



## Article

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### The genus *Bactrothrips* in China (Thysanoptera: Idolothripinae): morphological and molecular data, and a key with two new species

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#### Abstract

Seven species of *Bactrothrips* Karny are recognized from China, based on morphological and molecular data, including *Bactrothrips elongatus* n. sp. and *B. furvescra* n. sp. *Meiothrips baishanzuensis* Duan & Li is a new synonym of *B. brevitubus* Takahashi, and *Bactrothrips brevitubus zhamanus* Han & Zhang is a new synonym of *B. pictipes* Haga & Okajima. Molecular evidence provides clear relationships in the N-J tree among species studied here. A generic diagnosis and key to Chinese *Bactrothrips* species are also given.

**Key words:** Thysanoptera, Phlaeothripidae, Idolothripinae, *Bactrothrips*, morphology, COI, new species, China

#### Introduction

Karny (1912) erected the genus *Bactrothrips* for a single species, *longiventris*. The main diagnostic characters are: large body, abdominal tergites V–VIII of male with or without lateral tubercles, tube longer than head or slightly shorter, and tube surface with numerous fine setae. However, these character states do not satisfactorily distinguish *Bactrothrips* from two other genera of Idolothripinae, *Megathrips* Targioni-Tozzetti and *Meiothrips* Priesner. On present evidence these genera are distinguished as follows:

*Megathrips*—pelta lateral lobes narrowly joined to, or separated from, median lobe; postocular setae widely spaced, the distance between them about half of head width behind eyes, and located closer to outer margins of cheeks; macropterae with anterior pair of wing retaining setae reduced on each tergite; antennal segment III much shorter than head width across eyes.

*Bactrothrips*—pelta lateral lobes broadly joined to median lobe; postocular setae narrowly spaced, closer to each other than half of head width behind eyes, and posterior to inner margins of eyes; both pairs of tergal wing retaining setae equally well developed (except in *pitkini*); segment III longer than head width across eyes (excluding most Australian species).

*Meiothrips*—antennal segment III much longer than twice width across eyes; pelta with lateral lobes broadly joined to median lobe, joint between median part and lateral lobes slightly shorter than length of lateral lobe.

*Bactrothrips*—antennal segment III length less than twice width across eyes; pelta with lateral lobes less broadly joined to median lobe, joint between median part and lateral lobes slightly shorter than or as long as a half of the length of lateral lobe.

Some characters, such as antennal segment III and the pelta, have a gradient in changes through these three genera, and the genera are thus distinguished weakly from each other based on morphological characters. Some Australian *Bactrothrips* species have shorter antennae including segment III, and the stylets are deeply retracted into the head as in *Megathrips* (Mound & Tree, 2011). Moreover, in at least four species the males lack lateral abdominal tubercles (*B. alicae* and *perplexus* from Australia, and *B. inermis* and *pitkini* from Africa). Thus a broader systematic revision of the genus based on worldwide species is needed.

The genus *Bactrothrips* currently includes 51 species (Mound, 2012) worldwide, of which more than half are recorded from Africa and Madagascar, with only nine species from India, Japan and China. In China, four species have been recorded, including three from Taiwan, and one species is widely distributed in South China (Zhang, 1984; Han, 1997; Han, 2002). Amongst thrips samples collected from South China as part of an ongoing survey of Thysanoptera in Zhejiang and Guangxi, there were five samples of two undescribed species of *Bactrothrips*. These are described below, and a key is provided to the seven species now known from China.

In order to accurately identify the species of *Bactrothrips*, we provide DNA barcoding (*COI*) evidence, and the morphological and DNA barcoding (*COI*) results are well coincident. As voucher specimens, the remaining carcasses of thrips after DNA extracted were mounted on slides in Canada balsam for morphological study. In order to understand the phylogenetic relationships of *Bactrothrips* and the closely related genera, *Bacillothrips* Buffa, *Megathrips* Targioni-Tozzetti, *Megalothrips* Uzel and *Meiothrips* Priesner, research will be needed using both morphological and molecular data.

## Material and methods

Thrips specimens were collected in 95% or 100% ethanol at -20°C for DNA taxonomy. Total genomic DNA was extracted from single thrips using the method of Rugman-Jone *et al.* (2006) and Mound *et al.* (2010) or using the Dneasy Tissue Kit (Qiagen, Hildenberg, Germany) provided by the manufacturer. The remaining carcass (vouchers) was removed and stored in 10% KOH for several days (usually 4–6 days for the large thrips), then cleared through the following series: pure water, 75% ethanol, 95% ethanol, 50% clove oil (clove oil vs pure alcohol=1:1), pure clove oil, and finally mounted in Canada balsam. Descriptions are based on permanent slides of specimens under the microscope (Leica DM4000B), measurements and pictures are processed under the Leica Microsystems with Microsoft QWIN (Leica QWin plus). Thrips terminology in this paper generally follows Mound (2012) and Okajima (2006). The unit of measurements in this paper is micrometre (microns). Samples used in the DNA studies are listed in Table 1.

All the *COI* was amplified using primers LCO1490 and HCO2198 (Folmer *et al.*, 1994). PCR was performed in 30 ul reactions containing 2 ul of DNA template, 21 ul of sterile distilled water, 3 ul of 10×EasyTaq DNA Polymerase Buffer (+Mg<sup>2+</sup>), 2.4 ul of High Pure dNTPs, 0.4 ul of EasyTaq DNA Polymerase, and 0.6 ul of each primer. The samples were run using following PCR profile: 95°C for 5 min, then 40 cycles of 30 sec at 95°C, 30 sec at 50°C and 1 min at 72°C, with a final extension at 72°C for 10 min after the last cycle. PCR products were sequenced in both directions with BigDye Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, CA, USA) and run on an ABI 3730 automated sequencer (Applied Biosystems). Sequences were assembled by Seqman II (DNASTar, Inc., Madison, WI, USA) and then aligned using Clustal W. The neighbor-joining tree was constructed by MEGA 5.05 with Kimura 2-parameter model and 1,000 bootstraps. All sequences were deposited in GenBank under the accession numbers JQ698632–JQ698660 (see Table 1).

**Depositories and abbreviations.** All specimens including types and vouchers (except where indicated) are deposited in the National Zoological Museum of China, Institute of Zoology, Chinese Academy of sciences, Beijing, China. The following abbreviations are used for pronotal setae: *am*—anteromarginals, *aa*—anteroangulars, *ml*—midlaterals, *epim*—epimerals, *epima*—epimeral accessory, *pa*—posteroangulars, *pm*—posteromarginals.

## *Bactrothrips* Karny

*Bactrothrips* Karny, 1912: 131. Type-species: *Bactrothrips longiventris* Karny, 1912.

Among species of the genus *Bactrothrips*, some morphological characters are variable. In *B. flectoventris* the eyes are prolonged on the ventral surface of the head, but in the others the eyes are developed similarly on both sides of head. In two species from Australia, *B. alicae* and *B. kranzae*, the maxillary stylets are retracted almost to the eyes and closer together, but in other members of the genus the maxillary stylets are shorter and far away from each other. Males of some species lack abdominal tubercles, but in other species these lateral tubercles vary in shape from straight, to curved or even bifurcate. So it is difficult to define the genus based on morphological characters.

**TABLE 1.** Collection information of thrips samples for DNA studies

Species	The number of samples	Locality	Date	Collectors	GenBank No.
<i>B. brevitubus</i> Takahashi	3	Fujian Province: Meihua & Liangye Mountains	6–14.xi.2008	H.H. Zhang	JQ698632–JQ698634
<i>B. brevitubus</i> Takahashi	1	Hainan Province: Limu Mountain	6–16.iv.2010	M.Y. Lin	JQ698635
<i>B. brevitubus</i> Takahashi	7	Guangxi Auto. Reg.: Daming Mountain and Huaping County	27–28.v./8.vi.2011	L.H. Dang	JQ698636–JQ698642
<i>B. brevitubus</i> Takahashi	1	Hainan Province: Baisha County	15.iv.2010	M.Y. Lin	JQ698643
<i>B. quadriloberculatus</i> (Bagnall)	2	Yunnan Province: Xishuangbanna District	7.x.2010	M.Y. Lin	JQ698644–JQ698645
<i>B. pictipes</i> Haga & Okajima	2	Hainan Province: Limu Mountain	6.iv.2010	M.Y. Lin	JQ698646–JQ698647
<i>B. furvescens</i> n.sp.	4	Zhejiang Province: Qingliang Mountain	4.viii.2011	L.H. Dang & J. Wen	JQ698648–JQ698651
<i>B. flectoventris</i> Haga & Okajima	2	Hainan Province: Limu Mountain	6.iv.2010	M.Y. Lin	JQ698652–JQ698653
<i>B. honoris</i> (Bagnall)	2	Yunnan Province: Xishuangbanna District	7.x.2010	M.Y. Lin	JQ698654–JQ698655
<i>B. elongatus</i> n.sp.	2	Guangxi Auto. Reg.: Maoer Mountain and Huaping County	3–8.vi.2011	L.H. Dang	JQ698656–JQ698657
<i>Elaphrothrips</i> sp.	1	Hainan Province: Ledong County	1.xii.2009	L.N. Huang	JQ698658
<i>Liothrips</i> spp.	2	Hainan Province: Ledong County	6.v./6.xii.2009	L.H. Dang/L.N. Huang	JQ698659–JQ698660

Diagnosis. Body large. Head much longer than width across eyes, usually prolonged in front of eyes; eyes normal or obviously prolonged on ventral surface; interocellar, postocellar, postocular and mid-dorsal setae usually well developed, but sometimes small; posterior ocelli in contact with eyes. Maxillary stylets short and wide apart, or long and close together. Antennae 8-segmented, slender or stout; segments III and IV with 2 and 4 sense-cones separately. Pronotum usually with five pairs of major setae well developed, sometimes epimeral accessory setae also well developed; epimeral sutures incomplete or complete; basantra and ferna present. Mesopraesternum boat-shaped. Metathoracic sternopleural sutures absent. Wings fully developed with numerous duplicated cilia, or apterous. Fore legs not enlarged and tarsi unarmed. Pelta with two lateral lobes never separated; abdominal tergites II–VII each with two pairs of sigmoid wing-retaining setae in species with wings full developed; tergites V–VIII of male with or without lateral tubercles, the tubercles small, long, straight, curved, horn-like or forked; tube much longer or slightly shorter than head, surface with numerous fine setae; anal setae much shorter than tube.

### Key to Chinese *Bactrothrips* species

1. Eyes posteriorly prolonged on ventral surface (Fig. 32).....*B. flectoventris*
- Eyes not prolonged on ventral surface (Figs 31, 33–37).....2
2. Sense-cones on antennal segment III well developed, longer than one third of this segment (Fig. 1).....3
- Sense-cones on antennal segment III shorter than one third of this segment (Fig. 15) .....4
3. Tibiae largely dark brown, but yellowish at extreme bases and apices; lateral tubercles on male abdominal segment VI bicoloured, with basal 1/4 dark brown .....*B. elongatus* n. sp.
- Hind legs bicoloured, at least distal third of hind tibiae yellowish; lateral tubercles on abdominal segment VI largely dark brown, with extreme apices yellow. ....*B. honoris*
4. Tibiae largely dark brown, with extreme bases and apices yellowish ..... *B. furvescens* n. sp.
- Tibiae distinctly bicoloured, about yellow at apical half and dark brown at basal half .....5
5. Interocellar setae on head the longest (Fig. 34) ..... *B. pictipes*
- Mid-dorsal setae on head the longest (Figs 31, 35). ....6
6. Postocellar setae much longer than postoculars, about 3–5 times as long as diameter of posterior ocelli. .... *B. brevitubus*
- Postocellar setae much shorter than postoculars, about 1–1.5 times as long as diameter of posterior ocelli ..... *B. quadrituberculatus*

### *Bactrothrips brevitubus* Takahashi

(Figs 31, 38–39)

*Bactrothrips brevitubus* Takahashi, 1935: 61.

*Meiothrips baishanzuensis* Duan & Li, 1995: 211. **Syn. n.**

Described originally from Japan, this species is recorded widely in South China based on details given by Okajima (2006), and *Meiothrips baishanzuensis* Duan & Li is here considered a synonym based on examination of the holotype. Individuals are variable in morphology; in particular, the tubercles on abdominal segment VI are long in large males but short in small males (Figs 38, 39). The COI results support the interpretation that this variation is intraspecific. The species is identified by the long postocellar setae (about 3–5 times as long as diameter of one postocellus, sometimes a little shorter than the longest mid-dorsal setae) and short *epima* (always shorter than one third of *epim*).

**Material examined.** CHINA, holotype female of *baishanzuensis*, Zhejiang Prov. (Baishanzu Mountain), 20.vii.1994, H. Wu, in B.S. Duan collection; Hubei Prov. (Xingshan County), 3 females 8 males, 11.ix.1994, F.S. Li; Fujian Prov. (Meihua & Liangye Mountains), 7 females 7 males on dead tree leaves, 6–14.xi.2008, H.H. Zhang; Guangxi Auto. Reg. (Daming Mountain & Huaping County), 35 females 12 males on dead hanging tree leaves, 27.v–8.vi.2011, L.H. Dang; Yunnan Prov. (Xishuangbanna District), 1 male, 16.iii.1957, D.H. Liu; Yunnan Prov. (Menghai County, Nannuo Mountain), 3 females, 1.iii.1957, F.J. Pu; Yunnan Prov. (Nangun River), 1 female on dead hanging tree leaves, 16.xi.2009, J. Chen & X.N. Zhang; Hainan Prov. (Xinglong County), 10 females 4 males on dead tree leaves, 16.iv–7.vi.1963, B.L. Zhang; Hainan Prov. (Limu Mountain), 9 females 4 males on dead tree leaves, 15–26.iv.2010, M.Y. Lin; Hainan Prov. (Ledong County, Jianfengling Mountain), 1 male on dead hanging tree leaves, 18.v.2009, L.H. Dang & F.Q. Chen; Hainan Prov. (Ledong County), 1 female, 4.xii.2009, L.N. Huang.

**Distribution.** China (Hubei, Anhui, Fujian, Guangxi, Zhejiang, Guangdong, Yunnan, Hainan, Taiwan); Japan.

***Bactrothrips elongatus* n. sp.**

(Figs 1–14, 36, 42)

*Male macroptera.* Body uniformly brown; antennal segments I–II brown, III–VI yellow but shaded in their club-heads, VII–VIII brown; fore wings uniformly pale; femora and tibiae brown with pale extreme bases and apices, tarsi yellow; abdominal tubercles on segment VI yellow but dark brown in basal 0.3, tubercles on VIII dark brown, tube dark brown; major setae yellowish.

Head 2.1 times as long as wide across eyes, projecting in front of eyes, transversely striate; interocellar setae well developed, longer than width of one eye, one pair of postocellar setae about as long as diameter of posterior ocellus; eyes developed, about 0.3 of head length, postocular cheek setae shorter than postocular setae; mid-dorsal setae well developed, about as long as or a little longer than interocellar setae; cheeks with several pairs of minor setae (Figs 2, 9). Maxillary stylets wide apart, retracted into head one third way to posterior margin of eyes (Fig. 2). Antennal segment III a little longer than head width across eyes (Fig. 9), III with 2 sensoria, IV with 4, V with 2, VI and VII each with one, these sensoria on III about 2.5 times as long as apical width of segment, much longer than 0.3 times of this segment, segments VI–VII with a short apical, ventral prolongation.

Pronotum with irregular sculpture, anterior margin concave, epimeral sutures incomplete; one pair of *am* a little shorter than *aa*, *epima* much longer than half of *epim* (Figs 3, 10). Metanotal median setae developed, metanotum smooth on anterior third, with weak reticulate sculpture on posterior half (Figs 4, 11). Fore wings broad, with about 33 duplicated cilia (Fig. 5).

Pelta with reticulate sculpture slightly longitudinal, lateral lobes narrowly joined to median lobe (Figs 6, 11); lateral abdominal tubercles on VI well developed and straight, about 1.4 times as long as length of the segment, VII without lateral tubercles, VIII with one pair of short tubercles (Figs 8, 42); tergite IX setae much shorter than tube; tube about 1.4 times as long as head, weakly constricted near apex, laterally with few long setae. Sternites with an irregular single or double transverse row of discal setae no pore plates.

*Measurements* (holotype male in microns). Body length 4901. Head, length 563; width across eyes 271; head setae length: interocellars 111, postocellars 31, postoculars 72, postocular cheek setae 46, mid-dorsal setae 120; diameter of posterior ocellus 33. Antennal segments III–VIII length (maximum width), 285 (44), 237 (46), 221 (45), 151 (38), 85 (27), 77 (14), sensoria of segment III length 136. Pronotum length (maximum width) 237 (407); setae length, *am* 56, *aa* 65, *ml* 91, *epim* 147, *epima* 93, *pa* 108, *pm* 37. Metanotal median setae length 142. Pelta length (maximum width) 122 (501). Tubercles on tergite VI length 394, little tubercles on VIII length 36; tergite IX setae S1 263, S2 124; tube length 773.

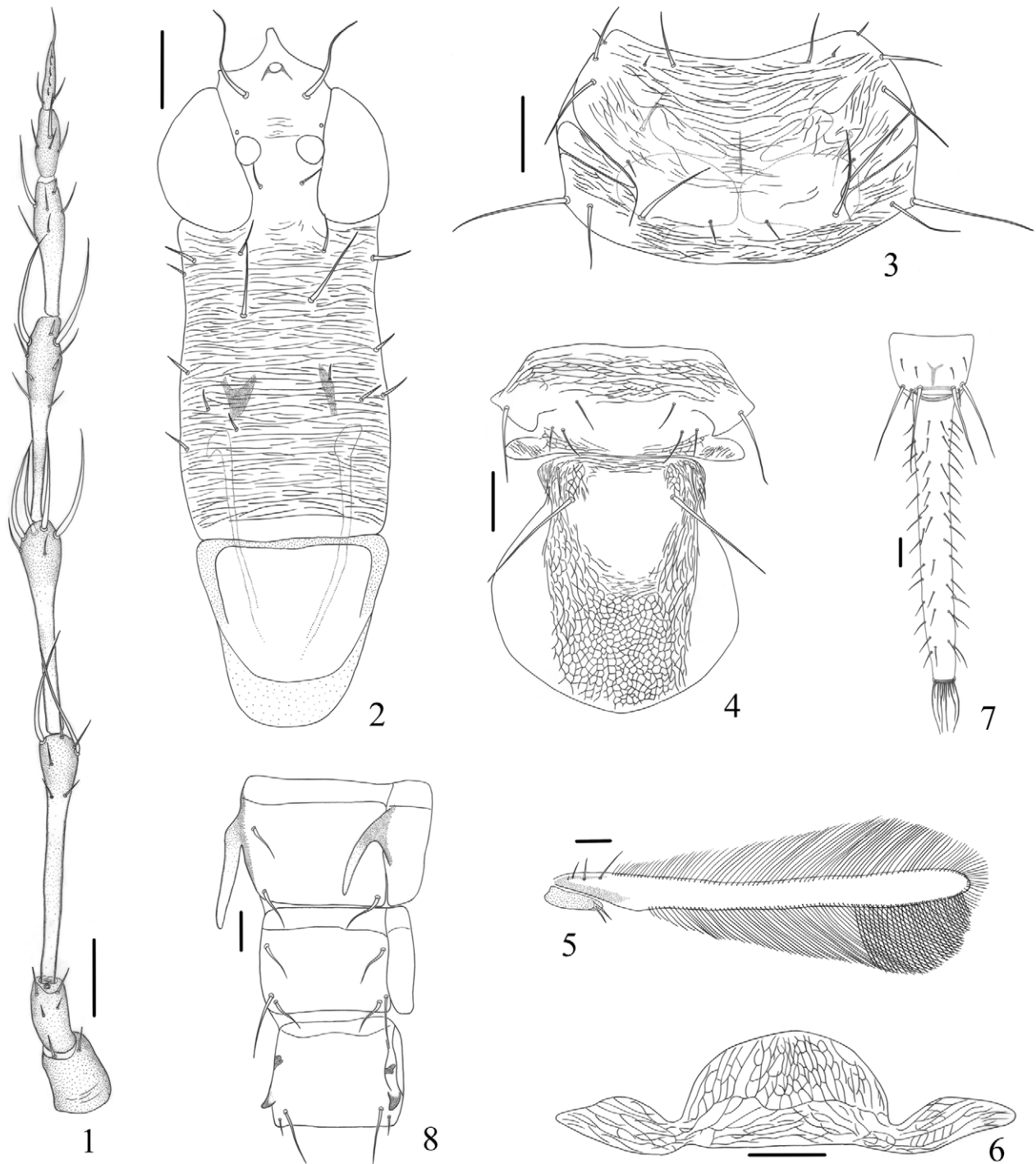
*Female macroptera.* Similar to male, but larger, without tubercles on abdominal segments VI–VIII, tergite IX with setae S1 and S2 similar in length.

*Measurements* (paratype female in microns). Body length 6282. Head, length 625; width across eyes 303; head setae length: interocellars 111, postocellars 36, postoculars 61, postocular cheek setae 50, mid-dorsal setae 108, diameter of posterior ocellus 33. Antennal segments III–VIII length (maximum width), 329 (50), 278 (52), 258 (48), 177 (40), 87 (34), 86 (17), sensoria of segment III length 153. Pronotum length (maximum width) 267 (463); setae length, *am* 68, *aa* 71, *ml* 111, *epim* 153, *epima* 91, *pa* 112, *pm* 24. Metanotal median setae length 201. Pelta length (maximum width) 150 (603). Tergite IX setae S1 341, S2 324; tube length 1029.

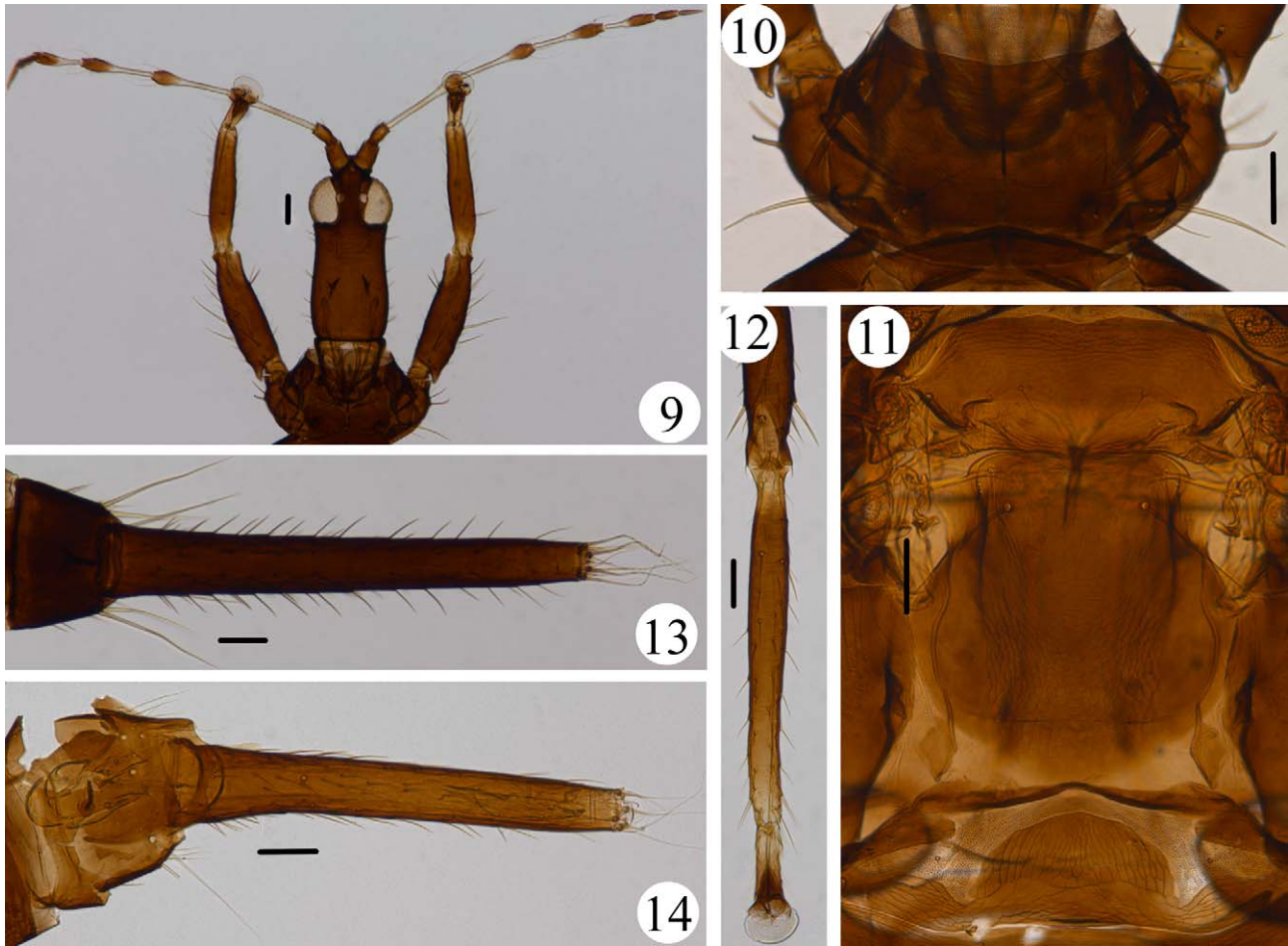
**Material examined.** Holotype male. CHINA, Guangxi Auto. Reg. (Xingan County, Maoer Mountain, 25.53°N, 110.25°E, altitude 1357m), on dried-up hanging tree leaves, 3.vi.2011, L.H. Dang, No. JM11119-3. Paratypes: Guangxi Auto. Reg. (Huaping County, 25.39°N, 109.55°E), 2 females on dried-up hanging tree leaves, 8.vi.2011, L.H. Dang, Nos. JM11159-2, JM11159-3; Guangxi Auto. Reg. (Wuming County, Daming Mountain, 23.27°N, 108.30°E), 1 female 1 male on dried-up hanging tree leaves, 28–30.v.2011, L.H. Dang, Nos. JM10068-1, JM11082-2.

**Remark.** This species is somewhat similar to *B. honoris* Bagnall in appearance, with the sense-cones on antennal segment III well developed, much longer than one third of this segment, and interocellar setae similar to mid-dorsal setae. But the new species can be distinguished by the following characters: sense-cones on antennal segment III obviously shorter than half of this segment (*honoris*: sense-cones on antennal segment III as long as half of this segment), *epima* much longer than half of *epim* (*honoris*: *epima* a little shorter than half of *epim*), and all tibiae uniformly dark brown not bicoloured (*honoris*: hind tibiae obviously bicoloured with apical third or half yellow).

**Etymology.** This species name is composed of one Latin word, “*elongatus* (= long)”, based on longer sensecones on antennal segments.



**FIGURES 1–8.** *Bactrothrips elongatus* n. sp. Female: **1**, antenna; **2**, dorsal view of head; **3**, dorsal view of pronotum; **4**, dorsal view of mesonotum and metanotum; **5**, fore wing; **6**, pelta; **7**, abdominal tergite IX and tube. Male: **8**, abdominal tergites VI–VIII showing the lateral tubercles. Scale bars =100µm.



**FIGURES 9–14.** *Bactrothrips elongatus* n. sp. Female: **9**, antenna, head, pronotum and fore legs; **10**, dorsal view of pronotum; **11**, dorsal view of mesonotum and metanotum; **12**, hind leg; **13**, abdominal tergite IX and tube. Male: **14**, abdominal tergite IX and tube. Scale bars=100µm.

***Bactrothrips flectoventris* Haga & Okajima**

(Figs 32, 40)

*Bactrothrips flectoventris* Haga & Okajima, 1989: 8.

Described originally from Japan, with paratypes from China (Taiwan), this species is unique in the genus in having the eyes prolonged posteriorly on the ventral surface of head. The specimens listed below were identified from the original description, but differ in the lengths of major setae on the head from the lengths in the original description (in parentheses): interocellar setae 106–152 (cf 65–125), postocellars 54–73 (cf 21–63), postocular cheek setae 50–62, postoculars 67–85 (cf 27–32), mid-dorsal setae 98–111 (cf 50–75). The major setae on the head are clearly longer than in the original specimens, and although the length of the postocular cheek setae was not given, the original illustration showed that the postocular cheek setae were much longer than the postoculars. This species presumably varies in some characters between different geographical populations. It is here recorded for the first time from the Chinese mainland (Hainan).

**Material examined.** CHINA, Hainan Prov. (Limu Mountain), 2 females 2 males on dried-up tree leaves, 26.iv.2010, M.Y. Lin.

**Distribution.** China (Hainan, Taiwan); Japan.

***Bactrothrips furvescrus* n. sp.**

(Figs 15–30, 37, 43)

*Male macroptera.* Body uniformly brown; antennal segments I–II brown, III–VI yellow but shaded in their club-heads, VII–VIII brown; fore wings uniformly pale; femora and tibiae brown with pale extreme bases and apices, tarsi yellow; abdominal tubercles on segment VI yellow with dark brown in basal 0.2, tubercles on VII–VIII dark brown, tube dark brown; major setae yellowish.

Head 2.1 times as long as wide across eyes, projecting in front of eyes, transversely striate; interocellar setae longest, longer than width of one eye, one pair of postocellar setae about as long as diameter of posterior ocellus; eyes developed, about 0.3 of head length, slightly prolonged ventrally, postocular cheek setae shorter than postocular setae; mid-dorsal setae developed, but much shorter than interocellar setae; cheeks with several pairs of minor setae (Figs 16, 37). Maxillary stylets wide apart, retracted into head one third way to posterior margin of eyes (Fig. 16). Antennal segment III length 1.1 times as long as head width across eyes (Fig. 25), III with 2 sensoria, IV with 4, V with 2, VI and VII each with one, these sensoria on III and IV about 2.1 times as long as apical width of segment, segments VI–VII with a short apical, ventral prolongation.

Pronotum with irregular sculpture, anterior margin concave, epimeral sutures complete; 2 pair of *am*, one pair almost as long as *aa*, *epima* about as long as half of *epim* (Figs 16, 26). Metanotal median setae developed, metanotum smooth on anterior third, with weak reticulate sculpture on posterior half (Figs 18, 27). Fore wings broad, with about 40 duplicated cilia.

Pelta with reticulate sculpture slightly longitudinal, lateral lobes narrowly joined to median lobe (Figs 31, 27); lateral abdominal tubercles on VI well developed and straight, about 1.9 times as long as length of the segment, tubercles on VII smaller than ones on VIII (Figs 22, 43); tergite IX setae much shorter than tube; tube about 1.4 times as long as head, weakly constricted near apex, laterally with few weak setae. Sternites with an irregular single or double transverse row of discal setae no pore plates.

*Measurements* (holotype male in microns). Body length 6379. Head, length 677; width across eyes 316; head setae length: interocellars 143, postocellars 36, postoculars 62, postocular cheek setae 49, mid-dorsal setae 82, diameter of posterior ocellus 33. Antennal segments III–VIII length (maximum width), 351 (52), 271 (57), 254 (48), 155 (41), 98 (31), 85 (24), sensoria of segment III length 108. Pronotum length (maximum width) 268 (534); setae length, *am* 83, *aa* 86, *ml* 111, *epim* 179, *epima* 84, *pa* 111, *pm* 44. Metanotal median setae length 170. Pelta length (maximum width) 166 (648). Tubercles on tergite VI length 756, little tubercles on VII–VIII length 22, 58; tube length 944.

*Female macroptera.* Similar to male, but without tubercles on abdominal segments VI–VIII, tergite IX with setae S1 and S2 similar in length.

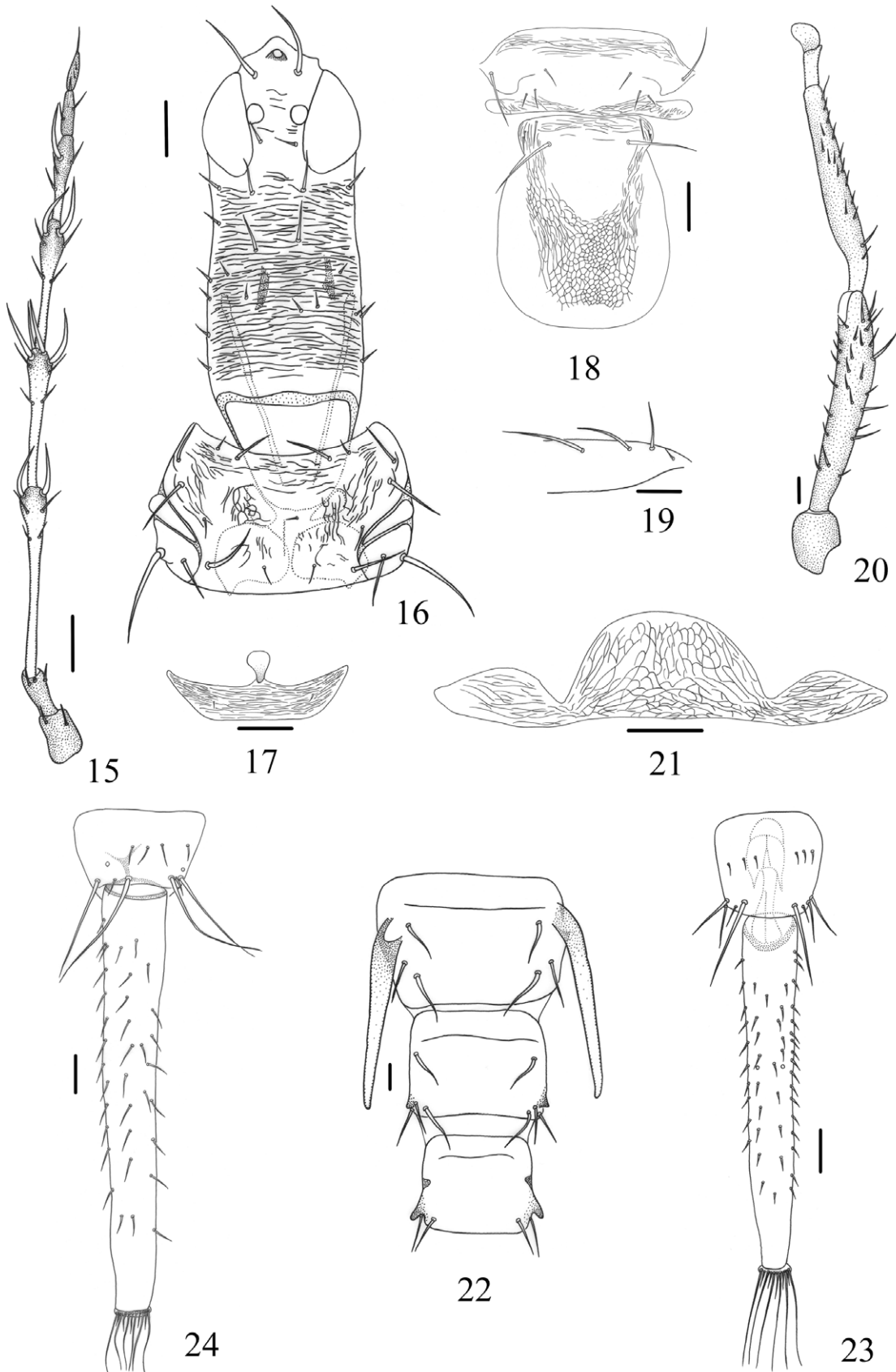
*Measurements* (paratype female in microns). Body length 5908. Head, length 624; width across eyes 321; head setae length: interocellars 150, postocellars 49, postoculars 69, postocular cheek setae 55, mid-dorsal setae 81, diameter of posterior ocellus 37. Antennal segments III–VIII length (maximum width), 318 (50), 277 (53), 243 (46), 148 (39), 87 (30), 81 (18), sensoria of segment III length 103. Pronotum length (maximum width) 259 (500); setae length, *am* 85, *aa* 85, *ml* 103, *epim* 184, *epima* 88, *pa* 129, *pm* 49. Metanotal median setae length 177. Pelta length (maximum width) 188 (682). Tergite IX setae S1 267, S2 300; tube length 989, anal setae length 249.

**Material examined.** Holotype male. CHINA, Zhejiang Prov. (Linan County, Qingliangfeng Mountain, 30.07°N, 118.51°E), on dead hanging tree leaves, 4.viii.2011, L.H.Dang & J.Wen, No. JM11241-2. Paratypes: 8 females 3 males, with same data as holotype, Nos. JM11241-1, JM11241-3 – -11.

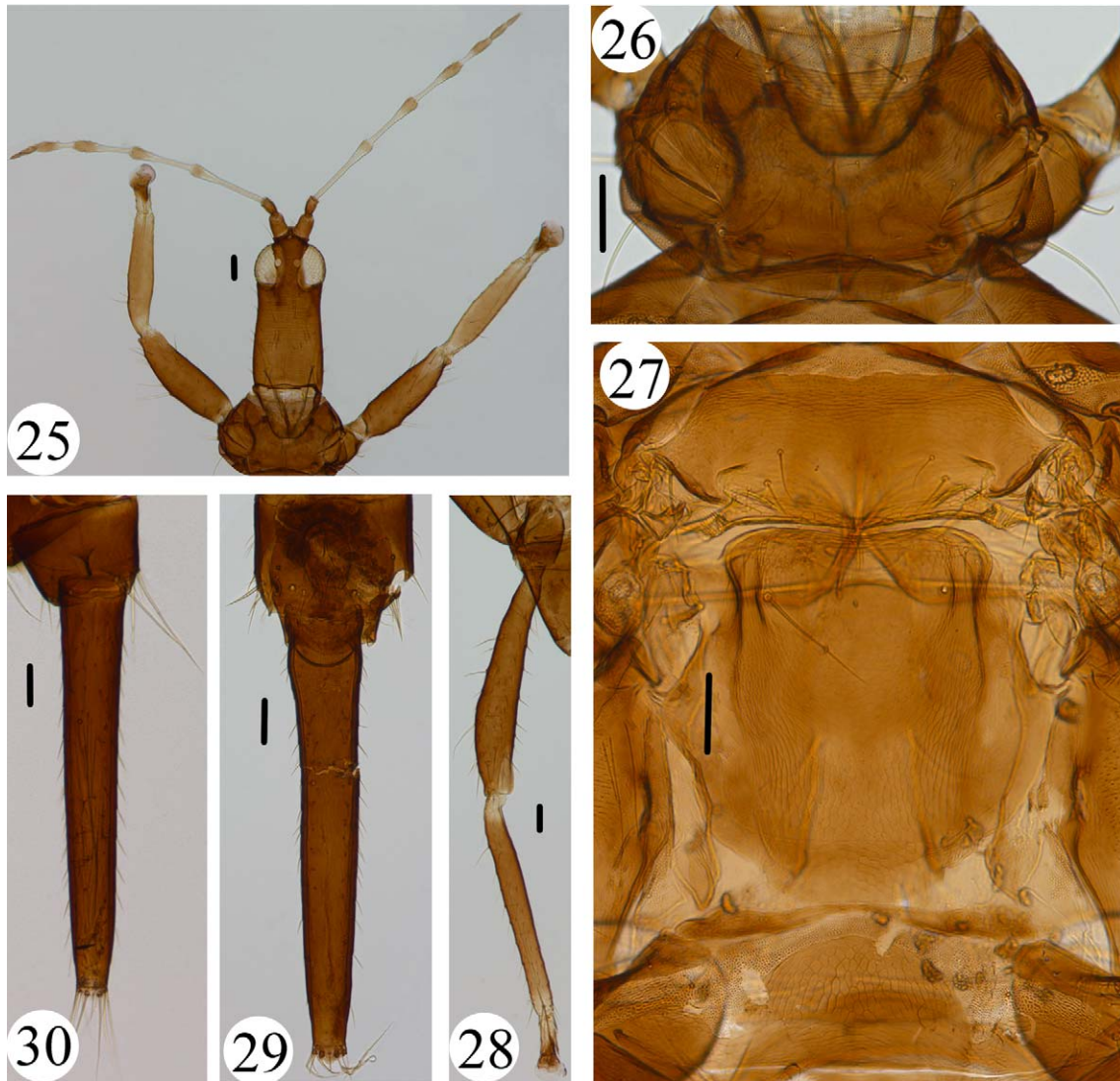
**Remark.** This species is somewhat similar to *B. carbonarius* Haga & Okajima in appearance, with interocellar setae longest and all tibiae brown. But the new species is distinguished by the following characters: postocellar setae as long as or a littler longer than the diameter of posterior ocellus, much shorter than postocular setae and mid-dorsal setae, postocular cheek setae shorter than postocular setae (*carbonarius*: postocellar setae more than twice as long as diameter of posterior ocellus, much longer than postocular setae and mid-dorsal setae, postocular cheek setae longer than postocular setae), pronotal *epima* about half as long as *epim*, epimeral sutures complete (*carbonarius*: pronotal *epima* usually much more than half as long as *epim*, epimeral sutures incomplete), abdominal tubercle on segment VI yellow with dark brown in basal 0.2, small tubercle present on VII (*carbonarius*: abdominal tubercle on segment VI uniformly dark brown, segment VII without lateral tubercles).

**Etymology.** This species name is composed of two Latin words, “*furvus* (= dark, black)” and “*crus* (= leg)”, based on all tibiae uniformly dark brown.





**FIGURES 15–24.** *Bactrothrips furvescрус* n. sp. Male: **15**, antenna; **16**, dorsal view of head and pronotum; **17**, mesopraesterum; **18**, dorsal view of mesonotum and metanotum; **19**, base of forewing; **20**, hind leg; **21**, pelta; **22**, abdominal tergites VI–VIII showing the lateral tubercles; **23**, abdominal tergite IX and tube. Female: **24**, abdominal tergite IX and tube. Scale bars=100µm.



**FIGURES 25–30.** *Bactrothrips furvescрус* n. sp. Male: **25**, antenna, head, pronotum and fore legs; **26**, dorsal view of pronotum; **27**, dorsal view of mesonotum and metanotum; **28**, hind leg; **29**, abdominal tergite IX and tube. Female: **30**, abdominal tergite IX and tube. Scale bars=100µm.

***Bactrothrips honoris* (Bagnall)**

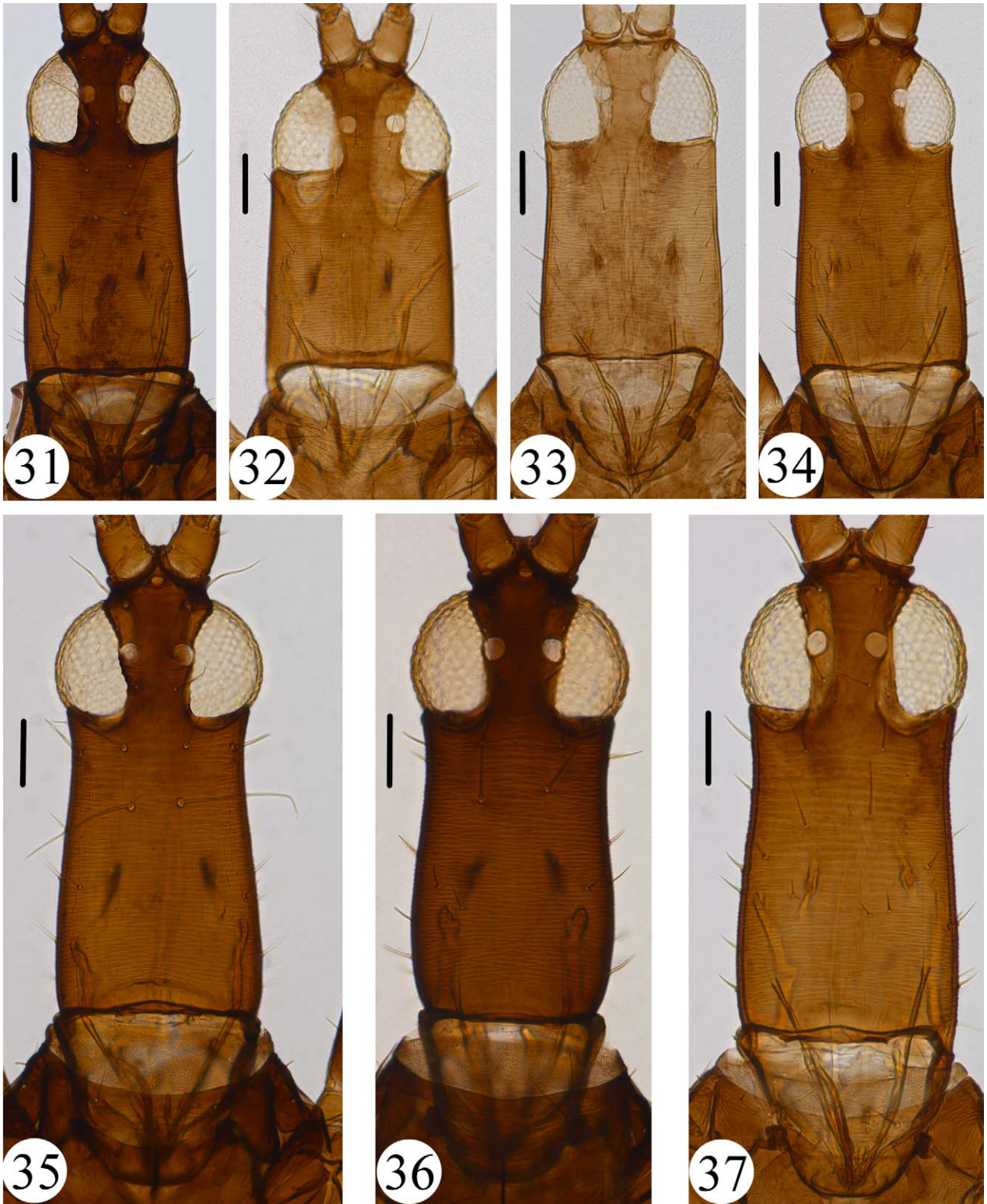
(Fig. 33)

*Megathrips honoris* Bagnall, 1921: 395.

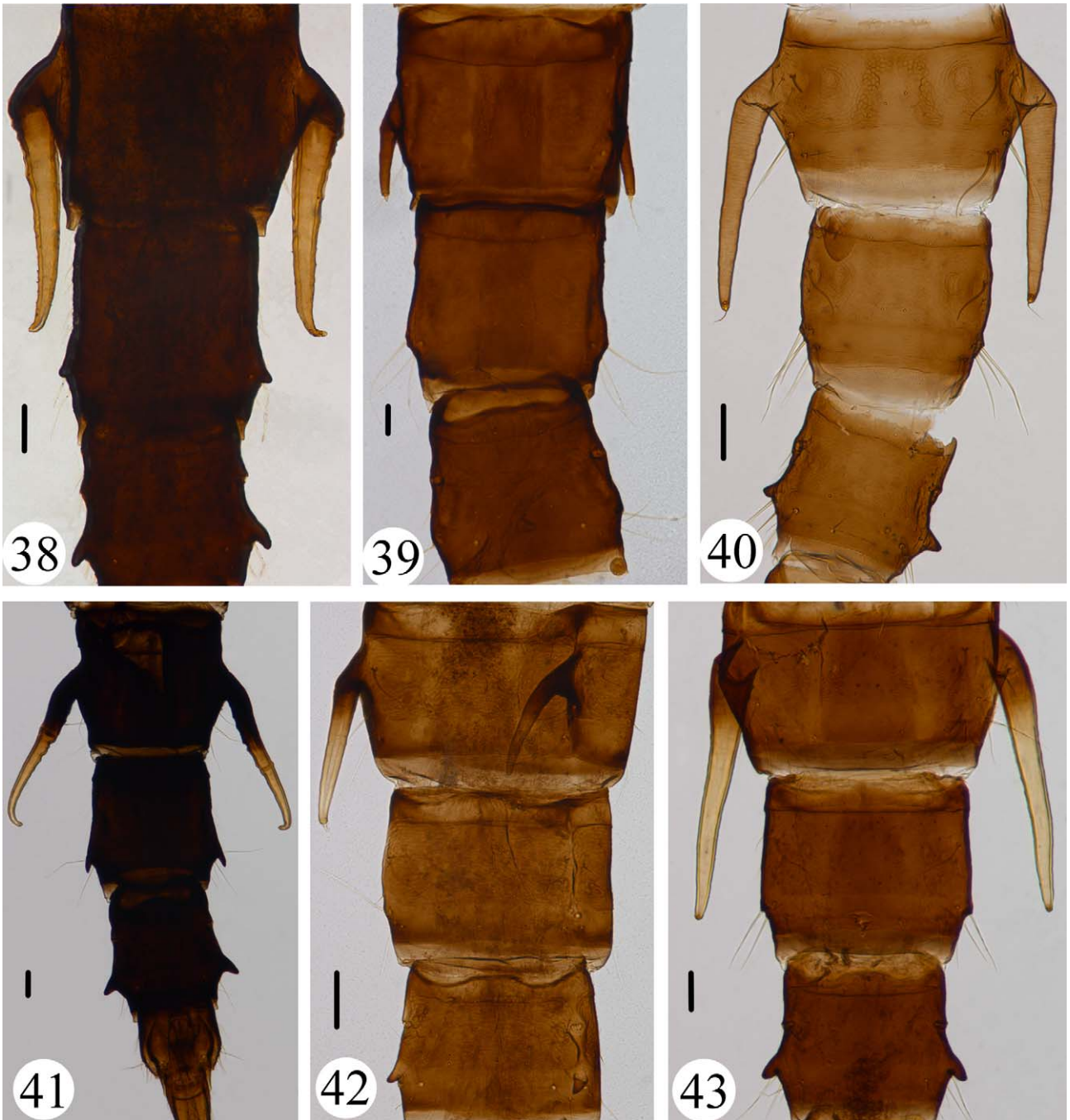
Described originally as *Megathrips honoris*, and recorded from Taiwan, China, by Chen (1982), this species was transferred to *Bactrothrips* by Mound & Palmer (1983). It is recorded here from mainland China for the first time, based on details in Haga & Okajima (1989) and Okajima (2006). It is distinguished from the other species except *B. elongatus* by the longer sense-cones on antennal segment III. It is distinguished from *B. elongatus* by hind tibiae bicoloured and tubercles on abdominal segment VI of male uniformly dark brown.

**Material examined.** CHINA, Guangxi Auto. Reg. (Wuming County, Daming Mountain), 1 female on dried-up hanging tree leaves, 28.v.2011, L.H. Dang; Yunnan Prov. (Xishuangbanna District), 2 females on dead tree leaves, 7.x.2010, M.Y. Lin.

**Distribution.** China (Guangxi, Yunnan, Taiwan); Japan.



**FIGURES 31–37.** *Bactrothrips* spp. Dorsal view of head: **31**, *B. brevitubus*; **32**, *B. flectoventris*; **33**, *B. honoris*; **34**, *B. pictipes*; **35**, *B. quadrituberculatus*; **36**, *B. elongatus* n. sp.; **37**, *B. furvescens* n. sp. Scale bars=100µm.



**FIGURES 38–43.** *Bactrothrips* spp. Abdominal tergites VI–VIII showing the lateral tubercles: **38 & 39**, *B. brevitubus*; **40**, *B. flectoventris*; **41**, *B. quadrituberculatus*; **42**, *B. elongatus* n. sp.; **43**, *B. furvescens* n. sp. Scale bars=100µm.

***Bactrothrips pictipes* Haga & Okajima**

(Fig. 34)

*Bactrothrips pictipes* Haga & Okajima, 1989: 15.

*Bactrothrips brevitubus zhamanus* Han & Zhang, 1981: 298. **Syn. n.**

Described originally from Japan, this species was subsequently recorded from Taiwan, China by Okajima (2006), and is here recorded for the first time from the Chinese mainland. The species is similar to *B. quadrituberculatus* (Bagnall), but can be distinguished by interocellar setae longest and longer *epima* (about as long as half of *epim*), and the genetic distance of COI sequences between them averaged 0.099 (range=0.098–0.100). In addition, the

species has a close relationship to *B. furvescrus* with genetic distance averaged 0.088 (range=0.086–0.090), but is distinguished by the tibia color; *B. pictipes* is bicoloured, yellow and dark brown, whereas *B. furvescrus* is uniformly dark brown.

Han & Zhang (1981) described *B. brevitubus zhamanus* from Tibet, China, and Haga & Okajima (1989) indicated that this subspecies is very similar to *B. brevitubus*. We studied the holotype of *zhamanus*, and regard it as a Tibetan population of *B. pictipes*. This holotype has four sense-cones on the right antennal segment IV but only three in the left, and it is obvious that one sense-cone has been lost during slide making.

**Material examined.** CHINA: holotype male of *zhamanus*, Tibet (Nielamu County, Zhangmu Town), 7.i.1975, F.S. Huang; Guangxi Auto. Reg. (Maoer Mountain), 1 female on dried-up hanging tree leaves, 3.vi.2011, L.H. Dang; Guangxi Auto. Reg. (Huaping County), 1 female on dried-up hanging tree leaves, 7.vi.2011, L.H. Dang; Hainan Prov. (Limu Mountain), 4 females on dead tree leaves, 6.iv.2010, M.Y. Lin; Hainan Prov. (Baisha County), 2 females on dead tree leaves, 15.iv.2010, M.Y. Lin; Hainan Prov. (Xinglong County), 2 females on withered leaves, 16.iv.1963, B.L. Zhang.

**Distribution.** China (Guangxi, Tibet, Hainan, Taiwan); Japan.

### ***Bactrothrips quadrituberculatus* (Bagnall)**

(Figs 35, 41)

*Idolothrips quadrituberculatus* Bagnall, 1908: 210.

Described originally as *Idolothrips quadrituberculatus*, the species was combined with *Bactrothrips* by Mound & Palmer (1983). The specimens listed below were identified using the detailed description in Haga & Okajima (1989) and Okajima (2006), and this is the first record of this species from China. It is very similar to *B. brevitubus* with large body and mid-dorsal setae of head the longest, but is distinguished in the key above by length of the postocellar setae. The genetic distance of COI averaged 0.064 (range=0.061–0.067).

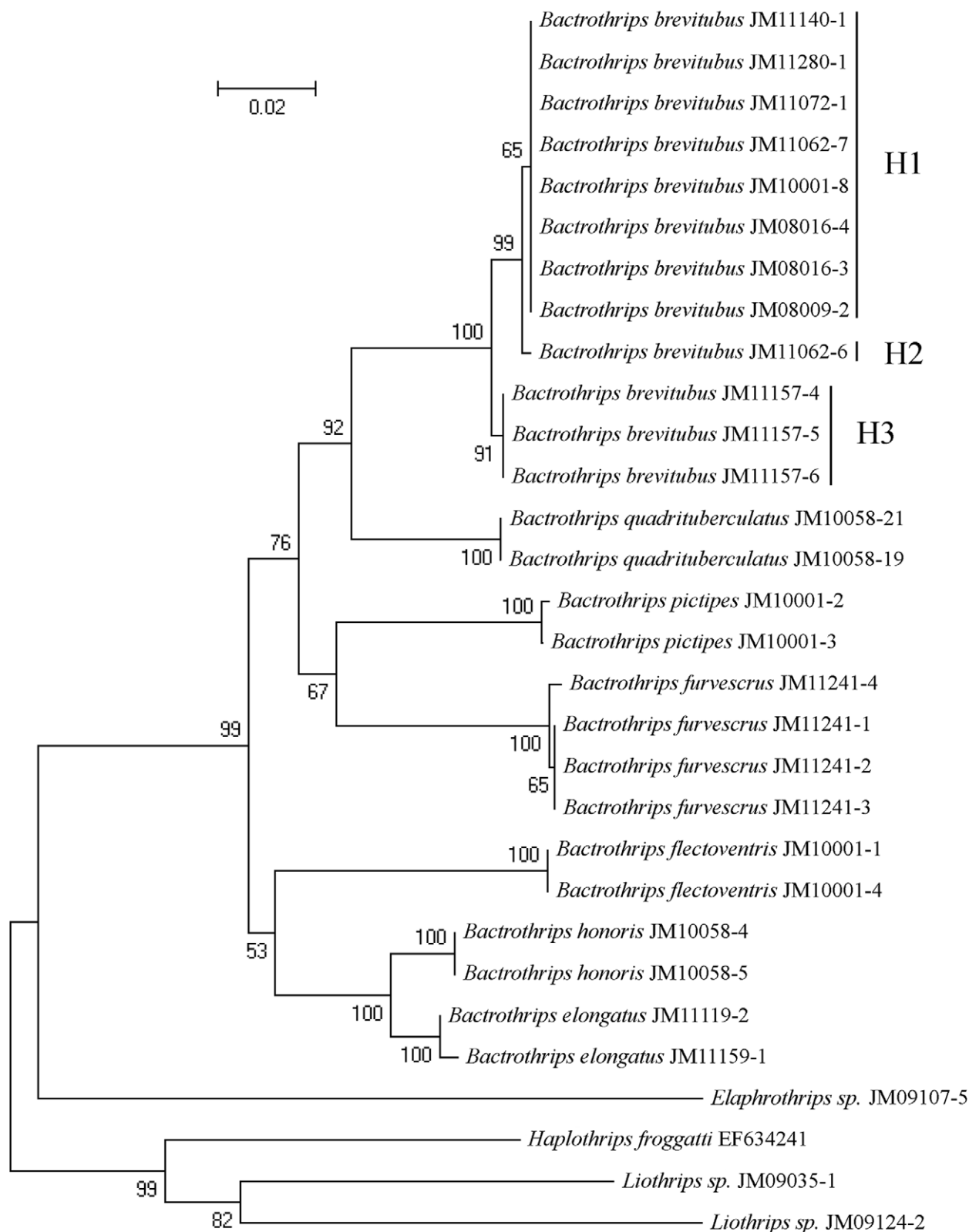
**Material examined.** CHINA, Yunnan Prov. (Xishuangbanna District), 4 females 2 males on dried-up tree leaves, 7.x.2010, M.Y. Lin; Hainan Prov. (Xinglong County), 3 males on withered leaves, 16.iv.1963, B.L. Zhang.

**Distribution.** China (Yunnan, Hainan); Japan.

### **DNA Barcoding**

The final alignments of COI sequences consisted of 579 bp for each individual, without heterozygous peaks, indels and stop codons. The consensus neighbor-joining tree resolved 7 species, *B. brevitubus* (H1 numbers: JM11140-1, JM11280-1, JM11072-1, JM11062-7, JM10001-8, JM08016-3/-4, JM08009-2; H2 number: JM11062-6; H3 numbers: JM11157-4/-5/-6), *B. quadrituberculatus* (numbers: JM10058-19/-21), *B. pictipes* (numbers: JM10001-2/-3), *B. furvescrus* (numbers: JM11241-1/-2/-3/-4); *B. flectoventris* (numbers: JM10001-1/-4), *B. honoris* (numbers: JM10058-4/-5); *B. elongatus* (numbers: JM11119-2, JM11159-1), as ingroups and 4 species, *Elaphrothrips* sp. (number: JM09107-5), *Haplothrips froggatti* (GenBank number: EF634241) and *Liothrips* spp. (numbers of two species: JM09035-1, JM09124-2) as outgroups. The genetic divergence between 7 species averaged 0.073 (range=0.023–0.122), and between ingroups and outgroups averaged 0.224 (range=0.192–0.255). Among 7 species, *B. honoris* is very close to *B. elongatus* with the genetic divergence averaged 0.025 (range=0.023–0.027), and *B. pictipes* is also close to *B. furvescrus* with the genetic divergence averaged 0.088 (range=0.086–0.090). In addition, the genetic divergence among each individual of one species averaged 0.005 (range=0.000–0.010) and between each haplotype (H1, H2, H3) within *B. brevitubus* clade averaged 0.007 (range=0.003–0.010).

All of 29 samples are eventually sequenced and analysed using the same amplification procedures and software. The phylogenetic analysis resulted in more than ten most parsimonious trees, the exact consensus of which is provided in Fig. 44. The bootstrap values ranged from 53% to 100% in different clades, but all sequences of each species are better to group in one clade and each clade is supported strongly respectively (bootstrap values with 100%, respectively).



**FIGURE 44.** Relationships of thrips inferred in this study using the Neighbor-Joining method and Kimura 2-parameter pairwise distance of mitochondrial COI sequences. The topology and branch lengths are shown. Bootstrap values are shown next to the branches. H1, H2 and H3 indicate three different haplotypes in the *B. brevitubus* clade.

The study better resolved the species boundaries of morphologically similar taxa. In Asia, the species of *Bactrothrips* are distinguished by the colour of antennal segments and legs, the length of antennal sense-cone and all setae, the ratio of antennal segment III and head width across eyes and so on. But these inconspicuous morphological characters are difficult to be interpreted. Therefore, we identify these species combining morphological data with DNA barcoding evidence. Results from the two sets of data show high congruence. Among the species from China, there is a clear relationship in the N-J tree (Fig. 44). *B. brevitubus* clade and *B. quadrituberculatus* clade are sister-groups in N-J tree, and these two species are morphologically similar; similarly, the *B. honoris* clade and *B. elongatus* clade. But the sister-group of *B. pictipes* and *B. furvescens* involves different morphological characters, such as tibiae dark brown in *B. furvescens*, but bicoloured in *B. pictipes*. However, in morphology, *B. pictipes* is closer to *B. brevitubus* and *B. quadrituberculatus* with tibiae bicoloured yellow and dark brown. *B. flectoventris* has the eyes prolonged on the ventral surface of the head, as in species of the genus *Ophthalmothrips* Hood; but in the N-J tree, the *B. flectoventris* clade is sister-group to the *B. honoris* and *B. elongatus* clades.

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## References

- Bagnall, R.S. (1908) On some new genera and species of Thysanoptera. *Transactions of the Natural History Society of Northumberland*, 3, 183–217.
- Bagnall, R.S. (1921) Brief descriptions of new Thysanoptera-XII. *Annals and Magazine of Natural History* (9), 8, 393–400.
- Chen, L.S. (1982) Studies on the subfamily Idolothripinae (Thysanoptera: Phlaeothripidae) in Taiwan. *National Taiwan University Phytopathologist and Entomologist*, 9, 53–67.
- Duan, B.S. & Li, M.Z. (1995) Thysanoptera: Phlaeothripidae. Pp. 211–213 in Wu Hong, (ed.) *Insect of Baishanzu Mountain, Eastern China*. Beijing: China Forestry Publishing House.
- Folmer, O., Black, M., Hoeh, W., Lutz, R. & Vrijenhoek, R. (1994) DNA primers for amplification of mitochondrial cytochrome oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology*, 3, 294–299.
- Haga, K. & Okajima, S. (1989) A taxonomic study of the genus *Bactrothrips* Karny (Thysanoptera, Phlaeothripidae) from Japan. *Bulletin of the Sugadaira Montane Research Centre, University of Tsukuba*. 125, 1–23.
- Han, Y.F. & Zhang, G.X. (1981) Thysanoptera. Pp.295–300 in Wang, B.H. & Huang, F.S. (eds.) *Insects of Tibet*. Vol. I. Science Press, Beijing.
- Han, Y.F. (1997) Thysanoptera. *Economic Insect Fauna of China*, Fasc. 55, 1–513. Science Press, Beijing.
- Han, Y.F. (2002) Thysanoptera. Pp.262–274 in Huang, F.S. [ed.] *Forest Insects of Hainan*. Science Press, Beijing.
- Karny, H. (1912) Einige weitere Tubuliferen aus dem tropischen Afrika. *Entomologische Rundschau*, 20, 130–133.
- Mound, L.A. & Palmer, J.M. (1983) The generic and tribal classification of spore-feeding Thysanoptera. *Bulletin of the British Museum (Natural History) Entomology*, 46, 1–174.
- Mound, L.A. & Tree, D.J. (2011) Australian spore-feeding Thysanoptera of the genus *Bactrothrips* (Phlaeothripidae-Idolothripinae). *Zootaxa*, 3087, 56–65.
- Mound, L.A. (2012) Thysanoptera (Thrips) of the World—a checklist. <http://www.ento.csiro.au/thysanoptera/worldthrips.html> [accessed 27.ii.2012]
- Mound, L.A., Wheeler, G.S. & Williams, D.A. (2010) Resolving cryptic species with morphology and DNA; thrips as a potential biocontrol agent of Brazilian peppertree, with a new species and overview of *Pseudophilothrips* (Thysanoptera). *Zootaxa*, 2432, 59–68.
- Okajima, S. (2006) The suborder Tubulifera (Thysanoptera). *The Insects of Japan*. Volume 2, 1–720. The Entomological Society of Japan, Touka Shobo Co. Ltd., Fukuoka.
- Rugman-Jones, P.E., Hoddle, M.S., Mound, L.A. & Stouthamer, R. (2006) Molecular identification key for pest species of *Scirtothrips* (Thysanoptera: Thripidae). *Journal of Economic Entomology*, 99, 1813–1819.
- Takahashi, R. (1935) An interesting thrips from Amami-Oshima, Loochoos. *Mushi*, 8, 61–63.
- Zhang, W.Q. (1984) Preliminary note on Thysanoptera collected from Hainan Island, Guangdong, China. II. Subfamily: Megathripinae (Thysanoptera: Phlaeothripidae). *Journal of South China Agricultural University*, 5, 18–25.