110. doi: 10.3897/zookeys.487.9262
- CULVER DC (1982) **Cave Life: Ecology and Evolution**. Cambridge, Harvard University Press, 189p.
- CULVER DC, PIPAN T (2009) **Biology of Caves and Other Subterranean Habitats**. New York, Oxford University Press, 254p.
- FRANCKE OF (2009) A new species of *Alacran* (Scorpiones: Typhlochactidae) from a cave in Oaxaca, Mexico. **Zootaxa** 2222: 46-56.
- FORD D, WILLIAMS P (2007) **Karst Hydrology and Geomorphology**. England, West Sussex, 576p.
- GALLÃO JE, BICHUETTE ME (2015) Taxonomic distinctness and conservation of a new high biodiversity subterranean area in Brazil. **Anais da Academia Brasileira de Ciências** 87: 209-217. doi: 10.1590/0001-3765201520140312
- HAMMER Ø, HARPER DAT, RYAN PD (2001) PAST. Paleontological Statistics software package for education and data analysis. **Paleontologia Electronica** 4: 1-9.

- HJELLE JT (1990) Anatomy and morphology, p. 9-63. In: POLIS GA (Ed.). **The biology of scorpions**. Stanford, Stanford University Press.
- HOLSINGER JR, CULVER DC (1988) The invertebrate cave fauna of Virginia and a part of Eastern Tennessee: Zoogeography and ecology. **Brimleyana** **14**: 1-162.
- JEFFERY WF (2010) Pleiotropy and eye degeneration in cavefish. **Heredity** **105**: 495-496. doi: 10.1038/hdy.2010.7
- KÖPPEN W (1948) **Climatología**. Mexico, Fondo de Cultura Económica, 478p.
- LENARDUCCI ARIP, PINTO-DA-ROCHA R, LUCAS SM (2005) Descrição de uma nova espécie de *Rhopalurus* Thorell, 1876 (scorpiones: Buthidae) do nordeste brasileiro. **Biota Neotropica** **5**: 173-180. doi: 10.1590/S1676-06032005000200015
- LOURENÇO WR (2000) More about Buthoidea of Madagascar, with special references to the genus *Tityobuthus* Pocock (Scorpiones, Buthidae). **Revue Suisse de Zoologie** **107**: 721-736.
- LOURENÇO WR, CLOUDSLEY-THOMPSON JL (1995) Stridulatory apparatus and the evolutionary significance of sound production in *Rhopalurus* species (Scorpiones: Buthidae). **Journal of Arid Environments** **31**: 423-429. doi: 10.1016/S0140-1963(05)80125-9
- LOURENÇO WR, DUHEM B (2010) Buthid scorpions found in caves; a new species of *Isometrus* Ehrenberg, 1828 (Scorpiones: Buthidae) from southern Vietnam. **Comptes Rendus Biologies** **333**: 631-636. doi: 10.1016/j.crvi.2010.05.005
- LOURENÇO WR, PHAM DS (2012) A second species of *Vietbocap* Lourenço & Pham, 2010 (Scorpiones: Pseudochactidae) from Vietnam. **Comptes Rendus Biologies** **335**: 80-85. doi: 10.1016/j.crvi.2011.11.004
- LOURENÇO WR, BAPTISTA RLC, GIUPPONI APL (2004) Troglotic scorpions: a new genus and species from Brazil. **Comptes Rendus Biologies** **327**: 1151-1156.
- OCHOA JA, BOTERO-TRUJILLO R, PRENDINI L (2010) On the troglomorphic scorpion *Troglotayosicus humiculum* (Scorpions, Troglotayosicidae), with first description of the adults. **American Museum Novitates** **3691**: 1-19.
- OUTEDA-JORGE S, MELLO T, PINTO-DA-ROCHA R (2009) Litter size, effects of maternal body size, and date of birth in South American scorpions (Arachnida: Scorpiones). **Zoologia** **26**: 45-53. doi: 10.1590/S1984-46702009000100008
- POULSON TL (1963) Cave adaptation in amblyopsid fishes. **The American Midland Naturalist** **70**: 257-290.
- PRENDINI L (2001) Substratum specialization and speciation in southern African scorpions: the Effect Hypothesis revisited, p. 113-138. In: FET V, SELDEN PA (Eds.). **Scorpions 2001. In Memoriam Gary A. Polis**. Burnham Beeches, British Arachnological Society.
- POLIS GA (1990) **The biology of scorpions**. Stanford, Stanford University Press, 587p.
- POLIS GA, SISSOM WD (1990) Life History, p. 81-111. In: POLIS GA (Ed.). **The biology of scorpions**. Stanford, Stanford University Press.
- PORTO TJ, BRAZIL TK, LIRA-DA-SILVA RM (2010) Scorpions, state of Bahia, northeast Brasil. **Check List** **6**: 292-297.
- REDELL JR (2012) Spiders and related groups, p. 554-564. In: CULVER DC, WHITE WB (Eds.). **Encyclopedia of Caves**. Amsterdam, Academic Press.
- REIN JO (2015) Buthidae. In: **The Scorpion files**. Available online at: <http://www.ntnu.no/ub/scorpion-files/buthidae.php> [Accessed: 25/06/2015]
- SANTIBÁÑEZ-LÓPEZ CE, FRANCKE OF, PRENDINI L (2014) Shining a light into the world's deepest caves: phylogenetic systematics of the troglotic scorpion genus *Alacran* Francke, 1982 (Typhlochactidae: Alacraninae). **Invertebrate Systematics** **28**: 643-664. doi: 10.1071/IS14035.
- STAHNKE HL (1970) Scorpion nomenclature and mensuration. **Entomological News** **81**: 297-316.
- TERUEL R (2001) Redescrición de *Alayotityus delacruz* Armas, 1973 (Scorpiones: Buthidae). **Revista Ibérica de Aracnología** **3**: 17-24.
- TERUEL R, FET V, GRAHAM MR (2006) The first mitochondrial DNA phylogeny of Cuban Buthidae (Scorpiones: Buthoidea). **Boletín de la Sociedad Entomológica Aragonesa** **39**: 219-226.
- TRAJANO E (2012) Ecological classification of subterranean organisms, p. 275-277. In: WHITE WB, CULVER DC (Eds.). **Encyclopedia of caves**. Amsterdam, Academic Press.
- TRAJANO E, BOCKMANN FA (1999) Evolution of ecology and behaviour in Brazilian heptapterine cave catfishes, based on cladistic analysis (Teleostei: Siluriformes). **Mémoires de Biospéologie** **26**: 123-129.
- VACHON M (1952) **Études sur les scorpions**. Alger, Publications de l'Institut Pasteur d'Algérie, 482p.
- VACHON M (1963) De l'utilité, en systématique, d'une nomenclature des dents des chélicères chez les Scorpions. **Bulletin du Muséum National d'Histoire Naturelle** **35**: 161-166.
- VACHON M (1974) Étude des caracteres utilisés pour classer les familles et les genres de Scorpions (Arachnides). 1. La trichobothriotaxie en arachnologie. Sigles trichobothriaux et types de trichobothriotaxie chez les Scorpions. **Bulletin du Muséum national d'Histoire naturelle** **140**: 857-958.
- VACHON M (1975) Sur l'utilisation de la trichobothriotaxie du bras des pédipalpes des Scorpions (Arachnides) dans le classement des genres de la famille des Buthidae Simon. **Comptes Rendus de l'Académie des Sciences** **281**: 1597-1599.
- VOLSCHENK ES, PRENDINI L (2008) *Aops oncodactylus* gen. et sp. nov., the first troglotic urodacid (Urodacidae: Scorpiones), with are-assessment of cavernicolous, troglotic and troglomorphic scorpions. **Invertebrate Systematics** **22**: 235-257. doi: 10.1071/IS06054

Submitted: 22 November 2015

Received in revised form: 9 June 2016

Accepted: 18 July 2016

Editorial responsibility: Ricardo Pinto da Rocha

**Author Contributions:** JEG and MEB contributed equally for the manuscript.

**Competing Interests:** The authors have declared that no competing interests exist.

Appendix 1. Data matrix of the Principal Component Analyses (PCA) for *T. translucidus*. Measurements are in mm.

Characters	Stage two		Stage three		Stage four				Male holotype	Female stage five	Female subadult		Female adult			
Lenght of chela	3.55	3.37	5.44	5.15	8.26	8.63	8.96	8.99	11.26	10.39	11.75	11.65	15.96	14.97	15.77	16.02
Lenght of fixed finger	2.35	2.31	3.48	3.49	5.17	5.12	5.89	6.03	7.28	7.11	7.53	8.15	9.58	9.85	10.20	10.38
Lenght of movable finger	2.71	2.33	3.98	3.75	5.93	6.12	6.69	6.27	8.13	7.56	8.21	8.51	11.25	10.27	10.91	11.32
Lenght of pedipalp femur	2.04	2.08	3.44	3.28	4.78	4.90	5.32	5.67	6.31	6.27	7.08	7.06	9.19	8.88	9.41	9.39
Lenght of pedipalp patella	2.45	2.55	4.05	3.84	5.45	6.13	6.29	6.26	7.38	7.67	8.21	8.26	11.10	10.02	10.69	11.01
Lenght of metasoma I	0.96	0.90	1.85	1.74	2.76	2.78	3.00	3.03	3.53	3.71	4.24	4.09	5.88	5.32	5.86	5.33
Lenght of metasoma II	1.16	1.09	2.23	2.01	3.17	3.23	3.26	3.64	4.23	4.29	4.93	4.70	6.64	6.42	6.90	6.39
Lenght of metasoma III	1.22	1.32	2.36	2.08	3.42	3.52	3.64	3.82	4.69	4.65	5.13	4.96	7.23	6.70	7.28	7.08
Lenght of metasoma IV	1.53	1.51	2.56	2.33	3.77	3.83	3.86	4.15	4.95	4.87	5.39	5.11	7.49	7.14	7.64	7.37
Lenght of metasoma V	1.86	1.89	3.14	3.06	4.55	4.72	4.64	4.91	5.80	5.94	6.56	6.38	8.75	8.5	9.12	8.89
Lenght of vesicle	1.21	1.15	1.70	1.53	2.33	2.51	2.44	2.68	2.85	3.21	3.08	3.00	4.15	3.79	4.22	4.02
Weidht of vesicle	0.60	0.46	0.71	0.56	1.01	0.99	1.05	1.04	1.29	1.43	1.32	1.49	2.11	1.89	2.05	2.06
Height of vesicle	0.52	0.48	0.62	0.74	1.12	1.13	1.25	1.19	1.50	1.54	1.61	1.60	2.27	2.01	2.24	2.30
Anterior weidht of prosoma	0.98	1.08	1.42	1.34	1.98	2.18	2.28	2.35	2.80	2.95	3.08	2.97	4.31	4.07	4.10	4.33
Posterior weidht of prosoma	1.71	1.59	2.30	1.98	3.25	3.33	3.31	3.51	4.28	4.29	4.56	4.24	6.39	5.93	5.85	6.25
Lenght of prosoma	1.79	1.79	2.56	2.37	3.46	3.80	3.93	3.97	4.59	4.72	5.07	5.14	6.84	6.50	6.78	6.97
Lenght of mesosoma	3.59	3.89	6.65	6.68	9.20	8.77	9.88	9.19	8.83	9.55	11.55	14.34	16.26	17.03	16.90	18.19