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Description of new species of oak leaf-miners (Lepidoptera: Nepticulidae), with notes on the species groups of *Stigmella* Schrank associated with *Quercus* as a host-plant

JONAS R. STONIS^{1, 3}, ARŪNAS DIŠKUS¹, ANDRIUS REMEIKIS^{1, 2}, ASTA NAVICKAITĖ¹ & AGNĖ ROCIENĖ¹

¹Department of Biology, Faculty of Science and Technology, Lithuanian University of Educational Sciences, Studentų St. 39, Vilnius LT-08106, Lithuania

²Nature Research Centre, Akademijos St. 2, Vilnius LT-08412, Lithuania

³Corresponding author. E-mail: stonis@leu.lt

Abstract

Stigmella acuta Diškus, Navickaitė & Remeikis, **sp. nov.**, a new species of oak-feeding leaf-miner belonging to the *S. hemargyrella* group, and *S. cornuta* Rocienė & Stonis, **sp. nov.**, belonging to the newly designated *S. cornuta* group, are described from Asia and, for the first time, the *S. hemargyrella* group is associated with *Quercus* as a host-plant. The new species are illustrated with photographs of the leaf mines, adults, and genitalia. Diagnostics and host-plant preferences of seven *Stigmella* species groups associated with oaks (the *S. caesurifasciella*, *S. saginella*, *S. quercipulchella*, *S. ruficapitella*, *S. castanopsiella*, *S. hemargyrella* and *S. cornuta* groups) are discussed.

Key words: Nepticulidae, new species, *Quercus*, species groups, host-plants, *Stigmella*

Introduction

Nepticulidae is a family containing the smallest known Lepidoptera, with plant-mining (predominantly leaf-mining) larvae. Among about 850 currently recognized Nepticulidae species worldwide, about 9% (i. e. 77 confirmed/reared species, excluding 16 species with expected mining on oaks) are already known as *Quercus*-feeders (see van Nieuwerkerken & Liu 2000; Diškus & Puplėsis 2003; van Nieuwerkerken & Johansson 2003; van Nieuwerkerken *et al.* 2010; Hirano 2010; Stonis *et al.* 2013a) and mostly belong to two genera: *Stigmella* Schrank and *Ectoedemia* Busck; only one species belongs to *Glaucolepis* Braun (see Wilkinson & Scoble 1979).

The genus *Quercus* is one of the most important groups of woody angiosperms in the northern hemisphere in terms of species diversity, ecological dominance, and economic value (Nixon 2006). Oak occurs in vast territories above the equator (except Indonesia) in temperate forests of Europe and North America (Menickiy 1984; Nixon 2006; Torres-Miranda *et al.* 2011).

Because of the importance of the tremendous diversity of leaf-mining or other herbivorous insects feeding on oaks and difficulties associated with identification of Fagaceae-feeding Nepticulidae, the *Quercus*-feeding species of *Stigmella* Schrank have recently received special attention. The East Palaearctic fauna (mostly Chinese) was treated by van Nieuwerkerken & Liu (2000) and the West Palaearctic fauna of *Stigmella* comprising 19 oak-feeding species was reviewed by van Nieuwerkerken & Johansson (2003). This was followed by descriptions of three new *Quercus*-feeding *Stigmella* from Japan (Hirano 2010) and, most recently, by illustrations of male genitalia of Nepticulidae from continental East Asia, including many species of *Stigmella* tropically associated with oaks (Stonis & Rocienė 2013; Rocienė & Stonis 2013), and by the first discovery of seven oak-feeding Nepticulidae species in Central America (Guatemala) (Stonis *et al.* 2013a, b).

In this paper we describe *Stigmella acuta* Diškus, Navickaitė & Remeikis, **sp. nov.**, a new *Quercus*-feeding species from the Himalaya belonging to the *S. hemargyrella* group, and *S. cornuta* Rocienė & Stonis, **sp. nov.**, a

new *Quercus*-feeding species from East Asia belonging to newly designated the *S. cornuta* group. The *S. hemargyrella* group is associated with *Quercus* as a host-plant for the first time. We also present some schematic illustrations of morphological structures of all species groups of *Stigmella* trophically associated with oak, which, we hope, might be helpful for diagnostic purposes.

Material and methods

The collection material of most species treated in the current paper was available to the authors from BMNH (London), LUES (Vilnius), ZMUC (Copenhagen) and ZIN (St. Petersburg). For additional published data on morphology and tropical relationships of some species, we mostly referred to Wilkinson & Scoble (1979), Newton & Wilkinson (1982), Kemperman & Wilkinson (1985), van Nieuwerkerken & Liu (2000), and van Nieuwerkerken & Johansson (2003).

The adults of the new species were reared from mining larvae using a standard method (Puplesis 1994; Diškus & Stonis 2012). Collecting methods, techniques for genitalia preparation and protocols for description are outlined in Puplesis & Robinson (2000), Puplesis & Diškus (2003), and Diškus & Stonis (2012).

Permanent slides were photographed and studied using a Leica DM2500 microscope and Leica DFC420 digital camera.

The descriptive terminology of morphological structures follows van Nieuwerkerken (1985, 1986), Johansson *et al.* (1990), Puplesis & Robinson (2000), and van Nieuwerkerken & Johansson (2003). The classification of Nepticulidae follows Puplesis (1994), Puplesis & Robinson (2000), Puplesis *et al.* (2002), and Puplesis & Diškus (2003).

Institutional abbreviations used in the text are as follows:

BMNH	Natural History Museum, London, U.K.;
LUES	Lithuanian University of Educational Sciences (formerly VPU), Vilnius, Lithuania;
ZIN	Zoological Museum, the Russian Academy of Sciences, St. Petersburg, Russia;
ZMUC	Zoological Museum, University of Copenhagen, Denmark.

Descriptions of new species

Stigmella acuta Diškus, Navickaitė & Remeikis, sp. nov.

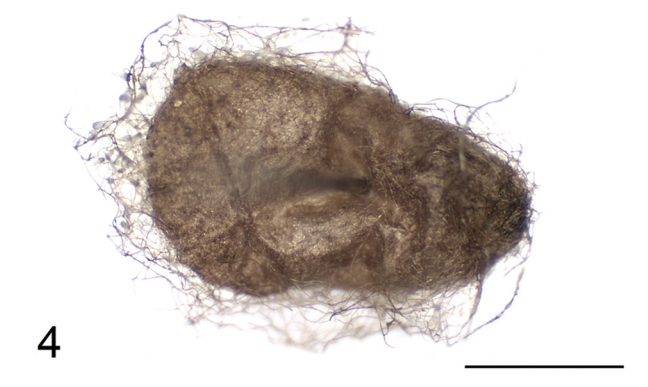
(Figs 1–17)

Type material. Holotype: ♂, Himalaya, India, Uttarakhand, Dehradun District (Mussoorie), 30°27'31"N, 78°01'46"E, elevation 1980 m, mining larva on *Quercus acutissima*, 15–18.viii.2010, ex pupa 02.ix.2010, genitalia slide no. AD480 (ZMUC). Paratypes: 1♂, the same label data, pupa, genitalia slide no. AD481; 1♀, Tehri Garhwal (Chamba), 30°20'39"N, 78°28'59"E, mining larva on *Quercus acutissima*, 24.viii.2010, ex pupa 06.ix.2010, genitalia slide no. RA265 (ZMUC).

Diagnosis. A distinctive, fuscous-winged species with a cream to pale orange fascia in the forewing; the pointed valva, M-shaped gnathos, uncus with four small caudal lobes, large acute cornuti, developed manica, androconial scales on male hindwing, and folded accessory sac in female genitalia indicate that it belongs to the *Stigmella hemargyrella* group. Externally, males of the new species can be easily distinguished from all other currently known *S. hemargyrella* group species, except the *Fagus*-feeding *S. hemargyrella* (Kollar), by the basal patch of dark brown androconia in the hindwing. In male genitalia, *S. acuta* differs from all *Stigmella* species by the shape and number of the large and pointed cornuti in the aedeagus.

Male (Fig. 8). Forewing length 2.3 mm; wingspan 5 mm. Head: palpi cream to orangish cream; frontal tuft orange to dark orange; collar and scape yellowish cream; antenna half length of forewing; flagellum with 27–28 segments, fuscous with purple iridescence. Thorax and tegulae fuscous with purple, blue and green iridescence. Forewings fuscous (slightly paler in basal third), with purple, blue and green iridescence and with yellowish, slightly shiny postmedian fascia; terminal cilia fuscous; tornal cilia dark grey; underside of forewing dark brown.

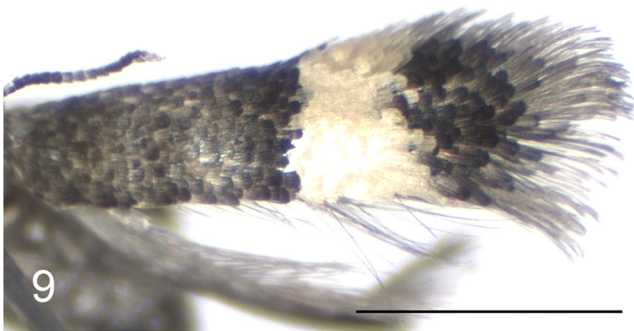
Hindwings grey, in basal third (except anal margins) densely covered with dark brown androconia with bluish and greenish iridescence; cilia grey; underside of hindwing grey, with no androconia. Legs fuscous on upper side, brownish cream to brown on underside. Abdomen dark grey-brown or fuscous with purple, green and golden iridescence on upper side, shiny, grey-cream (distally cream) with weak purple and green iridescence on underside; anal tufts brown-cream; plates cream.



FIGURES 1–7. *Stigmella acuta* Diškus, Navickaitė & Remeikis, **sp. nov.**, bionomics. 1, 2, habitat, mountainous broadleaf and mixed forests of the western Himalaya, Mussoorie, 30°27'31"N, 78°01'46"E, elevation 1980–2000 m; 3, host-plant, *Quercus acutissima* Carruth., Fagaceae; 4, cocoon. Scale bar 1 mm; 5–7, leaf-mines with feeding larvae.



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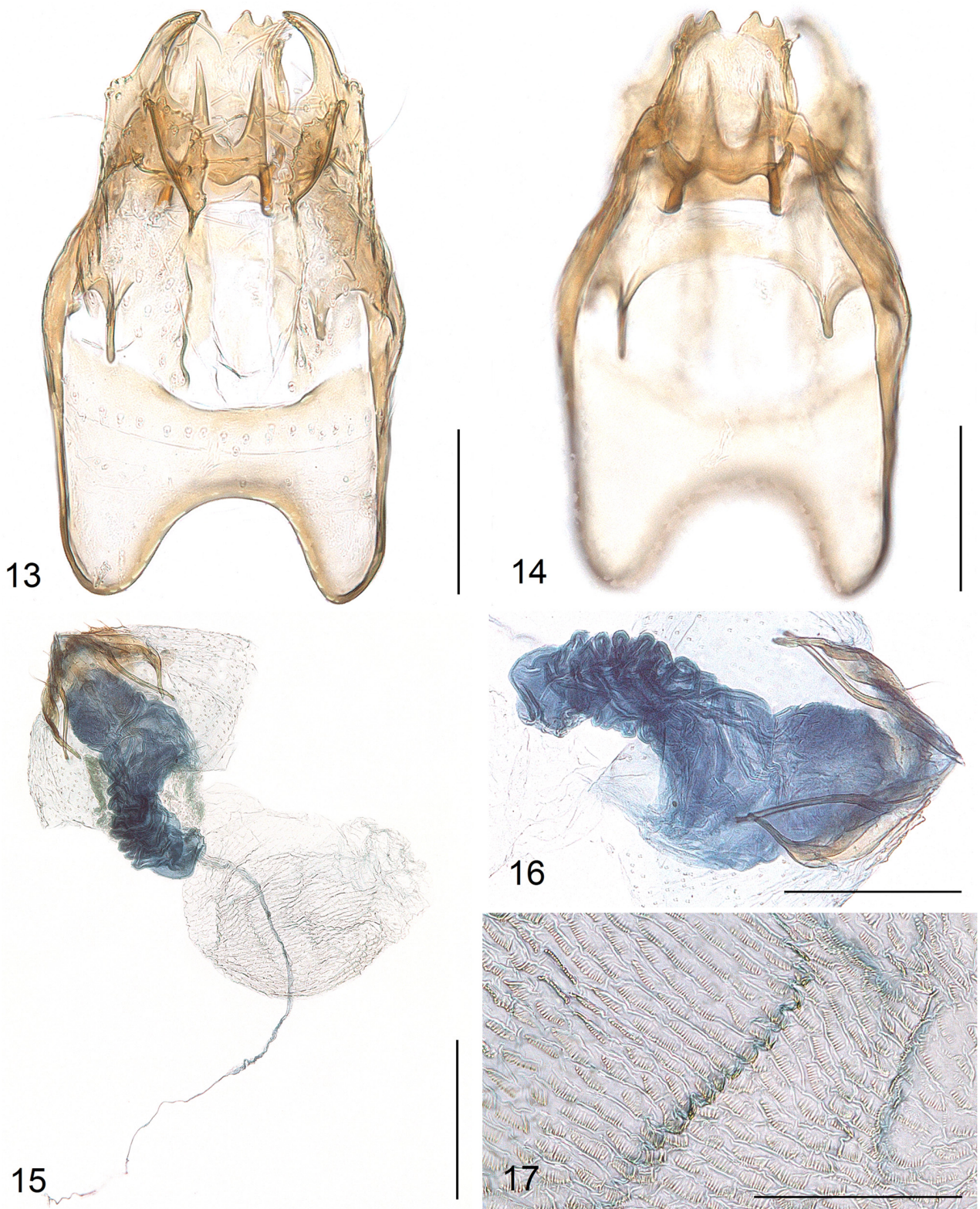


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FIGURES 8–12. *Stigmella acuta* Diškus, Navickaitė & Remeikis, **sp. nov.**, morphology. 8, male adult, holotype. Scale bar 1 mm; 9, female adult, paratype. Scale bar 1 mm; 10, male genitalia, paratype, gen. slide no. AD481. Scale bar 100 μ m; 11, male genital capsule, holotype, gen. slide no. AD480. Scale bar 100 μ m; 12, aedeagus, holotype, gen. slide no. AD480. Scale bar 100 μ m.



FIGURES 13–17. *Stigmella acuta* Diškus, Navickaitė & Remeikis, **sp. nov.**, genitalia. 13, male genital capsule, holotype, gen. slide no. AD480. Scale bar 100 μ m; 14, same, dorsal view. Scale bar 100 μ m; 15, female genitalia, paratype, gen. slide no. RA265. Scale bar 300 μ m; 16, same, accessory sac. Scale bar 200 μ m; 17, same, pectinations of bursa copulatrix. Scale bar 100 μ m.

Female (Fig. 9). Antenna with 23–24 segments. Postmedian fascia of forewings pale orange. Hindwings and their cilia brown-grey, without androconial scales. Otherwise as male.

Male genitalia (Figs 10–14). Capsule longer (335–345 μ m) than wide (210–215 μ m). Vinculum with two

large lateral (anterior) lobes. Uncus with four small caudal lobes (Figs 10, 11, 14). Gnathos with two larger and pointed caudal processes (Fig. 11). Valva (Figs 10, 13) 210–225 μm long, basally broad, narrowed apically, with large chitinized and pointed apical process; inner lobe small and rounded; transtilla with long transverse bar and short, slender sublateral processes. Aedeagus (Figs 10, 12) 265 μm long, 95–125 μm broad; vesica with basal band of large spine-like cornuti and a few separate (loose) very large spine-like cornuti; a few cornuti with rounded, plate-like extensions basally. Manica present, prominent (large) and spined.

Female genitalia (Figs 15–17). Total length about 1000 μm . Apophyses widely separated and equally long (about 160 μm). Vestibulum broad, without sclerites. Corpus bursae oval, without signa, densely covered with long and prominent pectinations (Fig. 17). Accessory sac 325 μm long, heavily folded (Fig. 16). Abdominal tip pointed.

Bionomics. Mines in leaves (Figs 5–7). Host-plant: *Quercus acutissima* Carruth. (Fagaceae) (Fig. 3). Egg on upper side of the leaf. Larvae mine in August. Contorted or sinuous gallery of mine filled with brown-black frass; the first half of the mine completely filled with frass; in the second half of the mine frass coiled, leaving clear margins (Figs 6, 7). Larva pale green to yellowish, with red-brown intestine and dark brown head capsule. Larval exit slit on upper side of the leaf. Cocoon brown to ochre-brown; length 2.5 mm, maximal width 1.5 mm (Fig. 4). Adults fly in September.

Distribution. It was found in mountainous broadleaf and mixed forests of the western Himalaya at altitude about 2 km (Figs 1, 2); possibly common, as inferred from many empty leaf-mines that were observed in different localities.

Etymology. The species name is derived from the Latin *acuta* (sharp, pointed) in reference to the large, pointed cornuti in the male genitalia.

Stigmella cornuta Rocien  & Stonis, sp. nov.

(Figs 18–36)

Type material. Holotype: ♂, China, Mutianyu, Huairou District, Beijing, 40°25'56"N, 116°33'20"E, elevation 390 m, mining larva on *Quercus dentata*, 7.viii.2013, ex pupa 18.ix.2013, leg. A. Rocien , gen. slide no. AG 419 (ZIN).

Diagnosis. A fuscous-winged species without fascia in the forewing. Some male genital characters (the apically narrowed valva, interrupted transverse bar of transtilla, broad lobate vinculum, and the uncus with the weakly individualized lobes) slightly resemble features of the species of the *S. betulicola* group, including the Oriental *S. xystodes* (Meyrick). However *S. cornuta* differs from all *Stigmella* species by the shape and number of the extremely large and pointed cornuti in the aedeagus and by the unusual shape of partially reduced caudal processes of gnathos. The combined leaf-mine (with a blotch-like second half) is also unique among *Quercus*-feeding *Stigmella* species.

Male (Figs 25, 26). Forewing length 1.9 mm; wingspan 4.2 mm (n=1). Head: palpi cream; frontal tuft beige-orange; collar and scape cream; antenna with 23 segments, shorter than half of forewing length; flagellum fuscous brown on upper side and brownish cream on underside. Thorax: dorsum and tegulae concolorous with base of forewing. Forewing: mottled grey-brown, coarsely scaled (particularly in apical half), with weak greenish and purplish iridescence; fascia absent; cilia grey; underside of forewing uniformly fuscous brown. Hindwing and its cilia grey-brown, with no androconia. Legs brownish cream, with brown darkenings on foreleg upper side.

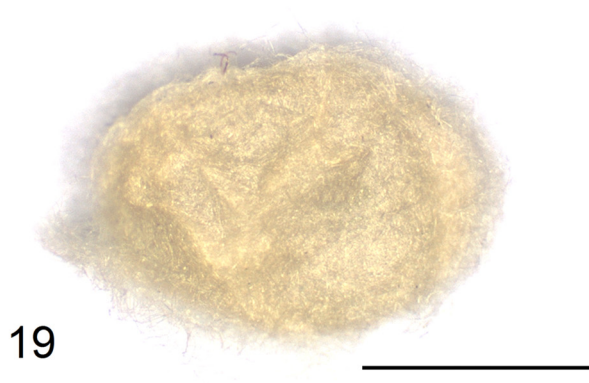
Female. Unknown.

Male genitalia (Figs 27–36). Capsule longer (245 μm) than wide (170 μm). Vinculum with two short but broad lateral (anterior) lobes (Figs 27–29). Uncus with large, weakly individualized anterior lobes (Figs. 31, 32). Gnathos 85 μm broad, with two anterior and two posterior (caudal) processes (Fig. 33). Valva (Figs 27, 30) 160 μm long, basally broad, narrowed apically, with small chitinized apical papilla; inner lobe absent; transtilla with interrupted transverse bar (Fig. 28), without sublateral processes. Aedeagus (Figs 10, 12) 180 μm long, 60–70 μm broad (Fig. 27); vesica with three extremely large pointed cornuti (Figs. 34–36). Juxta membranous, narrowed medially (Fig. 30). Manica absent.

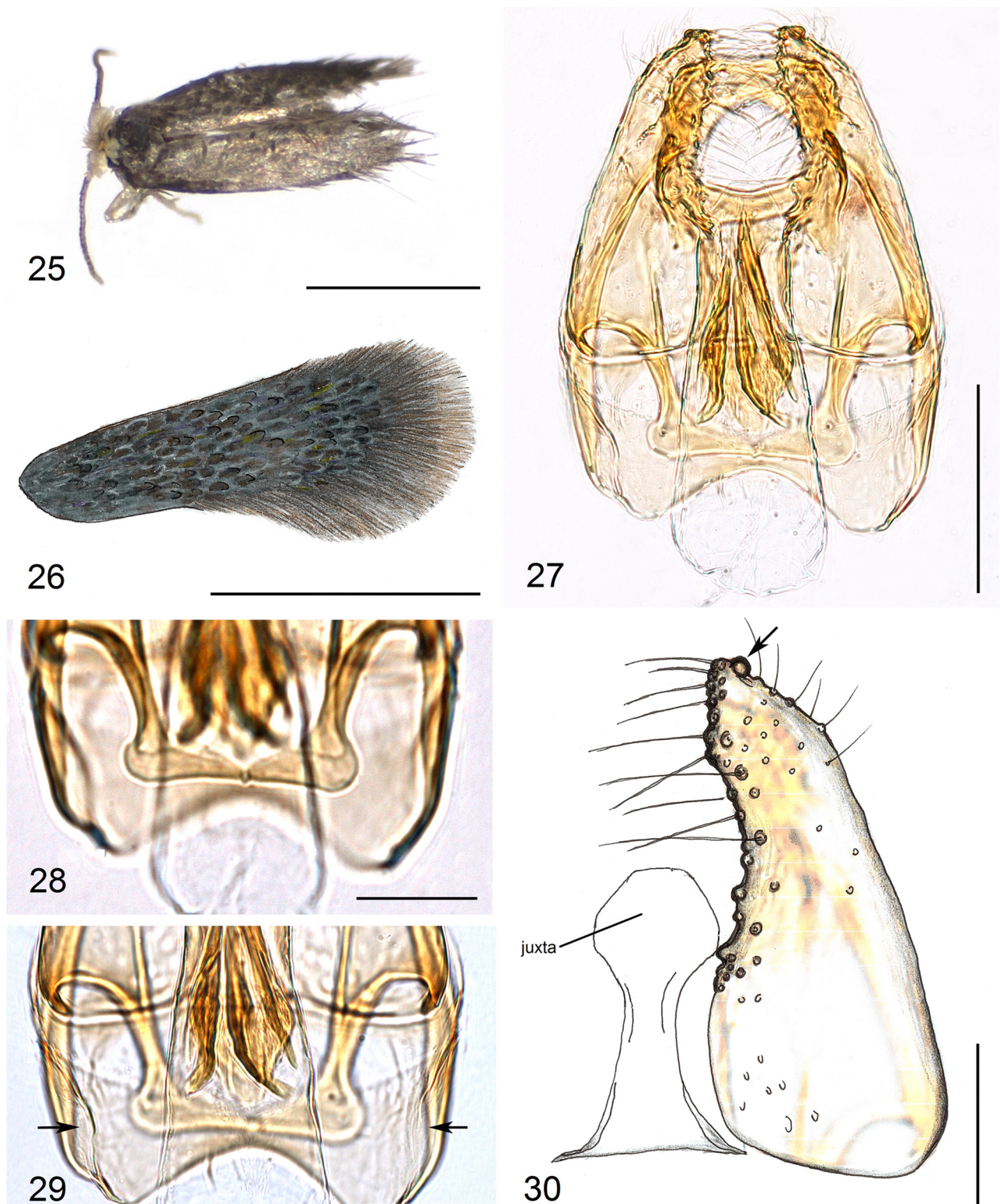
Bionomics. Host-plant *Quercus dentata* Thunb. (Fagaceae) (Fig. 20). Egg flat and oval, on upper side of the leaf. Larvae mine in August. The first half of the mine is a narrow contorted gallery completely filled with black-green frass (Fig. 23) which turns brownish in old mines (Fig. 24); in the second half of the mine gallery widens to an oval blotch with scattered black frass (Figs 21, 22). Larval exit slit on upper side of the leaf. Cocoon brownish cream; length 1.8 mm, maximal width 1.3 mm (Fig. 19). Adults fly in September.

Distribution. It was found in deciduous broad-leaved forests of NE China (Fig. 18).

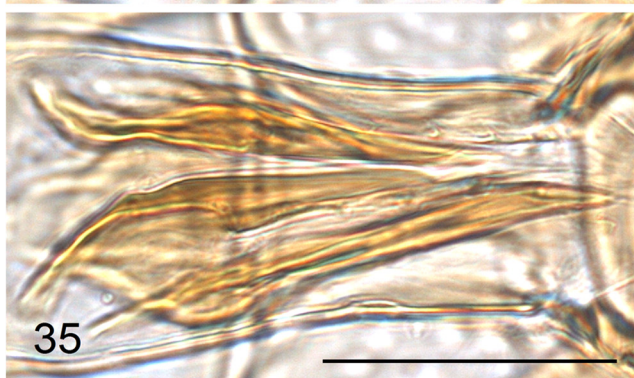
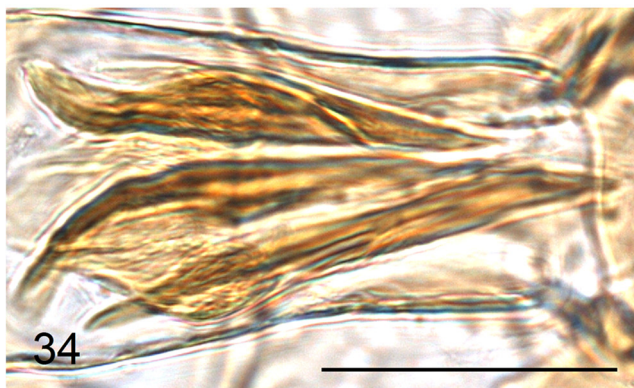
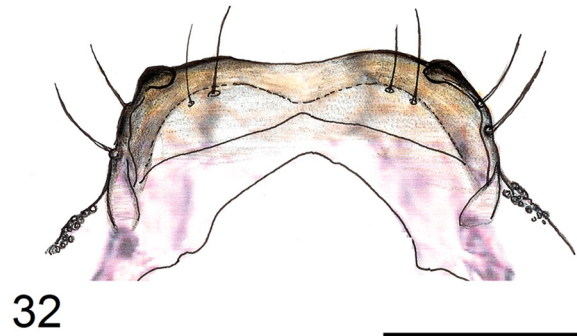
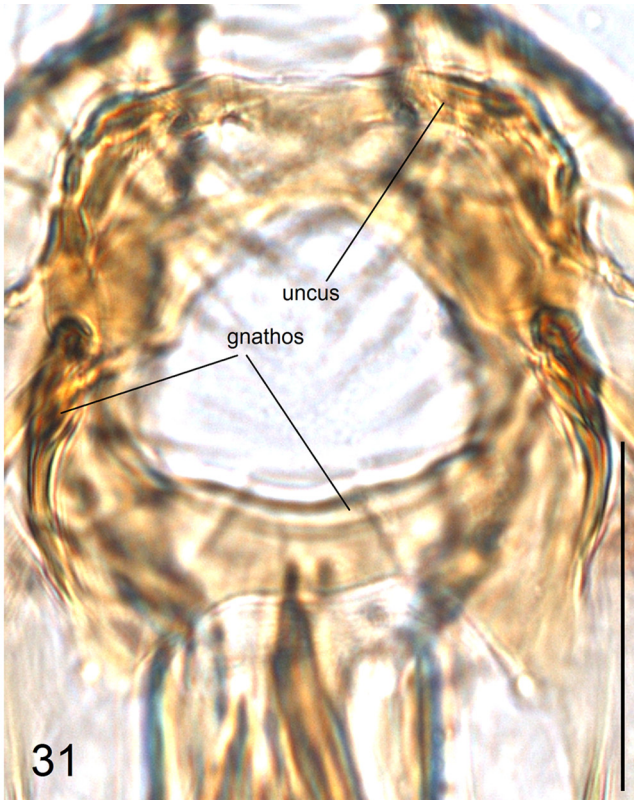
Etymology. The species name is derived from Latin *cornuta* (horned) in reference to the extremely large cornuti of aedeagus.



FIGURES 18–24. *Stigmella cornuta* Rocienè & Stonis, **sp. nov.**, bionomics. 18, habitat, deciduous broad-leaved forests in NE China, Huairou District, 40°25'56"N, 116°33'20"E; 19, cocoon, scale bar 1 mm; 20–24, leaf-mines on *Quercus dentata* Thunb., Fagaceae (arrows indicate the narrow part of the mines: a gallery completely filled with black-green or brownish frass).



FIGURES 25–30. *Stigmella cornuta* Rocienė & Stonis, **sp. nov.**, morphology. 25, male adult, holotype; 26, same, forewing, artist reconstruction, scale bar 1 mm; 27, male genitalia, holotype, gen. slide no. AG419, scale bar 100 μ m; 28, same, transtilla; 29, same, vinculum (constricted laterally); 30, valva and juxta (the arrow indicates a chitinized apical papilla). Scale bar 50 μ m.



FIGURES 31–36. *Stigmella cornuta* Rocienė & Stonis, **sp. nov.**, details of male genitalia, holotype, gen. slide no. AG419. 31, fragment with uncus and gnathos; 32, uncus, reconstruction; 33, gnathos, reconstruction; 34, 35, cornuti; 36, same, reconstruction. Scale bar 50 μ m.

Species groups of *Stigmella* Schrank associated with *Quercus* as a host-plant

The first species groups of *Stigmella* associated with *Quercus*, the *ruficapitella* and the *hemargyrella* groups, were proposed for European species on the basis of rather uncommon male genitalia and feeding preferences (Johansson 1971). Later, in the revisions of the NW European or West Palaearctic Nepticulidae, Johansson *et al.* (1990) and van Nieukerken & Johansson (2003) combined the *hemargyrella* and the *ruficapitella* groups into one, the *ruficapitella* group, because monophyly of the *hemargyrella* group seemed doubtful (van Nieukerken & Johansson 2003). If initially the *ruficapitella* group contained only one non-*Quercus*-feeding species (*Betula*-feeder *S. tristis* Wocke), now the enlarged group comprised a few non-*Quercus* feeding species, including the European *S. hemargyrella*, *S. speciosa* and *S. lonicerarum* feeding on *Fagus*, *Acer* or *Lonicera*, respectively (Johansson *et al.* 1990, van Nieukerken & Johansson 2003). Because of some differences in the genitalia, the merge of two groups was not followed in the world catalogue (Diškus & Puplesis 2003).

Revising the Canadian fauna, Wilkinson & Scoble (1979) recognized two other species groups, which both possess rather unique but different structures in male and female genitalia: the *saginella* group and the *quercipulchella* group.

Later, mostly on the basis of the shape of semi-rounded uncus and one-processed gnathos, the *caesurifasciella* group was designated by Kemperman and Wilkinson (1985) for the East Asiatic *Quercus*-feeding *Stigmella* species. In the same publication by Kemperman & Wilkinson (1985), the *suberivora* species group was erected. However, it was not recognized by any other authors, and its species currently are included in the *ruficapitella* group (van Nieukerken & Liu 2000, van Nieukerken & Johansson 2003, Diškus & Puplesis 2003).

Reviewing Asiatic Nepticulidae, Puplesis (1994) removed two species with a bulbous aedeagus and a coiled vesica from the *ruficapitella* group and erected a separate group for these, the *castanopsiella* group (Puplesis 1994). Later, in a paper mainly on Chinese *Stigmella* feeding on *Quercus*, the *castanopsiella* group was only partially recognized (van Nieukerken & Liu 2000). According to these authors, the *castanopsiella* group most likely constitutes a monophyletic entity, but separation from the *ruficapitella* group would probably render the remainder paraphyletic (van Nieukerken & Liu 2000). Thus, until a thorough phylogenetic analysis has been carried out, these authors (van Nieukerken & Liu 2000) preferred to keep the *castanopsiella* group in the wide sense (as part of the *ruficapitella* group).

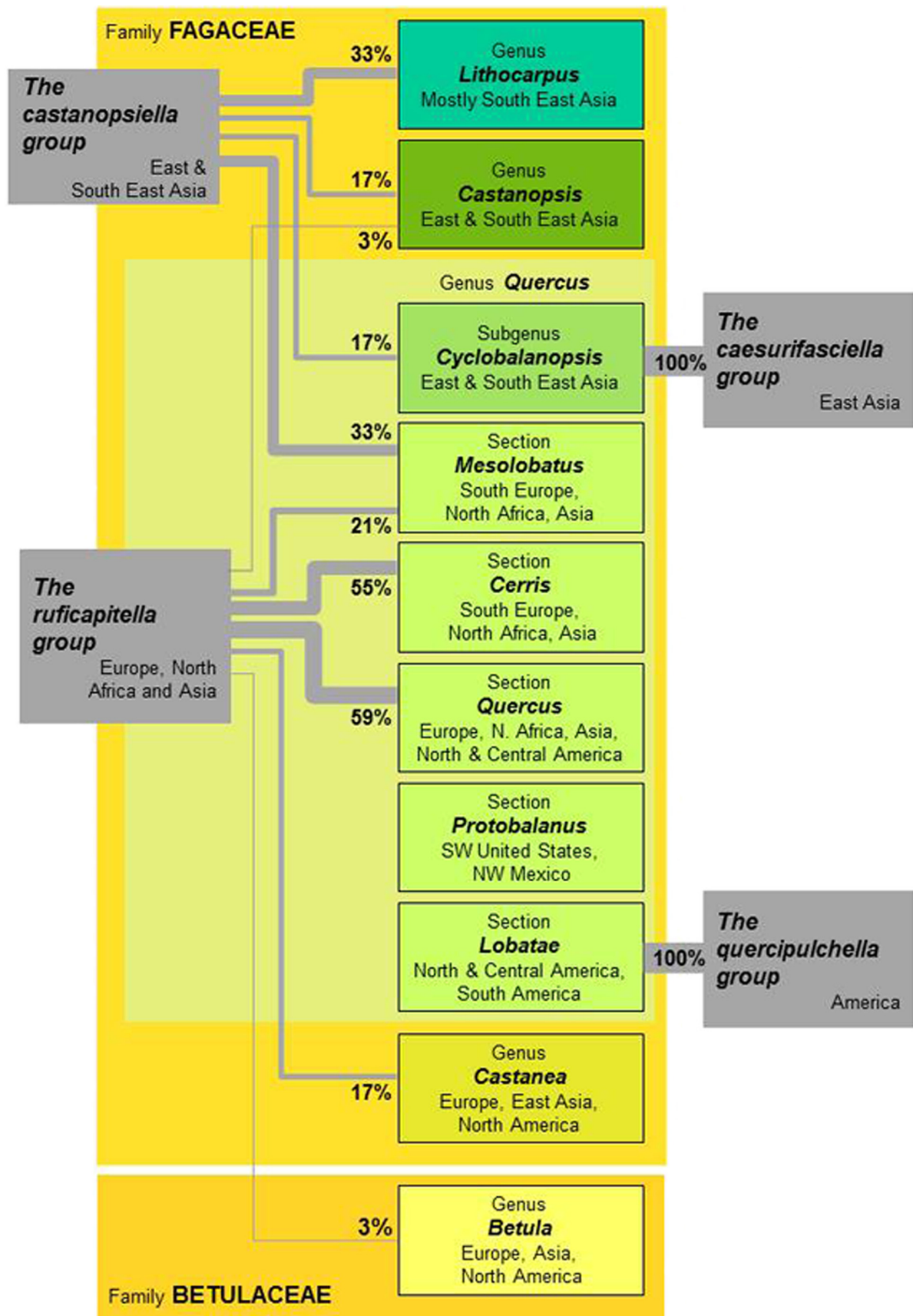
In present paper, we designated one more species group – the *cornuta* group, for a single *Quercus*-feeding species (*S. cornuta* **sp. nov.**) which possesses unusual male genitalia: the extremely large cornuti and the unique shape of gnathos; the leaf-mines are also unique among other *Stigmella* species feeding on oak: the second half of the mine gallery abruptly widens to a large oval blotch.

Since species groups in Nepticulidae are highly valuable for diagnostic purposes to make orientation easier, especially in such big genera as *Stigmella* with about 400 species described worldwide, in present paper we recognized most of the groups listed above: the *caesurifasciella*, the *cornuta*, the *saginella*, the *quercipulchella*, the *ruficapitella*, the *castanopsiella* and the *hemargyrella* groups. To support this concept and for easier diagnostics we attempted to provide species groups with illustrated sets of morphological characters (Figs 39–45). All seven species groups also exhibit slightly different host-plant preferences (Figs 37, 38). The most restricted feeding preferences are characteristic for the *quercipulchella* group; all species of this group are leaf-miners on plants belonging only to the section *Lobatae* of *Quercus* (Fig. 37). The other species groups (except the *caesurifasciella* and the *cornuta* groups, each with a single described species on *Quercus*, subgenus *Cyclobalanopsis* or *Quercus*, section *Mesolobatus*) feed on other genera of Fagaceae in addition to *Quercus*. The *hemargyrella* group (Fig. 38) seems more heterogeneous than the other six.

The *caesurifasciella* group

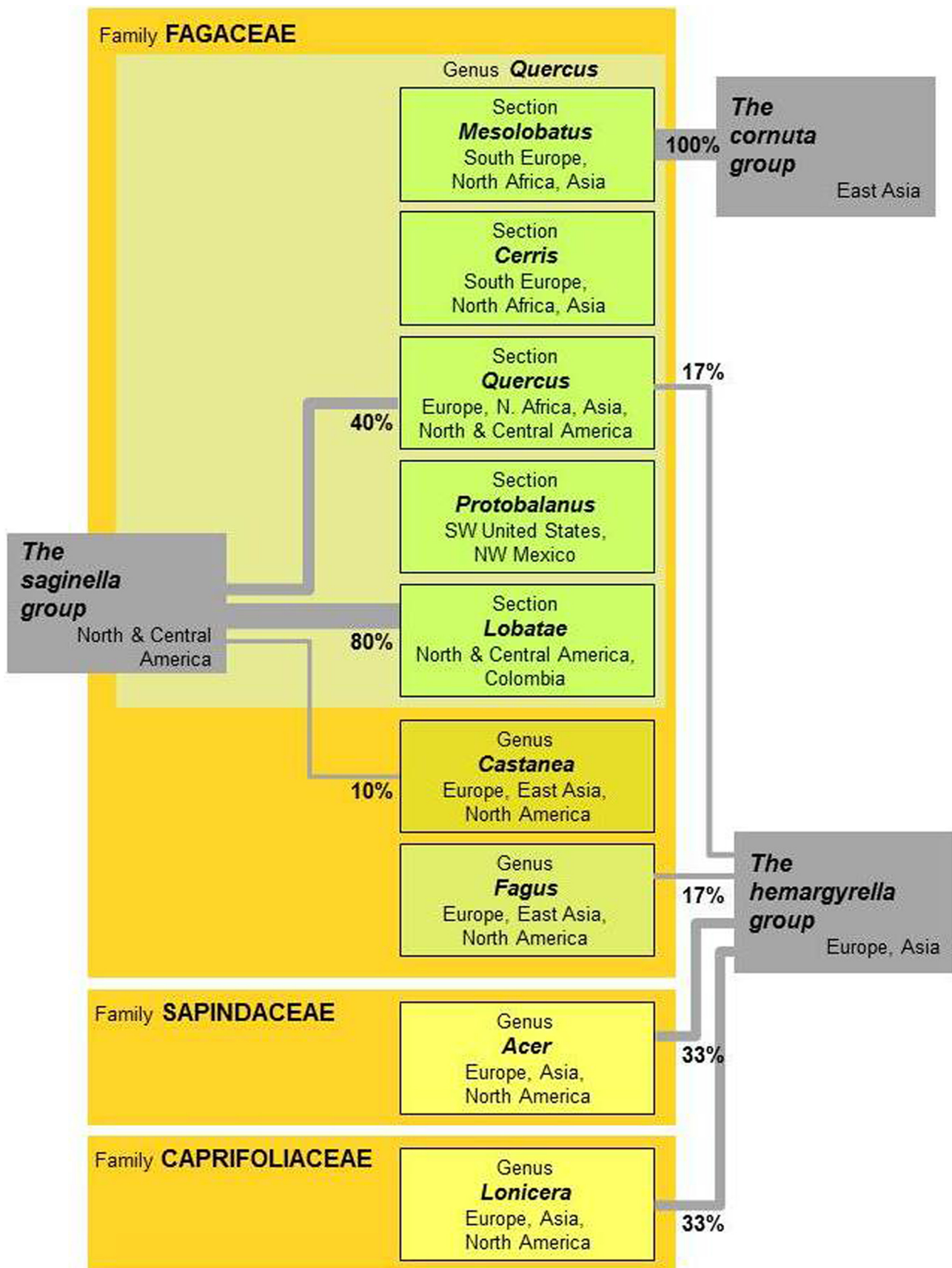
Diagnostic characters (Fig. 39): forewing with pattern (with fascia); in male genitalia, uncus semi-rounded distally, gnathos with one caudal process, aedeagus with numerous spine-like cornuti aggregated into a band, manica developed; in female genitalia, accessory sac short and wrinkled, distal half of bursa copulatrix narrow with numerous folds over length of this part; no signa.

Host-plant preferences. *Quercus* subgenus *Cyclobalanopsis* (*Quercus acuta* Thunb., *Q. glauca* Thunb.) (Fig. 37).



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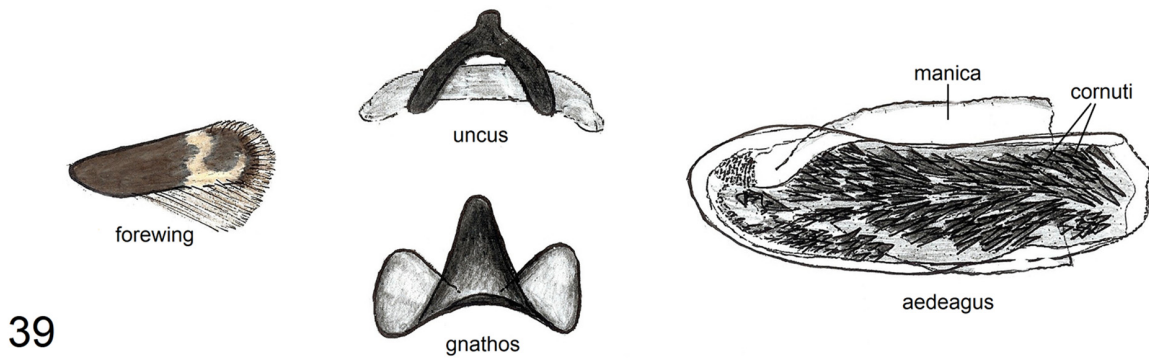
FIGURE 37. Feeding preferences of the species groups of *Stigmella* associated with *Quercus* as a host-plant. Some species of the *ruficapitella* group may feed on more than one host-plant, thus the total percentage of host use for the group exceeds 100%.



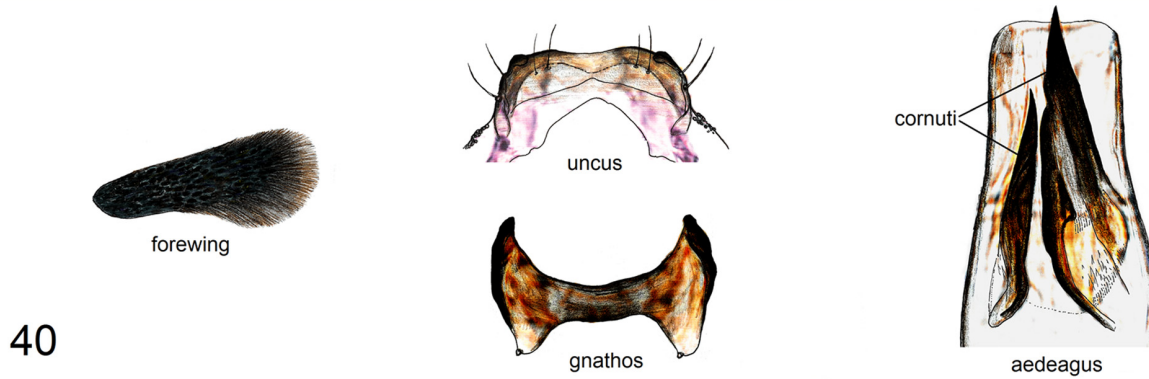
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FIGURE 38. Feeding preferences of the *saginella*, the *cornuta* and the *hemargyrella* groups. Some species of the *saginella* group may feed on more than one host-plant, thus the total percentage of host use for the group exceeds 100%.

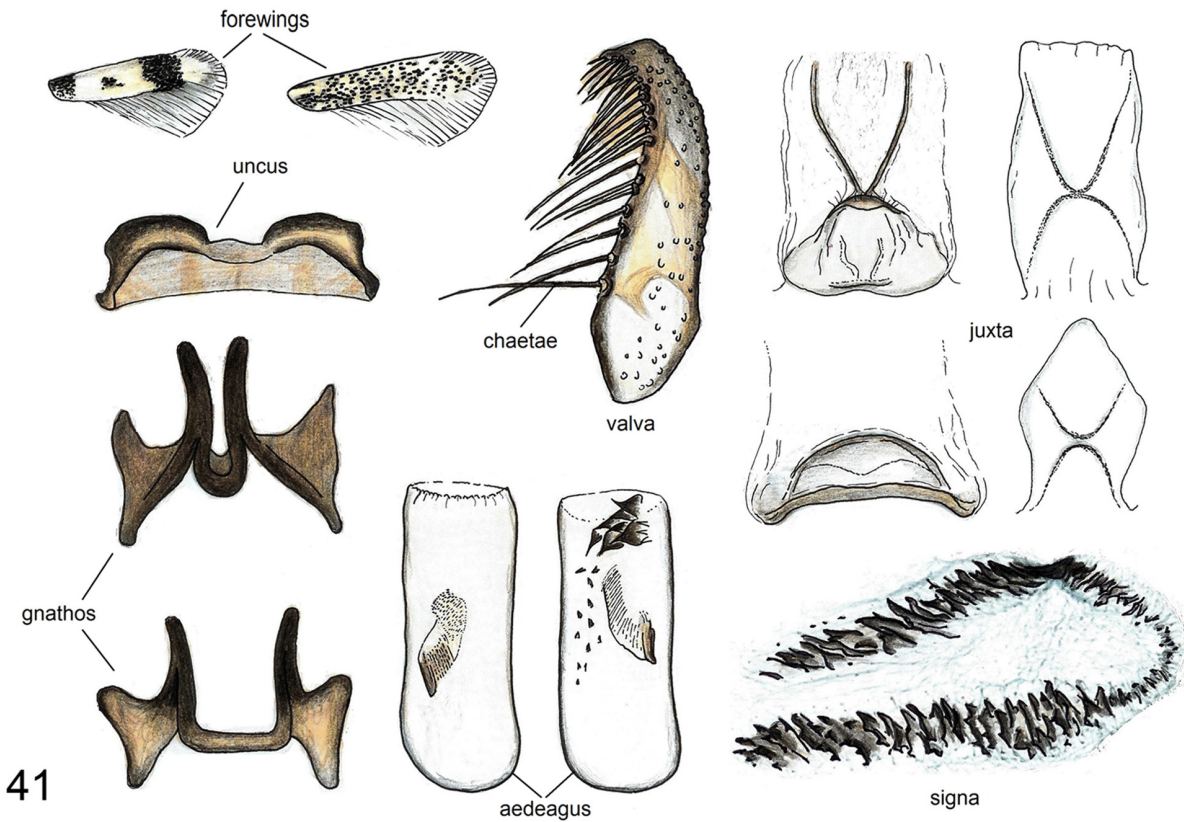
The caesurifasciella group



The cornuta group

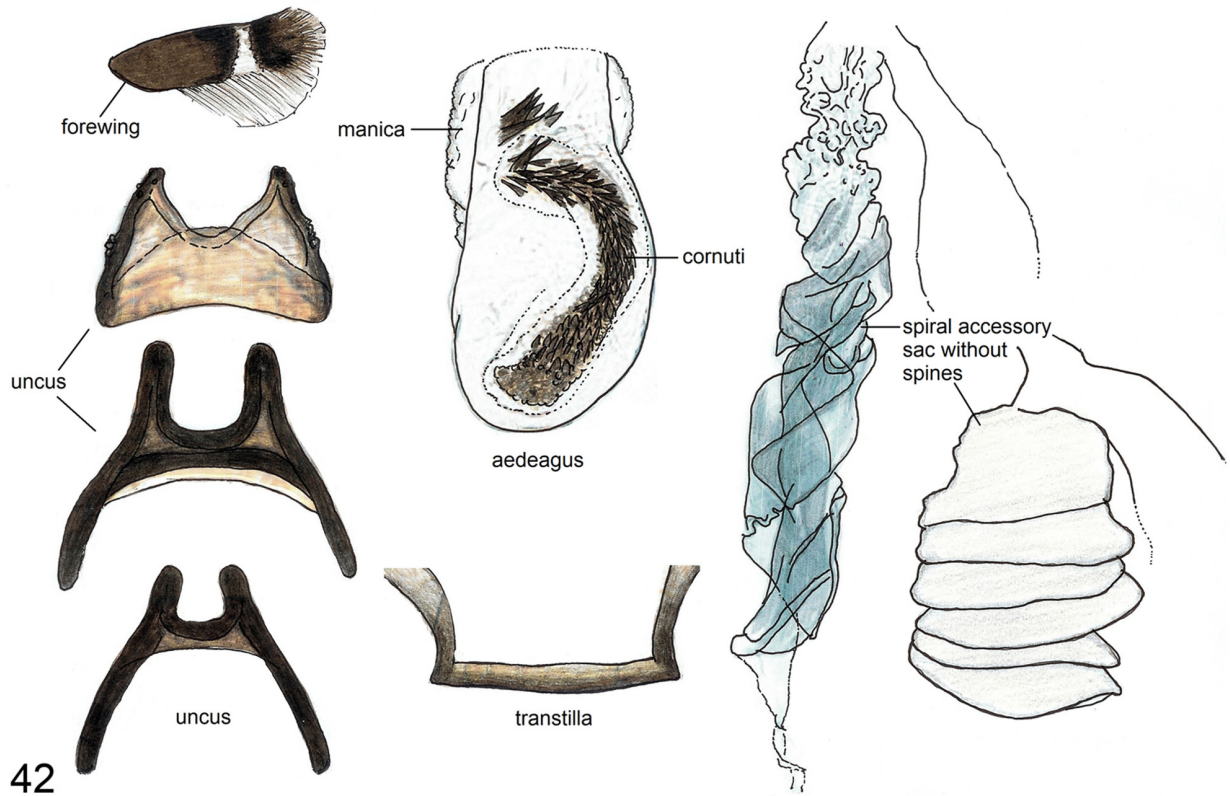


The saginella group

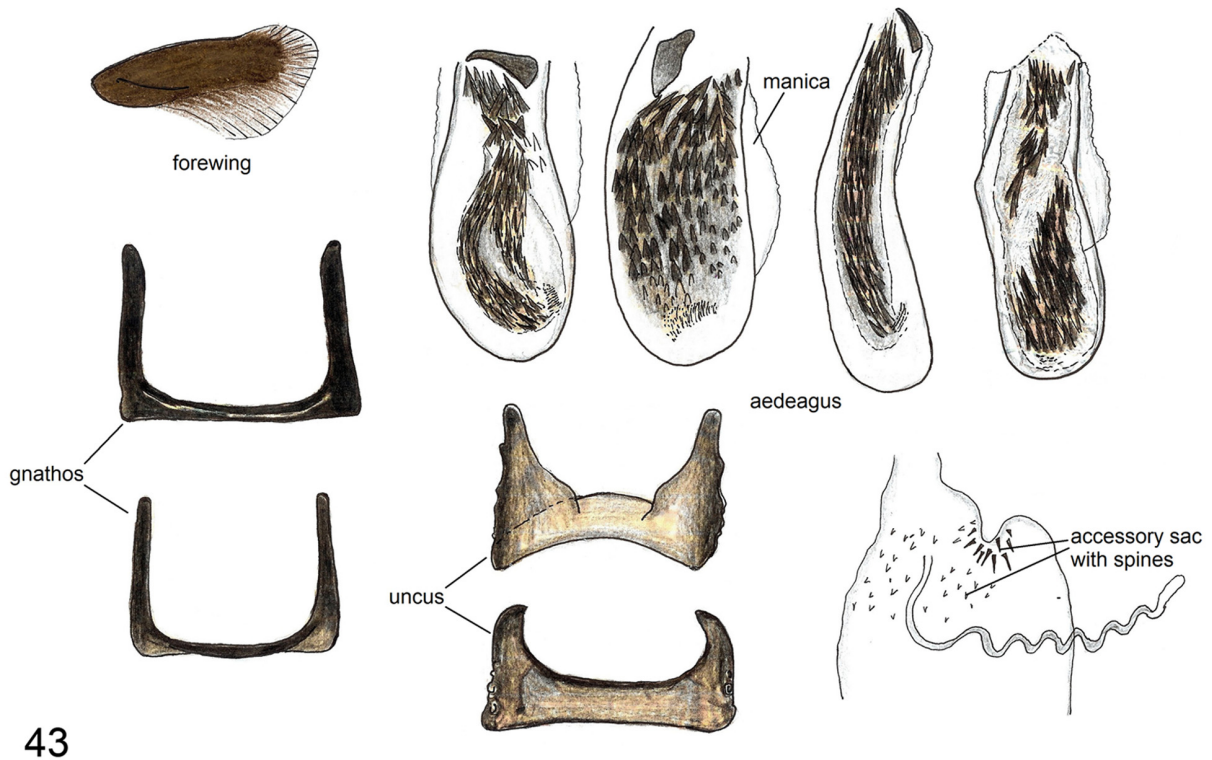


FIGURES 39–41. Diagnostic characters of the *caesurifasciella*, the *cornuta* and the *saginella* species groups.

The quercipulchella group

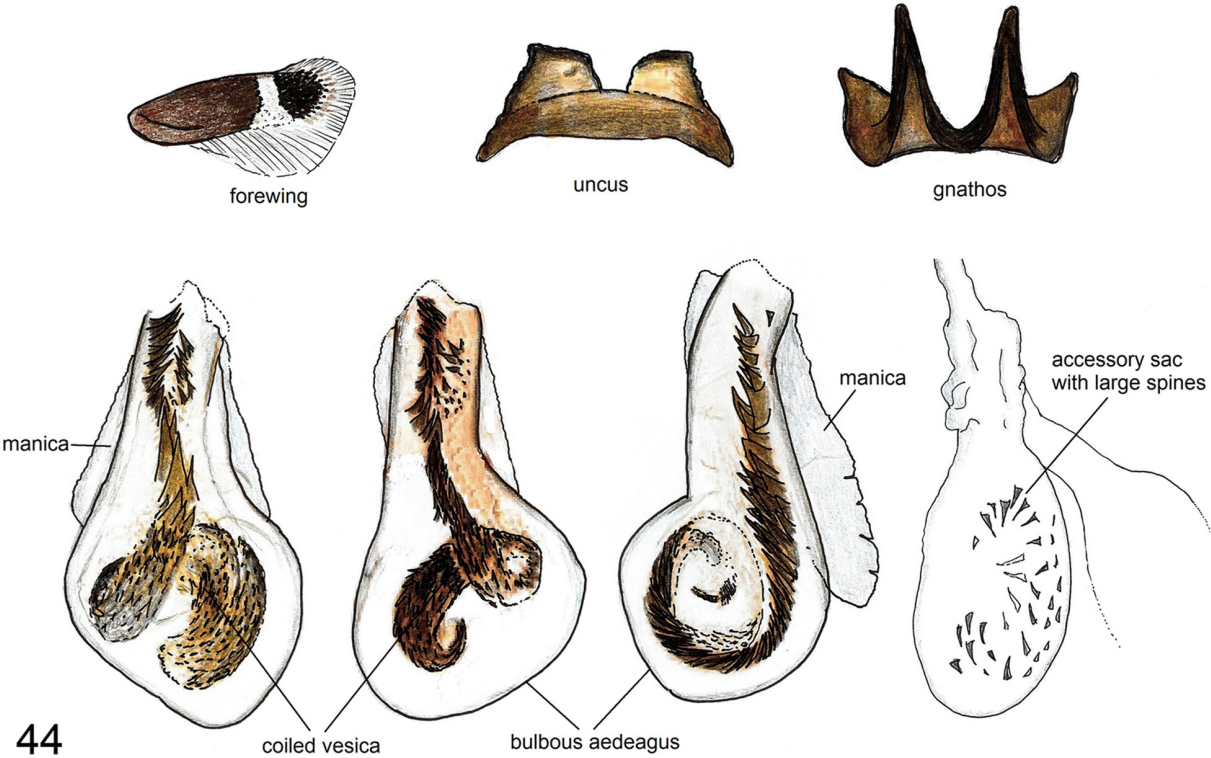


The ruficapitella group

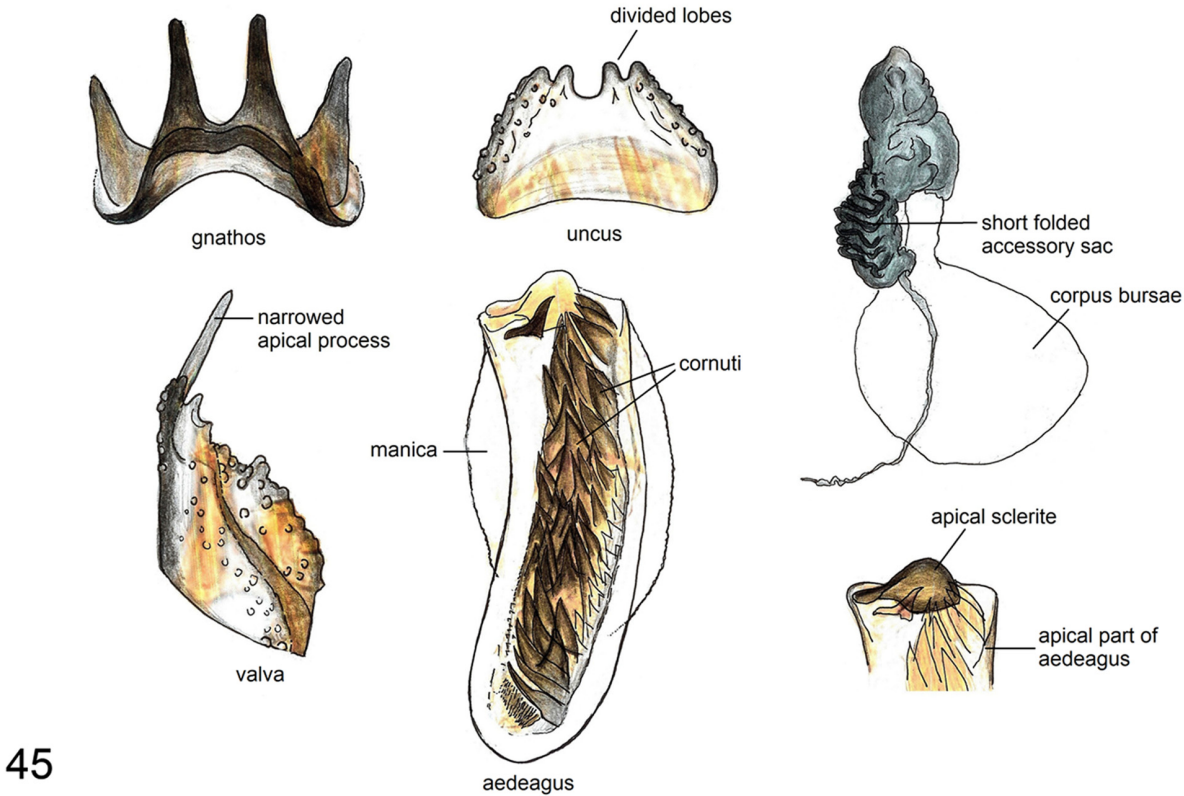


FIGURES 42, 43. Diagnostic characters of the *quercipulchella* and the *ruficapitella* species groups.

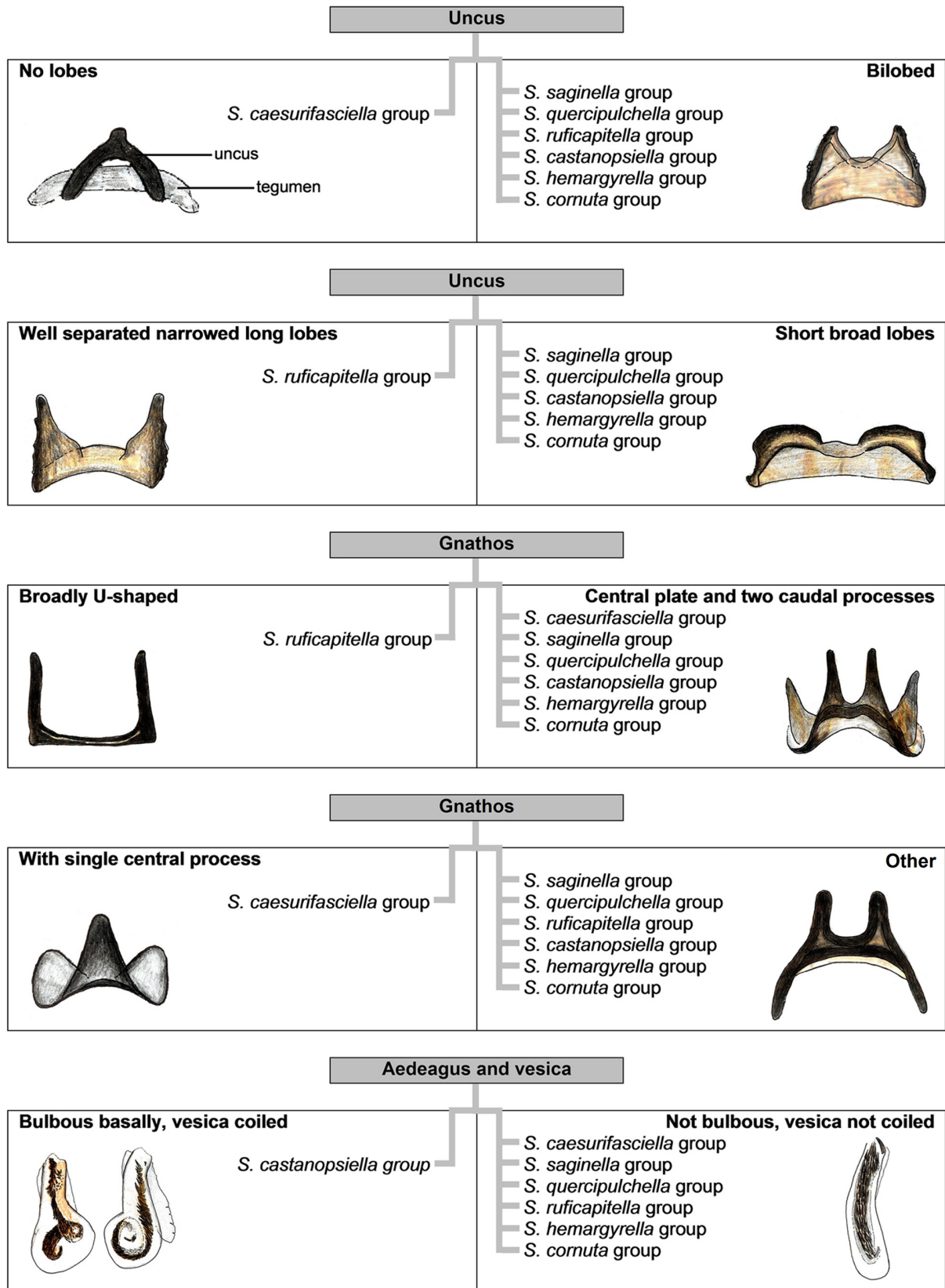
The castanopsiella group



The hemargyrella group

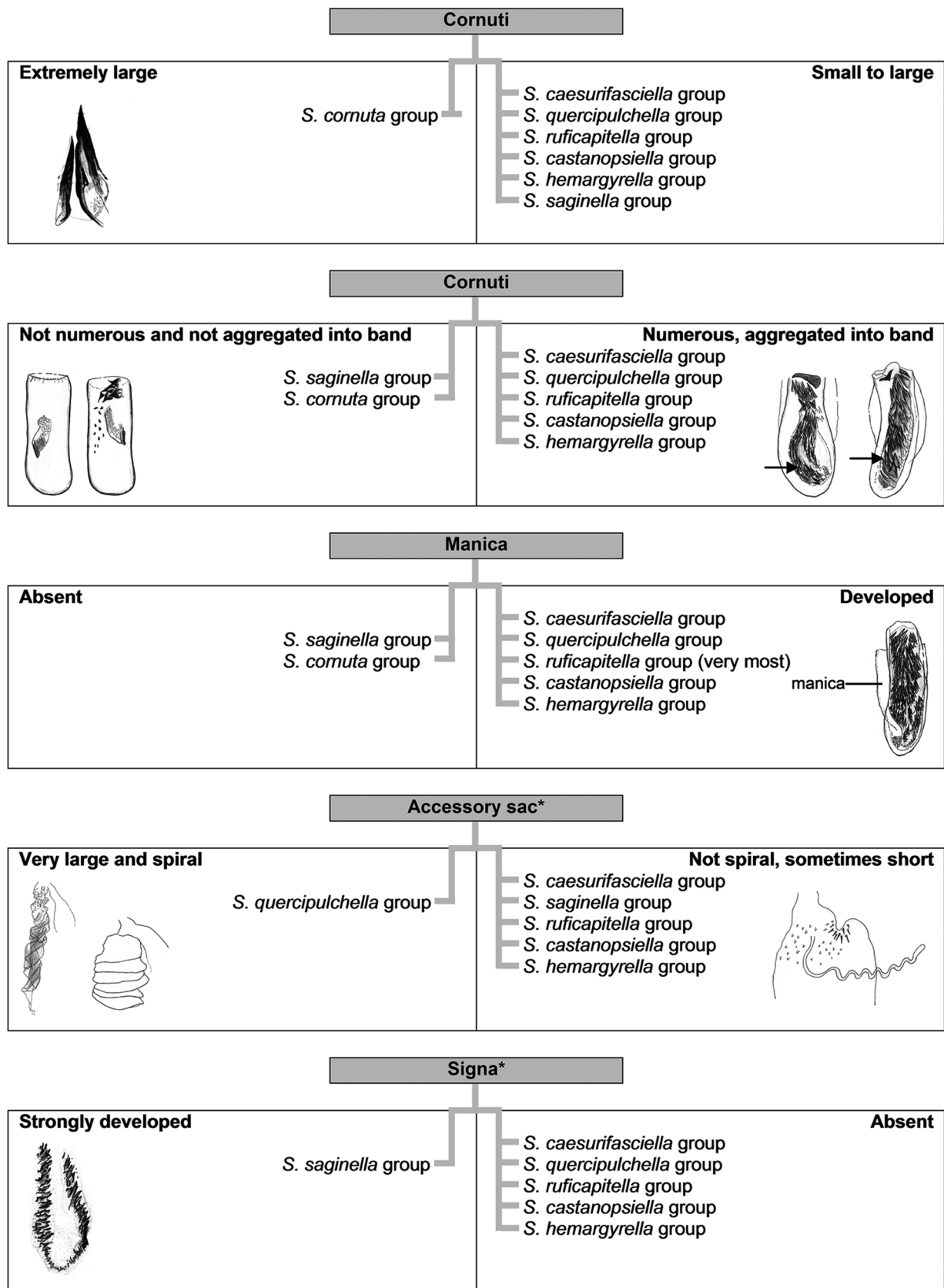


FIGURES 44, 45. Diagnostic characters of the *castanopsiella* and the *hemargyrella* species groups.



46

FIGURE 46. Dichotomies that usually help separate some species groups from all others groups of *Quercus*-feeding *Stigmella* on a basis of a single character.



47

FIGURE 47. Dichotomies that usually help separate some species groups from all others groups of *Quercus*-feeding *Stigmella* on a basis of a single character (* females of the *cornuta* group are unknown).

Distribution and taxonomic diversity. Currently includes a single East Palaearctic species (*Stigmella caesurifasciella* Kemperman & Wilkinson, 1985).

The *cornuta* group (designated here)

Diagnostic characters (Fig. 40): forewing without pattern (without fascia); in male genitalia, uncus with weakly individualized lobes, gnathos with two partially reduced caudal processes (and two anterior ones), valva with chitinized apical papilla, tranverse bar of transtilla interrupted medially, aedeagus with extremely large pointed cornuti, juxta present, constricted medially, manica absent; female genitalia unknown.

Leaf-mines combined. Comprise a narrow gallery in the first half and a large blotch in the second half (unique among other *Stigmella* species feeding on oak).

Host-plant preferences. Subgenus *Quercus*, section *Mesolobatus* (Fig. 38).

Distribution and taxonomic diversity. Currently includes a single East Palaearctic species (*Stigmella cornuta* Rocienè & Stonis, **sp. nov.** described above).

Note. In male genitalia, the *cornuta* group exhibit some similarity to the non *Quercus*-feeding *betulicola* group: apically narrowed valva with a chitinized apical papilla (Fig. 30), interrupted tranverse bar of transtilla (Fig. 28), broad lobate vinculum (Fig. 27), and weakly individualized lobes of uncus (Fig. 32). However, the newly designated group clearly differs from the *betulicola* group (and other *Stigmella*) by the shape of the extremely large cornuti (Fig. 36), and by the unusual shape of gnathos with partially reduced caudal processes (Fig. 33). The combined leaf-mine (Fig. 20) is also unique among *Quercus*-feeding *Stigmella* species (and uncommon or even rare among other Nepticulidae).

The *saginella* group

Diagnostic characters (Fig. 41): forewing either unicolorous, or speckled, or with fascia; androconial scales not characteristic (absent); in male genitalia, uncus always with two short and broad lateral lobes, gnathos always with two caudal processes, valva almost always with thickened long chaetae, apical process of valva usually weakly individualized, not prominent, juxta always present (X-shaped or closely similar), aedeagus only with a few (or none) spine-like cornuti, which are never aggregated into a band, manica always absent; in female genitalia, accessory sac always short to very short, not folded, without spines, corpus bursae always with signa.

Host-plant preferences. Subgenus *Quercus*, sections: *Lobatae* and *Quercus*, also genus *Castanea* (Fig. 38).

Distribution and taxonomic diversity. Comprises 10 species. Nearctic: *Stigmella saginella* (Clemens, 1861); *S. castaneaefoliella* (Chambers, 1875); *S. latifasciella* (Chambers, 1878); *S. flavipedella* (Braun, 1914); *S. sclerostylota* Newton & Wilkinson, 1982.

Nearctic and Neotropical (Central American): *Stigmella nigriverticella* (Chambers, 1875).

Neotropical (Central American): *Stigmella jaguari* Remeikis & Stonis, 2013; *S. lauta* Diškus & Stonis, 2013; *S. sublauta* Remeikis & Stonis, 2013; *S. aurifasciata* Diškus & Stonis, 2013 (Stonis et al. 2013a).

The *quercipulchella* group

Diagnostic characters (Fig. 42): forewing always with fascia, androconial scales sometimes developed; in male genitalia, uncus always with two short broad lateral lobes, gnathos always with two posterior processes, anterior processes of gnathos usually long, transtilla with very short (or none) sublateral processes, aedeagus always with numerous spine-like cornuti aggregated into a band, manica always present (large or small); in female genitalia, accessory sac always strongly developed (very long or broad) and always spiral (coiled), without spines, corpus bursae always without signa.

Host-plant preferences. Subgenus *Quercus*, section *Lobatae* (Fig. 37).

Distribution and taxonomic diversity. Comprises five species. Nearctic: *Stigmella quercipulchella* (Chambers, 1878); *S. variella* (Braun, 1910); *S. altella* (Braun, 1914).

Neotropical (Central American): *Stigmella guatemalensis* Diškus & Stonis, 2013; *S.* species 515 (Stonis *et al.* 2013a).

The *ruficapitella* group

Diagnostic characters (Fig. 43): forewing predominantly unicolorous, sometimes with fascia or with spots; androconial scales often developed; in male genitalia, uncus almost always with two long, narrowed, well separated lateral lobes, gnathos almost always broadly U-shaped, anterior processes of gnathos either very short or absent, aedeagus always with numerous spine-like cornuti aggregated into a full or broken band, manica often developed; in female genitalia, accessory sac often large or very large, usually with short or large spines (sometimes spines absent), corpus bursae often reduced, signa absent.

Host-plant preferences. Usually genus *Quercus* (subgenus *Quercus*), sections: *Quercus*, *Cerris*, *Mesolobatus*; sometimes other genera of Fagaceae (*Castanopsis*, *Castanea*: a few oligophagous representatives of the *ruficapitella* group) or Betulaceae: monophagous *Stigmella tristis* (Wocke) on *Betula* (Fig. 37).

Distribution and taxonomic diversity. Comprises 29 species, all in the Palaearctic Region.

West Palaearctic: *Stigmella atricapitella* (Haworth, 1828); *S. ruficapitella* (Haworth, 1828); *S. samiatella* (Zeller, 1839); *S. basiguttella* (Heinemann, 1862); *S. tristis* (Wocke, 1862); *S. suberivora* (Stainton, 1869); *S. ilicifoliella* (Mendes, 1918); *S. zangherii* (Klimesch, 1951); *S. svenssoni* (Johansson, 1971); *S. dorsiguttella* (Johansson, 1971); *S. roborella* (Johansson, 1971); *S. eberhardi* (Johansson, 1971); *S. szoeciella* (Borkowski, 1972); *S. macrolepidella* (Klimesch, 1978); *S. trojana* Z. Laštuvka & A. Laštuvka, 1998; *S. fasciata* van Nieukerken & Johansson, 2003; *S. cocciferae* van Nieukerken & Johansson, 2003; *S. bicuspidata* van Nieukerken & Johansson, 2003; *S. karsholti* van Nieukerken & Johansson, 2003; *S. kasyi* van Nieukerken & Johansson, 2003.

East Palaearctic: *Stigmella aladina* Puplesis, 1984; *S. omelkoi* Puplesis, 1984; *S. fervida* Puplesis, 1984; *S. fumida* Kemperman & Wilkinson, 1985; *S. clisiotophora* Kemperman & Wilkinson, 1985; *S. kao* van Nieukerken & Liu, 2000; *S. crenatiella* Hirano, 2010; *S. azuminoensis* Hirano, 2010; *S. hisakoeae* Hirano, 2010.

Note. *S. dentatae* Puplesis, 1984 (because the basally bulbous aedeagus with coiled vesica), and *S. circumargentea* van Nieukerken & Liu, 2000 (because the feeding on *Lithocarpus*) are excluded from the *ruficapitella* group here for the first time and transferred to the *castanopsiella* group.

The *castanopsiella* group

Diagnostic characters (Fig. 44): forewing usually with fascia, androconial scales often developed; in male genitalia, uncus usually with two short and broad lateral lobes, gnathos always with two posterior processes, aedeagus always bulbous basally, numerous spine-like cornuti always aggregated into a band, vesica always coiled, manica always present; in female genitalia, accessory sac always long and with (usually coiled) band of long spines, no signa.

Host-plant preferences. *Lithocarpus*, *Castanopsis* and *Quercus*: subgenera *Cyclobalanopsis* and *Quercus* (section *Mesolobatus*) (Fig. 37).

Distribution and taxonomic diversity. Comprises six species, all East Palaearctic: *Stigmella castanopsiella* (Kuroko, 1978); *S. kurokoi* Puplesis, 1984; *S. dentatae* Puplesis, 1984; *S. circumargentea* van Nieukerken & Liu, 2000; *S. lithocarpella* van Nieukerken & Liu, 2000; *S. vandrieli* van Nieukerken & Liu, 2000.

Note. *S. dentatae* and *S. circumargentea* are included in to the *castanopsiella* group here for the first time (previously they were placed in the *ruficapitella* group) (van Nieukerken & Liu 2000; Diškus & Puplesis 2003).

The *hemargyrella* group

Diagnostic characters (Fig. 45): forewing often with fascia, androconial scales often developed (present); in male genitalia, uncus often with two short, distally divided lateral lobes (i.e. four small distal lobes), gnathos large, always with two posterior processes (M-shaped), valva often with slender and subcaudally directed apical process,

aedeagus always with numerous spine-like cornuti aggregated into a band, manica almost always present; in female genitalia, accessory sac often wrinkled, corpus bursae always without signa.

Host-plant preferences. Fagaceae (*Fagus* and *Quercus*: section *Quercus*), Sapindaceae (*Acer*) and Caprifoliaceae (*Lonicera*) (Fig. 38).

Distribution and taxonomic diversity. Comprises six species, all in the Palaearctic Region.

West Palaearctic: *Stigmella hemargyrella* (Kollar, 1832); *S. lonicerarum* (Frey, 1857); *S. speciosa* (Frey, 1858).

Central Palaearctic (Central Asia and Himalaya): *S. kuznetzovi* Puplesis, 1994; *S. acuta* Diškus, Navickaitė & Remeikis, **sp. nov.**

East Palaearctic: *S. monticulella* Puplesis, 1984.

Note. *S. motiekaitisi* Puplesis, 1994 (Central Asia) is excluded from the *hemargyrella* group here for the first time but left assigned to any group).

Key to the species groups based on males (with a few additional data on females)

1. Gnathos with single caudal process; uncus semi-rounded, without lobes (Fig. 39) *S. caesusifasciella* group
- Gnathos with two caudal processes; uncus with lobes 2
2. Male genitalia with cornuti extremely large, each approx. as long as half length of aedeagus *S. cornuta* group
- Male genitalia with cornuti small to large 3
3. Cornuti not aggregated into a band (“loose”); manica absent [female genitalia with prominent, strongly chitinized signa] (Fig. 41) *S. saginella* group
- Cornuti aggregated into a full or broken band; manica (except a few species) present [female genitalia without signa] 4
4. Gnathos broadly U-shaped (Fig. 43); caudal lobes of uncus usually narrow and long (as it is shown in fig. 43); forewing usually without fascia (occurrence 70%) *S. ruficapitella* group
- Gnathos with central plate and two closely situated caudal processes; caudal lobes of uncus broad and (or) short; forewing usually with fascia 5
5. Aedeagus bulbous basally (Fig. 44), vesica (and band of cornuti) coiled [female genitalia with coiled spinose structure] *S. castanopsiella* group
- Aedeagus not bulbous basally, vesica (and band of cornuti) not coiled [female genitalia without coiled spinose structure] 6
6. Gnathos with long anterior processes (Fig. 42), uncus bilobed; host-plants exclusively from section *Lobatae*, genus *Quercus*; North and Central America [female genitalia with enormously enlarged, markedly spiral (coiled) accessory sac] *S. quercipulchella* group
- Gnathos without anterior processes (Fig. 45), uncus usually with four small caudal lobes or papillae; host-plants: *Lonicera*, *Acer*, *Fagus* and *Quercus* (but not section *Lobatae*); distributed from Europe to Central and East Asia [female genitalia with short accessory sac or without it] *S. hemargyrella* group

Key to the species groups based on females*

1. Corpus bursae with two (usually long, sometimes short) bands of signa (Fig. 41) *S. saginella* group
- Corpus bursae without signa 2
2. Accessory sac markedly spiral (coiled) (Fig. 42); host-plants only from section *Lobatae* of genus *Quercus* (Fig. 37); North and Central America *S. quercipulchella* group
- Accessory sac not spiral (not coiled), host-plants not from section *Lobatae* of genus *Quercus*; Europe and Asia 3
3. Accessory sac (or corpus bursae) without spines (Fig. 45) *S. hemargyrella* group (also a few species of *S. ruficapitella* group)
- Accessory sac (or corpus bursae) with spines (Fig. 44) 4
4. Accessory sac usually coiled, spines very large; forewing usually with fascia (Fig. 44); host-plants belong to *Lithocarpus*, *Castanopsis* and *Quercus*: subgenera *Cyclobalanopsis* and *Quercus* (section *Mesolobatus*); East or South East Asia. *S. castanopsiella* group
- Accessory sac never coiled, spines small to large; forewing usually without fascia (unicolorous) (Fig. 43); host-plants mostly belongs to sections *Quercus* and *Cerris* of *Quercus* (Fig. 37); Europe and Asia *S. ruficapitella* group

(* The East Asiatic *caesusifasciella* and the *cornuta* groups were not included in the key: females of the *cornuta* group are unknown; in the *caesusifasciella* group, despite the striking characters of the male genitalia and larval feeding on *Cyclobalanopsis*, the female genitalia do not exhibit unique characters).

It can be noted that some species groups treated in present paper can be diagnosed/recognized on a basis of even a single (polarized) morphological character (we call it “diagnostic dichotomies” in figs 46, 47). For example,

the unusual shape of the uncus with no lateral lobes, or the gnathos with a single caudal process separate the *caesurifasciella* group from all other groups of *Stigmella* trophically associated with *Quercus* (Fig. 46). The same applies to the strongly chitinized signa or X-shaped (or modified) juxta: each of these characters diagnoses the *saginella* group. The bulbous aedeagus with a coiled vesica immediately distinguishes the *castanopsiella* group, the enormously enlarged and markedly spiral (coiled) accessory sac – the *quercipulchella* group. Usually (with a few exceptions), it is possible to separate the *ruficapitella* group from all six remaining groups solely on the basis the broadly U-shaped gnathos (Fig. 46).

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