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Comparative morphology of the type-species of *Isotes* and *Synbrotica* (Coleoptera, Chrysomelidae, Galerucinae), with a new synonymy of species

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ABSTRACT. In order to solve the affinities of the species of *Isotes* Weise, 1922, a detailed morphological comparative study was carried out based on type-species of *Isotes* and its junior synonym, *Synbrotica* Bechyné, 1956. *Isotes tetraspilota* (Baly, 1865) and *Isotes borrei* (Baly, 1889) had their morphology of mouthparts, endosternites, wings and both male and female genitalia compared by the first time. A new synonymy is established between *Isotes borrei* (Baly, 1889) and *Isotes crucigera* (Weise, 1916) syn. nov. based on external and genitalia morphology. New structures for Section Diabroticites Chapuis, 1875 are presented and discussed.

KEYWORDS. Taxonomy, Neotropical, Luperini, Diabroticites.

RESUMO. Morfologia comparada das espécies-tipo de *Isotes* e *Synbrotica* (Coleoptera, Chrysomelidae, Galerucinae), com nova sinonímia de espécies. Para resolver as afinidades das espécies de *Isotes* Weise,1922, um estudo morfológico comparado foi realizado com base nas espécies-tipo de *Isotes* e de seu sinônimo-júnior, *Synbrotica* Bechyné, 1956. *Isotes tetraspilota* (Baly, 1865) e *Isotes borrei* (Baly, 1889) tiveram a morfologia de suas peças bucais, endosternitos, asas e genitálias masculina e feminina comparadas pela primeira vez. Uma nova sinonímia é estabelecida entre *Isotes borrei* (Baly, 1889) e *Isotes crucigera* (Weise, 1916) syn. nov., com base na morfologia externa e genitália. Estruturas inéditas para a Seção Diabroticites Chapuis, 1875 são apresentadas e discutidas.

PALAVRAS-CHAVE. Taxonomia, Neotropical, Luperini, Diabroticites.

The genus *Isotes* was proposed by Weise (1922) to include a single species, *Isotes quadrimaculata* Weise, 1922 – type-species by monotypy. The distribution of the genus is Neotropical, occurring in Central and South America. Aslam (1972) studied the holotype of *Isotes quadrimaculata* Weise, 1922, established synonymy with *Synbrotica tetraspilota* (Baly, 1865), and considered *Synbrotica* Bechyné as junior synonym of *Isotes*. The synonymy was proposed in a single note, without remarks of any features that led to genera synonymy.

This fact increased a problem because a great number of species were assigned to *Synbrotica* since the genus was proposed by Bechyné (1956). Additionally, subsequent authors never provided diagnostic features for the genus. Bechyné (1956) only designated *Diabrotica borrei* Baly, 1889, from Brazil, as type-species of *Synbrotica*.

Bechyné & Bechyné (1969) provided only six diagnostic features for *Synbrotica*, but also they affirmed that the genus included many not congeneric species, forming an artificial group, and that they should be transferred. Despite this, even after the synonymy with the genus *Isotes*, none other study has been conducted to investigate this problem.

Isotes currently includes 179 species (Bechyné & Bechyné, 1970; Wilcox, 1972, 1975; Moura, 2003) and the systematic was resumed to the addition of species, redescriptions, new combinations, citations in catalogue and key to genera. None other contribution provided detailed anatomical study, except Moura (2009) that illustrated the male terminalia of *Isotes eruptiva* (Bechyné, 1955).

Since that the previous authors synonymized these genera and did not compare both type-species, the aim of this work was to perform a detailed study of the morphology of the type-species *Isotes tetraspilota* (Baly) and the type-species of *Synbrotica*, *I. borrei* (Baly), including external morphology, mouthparts, wing venation, endosternites, and female and male genitalia. In parallel, a comparative study of *Isotes borrei* (Baly) and *Isotes crucigera* (Weise) is performed by first time to determine if they should be synonymized.

Taxonomic history. *Diabrotica tetraspilota* was described by Baly (1865) based on a single male from Mexico. Later, Smith & Lawrence (1967) noticed another male from Guatemala with a Baly's label, but could not be considered a syntype because Guatemala was not originally included in the description. This species was assigned to the genus *Synbrotica* by Smith & Lawrence (1967). After that, it was considered as senior synonym of *Isotes quadrimaculata* Weise by Aslam (1972).

Diabrotica borrei was described by Baly (1889) to a female from "Tejuca" (= Tijuca, a neighborhood in city of Rio de Janeiro, Brazil), with possible paralectotypes from Petropolis, Brazil (Smith & Lawrence, 1967). Bechyné (1956) designed posteriorly as type-species of *Synbrotica.*

Another species, *Diabrotica cruciata*, was proposed by Baly (1889) in the same paper and page of *D. borrei*, based on a male from Santa Catarina (Brazil). Both species had short descriptions with a minor variation between them.

Gahan (1891a) finished the uncompleted Baly's work (1890), transcribing the descriptions for *D. borrei* and noticed that "*D. cruciata*, Baly (Ent. Mo. Mag., xxv., p. 253) is merely a variety of this species". Finally, Gahan (1891b) and Weise (1916) provided the replacement name *crucigera*, pointing out *D. cruciata* Baly as junior homonym of *D. cruciata* Jacoby, 1887.

Weise (1924) considered *D. crucigera* as an aberration of *D. borrei* in the catalogue, and Bechyné (1958) placed *D. crucigera* in the genus *Synbrotica*. Despite of the overall similarity they were treated as distinct species.

MATERIAL AND METHODS

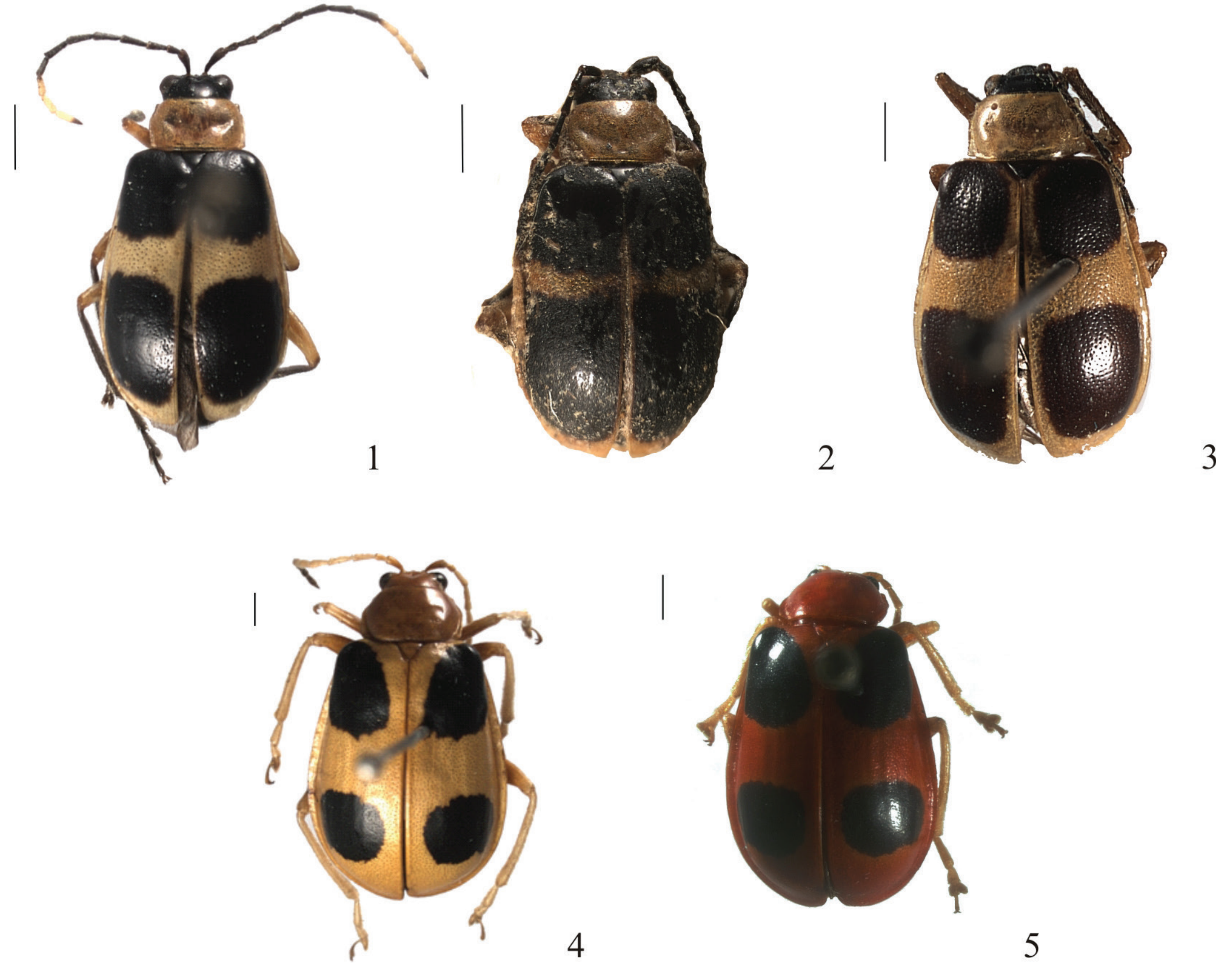
The material examined was provided by the following institutions (names of curators in parenthesis): DZRJ, Coleção José Alfredo Pinheiro Dutra, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (J. R. Mermudes); CEIOC, Coleção Entomológica do Instituto Oswaldo Cruz, Rio de Janeiro, Brazil (M. E. Felix); EMEC, Essig Museum of Entomology, University of California, Berkeley, USA (C. B. Barr); MNRJ, Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (M. L. Monné); MZSP, Museu de Zoologia, Universidade de São Paulo, São Paulo, Brasil (S. A. Casari); USNM, National Museum of Natural History, Smithsonian Institution, Washington D.C., USA (D. G. Furth); ZMHB, Museum für Naturkunde der Humboldt-Universität, Berlin, Germany (J. Frisch).

The terminology follow Moura (1998b, 2009), Konstantinov (1998), Lingafelter & Konstantinov (1999) and Cabrera & Durante (2003), except for numeration of mandibles' teeth that follow Savini & Joly (2006).

RESULTS

Morphological comparison between *Isotes borrei*, *I. crucigera* and *I. tetraspilota*

Integument, general coloration (Figs 1–5). In Galerucinae the pattern of the integument color is highly variable, often being the only feature used to separate species when lacking studies with genitalia. By other hand, the species also exhibit interspecific variation, while other



Figs 1–5. *Habitus:* 1, 2, *I. borrei* (Baly); 3, *I. crucigera* (Weise) syn. nov.; 4, 5, *I. tetraspilota* (Baly). Scale bars = 1,0 mm.

species morphologically distinct show the same color pattern. Both *I. borrei* (Figs 1–2), *I. crucigera* (Fig. 3) and *I. tetraspilota* (Figs 4–5) have elytra with integument yellow-brownish, with two large black or blue-black spots.

Head (Figs 6–11). The width across the eye is narrower than anterior margin of pronotum. Vertex convex (Figs 8, 11), with variable punctuation, and a weak depression near frontal tubercles. Antennal calli transverse and subtriangular, slightly larger than antennal cavities (Figs 6, 9). Eyes (Figs 6–11) small (by relation between the maximum eye diameter in lateral view, against the interocular distance), and well-marked orbital lines near the outer margin. Antennal cavities rounded, inserted just below the midline of the eye. Frons with frontal ridge and fronto-clypeal suture, surface variably punctate and rugose. *Isotes borrei* and *I. crucigera* exhibit elongated genal area (length subequal to half or feebly more than the maximum diameter of the eye), and front as wide as long (Figs 9–11). *Isotes tetraspilota* has genal area and front evidently wider than long (Figs 6–8).

Mouthparts. Clypeus (Figs 6, 9) narrow and subrectangular, with a row of setae (variable in number) near the basal margin. *Isotes tetraspilota* has eight setae (Fig. 6) while *I. borrei* and *I. crucigera* have six setae (Fig. 9). Both species have labrum (Figs 6, 9, 12–13) rounded at the sides, feebly notched at apex, and with a row of six submedian long setae in coarse punctate.

Mandibles (Figs 14, 15) symmetrical, subtriangular, outer margin distinctly curved, inner cutting edge with five apical teeth, with short and dense setae on the outer surface. First tooth small, attenuated at the apex; second tooth twice the length of the first; third narrowed and twice the length of the second and fourth teeth; fourth variable at apex, slightly longer than the fifth, this short and blunt; prostheca wide, with abundant setae, extending almost from the basal margin of the mandible to the first apical tooth; mola longer than wide and sculptured with rows of transverse elevations. Both species have similar shape and length of mandibles, except: 1) inner cutting edge concave in *I. tetraspilota* and distinctly straight in *I. borrei*; 2) mandibular teeth, in external view: tooth three with inner margin shaped and more projected in *I. borrei*, and inner margin with slight sinuosity and less projected in *I. tetraspilota*. While that in ventral view, it is robust and little curved in the last species and narrower and bent to the side in the first one; 3) tooth two and four, ventral view, blunt in *I. tetraspilota* and pointed in *I. borrei*; and 4) mola wider in *I. borrei* than in *I. tetraspilota.*

Savini & Joly (2006) observed that the presence or absence of mola is not an informative character for the classification when they studied the mandibles of 22 genera of Galerucinae. Thirteen of the 22 genera studied does not have mandibular mola, but when the mola exist, it is variable in the shape, can be formed by parallel blades, either toothed or fused with the body of mandible, and separated by a well-defined suture, an indication that the structure and shape of the mola could be contribute together with other characters to definition of genera or groups of genera in the subfamily. The shape of the mandible, prostheca and number of teeth of the incisive area are other valuable characters that may contribute to the classification of the group.

Maxilla (Figs 16, 17). In all species examined, the maxilla present cardo narrowed at proximal portion, wider apically, and with long setae; basistipe with long setae at the latero-external edge, and dististipe well developed with short setae at the inner margin, and short setae near the lacinia, with apical pubescence fringed and strongly dense; galea subcylindrical and slightly longer than lacinia, with long and dense setae at the apex. Maxillary palps well developed, with four palpomere, exceeding the galea by apical palpomere; palpomere one short, subrectangular, subequal as half the second; palpomere two subconical; palpomere three subcylindrical, twice longer than the apical; apically acute. Distal part of the galea twice the length of the basal, even more curve in *I. borrei* that in *I. tetraspilota*. Palpomeres clearly shorter and robust in *I. tetraspilota* and more elongated and narrower at the base in *I. borrei*.

Labium (Figs 18, 19). Labium poorly developed, with ligula membranous and not lobated. Labial palps with three palpomeres, basal short and strongly transverse; palpomere two slightly longer than the apical, subcylindrical, and slightly longer than wide; apical narrow to apex. Prementum subrectangular in both species. Ligula reaching the base of the apical palpomere in both species, but it is distinguished in the shape, apex narrowed in *I. tetraspilota*, and broadly rounded in *I. borrei*. Mentum (= postmentum Cabrera & Durante, 2003) transverse and subparallel at sides in *I. tetraspilota* and subtrapezoidal in *I. borrei*.

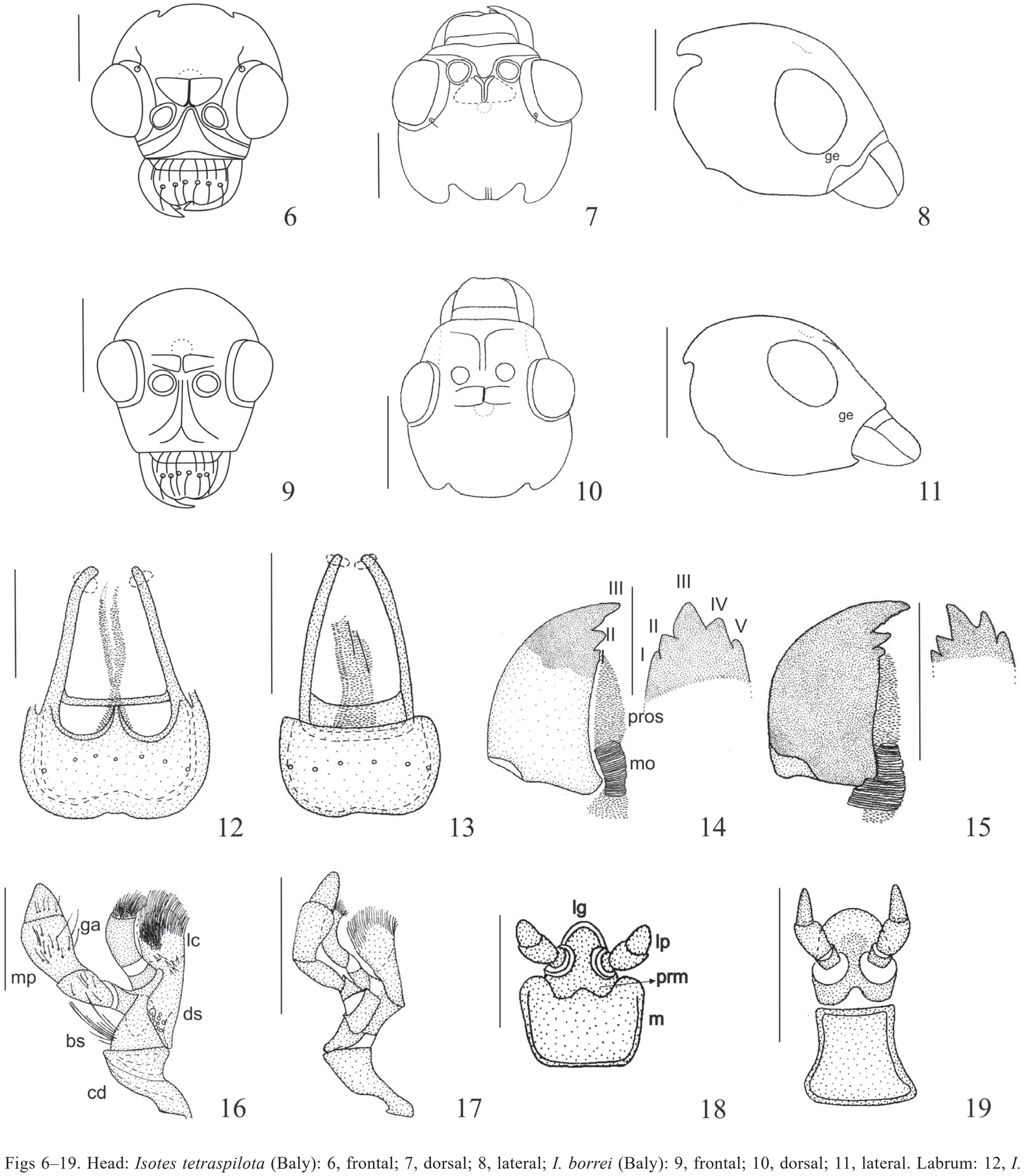
Antennae. Antennae with 11 antennomeres, exceeding the middle of elytra. Scape cylindrical, slightly thickened to apex, one third longer than the pedicel and subequal to the antennomere III; antennomere IV longer than the III; V–VI subequal in length, both slightly shorter than the IV; antennomeres VII–X lightly shorter; XI slightly longer than the X, acute at apex.

Thorax. Prothorax (Figs 20–22) wider than long and narrower than the elytral base. Pronotum (Figs 20–21) slightly convex, with variable depressions in the basal half. *Isotes borrei* exhibits well marked lateral margins, subparallel and slightly sinuous in the basal third (Fig. 21); anterior and posterior angles rounded; each angle with a long setae inserted in a coarse and deep punctuation; and other short setae between angles, unstable in number. In *I. tetraspilota* the lateral margins of pronotum is convex, slightly rounded, and wider in the middle (Fig. 20).

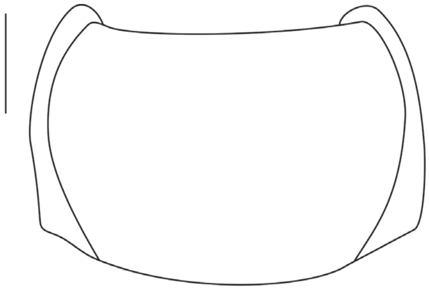
The species studied have the pronotum wider than long, but the proportion varies from 1.6 to 1.7 times wider in *I. tetraspilota* (Fig. 20), while in *I. borrei* and *I. crucigera* from 1.8 to 2.0 times (Fig. 21). The type-species *Isotes tetraspilota* has no depressions on pronotum (Fig. 20). On the other hand, *I. borrei* has a transverse depression in the posterior half (closer to the posterior margin), reaching the sides, where it is evidently deeper (Fig. 21). Prosternum (Fig. 22) transverse, with a short and laminar prosternal process between the procoxae. Procoxal cavities contiguous and opened behind. Proendosternite (Figs 23, 24) with divergent projections towards posteriorly, slightly curved in *I. tetraspilota* and linear in *I. borrei*.

Mesothorax (Figs 25, 27–28). Mesonotum with mesoscutellum elevated, subtriangular, smooth and shiny: in *I. tetraspilota* it is widely rounded, while *I. borrei* is more strongly convergent at sides. Mesosternal process subtriangular and narrowed. Mesocoxal cavities rounded, close to each other and closed at sides.

Metathorax (Figs 25, 26, 29–34). Metanotum (Figs 29, 30) transverse, wider than long in *I. borrei* and as wide as long in *I. tetraspilota*. The apodeme "d" of metanotum crossing with "c" near the middle of it, apodeme



Figs 6–19. Head: *Isotes tetraspilota* (Baly): 6, frontal; 7, dorsal; 8, lateral; *I. borrei* (Baly): 9, frontal; 10, dorsal; 11, lateral. Labrum: 12, *I. tetraspilota*; 13, *I. borrei*. Mandible: 14, *I. tetraspilota*; 15, *I. borrei*. Maxillae: 16, *I. tetraspilota*; 17, *I. borrei*. Labium: 18, *I. tetraspilota*; 19, *I. borrei* (bs, basistipes; cd, cardo; ds, dististipes; ga, galea; ge, gena; lc, lacinia; lg, ligula; lp, labial palp; m, mentum; mo, mola; mp, maxilar palp; prm, prementum; pros, prostheca; I–V, position of the mandible teeth). Scale bars = 0,5 mm.



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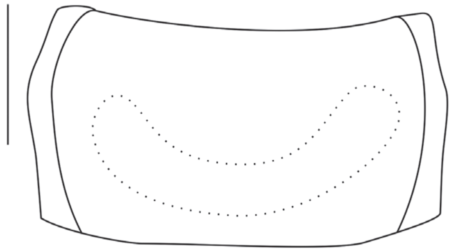

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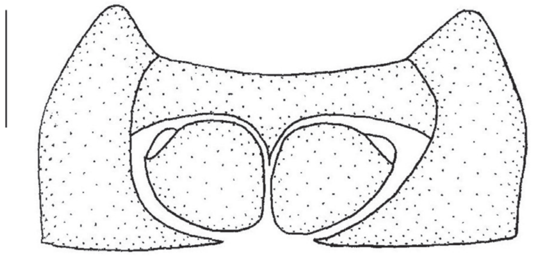

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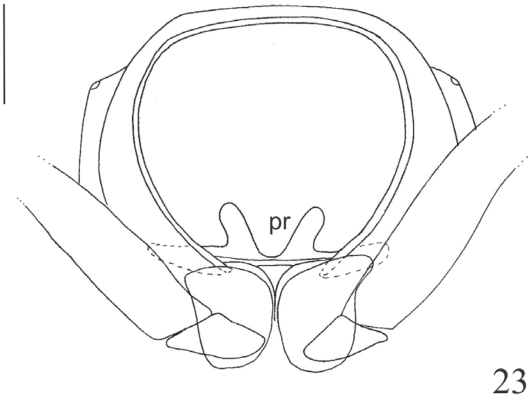

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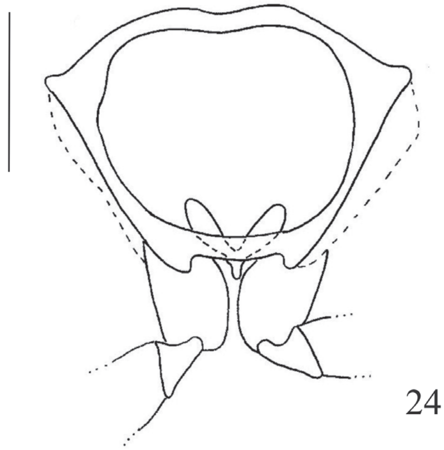

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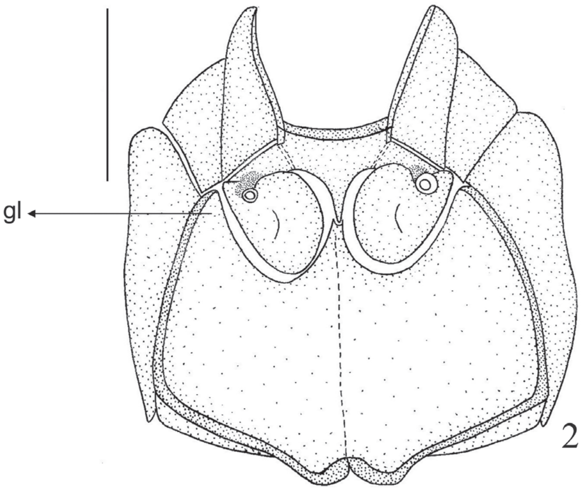

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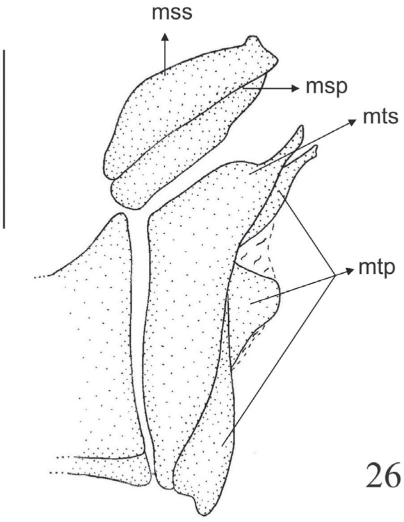

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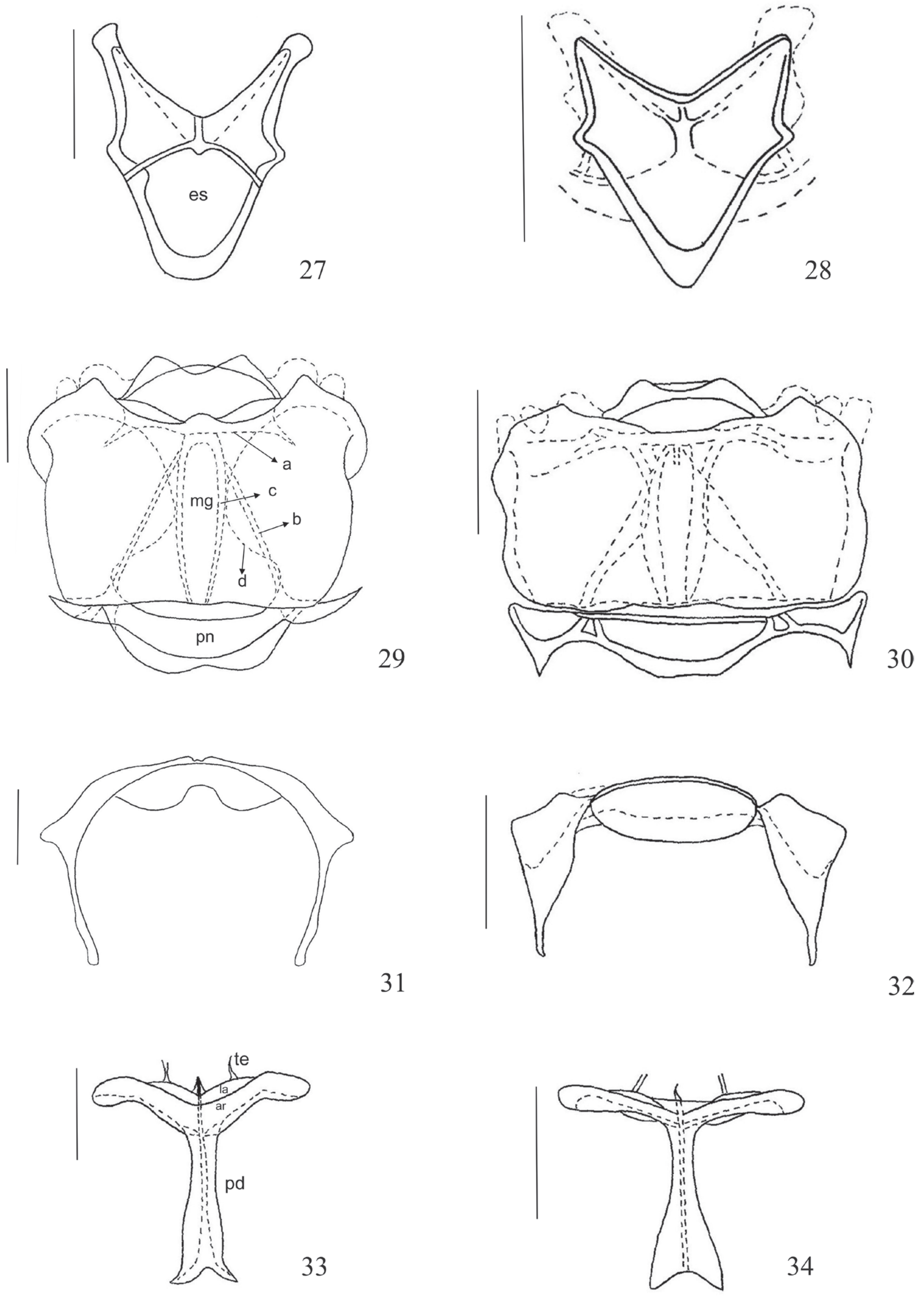
Figs 20–26. Pronotum, dorsal: 20, *I. tetraspilota* (Baly); 21, *I. borrei* (Baly). 22, Prosternum and procoxae, *I. tetraspilota.* Proendosternites, posterior view: 23, *I. tetraspilota*; 24, *I. borrei*. Pterothorax, *I. tetraspilota*: 25, ventral; 26, lateral (gl, gland; msp, mesepimeron; mss, mesepisternum; mts, metepisternum; mtp, metepimeron; pr, proendosternite). Scale bars: 20–24 = 0,5 mm; 25, 26 = 1,0 mm.



Figs 27–34. Mesoscutellum: 27, *Isotes tetraspilota* (Baly); 28, *I. borrei* (Baly). Metanotum: 29, *I. tetraspilota*; 30, *I. borrei*. Post-notum, posterior view: 31, *I. tetraspilota*; 32, *I. borrei*. Metendosternite: 33, *I. tetraspilota*; 34, *I. borrei* (a–d, metanotum apodemes; ar, arm; es, escutelum; la, lamina; mg, median groove; pd, peduncle; pn, post-notum; te, tendon). Scale bars = 0,5 mm.

"b" crossing "c" in the proximal region. Postnotum (Figs 31, 32) with sides projected distally in *I. borrei* and not projected in *I. tetraspilota*; in posterior view, *I. borrei* shows subtriangular sides, broader at the base, while in *I. tetraspilota* they are narrow and slightly convergent. Metendosternite (Figs 33, 34) with lateral arms fused to lamina, angulated at apex in *I. tetraspilota* and straight in *I. borrei*. Both species exhibit elongated peduncle; meso- and metafurcal tendons moderately developed, and inserted in the middle of the lateral arms.

Elytra (Figs 1–5). Elongated, with subparallel sides, emarginated, with apical margin subtruncated. Humeri slightly prominent. Punctuation with variable thickness. Setae present or absent. Epipleurae visible laterally or ventro-laterally, with variable width: in *I. tetraspilota* it is large only in the basal third, narrow in the apical two thirds, interrupted near the apex of elytra; in *I. borrei* and *I. crucigera* it is large only in the basal half, narrowed towards the apex. Integument with setigerous punctures, fine punctuation, or smooth and glabrous are species-specific characteristics.

Hindwings (Figs 35, 36). Length of the apical region, from the apex of the Radial cell to apex of the wing, slightly shorter than the basal region, from the base of the wing to the apex of the Radial cell. Costa (C) short, less than half of Subcosta (Sc) in *I. tetraspilota*, and elongated in *I. borrei*, at least two thirds of Sc length. Radial (RA) present. Both species with Radial cell (R) wide and closed. Radial cross vein 3 (r3) (= r4 by Cabrera & Cabrera Walsh, 2004a) present and developed. *Isotes tetraspilota* and *I. borrei* with Posterior Media 3 (MP$_3$) vestigial in the posterior region. *Isotes borrei* differs from *I. tetraspilota* by Radial Posterior (RP) present and Anal Anterior (AA) conspicuously sharpened. The veins Media Posterior 1+2 (MP$_{1+2}$), radial posterior-media posterior 2 (rp–mp2), Radial Posterior 3+4 (RP$_{3+4}$), Cubitus Anterior (CuA), Cubitus Anterior 3+4 (CuA$_{3+4}$), Media Posterior 3 (MP$_3$) and Jugal (Ju) present.

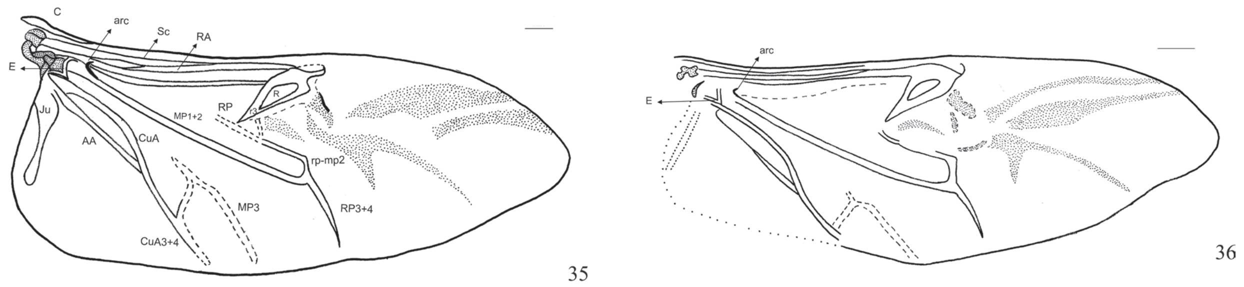
Important to note that the wing of *I. borrei* was severely damaged in the region of the anal and jugal lobe, not allowing the observation of variations in these regions. Apparently the pattern of *Isotes* in these two species is also similar to four subfamilies illustrated by Chaboo (2007, fig. 70, AC, E, HK) as the R, r3, RP and MP$_{1+2}$: Lamprosomatinae, Criocerinae, Galerucinae and Cassidinae. Regarding the veins AA, CuA, CuA$_{3+4}$ and MP$_3$ it is also very similar to the wing of galerucine *Ophraella* sp. (Chaboo, 2007, Fig. 79 C). Both wings keep the vein pattern of Diabroticites, as noted by Cabrera & Cabrera Walsh (2004a,b) in *Diabrotica calchaqui* Cabrera & Cabrera Walsh, 2004 and *Platybrotica misionensis* Cabrera & Cabrera Walsh, 2004.

Empusal (E) and arculus (arc) present. Hamilton (1972) designated the first anal vein as Empusal, being followed by researchers of Cerambycidae (Marinoni & Almeida, 1983; Napp, 1994). The arculus, according to Forbes (1922), is a fragment of the Media, in which the base is fused to the Radial and to the apex of Cubitus (= RP, MP$_{1+2}$ and RA$_{1+2}$, respectively, according to Kukalová-Peck & Lawrence, 1993). Napp (1994) noted that the arculus is poorly defined among the cucujoids studied, while in chrysomelids and some cerambycids it is clearly distinct. Crowson (1955), Jolivet (1957) and Suzuki (1969) did not mention the arculus to chrysomelids wings. Kukalová-Peck & Lawrence (1993), in turn, conducted a detailed study of the membranous wings of Coleoptera, being followed by the more recent works of Coleoptera (Kukalová-Peck & Lawrence, 2004; Lawrence *et al.*, 2011) and Chrysomelidae (Lingafelter & Konstantinov, 1999; Cabrera & Cabrera Walsh, 2004a,b; 2010 – Galerucinae; Chaboo, 2007 – Cassidinae; Chamorro-Lacayo & Konstantinov, 2011 – Lamprosomatinae). The scheme adopted by these authors agrees with the proposal that the Cubitus vein of Forbes (1922) is designed as Media. Kukalová-Peck & Lawrence (2004), however, gave a different definition for the arculus: alternative term for arm mp–cua present in all Endoneoptera + Hemineoptera and some Blattoneoptera. Herein we follow the term and interpretation adopted by Forbes (1922).

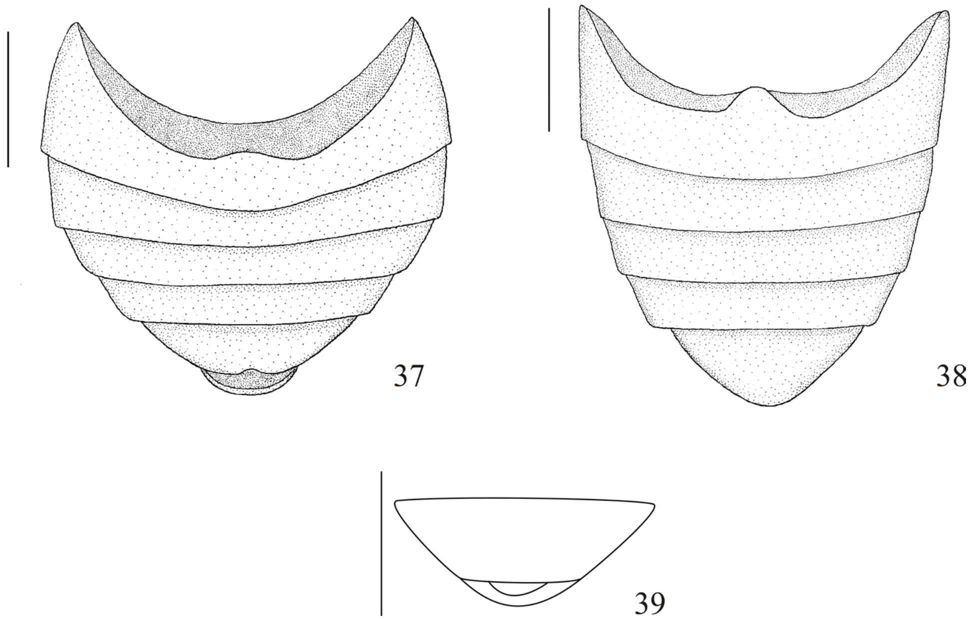
Legs. All legs are similar, slightly increasing in length. Coxae of pro- and mesolegs rounded, and mesocoxae with a glandular opening near the anterolateral area (Fig. 25). Metacoxae transverse. Trochanters subtriangular and reduced. Femora fusiform, tibiae slender, with apical spur – except protibiae of males.

Tarsi with tarsomeres I and II subrectangular (males with adhesive disc on the ventral surface of pro- and or mesotarsomeres); tarsomere III bilobed, with dense pubescence; tarsomere IV reduced on the basis of V, this elongated, with bifid claw at its end.

Abdomen (Figs 37–39). Abdomen with urosternites I–V subequal in length, wider than long, gradually decreasing in width until the urosternite V; this subtrapezoidal, with variable apex between male and female species of *Isotes*. Apex of the urosternite V of males weakly notched (Fig. 37) in *I. tetraspilota* and truncated (Fig. 39) in *I. borrei* and *I. crucigera*. In females, in turn, both species exhibit the apex of the urosternite V rounded (Fig. 38).



Figs 35–36. Hindwings: 35, *Isotes tetraspilota* (Baly); 36, *I. borrei* (Baly) (AA, Anal Anterior vein; arc, arculus; C, Costa; CuA, Cubitus Anterior vein; CuA$_{3+4}$, Cubitus Anterior vein 3+4; E, Empusal; Ju, Jugal; MP1+2, Media Posterior 1+2; MP3, Media Posterior vein 3; R, Radial cell; r3, Radial transversal 3; RA, Radial Anterior vein; RP, Radial Posterior vein; rp–mp2, radial posterior vein – media posterior 2; RP$_{3+4}$, Radial Posterior vein 3+4; Sc, Subcostal vein). Scale bars = 1 mm.



Figs 37–39. *I. tetraspilota* (Baly), Abdomen, ventral view: 37, male; 38, female. 39, Urosternite V, male, *I. borrei* (Baly). Scale bars: 37, 38 = 1,0 mm; 39 = 0,5 mm.

Male genitalia (Figs 40–47). Aedeagus (median lobe and tegmen; Figs 40–41). Median lobe, ventral view, placed laterally in the abdomen, with curvature toward the left side, and subequal in length to the last four urosternites in *I. borrei* and *I. crucigera*. In *I. tetraspilota* it reaches the first urosternite. Both species have variable curvature in the median lobe, as follows: 1) basal third strongly curved, 90° from the rest of the body of the median lobe at the height of the basal constriction, well-marked in *I. borrei* and *I. crucigera* (Fig. 40); and 2) basal third slightly curved, less than 45° relative to the apical two thirds of the median lobe, with well-marked constriction; apical third slightly curved in *I. tetraspilota* (Fig. 41). *Isotes borrei* and *I. crucigera* have a basal crest, slightly sclerotized with length equal to half of the basal third of the median lobe; *I. tetraspilota* also have this crest, but much shorter and narrowed.

According to Moura (2009), the basal orifice (= median foramen Matsumura & Suzuki, 2008) in Luperini is protected by a hood-shaped process, with rounded border. The basis of this process, in ventral view, is similar in both species, being truncated and notched at apex. In lateral view, all have rounded base, being sinuous in *I. borrei* and *I. crucigera* (Fig. 40) and straight in *I. tetraspilota* (Fig. 41). None of them have basal hooks, corroborating the results found for the tribe Luperini by Moura (2009).

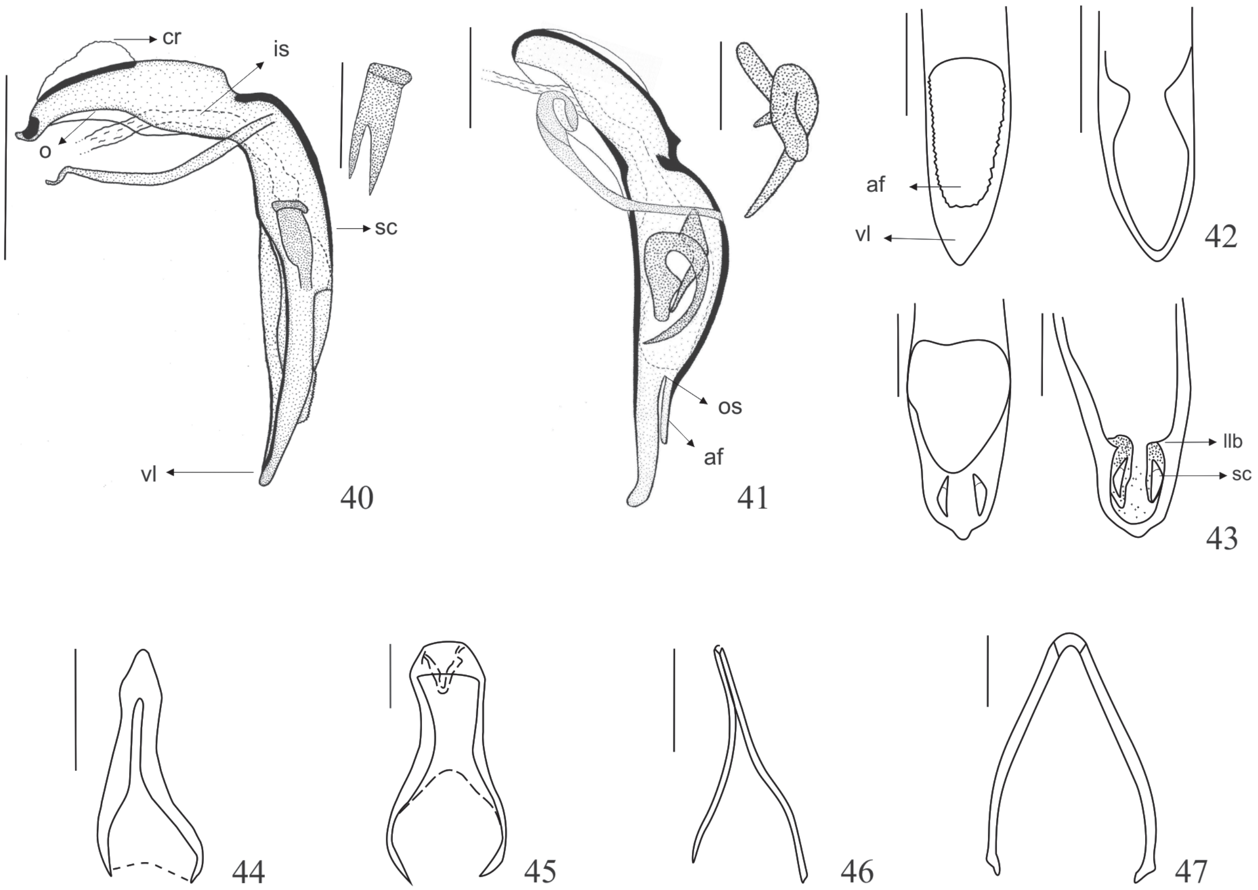
The apex of the median lobe is variable in Luperini (Moura, 2009). However the conformation of the apical flap together with the ventral lobe (Figs 42, 43) indicated importance for the determination of species. In this study we found the following relation of forms to the apex of the median lobe: 1) apical flap rounded, with crenulated margin, and ventral lobe narrowed at the apex, which is indented in *I. borrei* and *I. crucigera* (Fig. 42), and 2) apical flap rounded, with smooth margin, and ventral lobe with parallel sides that narrow at the apical margin in a rounded projection in *I. tetraspilota* (Fig. 43).

The lateral margins of the apical third of aedeagus, in ventral view, may or may not present a pair of lateral lobes (stuck to the sides of the ostium, according to Cabrera & Cabrera Walsh, 2004a,b) that vary in shape. Similarly to the apex in dorsal view, this feature is specific. The studied species show the following shapes: 1) subtriangular in *I. tetraspilota* (Fig. 43), and 2) sinuous in *I. borrei* and *I. crucigera* (Fig. 42). *Isotes tetraspilota* exhibit a highly sclerotized structure at apex surrounded by a moderately thick and dense punctuation (Fig. 43), not observed in the other species.

The internal sac is a membranous structure supported by the median lobe; during mating it is everted through the median orifice (= ostium Moura, 2009) under pressure from the hemolymph, forming the endophallus (Matsumura & Suzuki, 2008).

The internal sac in these two species varies in the number and shape of the sclerites (Figs 40, 41): one in *I. borrei* and *I. crucigera*, in the middle region of the median lobe, dorsally with the anterior half subretangular, rounded edges, and posterior half bifid – with two spiny projections directed towards the apex, the right greater than left; and two in *I. tetraspilota*, median, highly curved, pointed at the apex.

Tegmen (Figs 44, 45). The length of tegmen, in both species, is subequal to the basal third of the median lobe, and somewhat sclerotized. Two patterns were observed regarding form: 1) V, rounded at the base in *I. borrei* and *I. crucigera* (Fig. 44) and 2) U, subtruncated at the base in *I. tetraspilota* (Fig. 45); both with basal membranous projections. The lateral arms of tegmen meet the median



Figs 40–47. Aedeagus lateral and sclerites of the internal sac, dorsal: 40, *I. borrei* (Baly); 41, *I. tetraspilota* (Baly). Apex of median lobe, dorsal and ventral view, respectively: 42, *I. borrei* (Baly); 43, *I. tetraspilota* (Baly). Tegmen, dorsal view: 44, *I. borrei* (Baly); 45, *I. tetraspilota* (Baly). *Spiculum gastrale*: 46, *Isotes borrei* (Baly), Y-shaped, not fusioned; 47, *I. tetraspilota* (Baly), V-shaped, fusioned (af, apical flap; cr, basal crest of the median lobe; is, internal sac; llb, lateral lobe; o, basal orifice; os, ostium; sc, sclerite of the internal sac; vl, ventral lobe). Scale bars = 0,5 mm; except 40–43 = 1,0 mm and 0,5 mm, respectively.

lobe just below the dorsal constriction. Nadein (2006) appointed without performing phylogenetic analysis, that the simple Y-shaped tegmen, with a long basal part and two short branches forming a fork in the apical basal orifice of the penis, is plesiomorphic for representatives of the Tribe Alticini. According to Moura (2009), the tegmen of Metacyclini and Galerucini maintains this pattern, but in the species of Luperini – *Paranapicacaba teintuieri* (Allard, 1894) and *Isotes eruptiva* (Bechyné, 1955) – it consists of a subexagonal basal plate with a fork which originate a subparallel pair of arms directed laterally near the apex. The studied species show that Luperini displays various formats of tegmen, different from observed by Moura (2009).

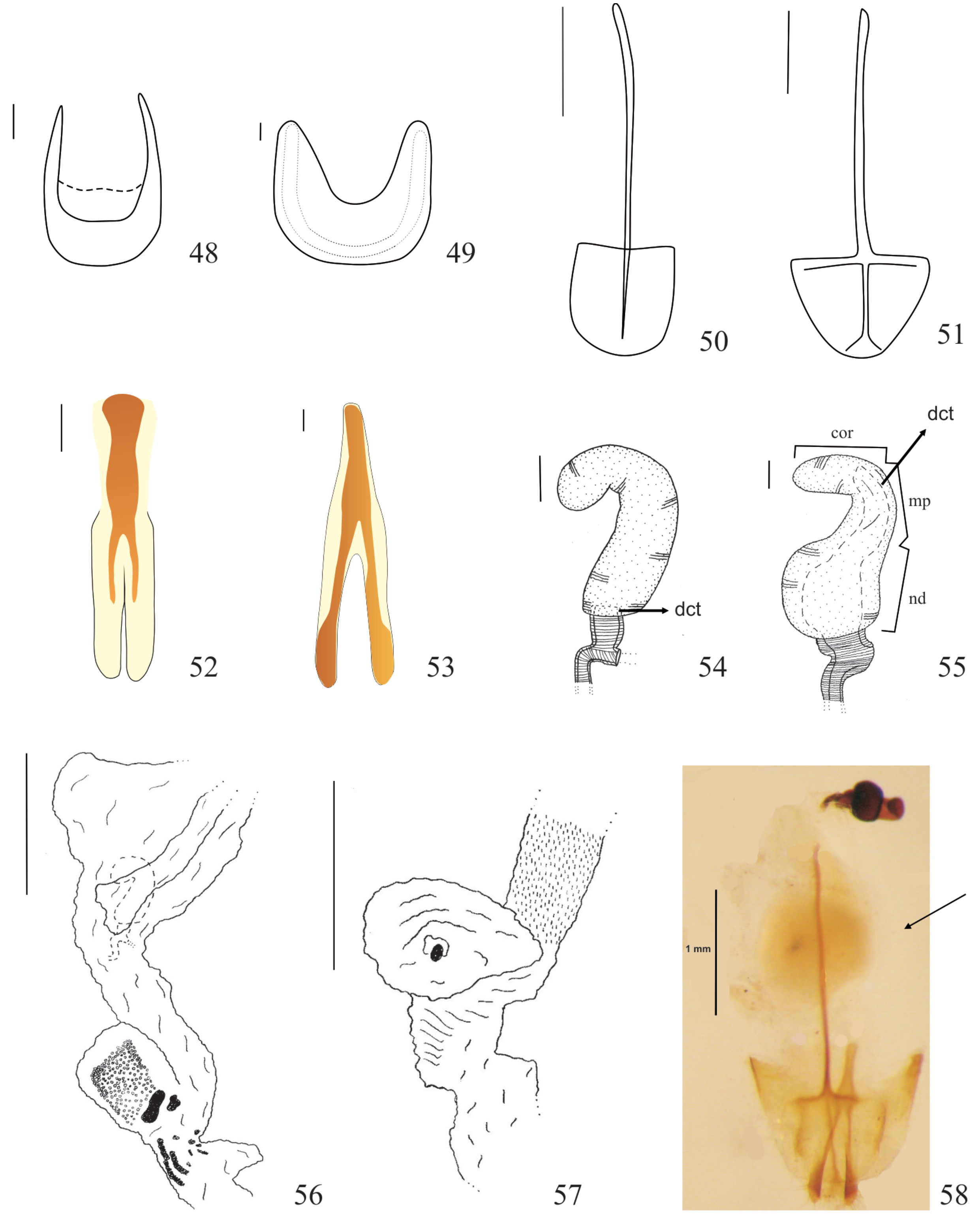
Spiculum gastrale (Figs 46, 47) with length subequal to half of the median lobe; in all species it is somewhat sclerotized. The studied species have two basic conformations: 1) Y–shaped, base united, not fused in *I. borrei* and *I. crucigera* (Fig. 46); and 2) V shaped, fused at base in *I. tetraspilota* (Fig. 47). According to Powell (1941) and Moura (2009), the Luperini species exhibit V-shaped *spiculum gastrale*, being the vertex (= base) not fused in *Paranapiacaba teinturieri* and, in *Luperodes meraca* (Say, 1825), Y-shaped.

Female genitalia (Figs 48–58). Both species present tergite VIII trapezoid shape, with sides slightly rounded, anterior angles rounded and pointed posteriorly. The sides fold toward the structures of the female genitalia, visible in ventral view.

Tergite IX (Figs 48, 49). Structure situated between the tergite VIII and sternite VIII, above the opening of the gut. It is characterized by a small plate, usually little sclerotized (Lingafelter & Konstantinov, 1999). The tergite IX is present in all species, with little observed variation in conformation and the length/width ratio: 1) longer than wide, inner margin sub truncated in *I. borrei* and *I. crucigera* (Fig. 48), and 2) as wide as long, robust with narrow sclerotized region in *I. tetraspilota* (Fig. 49). All tergites IX exhibit basal setae.

Despite being a structure present in most taxa of Chrysomelidae, including most Alticinae, Galerucinae and Chrysomelinae species (Lingafelter & Konstantinov, 1999), it is neglected in descriptions of female genitalia.

Sternite VIII (Figs 50, 51) slightly sclerotized,



Figures 48–58. Tergite IX: 48, *Isotes borrei* (Baly); 49, *I. tetraspilota* (Baly). Sternite VIII: 50, *Isotes borrei* (Baly); 51, *I. tetraspilota* (Baly). Vaginal Palpi: 52, *Isotes borrei* (Baly); 53, *I. tetraspilota* (Baly). Spermatheca: 54, *Isotes borrei* (Baly); 55, *I. tetraspilota* (Baly). *Bursa copulatrix*: 56, *Isotes borrei* (Baly); 57, *I. crucigera* (Weise, 1916) syn. nov.; 58, *I. tetraspilota*, female genitalia – arrow: *bursa copulatrix* with detail of the very dense median region (cor, cornu; dct, spermathecal duct; nd, nodulus; mp, median part). Scale bars: 48, 49, 52–55 = 0,1 mm; 50, 51, 56–57 = 0,5 mm; 58 = 1 mm.

with apical and lateral setae near the margins. It shows slight variation in specimens of the same species, but the general shape remains stable. Two forms were observed: 1) slightly longer than wide, with parallel sides and rounded apex, truncated at the proximal margin in *I. borrei* and *I. crucigera*, and 2) subtrapezoidal, with proximal margin truncated and wide, narrowing to the distal margin and subrounded in *I. tetraspilota* (Fig. 51).

Spiculum ventrale (Figs 50–51). The *spiculum ventrale* (= *tignum* Konstantinov, 1998) is a rod-shaped sclerite of the endoskeleton, begin the attachment of muscles (Torre-Bueno, 1989). It is present in the two species, in connection with the sternite VIII, varying in the degree of sclerotization, size – compared with sternite VIII – and within reach of the same in the sternite. Regarding the sternite VIII connection can reach the area: distal in *I. borrei* and *I. crucigera*, or proximal in *I. tetraspilota.*

Vaginal palpi (Figs 52, 53) are formed by invagination of the dorsal side of the vagina (Konstantinov, 2002). There are two opinions about the function of these structures: the first considers the palpi as adaptations for posture, with sensorial function in selecting the best substrate to lay eggs, and the second believes that they act in mating (Konstantinov, 1998; Moura, 2008). In all species studied, the palpi are subcylindrical (Cabrera & Cabrera Walsh, 2004b), approximately two times shorter than the *spiculum ventrale*, strongly punctuated in the apical half and with setae apically. The palpi are united at the basis on all species and vary according to it. At the apex they can be united or separated, a characteristic that varies among specimens of the same species. Moreover, they can be entirely sclerotized or not. Separated palpi apex were observed in *I. tetraspilota* (Fig. 53). There was variation in *I. borrei* and *I. crucigera*, from being completely united to moderately separated (Fig. 52). The shape of the sclerotization of the apex varies inter- and intraspecifically. Additionally, the sides of the palpi are sclerotized in all species, except *I. borrei* and *I. crucigera*.

Bursa copulatrix (Figs 56–58). In female insects, it works as a purse, being the genital chamber or part of it. In Coleoptera, it is the blind proximal end of the vagina, with which it is connected widely or closely (Torre-Bueno, 1989). In the studied species, the *bursa copulatrix* varied in relation to form and the presence or absence of sclerotization. The species present different types and forms of sclerotization: 1) *I. borrei* (Fig. 56) with median region slightly more sclerotized, quadrangular aspect, and with small bands more sclerotized anteriorly; 2) *I. crucigera* syn. nov. (Fig. 57) with small oval sclerotized area in the median region; 3) *I. tetraspilota* (Fig. 58) generally differentiated: median membrane very dense, sharply rounded, without sclerotization.

Spermatheca (Figs 54, 55). Considered a sperm receptacle during mating (Torre-Bueno, 1989). Several terminology are used for the same structure in other families of Coleoptera and even within subfamilies of Chrysomelidae: 1) nodulus, middle part and cornu (Middelhouve & Wagner, 2001; Wagner, 2002; Stapel *et al.*, 2008; Hazmi & Wagner, 2010; Curculionidae the median part is called the ramus); 2) receptacle (= proximal half) and pump (= distal half) (Moura, 1998a,b,c; Cabrera & Cabrera Walsh, 2004a,b, 2010; Cabrera *et al.*, 2005, 2008; Reid & Nally, 2008; Chamorro-Lacayo & Konstantinov, 2009 – Cryptocephalinae); 3) vasculum, vellum and ampulla (Rodriguez, 1994; Borowiec & Skuza, 2004; Borowiec & Pomorska, 2009); and 4) no specific terminology (Moura, 2007 – Galerucinae; Chamorro-Lacayo *et al.*, 2006 – Cryptocephalinae).

In this paper, the first terminology was adopted for the comparison of the morphology of the spermatheca of *Isotes* (Figs 54, 55). Both species have elongated spermathecae with curved cornus and rounded apex. The shape and width from nodulus varies from elongated, with the same width in the median part in *I. borrei* and *I. crucigera* (Fig. 54) to strongly enlarged, cylindrically shaped in *I. tetraspilota* (Fig. 55). The morphology of the spermatheca has been used to separate genera (Cryptocephalinae in Chamorro-Lacayo *et al.*, 2006), species groups (*Stolas*, Cassidinae in Borowiec & Pomorska, 2009) and species (Alticini, by Leonardi, 1970), however it was clearly neglected in Galerucinae studies that lacking information terminalia. This study showed the importance of using such characteristics and the real possibly can be tested in further phylogenies.

Spermathecal duct and gland. Both species have the duct length slightly greater than the spermatheca, narrower and slightly sclerotized at the base, and extending until the nodulus. The opening of the spermathecal gland is lateral and proximal to it, with a moderately dilated region after the same. *I. tetraspilota* (Fig. 55) shows a strongly sclerotized duct, similar to the spermatheca, and unlike other species where it is less sclerotized. The spermathecal gland is poorly sclerotized, narrow and elongated.

Material examined. *Isotes borrei* (Baly, 1889): BRAZIL, ♂, without date, F. C. Bowditch leg. [1st Jacoby Coll.] (USNM); **Rio de Janeiro**: Petrópolis, 1, 03.II.1952, H. Barth leg. (CEIOC); Teresópolis, ♀, XII.1925, Dirings leg. (MZSP); Mangaratiba, 2♂, VIII.1938 – II.1939, R. C. Shannon leg. (USNM); **Espírito Santo**, ♀, without additional data [ex coll. Fruhstorfer] (ZMHB); Córrego Itá, ♂, XI.1956, W. Zikán leg. (MNRJ); Guandú, 3♀, X.1920, F. Hoffmann leg. (MNRJ); **São Paulo**: Agantuba, ♂, I.1922, Azevedo Marques leg. (MNRJ); Santos, Ilha Santo Amaro, ♀, 02.IV.1912, G.E. Bryant leg. (USNM); **Minas Gerais**: 1, VII.1925, Loreto Moreira leg. (MNRJ); **Rio Grande do Sul**: São Leopoldo, ♂, ♀, F. Schneider leg. (ZMHB). *Isotes crucigera* (Weise, 1916): BRAZIL, **Minas Gerais**: Conceição da Paraíba, Fazenda S. José, ♀, 01.XI.1960, J. C. M. Carvalho leg. (MNRJ); **Rio de Janeiro**: Parque Nacional da Bocaina, Estrada Paraty-Cunha, 3♀, 24.I.2010, Mattos & Mermudes leg. (DZRJ); Petrópolis, Morro Castelo, 1, 08.VI.1991, Serpa-Filho, A. leg. (CEIOC); **São Paulo**, ♀, III-1958, Dirings leg. (MZSP); Bananal, Bocaina, ♂, I-1937, D. Mendes leg. (MNRJ); Barueri, ♂, 15.III.1955, K. Lenko leg. [Coleção Campos Seabra] (MNRJ); **Paraná**: Marumbi, ♀, II.1944, Dirings leg. (MZSP); **Santa Catarina**: Corupá, ♂, I.1953, A. Maller leg. [Coleção Campos Seabra] (MNRJ); Joinville, ♂, XI.1956, Dirings leg. (MZSP). *Isotes tetraspilota* (Baly, 1865): MEXICO, 2♀, 2♂, without date, J. Flohr leg. (ZMHB); 3♂, without date, Hoege S. & Kotze G. leg.; ♀, 1906, Stobre leg. (ZMHB); **Chiapas**: Tumbala, 4♀, 2♂ (ZMHB); Santo Domingo, S. E. Simojovel, 2♂, 08–15.VII.1949, Ray F. Smith leg.; 2♀, 4♂, 8–15.VII.1949, J. A. Chemsak leg. (EMEC); **Córdoba**: Fortin de las Flores, Sierra Zongolica [Sa Zongola], ♀, ♂, without additional data (ZMHB); **Veracruz**: Misantla, 2♂, Hoege leg. (ZMHB); **Sonora**: Cordova, 2♀, Hoege leg. (ZMHB); Jalapa, 3♀, Deppe leg. (ZMHB); San Andrés Tuxtla, ♂, XI.1944, (EMEC); W. Fortin de las Flores, 2♀, 06.VIII.1962 {*Cucurbita moschata* and *C. martinezi*} (EMEC); 2♀, 28.VIII.1962, Ray F. Smith leg. (EMEC); GUATEMALA, **Guatemala**: San Cristobal, 2♀ (ZMHB).

DISCUSSION

The comparison of *I. tetraspilota* (Baly, 1865) and *I. borrei* (Baly, 1889), type-species of the genera *Isotes* and *Synbrotica*, showed that the species have a very distinct morphology, including the frons (*I. borrei* as long as wide and gena elongated; *I. tetraspilota* wider than long and short gena), clypeus (*I. borrei* with six setae; and, *I. tetraspilota* with eight setae), mandibles (inner margin concave in *I. tetraspilota* and substraight in *I. borrei*; mola wider in *I. borrei* that in *I. tetraspilota*), maxillae (distal part of the galea more curved in *I. borrei* than in *I. tetraspilota*; with the articles of palp shorter and robust in *I. tetraspilota*), labium (ligula narrowed at the apex in *I. tetraspilota* and broadly rounded in *I. borrei*; mentum subretangular, transverse, with subparallel sides in *I. tetraspilota* and subtrapezoidal in *I. borrei*), pronotum (*I. borrei* twice wider than long and with depression; *I. tetraspilota* 1.63 to 1.74 times wider than long and without depression), proendosternite (projections posteriorly directed slightly curved in *I. tetraspilota* and linear in *I. borrei*), mesonotum (mesoscutellum more broadly rounded in *I. tetraspilota*, with sides strongly convergent in *I. borrei*), metanotum (wider than long in *I. borrei* and as wide as long in *I. tetraspilota*), postnotum (lateral projected distally in *I. borrei* and not projected in *I. tetraspilota*), metendosternite (angular at the apex in *I. tetraspilota* and straight in *I. borrei*), epipleura (*I. borrei* large to the basal half; *I. tetraspilota* large to the basal third), and hindwings (Costa short, less than half of Subcosta in *I. tetraspilota* and elongated in *I. borrei*, at least two thirds of Sc; Posterior Radial and Anterior Anal thinned in *I. borrei*).

Furthermore, regarding the genitalia: 1) basal third of aedeagus strongly curved in *I. borrei* and slightly curved in *I. tetraspilota*, 2) tegmen V-shaped, with rounded base with a projection in *I. borrei*, and U-shaped, truncated base with a projection in *I. tetraspilota*, 3) vaginal palpi slightly to moderately separated from the apical third in *I. borrei* and widely separated in the apical half *I. tetraspilota* and 4) spermatheca nodulus with the same width as the rest of spermatheca and duct ending in the base in *I. borrei*, and nodulus strongly broader, cylindrical, and the spermathecal duct reaching the cornus in *I. tetraspilota*, providing information to revalidate *Synbrotica* after a further test with cladistical methods.

Morphological characters presented by the type species showed that the synonymy of genera performed by Aslam (1972) was premature, since he did not observe the type species of *Synbrotica* (subjective synonymy). The characteristics cited by Weise (1922) in original description were confirmed to *Isotes*, but cannot be considered diagnostic since they include other genera. As initially discussed, Bechyné & Bechyné (1969) reported six diagnostic features for *Synbrotica*, which did not include all species of the genus. Comparative and more comprehensive studies can reinstatement of *Synbrotica*, only those species with the characteristics listed above remain, as pointed out by Bechyné & Bechyné.

Taxonomical remarks and synonymy of species

Isotes borrei (Baly, 1889)

(Figs 1–3, 9–11, 13, 15, 17, 19, 21, 24, 28, 30, 32, 34, 36, 39, 40, 42, 44, 46, 48, 50, 52, 54, 56, 57)

Diabrotica borrei Baly, 1889:253; Gahan, 1891a:449 (redescr.).
Diabrotica cruciata Baly, 1889:253 (non *Diabrotica cruciata* Jacoby, 1887:547).
Diabrotica borrei [ab.] *cruciata*; Gahan, 1891a:449 (syn.).
Diabrotica crucigera Weise, 1916:40 (new replacement name for *D. cruciata* Baly).
Diabrotica borrei [ab.] *crucigera*; Weise, 1924:28 (cat.); Blackwelder, 1946:680 (cat.).
Synbrotica borrei; Bechyné, 1955:5; Bechyné, 1958:573; Bechyné & Bechyné, 1962:50 (list); Smith & Lawrence, 1967:44, 153 (type-species); Bechyné & Bechyné, 1969:72 (list); Wilcox, 1972:379 (cat.).
Synbrotica crucigera; Bechyné, 1955: 7 (stat. rev.); Bechyné, 1958:573; Bechyné & Bechyné, 1962:30; 1969:72 (list); Smith & Lawrence, 1967:53 (type-species).
Isotes borrei; Wilcox, 1975:690 (cat.).
Isotes crucigera; Wilcox, 1975:690 (cat.). **Syn. nov.**

In the original descriptions, these species were considered as different species by the following characteristics (*I. borrei versus I. crucigera*): (1) body shape narrowly oblong-oval *vs.* oblong oval, (2) body slightly posteriorly enlarged *vs.* posteriorly enlarged, (3) apex of antenna yellow *vs.* articles 9 and 10 and base of the 11 whitish, (4) thorax yellow *vs.* thorax (this tinged dark) yellow, (5) thorax wide, with two foveae *vs.* thorax subarcuate excavated, groove more deeply impressed on both sides, (6) elytra punctured, margins, apex dilated, wide band near the middle, suture and apex yellow *vs.* yellow elytra with two large black stripes.

Isotes borrei (Baly) and *I. crucigera* (Weise) are synonymized in this paper by having the external morphology, the aedeagus (Figs 40, 42, 44, 46) and female genitalia identical (Figs 48, 50, 52, 54), varying only on the sclerotization of *bursa copulatrix* (Figs 56, 57), and the basal spot of elytra (reaching the elytral suture and scutellum in *I. borrei*, and not in *I. crucigera*) (Figs 1–3). Both these features vary among specimens of the same species and specimens with intermediate characteristics were observed.

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