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A note on the genitalia of *Endoclita signifer* (Walker) and *E. chalybeatus* (Moore) (Lepidoptera: Hepialidae) from the Indo-Burma region of southern Asia

John R. Grehan¹, Carlos C. G. Mielke¹, John E. Rawlins[†]

¹McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, University of Florida Gainesville, Florida, USA.

Email: calabar.john@gmail.com & cmielke1@uol.com.br

[†](posthumous). Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, USA.

Abstract

Female genitalia attributed to *Endoclita signifer* (Walker) and *E. chalybeatus* (Moore), and male genitalia attributed to *E. chalybeatus*, are redescribed and illustrated. Comparisons are made to earlier published diagrams of *Endoclita* genitalia. Our observations corroborate earlier determinations by Tindale that *E. signifer* is restricted to the Indian state of Meghalaya and the northern Bangladesh division of Sylhet. While the previously published distribution of *E. chalybeatus* extends between the region of northern West Bengal state (holotype location) of India and southern Burma, all records outside the immediate vicinity of the holotype locality require future verification through examination of genitalia for those and any additional specimens. The restricted range of *E. signifer* is particularly significant for forest management as species in southern China attributed to this species are probably either *E. vietnamensis* Grehan & Buchsbaum) or another species.

Keywords

Bangladesh, fauna, India, morphology, Myanmar, species, taxonomy

Introduction

Morphological differences in genitalia are often critical for clarifying probable species of Hepialidae, especially where external features such as wing pattern are sometimes highly variable, or show no consistent differences between species (e.g. *Wiseana* Viette (Dugdale 1994), *Dalaca* Walker (Nielsen & Robinson 1983)). The wing patterns of many *Endoclita* C & R. Felder species are similar, and while external differences may be present for these species, there is a lack of large verified samples to evaluate this possibility. In his taxonomic revisions of *Endoclita*, Tindale (1941, 1958) drew attention to genitalic differences for distinguishing species, but most of his comparisons and illustrations were of un-dissected specimens so that externally visible features only were documented and illustrated as diagrams. Even this limited approach to species delimitation provided an effective method to distinguish *Endoclita* species. Recent studies have continued to focus on genitalic morphology as an effective approach for recognizing new species (e.g. Buchsbaum *et al.* 2018, 2022; Buchsbaum & Grehan 2019; Grehan & Mielke 2019; Grehan *et al.* 2019, 2022).

Two examples of externally similar species with an overlapping geographic range in northeastern India are *Endoclita signifer* (Walker, 1856) and *E. chalybeatus* (Moore, 1879). The type series and other specimens of each species housed in the NHMUK (Natural History Museum, London, United Kingdom) were examined by Tindale (1941). He concluded that each species could be distinguished by the shape of the median dorsal spine of the lamella antevaginalis in the female genitalia. To corroborate his assessment, and to provide additional details of male genitalia (*chalybeatus* only), we borrowed a sample of two specimens from the NHMUK

assigned to each species. We present here the results of our dissections of this material and discuss the taxonomic implications.

Methods

Specimens were dissected by removing the abdomen that was then treated in a warm solution of 5% KOH for two hours. The abdomen was opened by a right lateral cut from the tergo-sternal bar to the genitalia, the latter being removed and preserved in ethyl alcohol along with the abdominal integument. Internal female genitalia, where intact, were stained with Chlorazol Black. Terminology for genitalia follows Mielke & Casagrande (2013) and Grehan *et al.* (2021). Labels of quoted verbatim, each separated by a forward slash.

Abbreviations

NCBS (Biodiversity Lab Research Collections, National Centre for Biological Sciences, Tata Institute of Fundamental Research, Bengaluru, India).
NHMUK (Natural History Museum, London, United Kingdom).
SAMA (South Australian Museum, Adelaide, South Australia, Australia).

Results

1. *Endoclita signifer* (Walker, 1856)

(Figs. 1a, 1b, 1c, 1d, 1e, 4a, 4b, 4c, 7)

Examined material

All India: 1 ♀ “Jaintia Hills, Assam [eastern Meghalaya] / ex. Coll. Swinhoe / NHMUK 010921482 / dissection JRG F324” (Fig. 1a); 1 ♀ “Khasi, Nat. Coll / NHMUK 010921481 / dissection JRG F325” (Fig. 1b); 1 ♀ “6. PHASSUS SIGNIFER / Type / 47... / BMNH(E)1626946” (Photo only; Fig. 1c); 1 ♂ “Phassus signifer Walk ♂ Assam-Khasia Hills, H.J. Elwes, I18934, Allotype ♂ [Tindale's handwriting] / id as signifer Walk / NB Tindale 3.1938 [signature] / Phassus signifer Walk ♂ compd with type / SAMA Database No. 31-000549” (Photo only; Fig. 1d); 1 ♀ “Phassus signifera [sic] Walk ♀, compared with type, a ♀ agrees closely in genit. Details (see sketch of type) / signifer Walk ♀ in Tring / Khasia Hills, Assam / SAMA Database No. 31-015516” (Photo only; Fig. 1e).

Genitalia

The external female genitalia of the dissected specimens have an apically narrow medial-dorsal spine on mesal lobe of lamella antevaginalis (Figs. 4a, b), and in this respect they correspond closely to Tindale's (1941) illustration of the spine in the lectotype of *E. signifer* from Sylhet (Fig. 4c). The bursa copulatrix was not recovered intact in specimen F324, but in specimen F325 it comprises a narrow ductus bursae that is sub-equal in length to the rounded corpus bursae and diverticulum. The diverticulum is about twice the length of the corpus bursae (Fig. 7).

2. *Endoclita chalybeatus* (Moore, 1879)

(Figs. 2a, 2b, 2c, 5a, 5b, 8a, 8b, 8c, 8d)

Examined material

1 ♀ “no data, NHMUK 010921484 / dissection JRG F323” (Fig. 2b); 1 ♂ “India, Sikkim, 4 [...] [18] 89 / J.G. Picher / Adams Bequest BM1912-399 / NHMUK 010921483 / dissection JRG M326” (Fig. 2c); 1 specimen “Abdomen missing / Moore Coll. 94-106 / Type / Phassus chalybeatus ♂ / BMNH(E)162694” (Photo only; Fig. 2a).

Genitalia

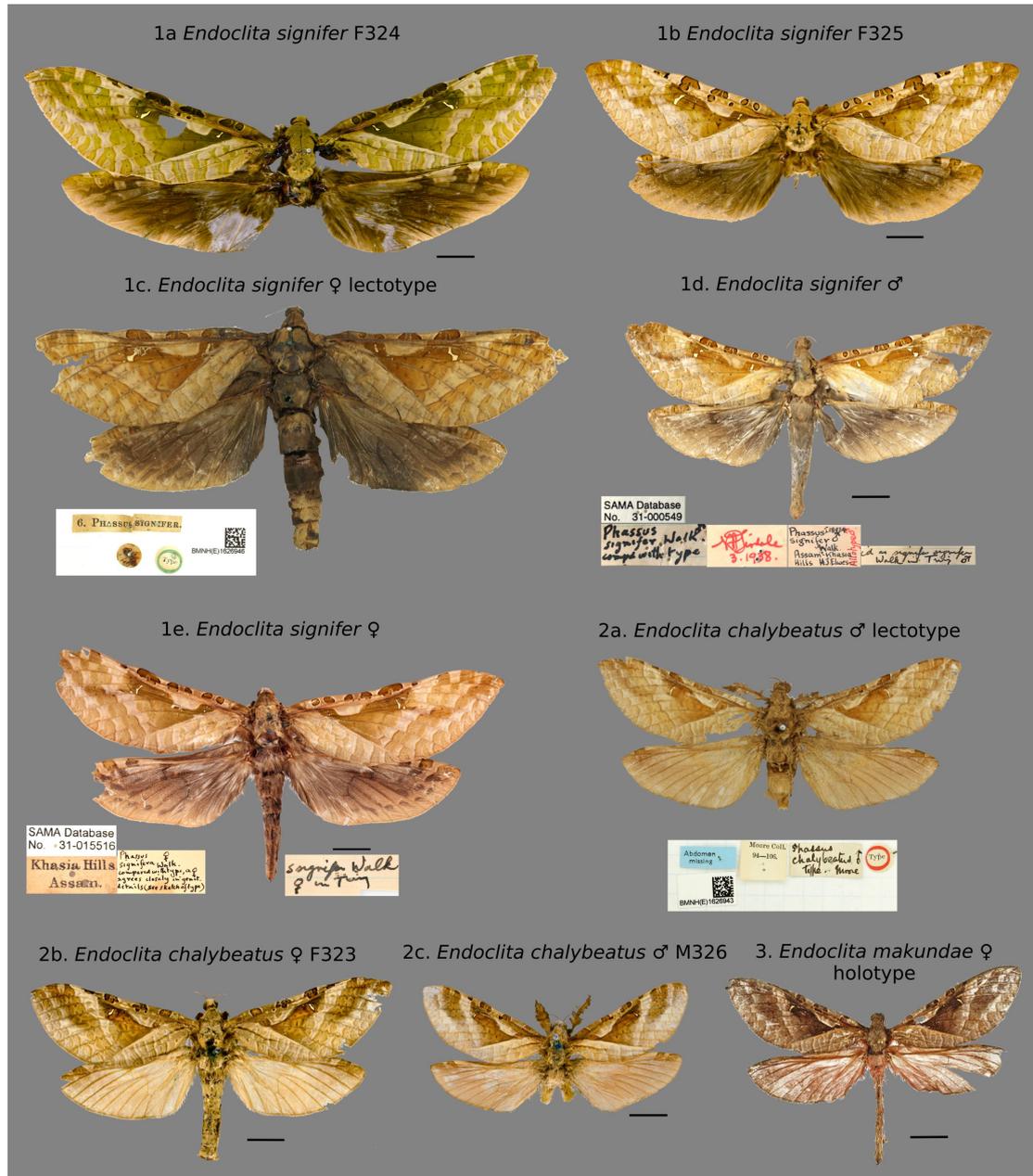
The external female genitalia of dissection F323 has an apically broad medial dorsal spine (Fig. 5b) which corresponds to Tindale's (1941) diagrammatic illustration of a female *E. chalybeatus* (Fig. 5a). The male genitalia of specimen M326 comprise an elongate pseudotegumen with a 'medial bridge' across postero-ventral median (Fig. 8a). The pseudotegumen ventral apex broad, sub-rectangular and distally rounded. Anogenital margin smooth, without any projections. Tegumen narrow, ventrally fused with the pseudotegumen bridge, and saccus medial posterior margin has a narrow, elongate spine. Postero-dorsal pseudotegumen forms a broad shelf (Fig. 8c) that narrows to dorsal medial junction (Fig. 8d). Lateral margins of the fultura inferior are concave.

Discussion

Walker's (1856) original description of *Phassus signifer* did not specify a primary type. He listed the following specimens: a. Silhet [Sylhet, now in Bangladesh]. From Mr. Argent's collection; b, c. Ceylon [Sri Lanka]. Presented by R. Templeton, Esq.; d. Sarawak, Borneo. From Mr. Horsburgh's collection." Tindale (1941: 30) recognized the Sylhet specimen as the female 'type' and in this respect the specimen (Fig. 1c) represents the lectotype for *E. signifer*. He concluded that the Sri Lanka and Sarawak specimens were not conspecific with the 'type' from Sylhet, and that *E. signifer* could be applied only to specimens from Khasia Hills, Jaintin Hills, and Cherrapunji (Fig. 10a). Further taxonomic evaluation of *Endoclita* by Tindale (1958) supported this conclusion, as all specimens he surveyed across southeastern Asia were found to be morphologically distinct from *E. signifer*. A male specimen in the SAMA collection (Fig. 1d) is labelled by Tindale (handwriting same as a label with his signature) as an allotype, but this designation is incorrect as no allotype was assigned in the original description of the species by Walker (1856).

At this time there is genitalic corroboration for the presence of *E. signifer* only within the Indian State of Meghalaya and the Bangladesh Division of Sylhet (or possibly Sylhet as the capital city of Sylhet division). A review of earlier literature by Tindale (1941) indicated that at one time or another, most of the common Oriental species of *Endoclita* (as '*Phassus*') had been regarded as synonyms under *E. signifer*. Continued reference to a widespread *E. signifer*, beyond the Meghalaya-Sylhet region (e.g. Yang *et al.* 2013, Das & Singh 2022) cannot be substantiated, as previously noted by Buchsbaum *et al.* (2022).

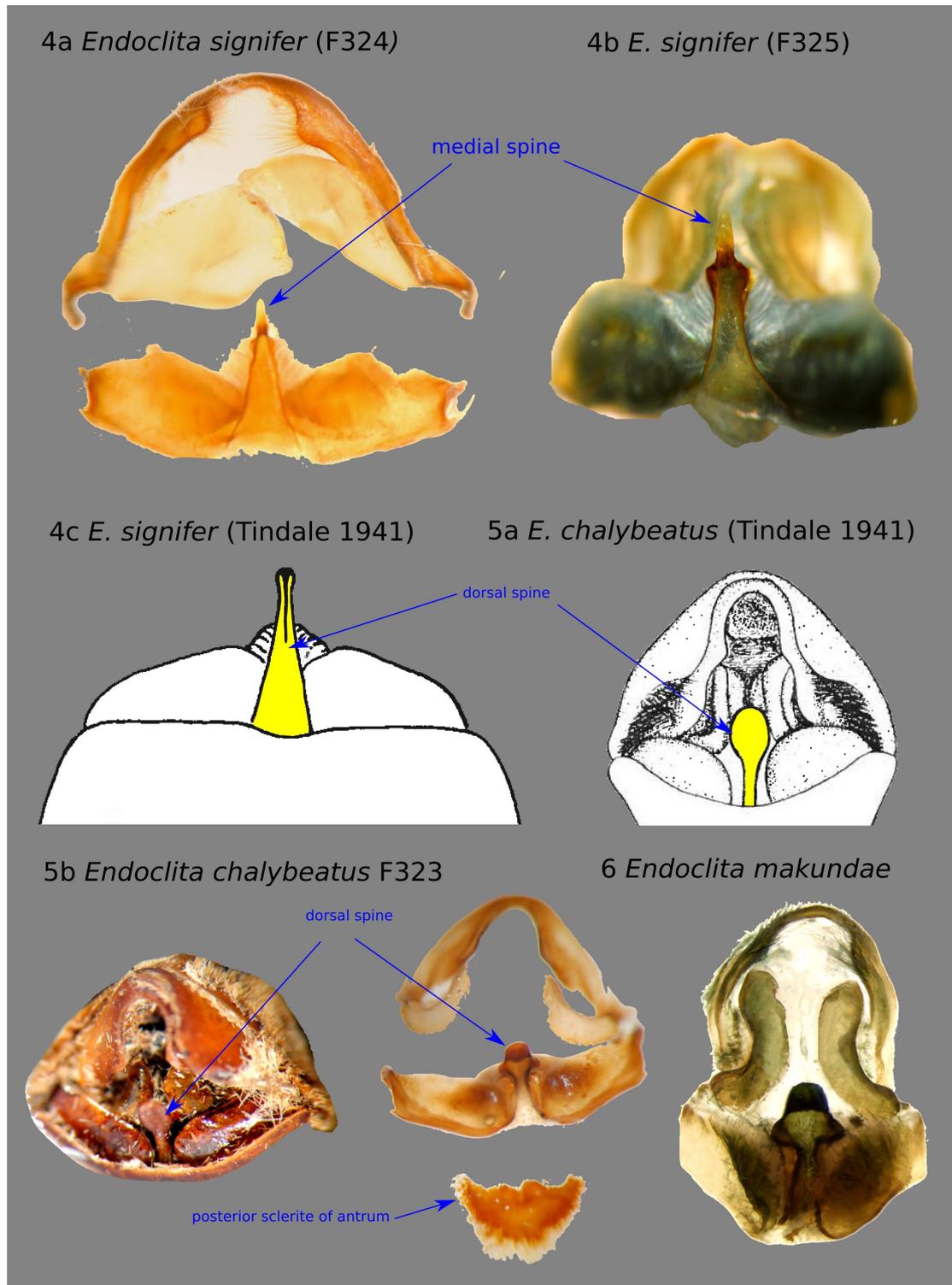
Moore's (1879) description of *E. chalybeatus* referred to at least one male, and one female, from Darjeeling (West Bengal), but Tindale (1941) found a single specimen only in the NHMUK collection (labeled Moore Coll. 94-106). He identified the specimen as a female and referred to it as the type (= lectotype). The specimen (Fig. 2a) includes a handwritten label (by unknown author) identifying the specimen as the 'type' and as a male. As noted by Tindale (1941), the abdomen has been missing since 1936. If the hindlegs are present, it will be possible in the future to confirm the sex by the presence or absence of metatibial androconia. The missing abdomen precludes any definitive comparison of genitalia with the lectotype. The external wing pattern of the M326 dissection specimen (Fig. 2c) conforms to the lectotype of *E. chalybeatus* (Fig. 2a), and is from the state of Sikkim which is adjacent to the type locality of Darjeeling in West Bengal.



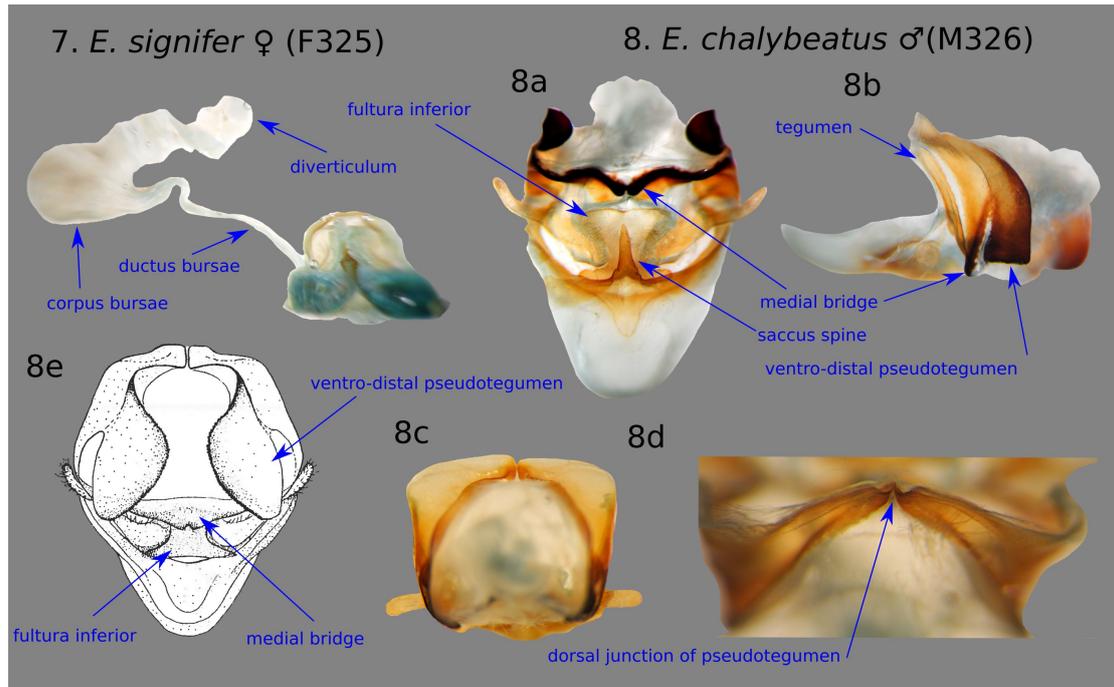
Figures. 1-3. *Endoclita* species: **1a**, *E. signifer* female from Jaintia Hills, Assam [eastern Meghalaya], ex. Coll. Swinhoe, NHMUK 010921482, dissection JRG F324; **1b**, *E. signifer* female from Khasia National Collection. NHMUK 010921481, dissection JRG F325; **1c**, *E. signifer* lectotype female from Sylhet, NHMUK 1626946, 47-36; **1d**, *E. signifer* male from Khasia Hills, SAMA 31-000549 (allotype label, by Tindale, not correct); **1e**, *E. signifer* female from from Khasia Hills, SAMA 31-015516; **2a**, *E. chalybeatus* lectotype, from Darjeeling. NHMUK 1626943; **2b**, *E. chalybeatus* from unknown location, NHMUK 010921484 dissection JRG F323; **2c**, *E. chalybeatus* male from Sikkim, NHMUK 010921483, dissection JRG M236; **3**, *E. makundae* holotype female from Patharkandi, Karimganj, Assam, India. NCBS. Figs. 1a-c, 2a-c photos by David Lees, reproduced by permission of the Trustees of the Natural History Museum; Figs. 1d-e photos by Peter Hudson (SAMA); Fig. 3 photo by Ujwala Pawar (Tata Institute of Fundamental Research).

Tindale (1941) described and illustrated male genitalia that he attributed to *E. chalybeatus* (Fig. 8e), but the specimen is from Mohnyin in central-northern Myanmar, about 800 km southeast of the type locality. The general shape of Tindale's (1941) male *E. chalybeatus* specimen from Mohnyin is similar in shape to dissection M326 (Fig. 8a) but appears to have a proportionally much larger expansion of the

ventro-distal pseudotegumen. There also appears to be no saccus spine. The apparent absence of this feature in particular raises uncertainty about conspecificity between the Mohnyin specimen and *E. chalybeatus*.



Figures. 4-6. *Endoclita* female genitalia: **4a**, *E. signifer* dissection JRG F324 (Jaintia Hills), **4b**, *E. signifer* dissection JRG F325 (Khasi National Collection); **4c**, *E. signifer* lectotype female genitalia, ventral habitus view, from Tindale (1941); **5a**, *E. chalybeatus* ventral habitus female genitalia from a Natural History Museum, United Kingdom specimen as illustrated by Tindale (1941: fig. 19); **5b**, *E. chalybeatus* external female genitalia, dissection JRG F323, left - habitus view, right - dissected; **6**, *Endoclita makundae*, from Buchsbaum *et al.* (2022).



Figures. 7-8. *Endoclita* genitalia: 7, female genitalia of *E. signifer* (dissection JRG F325); 8, *E. chalybeatus* male genitalia: a, ventral view, b, lateral view, c, posterior view, d, dorsal view of junction of pseudotegumen (dissection M326). 8e, ventral view of genitalia dissected by Tindale (1941) from a specimen found in Mohnyin, Myanmar.

Several localities were designated by Tindale (1941) for *E. chalybeatus* in Myanmar (Fig. 9b), but he did not directly confirm that the genitalia of female specimens from these localities conformed to the structure illustrated for the Darjeeling female specimen (Fig. 5a). In noting that the abdomen was missing from the female type, Tindale (1941) noted that the “...Darjeeling female example described herein compares so well in other respects that the genitalia of it may be regarded as typical of this species.”

We therefore conclude:

(1) *E. signifer* is a species of central and eastern Meghalaya and northern Bangladesh (Fig. 9a) that can be recognized by female genitalia with a narrowly pointed medial dorsal spine on the mesal lobe of the lamella antevaginalis

(2) *E. chalybeatus* occurs in the vicinity of the boundary between the states of Sikkim and West Bengal, as indicated by the locality of the type specimen, but the species may have a wider distribution in Meghalaya, Bangladesh, and Myanmar as indicated by Tindale (1941) - if the female specimens he examined have a distal expansion of the dorsal spine of the mesal lobe of the lamella antevaginalis, and only if the female genitalia he described and illustrated from Darjeeling do indeed represent *E. chalybeatus*.

The possibility of further species resembling *E. chalybeatus* in the Indo-Burma region is indicated by the discovery of *E. makundae* Grehan, C. Mielke & Kunte (Fig. 3) from southern Assam state (Grehan *et al.* 2022). This species has a similar forewing pattern, but the external female genitalia have a dorsal medial spine that lacks distal expansion (Fig. 6) as found in *E. chalybeatus*. Future review of all available specimens from this region will be necessary to verify whether *E. chalybeatus* has a distribution range as extensive as that documented Tindale (1941). In recent literature there are references to *E. signifer* inhabiting forest trees in southeastern China, but external appearance of the adults (no dissection has been published to date) matches

that of *E. vietnamensis* Buschsbaum & Grehan, 2022 rather than *E. signifer* (Buchsbbaum *et al.* 2022).

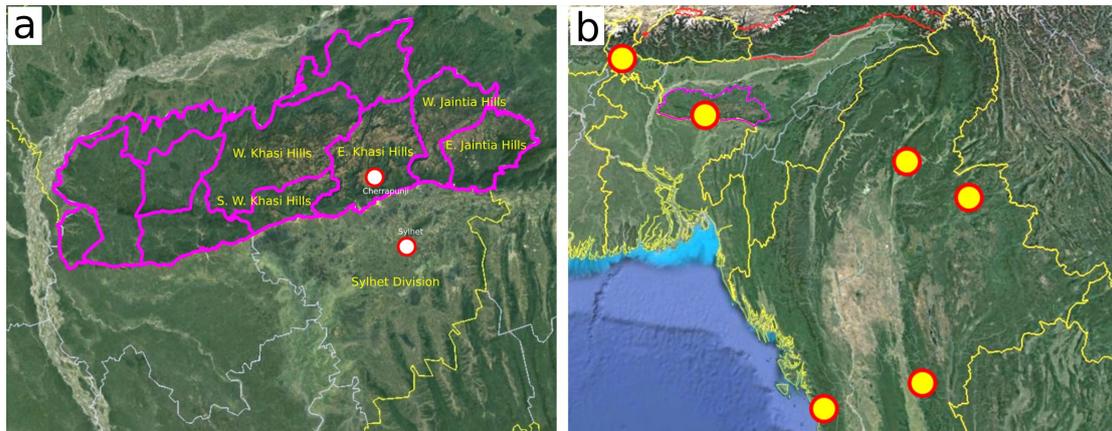


Figure 9. Distribution records in India and Myanmar of (a) *Endoclita signifer*, and (b) *E. chalybeatus* as documented by Tindale (1941). Crimson outline in (a): administrative districts of Meghalaya state. Labeled districts refer to regions reported for *E. signifer* (Khasi Hills, Jantia Hills). Fig. 9b reproduced from Grehan & Ismavel (2017).

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