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Taxonomic status of *Thitarodes armoricanus* (Oberthür, 1909) of China (Lepidoptera: Hepialidae)

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Abstract

The external genitalia of the female holotype of *Thitarodes armoricanus* (Oberthür, 1909) are illustrated and described for the first time. In addition, the genitalia of a male specimen attributed to this species are also described and illustrated. The lack of any or adequate illustrations of the female genitalia for most *Thitarodes* species precludes a comparative evaluation of the species represented by the holotype. The male genitalia of *T. armoricanus* show the presence of a strongly sclerotized basal spur on the valva that is characteristic of most *Thitarodes* species. On the basis of differences in forewing colour pattern we treat *T. altissima* (Daniel, 1940) **stat. rest.** as a distinct species. For clarification of *Thitarodes*' taxonomy and systematics it is essential that detailed illustrations of male and female genitalia are published for all species to complement future morphological and molecular studies.

Keywords

Redescription, genitalia, holotype, taxonomy

Introduction

Discovery and designation of *Thitarodes armoricanus* (Oberthür, 1909a) has a convoluted history as it was found at the residence of Charles Oberthür in the city of Rennes, France, even though the species was recognized as having originated in western China. A fresh, dark moth found in the spring of 1909 was recognized as being distinct by Oberthür, who sent it Otto Staudinger for identification, but the specimen was returned without comment (Oberthür 1909b). Concluding that the moth was a new species, and even though no further specimens were found, he decided to publish an illustration with the name, *Hepialus armoricanus*, of the species made in reference to Brittany (part of "Armorica") where Rennes is located (Oberthür 1909a). When he later examined some *Hepialus* Fabricius, 1775 specimens sent to him from the eastern borders of 'Tibet' in vicinity of Tâ-tsien-lou (now Kangding) and Tay-tou-ho (both in Sichuan province, China), he realized that they resembled *H. armoricanus* and concluded that the moth found flying at his home was actually a species native to the western portion of that country. This left a bit of a mystery as to how the moth ended up in his house. He surmised the seemingly likely possibility that a pupa was included among the parcel packing and that it somehow survived the journey and emerged at his home. He compared this situation to larvae of a butterfly species from Algeria that escaped into his garden. Nevertheless, Oberthür felt powerless to be able to give a satisfactory explanation for the *T. armoricanus* specimen, see also comment by Ueda (2000).

The taxonomic status and identification of *T. armoricanus* is important for future evaluation of the genus *Thitarodes* Viette, 1968, which is in need of a comprehensive revision, and for validation of biological research that makes reference to this species name (e.g. Zhu *et al.* 2004, Tao *et al*. 2015). The original description of *Hepialus armoricanus* did not include a written description (Oberthür 1909a). Instead a colour illustration (by J. Culot) was provided along with a caption naming it as a new species. Subsequent illustration of the female and male by Bang-Hass (1927: pl. 10, figs 17-18) appears to represent the same specimens presented in the current article.

Thitarodes represents one of the most species diverse genera of Hepialidae with a current total of 79 valid species (including *T. altissima*). Most species have been diagnosed on an individual basis rather than by extensive comparative analysis, and most species are known for the male genitalia only (Grehan e*t al.* 2021). Female genitalia are known for only 12 species, most of which are from the Himalaya (Fig. 5). This limited sampling precludes characterization of the female genitalia for *Thitarodes* as a whole.

Until now, the genitalia of the female holotype have never been described or illustrated. The holotype was originally labelled by Oberthür (1909a) as a male, but subsequent examination by Kyoichiro Ueda revealed that the specimen was a female (Ueda 2000). Male genitalia attributed to *T. armoricanus* were illustrated by Viette (1949), but other than a dissection number, he did not provide information on the collection depository or label information for the specimen. To help rectify the lack of diagnostic information, we present notes on the wing pattern and dissections of the female holotype and a male specimen from the Oberthür collection (MNHN) along with a revised taxonomic status for *T. altissima.*

Material & Methods

The holotype female and an unlabelled male, both deposited at MNHN, were dissected by P. Leraut. The abdomen was removed and placed into a 10% KOH solution, which was warmed for ca. 20 minutes. Genitalia were removed, stained with Chlorazol Black E, dissected in distilled water, placed again in hot KOH solution (to avoid any over-staining), rinsed in distilled water, dehydrated in 95% alcohol, and slide mounted in Euparal. Morphological terminology follows Mielke & Casagrande (2013) for the tegumen (= intermediate plate), saccus (= vinculum), and fultura inferior (= juxta), and Grehan & Mielke (2017) for the fultura superior (= trulleum).

Abbreviations

FW (forewing), HW (hindwing)
MNHN Muséum National d'Histoire Naturelle, Paris, France
ZFMK Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany.

Results

Thitarodes armoricanus (Oberthür, 1909a)
Figs. 1a, 1b, 3

Material examined: 1 female (holotype) **Verbatim labels** (separated by n-dash) (three of which are shown in Fig. 1a). 19.. [sic], ex-coll. Ch. Oberthür, R. Biedermann ded., Muséum Paris. – TYPE. – Env. de Rennes, Printemps 1895 [i.e. near Rennes, spring 1895]. – J'ai pris ce papillon vivant à Rennes. Il volait, le soir avec d'autres Hépiales, autour des lampes électriques de ma salle à manger. Ch. Obthr. [handwritten label – i.e. I took this (alive) moth in Rennes. It was flying, together with other ghost moths, around the electric lamps of my dining room]. – Vu par Staudinger [i.e. seen by Staudinger], Catalogue 1900. – A servi de Modèle à J. Culot de Genève, pour la IIIe livraison de Lépidoptérologie comparée 1908-1909 [i.e. illustrated by J. Culot (Geneva) in *Lepid. comp.* III, 1908-1909]. – PHOTO, det. E.S. Nielsen, 1984. – P. Leraut det., prep. N° 10374, ♀. (MNHN); 1 male, without labels (MNHN).

Redescription.

Forewing length. 16 mm in the female (Fig. 1a), 15.5 mm in the male (Fig. 1b.)

Wing pattern (Figs 1a, 1b). Ground colour medium greyish brown. FW with scattered white, and darker brown spots. Brown spots mostly located posterior to R and anterior to CuP to outer margin, comprising a basal concentration in the FW discal cell, a transverse outer discal row extending from anal margin at the intersection of CuP to R at outer edge of cell, with a transverse loop from CuA_2 to approximately base of M_1, with prominent white patch between this and discal row. A further postdiscal row of brown spots extends between anal margin posterior to intersection of CuA_2 and

apex. FW and HW margin with alternating narrow patches of brown (at each vein) and wider patches of yellowish white.

Female genitalia (Fig. 4a). Dorsal plate fused across median, laterally forming a narrow bar hinging with lamella antevaginalis. Anal papillae almost right angled convex posterior margin. Subanal sclerites trapezoidal, dorso-ventrally narrow, narrowly acute point ventro-medially. Lamella antevaginalis forming a dorso-ventrally broad plate that appears to be fused medially. Intact anterior portion of the bursa copulatrix indicates that the ductus bursa immediately expands posteriorly from the antrum to merge with basal corpus bursa, which is inferred here to be broadly ovoid in shape as documented for other *Thitarodes* species by Ueda (2000).

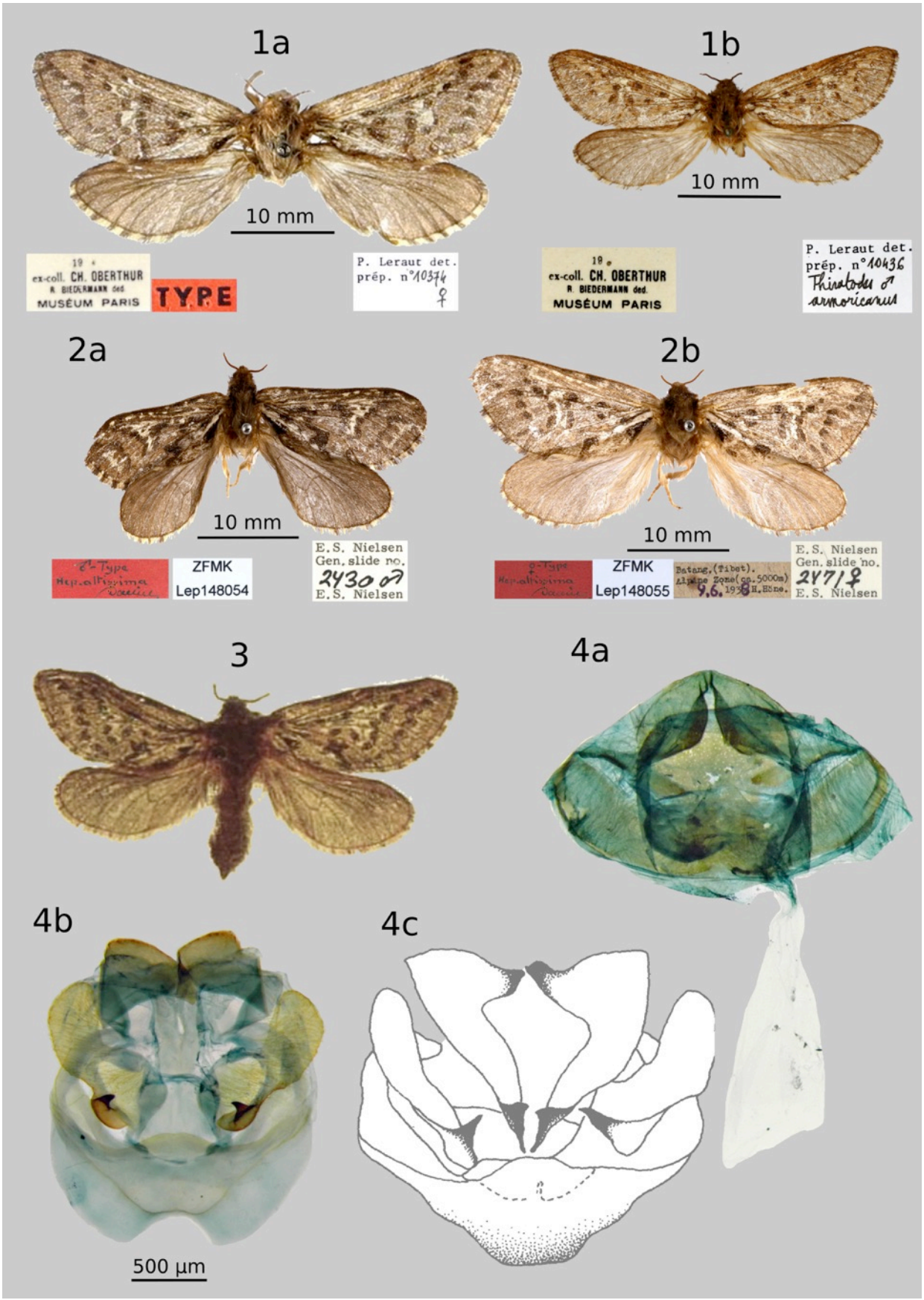
Male genitalia (Fig. 4b; prep. P. Leraut N° 10436): Pseudotegumen tapering to point at apex of pseudoteguminal arm. Tegumen narrow, weakly sclerotized, not fused with pseudotegumen. Valva sinuate, s-shaped, setose, distally lobate, sacculus with antero-basal strongly sclerotized shallow, distally acute spine with apex oriented medially and ventrally. Fultura inferior weakly sclerotized, subrectangular, wider than long with concave posterior margin. Fultura superior weakly sclerotized, longer than wide, about half as wide as fultura inferior, and postero-medially bifurcated, extends to base of pseudoteguminal arm. Saccus antero-posteriorly narrow, anterior margin medially concave, almost confluent with the central apodemal suture; anterior margin broadly convex and well separated from medial apodemal suture.

Discussion

The shape and size of structures in *T. armoricanus* are similar to at least some other species where the dorsal plate is broad and with a strongly angled hind margin in the region of the anal papillae. Other features are insufficiently defined in the dissection mount for *T. armoricanus* to make further comparison with other species. The male genitalia is similar to that illustrated by Viette (1949) for an unlocated *T. armoricanus* specimen. The presence of a strongly sclerotized basal spur on the valva is a feature shared with most other *Thitarodes* species and may correspond to a subclade within the genus (Grehan e*t al.* 2021). The shape of the saccus illustrated by Chu & Wang (1985) for *T. armoricanus* (Fig. 4c) is not the same as the MNHN dissection. In addition, the postero-ventral apex of the pseudotegumen is shown to be strongly sclerotized which is not evident in the MNHN dissection. Ueda (2000), (Fig. 4c) also noted that the saccus illustrated by Chu & Wang (1985) was different from that illustrated by Viette (1949, fig. 4) for a dissection (No. 1039) attributed to *T. armoricanus* that we have been unable to locate.

Thitarodes altissima (Daniel, 1940), **stat. rest.**
Figs. 2a. 2b

Daniel (1949) subsumed *T. altissima* (Daniel, 1940) under *T. armoricanus* without reference to evidence. This synonymy was also followed in Nielsen *et al.'s* (2000) world catalog of the Hepialidae. However, there are two considerations for recognizing *T. altissima* **stat. rest.** as a full species. First, the species was collected from Batang (Xiaqiong), Batang County, China, about 280 km west of the locality of other specimens sent to Oberthür with the same external appearance as the holotype of *T. armoricanus*. Second, while there are some general similarities of wing colour and pattern, the FW of *T. altissima* **stat. rest.** has a distinct, longitudinal white band extending along CuA_2 from the base of the wing to the posterior wing margin (Figs 2a, 2b). Daniel (1940) referred to a large series of specimens, although he did not specify the number, and stated that the basal band was always clearly present. This feature therefore represents as consistent difference from *T. armoricanus* and justifies recognition of *T. altissima* as a valid species. The genitalia dissection of the holotype by Ebbe Schmidt Nielsen has not yet been located. Future examination of the type series of *T. altissima*, housed at ZMFK, may afford the opportunity for additional corroboration by comparison of genitalic morphology.



Figs 1-4. *Thitarodes* comparisons: *Thitarodes armoricanus* (1a) holotype female, MNHN, (1b) male, MNHN; *T. altissima* (2a) holotype male (view slightly distorted by wings not in flat plane), (2b) paratype female, ZFMK, illustrated by Daniel (1940 pl. XXXI, figs 11-12); *T. armoricanus* (3) from Zhu e*t al.* (2004 pl. 2, fig. 6); *T. armoricanus*, (4a) external genitalia of holotype female, posterior view, MNHN, Gen. Prep. Patrice 10374; (4b) male genitalia of specimen in Fig. 1b, MNHN, Gen prep Patrice 10436; (4c) male genitalia illustrated by Chu & Wang (1985: fig. 4), as reproduced in Zhu *et al.* 2004: fig. 46d).

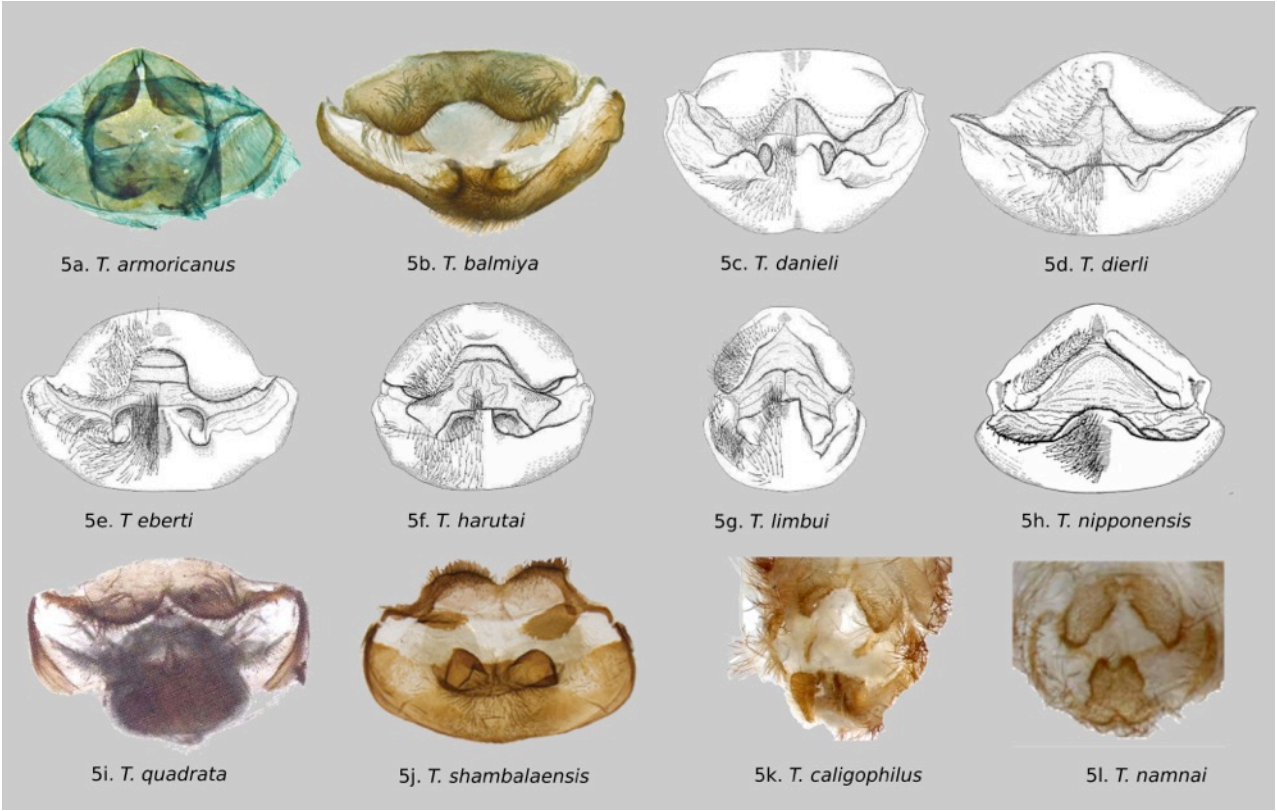


Fig. 5. External female genitalia (posterior view) of *Thitarodes* species: (a) *T. armoricanus*, (b) *T. balmiya* Grehan *et al.*, 2021: fig. 6; (c) *T. danieli* Viette, 1968 (Ueda 2000: fig. 1398B); (d) *T. dierli* Viette, 1968 (Ueda 2000: fig. 1410A); (e) *T. eberti* Viette, 1968 (Ueda 2000: fig. 1406A); (f). *T.* harutai Ueda, 2000: fig. 1418A; (g) *T. Limburger* Ueda, 2000: fig. 1419A; (h) *T. nipponensis* Ueda, 1996: fig. 7A; (i) *T. quadrata* Jiang, Li, Li, Li & Han, 2016: fig. 6; (j) *T. shambalaensis* Wang *et al.*, 2016: fig. 4d; (k,) *T. caligophilis* Maczey in Maczey *et al.* 2010: fig. 35 [partial view]; (l) *T. namnai* Maczey in Maczey *et al.* 2010: fig. 5 [partial view].

Conclusion

The proper characterization and identification of *T. armoricanus* is important for documentation of its biology. For example, the biology of a population *attributed to T. armoricanus* in Wen County, Gansu, about 400 km northeast of Kangding (Zhang *et al.* 1988), lacked corroborating species identification. A rearing study of a population in Yajiaogangou, Kangding County, by Huang *et al*. (1989) did not verify the species but the location is geographically close to that of the *T. armoricanus* holotype. A rearing study by Tao *et al.* (2015) attributed to *T. armoricanus* did not explicitly justify the species identification, but the wing pattern of the moth (Tao *et al*. 2015: fig. 4A) does conform to the appearance of the holotype. A major future challenge for *Thitarodes* taxonomy will be to accurately match males and females for each species, especially as some species are known by the female genitalia only and cannot currently be evaluated with respect to the majority of species known for the male genitalia only.

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