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Orthotylus ochrotrichus Fieber, 1864, an adventive European plant bug recently found in Osaka, Japan, with taxonomic changes for *Kiiorthotylus* Yasunaga, 1993 (Hemiptera: Heteroptera: Miridae)

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Abstract

Orthotylus ochrotrichus Fieber, 1864 (Orthotylinae) is reported from Japan for the first time. This plant bug species (Heteroptera: Miridae), which is indigenous to Western Europe and Morocco, is considered to have been accidentally introduced to Osaka (port area) with overseas shipment. In addition, the genus *Kiiorthotylus* Yasunaga, 1993 **stat. prom.** is upgraded from subgenus of *Orthotylus* Fieber, 1858, based on its unique morphological characters and specialized biology. Accordingly, a new combination, *Kiiorthotylus gotohi* (Yasunaga, 1993) **comb. nov.**, is also proposed.

Key words: *Orthotylus*, *Kiiorthotylus*, adventive species, Japan, taxonomy, SEM documentation.

Resumen

***El mírido europeo* Orthotylus ochrotrichus *Fieber, 1864, especie alóctona de reciente hallazgo en Osaka, Japón, junto con cambios taxonómicos en* Kiiorthotylus *Yasunaga, 1993* (*Hemiptera: Heteroptera: Miridae*)**

Se registra *Orthotylus ochrotrichus* Fieber, 1864 (Orthotylinae) por primera vez en Japón. Este mírido (Heteroptera: Miridae), que es autóctono en Europa occidental y Marruecos, es considerado como una introducción accidental en Osaka (área portuaria) con cargamentos de transporte transoceánico. Por otro lado, el género *Kiiorthotylus* Yasunaga, 1993 **stat. prom.** es ascendido desde subgénero de *Orthotylus* Fieber, 1858, con base en sus caracteres morfológicos exclusivos y biología especializada. En consecuencia, se propone la nueva combinación *Kiiorthotylus gotohi* (Yasunaga, 1993) **comb. nov.**

Palabras clave: *Orthotylus*, *Kiiorthotylus*, especie alóctona, Japón, taxonomía, documentación MEB.

Laburpena

Orthotylus ochrotrichus *Fieber, 1864 mirido europarra berriki aurkitua espezie aloktonotzat Osakan, Japonia, eta zenbait aldaketa taxonomiko* Kiiorthotylus *Yasunaga, 1993-en* (*Hemiptera: Heteroptera: Miridae*)

Orthotylus ochrotrichus Fieber, 1864 (Orthotylinae) lehenengo aldiz aipatzen da Japonian. Mendebaldeko Europan eta Marokon autoktonoa den mirido hau (Heteroptera: Miridae), Osakan (portu-eremuan) ustekabean sartuta suertatu dela jotzen da, ozeanoan zehar garraiatutako kargetan hain zuzen. Bestalde, *Kiiorthotylus* Yasunaga, 1993 **stat. prom.** generoa *Orthotylus* Fieber, 1858-ren barneko subgenero izatetik igoarazten da, beren karaktere morfologiko bereizietan eta biologia espezializatuan oinarrituta. Hori dela eta, konbinazio berri bat, *Kiiorthotylus gotohi* (Yasunaga, 1993) **comb. nov.**, proposatzen da.

Gako-hitzak: *Orthotylus*, *Kiiorthotylus*, espezie aloktonoa, Japonia, taxonomia, EME dokumentazioa.

Introduction

Since the late 1990s, more than a few adventive heteropteran species have been discovered in Osaka (Kansai) area, or the second largest urbanized zones in Japan, such as *Rhagadotarsus kraepelini* Breddin, 1905 (Gerridae), *Campyloneura virgula* (Herrich-Schaeffer, 1835) and *Mansoniella cinnamomi* (Zheng & Liu, 1992) (Miridae: Bryocorinae), *Pantilius tunicatus* (Fabricius, 1781) (Miridae: Mirinae) and *Dulinius conchatus* Distant, 1903 (Tingidae), in addition to a harmful fire ant, *Solenopsis invicta* Buren, 1972 (Hymenoptera: Formicidae), well-known as one of the worst invasive alien species in the world and as a medical pest (*cf.* Yasunaga *et al.*, 2016, 2018). Most of these exotic insects are considered to have been introduced with overseas shipment.

Recently, the second author observed a number of individuals of an unknown *Orthotylus* species aggregating on a landscaping and gardening tree, *Ulmus parvifolia* Jacq. (Ulmaceae), planted at a public park and along promenades in urbanized, reclaimed area in Osaka City (Fig. 1). The sampled specimens were carefully examined by the first author and eventually confirmed as *Orthotylus* (*O.*) *ochrotrichus* Fieber, 1864, originally described from UK (Aukema, 2018) and also known by introduced population in the Nearctic Region (Wheeler and Henry, 1992; Schwartz and Scudder, 1998; Schuh, 2002-2013).

The present paper reports this European adventive mirid species from Japan for the first time. *Orthotylus* (*O.*) *ochrotrichus* is at first sight very similar to *Orthotylus* (*Kiiorthotylus*) *gotohi* Yasunaga, 1993, which is endemic to Japan and is restricted to a Japanese indigenous azalea, *Rhododendron macrosepalum* Maxim. (Ericaceae) in Kinki Region (including Osaka Prefecture) and Shikoku (Yasunaga, 1993; Yasunaga *et al.*, 2001). During reexamination of the Japanese-indigenous species for comparison, *Kiiorthotylus* Yasunaga, 1993, that has been regarded as a subgenus of *Orthotylus* Fieber, 1858, was found to have several unique characters significantly different from the nominotypical *Orthotylus*. Therefore, *Kiiorthotylus* is herein given generic level status and a new combination, *K. gotohi* (Yasunaga, 1993) **comb. nov.**, is accordingly proposed.

FIGURE 1. Map showing the two collecting sites of *Orthotylus ochrotrichus* Fieber, 1864 within Osaka Bay-side reclaimed area.

Material and methods

The specimens examined in this study were collected by the second author (Ichikawa) and are deposited in T. Yasunaga collection, Nagasaki, Japan. Terminology for the genitalic structures principally follows Davis (1955), Yasunaga (1999), Schwartz (2011) and Yasunaga and Duwal (2017). Synonymic lists of known taxa are not cited, as several comprehensive catalogs are available (Schuh, 1995; Kerzhner and Josifov, 1999; Schuh, 2020-2013; Aukema, 2018).

All measurements are given in millimeters; for some of the SEM images, scale bars are shown in micrometers (μm). Scanning Electron Micrographs were taken with a Hitachi Miniscope® (TM3030, TM4000II); the genitalic structures were also observed using a Nikon Eclipse Ci upright microscope, with a photophase unit. For SEM documentation of the genitalic structures, the following method was used. After dissection under an Olympus SMZ12 binocular stereoscope the fragile minute organs of the internal genitalia were dipped and washed in 50–60% ethyl alcohol, placed on filter paper until dry, carefully attached to cards (Kent-paper, ca. 5 × 15 mm) using water soluble wood glue and placed in the Miniscope chamber for observation and imaging, without vapor deposition of metals.

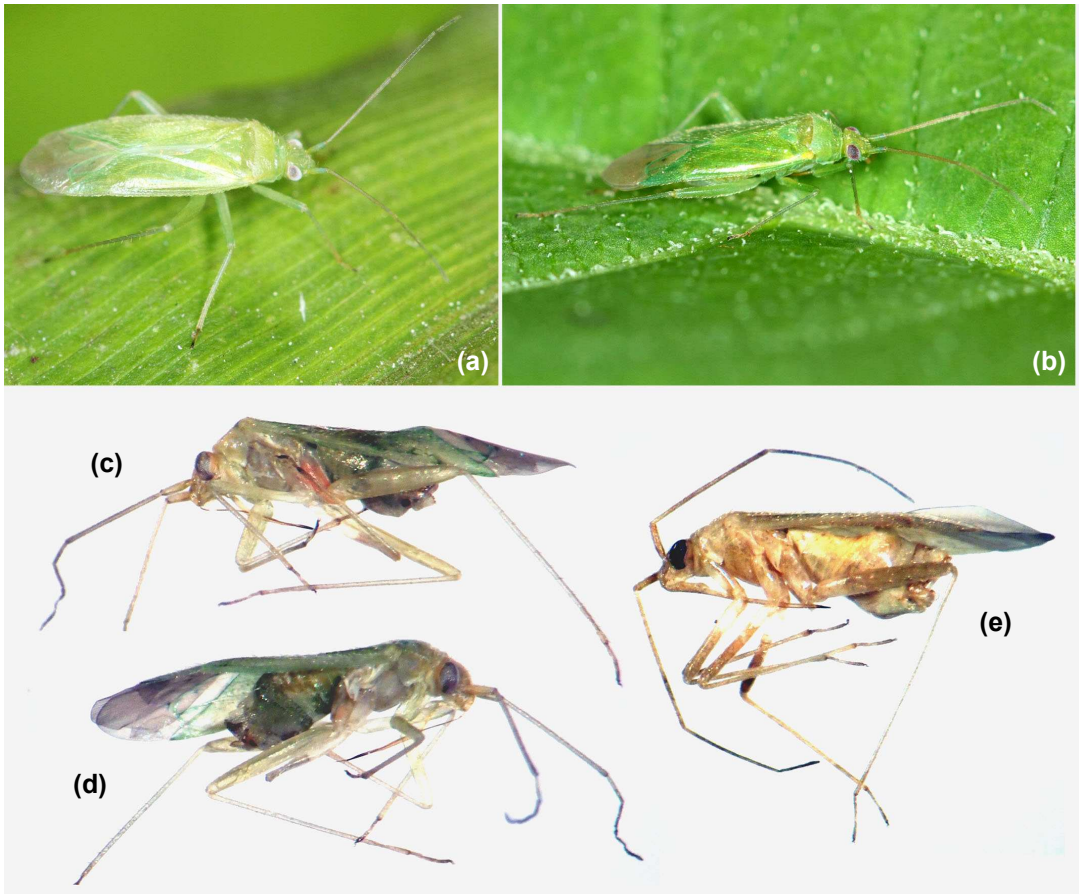

Figure 2. Habitus images of: (a)-(d) Japanese *Orthotylus ochrotrichus* Fieber, 1864; (e) *Kiiorthotylus gotohi* (Yasunaga, 1993) **comb. nov.** / (a) Live individual of Osaka population, male; (b) Same, female; (c)-(e) Dry-preserved male specimens, lateral view.

Results and discussion

Orthotylus ochrotrichus Fieber, 1864

(Figs. 1, 2a-d, 3, 5a-d, 6h-n, Table 1)

Material examined:

2 ♂♂ + 2 ♀♀: JAPAN: Kansai (Kinki) Region, Osaka City, Suminoe Ward, Nankou-Higashi, 34.6188, 135.4355 [Fig. 1-(1)], *Ulmus parvifolia*, 23.v.2021, A. Ichikawa.

3 ♂♂ + 3 ♀♀: Same data, except for date, 29–30.v.2021.

1 ♂ + 1 ♀: Osaka City, Taisho Ward, Chishima Park, SE Hill area, 34.6485, 135.4745 [Fig. 1-(2)], *Ulmus parvifolia*, 5.vi.2021, A. Ichikawa.

Diagnosis:

This Northeastern Atlantic indigenous mirid (Fig. 2a-d) is externally very similar to *Kiiorthotylus gotohi* (Figs. 2e, 4), which is also distributed sympatrically in the Kansai region including Osaka City; the similarity between these two species may cause further taxonomic confusion. In the key to species of Japanese Orthotylini (Yasunaga, 1999: p. 180), *Orthotylus* (*O.*) *ochrotrichus* will run to couplet 26 including *O.* (*O.*) *interpositus* Schmidt, 1938 and *Kiiorthotylus gotohi*, or may key out to the latter, and the key couplet is thus updated for the unequivocal identification as follows:

(26a) Body larger, more than 5.8 mm (usually > 6 mm) in total length; labium short, not exceeding apex of mesocoxa; typical trans-Palaearctic element inhabiting cold-temperate climatic zone and associated with willows (*Salix* spp.) in Hokkaido, Japan . . . . . ***Orthotylus interpositus***

– Body smaller, gracile, less than 5 mm in total length; labium long, reaching or exceeding apex of metacoxa; rather thermophilic mirid known from western Honshu and/or Shikoku **26b**

(26b) Antennal segment III shorter than basal width of pronotum; labium not exceeding apex of metacoxa; exotic mirid recently introduced to urbanized zone of Osaka City . . . . . ***Orthotylus ochrotrichus***

– Antennal segment III longer than basal width of pronotum; labium long, exceeding apex of metacoxa; restricted to *Rhododendolon macrosepalum* in western Honshu and Shikoku . . . . . ***Kiiorthotylus gotohi***

The genitalic structures of *O.* (*O.*) *ochrotrichus* (Osaka population, Figs. 3, 6i-n) exactly fit illustrations provided by several earlier works (*e.g.*, Wagner and Weber, 1964; Wagner, 1974; Schwartz and Scudder, 1998) and significantly differ from those of *Kiiorthotylus gotohi* (Fig. 7b-i).

Distribution:

England, France, Ireland, Morocco, Portugal and Spain (*cf.* Aukema, 2018); introduced populations known in Canada (British Columbia) and Japan (Osaka City).

Discussion:

According to previous authors (*e.g.*, Ehanno, 1987) and to recent observations on the native population in the Basque Country, Spain (Pagola-Carte, pers. comm.), *Orthotylus* (*O.*) *ochrotrichus* has always been found in and around forest zones but not in urban areas until now. Therefore, the immigrants to Osaka City represent a unique example, and further continuous effort to monitor the urban population is encouraged.

The hosts of this polyphagous species are diverse, belonging to at least seven plant families, such as *Acer* spp. (Aceraceae), *Carpinus betulus* (Betulaceae), *Ononis* sp. (Fabaceae), *Quercus* sp. (Fagaceae), *Salix* sp. (Salicaceae), *Ulmus* sp. (Ulmaceae) and *Urtica* sp. (Urticaceae) (Schuh, 2002-2013). The Japanese (Osaka) population of *Orthotylus ochrotrichus* was observed (by Ichikawa) to propagate predominantly on *Ulmus parvifolia* Jacq. (Ulmaceae) planted for gardening and landscaping within highly urbanized zones and to have a univoltine life cycle. The adults appear for a short period from late May to mid June and the eggs most probably hibernate.

		Body	Head	VTX	PRN	Max	Antennomere L				LBM	Metaleg L		
		L	W	W	W	W	I	II	III	IV	L	FM	TB	TS
Males (N = 3)	**Mean**	**4.15**	**0.72**	**0.35**	**1.03**	**1.37**	**0.39**	**1.52**	**0.93**	**0.55**	**1.48**	**1.56**	**2.44**	**0.43**
	Max	4.20	0.74	0.36	1.05	1.41	0.40	1.54	0.95	0.57	1.52	1.58	2.51	0.48
	Min	4.08	0.70	0.34	1.01	1.35	0.38	1.50	0.91	0.53	1.43	1.54	2.36	0.40
Females (N = 4)	**Mean**	**4.48**	**0.76**	**0.39**	**1.15**	**1.54**	**0.41**	**1.53**	**0.98**	**0.48**	**1.62**	**1.62**	**2.57**	**0.46**
	Max	4.65	0.78	0.40	1.20	1.56	0.46	1.56	1.10	0.51	1.71	1.67	2.62	0.49
	Min	4.23	0.74	0.38	1.12	1.52	0.38	1.48	0.82	0.42	1.52	1.58	2.47	0.44

TABLE 1. Measurements for Osaka (introduced) population of *Orthotylus ochrotrichus* Fieber, 1864 (Abbreviations: FM = femur; L = length; LBM = labium; PRN = pronotum; TB = tibia; TS = tarsus; VTX = vertex or interocular space; W = width).

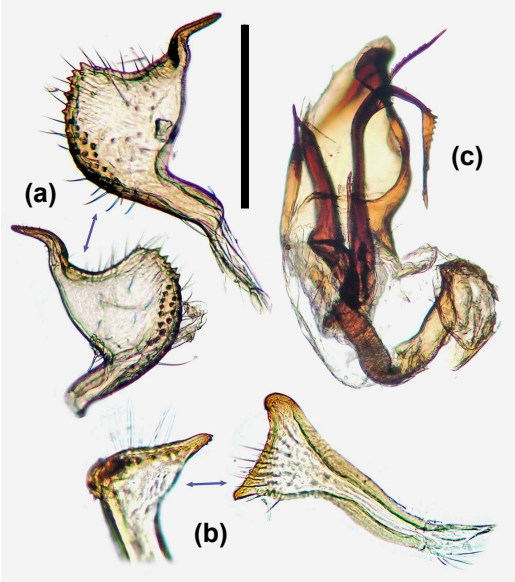

FIGURE 3. Male genitalia of *Orthotylus ochrotrichus* Fieber, 1864: (a) Left paramere; (b) Right paramere; (c) Endosoma (vesica) (Scale bar = 0.5 mm).

Genus *Kiiorthotylus* Yasunaga, 1993 stat. prom.

Kiiorthotylus Yasunaga, 1993: 56 (new subgenus of *Orthotylus* Fieber, 1858), type species: *O. gotohi* Yasunaga, 1993 by original designation; Yasunaga, 1999: 151 (diagnosis).

Diagnosis:

Kiiorthotylus is distinguished from *Orthotylus* or other related genera by the following characters: Body relatively small, gracile, parallel-sided, with long appendages (antennae, labium and legs) (Fig. 4); basic coloration pale green; dorsum with uniformly distributed, simple, semierect setae (Fig. 6o); antenna pale brown, partly tinged with red, generally slender, linear, slightly shorter than body length, with segment III longer than width of pronotum; labium long, exceeding apex of metacoxa (Fig. 5j); metathoracic scent efferent system with densely and uniformly arranged micro-processes (= «mycoid process» *sensu* Kment and Vilímová, 2010) (Fig. 5k-l); ventral surface of tarsi with densely distributed strong spines (Fig. 5o), notched margin of rather developed pulvillus and sharply pointed apex of parempodium (Fig. 5m-n), which presumably enable the mirid to move quickly on sticky host plant; pygophore stout, inflated ventrally, with a mesal, ventral keel anteriorly (Figs. 2e, 7a-b); apical part of left paramere fist-like, with two small, lateral dentate process (Fig. 7b-c); right paramere flattened, with sharp notches along posterior margin (Fig. 7e); phallotheca and endosoma (vesica) curved at right angle medially (Fig. 7d, f); endosoma with two main branches that are sharply bent at middle (Fig. 7f); posterior wall of bursae remarkably elongate, with mesal length twice as long

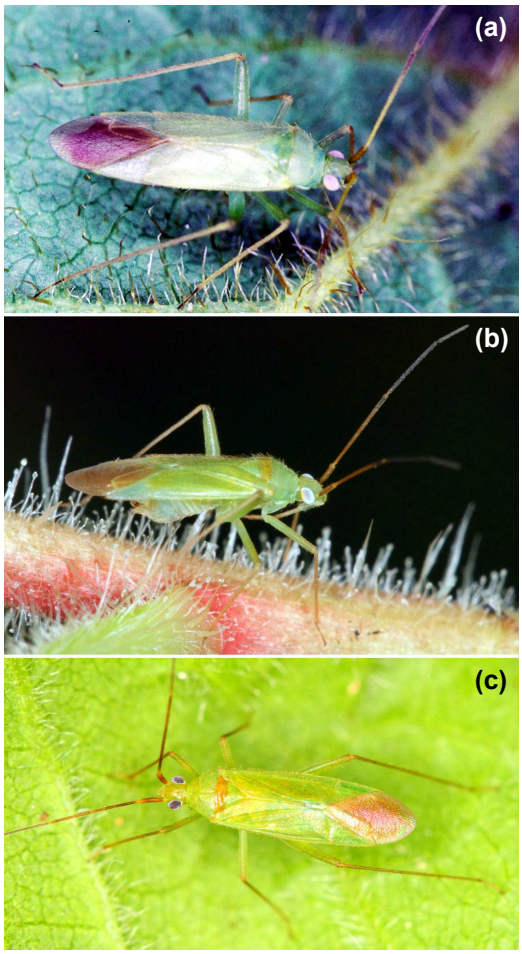

FIGURE 4. Live adult individuals of *Kiiorthotylus gotohi* (Yasunaga, 1993) **comb. nov.** on its particular host, *Rhododendron macrosepalum*: (a) Male from Nanki-area, Wakayama, Japan; (b) Male from Cape Muroto, Kochi, Japan; (c) Female from Cape Muroto.

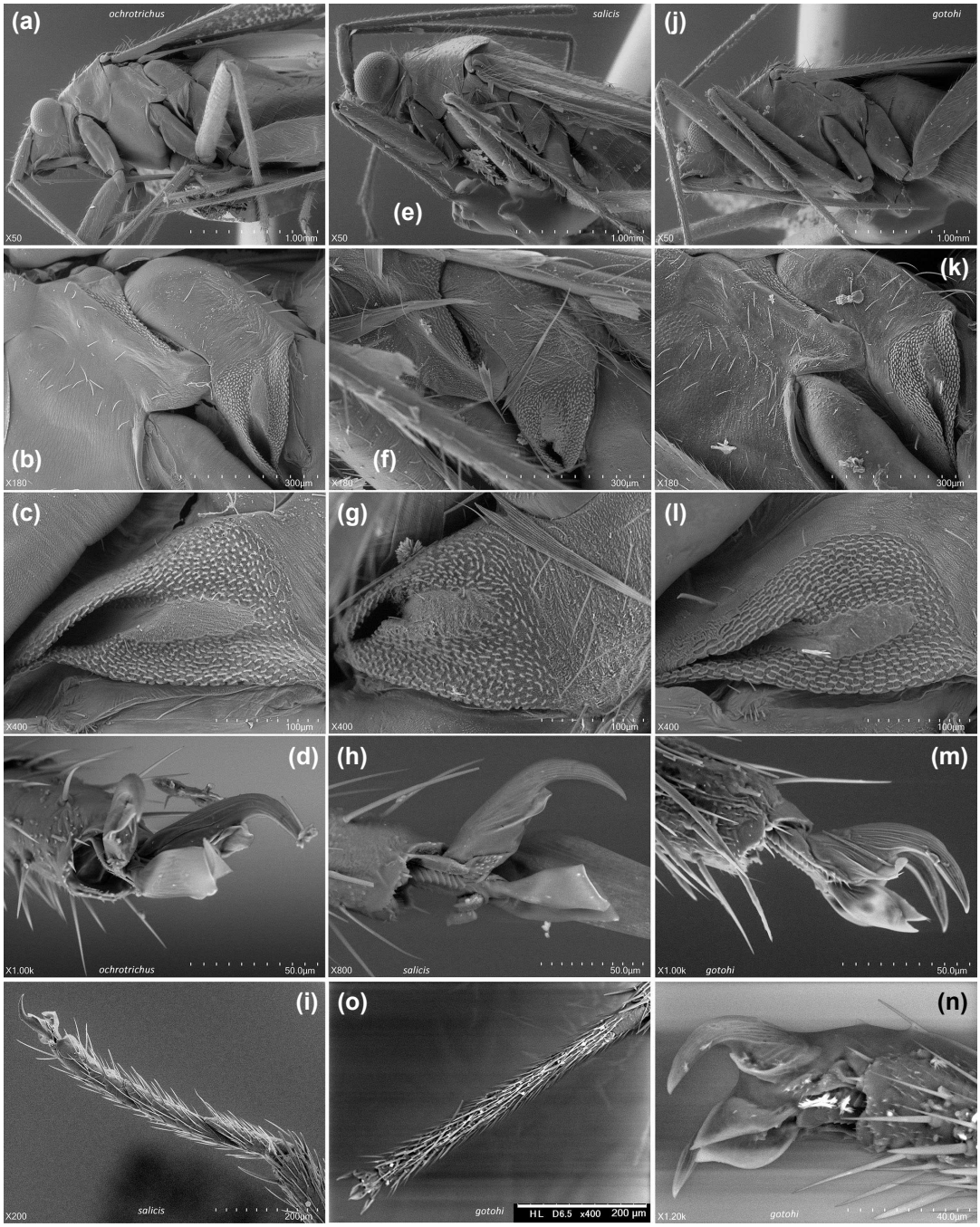

FIGURE 5. Scanning electron micrographs for: (a)-(d) *Orthotylus ochrotrichus* Fieber, 1864, from Osaka, Japan; (e)-(i) *O. salicis* Jakovlev, 1893 from Khasansky District, S. Primorsky, Russia; (j)-(o) *Kiiorthotylus gotohi* (Yasunaga, 1993) **comb. nov.** / (a), (e), (j) Anterior body in left lateral view; (b), (f), (k) Thoracic pleura, left lateral view; (c), (g), (l) Metathoracic scent efferent system, left lateral view; (d), (h), (m), (n) Pretarsal structure of metaleg; (i), (o) Metatarsus.

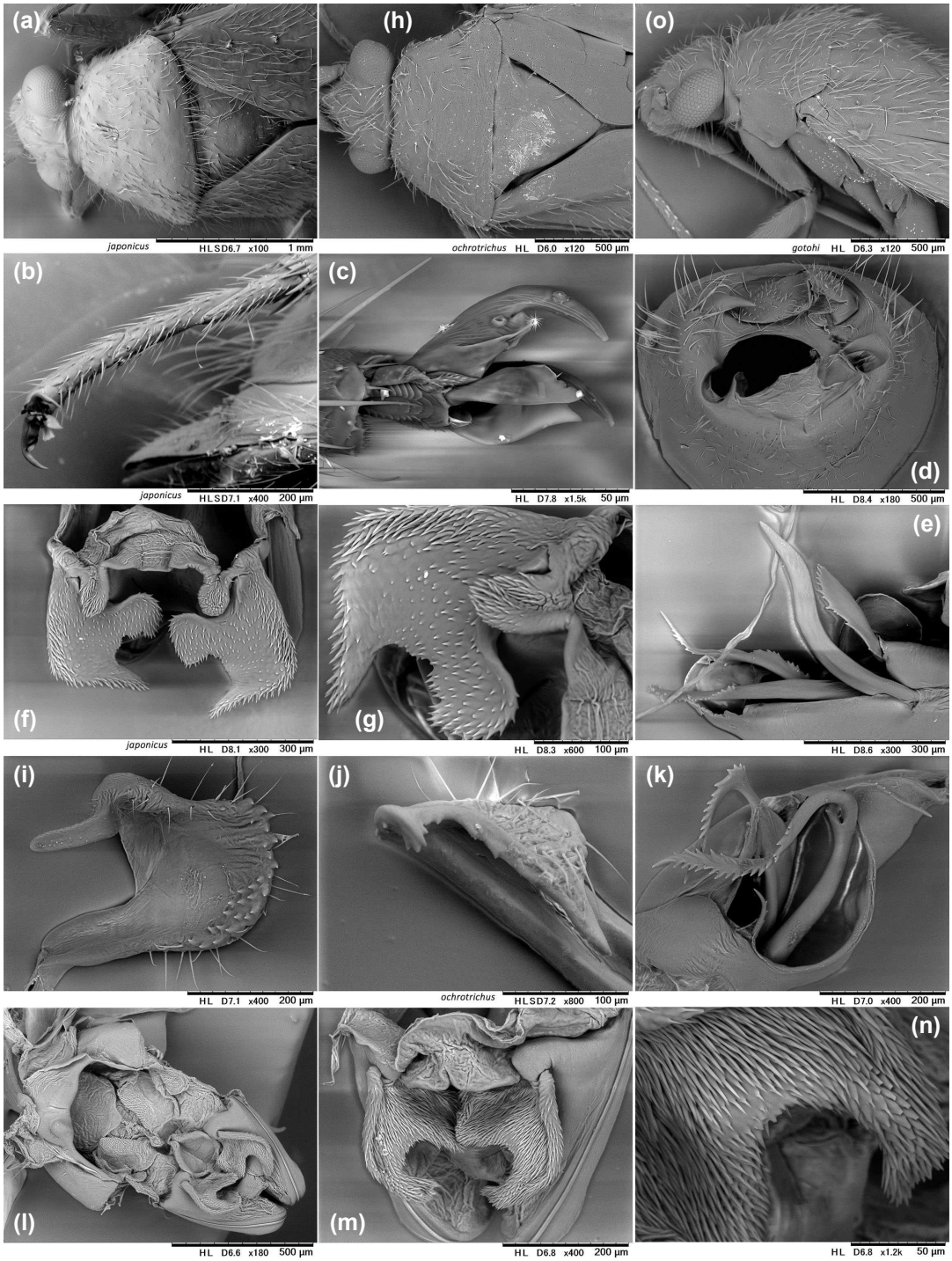

Figure 6. Scanning electron micrographs for: (a)-(g) *Orthotylus japonicus* Yasunaga, 1999 from Hokkaido, Japan; (h)-(n) *O. ochrotrichus* Fieber, 1864, Osaka population; (o) *Kiiorthotylus gotohi* (Yasunaga, 1993) **comb. nov.** / (a), (h), (o) Anterior body, dorsal view [left dorso-lateral view in (o)]; (b) Metatarsus; (c) Pretarsal structure of metaleg; (d) Pygophore, caudal view; (e), (k) Endosoma (vesica); (f), (l), (m) Posterior wall; (g), (n) Interramal lobe; (i) Left paramere; (j) Right paramere.

as width (Fig. 7g); interramal lobes asymmetrical, with longer left lobe (Fig. 7h); spines on interramal lobes short, almost uniformly distributed (Fig. 7i).

Discussion:

As argued repeatedly by a series of our previous works (*e.g.*, Yasunaga, 1999; Yasunaga *et al.*, 2001; Yasunaga and Duwal, 2017; Yasunaga and Shishido, 2020), *Orthotylus* Fieber, 1858, one of most speciose genera among the Miridae with approximately 400 described species worldwide, is apparently not a monophyletic group and cannot be defined by any consistent diagnostic characters possessed by the current members. Eight subgenera were proposed for classification of the Old World members (Kerzhner and Josifov, 1999; Aukema, 2018), but they are not perfectly applicable to the Asian and New World species, and some of them obviously require generic rank. For instance, *Melanotrichus*, previously proposed as a subgenus of *Orthotylus*, has been treated as a full genus (*cf.* Henry and Wheeler, 1988; Wheeler and Henry, 1992), as having the unique characters evidently different from those exhibited by the nominotypical *Orthotylus*.

Kiiorthotylus was also described as a subgenus of *Orthotylus* (Yasunaga, 1993). Nonetheless, detailed examination on the structures suggests that *Kiiorthotylus* has significant characters distinct from *Orthotylus* (*s. str.*) or other related genera as mentioned in above diagnosis section (especially, unique tarsal and pretarsal structures, and noticeably elongate posterior wall). Hence, *Kiiorthotylus* Yasunaga, 1993 **stat. prom.** is herein proposed to be given a generic level status, and a single representative, *K. gotohi* (Yasunaga, 1993) **comb. nov.**, is accordingly transferred from *Orthotylus*.

Most species of *Orthotylus* (*s. str.*) are arboreal and sometimes polyphagous, predominantly utilizing various deciduous broadleaf trees as breeding hosts, whereas *Kiiorthotylus gotohi* is associated only with a semi-evergreen Japanese-endemic azalea, *Rhododendron macrosepalum*, with the leaves and stems densely covered with «sticky» soft glandular hairs (*cf.* Fig. 4). Although most small-sized insects cannot move on (or often are captured by) the adhesive secretion of the azalea, the orthotyline can move agilely on them and scavenges on the cadavers of other insects trapped by the sticky hairs (*cf.* Yasunaga, 1999; Yasunaga *et al.*, 2001; Sugiura and Yamazaki, 2006). Anderson *et al.* (2012) posited that *Rhododendron macrosepalum* has a symbiotic relationship with *Kiiorthotylus gotohi*. Some specialized structures of *K. gotohi* (*e.g.*, remarkably spinose apical parts of the legs, Fig. 5o) are presumed to be correlated with its specialized ecology and imply a unique coevolution between the mirid bug and its host plant in a restricted area of the southwestern Japan Archipelago.

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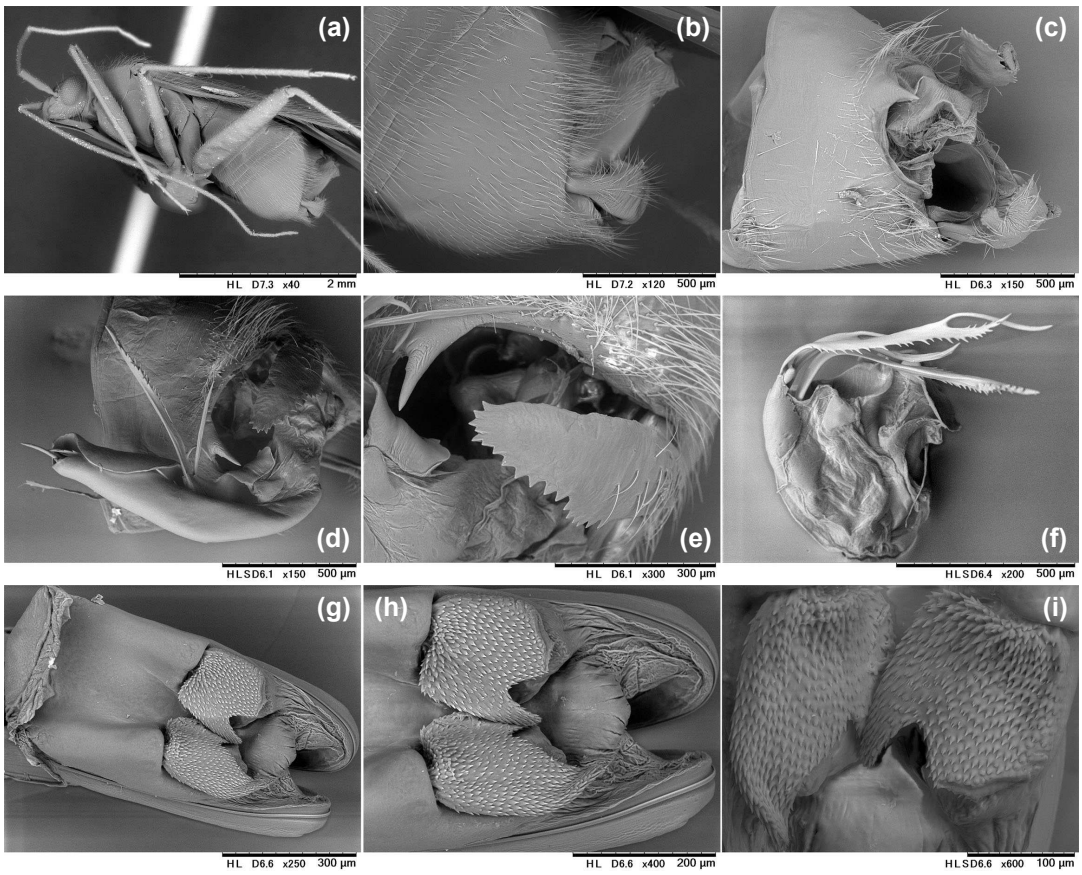

Figure 7. Scanning electron micrographs for *Kiiorthotylus gotohi* (Yasunaga, 1993) **comb. nov.**: (a) Left lateral habitus; (b) Pygophore, in left lateral view; (c) Same, left dorso-lateral view; (d) Same, with exposed phallotheca and endosoma; (e) Right paramere; (f) Endosoma (vesica); (g)-(h) Posterior wall; (i) Interramal lobes.

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