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Phylogenetic relationships within the *Frankliniella* genus-group based on morphology, with a revision of *Iridothrips* (Thysanoptera, Thripidae)

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Abstract

The *Frankliniella* genus-group comprises over 270 species in ten genera. It is one of the important groups in Thripinae, and includes some important pests. A phylogenetic analysis of genus-level relationships within the *Frankliniella* genus-group was performed, based on 55 morphological character states scored for 23 species representing 11 genera, including an outgroup, *Thrips physapus*. Six most parsimonious trees were generated from the analysis under equal weighting schemes. *Pseudanaphothrips* was recovered as monophyletic, and as sister group to a clade comprising five genera, *Yaobinthrips, Parabaliothrips, Sitothrips, Firmothrips, Kakothrips*, in which *Parabaliothrips* showed to be a paraphyletic group. *Frankliniella* was paraphyletic, with *Frankliniella zizaniophila* + *Iridothrips* + *Pelikanothrips kratochvili* forming one clade that was sister group to the rest of the species of *Frankliniella* + *Guerothrips moundi*. According to the phylogenetic analysis, *Guerothrips* is proposed as a **new synonym** of *Frankliniella*, and *Pelikanothrips* is considered a **new synonym** of *Iridothrips.* The genus *Iridothrips* is revised with a key to five species, including *I. zizaniophila* **comb.n.**, *I. kratochvili* **comb.n.** and *I. lobulatus* **sp.n.**. A key to the eight members of the *Frankliniella* genus-group is provided.

Key words: New synonym, new combination, new species, host associations, monophyly

Introduction

The *Frankliniella* genus-group was first proposed by Mound and Palmer (1981) to include the following eight genera: *Frankliniella, Firmothrips*, *Iridothrips*, *Kakothrips*, *Parabaliothrips*, *Pelikanothrips*, *Pseudanaphothrips*, and *Sitothrips*. To these, *Yaobinthrips* (Zhang *et al*. 2010) and *Guerothrips* (Goldarazena & Infante 2013) were described later as belonging to this group. Members of these genera share the following character states: head with ocellar setae pair I generally present, fore wing with two complete rows of vein setae, tergites VI–VII with submedian setae S2 shorter than median setae S1, tergites V–VIII usually with ctenidia and on segment VIII these are antero-lateral to the spiracle. The distribution patterns among these genera are of considerable evolutionary interest. *Frankliniella* species are found almost exclusively in the New World, also *Guerothrips*, and only five species of *Frankliniella* are native to Europe [one species described from China is here transferred to *Iridothrips*]. In contrast, the other genera are all from the Old World, with five from Europe (*Firmothrips*, *Iridothrips*, *Kakothrips*, *Pelikanothrips* and *Sitothrips*), one endemic to China (*Yaobinthrips*), and two with distributions from Southeast Asia to Australia (*Parabaliothrips*, *Pseudanaphothrips*). However, whereas 238 species are listed for *Frankliniella*, the other nine genera are smaller, each with less than 10 species, and *Firmothrips*, *Guerothrips*, *Pelikanothrips* and *Yaobinthrips* are monotypic (ThripsWiki 2019).

Species in this genus-group show certain host-plant specificity. *Iridothrips* and *Sitothrips* species are known to be grass living (Pelikan 1961; Minaei & Mound 2014), species of *Guerothrips*, *Kakothrips*, *Pseudanaphothrips* and *Yaobinthrips* live in flowers (Mound & Palmer 1990; Zhang *et al.* 2010; Marullo & Ravazzi 2016), and *Parabaliothrips* species apparently feed on leaves (Gillespie *et al*. 2002). However, the situation in *Frankliniella* genus is much more complex, with most species flower-living, some specific to the leaves of grasses, while others are polyphagous and feed on both flowers and leaves. The latter group includes several common species that are well

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known as crop pests, and two of these, *F. occidentalis* and *F. schultzei*, are also recorded as mite predators (ThripsWiki 2019).

The objective of the studies presented here was to consider the relationships of the genera that comprise the *Frankliniella* genus-group, based on a phylogenetic analysis of morphological characters. This included examining the disputed relationship between *Frankliniella* and *Iridothrips*. A key is presented to the species of *Iridothrips*, including one new species from China, also a key to distinguish the eight members of the *Frankliniella* genus-group.

Material and methods

The phylogenetic analysis presented here is based on 22 species in the ten genera of the *Frankliniella* genus-group, with *Thrips physapus* as the out-group. Based on our survey, 55 morphological characters obtained from adults from the head (16 characters, 29.1%), thorax (17 characters, 30.9%) and abdomen (22 characters, 40%) were coded numerically (Appendix 1). Thirty-eight characters are binary and seventeen are multistate. All characters were treated as unordered and with equal weight. The characters states were scored as question mark (?) if not available (Table 1). These characters were chosen based on study of specimens in *Frankliniella* genus-group and former discussion about character states in this group (Mound & Nakahara 1993; Mound 2002).

TABLE 1. Morphological character matrix.

Taxon	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Thrips physapus	0	0	1	0	0	0	1	0	1	1	0	0	1	0	0	1	2	1	0	0	1	0	?	1	0	1	1	0	1	0	1	0	0	0	0	?	0	1	1	2	1	0	?	1	1	1	1	0	1	1	0	2	2	0	1
Frankliniella cephalica	0	1	1	1	1	1	1	0	1	1	1	0	1	3	1	0	2	1	1	2	3	1	0	1	1	1	0	1	1	1	1	0	0	0	0	?	0	0	1	0	?	0	?	1	1	1	1	1	1	0	0	0	0	0	1
Frankliniella intonsa	0	1	1	1	1	1	1	0	1	1	1	0	1	3	1	1	1	1	1	2	3	1	0	1	1	1	0	0	1	1	1	0	0	0	0	?	0	0	1	2	1	0	?	1	1	1	1	1	1	0	0	0	1	0	1
Frankliniella lilivora	0	1	1	1	1	1	1	0	1	1	1	0	1	3	1	1	1	1	1	2	3	1	1	1	0	0	1	1	1	1	1	0	0	0	0	?	0	0	1	2	0	?	?	?	?	?	?	?	1	1	0	0	0	0	?
Frankliniella occidentalis	0	1	1	1	1	1	1	0	1	1	1	0	1	3	1	1	2	2	1	2	3	1	0	1	1	1	0	1	1	1	1	0	0	0	0	?	0	0	1	2	1	1	0	1	1	1	1	1	1	0	0	0	1	0	1
Frankliniella schultzei	0	1	1	1	1	1	0	1	1	1	1	0	1	3	1	1	2	1	1	2	3	1	0	1	1	1	0	0	1	1	1	0	0	0	0	?	0	0	0	?	?	0	?	0	?	1	1	0	1	0	0	0	1	0	1
Frankliniella tenuicornis	0	2	1	1	1	1	1	0	1	1	1	0	1	3	1	1	1	1	1	2	3	1	1	1	1	1	0	0	1	1	1	0	0	1	0	?	0	0	1	0	?	1	0	1	1	1	1	1	1	0	0	0	0	0	1
Frankliniella williamsi	0	1	1	1	1	1	1	0	1	1	1	0	1	3	1	1	2	2	1	2	3	1	0	1	1	1	0	1	1	1	1	0	0	1	0	?	0	0	1	2	1	1	0	1	0	1	1	1	1	0	0	1	0	0	0
Frankliniella zizaniophila	0	2	0	1	1	1	1	0	0	0	?	?	1	1	1	1	0	1	1	1	0	1	?	1	1	1	0	0	1	0	0	0	0	0	0	?	0	0	1	2	0	1	0	1	0	1	1	1	1	1	0	0	0	1	0	1
Firmothrips firmus	0	1	1	1	1	1	0	1	0	1	2	0	1	3	1	1	2	0	1	0	1	1	0	1	1	1	0	1	1	0	1	1	0	1	1	0	1	0	0	?	?	0	?	0	?	0	?	?	0	0	0	0	0	0	0
Guerothrips moundi	0	1	1	1	1	1	1	0	?	1	1	0	1	3	8	1	?	1	1	2	3	1	0	1	1	0	0	1	1	1	1	0	0	0	0	?	?	?	1	2	1	0	?	1	?	1	?	1	1	0	0	2	0	0	?
Iridothrips iridis	1	2	0	1	1	1	1	0	1	1	1	1	1	2	1	1	0	1	1	2	3	1	0	1	0	1	1	0	0	0	0	0	0	1	0	?	0	0	1	0	0	0	?	1	0	1	1	1	1	1	0	0	0	0	1
Iridothrips lobulatus sp.n.	1	2	0	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	2	3	1	0	2	1	1	1	0	1	0	0	0	0	0	1	1	0	0	0	1	2	0	0	?	1	1	1	1	1	1	0	1	0	0	1
Iridothrips mariae	0	2	1	1	0	1	1	0	1	1	1	1	1	2	1	1	0	0	1	2	2	1	0	2	1	1	1	0	1	0	0	0	0	0	1	1	0	0	0	1	2	0	1	0	1	1	1	1	1	1	0	0	0	0	?
Kakothrips pisivorus	0	1	1	0	1	1	0	1	0	1	2	0	1	3	1	1	1	0	1	2	2	1	?	1	1	1	0	1	1	1	1	1	0	1	0	?	1	0	1	2	0	0	?	0	?	1	0	2	1	0	0	0	2	1	?
Parabaliothrips coluckus	0	1	1	0	1	1	0	2	0	1	2	?	0	3	1	1	1	0	1	1	2	1	0	1	1	0	0	0	1	0	1	0	0	0	0	?	1	0	0	?	?	?	?	?	?	?	1	1	2	1	0	0	0	0	1
Parabaliothrips setifer	0	1	1	0	1	1	0	1	0	1	1	0	1	1	1	1	1	1	0	0	2	1	0	1	1	0	0	1	1	0	1	0	0	0	0	?	1	0	0	?	?	0	?	0	?	1	1	2	1	0	0	0	1	0	1
Pelikanothrips kratochvili	1	2	0	?	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	3	1	0	1	?	1	?	0	1	?	0	?	?	?	?	?	0	0	0	?	?	?	?	?	?	?	?	?	1	0	?	0	0	0	?
Pseudanaphothrips achaetus	0	1	1	0	1	0	0	1	1	1	1	0	1	1	1	1	2	1	0	0	2	0	0	0	1	1	0	1	1	1	1	1	0	0	1	0	?	0	0	1	1	1	1	2	1	2	1	2	1	1	0	0	0	1	0	1
Pseudanaphothrips araucariae	0	1	1	0	1	0	0	1	1	1	1	0	1	2	1	1	2	1	1	0	2	1	0	1	1	1	0	1	1	1	1	0	0	1	0	?	0	0	1	2	1	1	2	1	2	1	2	1	1	0	0	0	0	0	1
Pseudanaphothrips casuarinae	0	1	1	0	1	0	0	1	1	1	1	0	1	1	1	1	2	1	0	0	2	0	0	1	1	1	0	1	1	1	1	0	0	1	0	?	0	0	1	2	1	0	2	1	2	1	2	1	1	0	0	0	0	0	1
Sitothrips calcaratus	2	1	0	0	1	1	0	2	0	1	2	1	1	3	1	1	1	1	1	1	2	1	1	1	1	1	1	0	1	0	1	1	0	0	0	?	1	0	0	?	?	1	0	1	0	1	2	1	0	0	0	2	0	?
Yaobinthrips yangtzei	0	1	1	1	1	0	1	2	1	1	1	0	1	1	1	1	2	1	0	0	2	1	0	1	1	1	0	1	1	0	1	0	1	0	1	0	1	1	1	0	0	?	?	0	?	0	?	1	1	2	1	0	1	0	?

The analysis was performed in TNT ver. 1.1 (Goloboff *et al*. 2008) with implicit enumeration. Parsimony analysis was done holding 99999 trees in the memory. The 'traditional search' was settings of 900 replicates, tree bisection reconnection (TBR) branch swapping, saving 45 trees per replicate and a random seed of 0.

A strict consensus of the maximum parsimonious trees is generated in Winclada v.1.0 (Nixon 2002). Bremer support values were calculated with the function implemented in TNT (TBR from existing trees, retain trees sub optimal by 10 steps), as well as bootstrap values (standard, absolute frequencies, collapse groups < 51), both Bremer support (B) and bootstrap values (BS) are mapped on the strict consensus tree (Fig. 1). Character states were mapped on a maximum parsimonious tree using, showing only unambiguous changes.

Nomenclatural details for all taxa mentioned in this paper are available in ThripsWiki (2019). Examined specimens were slide-mounted in Canada balsam using the method of Zhang *et al*. (2006), and specimens are deposited in ANIC (Australian National Insect Collection, CSIRO, Canberra) and SCAU (Insect Collection, South China Agricultural University, Guangzhou). Observations were made with a Nikon Eclipse 80i phase contrast microscope, and the illustrations taken through a Leica DM 2500 microscope with DIC illumination using Automontage software.

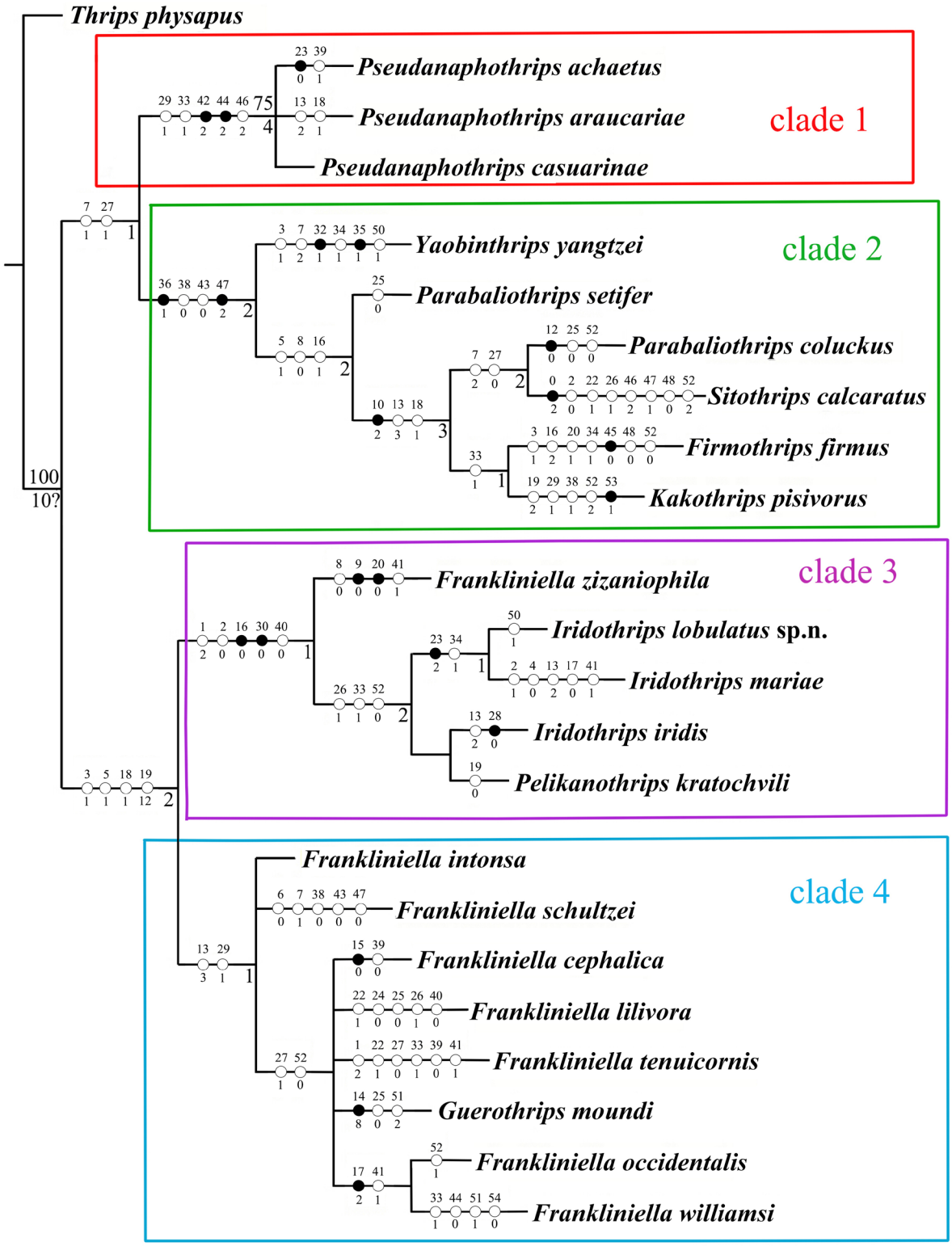


FIGURE 1. Phylogenetic relationships of genera of *Frankliniella* genus-group. Tree generated from morphological phylogenetic analysis, unambiguous apomorphies mapped on branches, black circles indicate nonhomoplastic changes; bremer support values and bootstrap mapped near the nodes below and above branches respectively.

Cladistics Results and Discussion

Analysis with TNT produced six most parsimonious trees, with length=177, consistency index=0.45 and retention index=0.59. The strict consensus tree (Fig. 1, with length=181, consistency index=0.44 and retention index=0.57) of these six most parsimonious trees in WINCLADA collapsed five nodes, only affecting the interspecific relationships in *Pseudanaphothrips* and *Frankliniella.* Bremer support values and bootstrap values are presented on the strict consensus tree. We here recognize four clades and the discussion below is based on these groups of taxa (Fig. 1).

Clade 1 comprises the three species of *Pseudanaphothrips* and its monophyly is strongly supported (B=4/BS=75) by two synapomorphies [ctenidia on tergite IV are formed by several rows of microtrichia (42:2), ctenidia on tergite V are formed by several rows of microtrichia (44:2)] and three homoplastic characters [fore wing first vein setal row complete with setae closely spaced (29:1), tergites with weak sculpture between S1 (33:1) and tergite VI–VII with ctenidia formed by several rows of microtrichia (46:2)]. It is also supported by its geographical distribution, with eight of the nine species in the genus from Australia (the exception is *querci* based on a single female recorded in 1920 from Taiwan, and subsequently known only from a few females collected in Java between 1912 and 1923) (Zhang *et al*. 2018).

The clade 2, including five genera, *Yaobinthrips*, *Parabaliothrips*, *Sitothrips*, *Firmothrips* and *Kakothrips*, is well supported (B=2) by two synapomorphies [tergites V–VII posteroangular seta mesad of angle (36:1); ctenidia on tergite VI–VII ending at median marginal seta (47:2)] and two homoplastic characters [tergite VIII posteromarginal comb absent (38:0); ctenidia on tergite V absent (43:0)]. In this clade, *Yaobinthrips* is recovered as a basal independent clade and sister group to the other four genera. *Parabaliothrips* is possibly polyphyletic, with *Pa. setifer* from Australia apparently not related to *Pa. coluckus* from South Asia.

According to the analysis, *Pseudanaphothrips* (clade 1) is sister group to clade 2, supported (B=1) by two homoplastic characters: ocellar setae III position between hind ocelli (7:1) and metanotum median campaniform sensilla present (27:1). This result differs from a previous suggestion that *Pseudanaphothrips* is a sister group to all other *Frankliniella* genera (Mound & Palmer 1981). However, the presence of metanotum median campaniform sensilla might be unreliable to support genus level relationships, because it varies in some species in *Frankliniella*. Therefore, further study of more samples is required with molecular data to test our results.

As interpreted below, *Frankliniella zizaniophila*, *Pelikanothrips kratochvili*, and species in *Iridothrips* form a group that is well supported by two synapomorphies (clade 3) [pronotum without discal setae (16:0), fore wing clavus with 3–4 veinal setae (30:0)] and three homoplastic characters [head obviously projected (1:2); dorsal eye length never longer than length of cheeks (2:0); tergite VIII posteromarginal comb short or irregular (40:1)]. Based on those characters, *Fr. zizaniophila* is sister group to *Pe. kratochvili* + *Iridothrips*, and the later four species form a monophylic group supported by three homoplastic characters [metanotum median setae behind anterior margin (26:1); tergite with weak lines exist between S1 (33:1); sternite VII median setae on posterior margin (52:0)]. Mound (2002) suggested *I. mariae* probably required a new genus because of its remarkable difference from *I. iridis*. However in this study, with a new species of *Iridothrips* added and using more character states, *I. mariae* and *I. iridis*, together with the new species and *Pe. kratochvili* form one clade. Therefore, *Pelikanothrips* should be a synonym of *Iridothrips*. *Fr. zizaniophila* from China, was considered an aberrant species, and Mirab-balou *et al*. (2014) suggested that it required a new genus in *Frankliniella* genus-group for having 2 pairs of pronotal posteromarginal setae, fore wing clavus with 3–4 vein setae and irregular metanotum sculpture. According to our analysis, *zizaniophila* is closer to species of *Iridothrips* than to *Frankliniella*, it is here transferred to *Iridothrips*. Species in clade 3 are all Palaearctic, living on grasses in wet areas, and these distribution and host relationships strengthen their generic association.

The clade 4 includes several species of *Frankliniella* and *Guerothrips moundi*. Some of them are originally from America and some are Palaearctic, but these species form a clade supported by two homoplastic characters: postocular setae pair IV twice or more longer than III (12:3), fore wing clavus with 5 or more vein setae (28:1). Therefore, *moundi* is considered an aberrant *Frankliniella* species with discal setae on the abdominal sternites.

The clade 4 is supported as sister group to clade 3 by four homoplastic characters: pigmented eye facets present (3:1), ocellar setae pair III length as long as or longer than distance between hind ocelli (5:1), pronotum anteromarginal long setae as long as posterior marginal setae (18:1) and pronotum anteroangular long setae present, shorter than posteroangular setae (19:1). The general appearance of some grass living *Frankliniella* species, such as *tenuicornis* resembles *Iridothrips* species.

Key to genera of *Frankliniella* genus-group

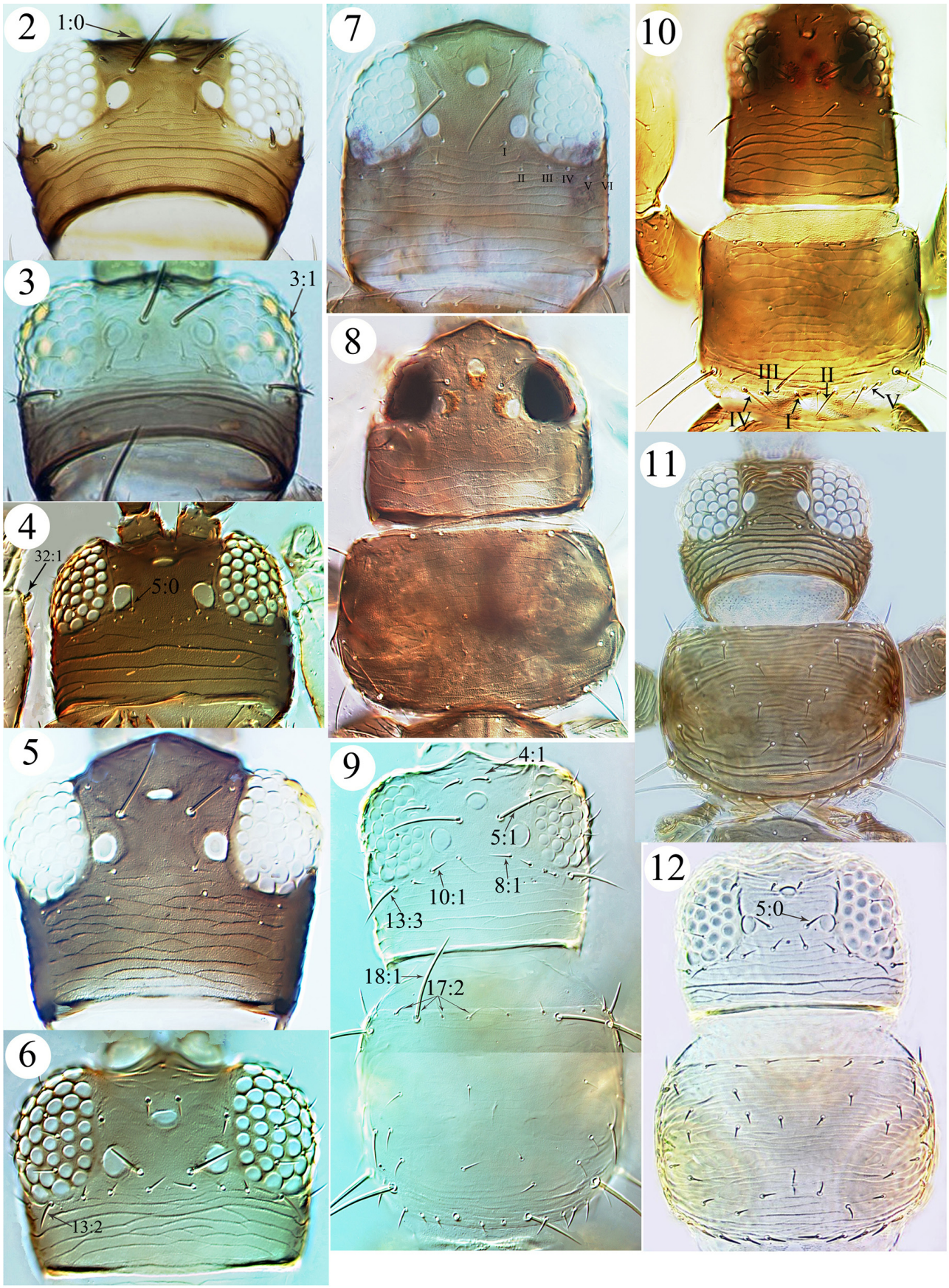
1. Tergites V–VII posteroangular seta arising close to angle or at angle (Fig. 21) 2
-. Tergites V–VII posteroangular seta arising far from posterior angle (Fig. 20) 4
2. Tergites V–VII with several short rows of ctenidia (Fig. 24); ocellar setae pair III short and arising between hind ocelli (Fig. 6); eyes without pigmented facets . . . . . *Pseudanaphothrips*
-. Tergites V–VII with a long row of regular ctenidia (Fig. 26); ocellar setae pair III long (Fig. 3); eyes usually with pigmented facets 3
3. Fore wing first vein with distal setae widely spaced (Fig. 30); clavus with 3 or 4 veinal setae; pronotum without discal setae (Fig. 13) . . . . . *Iridothrips*
-. Fore wing first vein setal row complete (Fig. 29); clavus with 5 veinal setae; pronotum with discal setae (Fig. 9) . . . . . *Frankliniella*
4. Tergites V–VII without ctenidia . . . . . *Firmothrips*
-. Tergites V–VII with regular ctenidia, at least VII with ctenidia 5
5. Ctenidia on tergites VI–VII ending anterior to discal setae S3 . . . . . *Sitothrips*
-. Ctenidia on tergites VI–VII ending at median marginal seta (Fig. 22) 6
6. Ocellar setae III posterior to tangent joining posterior margins of hind ocelli (Fig. 4); fore tibiae each with two short rounded setae . . . . . *Yaobinthrips*
-. Ocellar setae III situated between hind ocelli; fore tibiae without rounded setae 7
7. Pronotum anteroangular setae as long as posteroangular setae; fore tarsus with tooth at apex of pulvillus; fore wing first vein setal row complete and closely spaced . . . . . *Kakothrips*
-. Pronotum anteroangular setae shorter than posteroangular setae (Fig. 14); fore tarsus without tooth at apex of pulvillus; fore wing first vein with distal setae widely spaced . . . . . *Parabaliothrips*

Iridothrips Priesner

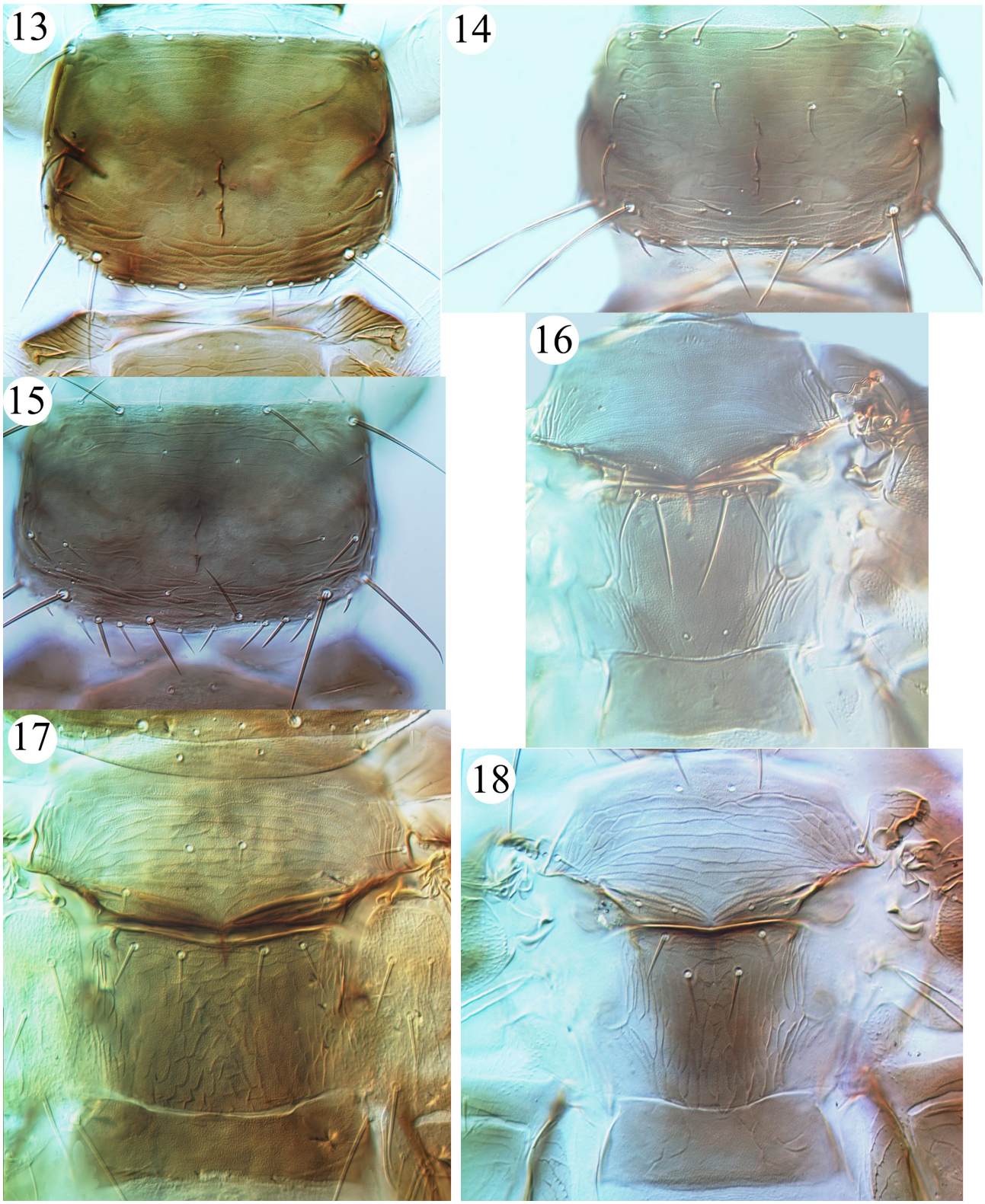
Iridothrips Priesner, 1940: 403. Type species *Bregmatothrips iridis* Watson.
Pelikanothrips Bhatti, 1978: 189. Type species *Taeniothrips kratochvili* Pelikan, by monotypy. **Syn. n.**

Previously comprising only two species, *Iridothrips* is a small genus from Europe in the *Frankliniella* genus-group with species living among the basal leaf-sheaths of grasses and similar plants in moist habitats (Pelikan 1961; Jenser 2013a). Species in this genus are stated by zur Strassen (2003) to differ from *Frankliniella* species in having the sense cone on antennal segments III and IV simple. However, as indicated by illustrations in Mound *et al*. (1976) and Mound *et al*. (2018), the sense cones of *iridis* on these segments are sometimes Y-shaped, and this condition is relatively common amongst European specimens (Vierbergen *pers. comm.* 2018). *Iridothrips* species share many similarities with grass-living species of *Frankliniella*, such as head clearly projecting between eyes, and ocelli rather smaller. These similarities may be associated with similar living conditions on grasses. Within both *Iridothrips* and *Frankliniella* there are species that are micropterous or apterous, and in such individuals the metanotal median setae are generally behind the anterior margin, whereas macropterous individuals have the metanotal median setae at the anterior margin. The diagnostic differences between *Iridothrips* and *Frankliniella* are given in the key above. According to the morphological analysis results indicated above, *Fr. zizaniophila*, *Pe. kratochvili* and *Iridothrips* species form a monophyletic group, thus *Pelikanothrips* is placed as a synonym of *Iridothrips*, and *F. zizaniophila* is transferred to *Iridothrips*. This genus possibly represents a small Eurasian radiation derived from the American genus.

***Generic diagnosis*:** macropterous or micropterous; head with wide projection in front of eyes, hind ocelli close to eyes (Fig. 7); ocellar setae pair I present or absent, pair III well developed and situated on margin of ocellar triangle; eyes with 5 pigmented ommatidia; maxillary palps 3-segmented. Antennae 8-segmented, segment I without paired dorso-apical setae, III–IV with sense cone simple or forked (Figs 27 & 28). Pronotum wider than long and medially without discal setae. Mesonotum with campaniform sensilla present. Metanotal median pair of setae at or behind anterior margin, campaniform sensilla absent. Mesosternum with sternopleural sutures complete, endofurca with or without spinula, metasternal endofurca without spinula. Fore wing slightly saber-shaped, posterior margin slightly more curved than front margin at apex, veinal setal rows complete but widely spaced (Fig. 30); posteromarginal fringe cilia wavy; clavus usually with 3–4 veinal setae. Tarsi 2-segmented. Tergites V–VII posteroangular setae close to angle (Fig. 21); tergites V–VIII with paired ctenidia, ctenidia on VI–VII ending anterior to minor setae S3, on VIII anterolateral to spiracles; IX with two pairs of campaniform sensilla. Sternites III–VII with three pairs of posteromarginal setae arising at posterior margin (Fig. 38). Male sternites III–VII each with a pore plate (Fig. 35).



FIGURES 2–12. Character states of *Frankliniella* genus-group. 2–7 head: **(2)** *Fr. insularis*; **(3)** *Fr. schultzei*; **(4)** *Y. yangtzei*; **(5)** *I. mariae*; **(6)** *Ps. araucariae*; **(7)** *I. lobulatus*. 8–12 head and pronotum: **(8)** *Fr. zizaniophila*; **(9)** *Fr. williamsi*; **(10)** *S. calcaratus*; **(11)** *T. physapus*; **(12)** *P. achaetus*. [see Appendix 1 for character state codes]



FIGURES 13–18. Character states on thorax. 13–15 pronotum: **(13)** *I. lobulatus*; **(14)** *Pa. setifer*; **(15)** *Fr. tenuicornis*. 16–18: meso and metanotum **(16)** *Pa. setifer*; **(17)** *I. iridis*; **(18)** *I. lobulatus*.

Key to *Iridothrips* species (females)
[* based on description]

1. Pronotum with 2 pairs of posteromarginal setae (Fig. 8); postocular setal pair I and pair II usually absent . . . . . *zizaniophila* **comb. n.**
-. Pronotum with 4–5 pairs of posteromarginal setae (Fig. 13); postocular setal pair I and pair II usually present, occasionally pair I missing 2
2. Ocellar setae I absent, cheeks convergent posteriorly (Fig. 5) [abdominal tergites posterior margin with short irregular dentiform lobes laterally, tergite VIII with complete comb (Fig. 25); sternites without obvious posteromarginal lobes] . . . . *mariae*
-. Ocellar setae I present, cheeks parallel (Fig. 7) 3
3. Pronotum anteroangular setae rather short, shorter than submedian anteromarginal setae . . . . . *kratochvili* **comb. n.** *
-. Pronotum anteroangular setae rather long, at least longer than submedian anteromarginal setae. 4
4. Mesosternal endofurca without spinula; mesonotum median setae situated in the middle of the sclerite; metanotal median setae near anterior margin (Fig. 17); tergites and sternites posterior margins without craspeda or teeth; tergite VIII posterior margin without comb . . . . . *iridis*
-. Mesosternal endofurca with spinula; mesonotum median setae close to posterior margin; metanotal median setae well behind anterior margin (Fig. 18); tergites and sternites posterior margin with craspeda or teeth; tergite VIII posterior margin with short teeth arising from lobes (Fig. 21) . . . . . *lobulatus* **sp. n.**

Iridothrips iridis (Watson)
(Fig. 17)

Bregmatothrips iridis Watson, 1924: 253.

Originally described by Watson (1924) from the Netherlands, this species has been recorded widely in Europe in the leaf sheaths of *Iris pseudacorus* (Mound *et al*. 1976; Gertsson 2015; Jenser 2013a; Karadjova & Krumov 2015). The original description does not mention the form of the antennal sense cones, but zur Strassen (2003) and Krumov (2013) report these structures as simple. However, Mound *et al*. (1976) illustrated the antenna of a specimen from Britain with the sense cone clearly forked on segment IV, and incompletely forked on segment III. When longer series of macropterous and micropterous individuals are examined it becomes clear that the sense cones in this species vary (apparently randomly) between individuals from the same population, and can be simple, Y-shaped or V-shaped. Structural variations in this species, including the occasional presence on the head of four pairs of ocellar setae, may possibly be related in some way to variation in the habitat occupied, with the host plants sometimes under water but at other times exposed during dry conditions. A detailed diagnosis of this species is provided by Mound *et al*. (2018).

Material examined. ENGLAND, Norfolk, Lopham Great Fen, 1 female and 1 male from base of *Iris pseudacorus*, 18.viii.1966, Pitkin B.R. (in ANIC).

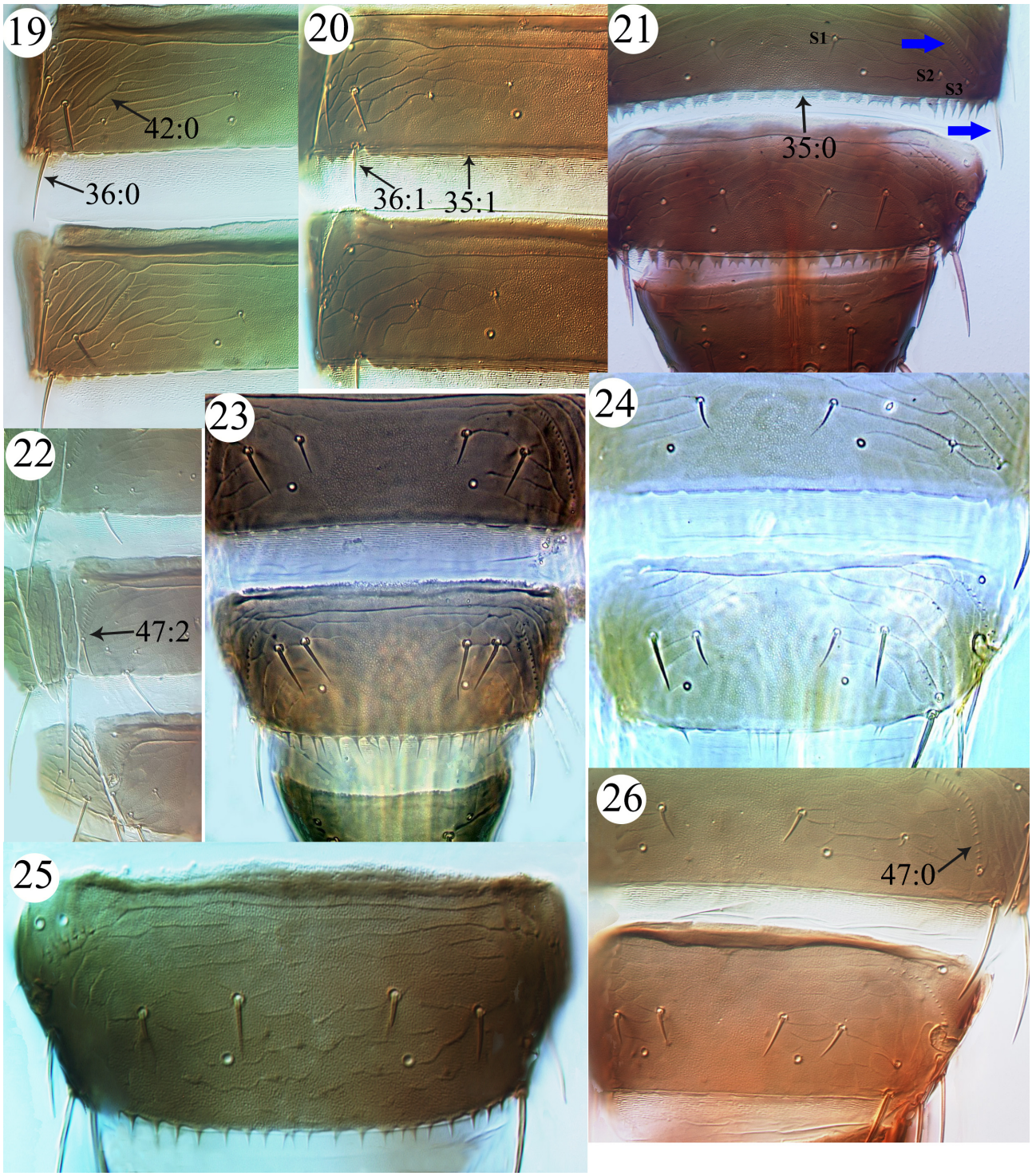
Iridothrips kratochvili (Pelikan)

Taeniothrips kratochvili Pelikan, 1947: 12.
Pelikanothrips kratochvili (Pelikan) Bhatti, 1978: 189.

This species was collected by Pelikan in the former Czechoslovakia living on an aquatic grass-like plant, *Carex*, and zur Strassen (2003) also records it on this plant from Poland, Netherlands and northern Germany. It is a typical *Iridothrips* with head rather long and projecting, the pronotum without median discal setae, the fore wing clavus with 4 pairs of veinal setae. Within the genus it is distinguished by the pronotum without long anteroangular setae, and tergite VIII with a complete comb. Bhatti (1978) indicated that this species varied in the number of pronotal posteromarginal setae and also the position of the mesonotal median setae. The genus *Pelikanothrips* was distinguished from *Iridothrips* by zur Strassen (2003) solely on the shape of the antennal sense cones (see discussed above).

Iridothrips lobulatus sp. n.
(Figs 7, 13, 18, 21, 27, 30, 35, 38)

Female macroptera. Body brown to pale brown; antennal segments I–II and VI–VIII brown, segments III–V pale (Fig. 27); femora brown, tibiae and tarsi pale; fore wing brown with basal 1/5 and clavus pale (Fig. 30).



FIGURES 19–26. Character states on tergites: **(19)** *Fr. tenuicornis* IV–V; **(20)** *Y. yangtzei* V–VI; **(21)** *I. lobulatus* VII–VIII; **(22)** *Pa. setifer* VI–VIII; **(23)** *T. physapus* VII–VIII; **(24)** *Ps. achaetus* VII–VIII; **(25)** *I. mariae* VIII; **(26)** *Fr. schultzei* VII–VIII. [see Appendix 1 for character state codes].

Head approximately as wide as long, projecting in front of compound eyes, cheeks parallel and as long as eyes; ocellar triangle smooth, 3 pairs of ocellar setae present, pairs I and II small, pair III as long as distance between hind ocelli (Fig. 7); postocular region sculptured with transverse anastomosing striae, 5 pairs of minute postocular setae present, pair II arising posterior of setal row. Antennae 8-segmented, segments III–IV with forked sense cones, usually Y-shaped with a short base; III–VI with sparse microtrichia on both dorsal and ventral surfaces. Pronotum (Fig.

13) sculptured with transverse lines at anterior and posterior margins, all setae situated on margins and no medial discal setae; anterior margin with 3 pairs of setae, submedian pair slightly longer; posterior margin with 4–5 pairs of setae, submedian setae elongate and median minor setae present or absent; posteroangular setae with inner pair longer than outer pair. Mesonotum with median pair of setae near posterior margin. Metanotum sculptured with irregular reticulation, median setae arising well behind anterior margin, campaniform sensilla absent (Fig. 18). Mesosternal endofurca with spinula and metasternal without spinula. Fore wing first vein with 11–12 setae, second vein with 4–6 setae, clavus with 3+1 (rarely 4+1) setae (Fig. 30). Abdominal tergites II–VII sculptured with widely spaced transverse lines, but smooth posterior to median setae; posterior margin with irregular short lobes; tergite I with ciliate microtrichia on lateral lines, tergite VIII with irregular short teeth arising from lobes on posterior margin (Fig. 21); tergite X with complete dorsal split. Sternites sculptured with transverse anastomosing striae, II–VII with short posteromarginal craspeda between posteromarginal setae, sternite VII without craspeda between median setal pair (Fig. 38).

Measurements (holotype female in microns). Distended body length 1420. Head, dorsal length 140, width across eyes 140; ocellar setae III 40; eye length 65. Pronotum length 125, width 175. Fore wing length 570. Antennal segments I–VIII length (width): 17(28), 33(26), 38(17), 34(17), 33(16), 48(17), 10(7), 15(5).

Male macroptera. Similar to female; abdominal tergite IX with tiny teeth on lines near anterior margin and 2 pairs of campaniform sensilla; sternites III–VII each with a small transverse pore plate medially (Fig. 35).

Measurements (male paratype): Distended body length 1130. Head, dorsal length 128, width across eyes 132; eye length 65. Pronotum length 112, width 155. Fore wing length 510. Antennal segments I–VIII length (width): 15(25), 30(24), 37(16), 29(16), 27(15), 40(15), 7(7), 13(5).

Material examined. Holotype female **CHINA**, Shandong province, Zhangqiu County, Duozhuang Reservoir (36°29'12"N, 117°24'26"E, alt. 340m), collected from base of *Themeda* sp. (Poaceae) by the lake shore, 24.ix.2015, Zhaohong Wang (in SCAU). Paratypes: 5 females and 1 male, same data as holotype (in SCAU & ANIC).

Etymology. The specific epithet is in reference to the abdominal tergites and sternites with obvious lobes.

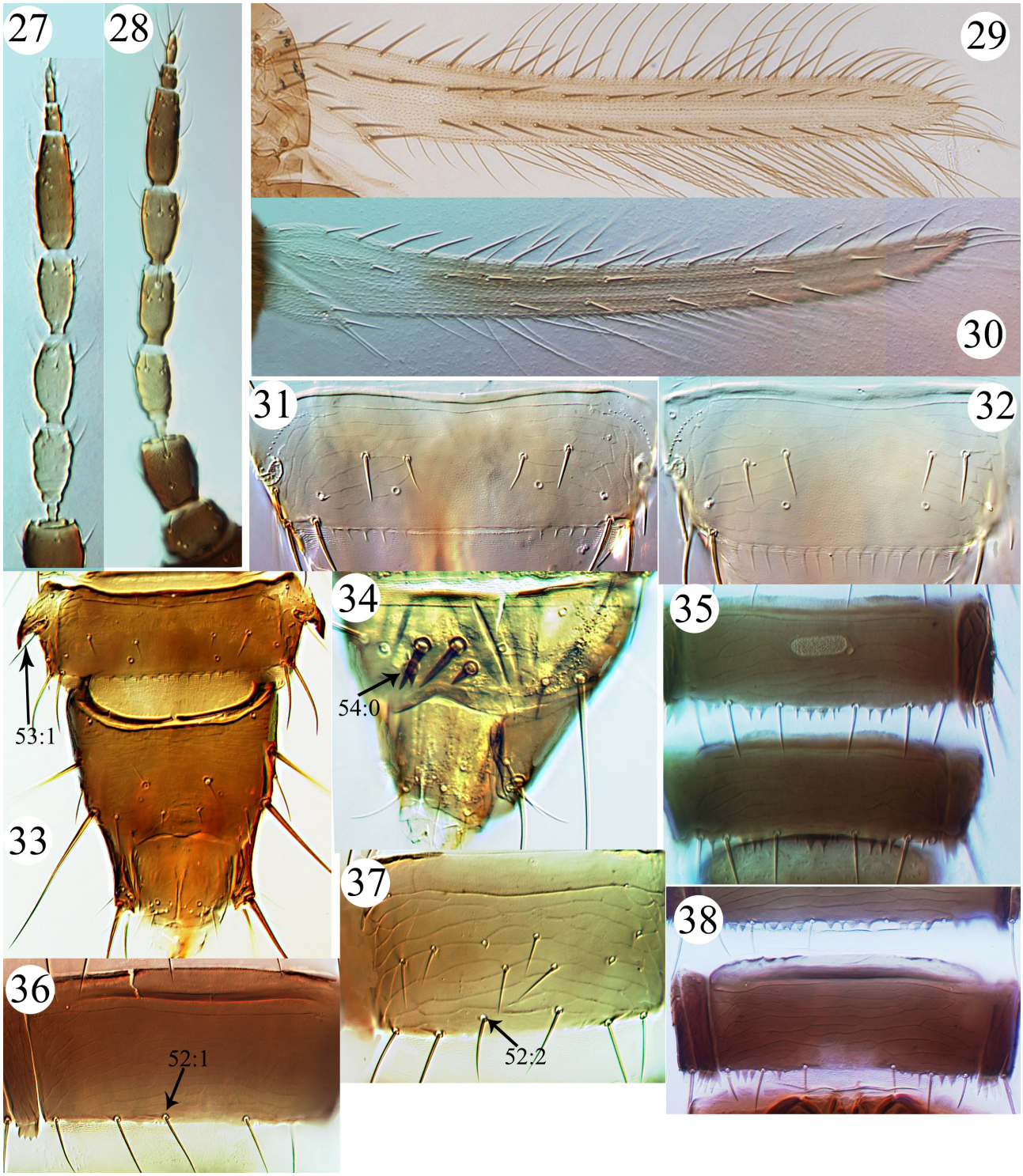
Comments. The two species previously placed in *Iridothrips* were thought to be unrelated (Mound 2002), but this new species has character states intermediate between the previous two species, thus linking them together. This species is recognizable by obvious craspedal lobes on the postior margin of tergites and sternites. One female among the type series was found to have a transverse pore plate on each of sternites III–VII. Such a character state is unusual for females, but females of several *Frankliniella* in South America also have one or two pore plates, but only on sternite III (de Borbon & Zamar 2018), and females of *Yaobinthrips* also have a pore plate on sternite VI. Females with this condition also are known in a few species of *Thrips* genus-group, including *Thrips knoxi* and *Stenchaetothrips bambusicola*. According to descriptions, the mesosternal spinula is absent in *I. iridis* but present in *I. mariae*; it is variable in *I. lobulatus*. The paratype female of this latter species in which a mesosternal spinula is not visible has a body considerably paler than the remaining dark specimens of the type series, all of which have an obvious spinula. This raises the possibility that in some species the sclerotization, and thus the visibility, of the mesosternal spinula may be related to maturity, and thus not entirely reliable for use in distinguishing species.

This new species was found living in the basal leaf sheaths of a species of *Themeda* by a lake shore. The plants were in a wet area during August to December when the lake contains much water, but during January to July there is lower water storage. Thus the plants will be submerged after the summer rainy season, but the land could be relatively dry and cold in early spring. As mentioned above for *I. iridis*, the instability of body structure may in some way be related to the instability of the habitat.

Iridothrips mariae **Pelikan**

(Figs 5, 25, 28)

Iridothrips mariae Pelikan, 1961: 64.



FIGURES 27–38. Character states of *Frankliniella* genus-group. 27–28 antennae: **(27)** *I. lobulatus*; **(28)** *I. mariae*. 29–30 fore wing: **(29)** *Fr. schultzei*; **(30)** *I. lobulatus*. 31–33 tergite VIII: **(31)** *Fr. cephalica*; **(32)** *Fr. williamsi*; **(33)** *K. pisivorus*. 34–35 male: **(34)** *Fi. firmus* tergites IX–X; **(35)** *I. lobulatus* sternites VII–VIII. 36–38 sternite VII: **(36)** *Fr. intonsa*; **(37)** *T. physapus*; **(38)** *I. lobulatus*. [see Appendix 1 for character state codes].

Described from former Czechoslovakia, this species is recorded from several European countries on the aquatic plant *Typha* (Pelikan 1961; Jenser 2013b). In lacking ocellar setae pair I it is almost unique among species in the *Frankliniella* genus-group. However, this loss is shared with two unrelated Neotropical species of *Frankliniella*, *antennata* and *speciosa* (Nakahara 1997). Some individuals of *iridis* have four pairs of ocellar setae (Mound *et*

al. 1976), thus the genetic control of these setae among these species is possibly less rigid than usually expected. According to Manfred Ulitzka (*pers. comm.* 2018) the sense cones on antennal segments III and IV of *mariae* are always simple.

Material examined. POLAND, Warsaw, Ursynow, 1 female collected from *Typlia* sp., 4.x.1985, Zawirska S. (in ANIC).

Iridothrips zizaniophila (Han & Zhang) comb.n.

(Fig. 8)

Frankliniella zizaniophila Han & Zhang, 1982: 210.

Mirab-balou *et al*. (2014) recorded this species in China from aquatic Poaceae, including *Zizania caduciflora* and *Oryza rufipogon*. These authors also suggested that *zizaniophila* might better be placed in a new genus. According to the analysis presented above, this species is sister-group to the other four species in *Iridothrips*. It is unique in having two pairs of pronotal posteromarginal setae and postocular setae pair I and pair II usually absent.

Material examined. CHINA, Guangdong, Guangzhou, Sanyuanli, 1 female from *Zizania latifolia*, 17.x.1979, Kuang Mingzhen (in ANIC). Materials recorded by Mirab-balou *et al*. (2014) in SCAU.

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APPENDIX 1. Morphological characters coded in the phylogenetic analysis

0. Head length: (0) wider than long (Fig. 2); (1) as long as wide (Fig. 7); (2) longer than wide (Fig. 10).
1. Head projection in front of eyes: (0) no projection (Fig. 2); (1) slightly projected (Fig. 3); (2) obvious projected (Fig. 5).
2. Eyes dorsal length: (0) never longer than length of cheeks (Fig. 8); (1) much longer than length of cheeks (Fig. 2).
3. Eye pigmented facets: (0) absent; (1) present (Fig. 3).
4. Ocellar setae pair I: (0) absent; (1) present (Fig. 9).
5. Ocellar setae pair III length: (0) shorter than distance between hind ocelli (Fig. 12); (1) as long as or longer than distance between hind ocelli (Fig. 9).
6. Ocellar setae III base separation: (0) base close, shorter than distance between hind ocelli (Fig. 3); (1) base apart, not shorter than distance between hind ocelli (Fig. 4).
7. Ocellar setae III position: (0) in front of hind ocelli (Fig. 5); (1) between hind ocelli (Fig. 12); (2) behind hind

ocelli (Fig. 4).
8. Postocular setae pair I: (0) absent (Fig. 10); (1) present (Fig. 7).
9. Postocular setae pair II: (0) absent (Fig. 8); (1) present.
10. Postocular setae pair II length: (0) much shorter than I and III (Fig. 11); (1) as long as I or III; (2) clearly longer than I and III (Fig. 10).
11. Postocular setae pair II position: (0) in a row with I & III (Fig. 2); (1) posterior to I & III (Fig. 7).
12. Postocular setae pair III: (0) absent; (1) present.
13. Postocular setae pair IV: (0) short than III; (1) as long as III (Fig. 12); (2) longer but never twice as long as III (Fig. 6); (3) twice or more longer than III (Fig. 9).
14. Number of antennae segments: (0) 7; (1) 8.
15. Antennae segment III base: (0) cup-shaped; (1) normal.
16. Pronotum discal setae number: (0) 0 (Fig. 13); (1) <= 10 (Fig. 15); (2) >10 (Fig. 12).
17. Number of setae on pronotal anterior margin: (0) 2 pairs; (1) 3 pairs; (2) 4 pairs (Fig. 9).
18. Pronotum anterior margin: (0) without long setae (Fig. 12); (1) with 1 pair of setae longer than others (Fig. 9).
19. Pronotum anteroangular setae: (0) short as pronotal dical setae (Fig. 12); (1) longer than pronotal discal setae but shorter than posteroangular setae; (2) as long as posteroangular setae (Fig. 15).
20. Pronotum posteromarginal setae number: (0) 2 pairs (Fig. 8); (1) 3 pairs (Fig. 11); (2) 4 pairs (Fig. 14); (3) 5 pairs (Fig. 15).
21. Pronotum posteromarginal submedian setae: (0) as shorter as other marginal setae (Fig. 10); (1) longer than other marginal setae (Fig. 12).
22. Pronotum posteromarginal setae IV length: (0) equal to setae III; (1) longer than setae III (Fig. 15).
23. Pronotum posteroangular setae: (0) both short (Fig. 12); (1) long and same length; (2) inner pair longer than outer pair (Fig. 13).
24. Mesonotum median setae: (0) in middle of sclerite (Fig. 17); (1) near post margin (Fig. 18).
25. Metanotum sculpture: (0) median area with no or weak sculpture (Fig. 16); (1) median area with obvious reticulated sculpture (Fig. 17).
26. Metanotum median setae: (0) on anterior margin (Fig. 16); (1) behind anterior margin (Fig. 18).
27. Metanotum median campaniform sensilla: (0) absent; (1) present (Fig. 16).
28. Mesosternum spinula: (0) absent; (1) present.
29. Fore wing first vein setae: (0) wide spaced on apical half (Fig. 30); (1) complete and closed spaced (Fig. 29).
30. Fore wing clavus vein setae: (0) 3 or 4 (Fig. 30); (1) 5 or more (Fig. 29).
31. Fore tarsus teeth: (0) absent; (1) present.
32. Fore tibiae teeth: (0) absent; (1) present (Fig. 4).
33. Tergite sculpture: (0) sculpture absent between S1 (Fig. 26); (1) weak lines exist between S1 (Fig. 21).
34. Tergites posteromarginal craspedum: (0) absent; (1) present.
35. Tergites posteromarginal craspedum shape: (0) craspedum toothed (Fig. 21); (1) craspedum entire (Fig. 20).
36. Tergites V–VII posteroangular seta: (0) close to angle (Fig. 19); (1) mesad of angle (Fig. 20).
37. Tergites VI–VII discal setae S2: (0) shorter or as long as S1 (Fig. 21); (1) clearly longer than S1 (Fig. 23).
38. Tergite VIII posteromarginal comb: (0) absent (Fig. 26); (1) present.
39. Tergite VIII posteromarginal comb development: (0) median teeth missing (Fig. 31); (1) lateral teeth missing (Fig. 24); (2) complete comb (Fig. 25).
40. Tergite VIII posteromarginal comb shape: (0) short and irregular (Fig. 25); (1) long and fine (Fig. 32).
41. Ctenidia on tergites IV: (0) absent; (1) present.
42. Ctenidia on tergites IV development: (0) a short row of microtrichia (Fig.19); (1) a long row of microtrichia; (2) several rows of microtrichia.
43. Ctenidia on tergites V: (0) absent; (1) present.
44. Ctenidia on tergites V development: (0) a short row of microtrichia; (1) a long row of microtrichia; (2) several rows of microtrichia.
45. Ctenidia on tergites VI–VII: (0) absent; (1) present.
46. Ctenidia on tergites VI–VII development: (0) a short row of microtrichia; (1) a long row of microtrichia; (2) several rows of microtrichia (Fig. 24).
47. Ctenidia on tergite VI–VII: (0) ending at discal setae S3 (Fig. 26); (1) ending anterior to discal setae S3 (Fig. 21); (2) ending at median marginal seta (Fig. 22).
48. Ctenidia on tergite VIII: (0) weak; (1) obvious.
49. Ctenidia on tergite VIII position: (0) anterior to spiracle; (1) posterior to spiracle (Fig. 23).
50. Sternite posteromarginal craspedum: (0) absent; (1) present (Fig. 38).
51. Sternites discal setae: (0) absent; (1) only present on sternite II; (2) present on sternite III–VII (Fig. 37).
52. Distance of sternite VII median setae from margin: (0) on posterior margin (Fig. 38); (1) no more than diameter of basal pore from margin (Fig. 36); (2) at least two diameters of basal pore in front of posterior margin (Fig. 37).
53. Male tergite VIII lateral projection: (0) absent; (1) present (Fig. 33).
54. Male tergite IX median setae: (0) stout (Fig. 34); (1) normal.