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A NEW SPECIES OF *ENDOCLITA* C. & R. FELDER, 1874 GHOST MOTH FROM KARIMGANJ DISTRICT OF ASSAM, INDIA, WITH COMMENTS ON THE GENUS IN NORTHEASTERN INDIA, AND CLARIFICATION OF *E. SIGNIFER* (WALKER, 1856) (LEPIDOPTERA: HEPIALIDAE)

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A new species of *Endoclita* C. & R. Felder, 1874 ghost moth from Karimganj District of Assam, India, with comments on the genus in northeastern India, and clarification of *E. signifer* (Walker, 1856) (Lepidoptera: Hepialidae)

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Abstract

A new species, *Endoclita makundae* sp. nov., from the state of Assam, represents the first new species of *Endoclita* described for India in the last 60 years. The external female genitalia are illustrated and described. We suggest the species name *E. signifer* can be applied with confidence only to populations in Meghalaya and northern Bangladesh. Data on genitalic illustrations in the literature are provided for all *Endoclita* species from India. Conservation concerns for *Endoclita* and its forest habitats in northeastern India are discussed.

Keywords

Asia, biodiversity, conservation, Makunda, taxonomy.

Introduction

The widespread eastern and southern Asian genus *Endoclita* has 70 described species and is taxonomically one of the largest genera of ghost moths (Hepialoidea, Hepialidae) (Grehan 2011). The genus includes the largest adult body sizes and wingspans of any Hepialidae in Eurasia; the wingspan of some species reaching about 130 mm. Larvae first develop as fungal feeders on the forest floor and then transition to the principal growth stage when they bore into the stems of trees and shrubs, feeding on callus tissue under a protective web of silk and frass. Larval tunnels in timber or sapling growth in commercial forests results in some species being designated as forestry pests (Grehan & Ismavel 2017, Grehan & Mielke 2017). The genus remains poorly collected, and biological and taxonomic studies are limited to a small number of species. There are indications from recent publications that a substantial number of species remain to be described (e.g. Grehan & Mielke 2016, 2019, Buchsbaum *et al.* 2018, Buchsbaum & Grehan 2019, Grehan *et al.* 2019).

The Indian *Endoclita* fauna includes about 20 species, many of which are endemic to the country. The northeastern region of India, comprising the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, include eight described species (Grehan & Ismavel 2017). The taxonomy of Indian *Endoclita* is impeded by the lack of unique morphological features documented for both males and females of each species. The last substantive taxonomic reviews were by Tindale (1941, 1942) who included photos of each

species along with genitalic descriptions and diagrams, although they are not always sufficient for accurate species identification. As a further contribution to understanding the *Endoclita* fauna of India, we describe a single female specimen as a new species that can be differentiated from other members of the genus in northeastern India through a combination of wing pattern and female genitalic morphology.

Materials & Methods

A female *Endoclita* specimen was collected at the Makunda Christian Leprosy and General Hospital, Karimganj District, Assam, India, and deposited in the Biodiversity Lab Research Collections (<http://biodiversitycollections.in>) at the National Center for Biological Sciences, Bengaluru. Genitalia were dissected by removing the abdomen which was treated in a cold solution of 5% KOH solution for more than 12 hours. The abdomen was opened by a right lateral cut from the tergo-sternal bar to the genitalia which was removed, stained with methylene blue, and preserved in glycerol along with the abdominal integument. Terminology follows Grehan *et al.* (2021). Wing venation diagrams were drawn over photographic images using InkScape® software.

Abbreviations

FW (forewing), HW (hindwing)

NCBS (Biodiversity Lab Research Collections, National Centre for Biological Sciences, Tata Institute of Fundamental Research, Bengaluru)

CMNH (Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, USA)

NHMUK (Natural History Museum United Kingdom, London, UK)

Taxonomic section

Endoclita makundae sp. nov. Grehan, Mielke & Kunte

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Figs. 1a-f, 2a, 3a-g, 4a-d, 5a, c-d

Holotype: ♀, Campus of the Makunda Christian Leprosy and General Hospital, Patharkandi, Karimganj, Assam, India. 28 February 2019. GPS 23.434227 N, 92.324692 E.

Holotype deposited in the Biodiversity Lab Research Collections at NCBS.

Etymology: Named for the Makunda Christian Leprosy and General Hospital. A noun in the genitive singular meaning “of Makunda”.

Diagnosis

The FW of *Endoclita makundae* n. sp. has a prominent dark brown discal patch, oblique broken transverse lines between the veins, and a sub-rectangular projection of the dorsal margin of the medial sclerite of the antevaginalis that is distally narrower with a rounded edge. *Endoclita chalybeatus* (Moore, 1879) (Fig. 2c), and *E. signifer* (Walker, 1856) (Fig. 2b) have similar FW patterns. The dorsal margin of the medial sclerite in the female of *E. chalybeatus* is oval in shape (Fig. 5e) while in *E. signifer* it narrows to a thin, elongate point (Fig. 5f). The FW patterns of *E. makundae* sp. n. is distinct from those of the other northeastern species *E. aboe* (Moore, [1860]) (Fig. 2h), *E. albosignata* (Tindale, 1941) (Fig. 2f), *E. aruatus* (Hampson, [1893]) (Fig. 2g), *E. damor* (Moore, [1860]) (Fig. 2d), *E. rustica* Tindale, 1941 (Fig. 2d), and *E. undulifer* (Walker, 1869) (Fig. 2i).

Description

♀ (Figs. 1a, 1b). Wingspan ~ 73 mm, FW length: 36 mm, width: 14 mm; HW length: 30 mm, width: 13 mm.

Head (Fig. 3a): Covered with dense greyish brown, piliform scales. Antenna greyish brown, filiform; scape barrel-shaped, covered with piliform scales. Labial palps mono-segmented, ovoid (Fig. 3b).

Thorax: Pro and mesothorax dorsally covered with dense, greyish brown piliform scales, metathorax with yellowish to pale reddish-brown scales other than most of scutum III where the brownish-black cuticle is exposed in spread specimen (Fig. 3f). FW covered mostly by lamellar scales (Fig. 4) interspersed with elongate lamellar scales such as near the central anterior FW (Fig. 4a), margins of transverse lines (Fig. 4c), and outer margin (Fig. 4d). Costal margin almost straight, slightly convex in vicinity of Sc1 (Fig. 3e), outer and posterior margins forming continuous curve without tornus. Venation 'hepialine' (Fig. 3d), Sc1 present in FW: common stalk of Rs1 + Rs2 near apex; Sc and R widely spaced from each other in distal half of wings. FW CuP merging distally with A (Fig. 3c). Basal stalk of M in HW parallel to CuA2 (Fig. 3g).

Dorsal FW ground color pale greyish brown from base to Cu2A (anal-cubital cells) and costa anterior to Sc; darker greyish-brown from CUA2 to outer margin and Sc. Ano-cubital region with irregular, sinuate transverse pale yellowish-brown lines edged with brown. Costal margin to Sc with five subovoid shaped patches of dark reddish-brown edged with white, outermost four patches arranged in two pairs edged with white. Dark shading over discal cells apart from pale central anterior patch edged with white (Fig. 1c), and a curved white stigma at outer edge of anterior discal cell (Fig. 1c). Outer FW with broad transverse band of darker brown shading, narrowed at CuA2 and widest toward apical region of costa; center of band with irregular row of dark brown lines, widest near veins (Fig. 1c). Dorsal HW pale reddish to greyish brown with some ornamentation near outer costa (Fig. 1e). Ventral FW and HW as for dorsal (dorsal pattern visible from ventral view). Legs (Figs. 1c, d): not dissected, pro- and meso-legs with long, greyish brown scales, laterally broad on tibia, narrowing distally on tarsus.

Pregenital abdomen (Figs. 1a, b): Dorsally covered with elongate, greyish brown scales, scales ventrally pale yellowish brown (Fig. 1f). Tergosternal sclerite (Fig. 5b) with elongate tergosternal bar narrowing ventrally to its connection with the lateral arm of SII; lateral and dorsal brace short, junction almost at right angles, intermediate zone reduced. Abdominal sclerites weakly sclerotized, indistinct and not sufficiently preserved for description.

Genitalia (Fig. 5a, c): External genitalia strongly sclerotized, dorsal plate narrow, fused across median. Anal papillae shallow, convex, setose. Subanal sclerites dorso-ventrally C-shaped. Lamella antevaginalis with broad, dorsally smooth, sub-rectangular lateral sclerites; medial sclerite with dorsal margin projected as sub-rectangular spine (Fig. 5), widest at base, laterally concave, and rounded distally. Bursa copulatrix linear (unbranched), without a diverticulum. Ductus bursae elongate (Fig. 5c), almost as wide as the corpus bursae, the two regions merging together without a distinct junction.

Habitat and phenology

The holotype of *E. makundae* sp. n. was collected within the campus of the Makunda Christian Leprosy and General Hospital (Karimganj District of Assam) (Fig. 6), located in the Barak River Valley at an elevation of 37 m above mean sea level, and near the Longai River (Fig. 7). The habitat consists of evergreen and semi-evergreen forest on low relief topography. Common tree species on campus include *Tectona grandis* (Lamiaceae; a known host of various other *Endoclita* species), *Mangifera indica* (Anacardiaceae), *Dipterocarpus turbinatus* (Dipterocarpaceae), *Litchi chinensis* (Sapindaceae), *Erythrina indica* and *Tamarindus indica* (Fabaceae), *Artocarpus heterophyllus* (Moraceae), and *Bombax ceiba* (Bombacaceae). Collection of *E. makundae* sp. n. in late February corresponds to the beginning of increasing

rainfall and temperatures (e.g., nearby Silchar, en.climate-data.org), and well before onset of the monsoon season beginning in June.

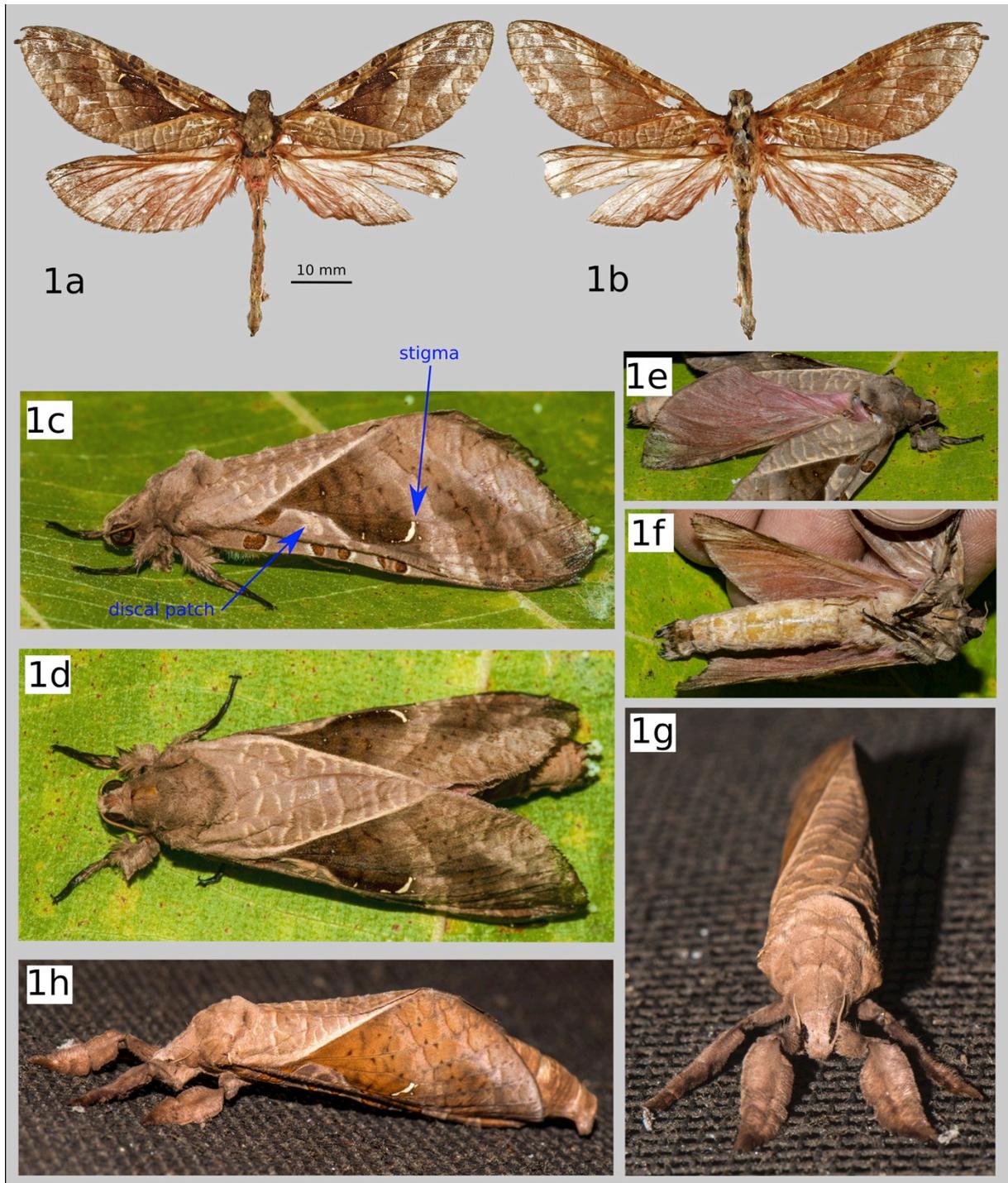


Fig. 1. *Endoclita makundae* sp. n. holotype female: (a) dorsal, (b) ventral, (c) habitus lateral, (d) habitus dorsal, (e) habitus, hindwing displayed, (f) ventral habitus. Habitus of a similar *Endoclita* species from the type locality (g,h). Photos **a-b** by Ujwala Pawar, **c-f** by Vijay Ismavel.

| | Species | State/Country | Reference |
|----|--|------------------|---|
| 1 | <i>E. aboe</i> (Moore, [1860]) | SK | E♂ (Tindale 1941: fig. 47), D♀ (Ueda 2000: fig.1421) |
| 2 | <i>E. albofasciatus</i> (Moore, 1879) | TN | E♂&♀ (Tindale 1942: figs.8-9) |
| 3 | <i>E. albosignata</i> Tindale, 1941 | AS | E♂ (Tindale 1941: fig.31-32) |
| 4 | <i>E. auratus</i> (Hampson, [1893]) | AS, MY | E♂ (Tindale (1941: fig.38-39) |
| 5 | <i>E. chalybeatus</i> (Moore, 1879) | WB, ML, MY | E♂&♀ (Tindale (1941: fig.17-20) |
| 6 | <i>E. chrysoptera</i> Tindale, 1941 | SK | E♂ (Tindale (1941: fig.37) |
| 7 | <i>E. damor</i> (Moore, [1860]) | HP, UK, WB, NP N | E♂&♀ (Tindale 1941: fig.11-14), E♂&♀ (Ueda 2000: fig.1423b) |
| 8 | <i>E. magnus</i> (Tindale, 1942) | TN | E♂ (Tindale 1942: fig.7) |
| 9 | <i>E. malabaricus</i> (Moore, 1879). | KA | D♂, E♀ (Tindale 1942: figs.3, 5-6) |
| 10 | <i>E. makundae</i> sp. n. Grehan, Mielke & Kunte | AS | D♀ |
| 11 | <i>E. metallica</i> Tindale, 1941 | SK | E♂ (Tindale 1941: fig.34) |
| 12 | <i>E. microscripta</i> Tindale, 1941 | TN | E♂&♀ (Tindale 1941: figs.40-41) |
| 13 | <i>E. punctimargo</i> (Swinhoe, 1892) | SK | E♂ (Tindale 1941: figs. 42-43) |
| 14 | <i>E. rustica</i> Tindale, 1941. | AS | External ♂ type (Tindale 1941: fig.33-34) |
| 15 | <i>E. salsettensis</i> (Moore, 1879) | MH | Genitalia not described |
| 16 | <i>E. signifer</i> (Walker, 1856) | ML, BA | E♂ (Tindale 1941: fig.427-30) |
| 17 | <i>E. strobilanthes</i> (Tindale, 1942) | KA | E♂&♀ (Tindale 1942: fig.12-13) |
| 18 | <i>E. undulifer</i> (Walker, 1869) | ML UP, WB, MY | E♂&♀ (Tindale 1941: fig.1-2, 16) |
| 19 | <i>E. viridis</i> (Swinhoe, 1892) | TN | E♂ (Tindale 1942: fig.10-11) |

Table 1. List of Indian *Endoclita* species, including *E. makundae* sp. n., with reference to states represented, other countries where applicable, and illustrations of genitalia. Distribution data from Tindale (1941, 1942), Grehan & Ismavel (2017), Grehan & Mielke (2017). Key to symbols: AS – Assam, BA – Bangladesh, HP – Himachal Pradesh, KA – Karnataka, MH – Maharashtra, ML – Meghalaya, MY – Myanmar, NP – Nepal, SK – Sikkim, TN – Tamil Nadu, UK – Uttarakhand, UP – Uttar Pradesh, WB – West Bengal, E♂ – external genitalia only, D♂ – dissected genitalia.

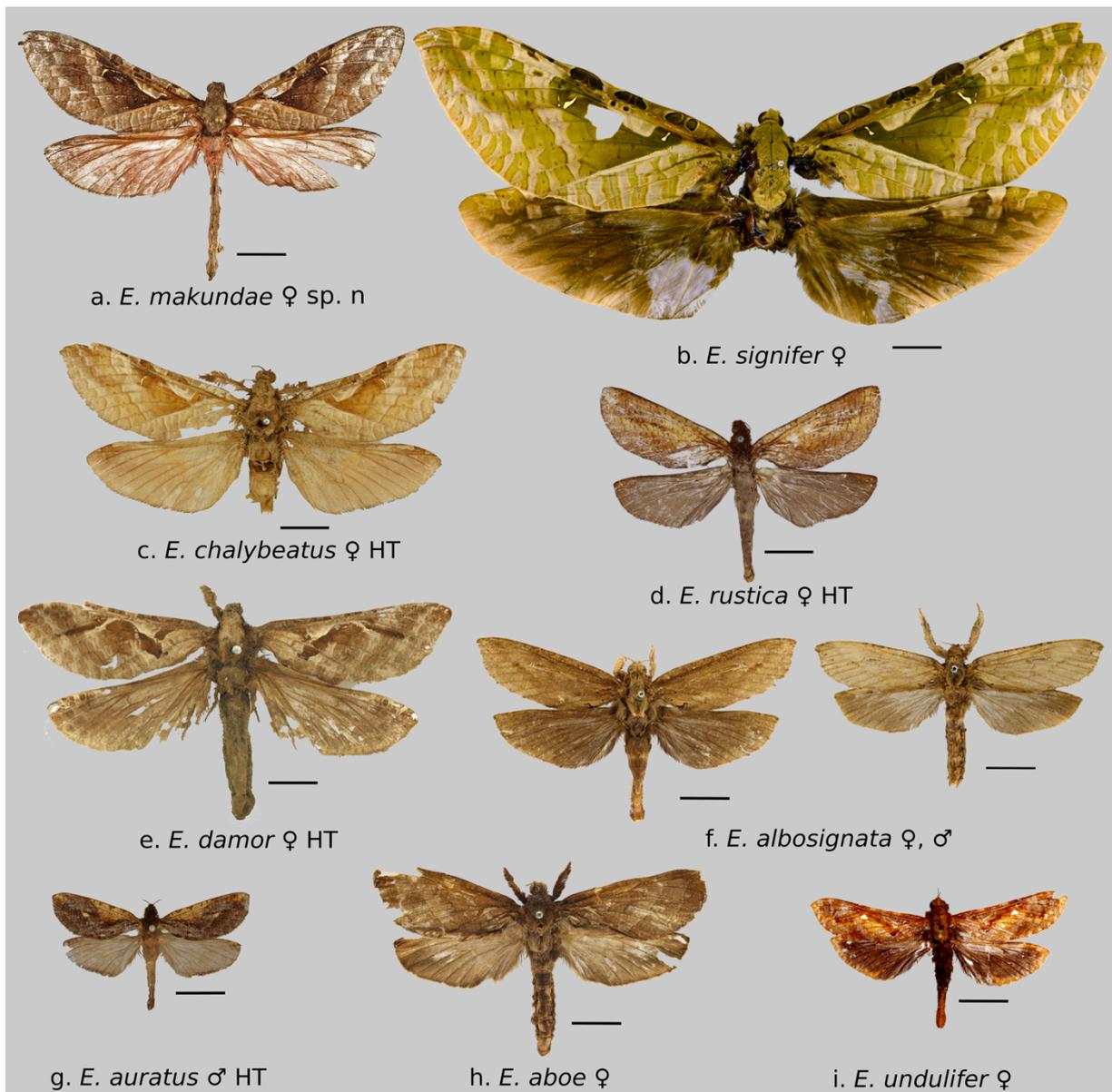


Fig. 2. *Endoclita* species from northeastern India. (a) *E. makundae* sp. n., (b) *E. signifer*, Khasi Hills, Meghalaya (NHMUK), dissection JRG 316, (c) *E. chalybeatus* holotype, Darjeeling, West Bengal (NHMUK), (d) *E. rustica*, Shillong, Assam (NHMUK), (e) *E. damor*, Darjeeling, West Bengal (NHMUK), (f) *E. albosignata*, Margherita, Assam (CMNH), (g) *E. auratus*, Bernardmyo, Myanmar (NHMUK), (h) *E. aboe* (CMNH), (i) *E. undulifer* (NHMUK). Size of specimens is not necessarily indicative of size variation for each species. Scale = 10 mm.

Discussion

The current geographic record of *Endoclita* is very scattered over much of India, particularly in the southwest and northeastern regions (Grehan & Ismavel 2017; Sondhi *et al.* 2022), including several species described before the turn of the last century (Walker, 1856, 1869, Moore 1860, 1879, Hampson 1893, Swinhoe 1892). Of the 19 recognized species of *Endoclita* recorded from India (Table 1), most are endemic to the country. Genitalia are illustrated in the literature for all northeastern *Endoclita* species other than *E. salsettensis* (Moore, 1879) from Maharashtra state. Many of the illustrations are, however, limited to externally visible features, and they are often insufficiently diagnostic for distinguishing individual species (see

Grehan & Mielke 2017). To some extent, the paucity of genitalic information for each species is offset by differences in wing shape and pattern that are often distinctive between named species. For the northeastern region, these external differences are sufficient to exclude confusion between *E. makundae* and six of the eight species recorded for the region (see diagnosis).

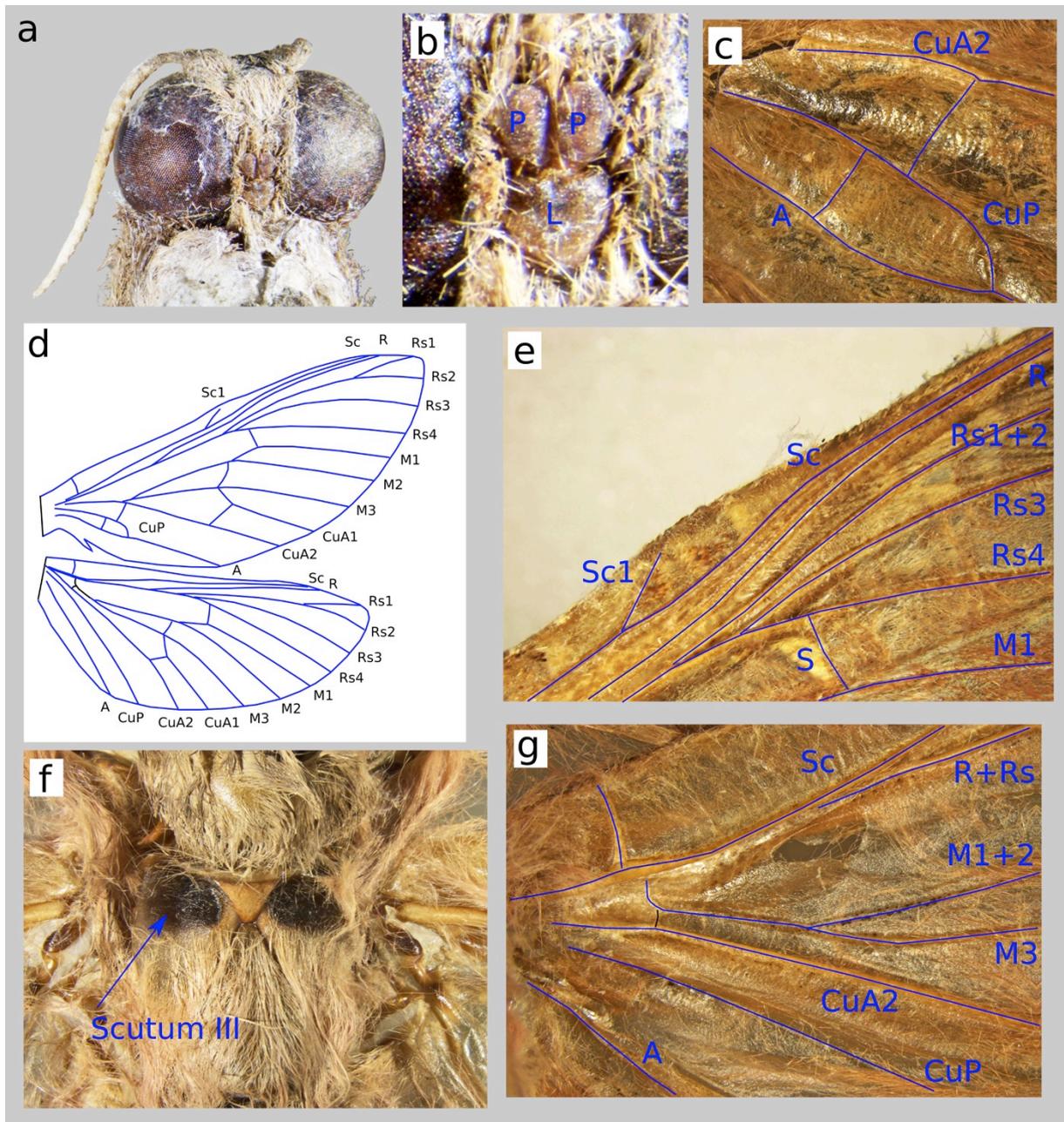


Fig. 3. *Endoclita makundae* sp. n. holotype head and thorax: (a) ventral head, (b) labium (L) and palps (P), (c) basal venation of hindwing, (d) wing venation, (e) central forewing venation near costal margin, (f) dorsal, meso- and metathorax showing unscathed, chocolate brown anterior scutum III sclerites, (g) basal venation of hindwing. Photos by Ujwala Pawar.

The external appearance of *E. chalybeatus* and *E. signifer* cannot be definitively distinguished from *E. makundae* sp. n (the size difference for specimens in Fig. 1 is not necessarily representative for each species). In the habitus dorsal view, the contrasting pale ground color

basal to CuA2 and the darker distal ground color of *E. makundae* presents a complementary pattern of three triangular regions (Fig. 1d) with a dorso-central pale region incorporating the basal area of each FW that is disto-laterally edged by a narrow whitish line along CuA2 (Fig. 1d). The two FW regions distal to CuA2 form mirror images of each other with an S-shaped curve between CuA2 and the stigma, and an oblique dark band between CuA2 and the outer costal margin. This general FW pattern is visible in the habitus resting position of the undetermined Makunda specimen (Fig. 1g, h), and is probably seen in the resting position of all other *Endoclita* species with a similar FW pattern.

When Tindale (1941: 24) found the abdomen was missing from the female type specimen of *E. chalybeatus* (from Darjeeling, West Bengal), he used another Darjeeling specimen to describe the genitalia. For the male, he used a specimen from Assam [Meghalaya] that he felt could be confidently associated with the type. Further specimens from the Khasi Hills (Meghalaya), northeastern Bangladesh (Sylhet), and Myanmar were attributed to *E. chalybeatus* (Grehan & Ismavel 2017). If Tindale's characterization is correct, the dorsally ovoid expansion of the dorsal margin of the medial sclerite of the antevaginalis (Fig. 5e) distinguishes *E. chalybeatus* from *E. makundae* sp. n. and *E. signifer*.

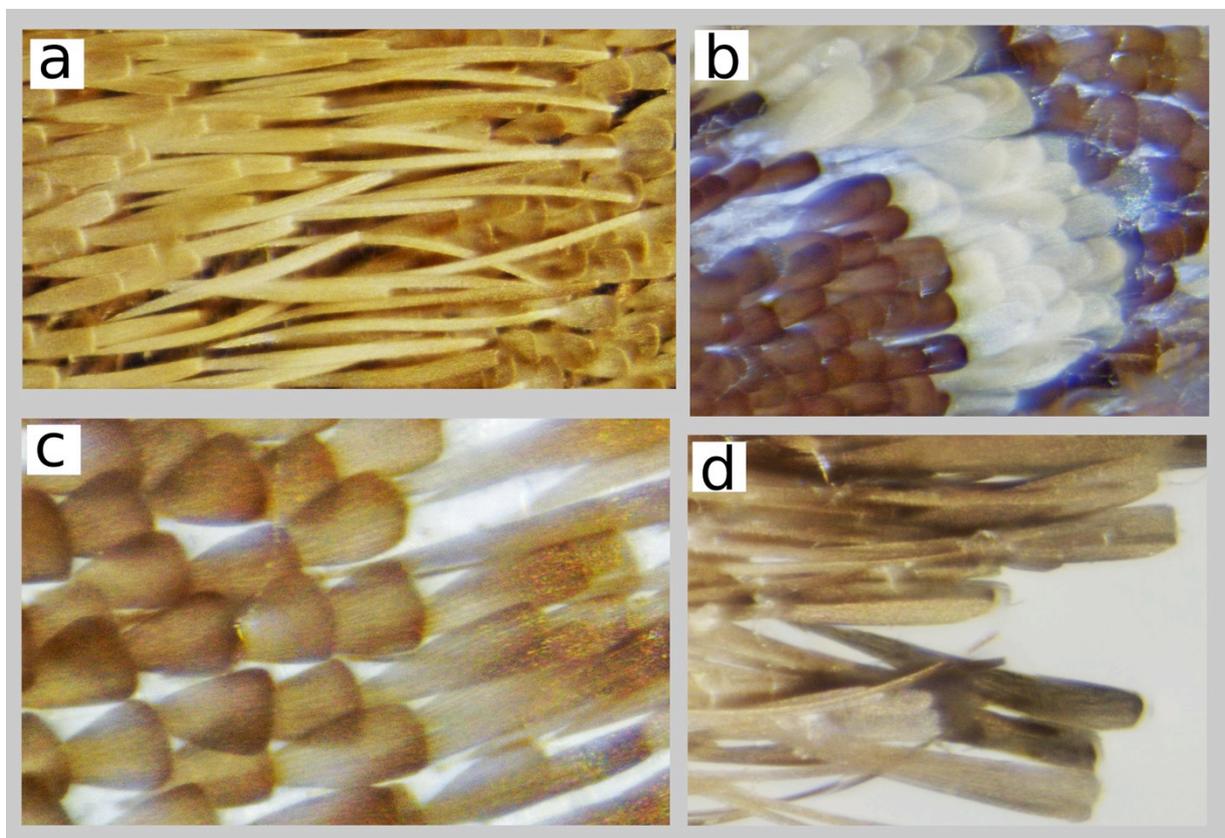


Fig. 4. *Endoclita makundae* sp. n. forewing scales: (a) central-anterior forewing, (b) outer anterior discal cell of forewing with portion of stigma (white scales), (c) post-discal transverse line scales, (d) forewing marginal scales. Photos by Ujwala Pawar.

The genitalia of the holotype of *E. signifer*, collected from Sylhet, Bangladesh, are not dissected. Tindale (1941: 30) assigned nine male and eleven female specimens, from nearby Cherrapunji and Jaintia Hills in Meghalaya, to *E. signifer*, and he characterized the species as having sub-falcate forewings, repetition of some of the forewing pattern on the hindwing, and the ‘peculiar’ genitalia. The first two features are found in other *Endoclita* species, and are therefore not diagnostic for *E. signifer*. The female genitalia of *E. signifer* are, however,

distinct from all other species by the shape of the dorsal margin of the medial sclerite of the antevaginalis that forms a medial spine which distally narrows into an elongate needle-like point (Fig. 5f). The rounded sub-rectangular shape of the medial spine of *E. makundae* is different from the ovoid spine of *E. chalybeatus* and the needle-like spine of *E. signifer* as characterized by Tindale (1941). A second *Endoclita* specimen from the Makunda hospital found in 2015 suggests the possibility of another undescribed species that has a lighter FW pattern (Fig. 1g, h). It was referred to as *E. signifer* by Grehan & Ismavel (2017), but its rectangular spine (Fig. 5b) contrasts with the spine shape of *E. signifer*, *E. makundae*, and all other female genitalia illustrated by Tindale (1941, 1942).

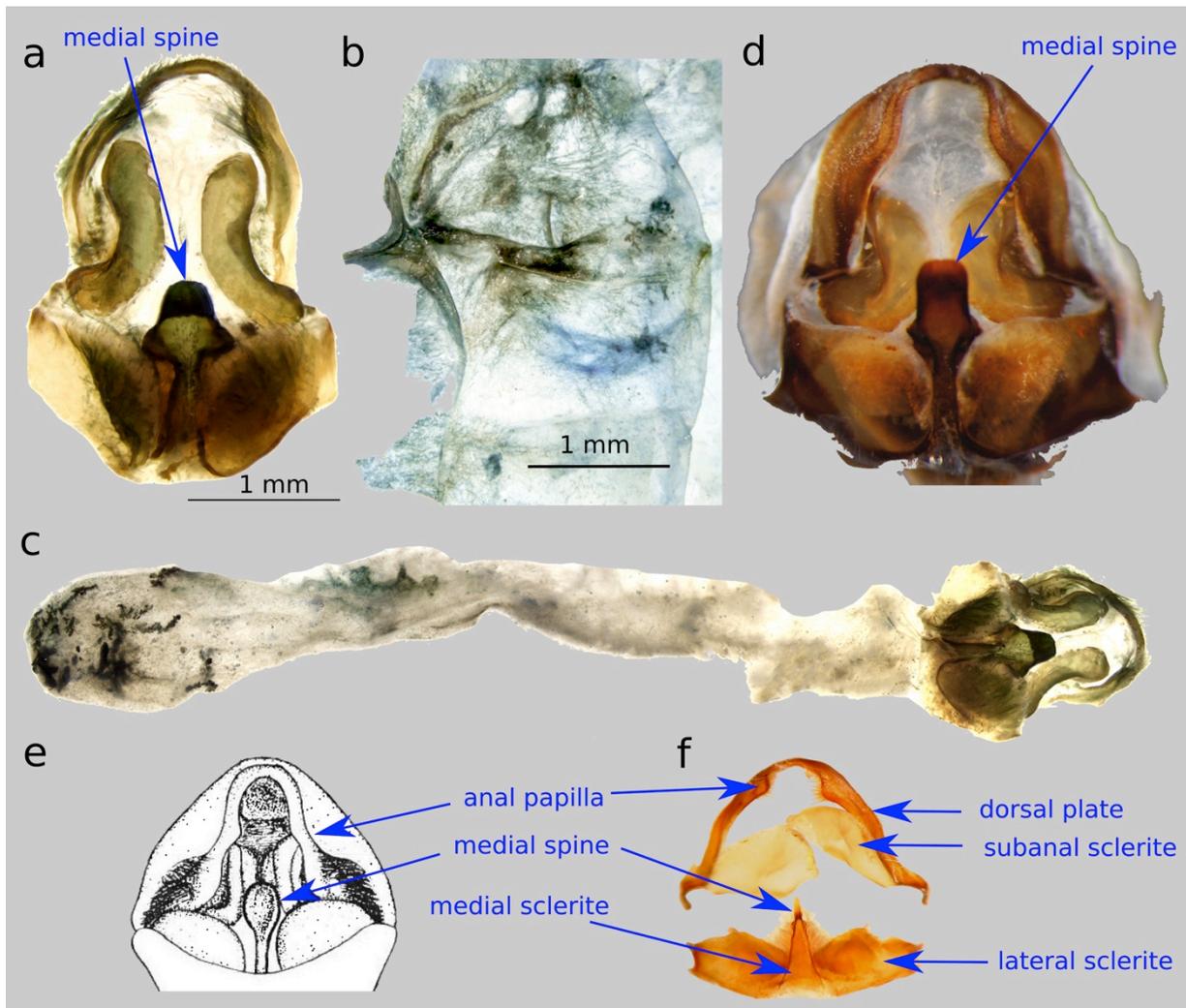


Fig. 5. Abdomen and genitalic morphology: (a-c) *Endoclita makundae* sp. n. external genitalia: (b), tergo-sternal sclerite (c) bursa copulatrix connection with external genitalia, (c); (d-f) External genitalia: (d) *Endoclita* sp.; (e) *E. chalybeatus* from Tindale (1941), (f) *E. signifer*, Khasi Hills (NHMUK, JRG dissection F316). Photos a-c by Dipendra Nath Basu. Photos d and f by John Grehan.

Conservation

Northeast India is located in one of the most biodiversity-rich regions of the world and is immediately adjacent to the 'Indo-Burma' regional biodiversity hotspot (Myers *et al.* 2000, Tordoff *et al.* 2012). The continued discovery of new animal and plant species in northeastern India has demonstrated the need to further strengthen conservation efforts in anticipation of further economic pressures to develop regional resources (Roy *et al.* 2015). Future survival of

Endoclita species will be dependent upon the continued existence of forested habitats that support a ground cover of plant detritus. The early instars require moist conditions and a source of fungi or fungal infested wood for early development. Later instars bore into the stems of live trees or shrubs where they feed on callus tissue that grows around the tunnel entrance following bark removal (Grehan & Ismavel 2017).



Fig. 6. *Endoclita makundae* sp. n. type locality: (a) exterior of hospital quarter where the moth specimens were found, (b) surrounding forest vegetation during the monsoon.

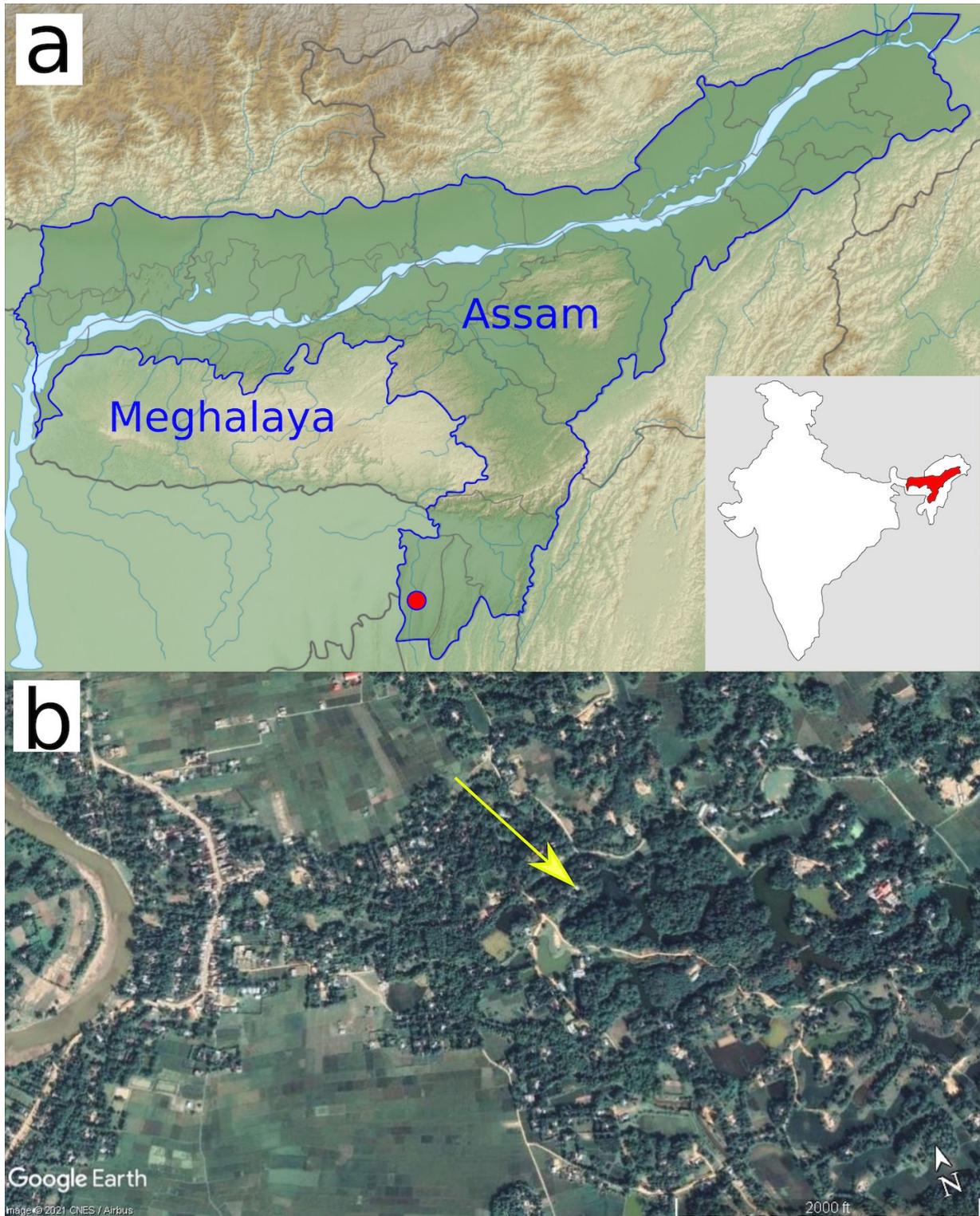


Fig. 7. *Endoclitia makundae* distribution: (a) type locality as red circle in the state of Assam, and (b) location of specimen collection in the campus of the Makunda Christian Hospital (yellow arrow). Section of the Longai River visible to the left of view.

The Makunda hospital is located in southern Assam, close to the border with Bangladesh (Fig. 7a), in an area of highly fragmented forest intermixed with patches of intense agricultural cultivation (Fig. 7b). The presence of *Endoclitia* at the hospital indicates that populations of at least one species continues to persist within these forest remnants. For the Karimganj district

as a whole, forest covers 47.07% of the total land area (NER 2021), although some areas are more intensely cultivated than others. During the decade 2011-2021, forested areas in northeast India decreased from 173,219 to 169,521 km² – a loss of 3698 km², or about 2.2% of the total forest cover in northeastern India (State of Forest Report 2011, 2021). Further decline in forest cover seems inevitable due to agricultural expansion and rural development, which would directly impact the survival of *Endoclita* populations. According to the Sustainable Development Goal 15 (NER 2021: fig. 15.2) the majority of districts within the northeastern region are in the 65-99% range of meeting the goal of a minimum 33% forest or tree cover.

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