

Three new species of *Endoclita* C. & R. FELDER, 1874 from northern Laos and Thailand (Lepidoptera: Hepialidae)

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Abstract

Three new species, *E. laosensis* nov.sp. and *E. collardi* nov.sp. from northern Laos, and *E. daenlao* nov.sp. from Thailand are shown to be distinct from previously described species from the region – *E. salvazi* TINDALE, 1958 and *E. topeza* TINDALE, 1958 also from northeastern Laos, and *E. coomani* VIETTE, 1949 from northern Vietnam. The genitalia of the holotypes for *E. salvazi* and *E. topeza* are also dissected and fully illustrated for the first time. The holotype of *E. coomani* is illustrated for the first time and VIETTE's (1949) diagram of the genitalia is now complimented by a photographic image. It is suggested that the inclusion of *E. coomani*, *E. collardi* nov.sp. and *E. laosensis* nov.sp. as a subclade within the genus *Endoclita* is supported by their sharing several derived features of the genitalia such as an elongate valve with an anterior basal setose lobe, and a V-shaped sternum VIII fused to the lateral and posterior borders of the saccus.

Zusammenfassung

Drei neue Arten, *E. laosensis* nov.sp. und *E. collardi* nov.sp. aus dem nördlichen Laos und *E. daenlao* nov.sp. aus Thailand wird gezeigt, dass es sich von zuvor beschriebenen Arten aus der Region unterscheidet – *E. salvazi* TINDALE, 1958 und *E. topeza* TINDALE, 1958, auch aus dem Nordosten von Laos, und *E. coomani* VIETTE, 1949 aus Nordvietnam. Die Genitalien der Holotypen von *E. salvazi* und *E. topeza* werden ebenfalls zum ersten Mal präpariert und vollständig dargestellt. Der Holotyp von *E. coomani* wird zum ersten Mal illustriert, und das Genitalien-Diagramm von VIETTE (1949) wird jetzt durch ein fotografisches Bild ergänzt. Es wird vorgeschlagen, dass der Einschluss von *E. coomani*, *E. collardi* nov.sp. und *E. laosensis* nov.sp. Als Unterklasse innerhalb der Gattung wird *Endoclita* unterstützt, indem sie mehrere abgeleitete Merkmale der Genitalien teilt, wie etwa eine längliche Klappe mit einem anterioren Basal-Setose-Lappen und ein V-förmiges Brustbein VIII, das an die seitlichen und hinteren Ränder des Saccus fusioniert ist.

Introduction

Comprising about 65 species, *Endoclita* C. & R. FELDER, 1874 is one of the most speciose genera of Hepialidae in the world (NIELSEN *et al.* 2000) with a broad distribution range between Sri Lanka and India in the west and Bali and the Russian Far East in the east (GREHAN 2011). Biology and host plants are known for only for a few species, all of which are callus-feeding stem borers (GREHAN & ISMAVEL 2017) and the genus has not received broad taxonomic attention since TINDALE (1941, 1942, 1958) revised the group. Recent new species recorded from northern Sumatra (GREHAN & MIELKE 2016) and Taiwan (BUCHSBAUM *et al.* 2018; BUCHSBAUM & GREHAN 2019) indicate that there are other undescribed species, particularly across regions that have been poorly sampled for this genus. This inference is supported by our description of two new *Endoclita* species from northern Laos and one from northern Thailand. We compare these to three nearby species and highlight features that may be of phylogenetic significance for species relationships within the genus.

Materials & Methods

Abdomens were removed and treated in a cold solution of 5% KOH. Abdominal skins were opened by a right lateral cut from the tergosternal bar to the genitalia which were removed and stained in Chlorazol black or gentian violet. Terminology for genitalia and wing pattern follows that of MIELKE & CASAGRANDE (2013) and the tergosternal connection follows GREHAN & MIELKE (2017). Outline diagrams of wings were made by tracing over photographs using InkScape Scalable Vector Graphics (SVG) 1.1 (Second Edition), version <http://www.w3.org/TR/2011/REC-SVG11-20110816/>.

Collection abbreviations

BDGRBenny DE GROOF collection, Lier, Belgium
CGCM.....Carlos MIELKE collection, Carambeí, Brazil
CUICCornell University, Ithaca, New York, USA
MNHNMuséum national d'Historie Naturelle, Paris, France
MWM.....Museum WITT, Munich, Germany
RMNH.....Naturalis Biodiversity Centre, Leiden, The Netherlands

Other abbreviations

HT (holotype), PT (paratype), FW (forewing), HW (hindwing)

Systematic Entomology

Order Lepidoptera LINNAEUS, 1758
Suborder Exoporia COMMON, 1975
Superfamily Hepialoidea STEPHENS, 1829
Family Hepialidae STEPHENS, 1829

Taxonomy

***Endoclita laosensis*, nov.sp., GREHAN & MIELKE** (Figs 1a-f, 8a, 9a, 10a, 11a-b, 14a, 15, 19a, 20a-b, 23)

E t y m o l o g y : Named for the country of Laos where the holotype was collected.

H o l o t y p e ♂ (with the following labels separated by forward slashes): Luang Prabang Prov., Kiew Mak Nao, +/-900m, 03/05[May]/2016 / Holotypus, *Endoclita laosensis* ♂, GREHAN & MIELKE des. 2018/. Dissection No 6. Holotype to be deposited in RMNH. Figs 1a, 1b.

P a r a t y p e s : in total 2 ♂, 5 ♀. All NE-Laos, Houapha province, Mt. Phu Phan: May-June, 1300-1600 m (1 ♂, 1 ♀ BDGR), May, June, 2060 m (1 ♂, 4 ♀ BDGR); 1 ♀, V.2014 ((CGCM 30.461 (Fig. 1e); CGCM).

D i a g n o s i s : Species with scattered dark spots in the central cubital region of the FW and along parts of the termen of FW and HW. Distinguished from *E. coomani* VIETTE, 1949 by presence of a prominent central lobe of the pseudotegumen and from *E. collardi* nov.sp. (Fig. 6) by subrectangular shape of the central lobe (rounded in *E. collardi* nov.sp.) and longer sacculus lobe of the valve. The FW pattern of dark spots and the cubital spot distinguish this species from *E. daenlao* nov.sp. (Fig. 3) of northern Thailand and *E. salvazi* TINDALE, 1958 (Fig. 4) and *E. topeza* TINDALE, 1958 (Fig. 5) of northeastern Laos.

Description

Male (Figs 1a-d): Wingspan 95 mm; FW length: 47 mm, width: 16 mm, ratio 1: 2.9; HW length: 39 mm, width: 18 mm, ratio 1: 2.2 (n=3). HW shape almost equilateral, strongly angled tornus. Head: frons and vertex covered greyish brown scales. Antenna filiform, blackish-brown, scape rounded, covered with short piliform scales, 23-24 flagellomeres (n=2), with numerous sensilla chaetica and scattered sensilla trichodea, tapering near apex, four terminal annuli narrow. Labium not examined.

T h o r a x : Dorsally and ventrally greyish brown, scutum III dark reddish brown, free of scales other than posterior and medial regions. Legs (Fig. 8a) colour as for thorax, metaleg with prominent dorsal tibial androconial gland. Wing venation hepialine (*sensu* DUMBLETON, 1966) (Fig. 9a). FW costal margin slightly convex basally, expanding slightly at Sc1 before curving to slightly falcate apex; outer margin with anal margin as an extended shallow curve; HW costal margin slightly convex centrally, apex almost right angled, termen with slight convex angle about Rs4, then almost straight to tornus at CuP; venation as for FW except for absence of Sc1, CuP extending to margin separate from A. FW dorsal ground colour pale greyish brown with patches of darker reddish brown shading. Dark brown cubital spot is present between CuA₂ and CuP+A (Fig. 10a) and small dark brown spots are present along termen and costa, with larger brown patches along mid costal margin. Anterior recess (yellow outline in Fig. 10a) of anterior discal cell forming a right-angled trapezoid shape. Silvery white stigma edged with dark brown near base of posterior and central discal cells (between CuA₂-M, and at junction of m-r cross vein with M₁). Small silvery white spots also near base of anterior discal cell and outer M₁. HW dorsal ground colour greyish black except for orange-brown patches and darker brown spots

along outer costa and termen. FW ventral pale greyish to yellowish brown with dorsal ornamentation along costal and outer margins; 'costal pocket' basal to humeral vein between costal margin and Sc. HW dorsally greyish black except for orange-brown patches and darker brown spots along outer costa and termen.

P r e - g e n i t a l a b d o m e n : Greyish brown. Tergites and sternites moderately sclerotized. Tergosternal connection with short tergosternal bar, lateral and dorsal braces short, forming a shallow curve, tergal knob absent (Fig. 14a). Tergum II with robust lateral ridge with anterior medial branch extending towards dorsal tuberculate plate, anterior margin edged with slightly concave ridges meeting at median (Fig. 11a). Segment II pleura with lateral membranous pocket (possibly structurally and functionally associated with metatibial androconial gland. Sternum II sub-rectangular, anterior margin broad V-shape with shallow central concave depression, anterior lateral arms long, apically pointed, lateral margins with sclerotized ridge from apex of anterior lateral arm, and narrowing posteriorly forming a waist anterior of posterior margin. Tergum VIII sub rectangular, longer than wide. Sternum VII reduced, edges indistinct, irregular (Fig. 11b). Sternum VIII forming a broad V shape and fused to lateral and anterior margins of saccus (Fig. 15).

G e n i t a l i a : Tegumen an elongate triangle, well separated from pseudotegumen, long posterior edge slightly dentate (Fig. 15). Saccus (vinculum) with central posterior unsclerotized patch, anteriorly subrectangular, anterior margin rounded, posterior margin centrally straight with narrow, sub-parallel posterior lateral arms; apodemal suture close to anterior margin. Tergal lobes absent. Pseudotegumen anogenital rim with 'posterior lobe' either side of 'dorsal nexus', a subrectangular 'central lobe', and acute pointed 'anterior lobe'; dorsoventral 'ascending spine' straight then curving medially to form an anteriorly projecting spout fused across the median; dorsal anogenital margin with strongly sclerotized T-shaped bar with narrow rectangular 'posteriodorsal spine' and a pointed, long narrow 'anteriodorsal spine'. Valve short, narrow, setose, apically rounded; sacculus long, narrow, anterior end angled medially and dorsally terminating in a ventrally projecting, narrow setose lobe (Fig. 19a). Fultura superior (trulleum) laterally sclerotized, centrally membranous. Fultura inferior (juxta) rectangular, laterally concave, posteriorly forming two convex edges lateral to the median. Phallus membranous without cornutus.

Female (Figs. 1e-f): Wingspan 108 mm; FW length: 53 mm, width: 19mm, ratio 1: 2.8; HW length: 43 mm, width: 20 mm, ratio 1: 2.2 (n=2). Ornamentation as for the male.

P r e - g e n i t a l a b d o m e n : Tergum VIII rectangular, three times wider than longer, with posterior edge concave; sternum VIII membranous.

G e n i t a l i a : External genitalia with narrow, inverted U-shaped tergum IX (dorsal plate), widened laterally (Fig. 20). Subanal plate broad, irregular with the anterior edge convex. Lamella antevaginalis sclerotized and complex, on each side dorso-laterally, a conspicuous triangular process that extends proximally to form a well-developed and posteriorly projected mesal lobe which bears a groove dorsally. From the mesal lobe emerges, dorso-anteriorly on each side a vertical and conspicuous plate that surrounds the antrum laterally and ventro-posteriorly as a shield-like structure forming a deep concavity. Internal genitalia (Fig. 23) with narrow ductus bursae four times longer than corpus bursae, and bearing minute spicules near insertion into corpus bursae. Corpus bursae cylindrical, narrowing distally, with posteriorly extending cylindrical caecum of subequal length.

D i s t r i b u t i o n : Known from two localities only - Kiew Mak Nao (here interpreted as being located at or near 19°40'34.56"N, 102°12'37.10"E) and Mt. Phu Phan (Fig. 26)

(here interpreted as being located at or near 20°15'N, 104°02'E based on coordinates given by AHRENS & PACHOLÁTKO (2003)). The two localities are about 200 km apart.

H a b i t a t : Forest (Fig. 28).

***Endoclita collardi* nov.sp., GREHAN, IGNATEV & DE GROOF** (Figs 2a-d, 8b, 9b, 10b, 12a-b, 14b, 16, 19b)

E t y m o l o g y : Named after Steeven Collard (Laos) who obtained the specimens.

H o l o t y p e : ♂ NE-Laos, Houaphanh prov. Mt. Phu Phan +/-2060m, 15/06[June]/2017/. Holotypus, *Endoclita collardi* ♂, GREHAN, IGNATEV & DE GROOF des. 2018/. Dissection No 5. Holotype deposited in RMNH. Figs 2a, 2b.

P a r a t y p e s : in total 5 ♂, 11 ♀. All NE-Laos, Houaphanh province, Mt. Phu Phan: 1300-1600 m, May-June 2018. Figs 2c-d (BDGR).

D i a g n o s i s : Similar to the previous species, but lacking scattered dark spots in the central cubital region of the FW and along parts of the termen of FW and HW. The rectangular shape of the futura inferior also contrasts with *E. collardi* from the narrower posterior margin in *E. laosensis*. Distinguished from *E. coomani* VIETTE, 1949 by presence of a prominent central lobe of the pseudotegumen and from *E. laosensis* nov.sp. by rounded central lobe (subrectangular in *E. laosensis* nov.sp.) and shorter lobe of the sacculus. Absence of a costal lobe separates this species from *E. daenlao* nov.sp.

Description

Male (Figs 2a, 2b): Wingspan (holotype only) 69 mm FW length: 34 mm, width: 12mm, ratio 2.8: 1; HW length: 27 mm, width: 13 mm, ratio 2.1: 1. HW shape almost equilateral, strongly angled tornus. Head: Frons and vertex covered yellowish brown scales. Antenna filiform, yellowish brown, 21-23 flagellomeres (n=3), tapering near apex, scape rounded, covered with short piliform scales. Labium not examined.

T h o r a x : Dorsally covered with pale reddish brown scales, scutum III pale greyish brown, free of scales other than posterior and medial regions; ventral thorax pale yellowish brown. Legs greyish brown, foreleg missing, metaleg with prominent metatibial gland (Fig. 8b) and bearing metatibial androconia. Wing venation hepialine (*sensu* DUMBLETON, 1966). HW and FW pattern as for *E. laosensis* nov.sp. (Fig. 9b). FW costal margin slightly convex basally after humeral vein, expanding slightly at Sc1 before curving to slightly falcate apex, space between costa and Sc narrowing distally after Sc1; termen a shallow curve merging with dorsum without distinct tornus. FW dorsal ground colour pale yellowish green and pale greyish green with darker irregular shaped yellowish to reddish brown shading with distinct longitudinal band between Rs4 and M₁, darker shading extending across the central region of the cell bounded by CuA₂ and A, but not forming a cubital spot as in *E. laosensis* nov.sp. (Fig. 10b). Elongate anterior recess sub-trapezoid (yellow outline in Fig. 10b). Reddish brown shading alternating with pale whitish grey between Sc and costa. Transverse indistinct bands visible between anterior margin and Rs4. Silvery white stigma edged with dark brown near base of posterior and central discal cells (between CuA₂ and M), and at junction of m-r cross vein with M₁. FW ventral pale yellowish brown to pale green with ornamentation partially visible; 'costal pocket' basal to humeral vein

between costal margin and Sc, HW dorsal pale yellowish brown with darker submarginal and marginal banding near apex. Ventral HW as the FW but paler.

P r e - g e n i t a l a b d o m e n : Greyish brown. Tergites and sternites moderately sclerotized. Tergosternal connection with short tergosternal bar, lateral and dorsal braces short, forming a shallow curve, tergal knob absent (Fig. 14b). Tergum II with robust lateral ridge with anterior medial branch extending towards dorsal tuberculate plate, anterior margin edged with slightly concave ridges meeting at median (Fig. 12a). Pleura with lateral membranous pocket (possibly structurally and functionally associated with metatibial androconial gland). Sternum II sub-rectangular, anterior margin forming a broad V-shape, anterior lateral arms long, apically pointed, lateral margins with sclerotized ridge from apex of anterior lateral arm, and narrowing posteriorly forming a waist anterior of posterior margin. Tergum VIII sub-rectangular, longer than wide, and narrowing posteriorly. Sternum VII reduced, edges indistinct, anterior margin wide, lateral margin concave. Sternum VIII forming a broad V shape and fused to lateral and anterior margins of saccus (Fig. 16).

G e n i t a l i a : Tegumen broadly trapezoid, well separated from pseudotegumen, posterior edge angled and smooth (Fig. 16). Saccus with large central posterior unsclerotized patch, anterior margin rounded, narrowly U-shaped, posterior margin centrally straight with apodemal suture near anterior and with narrow posterior lateral arms subparallel, curving postero-laterally. Tergal lobes absent. Pseudotegumen anogenital rim with 'posterior lobe' either side of 'dorsal nexus', a convex 'central lobe', and a bluntly pointed 'anterior lobe'; dorsoventral 'ascending spine' very narrow, straight then curving medially to form an anteriorly projecting spout fused across the median; dorsal anogenital margin with strongly sclerotized T-shaped bar with narrow rectangular 'posteriodorsal spine' with rounded apex, and a narrow 'anteriodorsal spine' with rounded apex. Valva short, narrow, apex setose, apically rounded, sacculus long, narrow, anterior end angled medially and dorsally terminating in a short, ventrally projecting narrow and setose lobe (Fig. 19b). Fultura superior (trulleum) membranous. Fultura inferior (juxta) an inverted pentagon, posterior margin as two lateral ridges separated medially by less sclerotized notch, anterior margins weakly ridged. Phallus membranous without cornutus.

F e m a l e : external appearance as for male. Not dissected.

D i s t r i b u t i o n : Known from the type locality only (Fig. 26)

H a b i t a t : Forest (Fig. 28).

***Endoclita daenlao* nov.sp., GREHAN, WITT, & IGNATEV** (Figs 3a-b, 7, 8c, 9c, 21, 25a-b)

E t y m o l o g y : Named for the Daen Lao Ranges that include the type locality Mt. Doi Pha Hom Pok.

H o l o t y p e ♀, (with the following labels separated by forward slashes): /THAILAND, Changwa Chang Mai, Mt Doi Pha Hom Pok, 16 km NW of Fang, 2000m, 15.11[November].1998 / Leg. Marton Hreblay & Csab Szaboky”, Museum WITT München (MWM)”, / Holotype, *Endoclita daenlao* ♀, GREHAN, WITT, & IGNATEV des. 2018 / Dissection No. 23.839. Holotype in the MWM. Figs. 3a-b.

No paratypes.

D i a g n o s i s : Forewing markings not as strongly differentiated as in *Endoclita* species with a distinct triangular discal shaded area and pale anterior discal 'recess' in species

such as *E. chalybeatus* (Moore, 1879) (India), *E. davidi* (POUJADE, 1886) (western China), *E. fujianodus* (CHU & WANG, 1985) (China), *E. signifer* (WALKER, 1856) (northeastern India), *E. sinensis* (WALKER, 1856) (eastern China and possibly Taiwan), and *E. yunnanensis* (CHU & WANG, 1985) (southwestern China) (cf. ZHU *et al.* 2004, BUCHSBAUM & GREHAN 2019). The presence of the costal lobe separates *E. daenlao* from the northern Laos and Vietnam species except for *E. salvazi* which also has a costal lobe, but this species has a dark cubital spot that is absent from *E. daenlao* nov.sp.

Description

Female (Figs. 3a-b) Wingspan 108 mm; FW length: 55 mm, width: 20 mm, ratio 2.8: 1; HW length: 54 mm, width: 19 mm, ratio 2.8: 1. Head: Antenna pale orange-brown, filiform, 24 flagellomeres, rounded, lacking lamellar scales. Eyes prominent. Mouthparts: prelabium elongate with convex anterior facets; labial palp single segmented, cylindrical; maxillae three segmented, embedded within lateral channel with apical segment visible lateral to labial palp (Fig. 7).

T h o r a x : Dorsal scales of pro- and mesothorax short, yellowish-brown with posterior fringe of pale yellowish-brown on the mesothorax, metathorax anterior scutum III, dark chocolate brown and lacking scale cover other than near posterior edge; posterior dorsal metathorax covered with long, prone scales extending over anterior of first abdominal segment. Legs: epiphysis absent; metatibia and first metatarsal segment curved; ventral surface of tibia and tarsal segments covered with short scales, lateral scales very long and spread laterally from the tibia and tarsus (Fig. 9c). FW costal margin slightly convex and widely separated from Sc from base to Sc₁, prominent costal lobe at Sc₁, then costal margin distance from Sc narrow to apex; outer margin continuous with anal margin without distinct anal angle. Venation 'hepialine' (DUMBLETON 1966) (Fig. 9c). Four cubital cells at base of FW, including a narrow vein enclosing posterior edge of cell IV; CuP short. FW ground colour pale yellowish to greyish brown with scattered darker shading; darker indistinct, transverse elliptical patches across much of the outer wing. Basal to CuA₂ predominantly pale greyish brown with transverse lines of raised pale whitish brown scales between veins; costal region anterior to R with two broad brown patches, ovoid patch filling the costal lobe, and a narrow blackish brown band distal to costal lobe where the separation between costa and R narrows. FW ventral ground colour greyish-brown; ornamentation between Sc and costal margin same as for dorsal surface; Sc lined with row of posterior projecting greyish-brown hairs; 'costal pocket' basal to humeral vein between costal margin and Sc, concave with anterior surface free of scales and posterior surface with short dark brown piliform scales. HW dorsally and ventrally dark greyish-brown, except for faint ornamentation along costal and outer margins towards apex. Sc and R distally parallel, separated by twice width of R (Fig. 5d); Rs₁ almost straight; 1A and 2A present.

P r e - g e n i t a l a b d o m e n (8 c) : Covered with dark greyish-black scales. Sclerites not observed.

G e n i t a l i a : dorsal plate (tergum IX) (Figs. 21) dorso-ventrally tall, forming narrow arch fused across the dorsal median. Anal papillae small, setose, subanal plates tall (dark blue dashed outline) with convex interior margins, weakly sclerotized medially; lamella antevaginalis with lateral and medial lobes, medial lobe (pale blue dashed outline) with

dorsally protruding margin forming sub-triangular spatulate extension. Antrum (green dashed outline) sclerotized. Ductus bursae and corpus bursae sub-equal in length (Fig. 25a), junction about 1/3 corpus bursae length, shorter end forming a slightly larger diameter caecum, longer section initially wider than distal end; ductus bursae near corpus bursae with spicules (Fig. 25b).

D i s t r i b u t i o n : Known from the type locality only (Fig. 26). The label data of 16 km northwest of Fang (Wiang) corresponds closely to a peak named Huamereng (20°4'N, 98°).

H a b i t a t : Forest.

Taxonomic and systematic remarks

Most species descriptions for *Endoclita* by TINDALE (1941, 1942, 1958) are limited to external features, including only those aspects of the male or female genitalia that are externally visible. Although these descriptions are supported by illustrations, the representations are either too generalized or do not sufficiently display those features that may be diagnostic for individual species. Descriptions of a number of species from China include generalized diagrams of male genitalia that are sufficient for species distinctions to be made for at least the male (cf. ZHU *et al.* 2004). With these constraints in mind it is still feasible to recognize new species due to differences in FW patterns between many species of *Endoclita*, unlike some genera where wing patterns are insufficient to always diagnose different species (cf. GREHAN & RAWLINS 2018; DUGDALE 1994). And for the purposes of this study, genitalic comparisons can be made as a result of dissections made for the type specimens of *E. salvazi* and *E. topeza* as well as a photograph of the dissection for the holotype of *E. coomani*.

The six species referred to in this article comprise four species currently known only by the male (*E. coomani*, *E. collardi* nov.sp., *E. laosensis* nov.sp., *E. salvazi*) and two species known only by the female (*E. daenlao* nov.sp. and *E. topeza*). Although genitalic comparison cannot be made between the two groups, the different FW patterns of the female primary types for *E. daenlao* nov.sp. and *E. topeza* distinguish them from the males of the other species. In particular, the FW of *E. topeza* (Fig. 5) has a transversely oriented stigma paralleling the r-m cross vein whereas the stigma is more compact and located adjacent to M₁ basal to the cross vein in the males of the other species in the region (Figs. 10a-d). The absence of a stigma in *E. daenlao* nov.sp. (Fig. 3a) distinguishes this species from those of northern Laos and Vietnam. The presence of a prominent costal lobe in *E. daenlao* nov.sp. is shared with *E. salvazi* (Fig. 10c). This feature represents a derived character state within the Hepialidae that is unique to some *Endoclita* spp., being absent other exporian groups (Mnesarchaidae, Anomosetidae, Neotheoridae, Paleosetidae, Prototheoridae). This feature requires further assessment as it is variable in size and there is no way to independently ascertain whether the large or small size represents the derived condition that may be phylogenetically informative.

The external female genitalia of *E. daenlao* nov.sp. (Fig. 21), *E. topeza* (Fig. 22) and *E. laosensis* (Fig. 20) have a similar shape to that of other *Endoclita* species (c.f. GREHAN & MIELKE 2016; BUCHSBAUM *et al.* 2018; BUCHSBAUM & GREHAN 2019) with curved and vertical oriented paranal lobes, a narrow U-shaped dorsal plate, and a trilobed lamellar anti-vaginalis with a prominent central lobe. In *E. daenlao* nov.sp. the central lobe is trapezoid

with lateral edges narrowing dorsally whereas in *E. topeza* nov.sp. it forms an expanded subrectangular blade tapering slightly dorsally while in *E. laosensis* the lobe forms a long narrow stalk that distally expands into an inverted trapezoid. The only other record of a distally expanded central lobe is for *E. chalybeatus* (northeastern India) but in this case the expanded area forms an oval and the lateral lobes are not dorsally expanded (TINDALE 1941). In *E. laosensis* nov.sp. and *E. topeza* (Fig. 24) the bursa copulatrix is characterized by a ductus bursae that is narrower and longer than the corpus bursae which also has a larger cylindrical caecum branching near the junction with the ductus bursae (Figs. 23, 24). The presence of an elongate caecum attached to the corpus bursae represents a derived condition within the Hepialidae (in non-hepialid Exoporia the ductus bursae and corpus bursae have a linear orientation). The structure of the bursa copulatrix is known for very few other *Endoclita* species. The bifurcated condition is recorded for *E. kosemponis* (STRAND, 1916) and *E. sinensis* of Taiwan (BUCHSBAUM & GREHAN 2019) while a linear condition is present in *E. atayala* BUCHSBAUM & HSU 2018 of Taiwan (BUCHSBAUM *et al.* 2018), and *E. fahringeri* GREHAN & MIELKE 2016 of Sumatra, Indonesia (GREHAN & MIELKE 2016).

The male genitalia of *E. collardi* nov.sp., *E. laosensis* nov.sp., and *E. coomani* share at least three derived features: (1) a postero-dorsal 'T-shaped extension of the pseudotegumen either side of the anogenital field, (2) an elongate sacculus with a setose basal lobe, (3) a narrowly V-shaped sternum VIII fused to the anterior and lateral borders of the saccus. Additional features may be applicable to all three species but the slide mounted genitalia of *E. coomani* (Fig. 18) precludes a more detailed examination at this time. The three shared features are derived with respect to the Hepialidae since they do not occur in the other exoporian groups (Mnesarchaeidae, Anomosetidae, Neotheoridae Palaeosetidae, Prototheoridae) and therefore support the three species as members of an *Endoclita* sub-clade (here referred to as the *laosensis* group). Sternum VIII in male of *E. salvazi* is also V-shaped, but much smaller, very strongly sclerotized with posterior lateral points (Fig. 13b) and not so strongly adhered to the saccus to prevent separation during dissection. The pseudotegumen lacks the T-shaped extension of *E. laosensis* nov.sp. and *E. collardi* nov.sp. The valva of *E. salvazi* is also larger relative to the side of the pseudotegumen, and the sacculus is compact with a posterior-basal lobe that curves distally from the site of the valve (Fig. 17). The tegumen of *E. salvazi* is also narrower and subrectangular than in the *E. laosensis* clade. The shared presence of an extended central lobe of the pseudotegumen within the *E. laosensis* nov.sp. clade supports a closer relationship between *E. collardi* nov.sp. and *E. laosensis* nov.sp. than either is to *E. coomani*. The genitalia of each species differ with respect to the central lobe of the pseudotegumen which is shallow in *E. coomani*, prominent and convex in *E. collardi* nov.sp. and prominent and blunt in *E. laosensis* nov.sp. The genitalia slide mount of *E. coomani* (Fig. 18) does not show an ascending dorsal spine but it is not possible at this time to be sure due to condition stated above.

The shape of sternum II in *E. laosensis* nov.sp. and *E. collardi* nov.sp. is very similar to that of *E. salvazi* (Fig. 10a), but there is insufficient comparative documentation for other species to assess the phylogenetic significance.

Partial or complete fusion of sternum VIII with the saccus occurs within various genera of Hepialidae and involves different configurations of the sternum and different levels of fusion. In *Limyra silvai* MIELKE, DELL'ERBA & DUARTE 2017 (MIELKE *et al.* 2017) sternum VIII forms a curved U-shaped structure where the lateral points are oriented anteriorly

rather than posteriorly as in the *laosensis* nov.sp. clade, and the line of fusion is medial rather than involving the entire posterior margin. Since well substantiated groups include species with or without fusion it is probable that fusion of itself does not indicate specific phylogenetic affinity, but particular modes of fusion, as noted here for *Endoclita*, may be phylogenetically informative.

Wing patterns can be useful in helping to identify individual species of Hepialidae but they appear to be often uninformative for species and generic relationships due to inconsistent variation (particularly when considering very broad variation within some species). Consideration of wing pattern may be informative in some instances where variation is consistent with other character states and where the patterns are stable for individual species. For *Endoclita* as a whole there is no shared pattern for all species currently included, but several species share a distinct triangular shaded discal patch of darker brown with an anterior 'recess' of paler grayish brown in the central anterior discal cell (BUCHSBAUM & GREHAN 2019). The triangular patch does not appear to be applicable to *E. collardi* nov.sp., *E. coomani*, and *E. laosensis* nov.sp. while the condition of the holotype wing of *E. salvazi* does not allow for characterizing this species. All these species have the anterior recess patch (Fig. 10, yellow polygon) and there is also a longitudinal shaded region between Rs4 and M₂ (Fig. 10). In addition, there is a darker brownish black transverse spot extending close to the terminus of CuP across the cell between CuA₂ and CuP+A in *E. laosensis* nov.sp. and possibly *E. salvazi* and *E. coomani* but not *E. collardi* nov.sp. The transverse cubital spot is present in a number of other *Endoclita* species, including *E. akasama* TINDALE, 1958 (Indonesia, Java), *E. damor* (MOORE, 1850) (northern India), *E. fujianodus* (China, Fujian), *E. gmelina* TINDALE, 1941 (Myanmar), *E. hosei* TINDALE, 1941 (Indonesia, Borneo), *E. ijereja* TINDALE, 1958 (Indonesia, Borneo), *E. kara* TINDALE, 1958 (Indonesia, Java), *E. paraja* TINDALE, 1958 (Indonesia, Borneo), *E. raapi* TINDALE, 1958 (Indonesia, Sumatra), *E. sericeus* (SWINHOE, 1901) (Indonesia, Java), *E. taranu* TINDALE, 1958 (Indonesia, Sumatra), *E. tosa* TINDALE, 1958 (Indonesia, Java), and *E. undulifer* (WALKER, 1869) (India, Assam) (JRG pers. obs). The Rs4-M₁ stigma is also present in many of these species, but the poor condition of many types prevents detailed comparison at this time.

Distribution and Habitat

Each of the six species from northern Laos and Vietnam are represented by single localities other than *E. laosensis* nov.sp. from both Kiew Mak Nao and Mt. Phu Phan. (Fig. 26). The type localities of *E. salvazi* (Thado, near Nong Het, cf. COTTON & RACHEL 2006) and *E. topeza* (Xiang Khong) are only about 30 km apart and both are less than 80 km south of Mt. Phu Phan. The type locality for *E. coomani* is Hòa Bình Province about 105 km eastwards of Mt. Phu Phan while *daenlao* nov.sp. is 225 km northwest of Kiew Mak Nao. The Laotian species are from a region that still predominantly forested, although interspersed with urban areas and grasslands (Fig. 27). Seasonal records for *Endoclita* in Laos are 14 April (*E. topeza*) and 6 June (*E. salvazi*) (TINDALE 1958), 3 May (*E. laosensis* nov.sp.) and 15 June (*E. collardi* nov.sp.) which are centered on the warmer months and increased rainfall as indicated for Luang Prabang in northern Laos where the warmest month is May and rainfall increases substantially from April, peaking in August and declining by the end of October <https://en.climate-data.org/asia/laos/luang-prabang/luang-prabang-1309/>, last accessed December 16, 2018).

The type locality of *E. daenlao* lies within Doi Pha Hom Pok National Park which includes Thailand's second highest mountain in Thailand (at 2,285m) and covers 524 km² of mountainous terrain in the Daen Lao Range on the Thai-Myanmar border. At 2000 m, the type locality lies near the uppermost elevation for this region where mountains reach up to 2,100 m (SRISUKA *et al.* 2015). The November record is soon after the rainy season of May-September (<http://www.thaifocus.com/climate.htm>, last accessed November 2018). This period presumably allows for sufficiently moist conditions for egg and early instar development in the surface detritus of the forest floor while older instars transfer to bore into host plants before the onset of dryer winter conditions. Doi Pha Hom Pok National Park is mostly forested with some localized areas of farming (cf. SRISUKA *et al.* 2015).

Acknowledgements

Type specimens of *E. salvazi* and *E. topeza* were kindly made available for dissection by Jason Dombroskie (CUIC). Joël Minet (MNHN) kindly provided holotype photos of *E. coomani*. We are also grateful to John Rawlins and Jane Hyland (Carnegie Museum of Natural History, Pittsburgh, USA) for access to facilities and photography, and to Eric Schoeters (Haacht, Belgium) for assistance with examination of specimens.

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Figures

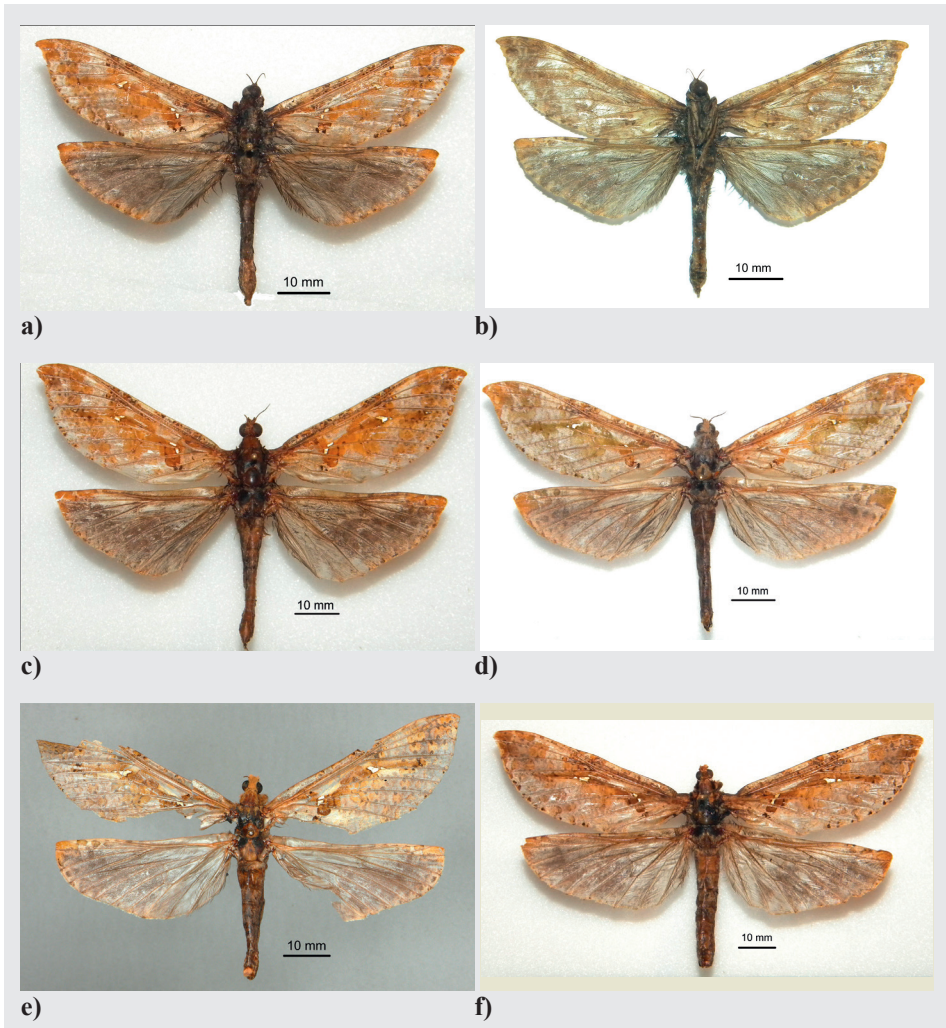


Fig. 1: *Endoclita laosensis* nov.sp.: **(a)** HT dorsal view, **(b)** HT ventral view, from Kiew Mak Nao; **(c-d)** PT males, **(e-f)** PT female, all from Mt Phu Phan, Laos. Figure 1e: Photo C. MIELKE. All other Photos Benny DE GROOF.

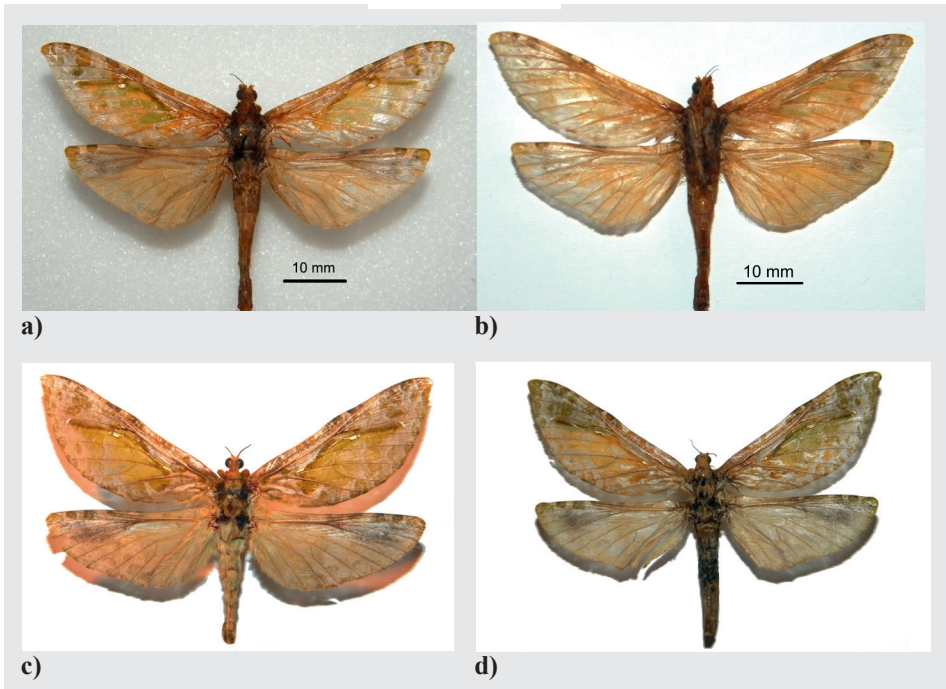


Fig. 2: *Endoclita collardi* nov.sp.: (a) HT dorsal view, (b) HT ventral view, (c) PT male – unscaled, (d) PT female – unscaled. All from Laos, Mt Phu Phan. Photos Benny DE GROOF.

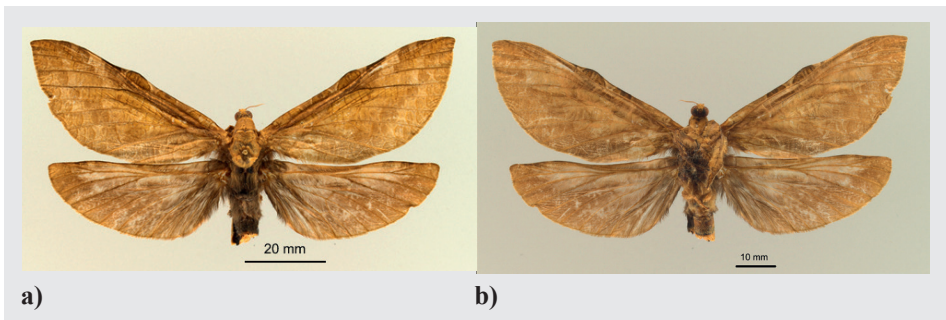


Fig. 3: *Endoclita daenlao* nov.sp.: (a) HT dorsal view, (b) HT ventral view. Photo Jayne HYLAND.

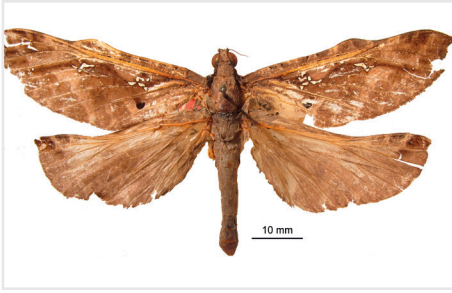


Fig. 4: *Endoclita salvazi*, HT male (CUIC). Photo Jason DOMBRONSKI.



Fig. 5: *Endoclita topeza*, HT female (CUIC). Photo Jason DOMBRONSKI.

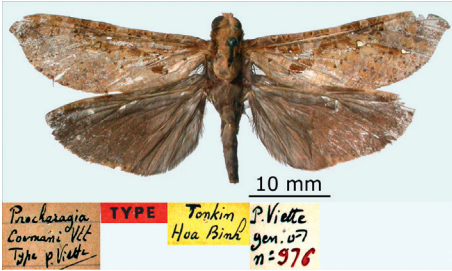


Fig. 6: *Endoclita coomani*, HT male (MNHN). Photo Joël MINËT.

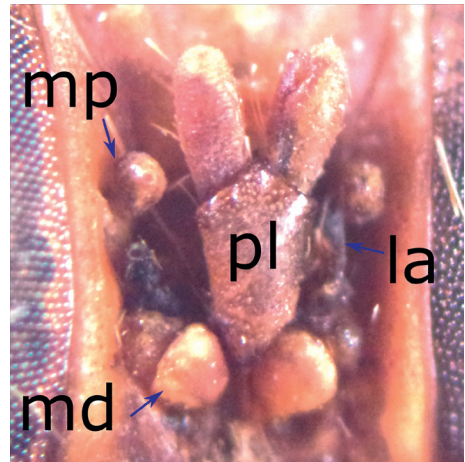


Fig. 7: *Endoclita daenlao*, HT mouthparts: la – lacinia, md – mandible, mp – maxillary palp, pl – prelabium.

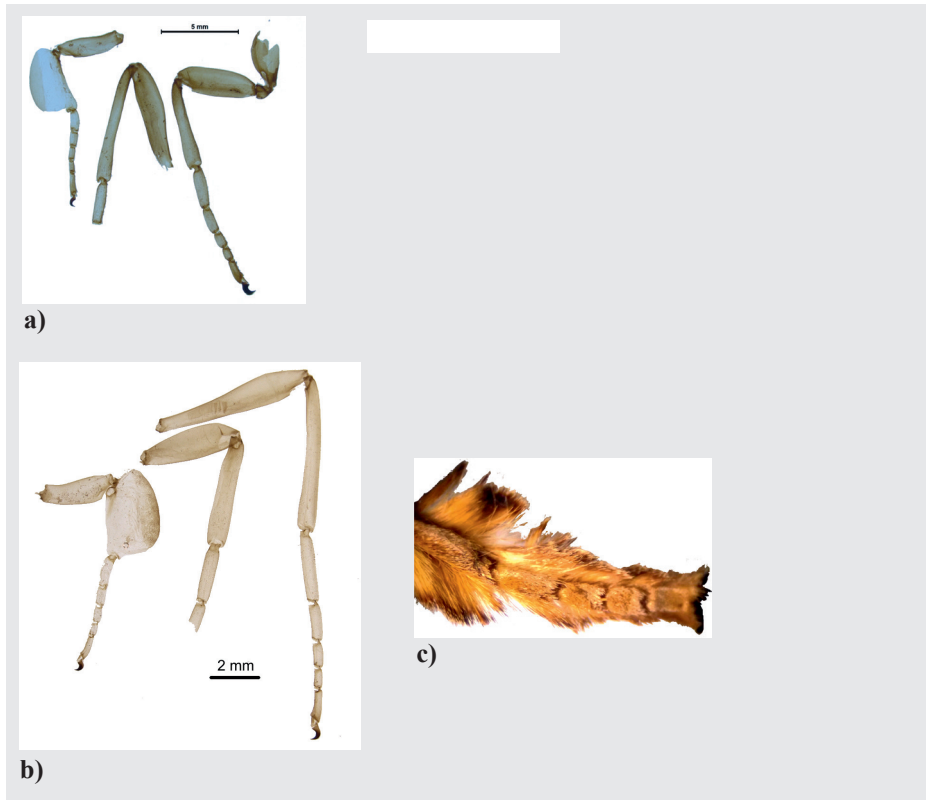


Fig. 8: Legs: **(a)** *Endoclita laosensis* HT, left to right – meta-, meso-, proleg; **(b)** *E. collardi* HT, left to right meta-, pro-, mesoleg. Photos Nikolai IGNATEV; **(c)** *E. daenlao* HT ventral protarsus– unscaled. Photo John GREHAN.

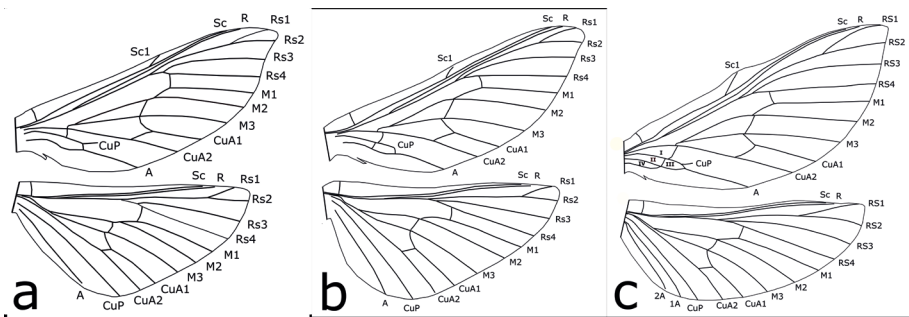


Fig. 9: Wing venation, all from HT's **(a)** *Endoclita laosensis* nov.sp.HT, **(b)** *E. collardi* nov. sp. HT, **(c)** *E. daenlao* nov.sp. HT. Photo John GREHAN.

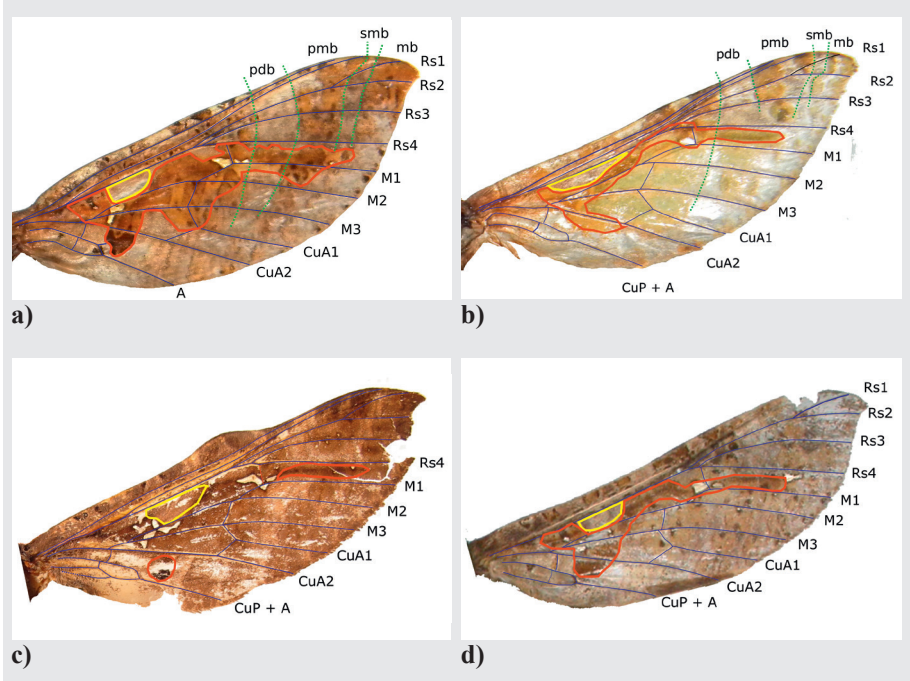


Fig. 10: FW patterns. Yellow outline – anterior recess with pale shading, red outline – region of darker shading. **(a)** *Endoclita laosensis* nov.sp. HT, **(b)** *E. collardi* nov.sp., **(c)** *E. salvazi*, **(d)** *E. coomani*.

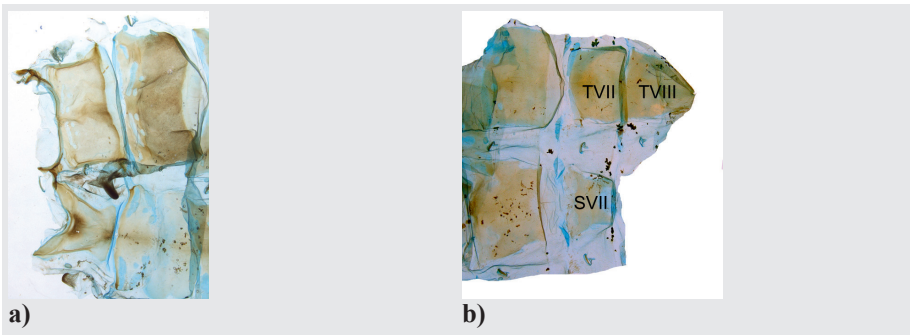


Fig. 11: *Endoclita laosensis* nov.sp. HT abdominal sclerites – unscaled: **(a)** anterior, **(b)** posterior. Photos Kyhl AUSTIN.

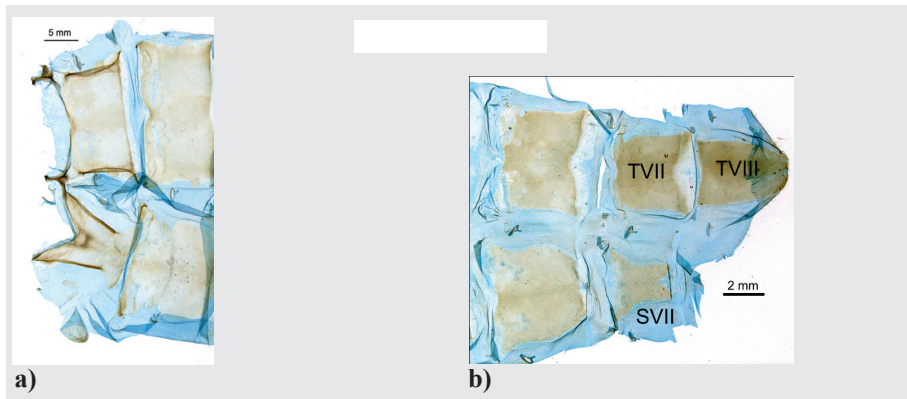


Fig. 12: *Endoclita collardi* nov.sp. HT abdominal sclerites: (a) anterior, (b) posterior. Photos Kyhl AUSTIN.

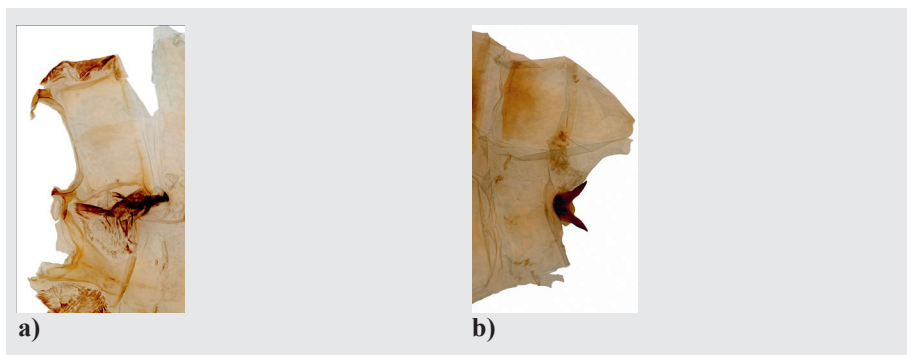


Fig. 13: *Endoclita salvazi* HT abdominal sclerites: (a) anterior, (b) posterior. Photos Kyhl AUSTIN.

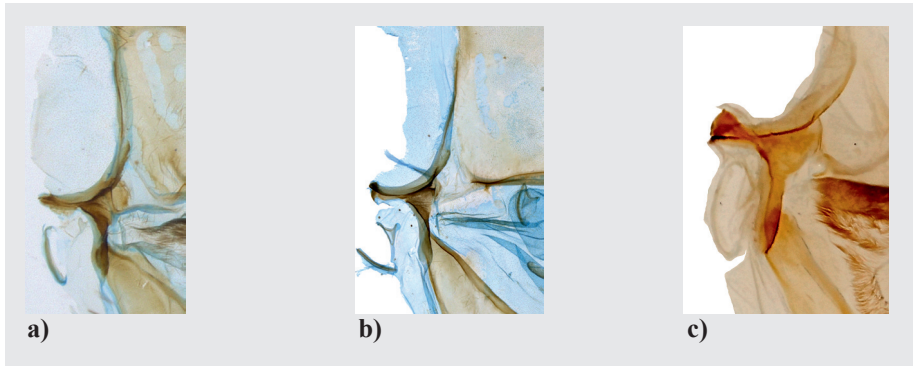


Fig. 14: Tergosternal connection: (a) *Endoclita laosensis* nov.sp. HT, (b) *E. collardi* nov.sp., (c) *E. salvazi* – unscaled. Photos Kyhl AUSTIN.

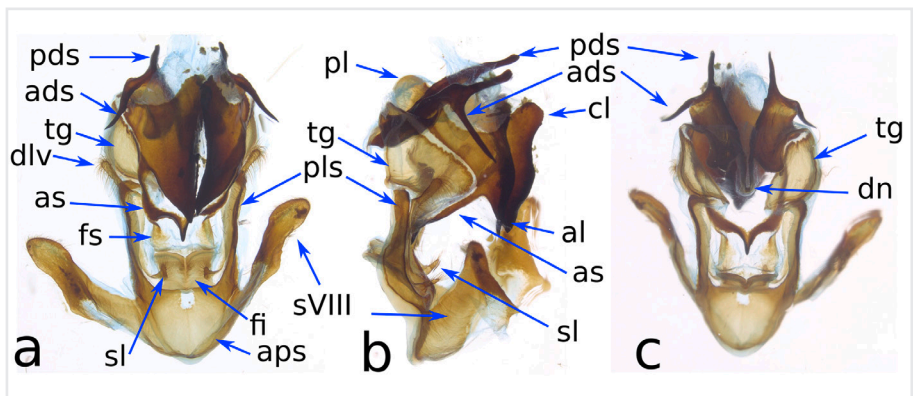


Fig. 15: *Endoclita laosensis* HT male genitalia – unscaled: a) ventral, (b) lateral, (c) dorsal (interior). ads – anterio-dorsal spine of pseudotegumen, al – anterior lobe of pseudotegumen, aps – apodemal suture, as – ascending spine of pseudotegumen, cl – central lobe of pseudotegumen, dlv – distal lobe of valve, dn – dorsal nexus of pseudotegumen, fi – fultura inferior, fs – fultura superior, pds – posterior-dorsal spine of pseudotegumen, pl – posterior lobe of pseudotegumen, pls – postero-lateral saccus, sl – sacculus lobe of valva, sVIII – sternum VIII of abdomen, tg – tegumen.

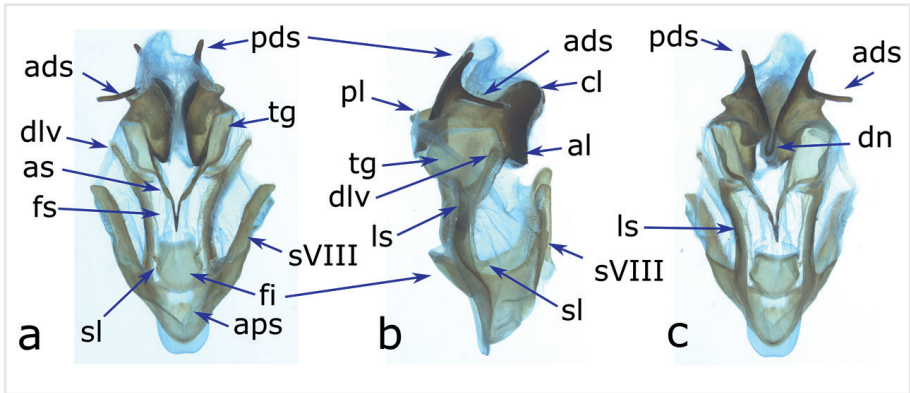


Fig. 16: *Endoclita collardi* HT male genitalia. a) ventral, (b) lateral, (c) dorsal (interior). Labels as for *E. laosensis* – unscaled. Photo Nikolai IGNATEV.

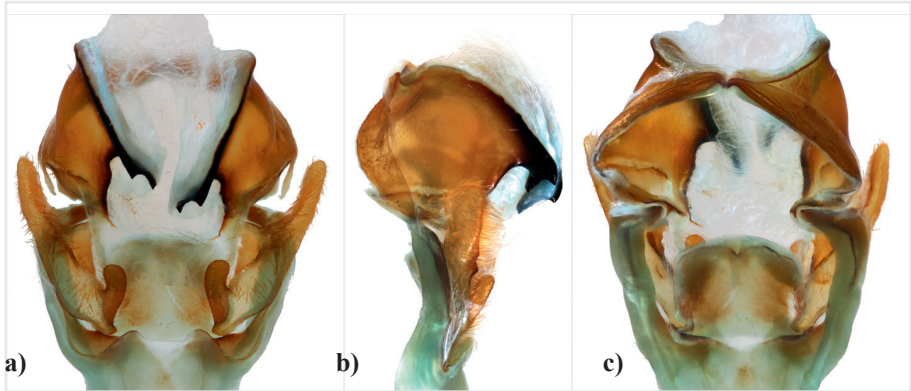


Fig. 17: *Endoclita salvazi* HT male genitalia (a) ventral, (b) lateral, (c) dorsal (interior) – unscaled. Photos Kyhl AUSTIN.

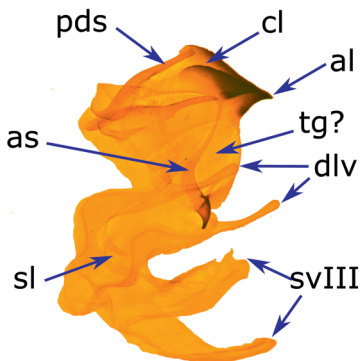


Fig. 18: *Endoclita coomani* HT male genitalia, lateral view – unscaled. Photo Joel MINET. al – anterior lobe of pseudotegumen, as – ascending spine of pseudotegumen, cl – central lobe of pseudotegumen, dlv – dorsal lobe of valve, pds – postero-dorsal spine of pseudotegumen, sl – sacculus lobe of valve, svIII – sternum VIII, tg? – tegumen?

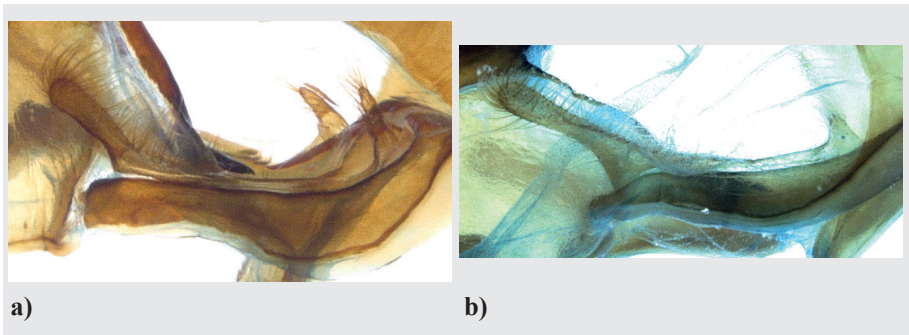


Fig. 19: Lateral view of valva – unscaled: (a) *Endoclita laosensis*, (b) *E. collardi* HT. Photos Kyhl AUSTIN.

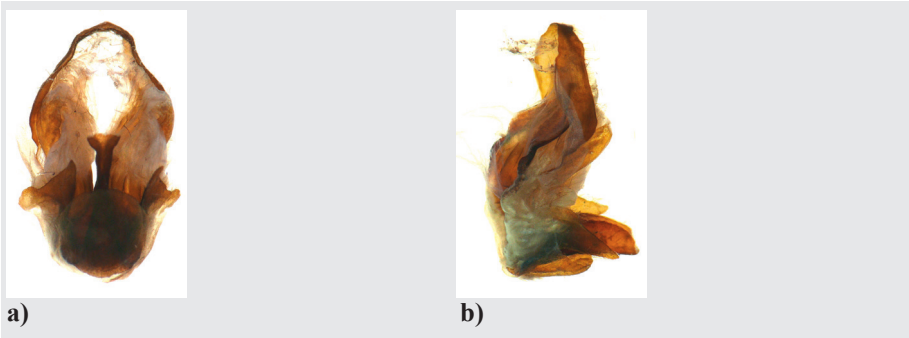


Fig. 20: *Endoclita laosensis* nov.sp. external female genitalia – unscaled. (a) posterior view, (b) lateral view. Photo Carlos MIELKE

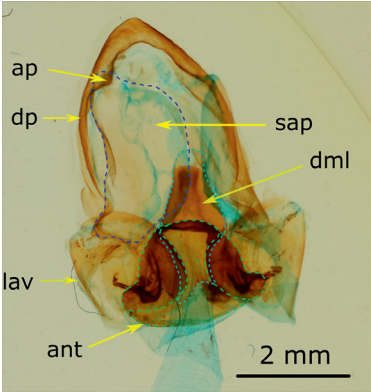


Fig. 21: *Endoclita daenalo* HT nov. sp. external female genitalia. ap – anal papilla, ant – antrum, dp – dorsal plate of tergum IX, lav - lateral lobe of antevaginalis, dml – dorsal medial lobe of antevaginalis, sap – subanal plate. Photos Nikolai IGNA-TEV.



Fig. 22: *Endoclita topeza* HT external female genitalia – unscaled. Photo Kyhl AUSTIN.



Fig. 23: *Endoclita laoesis* PT nov.sp. internal female genitalia. Photo Carlos MIELKE.



Fig. 24: *Endoclita topeza* HT internal female genitalia. Photo Kyhl AUSTIN.

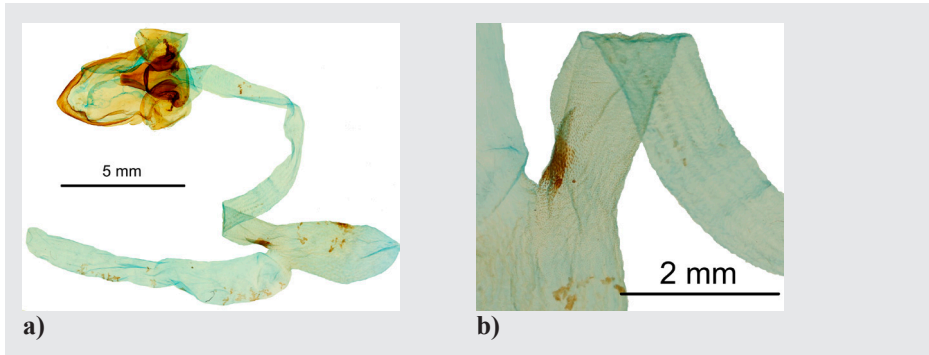


Fig. 25: *Endoclita daenalo* nov.sp. (a) internal female genitalia, (b) spicules at junction of ductus bursae and corpus bursae. Photos Nikolai IGNATEV.

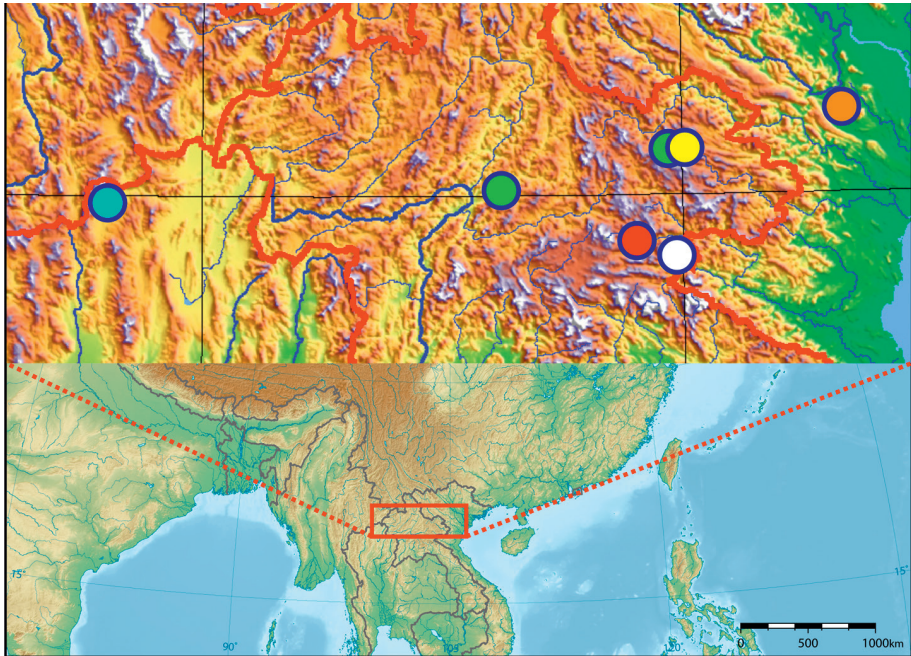


Fig. 26: Specimen localities for *Endoclita* in northeastern Laos and south western Vietnam: green circle: *E. laosensis* HT (Kiew Mak Nao) and PT (Mt. Phu Phan); yellow circle, *E. collardi* HT (Mt. Phu Phan); red circle, *E. topeza* holotype (Xiang Khong); white circle *E. salvazi* holotype (Nong Het), orange circle, *E. coomani* HT (Tonkin, Hoa Binh); blue circle *E. daenlao* HT (Mt. Doi Pha Hom Pok).

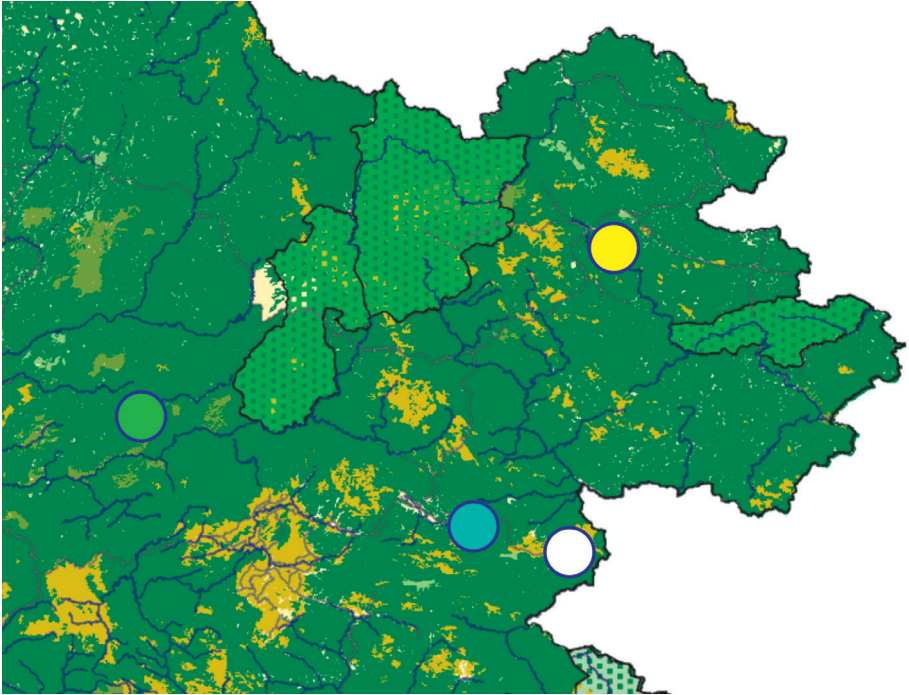


Fig. 27: Specimen localities in northeastern Laos mapped on to predominant land use. Reproduced by permission of CEM, 2003: Lao PDR National Report on Protected Areas and Development. Review of Protected Areas and Development in the Lower Mekong River Region, Hanoi, Vietnam. Available from: <http://icem.com.au/portfolio-items/special-reports-series-protected-areas-and-development/>



Fig. 28: Forest habitat at Mt. Phu Phan. Collecting site for *Endoclista collardi* nov.sp. and *E. laosensis* nov.sp. Photo by Steeven COLLARD.

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