

Descriptions of two new species of *Neuroterus* Hartig from China (Hymenoptera: Cynipidae)

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Two morphologically unusual new species of *Neuroterus* Hartig, *Neuroterus sculpturatus* Pujade-Villar & Wang **sp. n.** and *N. abdominalis* Pujade-Villar & Wang **sp. n.**, are described from China. Data about galls, distribution and biology of the new species are included. Taxonomic problems concerning some of the Palearctic *Neuroterus* species, including the species described here, are also commented.

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1. Introduction

Until recently, the genus *Neuroterus* was considered to comprise approximately 100 species widely distributed throughout the Holarctic region (Stone *et al.* 2002). These 100 species were classified into 6 subgenera by Kinsey in his monographic treatment of the genus (Kinsey 1923). However, the subdivision of Kinsey has become obsolete: some of the subgenera are hard to distinguish morphologically and the genus has been considerably redefined. *Trichagalma* Mayr, a genus previously synonymized with *Neuroterus* by Abe (2006), was re-established to include *Trichagalma serratae* (Ashmead) and *Trichagalma acutissimae* (Monzen) (Melika *et al.*

2010); *Cerroneuroterus* Melika & Pujade-Villar was erected to include four new European species, i.e., *C. aggregatus* (Wachtl), *C. cerrifloralis* (Müllner), *C. obtectus* (Wachtl) and *C. lanuginosus* (Giraud) (Melika *et al.* 2010); *Pseudoneuroterus* Kinsey, originally treated as a subgenus of *Neuroterus*, was elevated to the generic status to include *P. macropterus* (Hartig) (Pujade-Villar *et al.* 2004) and the subsequently added *P. saliens* (Kollar) (Melika *et al.* 2010); finally, the genus *Latuspina* Monzen, originally described as a subgenus of *Neuroterus*, was also raised to the generic status to include the single Japanese species, *L. stirps* (Monzen). Many new species have subsequently been described to the aforementioned genera (Melika 2006, Melika *et al.* 2010,

Pujade-Villar & Wang 2012, Tang *et al.* 2012). Furthermore, the recently described genus *Cyclo-neuroterus* Melika & Tang, with five known species from Taiwan, obviously belongs to the *Neuroterus* complex (Tang *et al.* 2011). The redefined *Neuroterus* Hartig, 1840 is currently represented by 84 species, including 6 from the Western Palaearctic area (Melika *et al.* 2010), 14 in the eastern Palaearctic – 6 of them are of uncertain systematic position – (Abe *et al.* 2007, Melika *et al.* 2010), 52 from North America (Burks 1979, Melika & Abrahamson 1997, 2002), and 8 from Mexico (Pujade-Villar *et al.* 2009, Pujade-Villar & Ferrer-Suay 2015).

The genus as previously defined consists of species forming galls on oaks (*Quercus*) in three sections: *Cerris*, *Quercus s.s.* (the white oaks), and *Protobalanus* (the intermediate oaks) (Stone *et al.* 2002), but the redefined *Neuroterus* appears to be relatively more specific regarding its host association; all species currently included in *Neuroterus* are associated with white oaks (section *Quercus s.s.*), the only exception is *N. chrysolepis* Lyon from California, USA, which is associated with *Q. chrysolepis* in the section *Protobalanus*. No species of *Neuroterus* is associated with the diverse North American red oaks (section *Lobatae*).

The alternating asexual and sexual generations are poorly known for the genus, except for the Western Palaearctic species (Pujade-Villar *et al.* 2001). The galls of *Neuroterus* species are usually structurally more primitive than those of other Cynipini genera and lack the highly specialized tissues and tissue layers of the other galls (Melika 2006).

Many of these species, especially those from Nearctic and the Eastern Palaearctic regions need revision (Melika *et al.* 2010). Abe *et al.* (2007) listed the *Neuroterus* species of the Eastern Palaearctic with taxonomic comments and indicated that some of the species were in need of revision.

As noticed by Melika *et al.* (2010), several species of the genus have distinctive morphological peculiarities – i. e. *N. anthracinus* (Curtis) and *N. politus* Hartig from Western Palaearctic region. In the present study, we describe two additional morphologically divergent new species from China and discuss their inclusion in *Neuroterus*.

2. Materials and methods

Throughout the paper, we followed the terminology used in Liljeblad and Ronquist (1998) and Melika (2006) for structural morphology, Ronquist and Nordlander (1989) for abbreviations on forewing venation, and Harris (1979) for cuticular surface sculpture. Measurements and abbreviations used are:

- F1–F12, first and subsequent flagellomeres
- POL, post-ocellar distance, the distance between the inner margins of the posterior ocelli
- OOL, ocellar–ocular distance, the distance from the outer margin of the posterior ocellus to the inner margin of the compound eye
- LOL, the distance between lateral and frontal ocelli
- The width of the forewing radial cell was measured from the margin of the wing to the Rs vein.

Descriptions and measurements were made under a Leica MZ 12.5 stereomicroscope (Wetzlar, Germany), and photos were taken by a digital camera (Q-Imaging, Micropublisher 3.3 RTV) attached to a Leica MZ APO stereomicroscope (Wetzlar, Germany) and stacked using Synoptics Auto-Montage version 5.0 software. The field-emission gun environmental scanning electron microscope (FEI Quanta 200 ESEM, Barcelona University) was used for high-resolution imaging without gold-coating.

Type specimens are deposited in the Hymenoptera Collection of Zhejiang Agricultural and Forest University, Lin'an, China (ZAFU) and the University of Barcelona (UB) as detailed in the species descriptions.

3. Descriptions of two new species of *Neuroterus*

3.1. *Neuroterus sculpturatus* Pujade-Villar & Wang sp. n. (Fig. 1, 2e–i)

Type material. Holotype ♀: China, Shaanxi, Houzhenzi (107°47' E, 33°50' N), galls collected from *Quercus variabilis* Blume on 17.V.2011, and adult wasp emerged on 5.VI.2011, Guo Rui

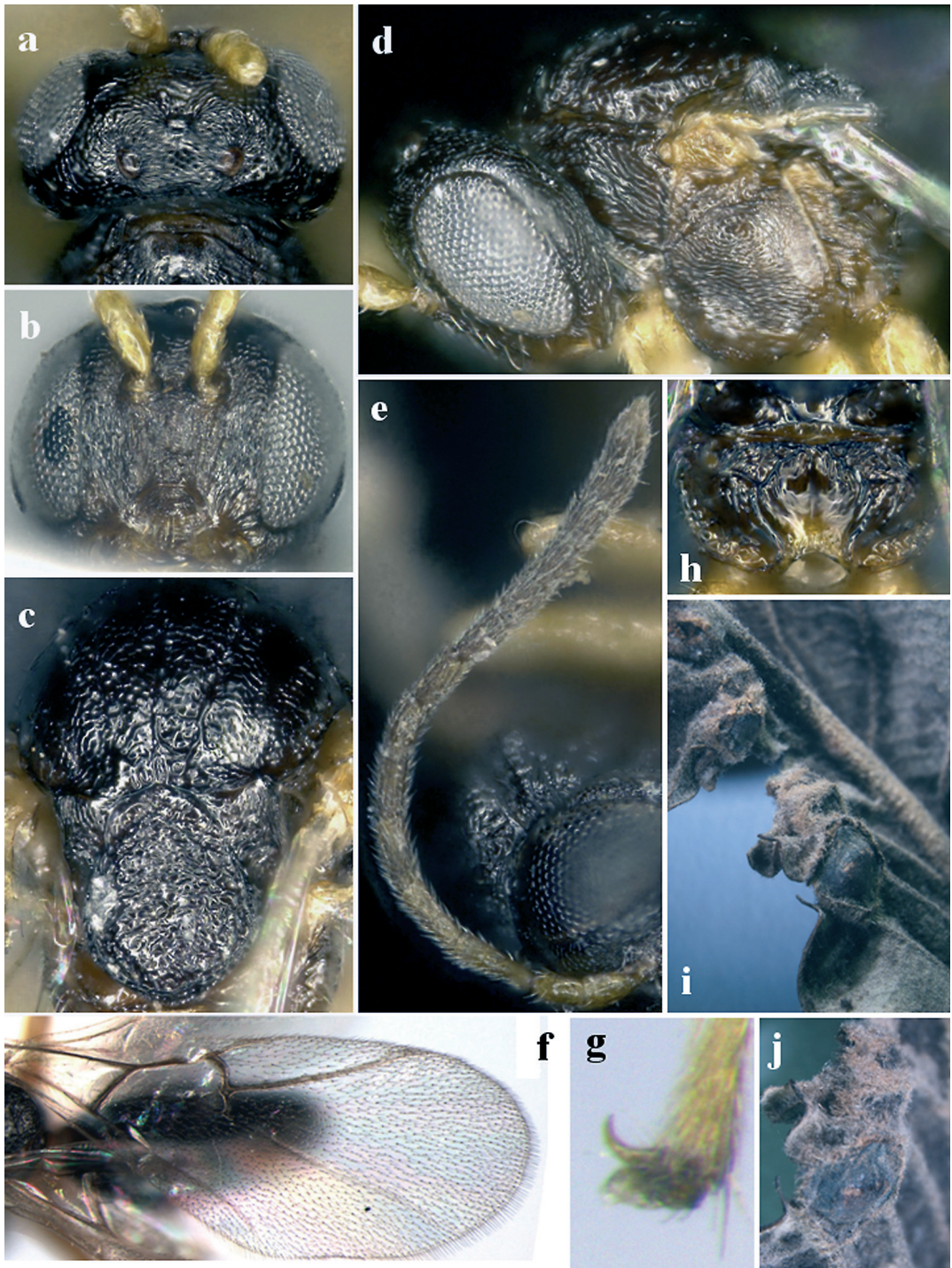


Fig. 1. *Neuroterus sculpturatus* sp. n. – a. Head, dorsal view. – b. Head, frontal view. – c. Mesosoma, dorsal view. – d. Head and mesosoma, lateral view. – e. Female antenna. – f. Forewing. – g. Tarsal claws. – h. Propodeum. – i–j. Gall.

leg. Paratypes: 1♀1♂, same data as holotype. Holotype and paratype ♂ deposited in ZAFU; ♀ paratype deposited in UB (JP-V collection).

Diagnosis. The new species differs from all known species of *Neuroterus* in having strong sculpture on mesosoma including mesopleuron.

Description, sexual generation.

Length. Female: 2.0 mm (n=2); male: 1.8 mm (n= 1).

Colour. Head yellowish brown or dark brown; antennal scape and pedicel pale yellow, flagellomeres yellowish brown (male antennae basally pale yellow and apically dark yellow); mesosoma dark brown, darker in some areas; mandibles pale yellow with dark brown tips, maxillae and labium yellow; legs dark yellow (yellowish in males); metasoma black; hypopygium pale red; wing veins brown.

Head (Figs 1a–b, 2h). Head subquadrate in frontal view, around 1.3–1.4 times as broad as high, distinctly broader than mesosoma in frontal view, with sparse short white setae, and 1.9–2.0 times as wide as long in dorsal view. Lower face without lateral striae radiating from clypeus while medially coriaceous; area below antennal sockets with a few interrupted striae. Transfacial distance equal to height of compound eye. Inner margins of compound eyes parallel. Distance between inner margin of compound eye and antennal socket equal to diameter of antennal socket, and 1.8–1.9 times the distance between antennal sockets. Clypeus conspicuous, anterior tentorial pits distinct but small; epistomal sulcus and clypeo-pleurostomal lines distinct. Malar space quite small and with short striae, extending to eye; malar sulcus only traceable. POL: OOL: LOL=7: 4: 4 (in males 5: 3: 3), diameter of lateral ocellus 2.5 in the same scale for POL (2.0 in males). Gena coriaceous and shiny, not broadened behind compound eye. Frons, vertex, and occiput uniformly coriaceous and shiny.

Antenna. Female (Fig. 1e): with 12 flagellomeres, slightly shorter than body length: pedicel 2.5 times as long as broad; F1 1.1 times longer than F2, 1.8 times longer than pedicel; F3 to F6 of equal length, F8 to F10 equal in length, F4 and subsequent flagellomeres each broader than the preceding one; F12 around 1.4 times longer than F11; antennal formula is: 6: 5: 9: 8: 6: 6: 6: 5.5: 5: 5: 5: 7; placodeal sensillas present from F4.

Male (Fig. 2e–f): with 15 segments, first flagellomere incised and apically expanded; antennal formula: 4.5: 4: 9: 8: 7: 7: 7: 5: 5: 5: 5: 4.5: 4.5: 6.

Mesosoma (Figs 1c–d, h, 2g, i). Mesoscutum 1.3 times as long as broad in dorsal view. Pronotum strongly coriaceous and laterally strongly striate. Mesoscutum strongly coriaceous in most of its surface and partially reticulate, with a few white setae; slightly longer than maximum width (measured across mesoscutum between tegulae at anterior tip). Notauli percurrent, reaching pronotum, impressed in its entire length; parapsidal lines present, median mesoscutal impression present, weakly impressed but extending almost to entire length of mesoscutum; anterior mesoscutal parallel lines absent; parascutal carina usually broad, extending to the point where notaulus reaches pronotum. Mesoscutellum slightly longer than wide, quadrangular, laterally uniformly covered by strong rugose sculpture and medially strongly coriaceous, slightly overhanging metanotum. Transscutal articulation absent; scutellar foveae absent but transversal scutellar depression present with weak rugae inside and not separated by a median carina. Mesopleuron and speculum strongly coriaceous, with thin but distinct longitudinal striation on lower mesopleuron. Dorsal axillar area reticulate, with white setae; mesopleural triangle rugose and alutaceous; lateral axillar area rugose, with few setae; metanotal trough smooth and shiny; subaxillular bar smooth, shiny; metapleural sulcus reaching mesopleuron at half of its height. Metascutellum delicately coriaceous; central propodeal area broad, smooth, shiny, with some interrupted longitudinal rugae; lateral propodeal carinae strongly bent outwards in the middle; lateral propodeal area smooth and shiny, without setae.

Legs (Fig. 1g). Tarsal claws simple, without basal lobe.

Forewing (Fig. 1f). Forewing longer than body, hyaline, with distinct long dense cilia on margin; radial cell open and long, 3.3–3.4 times as long as wide; R1 reaching wing margin and continuing along margin for a short distance; Rs slightly curved, nearly reaching wing margin; areolet closed, large, and triangular; vein Rs+M reaching toward basalis at lower one third, but not reaching basalis.

Metasoma. Female: slightly shorter than head

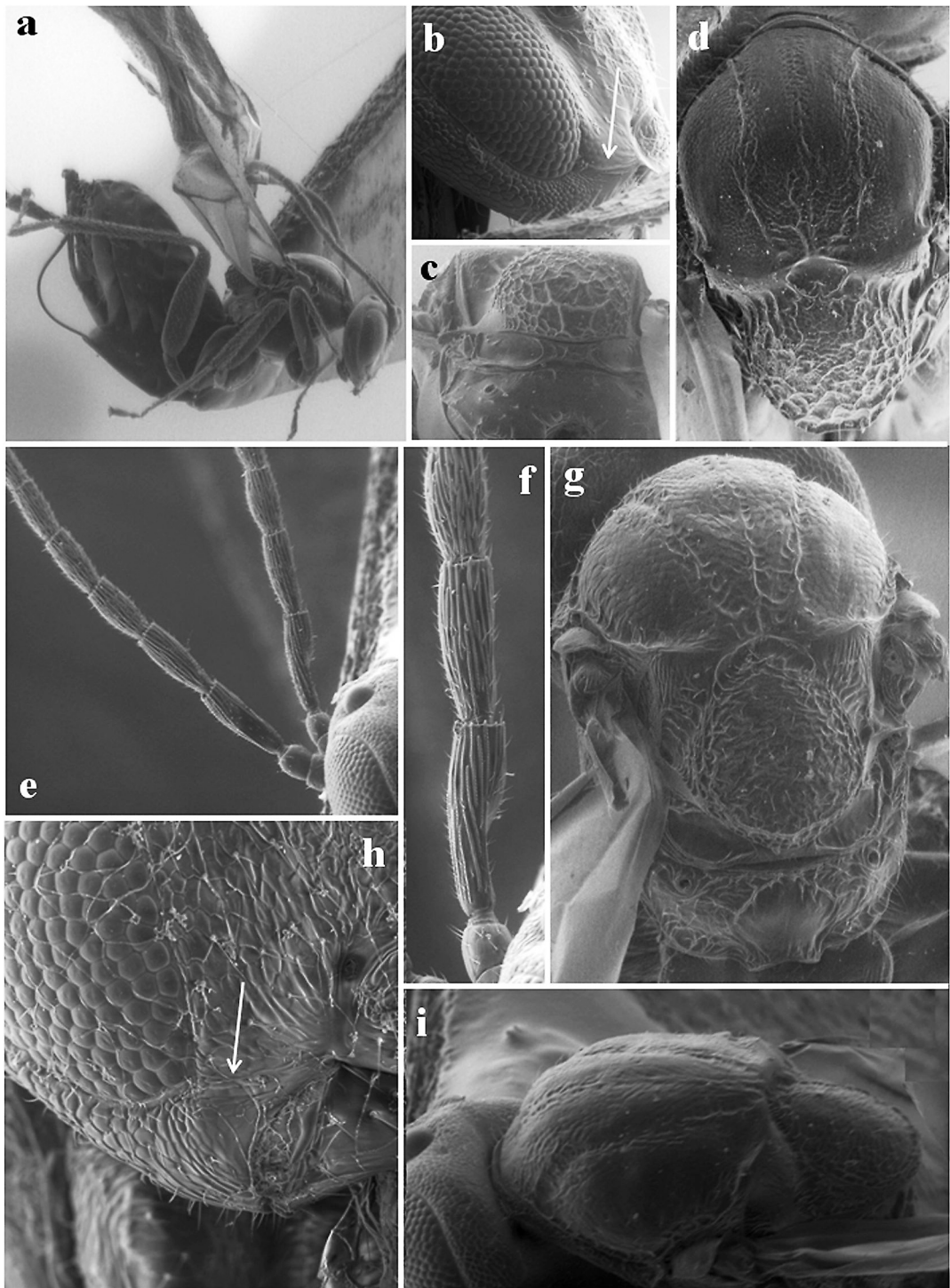


Fig. 2. *Neuroterus abdominalis* sp. n. (a–d) and *N. sculpturatus* sp. n. (e–i). – a. Body, general view. – b. Head, lateral view indicating malar sulcus. – c. Propodeum, dorsal view. – d. Mesosoma, dorsal view. – e. Basal antenna, male. – f. First flagellomere, male. – g. Mesosoma and propodeum, dorsal view. – h. Malar area indicating malar sulcus. – i. Mesoscutum, dorso-lateral view.

plus mesosoma, higher than long in lateral view; 2nd metasomal tergite occupying 1/3 of the length of metasoma in dorsal view, smooth and shiny, with a few white setae laterally, all subsequent tergites smooth and shiny without setae; prominent part of ventral spine of hypopygium short, pointed, 1.0–2.0 times as long as broad from ventral view, with long sparse white subapical setae, extending far beyond apex of spine. Male: distinctly shorter than head plus mesosoma.

Etymology. Latin, suggestive of the strong sculpture of mesosoma including mesopleuron.

Distribution. China (Shaanxi).

Gall (Fig 1i–j). Galls are formed in clusters on leaf edge, with 3–5 galls in each cluster, and individual galls are usually like soybeans in size and shape, 0.5–1.0 cm in diameter. Young galls are integral and pale green in colour, becoming dark green later, and turning to brown or dark brown as they mature, when they will also become detachable. Individual galls are hollow, with a tough and thin woody wall 3.0–4.0 mm thick; the interior space contains a single, free larval chamber.

Biology. All galls were found on leaves of *Quercus variabilis* belonging to the *Cerris* section. In the laboratory, adults emerged in early June from galls collected in mid-May.

3.2. *Neuroterus abdominalis* Pujade-Villar & Wang sp. n. (Figs 2a–d, 3)

Type material. Holotype ♀: China, Zhejiang, West Tianmu Mountain (119°27' E, 30°19' N), gall collected from *Quercus acutissima* Carruth. on 22.IX.2010, and adult wasp emerged on 5.III.2011, Guo Rui leg. Paratypes: 5♀♀, same data as holotype. Holotype and 3♀♀ paratypes deposited in ZAFU, 2♀♀ paratypes deposited in UB (JP-V collection).

Diagnosis. The new species is similar to *N. sculpturatus* sp. n. in the sculpture of mesoscutum, but it differs from the latter in having an almost smooth mesopleuron. In addition, the metasoma of these species is unusually large compared with the latter and all other species in the genus.

Description, asexual generation.

Length. Female: 2.2–2.4 mm (n= 6); male: unknown.

Colour. Head and mesosoma dark brown; me-

tasoma blackish to dark brown; clypeus, mandibles, palpi, labialis and maxillaris light yellow; legs uniformly dark yellow; antennae uniformly brown.

Head (Figs 2b, 3a–b). Head subquadrate in frontal view, around 1.3–1.4 times as broad as high and distinctly broader than mesosoma, with sparse short white setae, and about 2.8–2.9 times as wide as long in dorsal view. Lower face shiny, alutaceous, without thin lateral carinae radiating from clypeus. Clypeus conspicuous, anterior tentorial pits distinct but small; epistomal sulcus and clypeo-pleurostomal lines indistinct. Malar space 0.3 times as long as height of compound eye; malar sulcus traceable; transfacial distance 1.3 times as long as height of eye. Inner margins of compound eyes parallel. Distance between inner margin of compound eye and antennal socket 1.3 times as long as diameter of antennal socket, and 1.1 times as long as distance between antennal sockets. POL: OOL: LOL=15: 10: 7, diameter of lateral ocellus 3.0 to the same scale. Gena alutaceous and shiny, not broadened behind compound eye. Frons, vertex and occiput uniformly coriaceous and shiny.

Antenna (Fig. 1f). Antenna 14-segmented, pedicel nearly as long as its broad; F1 1.3 times longer than F2, 2.2 times as long as pedicel; F3 to F5 equals in length, F4 and each subsequent flagellomere broader than the proceeding one; F11 around 1.1 times longer than F10; antennal formula: 11: 9: 20: 15: 14: 14: 14: 13: 12: 10: 10: 9: 10. Placodeal sensillas present from F4.

Mesosoma (Figs 2c–d, 3c–d). Mesosoma 1.1 times as long as high in lateral view. Pronotum smooth, laterally with weak transverse carinae. Anterolateral mesoscutum strongly coriaceous to alutaceous, with somewhat medial and posterior rugulose sculpture; maximum width slightly broader than long (measured between tegulae at anterior tips). Notauli percurrent, but superficial; parapsidal lines present, median mesoscutal impression short, anterior parallel lines indicated by glabrous stripes. Mesoscutellum slightly broader or as broad as long, quadrangular, with brownish setae denser than on mesoscutum, uniformly covered by strong rugose sculpture at the laterals and strongly coriaceous in the medial region, slightly overhanging metanotum. Transscutal articulation absent; scutellar foveae absent but transversal

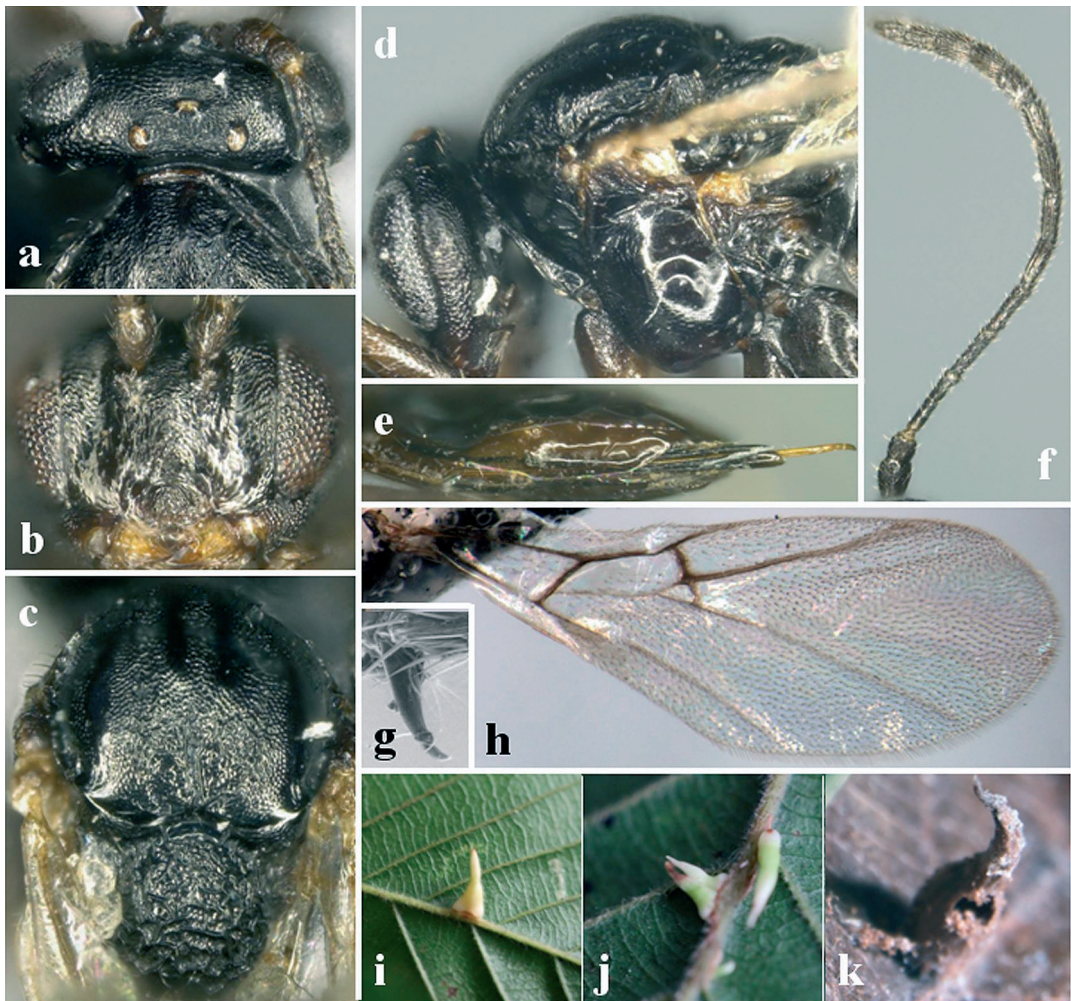


Fig. 3. *Neuroterus abdominalis* sp. n. – a. Head, dorsal view. – b. Head, frontal view. – c. Mesosoma, dorsal view. – d. Head and mesosoma, lateral view. – e. Female metasoma, ventral view. – f. Female antenna. – g. Tarsal claws. – h. Forewing. – i–k. Gall.

scutellar depression present not separated by median carina, smooth inside. Mesopleuron and speculum shiny, slightly alutaceous, with some smooth areas. Dorsal axillar area smooth, with white setae; mesopleural triangle alutaceous; lateral axillar area smooth, with few setae; sub-axillular bar smooth and shiny; metapleural sulcus reaching mesopleuron at half of its height. Metascutellum delicately coriaceous, metanotal trough smooth, shiny, with few short white setae; central propodeal area smooth and shiny, with some interrupted carinae basally; lateral propodeal carinae absent; lateral propodeal area glabrous.

Legs (Fig. 3g). Tarsal claws simple and without basal lobe.

Forewing (Fig. 3h). Forewing margin ciliated and relatively ventrally longer; radial cell open, 3.7–3.8 times as long as wide; areolet conspicuous; vein Rs only lightly curved apically, not reaching the margin of wing as vein R1; vein R1+Sc hardly interrupted before reaching basal vein.

Metasoma (Figs 2a, 3e). Very long, 1.5 times as long as head plus mesosoma, slightly shorter than 2.0 times as long as higher in lateral view; with sparse short setae anterolaterally, and smooth and shiny; prominent part of ventral spine

of hypopygium short and with sparse short setae apically.

Etymology. Latin, suggestive of length and shape of metasoma.

Distribution. China (Zhejiang).

Gall (Fig 3i–k). Ox horn-shaped, monothalms galls are formed on the main vein or lateral veins of leaf. The galls are 1.5–2.0 cm long, milk white young galls turning to yellowish green and hollow with a hard and thin woody wall 2.0–2.5 mm thick when they become mature, and inside the interior space contains a single and free larval chamber.

Biology. All galls were collected on *Quercus acutissima* belonging to the *Cerris* section. In the laboratory, adults emerged in early March from galls collected in the previous September.

4. Discussion

The numerous systematic studies on *Neuroterus* and the newly recognized and obviously closely related genera discussed in the introduction have certainly greatly improved our knowledge of the group. Nonetheless, *Neuroterus* remains one of the most problematic genera in Cynipini. The features diagnostic of *Neuroterus* are (i) malar sulcus at least traceable, (ii) tarsal claws with basal lobe (except simple in *N. tricolor* Hartig), (iii) notauli absent, incomplete or present in the posterior 1/2 or 1/3 of the mesoscutum, always superficial (exceptions: *N. anthracinus* with deep and complete notauli, and *N. tricolor* with shallow and complete notauli in sexual form and deeper notauli in agamic form), (iv) lateral propodeal carinae absent (except in *N. anthracinus* and *N. tricolor*), (v) mesoscutum smooth or with weak alutaceous or coriaceous sculpture, (vi) scutellar foveae absent (except in *N. anthracinus*), (vii) transscutellar carinae absent (except in *N. anthracinus*) and (viii) having a very compressed metasoma (except in *N. anthracinus*). Of these diagnostic features, only the first one, i.e., presence of traceable malar sulcus, appears to be synapomorphic for the genus, a feature not found in any other genera belonging to the “*Neuroterus* complex”, and supported by the putative synapomorphy of the lack of the medial transscutal articulation, namely, *Trichagalma*, *Pseudoneuroterus*, *Latuspina*,

Cerroneuroterus and *Cycloneuroterus* and *Neuroterus*.

On the other hand, the two species (*N. sculpturatus* sp. n. and *N. abdominalis* sp. n.) stand out among all *Neuroterus* species by being associated with oaks of the *Cerris* section. In Melika et al. (2010), all *Neuroterus* species described in Western Palaearctic species with galls on *Cerris* section belong to *Cerroneuroterus*. But all *Cerroneuroterus* have always the malar sulcus absent and the species here described have the malar sulcus more or less defined: clearly in *N. abdominalis* sp. n. (Fig. 2b) and present but inconspicuous in *N. sculpturatus* sp. n. (Fig. 2h). Therefore, *N. sculpturatus* sp. n. and *N. abdominalis* sp. n. share this putative synapomorphy of *Neuroterus*, justifying their inclusion in this genus. Then, according to our results, *Neuroterus* present galls also on *Cerris* section in Eastern Palaearctic area.

In addition, the species here described belong to *Neuroterus* also according to Melika et al. (2010) in having (besides characters above mentioned): head and mesosoma with sparse setae; in male antenna F1 slightly or not modified, never expanded and flattened, sometimes only curved or similar in shape to F2; notaulus if traceable in the anterior half than mesoscutum and/or mesoscutellum entirely or at least partially alutaceous or delicately coriaceous; transscutal articulation medially indistinct or absent, mesoscutum emarginate and elevated posterolaterally above dorsoaxillar area, fused with mesoscutellum; mesoscutellum without foveae, with anterior scutellar depression; prominent part of ventral spine of hypopygium always short, pointed to the apex, never more than 2.0–4.0 times as long as broad, with some long subapical setae, which never form a tuft; and hind tarsal claw usually with basal lobe. All these characters (and some mentioned above) are mentioned in the key published in Melika et al. (2010) and all of them are present in *N. abdominalis* sp. n. The only character not present in *N. sculpturatus* sp. n. is the shape of F1 in male; in this new species this flagellomere is expanded and flattened distally but it is clearly longer than F2 (equal or shorter in *Cerroneuroterus*).

Nonetheless, *N. sculpturatus* sp. n. and *N. abdominalis* sp. n. possess a number of unique

features not found in the majority of the species of the genus. They resemble another member of the genus, *N. tricolor*, in having simple tarsal claws and superficial notauli. The presence of lateral propodeal carinae in *N. sculpturatus* **sp. n.** is also found in *N. tricolor* and *N. anthracinus*. Despite the apparent morphological uniqueness of *N. anthracinus*, its inclusion in *Neuroterus* was supported by phylogenetic analyses based on morphology (Pujade-Villar *et al.* 1998) as well as on DNA sequence data (Stone *et al.* 2009). The membership of *N. tricolor* in *Neuroterus* is less problematic (Melika *et al.* 2010). Therefore, the only real peculiarities of *N. sculpturatus* **sp. n.** and *N. abdominalis* **sp. n.** with respect to the other *Neuroterus* species lie in the apparent sculpture present on the mesoscutum and mesoscutellum (also the mesopleuron in *N. sculpturatus*) (Figs 1c, 2d, g, i, 3c), which does not justify the recognition of a new genus.

The two species, *N. abdominalis* **sp. n.** and *N. sculpturatus* **sp. n.**, resemble each other morphologically. *Neuroterus abdominalis* **sp. n.** is probably an asexual generation, because the galls were collected in September and adults (of only the female gender) emerged in March of the following year. The galls of *N. sculpturatus* **sp. n.** were collected in May and adults of both sexes emerged in June of the same year. All these data suggest that they could correspond to the sexual and agamic generations of the same species, although they were collected from two locations that are more than 1,100 km apart. It would be especially interesting to experimentally corroborate this, because information on alternating generations of Eastern Palaearctic oak gall wasps is extremely rare.

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