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RESEARCH

Redescription of Aquatic Grass Inhabiting *Frankliniella zizaniophila* (Thripidae: Thripinae) With Remarks on Its Systematic Position Within the Genus *Frankliniella* (Thysanoptera)

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ABSTRACT. The aquatic grass-inhabiting thrip, *Frankliniella zizaniophila* (Han & Zhang 1982) (Thripidae: Thripinae), is redescribed and illustrated, and the larvae and the yellow color type of this species are described for the first time. Judging from its unique morphological characters and host plant, the systematic position of this species in *Frankliniella* is questionable, but until the thrips fauna of Asia is better explored, it seems best to leave this species in *Frankliniella*, rather than to erect a new monobasic genus.

Key Words: *Frankliniella*, aquatic grass, color variation, China

The genus *Frankliniella* (Karny), with more than 230 species, is the second most species-rich genus in the family Thripidae, approximately 90% of which are from Neotropics (Mound and Marullo 1996; Cavalleri and Mound 2012), with only 12 species recorded from China (Wang et al. 2010; Mirab-balou et al. 2011). Most *Frankliniella* species are found in the flowers of dicotyledonous plants and feed on leaves or flowers, but a few species are restricted to only monocotyledonous plants, e.g., *Frankliniella tenuicornis* (Uzel), *Frankliniella williamsi* (Hood), and *Frankliniella frumenti* (Moulton) breed in grass flowers or leaf sheaths (Mound et al. 2005), and *Frankliniella zizaniophila* (Han & Zhang 1982) damage the leaves of aquatic grass *Zizania latifolia* (Grideb.) (Syn. *Zizania caduciflora*) (Han & Zhang 1982).

Z. latifolia (Poaceae), native to China and eastern Asia, is often infected by the smut fungus, *Ustilago esculenta* (Henn.), causing culm enlargement and failure to produce flowers (Guo et al. 2007). The enlarged infected culms have been used as an aquatic vegetable (Chinese name: *jiao bai*) in China since the 10th century (You et al. 2008). Recently, the authors found that *F. zizaniophila* also causes damage to young leaves of the cultivated variety of *Oryza rufipogon* (Griffiths) (brownbeard wild rice, family Poaceae) with high population (Figs. 1–3) during the surveys on rice thrips in Zhejiang Province, eastern China. Moreover, two color types of *F. zizaniophila* were observed, i.e., brown type and yellow type. Yellow-type individuals were found in low frequency. As discussed below, *F. zizaniophila* is unusual within the genus *Frankliniella* in having atypical generic characteristics (Nakahara 1997); however, this species was described originally by Han and Zhang (1982) in Chinese, which meant *F. zizaniophila* was largely ignored outside China. The aim of this article is to redescribe *F. zizaniophila* based on the type specimens and more fresh specimens and discuss its taxonomic position within the genus *Frankliniella*.

Materials and Methods

Type specimens deposited at the National Zoological Museum of China, Institute of Zoology (IOZ), Chinese Academy of Sciences, Beijing, China, were used. Additional specimens studied include those from the Institute of Insect Sciences, Zhejiang University, Hangzhou, Zhejiang Province (ZJUH) and the Department of Entomology, South China Agricultural University (SCAU), Guangzhou, Guangdong Province; other specimens were collected from various sites in China, and prepared onto slides using the methods of Mirab-balou and Chen (2010). Specimens of *F. zizaniophila* were collected on *O. rufipogon* (Griffiths) (brownbeard wild rice) (Fig. 1) in Hangzhou, Zhejiang Province. All descriptions, measurements, and some of photos were made with a Leica DM IRB microscope, a Leica MZ APO microscope with a Leica Image 1000 system and a camera lucida. In addition, Figures 15–21 were made using a scanning electron microscope, under



Fig. 1. The cultivated variety of *O. rufipogon* (brownbeard rice), infected by *F. zizaniophila* (Huajiachi Campus at Zhejiang University, Hangzhou, China, 10.v.2011).

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Figs. 2–6. *F. zizaniophila*: (2) Larvae and female adults on leaf; (3) Damage symptoms on young leaf; (4) Larva I; (5) Larva II; (6) Adult (♀).

an XL-30-ESEM operated at 20 kV, at South China Agricultural University.

F. zizaniophila

F. zizaniophila Han and Zhang 1982: 210–211.

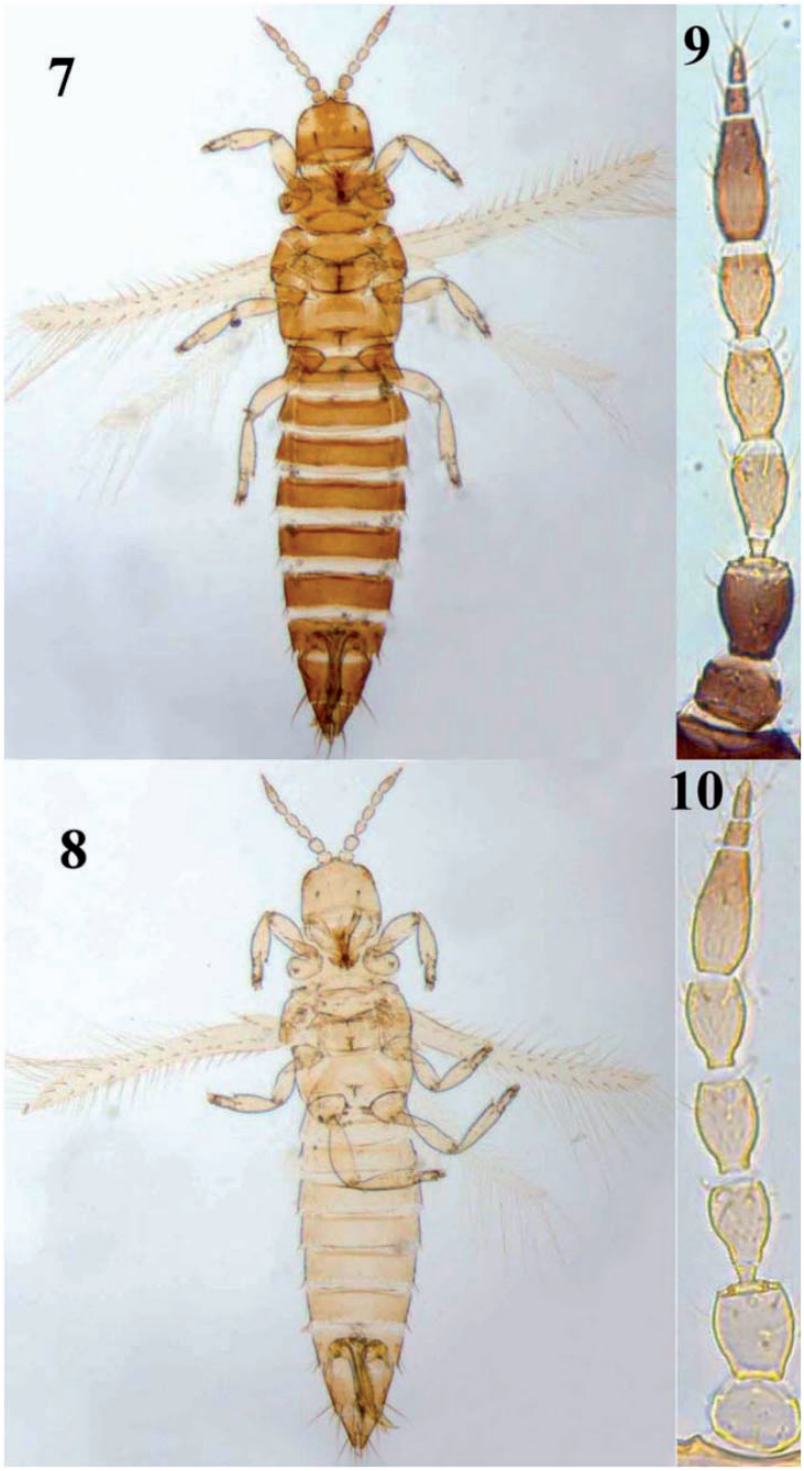
Material Examined. Two ♀ paratypes (in IOZ); 16♀, 4♂, two second-instars, one first instars (in ZJUH): CHINA: Huajiachi Campus at Zhejiang University, Hangzhou, Zhejiang Province, on *O. rufipogon*, 08.v.2011, coll. M. Mirab-balou; 13♀ (in SCAU): Huajiachi Campus at Zhejiang University, Hangzhou, Zhejiang Province, on *O. rufipogon*, 12.v.2011, coll. M. Mirab-balou; 1♀ (in SCAU): 1♀ (in SCAU): Yangzhou (32°21′N, 119°25′E), Jiangsu, on *Leersia hexandra* (Poaceae), 13.iv.1974, coll. Tian Lixin; 2♀ (in SCAU): Andong (33°35′N, 118°57′E), Jiangsu, on *Z. latifolia*, 13.v.1974, coll. Tian Lixin; 1♀ (in SCAU): Shuangqiao (32°23′N, 119°25′E), Yangzhou, Jiangsu, on *Z. latifolia*,? .vii.1978, coll. Unknown; 1♀ (in SCAU): Hangzhou (30°14′N, 120°07′E), Zhejiang Province, on *Z. latifolia*, 5.iv.1979, coll. Zhang Weiqiu; 43♀ (in SCAU): Sanyuanli (23°09′N, 113°15′E), Guangzhou, Guangdong, on *Z. latifolia*, 17.x.1979, coll. Kuang Mingzhen; 1♀ (in SCAU): Ningde (26°40′N, 119°32′E), Fujian, on *Z. latifolia*,? .v.1984, coll. Unknown; 15♀ (in SCAU): Lenshuijiang (27°41′N, 111°26′E), Hunan, on *Z. latifolia*, 3.vii.1985, coll. Pan Churui.

Diagnosis

Female macroptera: dark brown color type (Figs. 6–7). Body color dark brown; all tibiae and tarsi yellow; antennal segments I–II as dark as head, III–V yellow, VI yellow in base and dark in apex, VII–VIII pale brown (Fig. 9); fore wing including clavus yellowish white (Fig. 12).

Head. Head wider than long, sculpture distinctly striate behind eyes (Fig. 11). Head with three pairs of ocellar setae, pair III the longest and situated on margin of ocellar triangle, anterior to hind ocelli (Fig. 11); three (rarely two or four) pairs of short postocular setae present (Fig. 11); five ventral ommatidia weakly pigmented; mouth cone short. Maxillary palps three-segmented. Antennae eight-segmented (Figs. 9,

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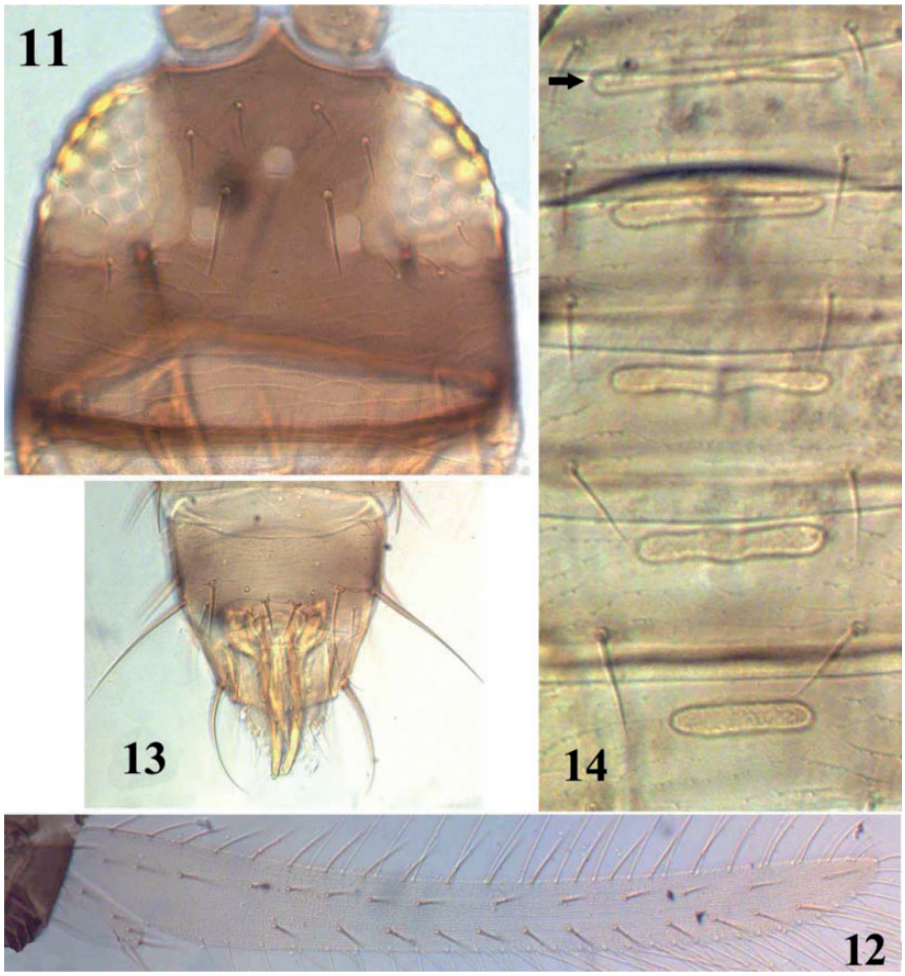


Figs. 7–10. *F. zizaniophila*: 7–8. Adult (♀): (7) brown type, (8) yellow type; 9–10. Antenna: (9) brown type, (10) yellow type.

10, and 15); segment III stalked; III and IV each with forked sensorium (Fig. 16); segments III–VI with microtrichial rows on both dorsal and ventral surfaces; segment VI longest; segment VIII longer than VII (Fig. 15). Antennal segments I–VIII length/width: 0.6, 1.2, 1.5, 1.4, 1.4, 1.9, 0.9, and 3.

Thorax. Pronotum wider than long, rectangular, weakly striate near posterior margin, with four pairs of major setae (anteroangular and anteromarginal, each one pair; posteroangulars, two pairs) well developed, with a few minute discal setae (9–13 setae), inner posteroangular setae longer than outer pair (Fig. 17). Mesonotum weakly and irregularly reticulated, campaniform sensilla present anteromedially. Metascutum with closely spaced, anastomosing and longitudinal striate; median metanotal setae situated at anterior margin; metanotal campaniform sensilla absent (Fig. 19). Fore wing first vein setal row almost complete, with 13–16 setae, second vein with 11–13 vein and one discal setae (Fig. 12); clavus with a discal seta and four marginal setae (Fig. 18); posterior cilia wavy. Prosternal ferna undivided. Mesothoracic furca with spinula, metathoracic furca without spinula. Tarsi two-segmented. Hind tibiae (inner side) with row of stout setae, absent in fore- and midtibiae.

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Figs. 11–14. *F. zizaniophila*: (11) Head; (12) Forewing; (13) Abdominal tergites IX–X (♂); (14) Abdominal sternites III–VII, showing pore plate (♂).

Abdomen. Abdominal tergite I transversely reticulate, without craspedum, median setae and campaniform sensilla wide apart; tergites IV–VII with sculpture laterally, lines extending to campaniform sensilla and median setae S1, with a few scatter microtrichia on sculpture lines, smooth medially; tergal chaetotaxy as follows: tergites II–IV with median setae S1 shorter than S2, S2 as long as S4, S5 setae minute; tergite V with median setae S1 as long as S2, S2 as half as S4; tergites VI–VII with median setae S1 longer than S2, S2 as long as S4; tergite VIII without posteromarginal comb (Fig. 20), with paired ctenidia anterolateral to spiracles (Fig. 20), VI–VII with ctenidia terminating at median lateral marginal seta (Fig. 21). Median split on tergite X not complete. Abdominal sternites II–VII with sculpture laterally, with a few scatter microtrichia on sculpture lines, smooth medially, without discal setae. Sternite VII with median pair of setae (S1) situated in front of posterior margin and far from each other. Ovipositor well developed.

Measurements *(*in Microns*). Length (Width)*

Body 1,300-1,400 (280-130); head 120-125 (165-170); ocellar setae III 50. Pronotum 125-130 (200-210). Fore wing 610-640 (44-50); hind wing 510-535 (35-39). Antennal segments I–VIII: I 21 (33), II 33 (27), III 33 (22), IV 29 (21), V 29 (21), VI 42 (22), VII 8 (9), and VIII 15 (5). Ovipositor 220.

Male Macroptera

Male similar to female but smaller (940-965 µm); setae S1 and S2 on tergite VIII a little thicker than these setae on other tergites; tergite IX sculptured with rows of striate lines that covered with irregular microtrichia on some sculpture lines (Fig. 13); abdominal sternites III–VII with linear pore plate (Fig. 14) (rarely present in females).

Female Macroptera: Yellow Color Type

(Fig. 8). This species exists as a yellow color type and dark brown color type. There are no prominent morphological characters between these two forms, but in the yellow form, there is a gray antecostal ridge on abdominal segments, which is absent in the brown form; also, antennal segments I and II are yellow in the yellow form (Fig. 10) but brown in the brown form.

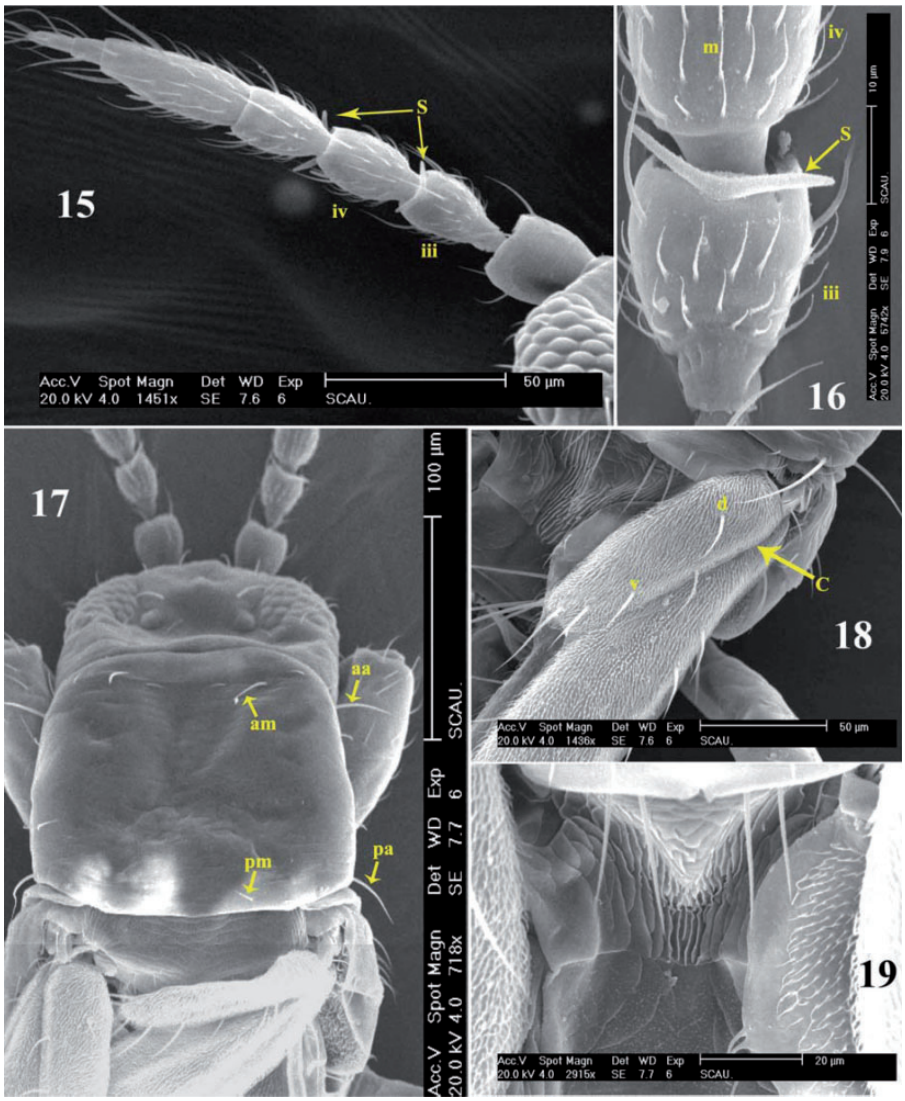
Larva

(Figs. 4–5). The mouth cone is short and the pronotum smooth in second instars; three pairs of capitate setae are present on abdominal segments. The plant damaged by this thrip is shown in Figures 2 and 3.

Taxonomic Relationships

The following characters all indicate that this species is a member of *Frankliniella* (Mound and Palmer 1981; Mound 2002; Mirab-balou and Chen 2011): the presence of paired ctenidia anterolateral to spiracles on abdominal tergite VIII, the presence of ocellar setae pair I, fore wing both veins with complete row of setae, and the metanotal median setae at anterior margin of sclerite; however, according to the following characters, this species can be moved to a new genus with further examination: four pairs of pronotal major setae (vs. usually five pairs in other species of *Frankliniella*) (Mound and Marullo 1996;

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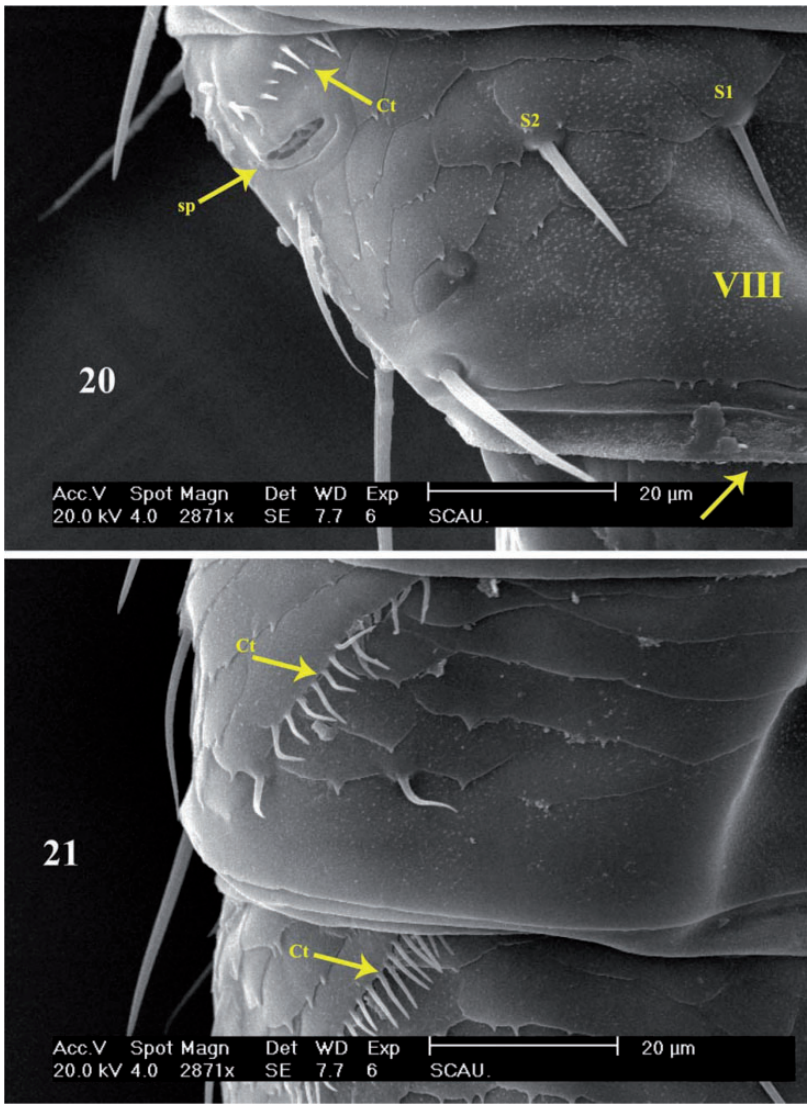
Figs. 15–19. *F. zizaniophila*: (15) Antenna; (16) Antennal segment III; (17) Pronotum; (18) Forewing clavus; (19) Metanotum. (*S. Sensorium; m. Microtrichia; C. Clavus; d. Discal setae; V. veinal setae; aa. Anteroangular setae; ps. Posteroangular setae; am. Anteromarginal setae; pm. Posteromarginal setae*).

Masumoto 2010); pronotum without setae medially on the posterior margin between the major pair of posteromarginal setae (vs. with a small pair of setae in other species of *Frankliniella*) (Mound and Ng 2009); metascutum not reticulated, with closely spaced, anastomosing, and longitudinal striate (vs. sculptured in other species of *Frankliniella*) (Masumoto 2010); and abdominal tergite IX without anterior pair of campaniform sensilla (vs. with two pairs of campaniform sensilla in other species of *Frankliniella*). In addition, the presence of a linear pore plate on abdominal sternites III–VI in some females, and median setae (S1) on abdominal sternite VII situated far from each other (most close to S2) is apparently unique to this species. The number of the postocular setae is variable in this species: two pairs (Nakahara 1997); two pairs in the drawings with the original description (Han and Zhang 1982); four pairs in drawings published by Han (1997); four pairs (Wang et al. 2010); and we also found two and three pairs of postocular setae. Especially the metanotum is very curious—so similar to the grass thrips *Stenchaetothrips* (Bagnall) and *Bolacothrips* (Uzel) and very different from the typical *Frankliniella* species (L.A. Mound, personal communication, 25.v.2011), which suggests the systematic position of this enigmatic species in the genus *Frankliniella* remains conjectural.

Many species of Thysanoptera show extraordinary phenotypic plasticity in structure and color (Mound 2005). It is not difficult to find intraspecific variation in color pattern in the genus *Frankliniella*. For example, there are three color forms of *Frankliniella occidentalis* (Pergande) in the United States: dark, pale, and bicolored, and their relative abundance differ according to the season (Bryan and Smith 1956). Similarly, *Frankliniella schultzei* (Trybom) also exists as two discrete color forms, brown and yellow (Sakimura 1969). Mound (2005) suggests that environmental conditions are probably of great importance in determining the body color differences in species showing intraspecific variation in color pattern. In this study, the yellow type in *F. zizaniophila* is found for the first time occurring together with the brown type, although brown individuals have an absolute predominance in the population. It is also possible that the yellow type represents teneral individuals that have just recently emerged from the pupa and are not completely sclerotized. Evaluation of this proposition will require rearing experiments.

In China, *F. zizaniophila* was found only in leaves of aquatic grass *Z. latifolia* before this study and was once considered a monophagous thrip. However, during the present study this species was found to damage the leaves of brownbeard wild rice when present in high numbers. In addition, the species was on a third host, the aquatic grass *L. hexandra* (Swartz: Poaceae). It is interesting that there was no *F. zizaniophila* on rice (*Oryza sativa*) planted near the brownbeard wild rice

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Figs. 20–21. *F. zizaniophila*: (20) Abdominal tergite VIII; (21) Abdominal tergite VI. (*Ct. Ctenidium; sp. Spiracle; S. seta*).

(<2 m distance between them). It seems that *F. zizaniophila* prefers only brownbeard wild rice (our field observations). Unlike other flower-living members of *Frankliniella*, this species breeds only on leaves on aquatic grass, *Z. latifolia* and *O. rufipogon*, both of which are endemic to China. Given the current knowledge of the distribution of the species and its host, it appears that the species is endemic to China.

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