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A classification of the penial microsetae of Gonyleptoidea (Opiliones: Laniatores)

ADRIANO B. KURY
Departamento de Invertebrados, Museu Nacional/UFRJ, Quinta da Boa Vista, São Cristóvão, 20.940-040, Rio de Janeiro - RJ – BRAZIL. E-mail: adrianok@gmail.com

The macrosetae of the ventral plate of Laniatores penis have been occasionally described and used for systematic purposes in the literature, to the point of having a whole system created for them in the recent study Of Kury & Villarreal (2015), in a paper where a phylogenetic analysis of the subfamily Gonyleptoidea was performed. Contrastingly, the microsetae of ventral plate of Gonyleptoidea are left undescribed in descriptive works, where the penis is often illustrated without a ventral view of the ventral plate. In some works with SEM images microsetae do appear, although they remain undescribed and/or unacknowledged (*e.g.*, Townsend *et al.*, 2010 figs 8–10; Coronato-Ribeiro & Pinto-da-Rocha 2015, where microsetae are visible in photos, but only barely mentioned). In the case of line drawings, exceptionally a few microsetae are shown mainly in the lateral view of the penis ventral plate (Acosta 2001, figs 17–21; Weber 1988, fig 6b). Exceptions to this treatment are Kury (2012: 41, figs 14–15) in which besides microsetae are illustrated their distribution pattern is described and Kury (2014), where even a subgroup of Gonyleptoidea was created and named—Microsetata—for species possessing a mat of microsetae on the ventral surface of ventral plate. Furthermore, among the characters used for the analysis in Kury & Villarreal (2015), the authors listed one containing five types of microsetae, which were not explained. Here, these types and their topology are described to make up for that omission.

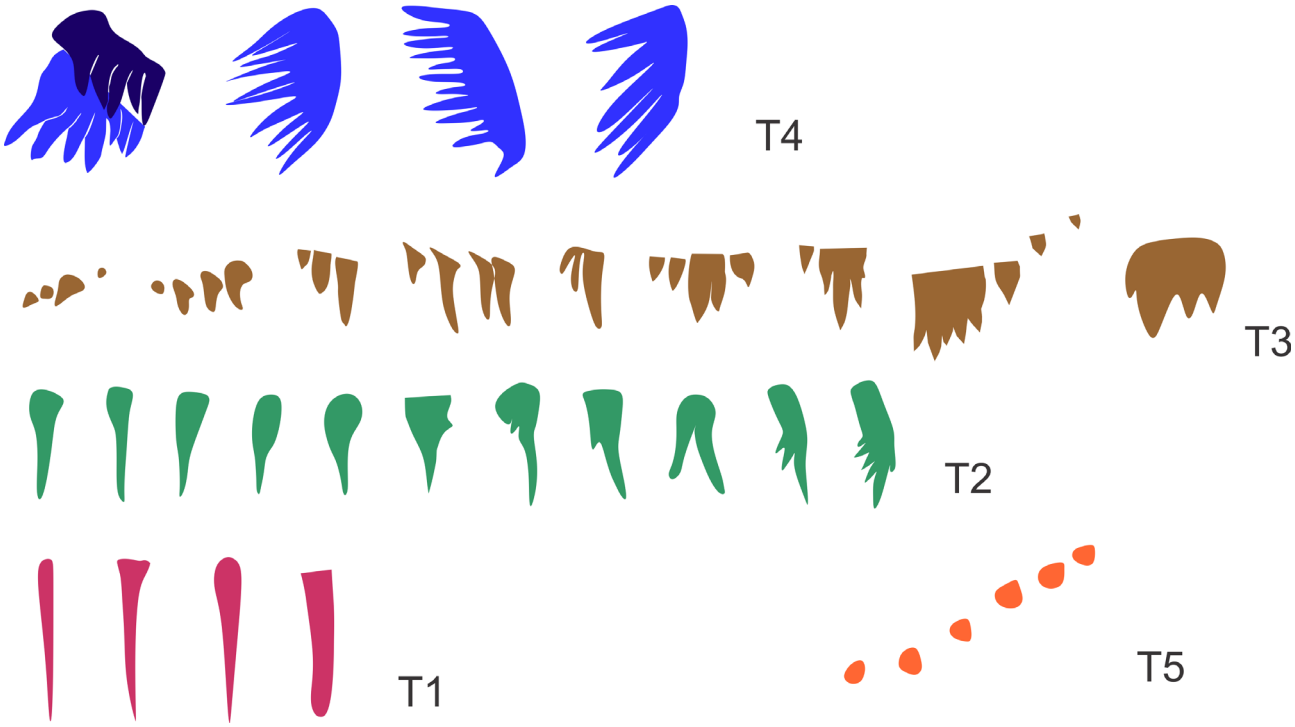

FIGURE 1. Examples of microsetae of penis ventral plate in Gonyleptoidea, illustrating the system of five categories proposed here: T1: type 1, simple, acuminate, tapering; T2: type 2, simple, laminar proximally and thinner distally; T3: type 3, bifid to multiple, short, common base may be reduced or absent; T4: type 4, multiple, superimposed on one another, mostly elongate, common base always present; T5: type 5, very short, always grouped in rows of 5 to 6 setae.

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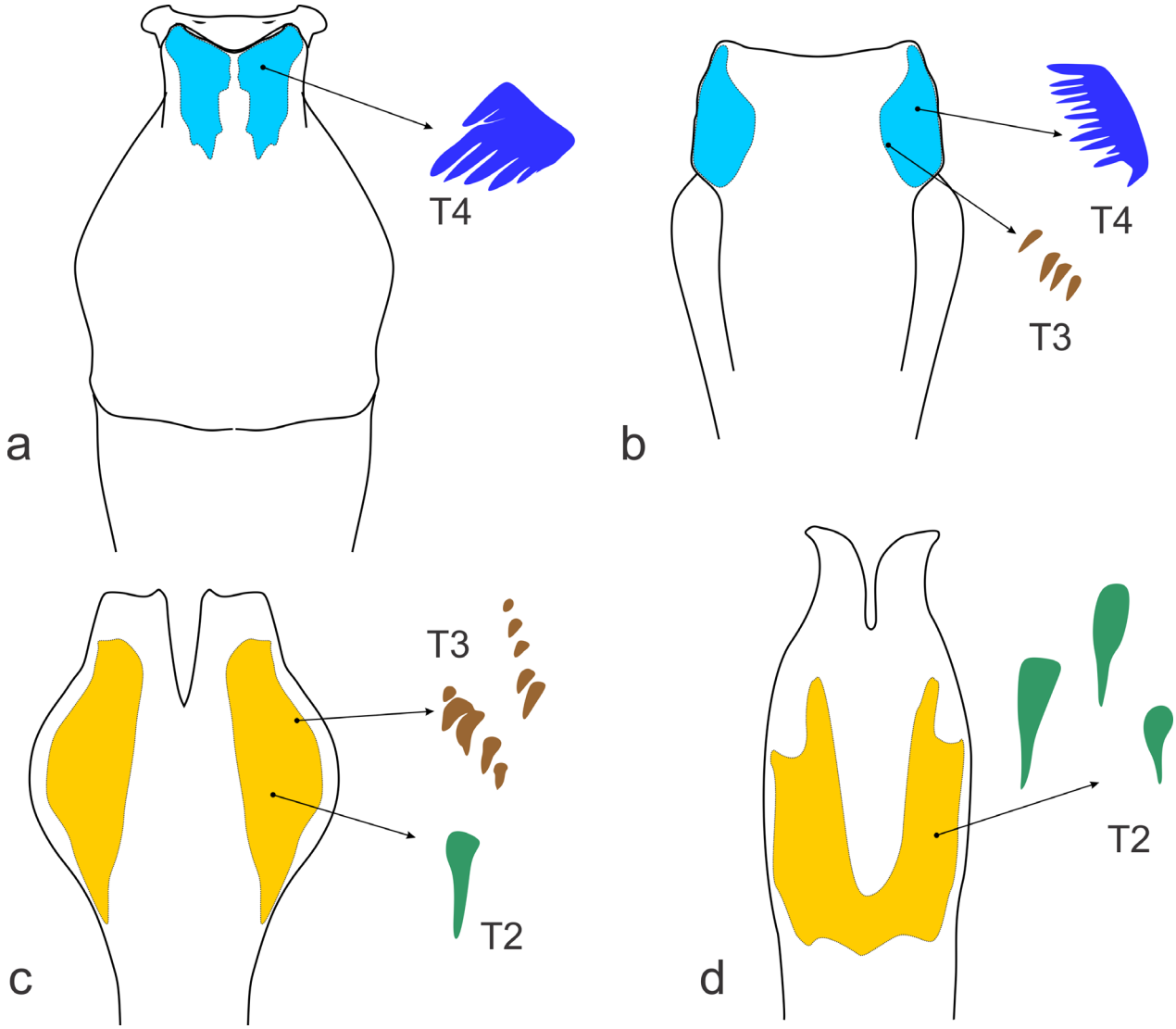

FIGURE 2. Distribution of microsetae on the ventral surface of penis ventral plate in Stygnidae (a), Nomoclastidae (b) and Ampycinae (c, d,): a. *Ricstygnus quineti* Kury, 2009, male holotype (MNRJ 2112); b. *Acaime machadoi* Villarreal et al., 2016, (MNRJ 2464); c. *Nesopachylus monoceros* Chamberlin, 1925 (AMNH AK 19); d. *Neopachyloides* sp. (FMNH AK 84).

Illustrations of patches of microsetae and microsetae themselves were made by vectoring upon SEM images, and while it is important to see how microsetae look, how they are arranged, in actual specimens, the cursory format of this note dictates that literature citations perform this illustrative task. Abbreviations of the repositories cited are: AMNH (American Museum of Natural History, Entomology, New York, USA); CAS (California Academy of Sciences, Entomology, San Francisco, USA); FMNH (Field Museum of Natural History, Chicago, USA); ICN AO (Universidad Nacional, Instituto de Ciencias Naturales, Bogotá, Colombia); MCZ (Museum of Comparative Zoology, Harvard University, Cambridge, USA); MNRJ-HS (Private Collection Helia Soares, presently in MNRJ), MNRJ (Museu Nacional, Rio de Janeiro); MUSM (Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru).

Microsetal fields: The distribution of microsetae may be interpreted as including two fields (Figs 2–5) on the ventral surface of ventral plate of penis: (1) the lateral or corner fields (depicted in blue in the schemes), which consist in a pair of latero-distal patches formed by microsetae T4, and which may extend proximally, but without ever joining each other in the middle, and (2) the midfield (depicted in yellow in the schemes), which is mostly a single field in the middle part of the ventral plate (VP), formed by the other four types of microsetae, and which may be expanded to cover almost all VP or conversely may be reduced or even split. The definition of the midfield could be challenged for example in Figs 4 b-c-d where it is divided into two lateral stripes that could also be interpreted as extensions of the corner fields.

Microsetae types: As for the individual microsetae, there is arguably a continuum among their shapes. However, for the sake of easy reference, they are here arranged into five types (Fig. 1).

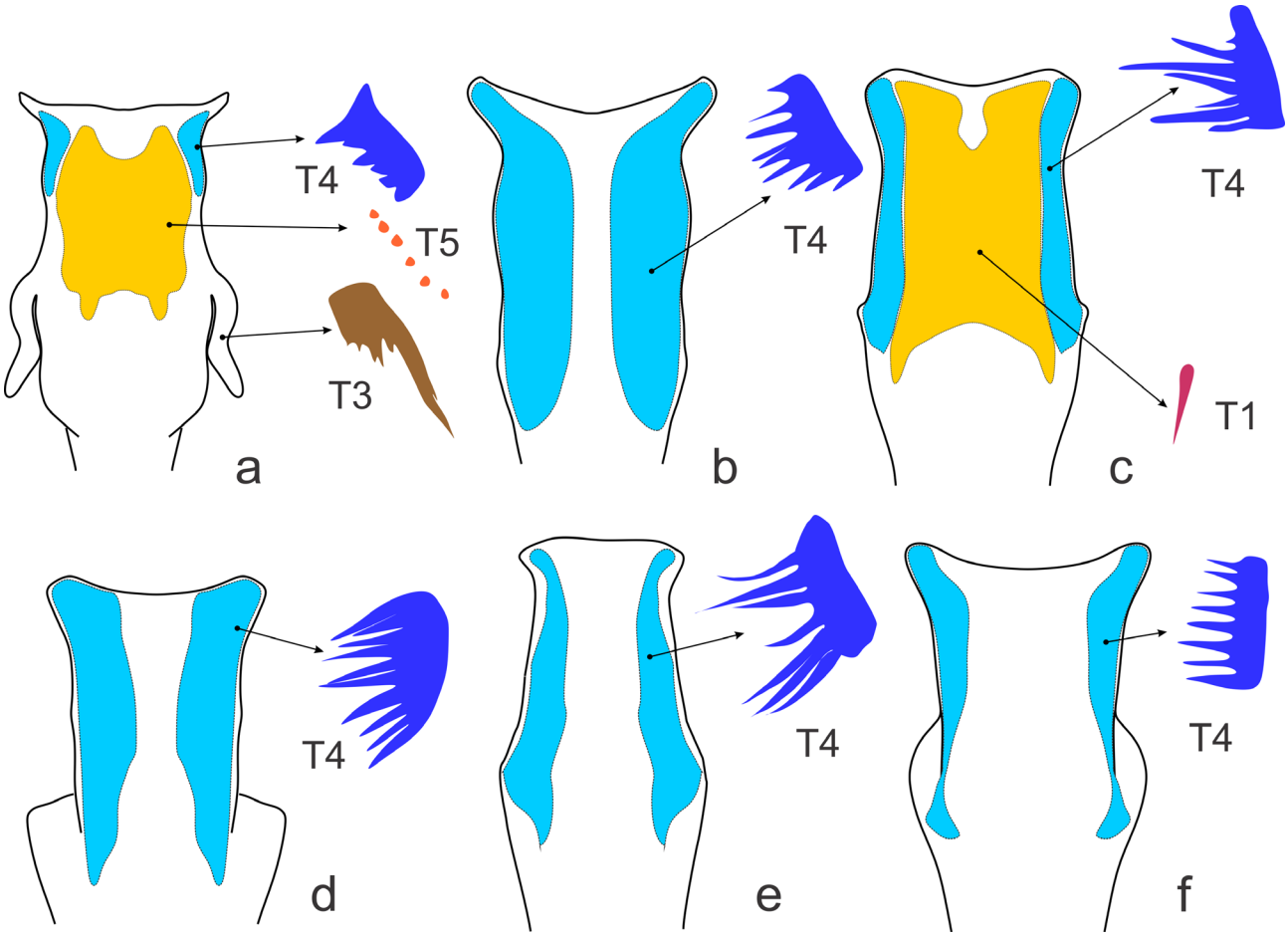

FIGURE 3. Distribution of microsetae on the ventral surface of penis ventral plate in Metasarcidae (a) and Cosmetidae (b-f): a. *Incasarcus dianae* Kury & Maury, 1998, male holotype (MUSM 410); b: *Rhaucus vulneratus* Simon, 1879 (ICN AO 437); c. *Cynorta conspersa* (Perty, 1833) (MNRJ 4560); d. *Taito juruensis* (Mello-Leitão 1923) (MNRJ 2288); e. *Gryne perlata* Mello-Leitão, 1936 (MNRJ 19162); f. *Eucynorta virescens* Mello-Leitão, 1942 (MNRJ 8500).

Type 1 (T1): simple, acuminate, and tapering. They are typical of Gonyleptidae, where they cover the midfield, in many cases spreading through all of VP. They also occur in a few species of Cosmetidae and puzzling also in Gerdesiidae (Fig. 6, here interpreted as a convergence).

Type 2 (T2): these appear to be dissociative states of the original T4, where the base is long and only one of the outer blades remaining long, while the other are much reduced.

Type 3 (T3): these appear to be dissociative states of the original T4, where, as opposed to T2, the base is dissolved resulting in a few independent stubs in a row. They are multiple, short, common base mostly absent. Easy to distinguish from T1 because they are always aligned.

Type 4 (T4): multiple, superimposed on one another, mostly elongate, common broad base always present. They occur only in the corner fields, and besides being the most widespread in Gonyleptoidea, they are also probably the earliest ones phylogenetically, as they may be interpreted as a synapomorphy for Stygnidae + Laminata (Fig. 6).

Type 5 (T5): these appear to be an extreme dissociation of type 3. Formed by stumps, always grouped in rows of 5 to 6. Known only from Metasarcidae.

Taxonomic distribution: Features derived from microsetae are mapped on a cladogram of the Gonyleptoidea (Fig. 6). Types and fields occur in the families of Gonyleptoidea as follows:

Agoristenidae, Cryptogeobiidae, and Stygnopsidae: absent.

Gerdesiidae: a patch probably homologous with the midfield, covered with T1.

Stygnidae: mostly absent, but in some Stygninae (Fig. 2a) there is a pair of corner fields covered with T4.

Nomoclastidae: mostly absent, but in a few species (Fig. 2b) they occur as in Stygninae, but the T4 inwards only marginally transform into T3. This could also be interpreted as a budding homolog of the midfield.

"Gonyleptidae" Ampycinae: corner fields are absent, and midfield mostly absent, but in a few species exceptionally there is a midfield, either deeply cleft (Fig. 2d) of split into two "lungs" (Fig. 2c), and covered with T2 and/or T3.

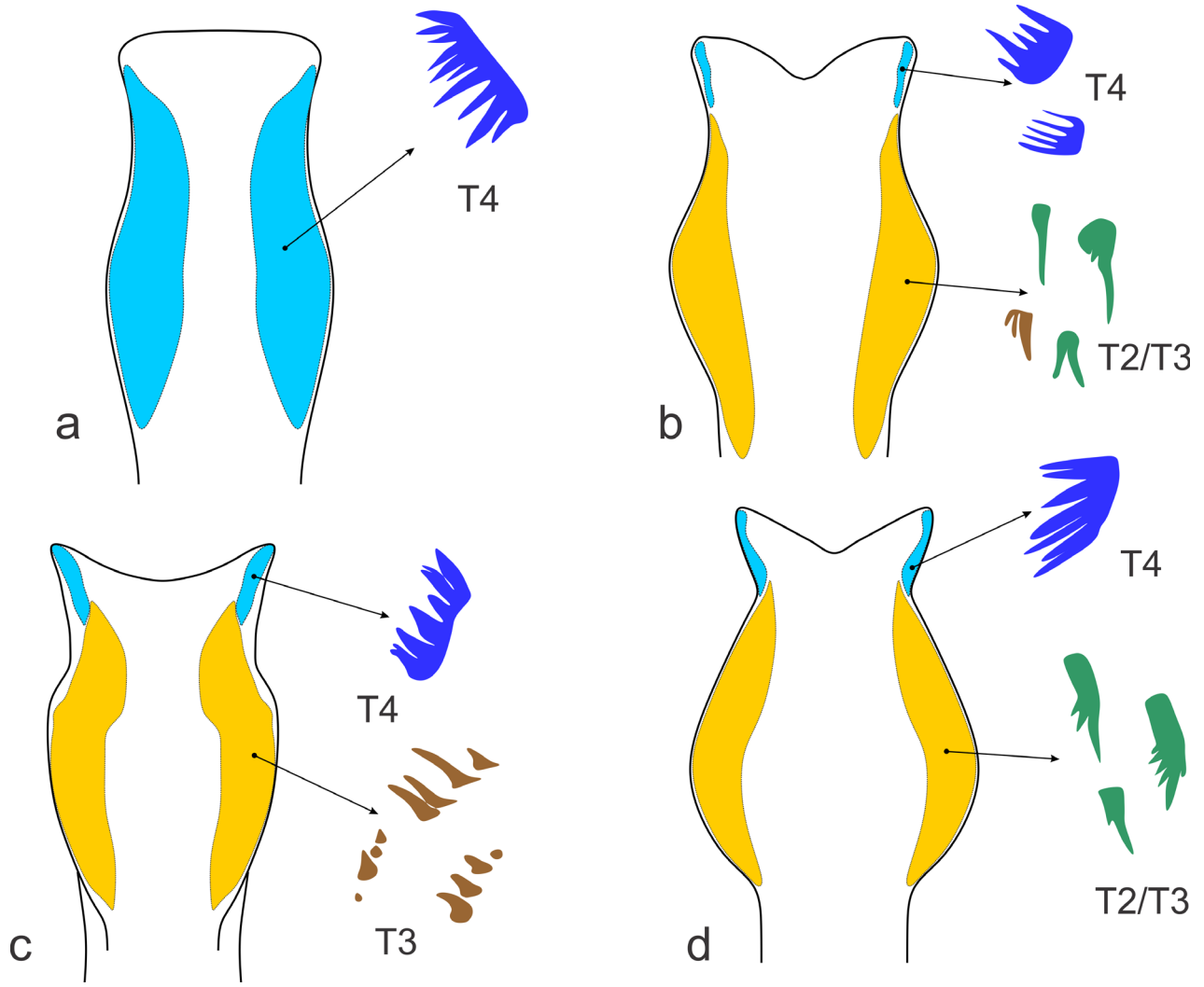

FIGURE 4. Distribution of microsetae on the ventral surface of penis ventral plate in Cranaidae: a. *Prostygnus* sp. (CAS); b. *Cranaus chlorogaster* (Gervais, 1844) (MNRJ 7634); c. *Chiriboga albituber* Roewer, 1959 (MCZ); d. *Carsevennia* sp. (AMNH AK 15).

Metasarcidae: mostly absent, but in a few species (Fig. 3a) there are two small corner field patches with T4 and a midfield covered with the strange T5. The lateral sacs are projections of ventral plate which can be homologized neither with corner fields nor with the midfield. They are covered with T3-like microsetae.

Cosmetidae: sometimes VP entirely glabrous, but mostly a pair of corner fields made of T4, extending long into proximal region (Figs 3b–f), sometimes expanding inwards but without touching each other (Fig. 3b). *Cynorta conspersa* (Perty, 1833) has exceptionally a midfield of T1 (Fig. 3c). The typical structure of microsetae in Cosmetidae as described above can also be seen in the literature (e.g., Coronato-Ribeiro & Pinto-da-Rocha 2015, figs 15, 18, 21; Ferreira & Kury 2010, figs 2, 11; Monteiro & Pinto-da-Rocha 2015, fig. 6; Townsend et al. 2010, fig. 8).

Cranaidae Prostygninae (Fig. 4a): exactly as in Cosmetidae, reinforcing the hypothesis that they are closely related to this family (O. Villarreal, pers. comm., 2015).

Cranaidae (Figs 4b–d): sometimes VP entirely glabrous, but mostly this family has a remarkable uniform pattern (except for the Prostygninae treated above). There are two small corner field patches with T4 and a "dual lung" midfield made up of T2 and/or T3. This condition is also shown in the literature (*e.g.*, Kury 2012, figs 15, 34).

Manaosbiidae (Figs 5a–b): microsetae restricted to the distal half of VP. Two small corner field patches with T4 with midfield made up of T2 and/or T3. It appears that some species lack the midfield (e.g., figs. 17, 27 and 31 in Townsend *et al.*, 2011).

Gonyleptidae (Figs. 5c–d): sometimes VP entirely glabrous, but mostly a pair of very small corner fields made of T4, and a greatly developed midfield made of T1 extending broadly over the VP. This condition is abundantly represented in the literature (*e.g.*, Pinto-da-Rocha *et al.*, 2012, figs 10b, 11b, 13b, 14b, 15b; Montemor *et al.* 2015, figs. 46, 49, 52, 55; Kury & Carvalho 2016, figs 6c–d, 7c–d).

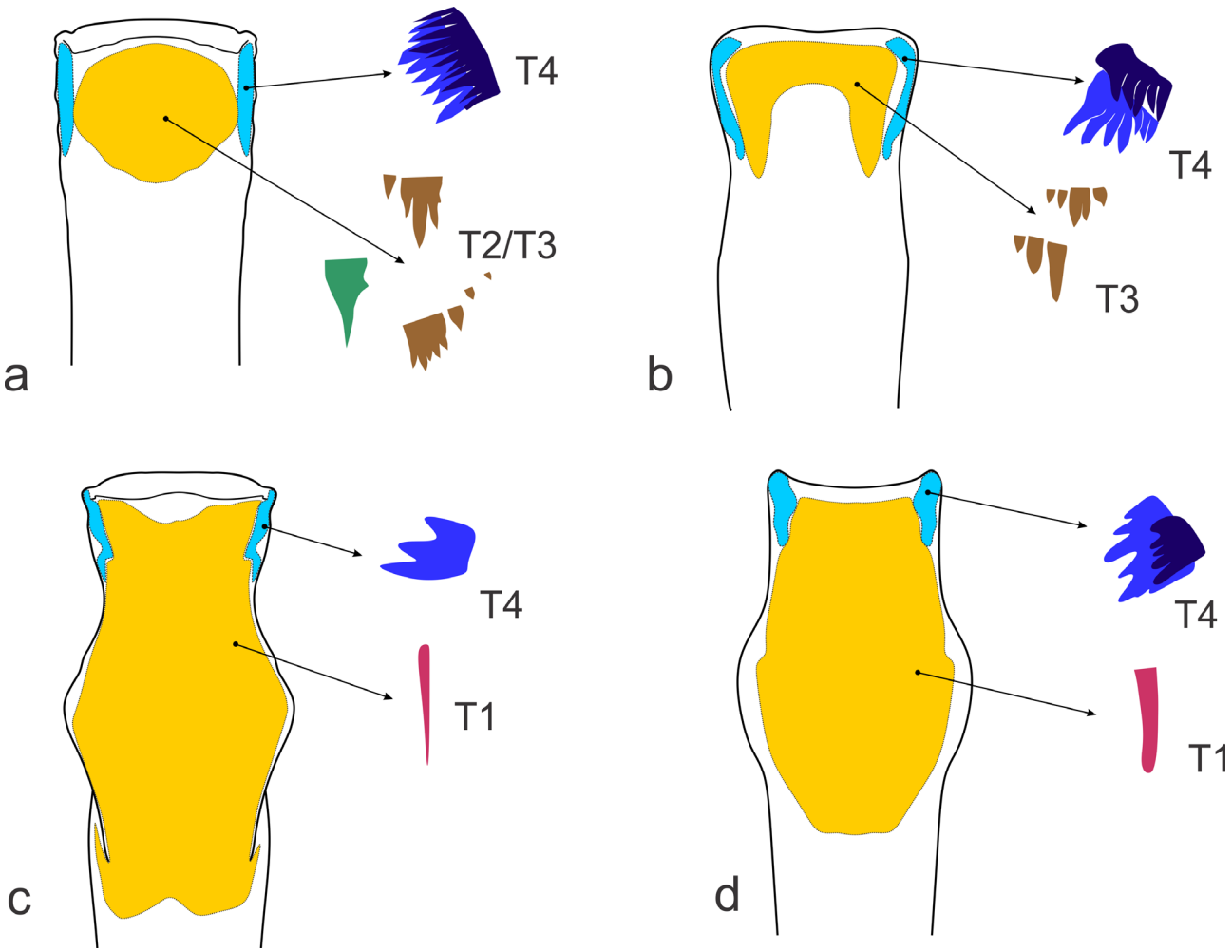

FIGURE 5. Distribution of microsetae on the ventral surface of penis ventral plate in Manaosbiidae (a-b) and Gonyleptidae (c–d): a. *Syncranaus cribrum* Roewer, 1913 (MNRJ-HS 692); b. *Rhopalocranaus bordoni* Šilhavý, 1979 (MNRJ); c. *Discocyrtus crenulatus* Roewer, 1913 (MNRJ 5380); d. *Camposicola sanctateresae* (Soares & Soares, 1946) (MNRJ 19366).

Conclusions: Characters provided by the study of ventral plate microsetae are surprisingly useful to define larger groups in Gonyleptoidea, although there is some noise generated by the glabrous ventral plate of many species. Images from the literature are of limited use because of the poor resolution with which SEM photographs are generally printed. Based on what is known about the phylogeny of the superfamily, it appears that there have been many independent losses of the microsetae: The T4 microsetae forming the lateral fields appear as a synapomorphy uniting Stygnidae + Laminata (Fig. 6, char. 1), being lost later in Ampycinae (char. R1) and many small groups nested inside the families. The elongate corner fields also appear as a possible synapomorphy uniting Prostygninae to the Cosmetidae (Fig. 6, char. 2). The midfield assumes different configurations, but it appears to be a synapomorphy for the Microsetata (Fig. 6, char. 3). The pair of "lungs" formed by T2/T3 appears to unite Ampycinae with Cranaidae, and might be useful to diagnose "true" cranaids (because there have been many extraneous species included in this family). The entire (as opposed to a pair of "lungs") midfield of T2/T3 restricted to the distal part of VP could be synapomorphic for the Manaosbiidae (Fig. 6, char. 5), pending on further investigation of this family. The greatly developed midfield of T1 could be a synapomorphy of the Gonyleptidae (Fig. 6, char. 4), another family which along its history came to include many spurious species. But it also appears strangely in Gerdesiidae.

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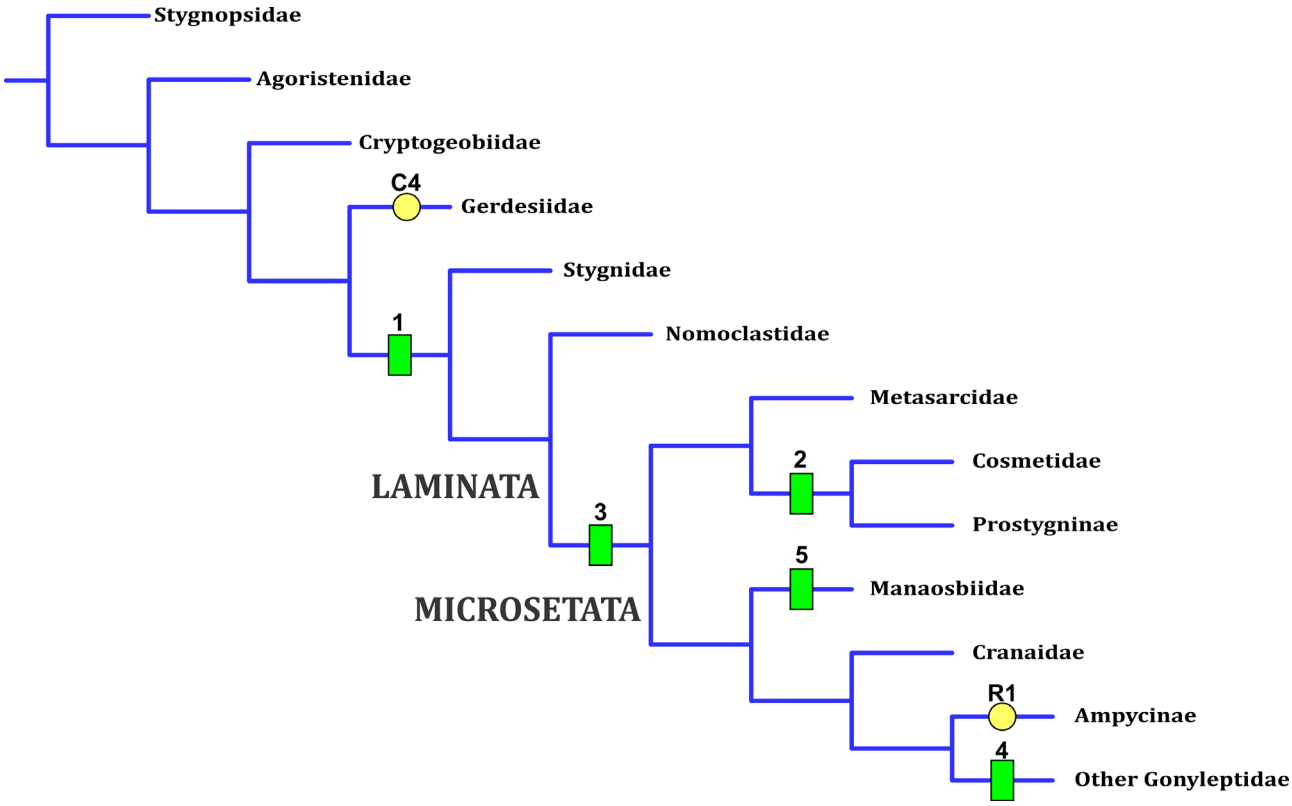

FIGURE 6. Characters from microsetae mapped (simplified) on a phylogeny of Gonyleptoidea (based on Kury & Villarreal, 2015 with the addition of Prostygninae according to Villarreal pers. comm.). Green rectangles are synapomorphic gains, yellow circles are homoplastic convergences (C) or reversals (R). Character states are: (1) presence of latero-distal fields of T4; (2) lateral fields greatly extended to proximal; (3) midfield of limited extension, entire or paired lungs, formed by T2, T3 or T5; (4) entire midfield greatly extended on VP, formed by T1; (5) midfield restricted to distal part of ventral plate.

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