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Paecilaema batman, a new species of Brazilian troglophilous harvestman that exhibits a remarkable color patches variation (Opiliones: Cosmetidae)

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ABSTRACT. A new species of harvestman, *Paecilaema batman*, from Brazilian limestone caves of the state of Goiás, is described, and a remarkable intraspecific color patch variation is discussed. *Paecilaema batman* **sp. nov.** differs from other species of the genus by the following combination of features: chelicera similar in both sexes; prosoma without color patches; typical color patches on area I; and area III with two high spines. The new species is considered troglophilous.

KEY WORDS. Intraspecific variation; Neotropics; Opilionids; polymorphism.

Cosmetids are distributed from central-southern USA to almost the extreme end of South America, including the Antilles (Kury 2003, Kury & Pinto-da-Rocha 2007), with most of the family's impressive diversity (125 genera and 716 species, according to Kury 2011) concentrated in the tropical rainforests of Central and South America and the Andes. Adults of the family are easily diagnosed by having extremely modified pedipalp, which are flattened and cover the chelicerae (Kury & Pinto-da-Rocha 2007). Most species are reddish to blackish brown, with a nice white or yellow pattern of stripes, dots and/or patches on the dorsal scutum. This pattern gives name to the family (from Greek means ornate, beautified), is quite variable among species, and is widely used to distinguish them (Kury & Pinto-da-Rocha 2007).

In spite of their beautiful color appearance, cosmetids are one of the less studied groups of the Neotropical region. The genera classification relies on the Roewerian system, in which only a few, and always the same characters, such as number of tarsomeres of leg I or armature on dorsal scutum (see Roewer 1923 and González-Sponga 1992), or even worse, only tarsomeres of leg I (Goodnight & Goodnight 1953), are used in combination to distinguish among taxa. Some "Roewerian" characters in cosmetid classification have been criticized. For instance, the number of tarsomeres of leg I, largely used to allocate species into genera, is variable in a number of species – for example in *Cynorta conspersa* (Perty, 1833), see Kury *et al*. (2007) –, in a large number of monotypic genera, and in diverse genera comprising unrelated species. Unfortunately, only one non-monotypic genus, *Roquettea* Mello-Leitão 1931, has been reviewed according to modern standards (Ferreira & Kury 2010 and Kury & Ferreira 2012). In these revisions, the authors propose that a different set of characters (other than those in the Roewerian system) should be used to better understand the relationships among cosmetid genera. A few other scattered contributions have recently been published: the redescription of the type species of *Cynorta* Koch 1839, with a discussion on the importance of the outline of the dorsal scutum to the genera classification (Kury *et al*. 2007); the review of *Platygyndes* Roewer, 1943, with comments on the use of some character (Pinto-da-Rocha & Hara 2011), and a key with an atlas containing the genitalic of cosmetids of Central America (Towsend *et al*. 2010). Despite of those contributions, the classification in genera of cosmetids is still caothic.

This article aims to describe a new species of Brazilian cavernicolous harvestmen, and to call attention to the intraspecific variation of the pattern color patches.

MATERIAL AND METHODS

The illustrations of external morphology were made under a Leica MZ-APO stereomicroscope using a camera lucida with recently dried material to better observe the tubercles. Preparation of the penis for scanning electron microscope followed Pinto-da-Rocha (1997). All the measurements are given in millimeters. Terminology on morphological features followed Kury *et al*. (2007) and Pinto-da-Rocha *et al*. (2007).

The studied material is deposited in Museu de Zoologia da Universidade de São Paulo (MZSP), Museu de História Natural Capão da Imbuia (MHNCI), and Museu Nacional do Rio de Janeiro (MNRJ).

TAXONOMY

Paecilaema Koch, 1839

Remarks. *Paecilaema* is the second largest genus of Cosmetidae, with 94 described species (Kury 2003). Unfortunately, its type species, *Paecilaema u-flavum* (Perty 1833), is lost, and was poorly described. Since the genus was not reviewed according to modern standards, the allocation of the species herein described in *Paecilaema* is made based the number of articles on tarsus I, and shape and armature of the dorsal scutum.

Paecilaema batman **sp. nov.**

Figs 1-20

Paecilaema sp.: Trajano, 1987 (distribution); Pinto-da-Rocha, 1995: 83 (distribution).

Cosmetidae: Trajano & Gnaspini, 1991 (distribution); Pinto-da-Rocha, 1995: 83 (distribution).

Diagnosis. This species possesses the main characteristics of most of the 102 species of *Paecilaema*, chelicerae subequal in size in both sexes, pair of long spines on area III, basitarsus I similar in both sexes (not swollen), tarsus I with 7 segments, body beta-type (see Kury *et al*. 2007), femur IV much longer than body length (ratio femur IV/dorsal scutum length about 3.6), straight and unarmed. *Paecilaema batman* **sp. nov.** differs from other species of the genus by the typical pattern of color patches on area I (from bat-shaped to small scattered patches, see Figs 8-19) and absence of color patches on carapace. Other species of the genus have pattern of color dark reticulate on carapace, lateral and posterior margins of dorsal scutum (e.g., *P. manifestum* Roewer, 1927, *P. cancellatum* Roewer, 1927), or white stripes of different sizes and shapes over sulci of dorsal scutum (e.g., *P. rectipes* Roewer, 1947, *P. sinuatum* Roewer, 1947, *P. whiti* Henriksen, 1932) or dots of different sizes and number on dorsal scutum (e.g., *P. chiriquensis* Goodnight & Goodnight, 1943, *P. guttatum* Roewer, 1912, *P. inglei* Goodnight & Goodnight, 1947).

Description. Male holotype (MHNCI-6554). Measurements. Body length: 4.9. Maximum width of scutum (near sulcus III): 4.3. Prosoma length 1.8, width 2.7 (ocularium). Pedipalpus: 5.6. Legs: I 25.5; II 58.5; III 34.5; IV 43.

Dorsal (Figs 1 and 2). Shape type Beta (see Kury *et al*. 2007). Anterior margin of dorsal scutum with two tubercles on each angle, cheliceral sockets weakly defined. Paracheliceral projections discrete. Lateral borders of dorsal scutum with row of small granules between coxa III and posterior margin. Ocularium narrow and low, with three marginal tubercles on each side. Posterior margin straight and with a row of small tubercles. Dorsal scutum clearly convex, prosoma clearly demarcated by groove I. Opisthosomal widest near sulcus III, region of scutum with dorsal areas weakly demarcated by grooves. Areas I-II with 5-6 tubercles on each side; III bearing a pair of large acute parallel spines, with nine to ten lateral tubercles, three tubercles between spines; IV divided, with one to two tubercles on each half. Free tergite I with one row of 13 tubercles; II and III with 11 each. Anal operculum with one submedian irregular row of eight tubercles and 24 sparse tubercles on posterior region.

Venter. Coxa and genital operculum densely granulate. Stigmatic area densely granulate between coxae and smooth between stigma. Posterior margin and free sternites with one row of tubercles. Anal operculum with irregularly disposed tubercles.

Chelicera. Bulla of basichelicerite with granulated surface near mesoapical and ectoapical regions, with row of large and closed each other tubercles on posterior margin. Fixed finger with five teeth, decreasing in size posteriorly; movable finger with 10 teeth very close to each other.

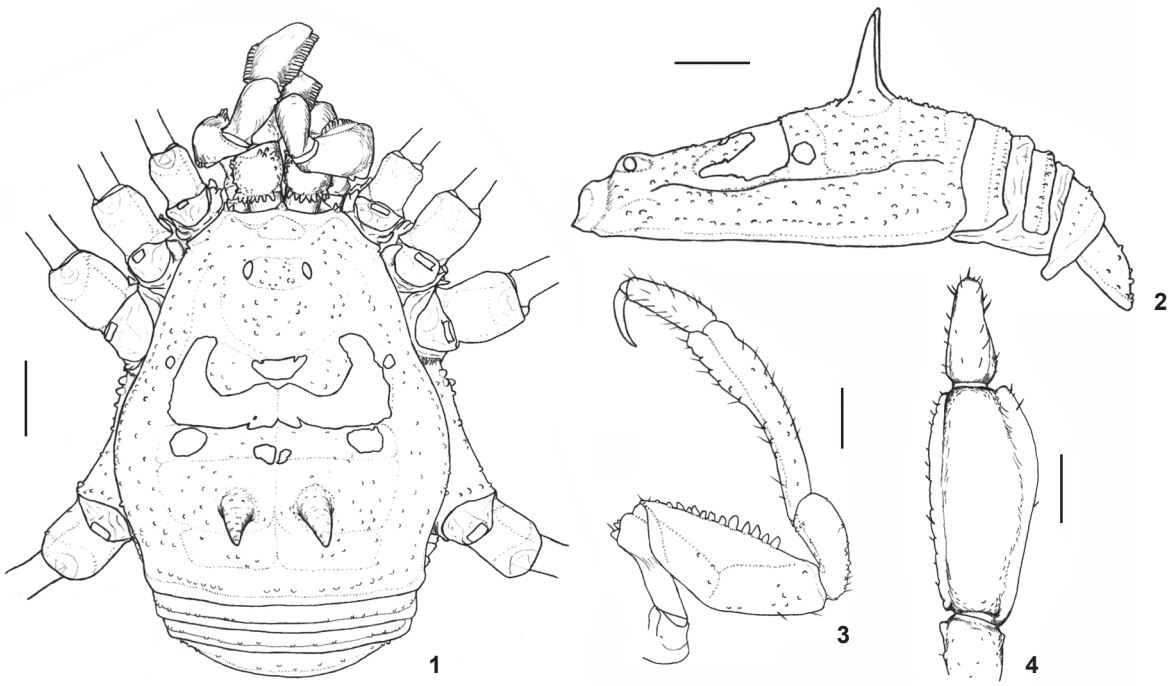
Pedipalpus (Figs 3 and 4). Femur expanded and flattened, with ventral row of 13 tubercles, larger on apical half, with one prolateral apical tubercle. Patella with small tubercles. Tibia (Figs 3 and 4) spoon-shaped bearing rows of setiferous small tubercles at its prolateral and retrolateral edges (apical larger), with two rows of small tubercles on dorsal surface. Tarsus (Figs 3 and 4) with a prolateral and retrolateral setiferous granule.

Legs. Long and slender, without swollen articles. Articles unarmed, except for coxae. Coxa I bearing long and trifid prolatero-dorsal apophysis, and smaller retrolatero-dorsal apophysis. Coxa II bearing large prolatero-dorsal apophysis, in front of ozophore. Coxa III bearing large anterior trifid apophysis. Coxa IV with sparse tubercles, more concentrated near coxa III. Femur IV 3.1 times longer than dorsal scutum length. Tarsal formula: 7 (3), 15 (3), 9, 10. Basitarsus I-IV normal.

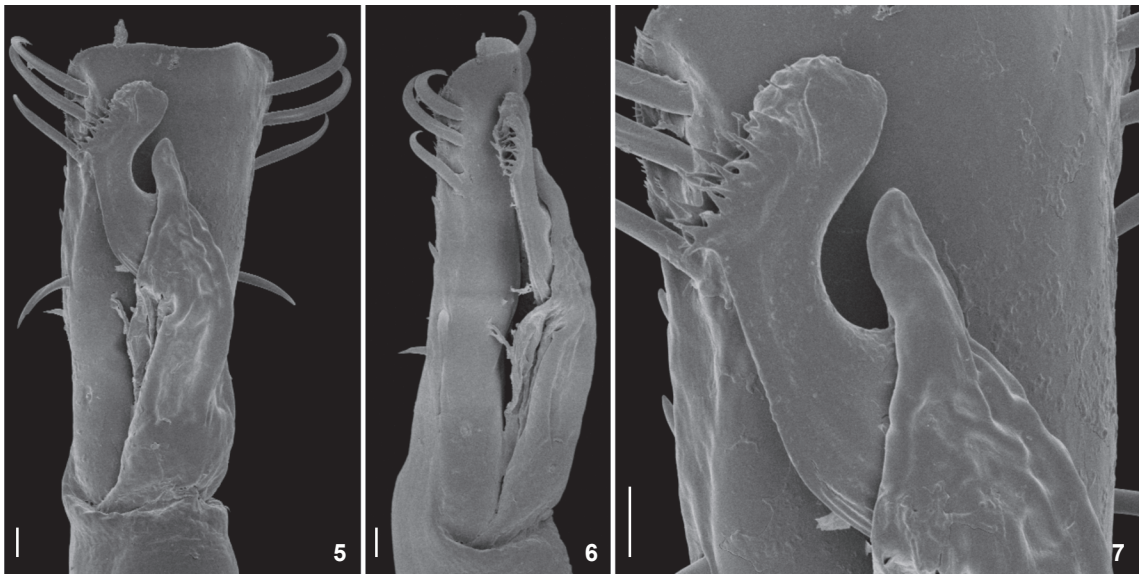
Coloration pattern in ethanol. Body brown, margins and free tergites with minute black dots. Leg I, metatarsus-tarsus I-IV yellowish-brown. Areas I and II almost entirely covered by large white patches resembling the batman symbol (but see color variation below).

Genitalia (Figs 5-7). Ventral plate subrectangular (apex 1.25X base width) and long (length 2.7X base width), apical margin straight, with three pairs of long and curved apical setae (basal 2/3 distalmost length) and one pair of median setae, two small intermediate setae between median and distal group. Glans with thumb-like dorsal process. Stylus with apex straight, bearing a ventral subapical double fringed crest surrounding genital opening.

Female (MZSP-26716). Measurements. Body length: 5.3. Maximum width of scutum (near sulcus III): 4.5. Prosoma length 2.1, width 2.9 (ocularium). Pedipalpus: 5.8. Legs: I 27.5; II 60.5; III 38; IV 50.5. No secondary sexual dimorphism observed on chelicerae size, legs and dorsal scutum armature. Anterior margin of dorsal scutum smooth, lateral margin densely tuberculate from coxa II to posterior margin. Areas much more densely tuberculate than in male (smooth only over white patches and on area III spines). Free tergites with one row of tubercles of similar size; I with 24; II with 25; III with 15 tubercles. Pedipalpal femur with ventral row of 16 tu-



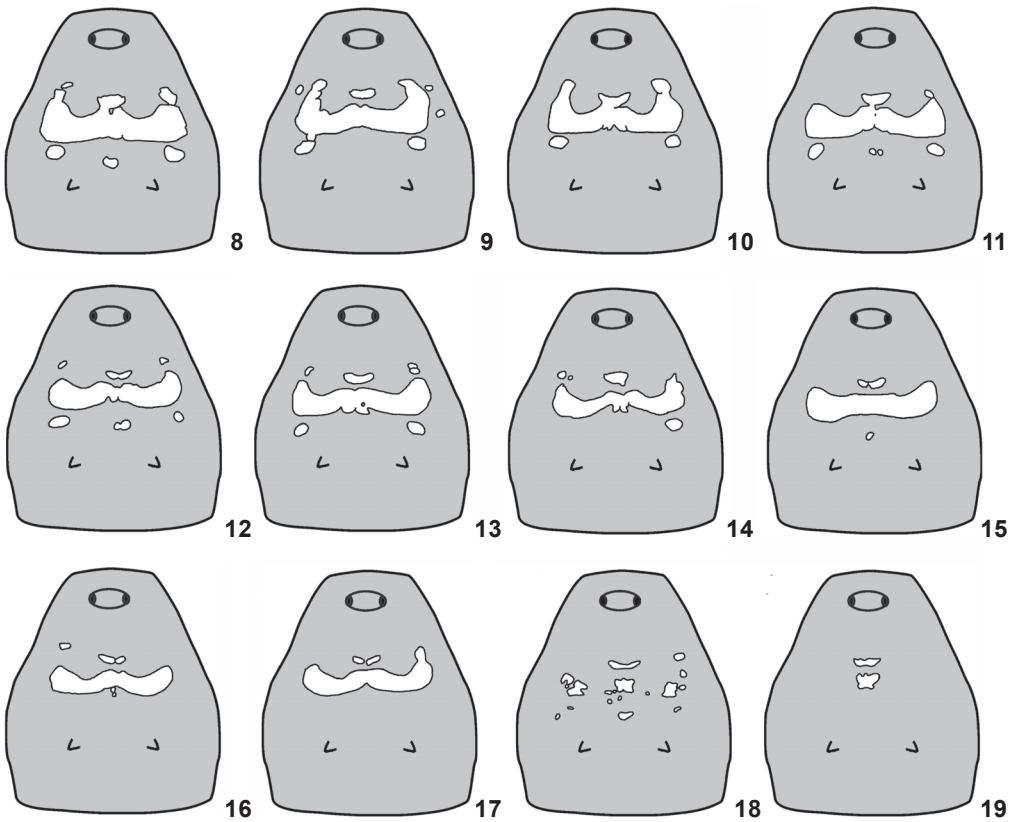
Figures 1-4. Holotype male of *Paecilaema batman* **sp. nov.**: (1) dorsal view; (2) lateral view; (3) pedipalp; (4) pedipalpal tibia and tarsus. Scale bars: 1-2 = 1 mm, 3-4 = 0.5 mm.



Figures 5-7. Penis of *Paecilaema batman* **sp. nov.**: (5) dorsal view; (6) lateral view; (7) detail of glans. Scale bar = 0.02 mm.

bercles, 1 prolateral apical tubercle. Cheliceral finger II with 5 tooth, basal much larger; III with 9 tooth very close to each other. Femur IV 3.3 times longer than dorsal scutum length. Tarsal formula: 7 (3), 16 (3), 9, 10.

Type material. Brazil, *Goiás*: São Domingos (Gruta São Mateus-Imbira III), 06.VII.1988, F.H.G. Rodrigues *leg.*, holotype male, paratype male (MHNCI-6554). Paratypes: (Caverna São Vicente I), 28.VII.1988, 2 females (MHNCI-6445); (Caverna São



Figures 8-19. Variation on pattern of color paches on mesotergal region observed in twelve specimens of *Paecilaema batman* **sp. nov.**: (8) MZSP-19194; (9) MZSP-21660; (10) MZSP-6445; (11) MHNCI-6445; (12) MZSP-19193; (13) MZSP-19195; (14) MZSP-19191; (15) MZSP-17446; (16) MZSP-19197; (17) MZSP-26716; (18) MZSP-19188; (19) MZSP-19197.

Vicente II), 11.V.2001, M.E. Bichuette *leg.*, 2 males (MNRJ 07651) (Lapa da Angélica), 10.V.2001, A. Chagas Jr *leg.*, 2 males (MNRJ 07652); same locality; 07.V.2001, A. Chagas Jr *leg.*, 2 males and 1 female (MNRJ 07653), same locality, 13.VII.1994, L.Horta & R.Moura *leg.*, 2 males (MZSP-17446); same locality, C.A. Rheims *leg.*, 1 male, 2 females (MZSP-19197); same locality, F.P. Franco *leg.*, male (MZSP-19190); same locality, 20.V.1999, F.C.Lima *leg.*, 1 female (MZSP-26716); 25.V.1999, E. Trajano *leg.*, 1 male and 1 female (MZSP-26715); same locality, 2 males (MZSP-19188); same locality, F.P.Franco *leg.*, 6.IX.2000, 3 females (MZSP-19193); (Lapa do Bezerra), 7.IX.2000, C.A.Rheims *leg.*, 1 male (MZSP-19195); same locality, F.P.Franco *leg.*, 1 female (MZSP-19191); (Gruta São Bernardo III), 29.VII.1997, L. Horta *leg.*, 1 female (MZSP-21660); (Lapa do Passa Três), 5.IX.2000, C.A. Rheims *leg.*, female (MZSP-19197); same data, 1 female (MZSP-19194).

Distribution and habitat. This species was recorded in seven limestone caves of the Parque Estadual Terra Ronca, state of Goiás, Brazil (Fig. 20). The immatures and adults are mainly found near entrances but can be found also in the aphotic zone. *Paecilaema batman* **sp. nov.** does not have any troglomorphisms recorded for cave-restricted opilionids, such as elongated appendages, depigmentation or reduction/absence of eyes, and one population was also observed outside caves, thus being considered troglophile (M.E. Bichuette, pers. com.). Cosmetids were recorded in some caves (Pinto-da-Rocha 1995, Kury 2003) in Central-Northern South America to Mexico. In Brazil, the dominant groups of harvestmen are members of the family Gonyleptidae (see Pinto-da-Rocha 1995). However, the apparent few numbers of cosmetid records in caves is mainly related to the existence of large numbers of caves and few biospeologists in southeastern Brazil, where most of gonyleptid diversity is recorded.

Etymology. In reference to the white pattern of color patches on dorsal scutum that lead speleologists to name this harvestmen after the famous superhero of comic books and movies.

Remarks on instrapecific variation. The study of a moderate sample (28 specimens) from different places shows that this species exhibits remarkable variation of color patches. The pattern of white patches varies from two small patches on area I (Fig. 19), to several small white patches (Fig. 18), and specimens with white stripe on area I and few small patches (Figs 8-

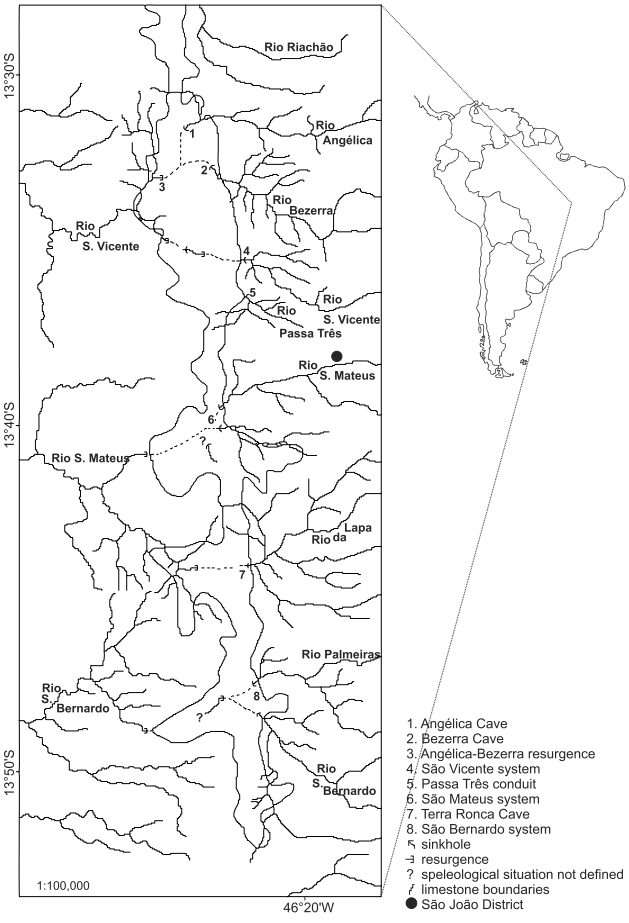


Figure 20. Map of distribution of *Paecilama batman* **sp. nov.** in the state of Goiás, Brazil.

17). The white stripe can be narrow (Figs 14, 16, and 17) to wide (Figs 8-11), and the number of small patches is quite variable, from two (Fig. 17) to nine (Fig. 12). The white small patches sometimes are fused with the wide stripe. The observed variation does not seem to be related to geographic distribution, since the best sampled cave (Angélica) harbors the largest variation (Figs 12, 14, 15, 16, and 18). Specimens from other poorly sampled caves show variation as well, such as those from São Bernardo (Figs 9 and 17) and São Vicente (Figs 10 and 11). This impressive variation of pattern of color patches calls attention to the systematics of the family Cosmetidae, which gives great importance to the white color pattern to distinguish species within a genus. Variation was also observed in other features, such as penis (n = 10) and tarsal segment counts (n = 22 individuals). There was no variation in the number of lateral setae of penises, and the position of the basalmost seta is a little more ventral in two specimens; stylus are slightly shorter and wider in some specimens and distal border of ventral plate can be straight or very slightly concave. The observed genital variation is of no systematic importance. Tarsal counts are variable, even within the same specimen: tarsus I from 7 to 8 segments (only one specimen); tarsus III, two individuals with 10 in both legs and all others with 9); and less variable on IV (10 segments in 14 specimens and 11 in one; 10-11 in five and 9-10 in one specimen). The tarsus II has a remarkable variation (even in the same specimen), from 13 to 18 segments, with 15-17 being the most frequent counts (six legs each). We observed the following counts on tarsus II: one specimen (13, 15, 15-16, 15-17, 15-18), two specimens with 14-15 and 17-18; three specimens with 17; four with 16-17 and five with 16. The examination of a large series might reveal intraspecific variation, as observed for *Paecilaema batman*. The study of the variation of poorly sampled species (which is the general rule for harvestmen), such as in the case of *Paecilaema batman* **sp. nov.** could lead to the description of one specimen (Fig. 19) as a new species, one specimen (Fig. 18) as another species and maybe more specimens (Figs 8-17) as a third one. Goodnight & Goodnight (1953), who studied a large sample of *Vonones sayi* (Simon, 1879), first documented color variation in cosmetids. The intraspecifc variation they recorded ranged from a small patch only on sulcus I to a wide white stripe on sulci I and IV, a pair of stripes on sulci II-III and a median stripe from sulcus I to IV (interrupted twice). They also observed a wide color variation in *Cynorta casa* Goodnight & Goodnight, 1953 and in *Erginulus clavotibialis* (Cambridge, 1905) (Goodnight & Goodnight 1976). However, a more comprehensive study, including genitalia and external features, on the two species mentioned above, should be conducted to justify that they belong in same species. Goodnight & Goodnight (1976) based their conclusion on authority rather than proving extensive description and lists of examined material. Furthermore, they were reductionist in terms of their genera delimitations (Goodnight & Goodnight 1953), which leads us to suggest that a more detailed study on the interspecific variations of *C. casa* and *E. clavotibialis* are needed. The impressive variation of cosmetid pattern of color patches calls attention for the importance of detailed studies of broad samples and predicts that several synonymies can be expected in cosmetids, as has been observed in several other Neotropical taxa described based on small samples (usually a single specimen) (e.g., Kury 1990, Bragagnolo & Pinto-da-Rocha 2009, Ferreira & Kury 2010, Hara & Pinto-da-Rocha 2010).

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