



Discovery of Ulmaceae-feeding Tischeriidae (Lepidoptera, Tischerioidea), *Tischeria ulmella* sp. nov., and the first report of the *Quercus*-feeding *T. naraensis* Sato in China

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Abstract

We provide the first report of Tischeriidae on Ulmaceae, a novel host-plant family, and describe *Tischeria ulmella* Xu & Dai, sp. nov., a new species discovered in the Yellow River Scenic Area of Zhengzhou (Henan Province, China), feeding on *Ulmus pumila* L. We also provide a redescription of the *Quercus*-feeding *Tischeria naraensis* Sato discovered in China for the first time. Both species are illustrated with photographs of the adults, male and female genitalia, and the leaf mines.

Key words: China, leaf miners, new species, *Tischeria* Zeller, Tischeriidae, Ulmaceae

Introduction

Tischeriidae is a family of monotrystian Lepidoptera with very small moths, their wingspan only about 6–10 mm. Larvae of Tischeriidae (trumpet moths or trumpet leaf-miner moths) are miners during all instars and feed inside leaves of plants. The most detailed characterization of Tischeriidae were provided by Braun (1972) and Diškus & Puplėsis (2003), while additions on generic composition, diagnostics or host-plant relationships were made by Kobayashi *et al.* (2016), Stonis *et al.* (2017), and Xu *et al.* (2017).

So far eleven Tischeriidae species have been reported from Japan (Kuroko 1982; Sato 1993, 2011; Diškus & Puplėsis, 2003a, 2003b; Oishi & Sato 2009; Kobayashi *et al.* 2016), and ten species from Far Eastern Russia (Ermolaev 1986; Kozlov 1986, 1987; Diškus & Puplėsis, 2003b; Navickaitė *et al.* 2011; Stonis *et al.* 2014).

China is famous for its amazing habitat and plant diversity, therefore we also expect an exceptionally rich Tischeriidae fauna. However, compared to the other regions of Asia, data on Chinese Tischeriidae are still scanty. Until recently only a few species have been reported from this extraordinary region, including *Tischeria quercifolia* Kuroko, *T. decidua* Wocke (Cao *et al.* 1983, Tao *et al.* 2003), *Coptotriche japoniella* Puplėsis & Diškus (Huan & Tan 2009), and *Paratischeria jingdongensis* Xu & Dai (Xu *et al.* 2017). We neither confirm or reject the doubtful record of *Coptotriche gaunacella* (Duponchel) (Cao *et al.* 1983) because the Chinese specimens were not available for our study.

In the current paper we describe *Tischeria ulmella* Xu & Dai, sp. nov. feeding on *Ulmus laevis* L., Ulmaceae, and also report on *Quercus*-feeding *Tischeria naraensis* Sato which was formerly known only from Japan, now recorded from China for the first time.

Material and methods

Descriptions of taxa are based on material collected in Zhengzhou, Song County (Henan Province), Kunming and

Jingdong (Yunnan Province), Nanjing (Jiangsu Province), Ji County (Tianjin Municipality) and Jinzhai (Anhui Province). The specimens of *Tischeria ulmella* sp. nov. are deposited in the collection of the School of Life and Environmental Science, Gannan Normal University, Jiangxi, China.

Collecting methods, techniques for genitalia preparation, and protocols for description are outlined in Puplesis & Diškus (2003). Adults were reared from leaves with mining larvae during July to October from 2012 to 2016. Mined leaves and branches of the host plants were scanned by the Epson Expression 10000XL scanner in laboratory at the GNU. Adult morphology was examined using a Leica M-205C stereomicroscope and photographed using a Canon 7D + macro lens. Genitalia slides were studied using an Olympus BX-53 microscope and photographed using an Olympus DP-26 digital camera connected to an Olympus BX-53 microscope.

The descriptive terminology of morphological structures and the classification of Tischeriidae follow Puplesis & Diškus (2003) and Xu *et al.* (2017).

Abbreviation for specimen depository:

GNU—School of Life and Environmental Science, Gannan Normal University, Jiangxi, China.

Description of *Tischeria ulmella* Xu & Dai, sp. nov.

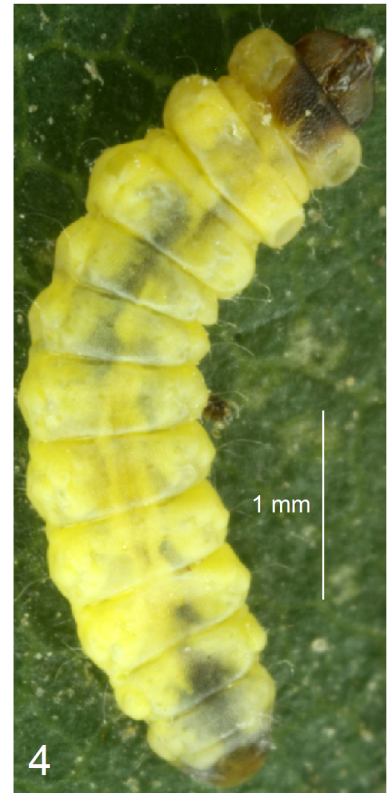
(Figs 1–14)

Type material. Holotype: ♂, CHINA, the Yellow River Scenic Area of Zhengzhou, Zhengzhou, Henan Province, elevation 97 m, N34°57'35", E113°30'46", pupa in leaf mine on *Ulmus pumila* L. 20.viii.2015, ex. pupa 26.viii.2015, leg. Jiasheng Xu *et al.*, genitalia slide no. BX15009♂ (GNU). Paratypes: 7 ♂, 12 ♀, same label data as holotype, mining larvae and pupae 20.viii.2015, ex pupae 26.viii–4.ix.2015, leg. Jiasheng Xu *et al.*, genitalia slide nos BX15008♀, XJS17002♀, XJS17001♂, XJS17003♂ (GNU).

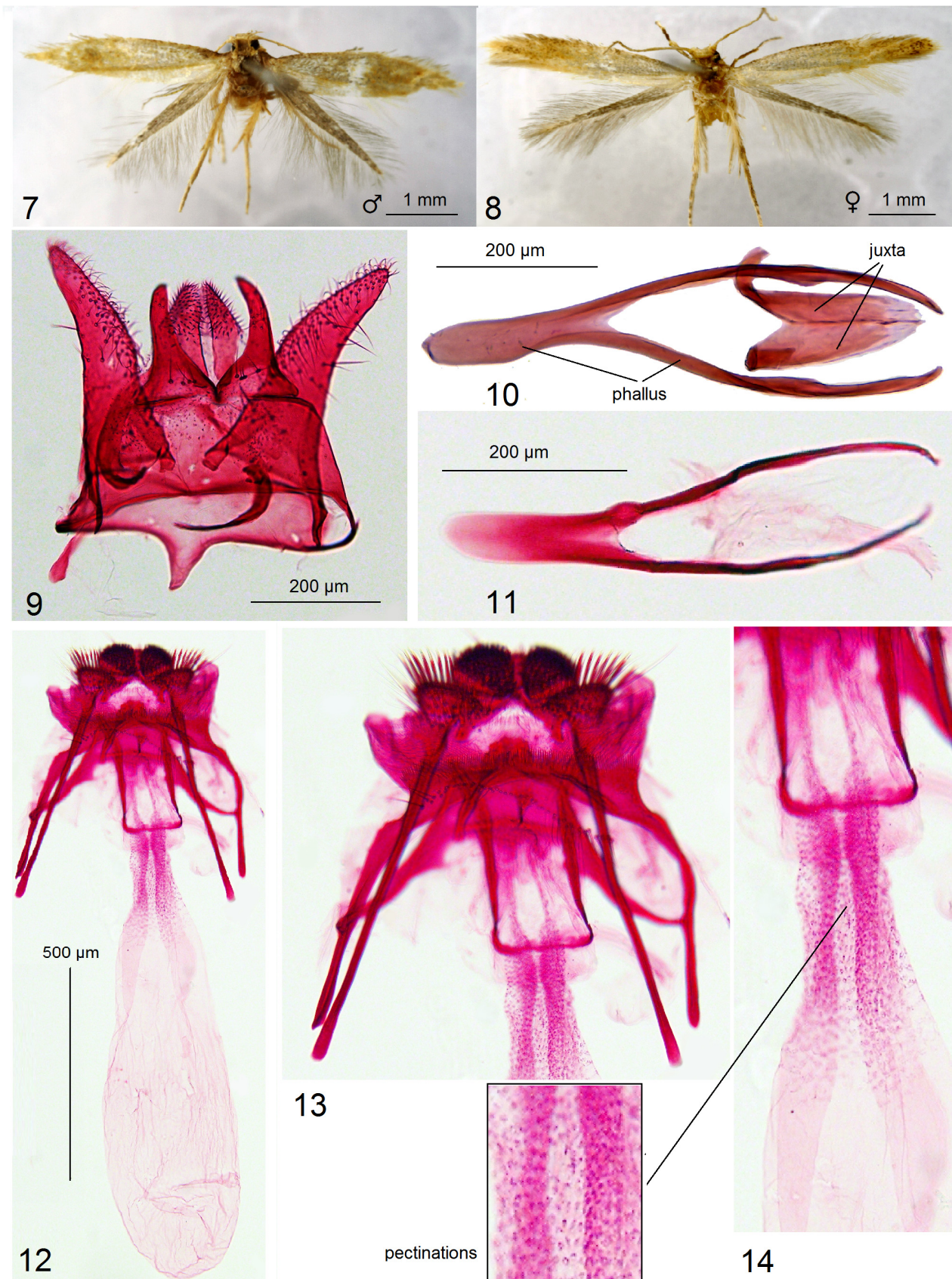
Diagnosis. *T. ulmella* sp. nov. cannot be recognized by external characters such as forewing pattern and can be easily confused with the following very similar and related *Quercus*-feeding species: *Tischeria decidua* Wocke, 1876, *T. naraensis* Sato, 1993, and *T. dodonaea* Stainton, 1858. However, the new species differs in the male genitalia from all of these, as well as other *Tischeria* species. From the trans-Palaeartic *T. decidua* (including its subspecies *T. decidua siorkionla* Kozlov, 1986), the new species differs in the absence of a transverse bar in the phallus (apical processes of the phallus are connected by a distinctive transverse bar in *T. decidua*), much longer and slender base of the phallus, gradually narrowed valva (in *T. decidua*, valva very wide in basal 2/3 but abruptly narrowed in apical 1/3), large socii, translucent leaf mine without dark concentric arcs, and the host plant *Ulmus pumila* L. From the east Asiatic *T. naraensis*, the new species differs in the slender anterior process of vinculum (gradually narrowed, triangular in *T. naraensis*), strongly setose socii with short, thick setae (weakly setose in *T. naraensis*), compact juxta (in *T. naraensis*, processes of juxta are loose basally), abruptly narrowed lobe of uncus with a wide base (in *T. naraensis*, lobe of uncus becomes gradually narrow, triangular), fully translucent leaf mine without dark concentric arcs, and the host plant *Ulmus pumila*.

From the west Palaeartic *T. dodonaea*, the new species differs in the much longer and slender base of the phallus with distally well-separated processes, uncus with a wide base (slender in *T. dodonaea*), absence of frass in a fully translucent leaf mine without dark concentric arcs (in *T. dodonaea*, leaf mine pale ochre, with dark ochre concentric arcs), and the host plant *Ulmus pumila*.

Male (Fig. 7). Forewing length 2.7–3.0 mm; wingspan 6.5–7.0 mm. Head: palpi and face cream to brownish or yellowish cream; frontal tuft brownish cream, comprised of wide lamellar scales; collar glossy, comprised of lamellar, yellowish cream and cream scales; antenna about 2/3 the length of forewing; flagellum yellowish cream, with long piliform sensillae. Thorax and tegula yellowish cream, dark brown anteriorly. Forewing yellowish cream, sparsely speckled with blackish brown and pale brown scales; blackish brown scales prevail along costa and apically; fringe yellowish cream to grey; underside of forewing pale grey, without spots. Hindwing without androconia, grey to dark brown-grey on upper side and underside; fringe dark grey. Legs cream; foreleg, particularly tarsi, densely covered with blackish brown scales on upper side. Abdomen glossy, dark brown on upper side, yellowish ochre on underside; anal tufts indistinctive.



FIGURES 1–6. *Tischeria ulmella* Xu & Dai, **sp. nov.** 1, host plant *Ulmus pumila* L., Ulmaceae, Zhengzhou, Henan Province, China; 2, leaf mine; 3, larva in opened nidus; 4, mature larva; 5, pupa, emerged from the leaf mine through exit slit; 6, pupa, general view.



FIGURES 7–14. *Tischeria ulmella* Xu & Dai, **sp. nov.** 7, adult, male, holotype; 8, same, female, paratype; 9, male genitalia, holotype, slide no. BH15009, capsule with phallus removed; 10, same, slide no. XJS17003, phallus and juxta; 11, same, slide no. BH15009, phallus; 12, female genitalia, paratype, slide no. XJS17002; 13, same, genitalia slide no. BH15008, antrum and apophyses; 14, same, genitalia slide no. BH15008, pectinations on corpus bursae.

Female (Fig. 8). Forewing length 3.0–3.3 mm; wingspan 7.0–7.6 mm. Antenna half the length of forewing; flagellum pale yellowish brown on upper side, yellowish cream or greyish cream on underside, without long sensillae. Forewing densely speckled with blackish brown and pale brown scales on costa and apically. Abdomen with dark grey anal tufts. Otherwise as male.

Male genitalia (Figs 9–11). Capsule 470–485 µm long, 390–420 µm wide. Lateral lobes of uncus long and slender, basally abruptly widened. Socii large, triangular (Fig. 9), densely covered with short but distinctive, thickened setae in apical half. Vinculum with a short anterior process. Valva 300–330 µm long, gradually narrowed, slightly bent outward (Fig. 9); basal process of valva short. Juxta comprised of two, 200 µm long, basally bent sclerites, connected with a membranous joint (Fig. 10). Phallus about 460 µm long, bifid; processes connected with juxta by a membrane (Figs 10, 11).

Female genitalia (Figs 12–14). Total length 1400–1500 µm. Ovipositor lobes densely clothed with short stout setae; second pair of lobes covered with long thickened setae and bristles. Posterior apophyses slightly longer and slender than anterior apophyses. Antrum (Fig. 13) moderately sclerotized. Ductus spermathecae membranous, with one convolution. Corpus bursae 950–1000 µm long, with distinctive spine-like pectinations distally (Fig. 14).

Bionomics (Figs 1–6). Host plant: *Ulmus pumila* L., Ulmaceae (Fig. 1). Larvae mine from late July to late August (or early September) and produce translucent, white or brownish white, blotch-like leaf mines (Fig. 2). Nidus distinctive (Figs 2, 3), except for early stages of the mining. Mature larva yellow (Fig. 4); transforms into pupa (Fig. 6) in a silk-lined nidus, an oval-shaped depression inside of the leaf mine (Fig. 3). Exit slit on margin of the leaf mine (Fig. 5). Adults emerge from late August to early September.

Distribution. So far, the new species is only found in the Yellow River Scenic Area of Zhengzhou, Henan Province, China.

Etymology. The species is named after the host-plant genus *Ulmus*, Ulmaceae, a novel host-plant taxon for the Tischeriidae.

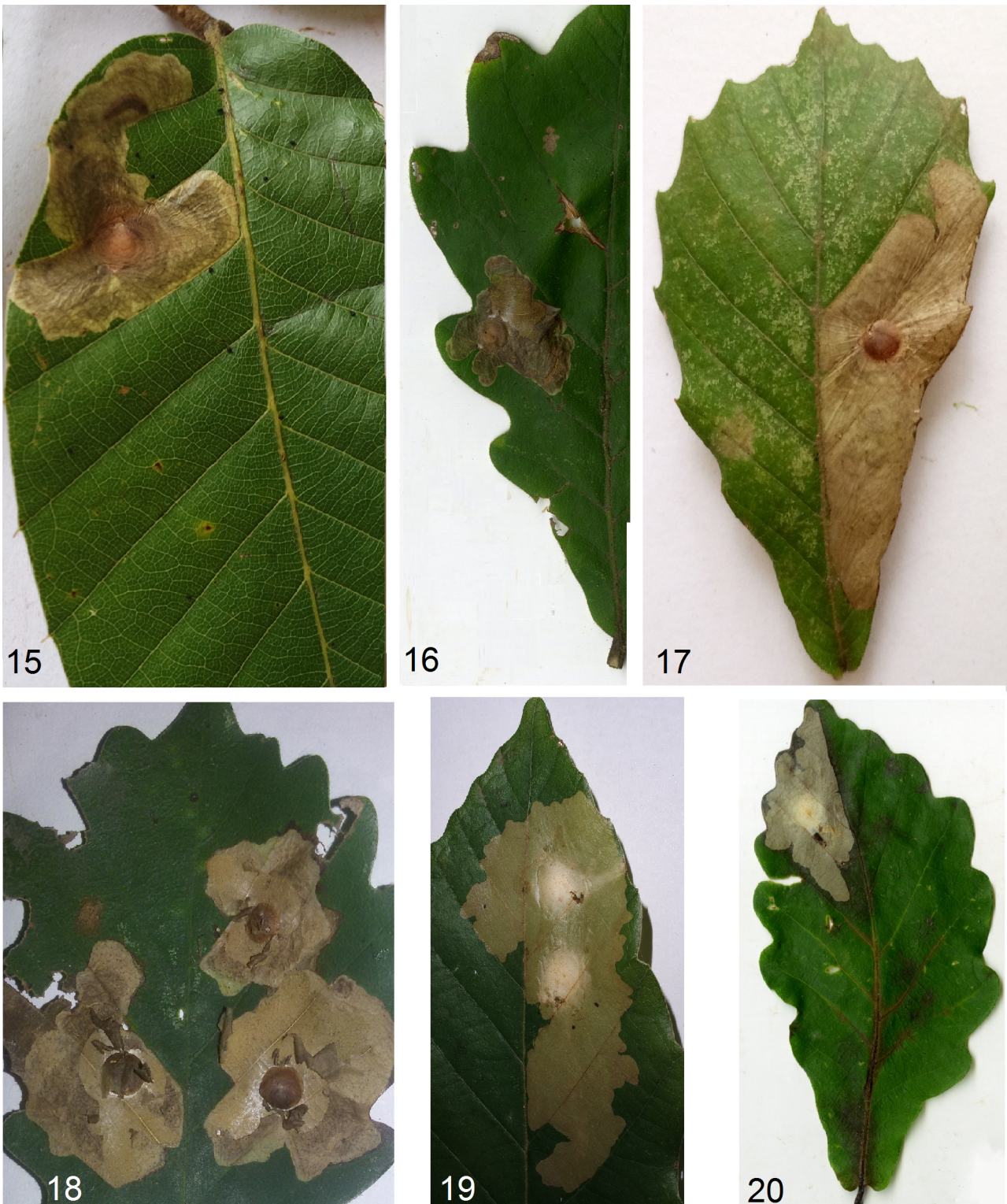
Re-description of *Tischeria naraensis* Sato, 1993, based on material from China (new record for the fauna of China) (Figs 15–25)

Material examined (4 ♂, 8 ♀): 1 ♂, CHINA, Muzhaling, Song County, Luoyang, Henan Province, leg. Jiasheng Xu & Chenqing Liao, pupa in a leaf mine on *Quercus variabilis* Bl. 23.vii.2012, ex. pupa 03.viii.2015, genitalia slide no. B12101 (GNU); 1 ♂, Tiantangzhai Nature Reserve, Jinzhai County, Lu'an, Anhui Province, leg. Jiasheng Xu & Chenqing Liao, pupa in a leaf mine on *Quercus variabilis* Bl. 17.vii.2012, ex. pupa 31.vii.2012, genitalia slide no. B12084 (GNU); 1 ♂, Zijinshai, Nanjing, Jiangsu Province, leg. Jiasheng Xu *et al.*, pupa in leaf mine on *Quercus variabilis* Bl. 23.vii.2012, ex. pupa 03.viii.2015, genitalia slide no. B12033; 1 ♂, 2 ♀, Kunming Institute of Botany of the Chinese Academy of Science, Kunming, Yunnan Province, leg. Jiasheng Xu *et al.*, pupae in leaf mines on *Quercus variabilis* Bl. 17.vii.2016, ex. pupae 03.vii.2016, genitalia slide nos B16003, B16003 (GNU); 5 ♀, Taizhong Town, Jingdong County, Pu'er, Yunnan Province, leg. Jiasheng Xu *et al.*, pupae in leaf mines on *Quercus variabilis* Bl. 09.viii.2016, ex. pupa 21.viii.2016, pupae in leaf mines on *Quercus acutissima* Carruth. 26.vii.2014, ex. pupae 12.viii.2016 (GNU); 1 ♀, Baxianshan, Ji County, Tianjin Municipality, leg. Jiasheng Xu & Peng Liu, leaf mine on *Quercus mongolica* Fisch. ex Ledeb. (GNU).

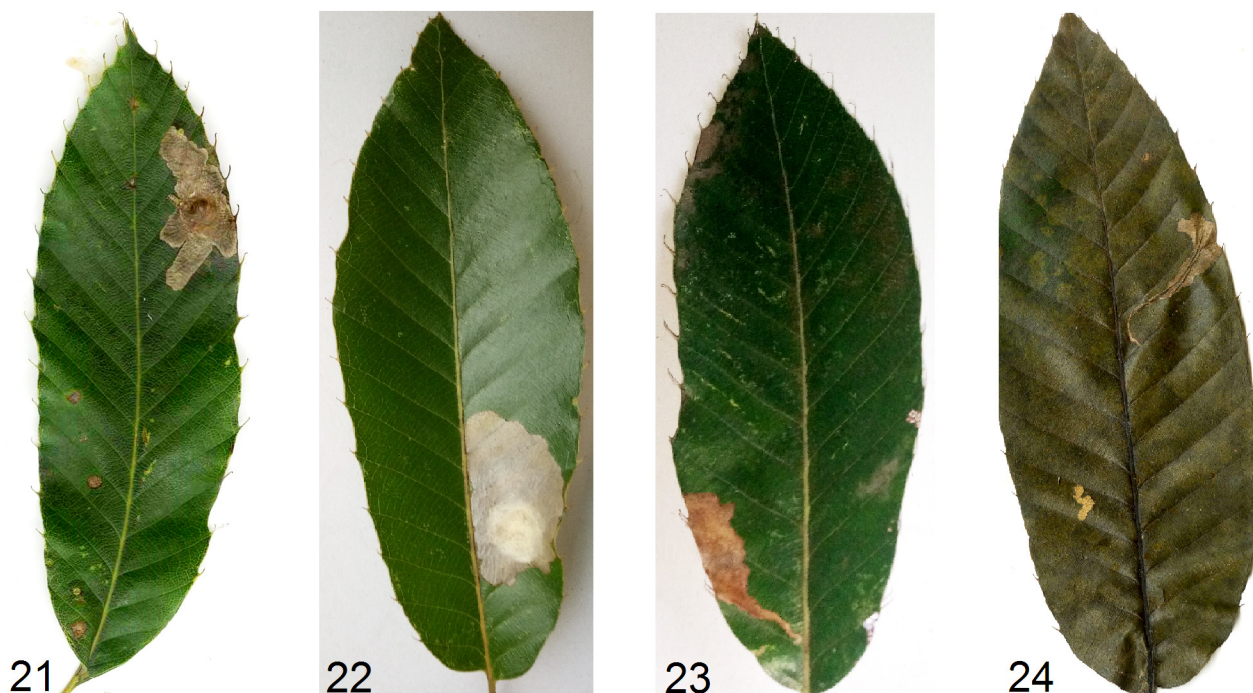
Diagnosis. *T. naraensis* cannot be distinguished by external characters such as forewing pattern and can be easily confused with the following very similar and related species: *T. decidua* Wocke, 1876, *T. dodonaea* Stainton, 1858, and *T. ulmella* Xu & Dai, sp. nov. However, the new species differs in the male genitalia from all of these, as well as other *Tischeria* species. From the trans-Palaeartic *T. decidua* (including its subspecies *T. decidua siorkionla* Kozlov, 1986), *T. naraensis* differs in the absence of a distinctive transverse bar in the phallus (apical processes of the phallus are connected by a distinct transverse bar in *T. decidua*), much longer and slender base of the phallus, gradually narrowed valva (in *T. decidua*, valva very wide in basal 2/3 but abruptly narrowed in apical 1/3), large socii, and the irregular dark arcs around the nidus in the leaf mine (in *T. decidua*, leaf mine remains pale, without dark arcs around the nidus).

From the west Palaeartic *T. dodonaea*, *T. naraensis* differs in the much longer and slender base of the phallus with distally well-separated processes, wide, triangular lobe of uncus (slender in *T. dodonaea*), triangular vinculum without processes, and the irregularly scattered fuscous arcs in the dark leaf mine (in *T. dodonaea*, leaf mine pale ochre with dark ochre concentric arcs).

From the east Asiatic *T. ulmella* Xu & Dai, sp. nov., *T. naraensis* differs by the triangular vinculum without anterior process (with a slender anterior process in *T. ulmella*), very fine setae of socii (setae thickened in *T. ulmella*), basally loose processes of juxta, triangular, gradually narrowed lobe of uncus (slender, with a wide base in *T. ulmella*), irregularly scattered black-brown arcs in the leaf mine (arcs or other pattern absent in a translucent leaf-mine of *T. ulmella*), and the host plant *Quercus*.



FIGURES 15–20. Leaf mines of *Tischeria* spp. on leaves of *Quercus*. 15, 16, *T. naraensis* Sato on *Quercus acutissima* Carruth. (15) and *Q. dentata* Thunb. (16); 17, 18, *T. quercifolia* Kuroko on two different unidentified *Quercus* spp.; 19, 20, *T. decidua* Wocke on *Q. aliena* var. *acuteserrata* Maxim. (19) and *Q. mongolica* Fisch. ex Ledeb. (20).



FIGURES 21–24. Leaf mines of Tischeriidae on *Quercus variabilis* Bl. from China. 21, *Tischeria naraensis* Sato; 22, *T. quercifolia* Kuroko; 23, 24, two different unnamed species of *Coptotriche* collected in Yunnan.

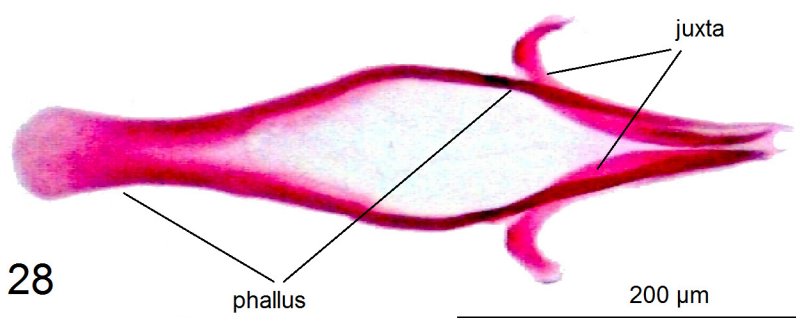
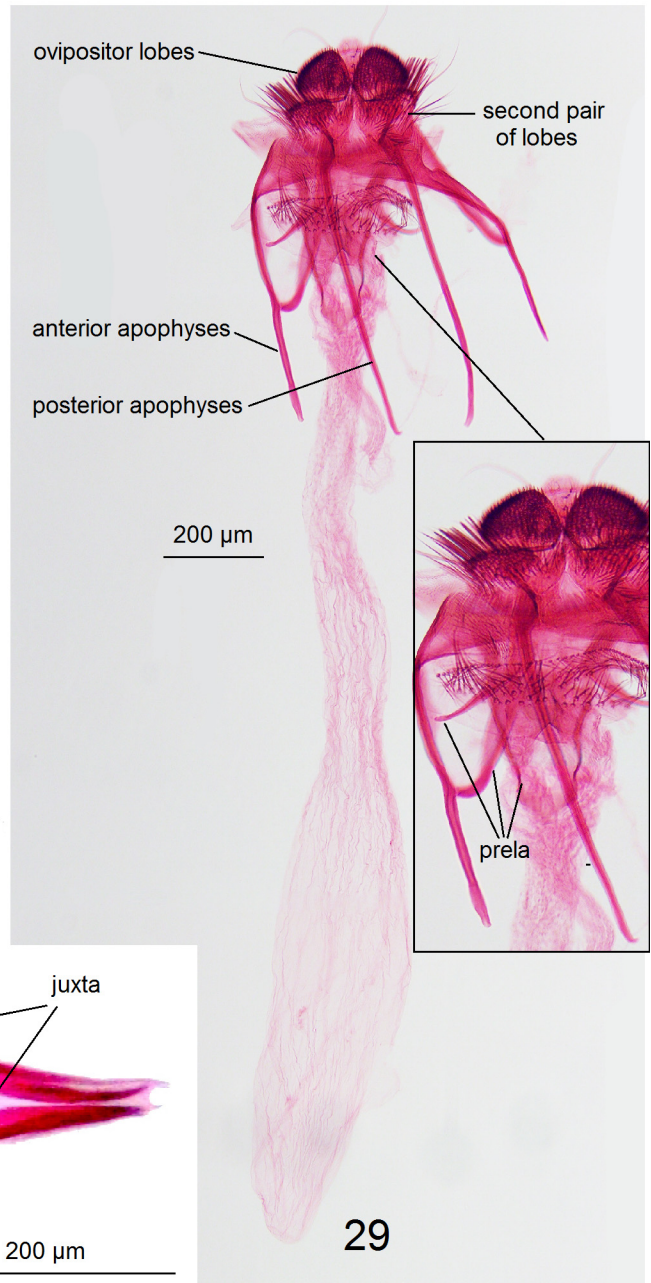
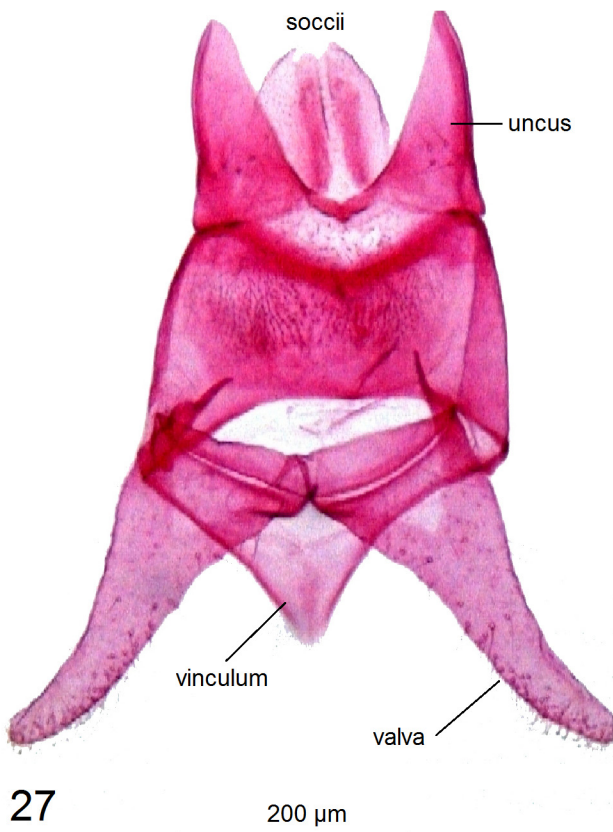
Male (Fig. 25). Forewing length 2.8–3.3 mm; wingspan 6.2–7.2 mm. Head: palpi and face pale ochre; frontal tuft and collar comprised of yellowish cream to pale ochre lamellar scales; antenna about 2/3 the length of forewing; flagellum with long piliform sensillae, yellowish cream or greyish cream annulated with grey-black on upper side, yellowish cream to ochre on underside. Thorax, tegula and forewing ochreous cream to pale ochre; forewing darkened with blackish brown scales on costa and speckled with brown and dark brown scales apically; fringe pale ochre. Hindwing and its fringe yellowish grey to dark grey. Foreleg and midleg yellowish cream to pale ochre, covered with black-brown scales on upper side; hindleg pale ochre, with some grey-brown scales. Abdomen glossy, dark ochre-brown on upper side, pale ochre on underside; anal tufts indistinctive.

Female (Fig. 26). Forewing length 3.9–4.4 mm; wingspan 8.4–9.5 mm. Antenna half the length of forewing; flagellum yellowish cream, annulated with grey-black scales on upper side and underside, without long sensillae. Abdomen dark brown on upper side, ochre on underside; anal tufts yellowish ochre. Otherwise as in male.

Male genitalia (Figs 27, 28). Capsule 660–720 µm long. Lateral lobes of uncus large, triangular (Fig. 27). Socii large, membranous, covered with short, very fine, almost indistinctive setae. Valva about 225 µm long, gradually narrowed distally. Vinculum triangular, short. Juxta comprised of two, 210 µm long, strongly sclerotized, hook-like sclerites. Phallus (Fig. 28) 460 µm long, bifurcate; processes slender, pointed, distally connected with a membranous joint (Fig. 28).

Female genitalia (Fig. 29). Total length 1900–2000 µm. Antrum very weakly sclerotized, indistinctive. Ductus spermathecae membranous. Corpus bursae about 1600 µm long.

Bionomics (Figs 15, 16, 21). Host plants: *Quercus aliena* Blume, *Q. aliena* Bl. var. *acuteserrata* Maxim. ex Wenz., *Q. acutissima* Carruthers, *Quercus dentata* Thunb., *Q. variabilis* Blume (Fagaceae). Two generations: larvae of the first generation mine in early and mid-June, adults fly in early and mid-July; larvae of the second generation mine in late August, adults fly in mid-October. Leaf mine (Figs 15, 16, 21) is blotch-like, irregularly-shaped, somehow similar to the leaf mine of *T. dodonaea* Stainton, but distinguishable by the color: in *T. dodonaea*, mine is ochre; in *T. naraensis*, mostly dark brown because the black-brown concentric arcs (see Fig. 15). Frass ejected from the mine (Sato, 1993). Nidus pale grey-brown to red-brown, becomes pronounced only in the late stages of development, especially when filled with silken lining. Mature larva turns into pupa in the silk-lined nidus inside of the leaf mine.



FIGURES 25–29. *Tischeria naraensis* Sato. 25, adult, male; 26, female; 27, male genitalia, slide no. BH12101, capsule with phallus removed; 28, same, phallus; 29, female genitalia, slide no. BH16012.

Distribution. Previously the species was known only from Honshu (Japan). In this paper we report *Tischeria naraensis* from five following provinces or municipalities of China: Tianjin (Ji County), Henan (Song County), Anhui (Jinzhai County), Jiangsu (Nanjing City), and Yunnan (Kunming City, Jingdong County).

Discussion

Ulmaceae has never been reported as a host-plant family for the Tischeriidae. Prior to this publication Xu *et al.* (2017) listed the following sixteen host-plant families for Tischeriidae: Euphorbiaceae, Rosaceae, Rhamnaceae, Fagaceae, Betulaceae, Malvaceae (including former Sterculiaceae), Combretaceae, Ericaceae, Symplocaceae, Anacardiaceae, Theaceae, Hypericaceae, Apocynaceae, Asteraceae (Diškus & Puplesis 2003a, 2003b; Diškus 2005; Kobayashi *et al.* 2016), Urticaceae (Stonis *et al.* 2017), and Fabaceae (Xu *et al.* 2017).

Discovery of an Ulmaceae-feeding taxon was unexpected, despite a rather wide known taxonomic range of host-plant families for the Tischeriidae. In general, Tischeriidae are known to be either monophagous or strictly oligophagous, i.e. narrow diet breadth (stenophagy) is characteristic for the family. However, *T. ulmella*, a new species closely related to *Quercus*-feeding species (*T. decidua* Wocke, *T. naraensis* Sato, and *T. dodonaea* Stainton) and possibly belonging to the same, but not designated as of yet, species group as the *Quercus* feeding species, appeared to be an *Ulmus*-feeding taxon. It should be noted that *Ulmus* belongs to the Rosales clade and *Fagus* to the Fagales clade (Chase *et al.* 2016).

The other taxon reported from China is the *Quercus*-feeding *T. naraensis* Sato. Judging from the material collected in five distant provinces of China, we also report a broad distribution range for *T. naraensis* in East Asia, from Japan (Sato 1993) to Tianjin and Yunnan. Additionally, we observed that *T. naraensis* and two other *Quercus*-feeding *Tischeria* species (*T. decidua* Wocke and *T. quercifolia* Kuroko) may be found together and sometimes on the same host-plant tree, at least in some provinces of China. These *Quercus*-feeding species can be differentiated by the shape and color of leaf mines (Sato 1993) (Figs 15–20). For comparison and better characterization of leaf mines of *Quercus*-feeding *Tischeria*, we also provide illustrations of some leaf mines of the *Quercus*-feeding *Coptotriche* collected in central and south China (Figs 23, 24).

Acknowledgments

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