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Review of terminology for the outline of dorsal scutum in Laniatores (Arachnida, Opiliones)

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In many Opiliones (notably the Laniatores) the five most anterior opisthosomal tergites are fused with the carapace forming the so called **dorsal scutum** (DS) (Latreille 1804; Simon 1879; Hadži 1942) with a highly variable shape arising from multiple factors, such as differential development of musculature (especially of coxa IV), internal organs and influence of appendages (Loman 1903; Winkler 1957). The different degrees of fusion of the tergites were first studied by Hadži (1942), who proposed a terminology for them. This terminology was adopted and enhanced by Kratochvíl (1958) and Martens (1978). A shield formed by the fusion of the carapace with abdominal tergites I to V is called **scutum magnum** (Hadži 1942). The shield formed by the fusion of carapace with abdominal tergites I to VII is called **scutum complexum** (Kratochvíl 1958) and occurs in the males of Heteropachylinae Kury, 1994 (Kury 1994) and Paralolidae Kratochvíl, 1958 (Kratochvíl 1958). Finally, the **scutum completum** (Hadži 1942) is formed by the complete fusion of the carapace and abdominal scutum, formed by tergites I to VIII, and occurs in the Sandokanidae (Martens 1978). In this paper we focus on the different forms of the scutum magnum.

The plasticity of the DS outline has been ignored as a source of morphological characters by almost all authors. Ringuelet (1959) commented briefly on the differences of shapes of the DS in Gagrellinae, Triaenonychidae and Gonyleptidae. However, scutal shapes have only been abundantly illustrated for the Cryptogeobiidae by Kury (2014), who first used them as character states in a cladistic analysis. This richness of DS shapes is also known for Cosmetidae (Kury *et al.* 2007) and other Gonyleptoidea (Kury & Villarreal 2015).

Kury *et al.* (2007) proposed four categories to summarize the diversity of DS in Cosmetidae. These categories have been mentioned by Townsend *et al.* (2010) regarding the difficulty to match with some Central-American species and by Pinto-da-Rocha & Hara (2011) regarding the sexual dimorphism in *Platygyndes* Roewer, 1943 (Cosmetidae). More recently, Rodriguez *et al.* (2014) included shapes alpha, beta and gamma in a table of DS outline for cosmetids, highlighting sexual dimorphism. We propose here an expansion of the Greek alphabet terminology for the shapes of DS in Laniatores (started by Kury *et al.* 2007), in an attempt to refine, stabilize and enhance the usefulness of this terminology. In addition, we aim to improve the original diagnoses to help in the recognition of the proposed categories.

The scutum magnum of Laniatores may be conveniently divided into three sections, from anterior to posterior: carapace, mid-bulge and coda (Fig. 1). Carapace (Roewer 1923: 4) is the prosomal part of the DS. Mid-bulge (Kury 2014) is the mid-section of the scutum defined by the more or less convex sides and separated from the other two sections by an anterior and a posterior constriction. Coda (Kury 2012: 32) is the part of the DS posterior to the second constriction. Refining the terminology for the outline of the DS in Laniatores may alleviate the shortcomings pointed out below and help to describe the diversity of the group.

Because of the above mentioned difficulties in ascribing individual shapes to the categories in the nicknames system, we here try to improve it: (1) Systems of categorical units typically have space for additional categories, derived from refined knowledge. Indeed, the original 4-category set of DS shapes in Cosmetidae had to be expanded in order to be inclusive of forms observed in Cryptogeobiidae (see Kury 2014) and Gonyleptoidea (see Kury & Villarreal 2015). (2) Sexual dimorphism in the shape of the DS has been described and discussed in Kury & Barros (2014), who created an additional category, βL, for the extremely elongate males of some species of *Taito*, while the females exhibited the normal β pattern. Males and females belonging to different categories is not *per se* a flaw in the system—it only demonstrates one more facet of the kaleidoscopic aspects of sexual dimorphism in Opiliones. So it is possible to have a female β and the male βL, or, as occurs in many cosmetids, a male β and a female α. (3) A morphometric geometric analysis would be the most effective way to interpret this variation, but that would demand a huge effort to measure hundreds of specimens. We think that the use of easy to detect categories, even in the field, or at least unaided by special

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techniques for routine lab identification is highly desirable. The codes for the DS outlines are not necessarily intended to infer relationships, but only as a convenient naming system for familiar shapes as previously used *e.g.*, in Kury (2014). These categories are illustrated in Figs. 1 and 2 and are explained below. Note that some of the categories have a "fat" and a "narrow" version which are illustrated independently but described as a single form.

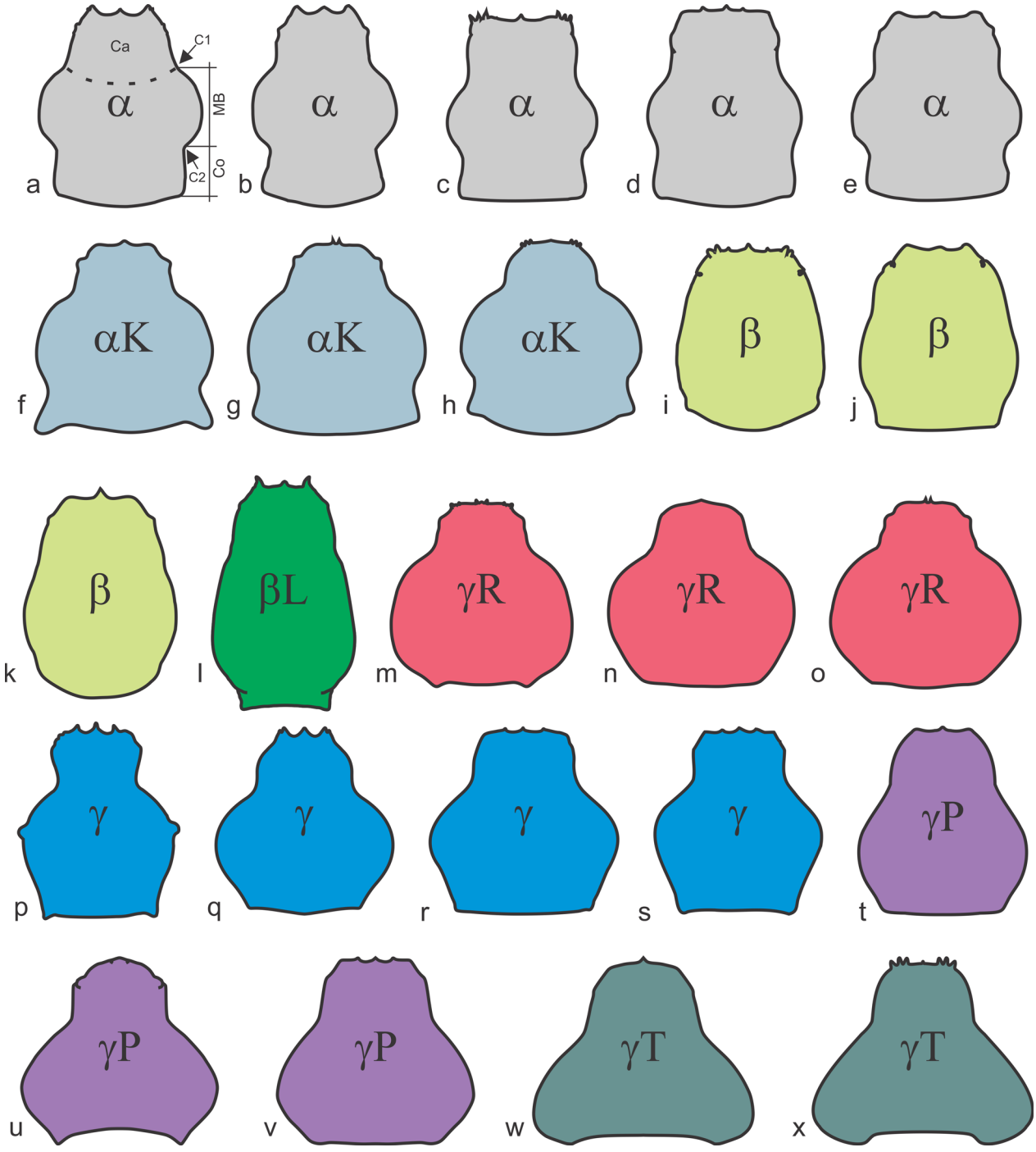

FIGURE 1. Assorted Laniatores. Outline of dorsal scutum in dorsal view, schematic, not to scale: a. Cosmetidae *Ambatoiella* (α); b. Cosmetidae *Caracarana* (α); c. Tricommatinae *Caramaschia* (α); d. Tricommatinae *Tricommatus* (α); e. Cosmetidae *Rhaucus* (α); f. Gonyleptinae *Ypsilonurus* female (αK); g. Gonyleptinae *Inhuma* female (αK); h. Gonyleptinae *Parapachyloides*, female (αK); i. Nomoclastidae *Quindina* (β); j. Cosmetidae *Cynorta* (β); k. Manaosbiidae *Syncranaus* (β); l. Cosmetidae *Taito* (βL); m. Gonyleptinae *Ypsilonurus*, male (γR); n. Gonyleptinae *Parapachyloides*, male (γR); o. Gonyleptinae *Inhuma* male (γR); p. Stygnopsidae *Karos* (γ); q. Cosmetidae *Metalibitia* (γ); r. Pachylinae *Soaresia* (γ); s. Cryptogeobiidae *Cryptogeobius* (γ); t. Pachylinae *Eusarcus* (γ); u. Gonyleptinae *Gonyleptes* (γP); v. Gonyleptinae *Acanthogonyleptes* (γP); w. Caelopyginae *Caelopygus* (γT); x. Progonyleptoidellinae *Deltaspidium* (γT). Abbreviations: C1, constriction 1; C2, constriction 2; Ca, carapace; Co, coda; MB, mid-bulge.

Alpha (α) Kury et al. 2007 (Figs. 1a–e). Also called "alpha classic" (Kury 2014, char. 1, state 0). Constrictions 1 and 2 well-marked. Mid-bulge symmetrical, centered around mid-DS, about one third of scutum length. Coda long or moderately long (as long as mid-bulge), with subparallel sides or only slightly divergent. Carapace narrower than mid-bulge, subparallel, gently convex or widening posteriorly. Posterior border of scutum moderately convex, narrower than mid-bulge. Occurs in some Cosmetidae and Gonyleptidae. Original description: "scutum subrectangular with laterals convex, forming two well-marked constrictions". Examples: Cosmetidae *Ambatoiella*, *Caracarana* and *Rhaucus*; Gonyleptidae Tricommatinae *Caramaschia* and *Tricommatus*.

Alpha-keyhole (αK) new name (Figs. 1f–h). Constrictions 1 and 2 well-marked. Mid-bulge symmetrical, located at mid-DS, about half-length of scutum. Coda long or moderately long, with flaring sides. Carapace narrower than mid-bulge. Posterior border of scutum convex, as wide as mid-bulge. This condition occurs in females of a group of genera of Gonyleptinae. Examples: *Ypsilonurus*, *Inhuma* and *Parapachyloides*.

Beta (β) Kury et al. 2007 (Figs. 1i–k). Constrictions 1 and 2 very attenuated. Mid-bulge fairly symmetrical, about 1/2 of scutum length, located at posterior quarter of DS. Coda short. Carapace narrower than mid-bulge. Posterior border of scutum straight or moderately convex, narrower than mid-bulge. Examples: Cosmetidae *Cosmetus*, *Cynorta*, *Flirtea*, *Metavononoides*, *Paecilaema*, *Taito* (females), *Vonones*; Nomoclastidae *Quindina*, *Zygopachylus*; Manaosbiidae *Saramacia*, *Syncranaus*; many Assamiidae.

Beta elongate (βL) Kury & Barros 2014 (Fig. 1l). This is a variation of the classical beta type in which the DS is extremely elongate and the mid-bulge is strongly asymmetrical. This condition is known to occur in males of some species of the genus *Taito* of cosmetids.

Gamma (γ) Kury et al. 2007 (Figs. 1p–s). Constriction 1 strongly marked, 2 non-existent. Carapace with subparallel sides. Mid-bulge slightly asymmetrical, located at mid DS, with convergent sides. Coda undefined, coalescing with mid-bulge. Posterior border straight, narrower than mid-bulge. This condition occurs in many Cosmetidae, Gonyleptidae and some Cryptogeobiidae. Examples: Cosmetidae *Metalibitia*: Pachylinae *Soaresia* and Cryptogeobiidae *Cryptogeobius*.

Gamma pyriform (γP) new name (Figs. 1t–v). This is a variation of the classical gamma type in which the mid-bulge is slightly asymmetrical and displaced posteriorly, the coda is totally lost and the posterior border of the DS may be concave. This condition occurs in many Gonyleptidae. Examples: Gonyleptinae *Acanthogonyleptes, Gonyleptes*; Pachylinae *Acanthopachylus*, *Discocyrtus*, *Eusarcus*; Ampycinae *Hutamaia*, *Licornus*.

Gamma rotund (γR) new name (Figs. 1m–o). This is a variation of the classical gamma type in which the mid-bulge is very long, symmetrical and rounded, engulfing the coda. This condition occurs in males of a group of genera of Gonyleptinae. Examples: Gonyleptinae *Inhuma* (male), *Parapachyloides* (male), *Ypsilonurus* (male).

Gamma triangular (γT) new name (Figs. 1w–x). This is a variation of the classical gamma type in which the mid-bulge is more asymmetrical than in γP**,** displaced more posteriorly and without coda (i.e., DS ends in the mid-bulge). The mid-bulge instead of being curved to transversal, is curved obliquely more posteriorly. Posterior border of scutum concave (which is the etymology of the generic name *Caelopygus*). This condition occurs in some genera of K92 clade, typically in Gonyleptidae Caelopyginae and Progonyleptoidellinae. Examples: *Caelopygus*, *Deltaspidium*.

Delta (δ) Kury et al. 2007 (Fig. 2a). DS essentially reduced to a circle. Constrictions 1 and 2 entirely lost. Mid-bulge and coda not defined. Posterior border of scutum straight. This condition occurs in some genera of Cosmetidae, currently in the Discosomaticinae. Examples: Discosomaticinae *Discosomaticus* and *Sibambea*.

Epsilon (ε) Kury & Villarreal 2015 (Figs. 2b–d). Called "hexagon" by Kury (2014, char. 1, state 7). Constrictions 1 and 2 lost. Mid-bulge symmetrical, greatly attenuated, located at mid DS or 3/4 length. Coda ill-defined. Posterior border of scutum straight, slightly narrower than mid-bulge. This condition occurs in Agoristenidae. Examples: *Agoristenus*, *Avima* and *Globibunus*.

Zeta (ζ) Kury & Villarreal 2015 (Figs. 2e–i). Not named, but described in Kury (2014, char. 1, state 6). Constrictions 1 and 2 well-marked but shallow. Mid-bulge soft, symmetrical, located at mid DS. Coda long or moderately long, with divergent sides. Carapace and coda as wide as mid-bulge, with anterior border wide, giving a rectangular (or subrectangular) appearance to the outline of DS. Posterior border of scutum convex, as wide as mid-bulge. This condition occurs in some Nomoclastidae, Podoctidae, Prostygninae, Stygnopsidae and Zamorinae. Examples: Stygnopsidae *Hoplobunus*; Zamorinae *Zamora*; Nomoclastidae *Liomma*; Prostygninae *Yania*; Podoctidae *Santobius*.

Eta (η) Kury & Villarreal 2015 (Figs. 2j–n). Called "trapezoid" by Kury (2014, char. 1, state 3). Constriction 1 ill-defined, and 2 absent. Mid-bulge soft, strongly asymmetrical, gradually increasing posteriorly, located at posterior third of DS. Coda absent. Carapace convex laterally, almost as wide as mid-bulge. Posterior border of scutum straight or convex. This condition occurs in most basal Laniatores. Examples: Travuniidae *Erebomaster*; Triaenonychidae *Equitius;* Synthetonychiidae *Synthetonychia*; Phalangodidae *Phalangodes* and Stygnommatidae *Stygnomma*.

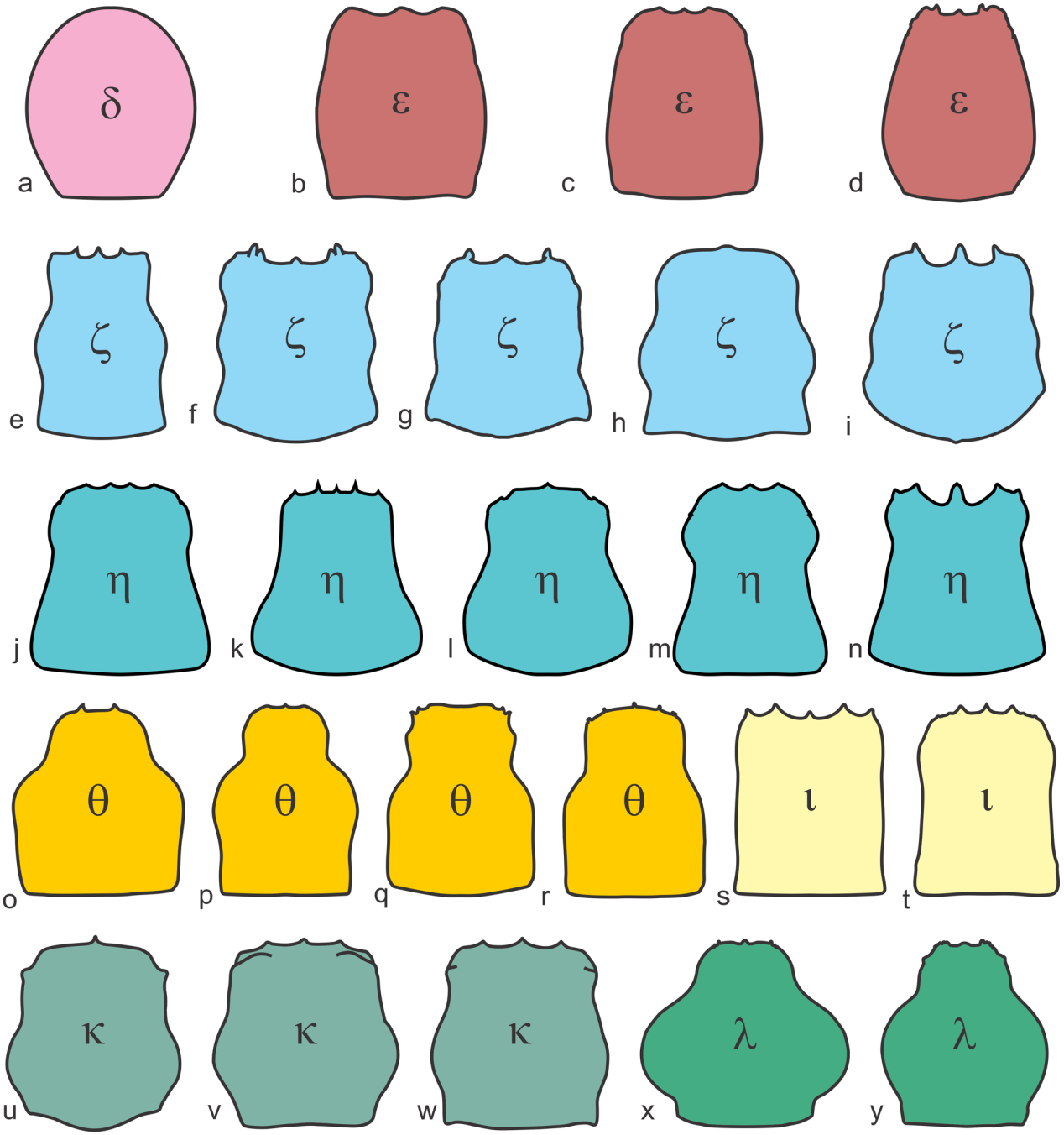

FIGURE 2. Assorted Laniatores. Outline of dorsal scutum in dorsal view, schematic, not to scale: a. Cosmetidae *Sibambea* (δ); b. Agoristenidae *Globibunus* (ε); c. Agoristenidae *Avima* (ε); d. Agoristenidae *Agoristenus* (ε); e. Stygnopsidae *Hoplobunus* (ζ); f. Zamorinae *Zamora* (ζ); g. Nomoclastidae *Liomma* (ζ); h. Prostygninae *Yania* (ζ); i. Podoctidae *Santobius* (ζ); j. Travuniidae *Erebomaster* (η); k. Triaenonychidae *Equitius* (η); l. Synthetonychiidae *Synthetonychia* (η); m. Phalangodidae *Phalangodes* (η); n. Stygnommatidae *Stygnomma* (η); o. Cryptogeobiidae *Tibangara* (θ); p. Kimulidae *Kimula* (θ); q. Escadabiidae Gen. sp. (θ); r. Icaleptidae *Icaleptes* (θ); s. Stygnidae *Protimesius* (ι); t. Epedanidae *Dibunus* (ι); u. Cranaidae *Heterocranaus* (κ); v. Prostygninae *Cutervolus* (κ); w. Prostygninae *Prostygnus* (κ); x. Ampycinae *Ampycus* (λ); y. Cosmetidae *Platygyndes* (λ).

Theta (θ) Kury & Villarreal 2015 (Figs. 2o–r). DS campaniform (bell-shaped). Constriction 1 well-marked and 2 absent. Mid-bulge soft, asymmetrical, very long, located anteriorly in DS. Coda not defined. Carapace much narrower than mid-bulge. Posterior border of scutum straight. Differs from gamma by the almost parallel sides of mid-bulge. This condition occurs in many Cryptogeobiidae, Escadabiidae, Gerdesiidae, Icaleptidae and Kimulidae. Examples: *Gerdesius*, *Icaleptes*, *Kimula*, *Taquara*, *Tibangara*.

Iota (ι) Kury & Villarreal 2015 (Figs. 2s–t). DS subrectangular. Constriction 1 and 2 almost entirely lost. No mid-bulge, no coda. Posterior border of scutum straight, as wide as carapace. This condition occurs in many Epedanidae and Stygnidae. Examples: Epedanidae *Dibunus* and Stygnidae *Protimesius*.

Kappa (κ) new name (Figs. 2u–w). Constriction 1 well-marked, 2 faint. Carapace and mid-bulge very long (each about 40% of DS length), coda short. Carapace very wide. Examples: Cranaidae *Heterocranaus*; Prostygninae *Cutervolus*; *Prostygnus*.

Lambda (λ) new name (Figs. 2x–y). Carapace narrow. Constriction 1 gentle, 2 variable. Mid-bulge symmetrical elongate (about 50% of DS length). Coda short. Appears like an intermediate between alpha and gamma conformations. Differs from alpha by the short narrow coda and long mid-bulge. Differs from gamma only by the defined coda and divergent sides of carapace. Examples: Ampycinae *Ampycus* and Cosmetidae *Platygyndes*.

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