A THESIS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Systematic study of Sciaridae (Diptera: Sciaroidea) in the Korean Peninsula, with discussion of larval habitats evolution

한반도산 검정날개버섯파리과 (파리목: 버섯파리상과)의 계통분류 및 유충서식처 진화 연구

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UNDER THE DIRECTION OF ADVISER SEUNGHWAN LEE
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF SEOUL NATIONAL UNIVERSITY

By
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APPROVED AS A QUALIFIED DISSERTATION OF SEUNGGWAN SHIN
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
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ABSTRACT

Systematic study of Sciaridae (Diptera: Sciaroidea) in the Korean Peninsula, with discussion of larval habitats evolution

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Systematic studies on the family Sciaridae are conducted on three subjects: Taxonomic review of the Sciaridae in the Korean Peninsula, DNA barcoding of *Bradysia* for the identification of larval stages on agriculture plants, and molecular phylogeny of black fungus gnats and the evolution of larval habitats. The first part is mainly composed of taxonomic revision of the Korean Sciaridae, with provision of the new key to subfamilies regarding molecular (part 3) and morphological studies. In this part, a total of 61 species are recognized, with descriptions of 3 new species and 26 newly recorded species from Korea. The second part is molecular identification of the sciarids using the COI DNA barcode. In this part, the COI DNA barcode database of the 25 species within genus *Bradysia* are constructed. As a result, I suggested that DNA barcodes could be an effective tool for identifying sciarids. Also it is useful for confirmation of the larval habitats in Sciaridae. The third part is study on the phylogenetic relationships of the black fungus gnats (Diptera: Sciaridae) with materials from worldwide. This part provides the molecular phylogenetic system, which could test controversial classifications of family Sciaridae, and infers new phylogenetic relationships within Sciaridae. Consequently, five subfamilies are newly proposed within Sciaridae, and I could infer that their evolution of larval habitat transition patterns. In conclusion, systematic relationship of the Sciaridae is reconstructed, with two new subfamilies suggested by both of taxonomic studies and molecular analyses. Furthermore, the rules of agricultural and ecological importance of Sciaridae are also studied.

Keywords : Black fungus gnats, Ancestor character states, Phylogenetics, New species, Unrecorded species, Evolution, Taxonomy.

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PART I. **Taxonomic review of the Sciaridae (Diptera**: **Bibionomorpha**: **Sciaroidea) in the Korean Peninsula**

ABSTRACT

The Sciaridae is represented by 15 genera, 61 species in the Korean peninsula. Among them, three genera and 29 species are recorded for the first time from Korea. Also three species are described as new to science. The new species are as follows: *Cratyna* (s. str.) *suwonensis* sp. nov., *Scythropochroa pseudoquercicola* sp. nov., *Phytosciara* (*Dolichosciara*) *koreansis* sp. nov., and the new records are as follows: *Bradysia aprica* (Winnertz 1867), *Bradysia atracornea* Mohrig and Menzel 1992, *Bradysia chlorocornea* Mohrig and Menzel 1992, *Bradysia hilariformis* Tuomikoski 1960, *Bradysia ocellaris* (Comstock 1882), *Bradysia protohilaris* Mohrig and Krivosheina 1983, *Chaetosciara umbalis* Mohrig and Krivosheina 1990, *Corynoptera dentata* (Bukowski and Lengersdorf 1936), *Corynoptera micula* Hippa, Vilkamaa and Heller 2010, *Cratyna* (s. str.) *ambigua* (Lengersdorf 1934), *Cratyna* (s. str.) *nigerrima* (Mohrig and Krivosheina 1979), *Cratyna* (*Peyerimhoffia*) *vagabunda* (Winnertz 1867), *Ctenosciara insolita* (Sasakawa 1994), *Leptosciarella* (s. str.) *trochanterata* (zetterstedt 1851), *Leptosciarella* (s. str.) *rejecta* (Winnertz 1867), *Leptosciarella* (*Leptospina*) *dentata* (Mohrig and Krivosheina) 1979, *Lycoriella* (s. str.) *castanescens* (Lengersdorf 1940), *Lycoriella* (*Hemineurina*) *flavicornis* Mohrig and Mamaev 1985, *Phytosciara* (*Dolichosciara*) *semiferruginea* Menzel 1995, *Phytosciara* (*Prosciara*) *ussuriensis* Antonova 1977, *Pseudolycoriella horribilis* (Edwards 1931), *Sciara humeralis* Zetterstedt 1851, *Sciara ruficauda* Meigen 1818, *Scythropochroa radialis* Lengersdorf 1926, *Trichosia* (s. str.) *confusa* Menzel and Mohrig 1997, and *Zygoneura* (*Pharetratula*) *bidens* (Mamaev 1968). All species except for the recorded only in North Korea are described based on the microscope slide specimens. And the illustrations for each species are presented. The keys to 5 subfamilies are described as new to science based on morphological and molecular (Part III) phylogenetic studies of the Sciaridae. Furthermore, keys to genera and species are also given for those species occurring in the Korean Peninsula.

Keywords: Diptera, Sciaridae, New subfamily, New species, Mushroom pest, greenhouse pest, Taxonomic key

1–1. Introduction

The family Sciaridae is one of the largest groups in the superfamily Sciaroidea. It contains more than 2,000 described species, which were distributed worldwide (Amorim, 1992; Menzel and Mohrig, 1997, 2000; Mohrig, 2003; Mohrig and Menzel, 2009; Mohrig et al., 2004; Steffan, 1981). Sciarid flies are very small and dark colored; thus, the common name is "dark–winged fungus gnat" or "black fungus gnat" because the body and wing membrane are mostly dark. A total of 32 species Korean Sciaridae has been recognized to date, including 24 species from North Korea (Mohrig et al., 1992). Most species from South Korea have been investigated with emphasis on the pest of mushrooms and greenhouse plants (Hurley, 2006; Kim et al., 2000; Kim and Hwang, 1996; Kim and Choi, 1999; Lee et al., 1999; Lee et al., 2010; Meers and Cloyd, 2005; Menzel et al., 2003; Shin et al., 2011; Shin et al., 2012).

The most species of Sciaridae live in forests, swamps, and moist meadows, such as moist and shadowy area (Menzel et al., 2006). Most species of the family Sciaridae are known as decomposers, usually feeding on decaying plant materials, animal excrements, and fungus in larval stage. Some species feed deadwood such as rotting wood or under the bark of dead woods. Furthermore, several species have been found in animal burrows, bird's nests, and caves (McAlpine et al., 1981; Menzel and Mohrig 2000; Menzel et al., 2006). Some species of sciarids were reported in extreme habitats, like subantarctic islands and mountainous regions above 4,000 m. The genus *Parapnyxia* was found in deserts, where they dig into the sand at extreme temperatures (Menzel and Mohrig, 2000). The *Bradysia farlanei* (Jones) was uniquely reported feeding on dead insects in the tubes of pitcher plants (*Sarracenia sledge*). The larval habitat of genera *Trichosia*, *Leptosciarella*, and *Xylosciara* have been reported xylophagous (live on decomposing woods) (Menzel and Mohrig, 2000; Menzel et al., 2006). The genera *Cratyna* and *Corynoptera* have been reported as plant litters inhabitat. Most of the genus *Lycoriella* s. str. species are feeding on the mycelium of mushrooms as fungivore (Lee et al., 1999; Menzel and Mohrig, 2000; Shin et al., 2012). The genera *Pseudolycoriella*, *Ctenosciara*, and a few Palaearctic species of the genus *Scatopsciara* are known as phytosaprophagous (Sutou and Ito, 2003; Buck et al., 1997; Menzel and Mohrig, 2000; Menzel et al., 2006). In contrast, the genus *Phytosciara* s. l. and part of the genus *Bradysia* s. l. are known as pest on living plants. The *Eugnoriste* species feed on flowers (Steffan, 1966). And the genus *Zygoneura* is associated with both woody and herbaceous plants. The subgenus *Allozygoneura* is known as a plant miner (Sasakawa, 1997; Tuomikoski, 1960), and other subgenera are known as xylophagous (Menzel and Mohrig, 2000).

The life cycle of the Sciaridae has been studied only for a few pest species (McAlpine et al., 1981; Menzel and Mohrig, 2000). Adult females lay about 200 eggs. After about one week, the larvae hatched out. The adult do not bite, and only ingest liquids. They live only for mate and produce eggs. After about five days adult flies die.

The etiological study of pest symptom of those species has been concentrated in the habitat of larval stage (Hurley, 2006; Lee et al., 1999; McAlpine et al., 1981; Menzel and Mohrig, 2000; Menzel et al., 2006; Menzel et al., 2003; Sutou and Ito, 2003). Most larvae of the Sciaridae are known as decomposers. However, some larvae in subfamilies Megalosphyinae and Lycoriellrinae mine the living stems, leaves, or inhabit under the bark of live trees. Furthermore, species of *Bradysia* (*B. difformis*) and *Lycoriella* (*L. castanescens* and *L. ingenua*) have a wide range of larval habitats based on mycophagy (Menzel and Mohrig, 2000; Shin et al., 2012). Thus, these species exist as pests for mushroom and plant cultivation

(Forbes, 1896; Gerbachevskaja, 1963; Hafidh and Kelly, 1982; Hopkins, 1895; Kim et al., 2000; Kim and Hwang, 1996; Kim and Choi, 1999; Lee et al., 1999; Lewandowski et al., 2004; Menzel et al., 2003; Park et al., 1999; Shin et al., 2012; White et al., 2000; Yi et al., 2008). Nevertheless, the most Sciarinae, Cratyninae, and Chaetosciarinae live in the soil and plant litter feeding upon dead plant matters. Consequently, the family Sciaridae is one of the most important decomposers in forest ecosystem as well as pests in agriculture condition.

According to early classifications of Sciaridae, three subfamilies were proposed (Enderlein, 1911) (Fig. 2–1A): Cratyninae, Lestremiinae, and Sciarinae. And Lengersdorf (1928–30) reported that relationships within the Sciaridae comprise four subfamilies: Cratyninae, Sciarinae, Megalosphyinae, and Zygoneurinae. However, Frey (1942) placed all subfamilies under three specialization levels genus groups with fossil species (Fig. 2–1C), using the number of maxillary palpus segments and macrotrichia on Cu and M wing veins for classification. Recently, the existence of a system of four subfamilies was indicated by cladistic analysis with morphological characters (Menzel and Mohrig, 2000) (Fig. 2–1E): Sciarinae, Megalosphyinae, Cratyninae with the inclusion of Zygoneurinae, and "New subfamily (current Lycoriellrinae)." The molecular phylogenetic studies are reconstructed as a new system consisting of 5 subfamilies for Sciaridae with evolutionary hypotheses of larval feeding habitats that is one of the main works in Part III.

Study for the Korean Sciaridae has been poorly conducted to date. For the pest studies, only 9 species (Kim et al., 2000; Lee et al., 1999; Lee et al., 2010) have been recorded in the South Korea, which were 3 species collected from agriculture crops, and 6 species from mushroom farm (Shin et al., 2012). As a result, totally 61 species are recognized, with descriptions of 3 new species and 26 newly recorded species. Furthermore, new taxonomic key characters are provided for systematics of Sciaridae.

1–2. Materials and Methods

Sample Collection. Adult flies were collected by malaise trap (Lightweight Malaise Trap, Townes Style, BioQuip Products, Inc., CA, USA) and sweeping net (Collapsible Insect Nets 7118CP, BioQuip Products, Inc., CA, USA).

Adult specimens preparation, **and terminology**. For identification and description, adult flies were mounted on microscope slides in Canada balsam. Before mounting in Canada balsam, the head, wings, and male genitalia were separated from the body with fine needles, dehydrated successively into 99 % alcohol, and soaked in clove oil. Then, each specimen was placed into 1 or 2 drops of Canada balsam on a slide glass.

Photographs were taken with a digital camera (18.3 Three Shot Color, Diagnostic Instruments, Sterling Heights, MI, USA) attached to a microscope (DM 4000B, Leica Microsystems, Wetzlar, Germany) and the images were combined using IMT isolution System (IMT i-Solution inc., Vancouver, BC, Canada).

Morphological terminology of adults follows those of Menzel and Mohrig (1997b, 2000). Abbreviations used for descriptions are as follows: Ant. = antennae; Flgm. = flagellomere. All samples of this study are deposited in the College for Agriculture and Life Sciences, Seoul National University (CALS, SNU), Seoul, Korea.

Abbreviations of collection sites in Korea and depositories are as follows: GG – Gyeonggi–do; GW – Gangwon–do; CB – Chungcheongbuk–do; CN – Chungcheongnam–do; GB – Gyeongsangbuk–do; GN – Gyeongsangnam–do; JB – Jeollabuk–do; JN – Jeollanam–do; JJ, Jeju–do; SNU – Seoul National University, Seoul, Korea. Distribution with an asterisk (*) indicates new record of the region. The asterisk (*) at the end of taxa name also indicate a new record in the Korean Peninsula.

1–3. Results

Checklists of the Black fungus gnats in the Korean Peninsula with biological data. Species name with an asterisk (*) indicates new records to the fauna from this study.

	Subfamily	Species	larval Habitats
1	**Cratyninae**	*Corynoptera blanda* (Winnertz 1867)	mushroom
2		*C. dentata* (Bukowski and Lengersdorf 1936) *	mushroom
3		*C. micula* Hippa, Vilkamaa and Heller 2010 *	-
4		*C. saetistyla* Mohrig and Krivosheina 1985	plant bed
5		*C. barbata* Tuomikoski 1960	-
6		*Cratyna* (s. str.) *ambigua* (Lengersdorf 1934) *	-
7		*Cr.* (s. str.) *nigerrima* (Mohrig and Krivosheina 1979) *	rotten wood
8		***Cr*. (s. str.) *suwonensis* sp. nov. ***	-
9		*Cr.* (*Diversicratyna*) *salomonis* (Mohrig and Mamaev 1985)	-
10		*Cr.* (*Peyerimhoffia*) *vagabunda* (Winnertz 1867) *	mushroom
11		*Cr.* (*Spathobdella*) *longispina* (Pettey 1918)	-
12	**Chaetosciarinae**	*Chaetosciara umbalis* Mohrig and Krivosheina 1990 *	mushroom
13		*Scythropochroa radialis* Lengersdorf 1926 *	rotten wood
14		***Scy*. *pseudoquercicola* sp. nov. ***	-
15	**Lycoriellinae**	*Lycoriella* (s. str.) *castanescens* (Lengersdorf 1940) *	fungus
16		*L.* (s. str.) *ingenua* (Dufour 1839)	fungus
17		*L.* (*Hemineurina*) *flavicornis* Mohrig and Mamaev 1985 *	-
18		*L.* (*Hemineurina*) *venosa* (Staeger 1840)	-
19		*Pseudolycoriella koreensis* (Mohrig and Menzel 1992)	-
20		*P. horribilis* (Edwards 1931) *	-
21		*Xylosciara inornata* Mohrig and Krivosheina 1979	dead wood

22		*X*. (*Xylosciara*) *steleocera* Tuomikoski 1960	-
23	**Megalosphyninae**	*Bradysia aprica* (Winnertz 1867) *	fungus
24		*B. atracornea* Mohrig and Menzel 1992 *	plant bed
25		*B. chlorocornea* Mohrig and Menzel 1992 *	-
26		*B. difformis* Frey 1948	plant, fungus
27		*B. hilariformis* Tuomikoski 1960 *	-
28		*B. hilaris* (Winnertz 1867)	-
29		*B. lapponica* (Lengersdorf 1926)	-
30		*B. longimentula* (Sasakawa 1994)	-
31		*B. ocellaris* (Comstock 1882) *	plant, fungus
32		*B. procera* (Winnertz 1868)	ginseng
33		*B. protohilaris* Mohrig and Krivosheina 1983 *	dead wood
34		*B. trispinifera* Mohrig and Krivosheina 1979	dead wood
35		*B. bilobata* Mohrig and Kozánek 1992	-
36		*B. fungicola* (Winnertz 1867)	-
37		*B. scabricornis* Tuomikoski 1960	-
38		*B. globulifera* (Lengersdorf 1934)	-
39		*Ctenosciara insolita* (Sasakawa 1994) *	-
40		*Ct. nudata* Mohrig and Kozánek 1992	-
41		*Phytosciara (Dolichosciara) flavipes* (Meigen 1804)	-
42		*Ph. (Dolichosciara) semiferruginea* Menzel 1995 *	-
43		***Ph*. (*Dolichosciara*) *koreansis* sp. nov. ***	-
44		*Ph*. (*Prosciara*) *ussuriensis* Antonova 1977 *	-
45		*Scatopsciara camptospina* Mohrig and Mamaev 1990	dead wood
46		*Sc. Buccina* Mohrig and Mamaev 1985	-
47		*Sc. nacta* (Johannsen 1912)	-

48		*Sc*. (s. str.) *postgeophila* Mohrig and Kozánek 1992	-
49		*Zygoneura* (*Pharetratula*) *bidens* (Mamaev 1968) *	dead wood
50		*Z.* (*Pharetratula*) *flavicornis* Mamaev 1968	-
51		*Z.* (*Zygoneura*) *sciarina* Meigen 1830	-
52	**Sciarinae**	*Leptosciarella* (s. str.) *trochanterata* (zetterstedt 1851) *	dead wood
53		*Le*. (s. str.) *rejecta* (Winnertz 1867) *	dead wood
54		*Le*. (*Leptospina*) *dentata* (Mohrig and Krivosheina) 1979 *	-
55		*Le*. (*Leptospina*) *subdentata* (Mohrig and Menzel 1992)	dead wood
56		*Sciara helvola* Winnertz 1867	-
57		*S. ruficauda* Meigen 1818 *	-
58		*S. multispinulosa* Mohrig and Kazanek 1992	-
59		*S. humeralis* Zetterstedt 1851 *	-
60		*S. mendax* Tuomikoski 1960	-
61		*Trichosia (Trichosia) confusa* Menzel and Mohrig 1997 *	dead wood

Systematic Accounts

Order Diptera 파리목

Suborder Nematocera 모기아목

Infraorder Bibionomorpha 털파리하목

Superfamily Sciaroidea 버섯파리상과

Family Sciaridae 검정날개버섯파리과

Key to the subfamilies of the family Sciaridae

1. Neck parts of the Flgm. cylindrical and rectangular, basal part narrows [neck base to the basal part clearly separated (Plate A–27E)]; wing membrane without macrotrichia, rear wing veins usually without macrotrichia (Plate A–28C); apex of fore tibia with margin and/or comblike bristles, and sometimes with only strong spines (Plates A–15F, 17F, 22F). 2

– Neck parts of the Flgm. usually with seamless transition to the basal [neck of Flgm. bottle–shaped neck, base to the basal part do not clearly separated (Plates A–42D, 45D)]; wing membrane and rear wing veins usually with macrotrichia (Plates A–45C, 49C); apex of fore tibia without margin and comblike bristles (Plate A–42F) (some species of genus *Sciara* have incomplete margin; Plate A–48F). .... Sciarinae

2. M–fork wing vein stretched [M and M_1 is not curved (Plates A–10C, 11C, 12C)]; Flgm. honeycomb–like surface structure (Plate A–10E; genus *Chaetosciara*); neck of Flgm. shorter than 1/2 wide of neck (Plates A–10E, 11E). .... Chaetosciarinae Subfam. Nov.

– M–fork wing vein arched [M_1 and M_2 approximately convex (Plate A–34C, 38C, 38C, 40C)]; Flgm. without honeycomb–like surface structure; neck of Flgm. longer than wide of neck (Plate A–34E). 3

3. Apex of fore tibia with sparse strong spines; without curved margin, and strong bristles are without alignmented (Plates A–1F, 7F). .... Cratyninae

– Apex of fore tibia with dense bristles or/and row of spines (Plate A–17F); comblike spines alignmented (Plates A–14F, 15F, 34F). 4

4. Apex of fore tibia without strict comblike row; with curved margin on apex of fore tibia (Plates A–15F, 17F); inner side of gonostylus with whip–like long hair (Plates A–17B, 18B). .... Lycoriellinae Subfam. Nov.

– Apex of fore tibia with strict comblike row on the lobe like structure (Plate A–22F); without curved margin on apex of fore tibia; inner side of gonostylus without whip–like long hair. .... Megalosphyninae

Subfamily Cratyninae Enderlein 1911

Type genus: *Cratyna* Winnertz 1867

Diagnosis. Gonostylus usually compact, and inner side with lobes or emarginated (Plates A–2A, B). Apex of fore tibia with sparse strong spines; without curved margin, and strong bristles are without alignmented (Plates A–1F, 2F).

Key to genera of the subfamily Cratyninae in the Korean Peninsula

1. Tegmen with strongly sclerotized finger–shaped extension and semi–circular cross–bar structure; apex of gonostylus rounded (Plates A–2A, 3A, 4A, 5A). .... *Cratyna*

– Tegmen without sclerotized finger–shaped extension and semi–circular cross–bar structure; apex of gonostylus tapered (Plate A–1A). .... *Corynoptera*

Genus *Cratyna* Winnertz 1867

Type species: *Cratyna atra* Winnertz 1867

Key to species of the genus *Cratyna* in Korea

1. Gonostylus oval to spherical and with a rounded on apex (Plates A–1B, 2B, 3B); tegmen rounded (Plates A–1A, 2A, 3A) usually with a semicircular cross–bar. 2

– Gonostylus narrow (Plate A–5B) or triangular apex; tegmen trapezoid, simple (Plate A–5A) or with two horizontal strips. 5

2. Gonostylus without apical tooth (Plates A–1B, 2B, 3B). 3

– Gonostylus with apical tooth. .... *Cr*. (*Spathobdella*) *tuberculata*

3. Maxillary palpus (Plate A–2D) one–segmented. Inner side of gonostylus spines unpaired (Plate A–2B). .... *Cr*. (s. str.) *nigerrima* *

– Maxillary palpus (Plates A–1D, 3D) two or three–segmented. Inner side of gonostylus with

2 paired spines (Plates A–1B, 3B). 4

4. Maxillary palpus three segmented (Plate A–1D). Gonostylus inner spines on same lobe (Plate A–2B). .... *Cr*. (s. str.) *ambigua* *

– Maxillary palpus two segmented (Plate A–3D). Gonostylus inner spines on separate lobus (Plate A–3A,B). .... *Cr*. (s. str.) *suwonensis* sp. nov. *

5. Gonostylus short triangular, with distinct strong sabre like tooth (Plate A–5B); palpus 1 segmented (second segment sometimes with fine vestigial); basal segment club like; legs short and strong; R_5 with single sided macrotrichia. .... *Cr*. (*Pryrimhoffia*) *vagabunda* *

– Gonostylus narrow; with strong and long tooth with three spines (Plate A–4B); palpus 3 segmented; basal segment usually narrow; legs long and narrowed, R_5 with macrotrichia on both sided. .... *Cr*. (*Diversicratyna*) *Salomonis*

Cratyna* (s. str.) *ambigua (Lengersdorf 1934) * (Plate A–1)

Peyerimhoffia ambigua Lengersdorf (1934): 55–56.

Neosciara latiforceps Bukowski and Lengersdorf 1936: 111–112.

Neosciara lignea Lengersdorf 1941: 3–4.

Decembrina prima Frey 1942: 35.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. rough and brown; Flgm. IV (Plate A–1E) about 2.5 ~ 2.7 times as long as wide, with unicolor distinct neck. Maxillary palpus (Plate A–1D) three–segmented; basal segment with bristles, and without patch of sensillae; sensilla long and curved; second and third segments as long as base segment, third segment about 1.0 ~ 1.2 times as long as 2nd.

Thorax: brown, with coarse and fine dark brown hairs. Posterior pronotum with bristles. Mesonotum with sparse dark hairs. Katepisternum slightly extended and short. Wings (Plate A–1C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M as long as M–fork; x = 1.0 ~ 1.2 y, bristles on half of y; stem of CuA = 1/3 x; R_1 = 4/5 R; R_5 dorsal and apex of ventral with macrotrichia; length of C = 3/4 w. Halteres short stalked and dark. Legs pale yellow; apex of fore tibia spine like bristles group without margin (Plate A–1F); claws untoothed.

Abdomen: genitalia (Plate A–1A) brown and much wider than high and without basal lobe; ventrally sparse strong haired; base of gonocoxite semi circular. Gonostylus (Plate A–1B) short and swollen, about 1.2 times as long as broad, with 2 pairs evenly curved hyaline spines on inner side of gonostylus. Tegmen membranous, rounded and as high as wide, Tegmen structures exist (semi–circular cross–bar). Aedeagus short and slender.

Body length: 2.3 ~ 3.0 mm

Female. Unknown.

Material examined. Korea, 4 males: Mt. Ungil, Sonchon–ri, Choan–myeon, Namyangju–si, GG, altitude 99 m, 4 males, 26.vi.2009 ~ 16.vii.2009, malaise trap, Leg. J. Lim.

Habitats. Adult specimens usually collected in woodland and sometimes in calcareous grassland (Menzel et al., 2006).

Distribution. New to Korea *, Austria, British Isles, Bulgaria, Czech Republic, Finland, France, Germany, Greece, Italy, Luxembourg, Slovakia, Spain, Sweden, Switzerland, The Netherlands and Ukraine (Camaño Portela et al., 2008; Heller and Menzel, 2012; Menzel et al., 2006).

Remarks. This species is widely spread in Europe; however, has not been recorded in other region. Through this study, I recorded first in Asia. This species is easily recognized by three segment of maxillary palpus.

Cratyna* (s. str.) *nigerrima (Mohrig and Krivosheina 1979) * (Plate A–2)

Scythropochroa nigerrima Mohrig and Krivosheina (1979): 578–579.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. rough and brown; Flgm. IV (Plate A–2E) about 2.2 times as long as wide; with unicolored distinct neck. Maxillary palpus (Plate A–2D) one–segmented, with strong bristles (about 10 ~ 12), and without patch of sensillae.

Thorax: dark, with very short and fine hairs. Posterior pronotum bare. Mesonotum with sparse dark hairs. Scutellum with strong bristles. Katepisternum slightly extended. Wings (Plate A–2C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M 1.5 times longer than M–fork; x = 1.0 ~ 1.1 y, bare; stem of CuA = 1/2 x; R_1 = 1 R; R_5 dorsally and apex of ventral with macrotrichia; length of C = 2/3 w. Halteres short stalked and dark. Legs pale yellow; apex of fore tibia with spine like dense bristle group without margin (Plate A–2F); claws untoothed.

Abdomen: genitalia (Plate A–2A) brown and much wider than high and without basal lobe; ventrally sparse short haired; base of gonocoxite semi circular. Gonostylus (Plate A–2B) short and swollen, about 1.3 times as long as broad, on inner surface with 6 ~ 7 hyaline and strong spines between longer bristles. Tegmen membranous, rounded and as high as wide, tegmen structures exist (strongly sclerotized finger–shaped extension and semi–circular cross–bar). Aedeagus moderately long and slender.

Body length: 3.0 ~ 4.0 mm.

Female. Unknown.

Material examined. Korea, 3 males: Mt. Suraksan, Sanggye–dong, Noweon–gu, Seoul, 37°41'N, 127°04'E, altitude 230 m, 1 male, 25 ~ 31.viii.2007, Leg. J. Lim.; Mt. Ungil, Sonchon–ri, Choan–myeon, Namyangju–si, GG, altitude 99 m, 2 males, 26.vi. ~ 16.vii.2009, malaise trap, Leg. J. Lim.

Habitats. The larvae of type specimens from Russia (Khabarovsk) were reared from rotten alder (Mohrig et al., 1979).

Distribution. New to Korea *. Far East Russian (Khabarovsk), Sweden (Mohrig et al., 1979; Heller et al., 2009).

Remarks. Larvae of this species known as xylophagous, This species is easily recognized by one–segmented palpus, with unpaired dense spines on gonostylus.

Cratyna* (s. str.) *suwonensis sp. nov. * (Plate A–3)

Diagnosis. This species is easily distinguished by inner side of gonostylus have distinct separated lobus and pair of spines on each lobus.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. rough and brown; Flgm. IV (Plate A–3E) about 2.7 times as long as wide, with unicolored distinct neck, bristles as long as width of Flgm. basal. Maxillary palpus (Plate A–3D) two–segmented, (second and third segments were fused), with 3 ~ 4 bristles, patch of sensillae small; sensilla long and curved.

Thorax: dark brown, with very short and fine hairs. Posterior pronotum with bristles. Mesonotum with sparse dark hairs. Scutellum with strong bristles. Katepisternum slightly extended. Wings (Plate A–3C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M 1.1 ~ 1.2 times longer than M–fork; x = 1.0 ~ 1.2 y, 3 bristles on y; stem of CuA = 1/2 x; R_1 = 4/5 R; R_5 dorsally and apex of ventral with macrotrichia; length of C = 2/3 w. Halteres short stalked and brown. Legs pale yellow; apex of fore tibia with dense bristles group without margin (Plate A–3F); claws untoothed.

Abdomen: genitalia (Plate A–3A) brown and much wider than high and without basal lobe or ventral hair; base of gonocoxite semi circular. Gonostylus (Plate A–3B) short and thickened, about 2 times as long as broad, trapezoid shape; ventral side with 4 hyaline spines, 2 spines on lobus in subapical part and 2 spines on lobus in swollen inner surface. Tegmen membranous, rounded and as high as wide, tegmen structures exist (semi–circular cross–bar). Aedeagus short and very weakly sclerotized.

Body length: 1.9 ~ 2.2 mm

Material examined. *Holotype male*. Mt. Yeogi, Seodun–dong, Gwonseon–gu, Suwon–si, GG, Korea, 8.v.1995. Leg. H. Lee. *Paratype*. 2 males, 4.ix.1995, same data as holotype; Mt. Suraksan, Sanggye–dong, Noweon–gu, Seoul, 37°41'N, 127°04'E, altitude 230 m, 1 male, 15 ~ 21.viii.2009, Leg. J. Lim.

Habitats. Unknown.

Distribution. Korea *.

Remarks. This species belong to *Cratyna* (s. str.). It is similar with *Cratyna* (s. str.) *freemani* Menzel and Mohrig 2000 in maxillary palpus and genitalia. However, the new species is differs in distinct separated lobus and pair of spines on each lobus on inner side of gonostylus.

Cratyna* (*Diversicratyna*) *salomonis (Mohrig and Mamaev 1985) (Plate A–4)

Plastosciara (*Decembrina*) *salomonis* Mohrig and Mamaev (1985a): 301–302.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. rough and brown; Flgm. IV (Plate A–4E) about 2.0 ~ 2.5 times as long as wide, with unicolored distinct neck, bristles 2/3 ~3/4 times as long as width of neck. Maxillary palpus (Plate A–4D) three–segmented, with 3 ~ 5 bristles, without patch of sensillae, sensilla fine; third segment about 1.5 times as long as 2nd.

Thorax: dark, with coarse long and dark hairs. Posterior pronotum with bristles. Mesonotum with sparse dark hairs. Scutellum with long and strong lateral bristles. Wings (Plate A–4C) light brown; posterior veins and wing membrane clearly without macrotrichia; stem of M as long as M–fork; x = 0.8 ~ 1.0 y, both bare; stem of CuA = 1/3 x; R_1 = 4/5 R; R_5 dorsally and apex of ventral with macrotrichia; length of C = 3/4 w. Halteres short stalked and dark brown. Legs pale yellow; apex of fore tibia with dense bristles group without margin (Plate A–4F); claws untoothed.

Abdomen: genitalia (Plate A–4A) as high as wide and without basal lobe or ventral hair. Gonostylus (Plate A–4B) narrow, about twice as long as wide with strong apical spines; on apex strong and long tooth with three spines. Tegmen wider than higher and flattened apically with very short and fine teeth; apical with heart–shaped overlap structure. Aedeagus short and strong.

Body length: 2.5 ~ 2.8 mm

Material examined. Korea, 2 males. Mt. Seorak, Osaek–ri, Seo–myeon, Yangyang–gun, GW, 2 males, 28.vi.2002, Yellow pan trap, Leg. H. Lee.

Habitats. Unknown.

Distribution. Korea, Austria, Latvia, Lithuania, Russian Far East (Sakhalin), Germany (Mohrig et al., 1985a; Mohrig et al., 1992; Röschmann and Mohrig, 1993; Rudzinski, 1994).

Remarks. This species is easily recognized by relatively long legs and maxillary palpus, with strong apical spines on gonostylus.

Cratyna* (*Peyerimhoffia*) *vagabunda (Winnertz 1867) * (Plate A–5)

Sciara vagabunda Winnertz (1867): 81–82.

Peyerimhoffia braehyptera Kieffer 1903: 198–200.

Peyerimhoffia alata Frey 1948: 72, 88.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. slightly rough and dark brown; Flgm. IV (Plate A–5E) about 2.3 ~ 2.6 times as long as wide; with unicolored distinct neck; bristles 4/5 times as long as diameter of Flgm. basal. Maxillary palpus (Plate A–5D) one–segmented, short club shaped and brown (second segment sometimes with fine vestigial), with 4 ~ 6 bristles, patch of sensilla small.

Thorax: dark, with very short and fine hairs. Posterior pronotum bare. Mesonotum with sparse dark hairs without long lateral bristles. Scutellum with strong bristles. Katepisternum slightly long. Wings (Plate A–5C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M 1.2 times longer than M–fork; M–fork slightly triangular, M_1 and M_2 slightly curved; x = 1.0 ~ 1.5 y, bare; stem of CuA = 2/3 ~ 1.0 x; R_1 = 4/5 ~ 1 R; R_5 only dorsally with macrotrichia; length of C = 2/3 w. Halteres moderately short stalked and brown. Legs pale yellow; apex of fore tibia coarse and dense bristle group without margin (Plate A–5F); claws untoothed.

Abdomen: genitalia (Plate A–5A) brown and much wider than high and without basal lobe or ventral hairs; base of gonocoxite semi circular. Gonostylus (Plate A–5B) short and thickened, about 1.5 ~ 1.9 times as long as broad, shape of gonostylus triangular, apical part of gonostylus with a long and strong tooth (with a long center seam without lobe–like socket), tooth structure varying in length, but usually quite long, inside of Gonostylus without spines and with numerous strong and long bristles. Tegmen wider than high and trapezoid, lateral with strong S–shaped curved, upper half very membranous, in middle with two horizontal bars sclerotized. Aedeagus short and very weak sclerotized.

Body length: 1.8 ~ 2.8 mm

Material examined. Korea, 1 male: Mt. Ungil, Sonchon–ri, Choan–myeon, Namyangju–si, GG, altitude 99 m, 1 male, 26.vi ~ 16.vii.2009, malaise trap, Leg. J. Lim.

Habitats. Adult specimens collected in woodland open montane habitats; heath land; moorland; wetlands including fens, mires, water meadows, sedge beds and riverside habitats; unimproved calcareous grassland; garden. Larvae were mining spoil heaps and reared from dung (Menzel et al., 2006).

Distribution. New to Korea *. Austria, Czech Republic, Denmark, Far East Russia, Finland, France, Germany, Great Britain, Iceland, Italy, Romania, Sweden, Switzerland, Northern European and Central Asian (Metzner and Menzel, 1996; Vilkamaa and Hippa, 2005).

Remarks. This species is widely spread in Palaearctic. I have studied material from Sweden and Korea. Korean specimens are smaller than European specimens (less than 2 mm). This species is easily recognized by long and strong sabre like tooth on gonostylus.

Cratyna* (*Spathobdella*) *longispina (Pettey 1918)

Neosciara longispina Pettey (1918): 325.

Plastosciara (*Spathobdella*) *tuberculata* Tuomikoski 1960: 36, 39.

Cratyna (*Spathobdella*) *longispina* (Pettey): Mohrig et al. (in press).

Habitats. Found in high mountain, at flowers of moss campion (Menzel et al., 2006).

Distribution. Korea (north), Britain, Finland, Norway, Sweden (Tuomikoski, 1960; Mohrig et al., 1992; Menzel et al., 2006; Heller et al., 2009).

Remarks. Mohrig et al., 1992 recorded this species in North Korea; however, I could not examine this species from Korea.

Genus *Corynoptera* Winnertz 1867

Type species: *Corynoptera perpusilla* Winnertz 1867

Key to species of the genus *Corynoptera* in the Korean Peninsula

1. Apex of fore tibial with transverse comb–like row. 2

– Apex of fore tibial with bristle group. 3

2. Apical tooth of gonostylus long, as long as apical spines (Plate A–8A). .... *C. macula* *

– Apical tooth of gonostylus short, about 1/2 shorter than length spines (Plate A–9A). ....
.... *C. saetistyla*

3. One spear–like spine below middle of inner side on the gonostylus (Plate A–7B). ....
.... *C. dentate* *

– without spear–like spine below middle of inner side on the gonostylus (Plate A–6B). ....
.... *C. blanda*

Corynoptera blanda (Winnertz 1867) (Plate A–6)

Sciara blanda Winnertz (1867): 152–153.

Sciara villica Winnertz 1867: 101.

Neosciara curviligula Lengersdorf 1952: 45–46.

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. slightly rough; Flgm. IV (Plate A–6E) about 2.5 ~ 3.1 times as long as wide; Flgm. bristles little longer than width of neck; neck dark colored and short. Maxillary palpus (Plate A–6D) pale and three–segmented; basal segment with long bristles and without sensillae pit; sensilla long and curved; basal and third segment same long, second segment about 2/3 times as long as 3rd segments.

Thorax: dark brown, with laterally bright. Posterior pronotum bare. Mesonotum with pale with hairs; lateral and central with strong bristles. Scutellum with 2 strong bristles. Katepisternum high triangular. Wings (Plate A–6C) light brown; posterior veins poorly developed and without macrotrichia; stem of M as long as M–fork; x = 0.8 ~ 1.0 y, both bare; stem of CuA = 1/2 ~ 2/3 x; R_1 = 2/3 R; length of C = 3/5 ~ 3/4 w. Halteres light and bright yellow short stalked with row of bristles. Legs, slander, narrow and long; apex of fore tibia with curved bristles group without margin (Plate A–6F); claws untoothed.

Abdomen: genitalia (Plate A–6A) higher than wide; gonocoxites base without basal lobes or ventral hair; inside of basal half gonocoxite covered with short hairs and in upper half with very long bristles. Gonostylus (Plate A–6B) 2.5 times as long as wide; and toward apex narrowed; upper gonostylus with 4 ~ 5 hyaline long spines, apical tooth fine and center seamed; below the apex with long bristles. Tegmen slightly wider than high; rounded apically; toothed area small, wider than high. Aedeagus slander moderately long and without sclerotized base.

Body length: 1.8 ~ 2.3 mm

Female. Probe Flgm. shorter and narrower than male, all Flgm. bristles shorter and sparser; Flgm. IV 2.3 ~ 2.5 times as long as wide, filled with the longer and stronger bristles, wings well developed; CuA stem short about 1/3 ~ 1/2 x; C = 2/3 w, and all other features as the male.

Body length: 2.2 ~ 2.5 mm.

Material examined. Sweden, 3 males: Stensjön, Stensjön–Lomtjärn, Hudiksvalls kommun, Hälsingland, Marsh pine wood close to bog, 3 males, 21.v–02.vi.2005.

Habitats. Larvae reared in *Leccinum* sp. and adult collected in forests and grassland (Buck et al., 1997; Mohrig and Blasco–Zumeta, 1996).

Distribution. Korea (north), Britain, Germany, Russia, Slovakia, Sweden (Heller et al., 2009; Mohrig and Blasco–Zumeta, 1996; Mohrig and Krivosheina, 1986; Rudzinski, 2009; Smith and Menzel, 2007).

Remarks. Mohrig et al., 1992 recorded this species in North Korea; however, I could not examine Korean specimens.

Corynoptera dentata (Bukowski and Lengersdorf 1936) * (Plate A–7)

Neosciara dentata Bukowski and Lengersdorf (1936): 109–110.

Description. *Male*. Head: eye bridge 5 facets wide. Flgm. IV (Plate A–7E) about 2.8

times as long as wide, with unicolor distinct neck, bristle–like hair slight shorter than width of Flgm. Maxillary palpus (Plate A–7D) three–segmented; basal segment with only 1 bristle with patch of sensillae. Clypeus with 3 hairs.

Thorax: brown. Posterior pronotum bare. Mesonotum dark with central moderately short hairs; prescutellar with hairs, laterally 2 strong hairs. Scutellum with 2 strong bristles and some short hairs. Wings (Plate A–7C) smoky; length of R_1 = 2/3 R; R_5 with dorsal macrotrichia; length of y = x, bare; length of C = 2/3 w; posterior veins bare. Halteres long. Legs yellowish–brown; fore tibia at inner apex with an unbordered patch of bristle–like hairs (Plate A–7F); spurs of mid and hind tibiae equal, longer than diameter of apex; claws untoothed.

Abdomen: genitalia (Plate A–7A) ventrally sparse short–haired, also inner margin of gonocoxites. Gonostylus (Plate A–7B) moderately long and curved, apically with 3 ~ 4 strong and short spines, one spear–like spine below middle of inner side. Tegmen slightly broader than high and without teeth. Aedeagus. Aedeagus moderately long.

Body length: 1.2 mm

Female. Differs from male in following points: Ant. shorter than male; Flgm. IV about 1.8 times as long as wide, bristle–like hair shorter than width of Flgm; maxillary palpus short; wings slender than male.

Body length: 1.4 mm

Material examined. Korea, 4 males, 3 females: Jeongam–ri, Hoengseong–eup, Hoengseong–gun, GW, 14.vi.2009 (larvae, collected under the bark of shiitake logs and reared in the laboratory) Leg. S. Shin.

Habitats. The larvae were found on the shiitake mushroom (*Lentinula edodes*) logs.

Distribution. New to Korea *, Britain, Czech Republic, Germany, Russia, Ukraine, (Buck et al., 1997; Mohrig and Krivosheina, 1986).

Remarks. This species is easily recognized by the one spear–like spine below middle of inner side on the gonostylus, with apically 3 ~ 4 strong and short spines.

Corynoptera micula Hippa, Vilkamaa and Heller 2010 * (Plate A–8)

Corynoptera micula Hippa et al. (2010): 45–46.

Description. *Male*. Head: eye bridge 3 facets wide. Ant. paler; Flgm. IV (Plate A–8E) about 1.9 ~ 2.7 times as long as wide; bristles as long as width of basal segment. Maxillary palpus (Plate A–8D) three–segmented; basal segment with 1 or 2 bristles, and with patch of sensillae; second segment as long as base segment, third segment about 1.8 ~ 2.0 times as long as 2nd.

Thorax: brown, with dark hairs. Posterior pronotum without bristles. Anterior pronotum with 3 setae. Episternum 1 with 7 ~ 8 setae. Wings (Plate A–8C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M is longer than M–fork; x = y, bare; stem of CuA = 1/3 x; R_1 = R; R_5 dorsally with macrotrichia; length of C = 3/4 w. Halteres pale brown. Legs pale yellowish brown; apex of fore tibia with dark and strong bristle group, forming an uneven comb–like row (Plate A–8F); claws untoothed.

Abdomen: genitalia (Plate A–8A) brown and wider than high and without basal lobe; ventrally sparse haired, few setae at middle apical part were elongated. Gonostylus (Plate A–8B) slightly swollen, and sparse bristles, with few elongated setae; with one apical tooth, and 3 spines as long as tooth. Tegmen membranous, rounded and as high as wide, with narrow dorsal finger–like structure. Aedeagus long.

Body length: 2.3 mm

Material examined. Korea, 4 males: Mt. Ungil, Sonchon–ri, Choan–myeon, Namyangju–si, GG, altitude 99 m, 4 males, 26.vi ~ 16.vii.2009, Malaise trap, Leg. J. Lim.

Habitats. This species ware collected in forest from Japan (Hippa et al., 2010).

Distribution. New to Korea *. Japan (Hippa et al., 2010).

Remarks. Hippa et al. (2010) described *C. micula* similar with *C. uncata* and *C. uncinula* by its swollen gonostylus. However, this species recognized by having finger–like structure on tegmen. Furthermore, it differs from *C. uncata* by having gonostylus spines stout and curved, not slender needle–like and straight and from *C. uncinula* by having the gonostylus spines sharper and more strongly curved, and difference from both species by having the mesial side of the gonostylus more widely impressed.

Corynoptera saetistyla Mohrig and Krivosheina 1985 (Plate A–9)

Corynoptera saetistyla Mohrig et al., (1985b): 253.

Corynoptera densiseta Mohrig and Menzel 1990: 280.

Description. *Male*. Head: eye bridge 3 facets wide. Ant. pale–yellow, with very short neck; Flgm. IV (Plate A–9E) about 2.0 ~ 2.8 times as long as wide; bristles as long as width of Flgm. Maxillary palpus (Plate A–9D) three–segmented; basal segment with 1 bristle, and without patch of sensillae; second and third segments as long as base segment, third segment about 1.0 ~ 1.2 times as long as 2nd.

Thorax: dark, with dark hairs. Posterior pronotum with bristles. Wings (Plate A–9C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M longer than M–fork; x = 1.0 ~ 1.2 y, bare; stem of CuA = 1/3 x; R_1 = 5/6 R; R_5 dorsally with macrotrichia; length of C = 3/4 w. Halteres dark. Legs brown; apex of fore tibia with dark and strong bristle group, forming an uneven comb–like row (Plate A–9F); claws untoothed.

Abdomen: genitalia (Plate A–9A) brown, wider than high and without basal lobe; ventrally sparse long haired. Gonostylus (Plate A–9B) short, and sparse bristles, with few elongated setae; with one short apical tooth, and 4 spines longer than tooth. Tegmen membranous, rounded and wider than high, with small dorsal finger–like structure. Aedeagus short.

Body length: 1.8 ~ 2.0 mm

Material examined. Korea, 1 male: Mt. Yongmun, Yongmun–myeon, Yangpyeong–gun, GG, altitude 324 m, 1 male, 26.vi ~ 16.vii.2009, Malaise trap. Leg. J. Lim.

Habitats. Found in woodland; wetlands including water meadows, fens with *Cladium* and *Phragmites* beds; reed and sedge beds, bogs and lakeshore (Menzel et al., 2006).

Distribution. Korea, Austria, Canada, Czech Republic, Estonia, Finland, Germany, Great Britain, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Russia (Amur region, Vologda region, Adygeya Republic, Polar Ural, Primorsk region and Krasnodar region), Sweden, Slovakia, Slovenia, Switzerland, Ukraine (Menzel et al., 2006; Mohrig et al., 1992; Rudzinski, 2009; Smith and Menzel, 2007).

Remarks. According to Hippa et al. (2010) *C. saetistyla* is similar to *C. grothae*, *C. inexspectata*. *C. saetistyla* from northern Sweden show tendency towards nearly complete reduction of apical tooth of gonostylus but are otherwise indistinguishable from the others.

Corynoptera barbata Tuomikoski 1960

Corynoptera barbata Tuomikoski (1960): 71.

Distribution. Korea (north), Finland (Mohrig et al., 1992; Tuomikoski, 1960).

Remarks. Mohrig et al. (1992) recorded this species in North Korea; however, I could not examine this species due to the lack of specimens.

Subfamily Chaetosciarinae Subfam. Nov. *

Type genus: *Chaetosciara* Frey 1942

Diagnosis. Flgm. cylindrical, neck of basal parts narrow [neck base to the basal part clearly separated (Plate A–10E)]; neck of Flgm. shorter than 1/2 wide of neck (Plate A–10E,11E). Wing membrane without macrotrichia (Plate A–28C); M–fork wing vein stretched [M and M_1 is not curved (Plate A–10C,11C,12C)]; apex of fore tibia with strong spines.

Key to genera of the subfamily Chaetosciarinae in the Korean Peninsula

1. length of Flgm. IV as long as wide, Flgm. surface honeycomb–like structure (Plate A–10E). .... *Chaetosciara* *

– length of Flgm. IV longer than wide, Flgm. surface without honeycomb–like structure (Plates A–11E, 12E). .... *Scythropochroa* *

Genus *Chaetosciara* Frey 1942 *

Type species: *Chaetosciara estlandica* (Lengersdorf 1929): *Sciara fenestralis* sensu Frey 1942 (= *Sciara estlandica* Lengersdorf 1929)

Chaetosciara umbalis Mohrig and Krivosheina 1990 * (Plate A–10)

Chaetosciara umbalis Mohrig and Krivosheina (1990): 225–226.

Description. *Male*. Head: eye bridge 4 ~ 5 facets wide. Ant. dark brown; Flgm. IV (Plate A–10E) about 1.0 ~ 1.2 times as long as wide; bristles about 1/2 times as long as width of Flgm. basal. with honeycomb–like surface structure. Maxillary palpus brown and three–segmented (Plate A–10D); basal segment with 5 ~ 7 bristles, and without patch of sensillae; sensilla fine; second segment ovate, third segment about 1.3 times as long as 2nd.

Thorax: reddish brown, with rough, long and dark hairs. Posterior pronotum bare. Mesonotum with long, strong, and dark hairs, with numerous strong and very long lateral and central bristles. Scutellum with 3 ~ 4 strong, long bristles, with numerous short bristles. Katepisternum triangular. Wings (Plate A–10C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M little bit shorter than M–fork; x = 3/4 y, bare; stem of CuA = 1/3 ~ 1/2 x; R_1 = 1.2R; R_5 dorsal and apex of ventral with macrotrichia; length of C = 3/4 w. Halteres short stalked and brown. Legs pale yellow; apex of fore tibia with dense bristles without curved margin (Plate A–10F); claws untoothed.

Abdomen: genitalia (Plate A–10A) dark, much wider than high, with coarse bristles; base of gonocoxite with basal lobe, apex bare and side with 4 ~ 6 marginal bristles; base of gonocoxite emarginated v–shaped. Gonostylus long about 1.7 times as long as wide, apical bristles coarse and long; apex of gonostylus without tooth, and with 3 strong spines; long bristles in middle of inside of gonostylus; ventrally inside emarginated and short haired. Tegmen wider than higher, square shaped, with teeth. Aedeagus slender, and short.

Body length: 2.1 ~ 2.3 mm

Female. Unknown.

Material examined. Korea, 2 males: youngnam–dong, Seoguipo–si, JJ, 1 male, 08.v.2009, Shiitake mushroom farm, Leg. S. Shin.; Doradaedae, Munsan–eup, Paju–si, GG, 1 male, 21.vii.2008, Leg. S. Shin.

Habitats. Collected from Shiitake mushroom farm in Korea. widespread in broad–leaved wood–land; also found in bogs; lakeshore (Menzel et al., 2006).

Distribution. New to Korea *. Russia Far East (Primorsky Krai), Japan.

Remarks. The *Ch*. *umbalis* is recognized the bare basal lobes and the short Flgm. segments with honeycomb–like surface structure. *Ch*. *estlandica* is similar but clearly differs in the shorter Flgm. short limbs, and spine on apex of gonostylus.

Genus *Scythropochroa* Enderlein 1911 *

Type species: *Scythropochroa latefurcata* Enderlein 1911

Key to the species of the genus *Scythropochroa* in the Korean Peninsula

1. Apex of gonostylus tapered, with 3 slightly curved spines (Plate A–11B). ... *Scy*. *Radialis* *

– Apex of gonostylus rounded, without spines (Plate A–12B). .... *Scy*. *pseudoquercicola* sp. nov. *

Scythropochroa radialis Lengersdorf 1926 * (Plate A–11)

Scythropochroa radialis Lengersdorf 1926: 123–124.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. slightly rough and dark brown; Flgm. IV (Plate A–11E) about 2.0 ~ 2.5 times as long as wide, distinct short and unicolored neck; bristles 1/2 ~ 2/3 as long as the width of neck. Maxillary palpus (Plate A–11D) one–segmented and dark; basal segment with 3 ~ 7 bristles, and without clear patch of sensillae; sensilla long and curved.

Thorax: dark, hairs are sparse and dark. Posterior pronotum bare. Mesonotum dark, sparse hairs with slightly long lateral bristles. Scutellum with slightly long and dense bristles. Katepisternum triangular. Wings (Plate A–11C) large and dark brown; posterior veins and wing membrane without macrotrichia; stem of M as long as M–fork; x = 1.0 y, 3 bristles on y; stem of CuA = 2/3 x; R_1 very long, = 2.0 ~ 2.5 R and joining C over Stem of M; length of C = 3/4 w. Halteres short stalked and brown. Legs dark yellow; apex of fore tibia with coarse bristles groups (Plate A–11F); spurs of mid and hind tibia same long; claws untoothed.

Abdomen: genitalia (Plate A–11A) dark and wider than high; coarse and dark bristles; without significant basal lobes or hairs. Gonostylus (Plate A–11B) swollen, pointed out and rounded apically; apical with 3 slightly curved spines, including bristles. Tegmen slightly wider than high. Laterally sclerotized and apex broadly rounded (or sometimes trapezoid). Aedeagus very long and strong; end of aedeagus strongly sclerotized.

Body length: 4.6 ~ 5.0 mm

Female. Unknown.

Material examined. Korea, 3 males: Mt. Ungil, Sonchon–ri, Choan–myeon, Namyangju–si, GG, 99 m, 26.vi.2009 ~ 16.vii, 2009, malaise trap, Leg. J. Lim.

Habitats. Common in all types of woodland; heath land; wetlands including fens and water meadows; grassland at woodland fringe; acid grassland and wet woodland; parkland. Reared from rotten elm, birch and beech wood; also found on dead pines (Menzel et al., 2006; Sutou and Ito, 2004).

Distribution. New to Korea *, Albania, Britain, Finland, Germany, Japan, Russian far east (Menzel and Mohrig, 2000; Menzel et al., 2006; Sutou and Ito, 2004).

Remarks. This species similar with *Sc*. *quercicola* but differs in size, longer fork of M and narrow gonostylus.

Scythropochroa pseudoquercicola sp. nov. * (Plate A–12)

Diagnosis. This species have longer Flgm. IV than *Scy*. *Quercicola*. Posterior pronotum with bristles; tegmen laterally strongly curved S–shaped.

Description. *Male*. Head: eye bridge 2 ~ 4 facets wide. Ant. long, rough and dark brown; Flgm. IV (Plate A–12E) about 2.7 ~ 3.0 times as long as wide, distinct unicolored neck; bristles about 3/2 times as long as diameter of Flgm. basal. Maxillary palpus (Plate A–12D) one–segmented and around of sensilla pit is dark brown; basal segment with 4 ~ 8 bristles, and with pitted patch of sensillae. Clypeus with dark bristles.

Thorax: dark, with sparse dark hairs. Posterior pronotum with bristles. Mesonotum dark and short hairs with long lateral bristles. Scutellum with long bristles. Katepisternum triangular. Wings (Plate A–12C) dark brown; posterior veins and wing membrane clearly without macrotrichia; stem of M slightly longer than M–fork; x = 0.7 ~ 1.0 y, 3 ~ 5 bristles on y; stem of CuA = 1/2 ~ 1 x; R_1 = 2.0 ~ 2.1 R and joining C over stem of M; length of C = 4/5 w. Halteres short stalked and brown, with several row of bristles. Legs pale yellow; apex of fore tibia coarse bristles (bristles on apical parts almost row like but out of alignment) (Plate A–12F); spurs of mid and hind tibia same long; claws untoothed.

Abdomen: genitalia (Plate A–12A) dark and wider than high; short and dark bristles, base of gonocoxite with bristles. Gonostylus (Plate A–12B) large and swollen, apically rounded, apical bristles densely furred, Gonostylus inner apex with four short spines on lobe; tegmen strongly sclerotized, lateral parts strong curved S–shaped and apical part broadly rounded. Aedeagus extremely short and strong.

Body length: 4.0 ~ 4.5 mm

Female. Unknown.

Material examined. *Holotype male*. Mt. Yeogi, Seodun–dong, Gwonseon–gu, Suwon–si, GG, Korea, 17.vii.1995, Leg. H. Lee. *Paratype*. 1 male, same data as holotype; Mt. Ungil, Sonchon–ri, Choan–myeon, Namyangju–si, GG, altitude 99 m, 6 males, 26.vi.2009 ~ 16.vii.2009, malaise trap, Leg. J. Lim.

Distribution. Korea *

Remarks. This species is very similar with *Scythropochroa quercicola* (Winnertz, 1869). However, easily recognized by differences as fallows. Flgm. IV is long, about 2.7 ~ 3.0 times as long as wide; posterior pronotum with bristles; tegmen laterally strongly curved S–shaped; aedeagus extremely short and strong.

Subfamily Lycoriellinae Subfam. Nov *

Type genus: *Lycoriella* Frey 1942

Diagnosis. Inner side of gonostylus with a whip–like long hair (Plates A–17B, 18B). Apex of fore tibia with curved margin on apex of fore tibia (except *Xylosciara*) (Plates A–15F, 17F).

Key to genera of the subfamily Lycoriellinae in the Korean Peninsula

1. Apex of fore tibia without curved margin (Plate A–18F). .... *Xylosciara*
– Apex of fore tibia with curved margin (Plates A–14F, 17F). 2

2. Apex of gonostylus tapered and with strong tooth, middle of inner side with a whip–like hair toward apex (Plate A–4B). .... *Lycoriella*
– Apex of gonostylus usually rounded and without strong tooth, near the apex of inner side with a whip–like hair toward base (Plate A–7B). .... *Pseudolycoriella*

Genus *Lycoriella* Frey 1942

Type species: *Lycoriella* (s. str.) *castanescens* (Lengersdorf 1940): *Bradysia* (*Chaetosciara*) *paucisetulosa* Frey 1948 (=*Neosciara castanescens* Lengersdorf 1940)

Key to species of the genus *Lycoriella* in the Korean Peninsula

1. Ventral side of gonocoxite broadly semicircular; gonostylus swollen (Plate A–15A, B). .. 2
– Ventral side of gonocoxite V–shaped; gonostylus narrow (Plates A–13A, 14A). 3

2. Inner side of gonostylus with two strong hyaline spines, which are as long as apical tooth (Plate A–15B). .... *L*. (*Hemineurina*) *flavicornis*

– Inner side of gonostylus with two bristle–like hyaline spines (Plate A–16B). .... *L*. (*Hemineurina*) *venosa*

3. basal lobes on ventral inner surface of the gonocoxite bristles hyaline and moderately long (Plate A–13A). .... *L*. (s. str.) *castanescens* *

– basal lobes on ventral inner surface of the gonocoxite bristles darken and moderately short (Plate A–14A). .... *L*. (s. str.) *ingenue*

Lycoriella* (s. str.) *castanescens (Lengersdorf 1940) * (Plate A–13)

Neosciara castanescens Lengersdorf 1940: 28–29.

Bradysia (Chaetosciara) *difficilis* Frey 1948: 64, 82.

Bradysia (Chaetosciara) *fucorum* Frey 1948: 60, 80.

Bradysia (Chaetosciara) *paucisetulosa* Frey 1948: 63, 82.

Lycoriella (Lycoriella) *rufotincta* Tuomikoski 1959: 172.

Lycoriella agarici Loudon 1978: 163–165.

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. dark brown; with whitish–yellow to brownish bristles; Flgm. IV (Plate A–13E) about 2.5 ~ 2.7 times as long as wide, bristles 2/3 as long as width of neck; neck short. Maxillary Palpus (Plate A–13D) three–segmented relatively short; basal segment with several bristles, with deeply pitted patch of sensillae; final segment about 1.1 times as long as 2nd. Clypeus bristles pale and fine.

Thorax: dark brown, hairs short and fine. Posterior pronotum bare. Mesonotum bright with sparse hairs and few lateral bristles. Scutellum with 2 ~ 3 long marginal bristles. Wings (Plate A–13C) narrow and light brown; posterior veins clear and wing membrane without macrotrichia; stem of M 1.1 ~ 1.2 times longer than M–fork; x = 1.0 ~ 1.5 y, bare; stem of CuA = 1/2 ~ 2/3 x; R_1 short, = 1/3 R; length of C = 3/5 w. Halteres moderately long stalked and yellow. Legs light yellow; apex of fore tibia with curved margin and bristles group (apex bristles row like but out of alignment) (Plate A–13F); spurs of mid and hind tibiae same; claws untoothed.

Abdomen: genitalia (Plate A–13A) pale to dark brown and as high as wide; base of gonocoxite with distinct bristles group; basal bristles group is hyaline and moderately long. Gonostylus (Plate A–13B) pointed and rounded apically with strong and dark apical tooth, inner side with 4 ~ 6 diverging spines (number and arrangement varying), in lower third of stylus with long whip like hair. Tegmen wider than high, laterally sclerotized; rounded broadly. Aedeagus long.

Body length: 2.0 ~ 2.6 mm

Female. Flgm. segments shorter; Flgm. IV = 2.2 ~ 2.4 times as long as wide; CuA = 1/3 to 1/4 x, and others same, Size: 2.2 ~ 3.0 mm.

Material examined. Korea: 1 male. National Institute of Highland Agriculture, Hoenggye–ri, Daegwallyeong–myeon, Pyeongchang–gun, GW, 37°40'52.26"N, 128°43'41.22"E, 767 m, 08.vi.2010. Collected in onion greenhouse, Leg. S. Shin.

Habitats. Collected in onion greenhouse from Korea. Common in broad–leaved and carr woodland; also found in mixed woodland; wet and humid heath land; wetlands including fen; reed and sedge beds, raised mire and water meadows; gravel pits; old hedges; grassland with ping pools; unimproved calcareous grassland; parkland; gardens; grounds of horticultural research station; school grounds with old poplars; decaying vegetation by race track; vegetable detritus on cliff top with salty spray; shingle beach; greenhouses; mushroom farms. Reared from nests of dormouse, mole, moorhen, coot, linnet and blackbird; rotten fungus–covered wood; daffodil bulbs; haystack; old wasp nest; rotting onions; stable manure; mushroom compost; the fungi *Laetiporus sulphureus* and *Lepiota cristata*; soil from rabbit burrow; crowns of sea kale (Menzel and Mohrig, 2000; Menzel et al., 2006)

Distribution. New to Korea *, British, Taiwan, Sweden (Heller et al., 2009; Rudzinski, 2006; Smith and Menzel, 2007).

Remarks. This species differs with *L*. *ingenua* in the basal group of bristles on the ventral inner surface of the gonocoxite, basal bristles group is hyaline and moderately long.

Lycoriella* (s. str.) *ingenua (Dufour 1839) (Plate A–14)

Sciara ingenua Dufour 1839: 29–31.

Molobus mali Fitch 1856: 484–487.

Sciara bigoti Laboulbene 1863: 105–110.

Sciara celer Winnertz 1867: 113.

Sciara debilis Winnertz 1867: 116.

Sciara decliva Winnertz 1867: 121–122.

Sciara flaviventris Winnertz 1867: 116–117.

Sciara humilis Winnertz 1867: 117–118.

Sciara velox Winnertz 1867: 111.

Sciara venusta Winnertz 1867: 115–116.

Sciara segnis Winnertz 1871: 858–859.

Sciara solani Winnertz 1871: 852–853.

Sciara pauciseta Felt 1897: 224–225.

Sciara ramicola Kieffer 1919: 201, 202–203.

Bradysia (*Chaetosciara*) *mycorum* Frey 1948: 59, 80.

Psilosciara flammulinae Sasakawa 1983: 321.

Lycoriella ingenua: Menzel and Mohrig 2000: 393.

Description. *Male*. Head: eye bridge 3 facets wide. Ant. unicolored brown; Flgm. IV (Plate A–14E) about 1.8 ~ 2.8 times as long as wide, bristles bright slightly longer than wide of neck; neck short. Maxillary palpus (Plate A–14D) short and three–segmented; basal segment with several bristles (one of them much longer than others), and with patch of sensillae; sensilla fine; 3rd segment narrow and about 1.5 times as long as 2nd.

Thorax: dark brown. Posterior pronotum bare. Mesonotum bright and sparse haired; lateral and scutellum bristles strong. Wings (Plate A–14C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M as long as M–fork; x = 1.0 ~ 1.3 y, both bare; stem of CuA = 1/2 x; R_1 = 4/5 R; R_5 dorsal and apex of ventral with macrotrichia; length of C = 2/3 ~ 4/5 w. Halteres paled–grey short stalked. Legs yellowish brown, long and narrow; apex of fore tibia with dense bristles group and sharp margin (Plate A–14F); claws untoothed.

Abdomen: genitalia higher than wide; basal lobes with bright sparse hairs. Gonostylus (Plate A–14B) pointed and narrowed apically with strong apical tooth, inner side with 6 ~ 7 hyaline spines (number and arrangement varying), ventral side gonostylus almost naked, only the top third with dense hair, in lower third of stylus with long whip like hair. Tegmen slightly wider than high, laterally sclerotized; evenly rounded apically; tooth area as high as wide with fine teeth. Aedeagus short.

Body length: 2.2 ~ 3.0 mm

Female. Unknown.

Material examined. Korea, 48 males: Jeongam–ri, Hoengseong–eup, Hoengseong–gun, GW, 3 males, 3.xi.2007, Leg. S. Shin.; *ditto*, 4 males, 4.iv.2008, Leg. S. Shin.; Soksa–ri, Yongpyeong–myeon, Pyeongchang–gun, GW, 27 males, 18.viii.2009, Leg. S. Shin.; Gwangpyeong–ri, Jangpyeong–myeon, Jangheung–gun, JN, 14 males,16.v.2009, Leg. S. Shin.

Habitats. Adults and larvae have been found in glasshouses, crop fields, and in mushroom nurseries (*Agaricus bisporus*, *Lentinula edodes*, and *Pleurotus ostreatus*). The larvae have also been found on rotten wood and decaying potatoes (Lee et al., 1999).

Distribution. Korea, Japan, Europe, North America.

Remarks. *L*. *ingenua* is differs with *L*. *castanescens* by the conspicuous bristles on basal lobe of male genitalia. And gonostylus is narrower.

Lycoriella* (*Hemineurina*) *flavicornis Mohrig and Mamaev 1985 * (Plate A–15)

Lycoriella (*Hemineurina*) *flavicornis* Mohrig et al., 1985: 430

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. brown; Flgm. IV (Plate A–15E) about 2.8 ~ 3.0 times as long as wide, bristles light, fine and short, base of Flgm. I yellow and/or base of Flgm. II yellow; bristles as long as width of neck. Maxillary palpus (Plate A–15D) three–segmented and yellow; basal segment with 5 ~ 6 bristles, and without detailed patch of sensillae; final segment about 1.5 times as long as 2nd.

Thorax: dark brown, hairs fine and short. Posterior pronotum bare. Mesonotum with fine hairs without long lateral bristles. Scutellum without long marginal bristles. Wings (Plate A–15C) light brown; posterior veins clear and wing membrane without macrotrichia; stem of

M slightly shorter than M–fork; x = 0.8 y, 2 bristles on y; stem of CuA = 1/2 x; R_1 short, = 2/3 R; length of C = 1.0 w. Halteres yellow. Legs yellow; apex of fore tibia with curved margin and fine bristles group, almost row like bristles (Plate A–15F); spurs of mid and hind tibiae same; claws untoothed.

Abdomen: genitalia (Plate A–15A) yellow and little wide; base of gonocoxite without lobe or bristle groups. Gonostylus (Plate A–15B) inside arcuate and narrowed apex, apical tooth slightly curved, long and dark, with two hyaline spines near apex and two more inside; in lower third of stylus with long whip like hair. Tegmen wider than high and trapezoid, (middle of tegmen apex swollen like lobe). Aedeagus moderately long.

Body length: 2.2 ~ 3.0 mm

Female. Unknown.

Material examined. Korea, 1 male: Jinjo–ri, Bongpyeong–myeon, Pyeongchang–gun, GW, 37°33'28.58''N, 128° 20'31.63''E, 584 m, 1 male, 29.v.2009. Sweeping, Leg. S. Shin.

Distribution. New to Korea *, China, Russia (Menzel and Mohrig, 2000; Zhang, 1990).

Remarks. This species is easily recognized by two hyaline spines standing on shared lobe in middle of gonostylus. Korean species bristles on body moderately longer than other region.

Lycoriella* (*Hemineurina*) *venosa (Staeger 1840) (Plate A–16)

Sciara venosa Staeger 1840: 285–286.

Sciara lepida Winnertz 1867: 148–149.

Lycoria (*Neosciara*) *crassivenosa* Lengersdorf 1943: 4–5.

Lycoriella (*Hemineurina*) *praevenosa* Mohrig and Menzel 1990: 337–338.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. brown; Flgm. IV (Plate A–16E) about 3.2 times as long as wide, bristles light, fine and short; bristles as long as width of neck. Maxillary palpus (Plate A–16D) three–segmented and yellow; basal segment with 4 ~ 5 bristles, and without detailed patch of sensillae; final segment about as long as 2nd.

Thorax: dark, hairs fine and short. Posterior pronotum bare. Mesonotum with fine hairs without long lateral bristles. Scutellum without long marginal bristles. Wings (Plate A–16C) light brown; posterior veins clear and wing membrane without macrotrichia; stem of M as long as M–fork; x = 0.6 y, bare; stem of CuA = 1/2 x; R_1 short, = 2/3 R; length of C = 1.0 w. Halteres yellow. Legs yellow brown; apex of fore tibia with curved margin and fine bristles group, (Plate A–16F); spurs of mid and hind tibiae same; claws untoothed.

Abdomen: genitalia (Plate A–16A) brown and little wide; base of gonocoxite without lobe or bristle groups. Gonostylus (Plate A–16B) inside arcuate and narrowed apex, apical tooth slightly curved, long and dark, with two hyaline bristle–like spines near apex and more short spines on inside; in lower third of stylus with long whip like hair. Tegmen wider than high and rounded. Aedeagus moderately long.

Body length: 3.0 mm

Female. Unknown.

Material examined. Germany, 1 male: Wasserfälle, Hinanger, Hinang (Bay), Sonthofen, 1 male, 26.v.2004, Leg. K. Heller.

Distribution. Korea (north), Germany, Hungary (Menzel and Heller, 2006; Mohrig et al., 1992; Rulik et al., 2001).

Remarks. Mohrig et al., 1992 recorded this species in North Korea; however, I could not examine Korean species due to the lack of specimens. This species is easily recognized by two bristle–like hyaline spines standing on shared lobe in middle of gonostylus.

Genus *Pseudolycoriella* Menzel and Mohrig 2000

Type species: *Pseudolycoriella bruckii* (Winnertz 1867): *Sciara bruckii* Winnertz 1867

Key to species of the genus *Pseudolycoriella* in the Korean Peninsula

1. Gonostylus about 2.5 times as long as wide; upper gonostylus with 4 ~ 5 spines; below the apex; with long whip–like bristles. .... *P. koreensis*

– Gonostylus about 1.5 times as long as wide; two spines in the middle of apex; strong tooth with whip–like hair on below of apex (Plate A–17A). .... *P. horribilis* *

Pseudolycoriella koreensis (Mohrig and Menzel 1992)

Lycoriella koreensis Mohrig et al., 1992: 23.

Description. *Male*. Head: eye bridge 3 facets wide. Flgm. IV about 1.8 times as long as wide; Flgm. bristles little longer than with of Flgm. Maxillary palpus pale and three–segmented; basal segment without sensillae fit; sensilla long and curved.

Thorax: dark. Posterior pronotum bare. Mesonotum, lateral scutellum with strong bristles. Wings light brown; posterior veins poorly developed and without macrotrichia. Apex of fore tibia with slightly curved margin with bristles; claws toothed.

Abdomen: genitalia as high as wide; gonocoxites base without basal lobes or ventral hair; inside of basal gonocoxite covered with short hairs. Gonostylus about 2.5 times as long as wide; upper gonostylus with 4 ~ 5 spines; below the apex with long whip–like bristle. Tegmen rounded apically; toothed area small. Aedeagus slander moderately long

Body length: 2.0 mm

Female. Unknown.

Material examined. Great Britain, 1 male: Deer park SW von Helmsley, North Yorkshire, England, 54°14’17”N, 01°05’53”W, altitude 90 ~100 m, 7.viii.2005, leg F. Menzel. Spain, 1 male: Mte. Jaizkibel, Gipuzkoa, 300 m, 8.viii.1991, leg. Hartmann.

Habitats. Found on sandy heath land (Menzel et al., 2006)

Distribution. Korea (north), Africa, British, Japan, Nepal, Spain (Mohrig et al., 1992; Mohrig et al., 1999; Rudzinski, 1997; Smith and Menzel, 2007).

Remarks. Mohrig et al. (1992) recorded this species in North Korea; however, I could not examine Korean specimens.

Pseudolycoriella horribilis (Edwards 1931) * (Plate A–17)

Sciara horribilis Edwards 1931: 274–275.

Corynoptera longiculmi Alam 1988: 120–121.

Description. *Male*. Head: eye bridge 3 facets wide. Ant. dark and rough; Flgm. IV (Plate A–17E) about 2.6 times as long as wide, bristles dense and 1/2 times as long as wide of neck. Maxillary palpus (Plate A–17D) very long and three–segmented; all segment slander and equal length; without sensillae pit; sensilla very fine and short; basal segment with 4 long bristles (one of them much longer than others).

Thorax: yellowish brown. Posterior pronotum bare. Mesonotum with sparse and fine bristles; 5 ~ 6 lateral long bristles. Wings (Plate A–17C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M slightly longer than M–fork; x = y, both bare; stem of CuA = 2/3 x; R_1 = 0.8 R; R_5 dorsally and apex of ventral with macrotrichia; length of C = 2/3 w. Halteres dark brown and short stalked. Legs pale, long and narrow; apex of fore tibia small curved margin with row–like bristles (Plate A–17F); claws finely toothed.

Abdomen: genitalia (Plate A–17A) much wider than high; deeply emarginated anteriorly without basal lobes and central bristles; inside of gonocoxite with short and sparse hairs. Gonostylus (Plate A–17B) strongly compact; upper half completed angled and anteriorly slightly concaved; apex with dense and strong bristles; two spines in the middle of apex; strong tooth with whip–like hair on below of apex. Tegmen much wider than high, strongly sclerotized and with finger–shaped structure; tooth area higher than wide. Aedeagus with short and very broad, base bulbous.

Body length: 3.0 mm

Female. Unknown.

Material examined. Korea, 2 males: Chusan–ri, Okryoung–myeon, Gwangyang–si, JN, 2 males, 16.vi.2009, Leg. S. Shin.; China, 3 males: Jilin–sung, 3 males, 16.vi.2009, Leg. S. Shin.

Distribution. New to Korea *. Russia, Sumatra, New Guinea (Menzel and Mohrig, 2000).

Remarks. This species recognized in long maxillary palpus without sensillae pit and with more than one bristle on the basal, claws toothed; almost single row of bristles on fore tibia with the curved boundary.

Genus *Xylosciara* Tuomikoski 1957

Type species: *Xylosciara* (*Trixylosciara*) *trimera* Tuomikoski 1960

Xylosciara inornata Mohrig and Krivosheina 1979 (Plate A–18)

Xylosciara inornata Mohrig et al., 1979: 581–582

Description. *Male*. Head: eye bridge 3 facets wide. Antennae long; Flgm. IV (Plate A–18E) about 2 times as long as wide, with unicolor distinct neck, sparsely and more short–haired than diameter of basal part of Flgm. Maxillary Palpus (Plate A–18D) two–segmented; basal segment with 8 bristles and patch of sensillae. Clypeus with 2 ~ 3 hairs.

Thorax: dark brown. Posterior pronotum bare. Mesonotum with dark and moderately short central and prescutellar hairs. Scutellum with 4 strong bristles and some short hairs. Wings (Plate A–18C) smoky; length of R_1 = 1/2 R; R_5 only dorsally with macrotrichia; length of y = 1/2 x; length of C = 2/3 w; posterior veins bare. Halteres darkened. Legs yellowish–brown; apex of fore tibia without distinctly arranged bristles (Plate A–18F); spurs of mid and hind tibiae equal, shorter than diameter of apex; claws untoothed.

Abdomen: tergal and sternal hairs short. Genitalia (Plate A–18A) ventrally sparse short–haired, also inner margin of gonocoxites. Gonostylus (Plate A–18B) swollen, with curved apical tooth and 4 subapical spines. Tegmen trapezoid–shaped, apical part is not strongly sclerotized. Aedeagus moderately long.

Body length: 1.3 mm.

Female. Very similar to *X. betulae*. It is distinguished by the relatively pale coxa and short M–fork.

Material examined. Korea, 5 males: Jeongam–ri, Hoengseong–eup, Hoengseong–gun, GW, 1 male, 3.xi.2007, Leg. S. Shin.; *ditto*, 1 male, 15.iv.2008, Leg. S. Shin.; *ditto*, 2 males, 02.v.2008, Leg. S. Shin.; *ditto*, 1 male, 14.vii.2009, Leg. S. Shin.

Habitats. The larvae were found on shiitake mushroom logs (*Lentinula edodes*). According to Mohrig et al. (1979), they live under the bark of the oak.

Distribution. New to Korea *, Russia (Amur region).

Remarks. *X*. *inornata* is easily recognized by the club shaped gonostylus with curved apical tooth and 4 subapical spines.

Xylosciara* (*Xylosciara*) *steleocera Tuomikoski 1960

Xylosciara (*Xylosciara*) *steleocera* Tuomikoski 1960: 91–94.

Distribution. Korea (north), Russia, Slovakia, Sweden (Menzel and Heller, 2006; Rudzinski, 2009).

Remarks. Mohrig et al., 1992 recorded this species in North Korea, however, I could not examine this species due to the lack of specimens.

Subfamily Megalosphyninae Enderlein 1911

Type genus: *Pseudosciara* (Edwards 1934) [=Megalosphys Enderlein 1911]

Diagnosis. Apex of fore tibia with strict comblike row on the lobe like structure (Plate A–22F).

Key to genera of the subfamily Megalosphyninae in the Korean Peninsula

1. Fork of M wing vein widely curved (Plates A–38C, 39C, 40C). .... *Zygoneura*

– Fork of M wing vein slightly curved. 2

2. M and CuA wing vein with macrotrichia (Plates A–33C, 34C). 3

– M and CuA wing vein without macrotrichia(Plates A–29C, 37C). 4

3. Comb like spines on apex of fore tibia strict row shaped. .... *Ctenosciara*

– Comb like spines on apex of fore tibia slightly irregular. .... *Phytosciara*

4. Comb like spines on apex of fore tibia on small lobe. .... *Scatopsciara*

– Comb like spines on apex of fore tibia on wide carina (Plate A–22F). .... *Bradysia*

Genus *Bradysia* Winnertz 1867

Type species: *Bradysia angustipennis* Winnertz 1867

Key to species of the genus *Bradysia* in the Korean Peninsula

1. Tegmen trapezoid, membranous or weakly sclerotized; apex flattened (Plate A–22A). Sensory area of basal segment of maxillary palpus small, roundish, dark and deeply pitted. Mesonotum with sparse, short and really coarse hairs, often with very strong lateral bristles. 2

– Tegmen widely rounded (Plate A–29A) or conical (Plate A–29A), usually distinctly sclerotised. Basal segment of maxillary palpus with simple to flatly bordered sensory area or with larger, less distinct sensory pit. Mesonotum usually with sparse, fine, short hairs. 3

2. Ant. uniformly dark (Plate A–22E). Subapical of gonostylus without inner spines (Plate A–22B). .... *B. difformis*

– Neck of Ant. bright (Plate A–28E). Subapical of gonostylus with 2 ~ 3 inner spines (Plate A–28B). .... *B. ocellaris*

3. Ant. segments with bi–colored necks [pale and dark banded] (Plate A–27E, 19E); basal part scarred and with coarse transversely wrinkled surface structure. Apex of Gonostylus without claw shaped tooth. Genital apodeme long. 4

– Ant. segments usually with uniform colored necks (Plate A–20E). Apex of Gonostylus often with tooth. Genital apodeme short. 8

4. R_1 short; R_5 usually with only a single dorsal row of macrotrichia. Claws untoothed. Tegmen usually rounded, with short (Plate A–29A). Gonostylus, subapical with 3 ~ 4 short spines, not distinctly swollen basal appendage (Plate A–29B). 5

– R_1 long; sometimes R_5 with bristles on both sides; Claws toothed. Abdomen long with coarse hairs. Tegmen conical and narrowly rounded (Plate A–29A). Gonostylus, with long, strong and swollen basal appendage (Plate A–29B). 7

5. Inner 1/2 of gonostylus covered with 4 ~ 5 strong spines (Plate A–29B). .. *B. protohilaris* *

– Only near apex of gonostylus with 3 ~ 4 strong spines (Plate A–24B). 6

6. Apex of gonostylus broadly rounded (Plate A–25B). .... *B. hilaris*

– Apex of gonostylus slightly narrowed (Plate A–24B). .... *B. hilariformis* *

7. M–stem with macrotrichia; fork of M with dorsally macrotrichia (Plate A–27G), apex of gonostylus is convex (Plate A–27B). .... *B. longimentula*

– M–stem without macrotrichia; fork of M without dorsally macrotrichia, apex of gonostylus is rounded (Plate A–29B). .... *B. procera*

8. Neck of Ant. long, as long as wide of Flgm. Basal (Plate A–31E). .... *B. trispinifera*

– Neck of Ant. shorter than wide of Flgm. Basal. 9

9. Apex of gonostylus rounded and not curved, without apical spines; and subapical part with 4 spines (Plate A–20B). .... *B. atracornea* *

– Apex of gonostylus narrow and curved, with apical spines; and inner of subapical with only bristles (Plate A–19B). 10

10. Claw untoothed. .... *B. aprica* *

– Claw toothed. .... *B. Chlorocornea* *

Bradysia aprica (Winnertz 1867) * (Plate A–19)

Sciara aprica Winnertz 1867: 161–162.

Sciara Ingrate var. *varicornis* (Strobl 1910): 237.

Description. *Male*. Head: eye bridge 3 facets wide. Flgm. 1 and 2 members yellow, Flgm. IV (Plate A–19E) about 2.2 ~ 2.5 times as long as wide, with monochromatic brown distinct neck, rougher hairs that are shorter than width of basal part of Flgm. Maxillary Palpus

(Plate A–19D) three–segmented; basal segment with 3 bristles and without sensillae. Clypeus with 1–3 hairs.

Thorax: brown. Posterior pronotum bare. Mesonotum hairs light brown. Scutellum with 2 strong bristles and some short hairs. Wings (Plate A–19C) slightly clouded; R_1 = R; R_5 only dorsally with macrotrichia; y = x, bare; C = 2/3 w; sometimes with some macrotrichia. Halteres light yellow. Legs light yellow; fore tibia with comb–like row of bristles at inner apex (Plate A–19F); spurs of mid and hind tibiae equal, slightly longer than diameter of apex; claws untoothed.

Abdomen: very bright. Genitalia (Plate A–19A). ventrally sparse haired, and inner margin of gonocoxite fine haired. Gonostylus (Plate A–19B) browned on top and about 3 times as long as wide and moderately swollen, sub apically with 4 ~ 5 spines. Tegmen trapezoid–shaped and rounded up. Aedeagus short.

Body length: 2.5 mm

Female. Unknown.

Material examined. Korea, 3 males: SNU, garden, Suwon– si, GG, 1 male, 29.viii.2009, Leg. S. Shin.; Micheongol–Nat. Park, Seo–myeon, Yangyang–gun, GW, 2 males, 15.vii.2010, light trap, Leg. S. Shin.; Mt. Jeambong Nat. Park, Kilin–myeon, Injae–gun, GW, 1 male, 24.viii.2011, light trap, Leg. H. Choi.

Habitats. Found in woodland and wet meadow; very common on fens; reared from the fungus *Leccinum scabrum* and mole nest (Menzel et al., 2006)

Distribution. New to Korea *, Britain, Finland, Germany (Menzel, 2006; Salmela and Vilkamaa, 2005; Smith and Menzel, 2007).

Remarks. This species is very similar with *B. subaprica*. It differs in big size, darker Thorax, longer Flgm.

Bradysia atracornea Mohrig and Menzel 1992 * (Plate A–20)

Bradysia atracornea Mohrig et al., 1992: 21–22.

Description. *Male*. Head: eye bridge 3 facets wide. Ant. dark; Flgm. IV (Plate A–20E) about 2.3 times as long as wide, with bright unicolored neck, hairs shorter than width of neck of Flgm. Maxillary Palpus (Plate A–20D) three–segmented; basal segment with 2 ~ 3 bristles and with sensillae. Sensillae pit broad with long curved sensilla. Clypeus with 1 ~ 2 hairs.

Thorax: brown. Posterior pronotum bare. Mesonotum with short hairs and 2 long lateral bristles. Scutellum with 2 strong bristles and some short hairs. Wings (Plate A–20C) bright; R_1 = R; R_5 only dorsally with macrotrichia; y = x, bare; C = 2/3 w. Halteres brown. Legs light brown; fore tibia with bright comb–like row bristles at inner apex (Plate A–20F); spurs of mid and hind tibiae equal, slightly shorter than diameter of apex; claws 4 toothed basally.

Abdomen: genitalia (Plate A–20A) ventrally sparse short–haired, also inner margin of gonocoxite; gonostylus (Plate A–20B) darkened on top and about 2.5 times as long as wide 4–5 spines on subapical parts. Tegmen narrowly rounded. Aedeagus moderately long.

Body length: 1.5 ~ 2.0 mm

Female. Unknown.

Material examined. Korea, 2 males: Hoengseong–gun, GW, 2 males, 29.i.2009, scallion pot in the house, Leg. S. Lee.

Distribution. Korea, Japan (Mohrig et al., 1992).

Remarks. This species similar with *B. chlorides*, but differences in short gonostylus and unicolored neck of Flgm.

Bradysia chlorocornea Mohrig and Menzel 1992 * (Plate A–21)

Bradysia chlorocornea Mohrig et al., 1992: 28–29.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. dark brown, with coarse hair; base and neck of Flgm. I and II distinctly yellow; Flgm. IV (Plate A–21E) about 2.0 times as long as wide; bristles about 1/2 times as long as width of Flgm. basal. Maxillary palpus (Plate A–21D) three–segmented; basal segment with 2 ~ 3 bristles, with small patch of sensillae; sensilla short and fine; third segment about 1.5 times as long as 2nd.

Thorax: yellowish brown, with coarse and long hairs. Posterior pronotum without bristles. Wings (Plate A–21C) bright; posterior veins and wing membrane clearly without macrotrichia; stem of M longer than M–fork; x = y, bare; stem of CuA = 4/5 x; R_1 = 1/2 R; R_5 dorsally with macrotrichia; length of C = 2/3 w. Halteres dark. Legs pale yellow; apex of fore tibia with comb–like row bristles (Plate A–21F); claws toothed.

Abdomen: genitalia (Plate A–21A) dark, higher than wide and without basal lobe or hairs; base of gonocoxite emarginated v–shaped. Gonostylus (Plate A–21B) long about 2.5 times as long as wide, apical bristles coarse and variable; apex of gonostylus with tooth and 7 ~ 9 spines as long as tooth; upper half inside emarginated. Tegmen wider than higher, broadly rounded; aedeagus slender, and moderately long

Body length: 2.9 mm

Female. Unknown.

Material examined. Korea, 1 male: Micheongol–Nat. Park, Seo–myeon, Yangyang–gun, GW, 1 male, 15.vii.2010, light trap, S. Shin.

Distribution. New to Korea *, Japan.

Remarks. This species is similar with *B. scabricornis*, but differs in less rough Flgm. and 4 spines on apex of gonostylus.

Bradysia difformis Frey 1948 (Plate A–22)

Bradysia (*Chaetosciara*) *tristicula* var. *difformis* Frey (1948): 61, 83.

Bradysia paupera Tuomikoski 1960: 130, 134.

Bradysia agrestis Sasakawa 1978: 27.

Bradysia difformis: Menzel and Mohrig 2000: 152.

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. compressed, and uniformly dark; basal Flgm. (scape and pedicel) dark brown; Flgm. IV (Plate A–22E) 1.2 ~ 1.7 times as long as wide and with slightly roughened surface; hairs on Flgm. curved and erect, hairs one–half to two–thirds as long as width of Flgm.; necks short, uniformly dark brown, and distinct. Maxillary palpus (Plate A–22D) moderately long, three segmented and yellow to light brown; basal segment with 3 ~ 7 bristles and with darker, distinctly edged and deep sensory pit; sensillae blunt, long, and slightly curved; last segment 1.3 ~ 1.5 times as long as short, oval second segment; basal segment compact, slightly thickened and club shaped, and about as long as last segment.

Thorax: dark brown to black, with light brown to yellow areas laterally. Postpronotum bare. Mesonotum with strong and dark ground setae with long and lateral bristles. Katepisternum short and triangular, not elongated. Scutellum with three long, strong bristles among finer ground setae. Inner side of fore tibia with comblike row of 6 ~ 7 strong bristles. Mid and hind tibiae with two yellowish, thin and sub equal spurs. Tarsal claws untoothed. Wings (Plate A–22C) smoky gray–brown; posterior veins (all M and Cu) strong; wing membrane without macrotrichia; stem of M rather longer than fork of M; fork of M short, compressed and wide apart; x = y, both bare or end of y with one or two macrotrichia; stem of CuA 0.6 ~ 0.8 x; R_1 very short = 0.7 R and joining Costa well before base of fork of M; C = 1/2 w or only slightly longer. Halter brown with very short stalk. Coxae and femora light brown to whitish–yellow; tibiae and tarsi blackened because of thick, dark bristles. apex of fore tibia with comb–like row bristles (Plate A–22F).

Abdomen: genitalia (Plate A–22A) compact and almost as high as wide; ventral inner side without basal lobe or group of hairs; inner side of gonocoxites short, covered with dark hairs; hairs thicker and longer at most basally; tergite IX short, trapezoid, slightly emarginate apically and edged with several long bristles. Gonostylus (Plate A–22B) about 2.5 times as long as wide. Apex of gonostylus with thicker and coarser bristles, apex with distinct raised, thin, hooked tooth as well as 5 ~ 7 sub equal curved spines directed ventromedially. Tegmen wider than high, slightly curved laterally, and flatly rounded apically. Tooth field obviously wider than high and with strong single–tipped teeth. Aedeagus moderately long, and with sclerotized base.

Body length 1.8 ~ 2.1 mm.

Female. Flgm. IV not obviously shorter than male, but at most 1.6 ~ 2.0 times as long as wide. Maxillary palpus three segmented; basal segment often with larger sensory pit. Wing larger and narrower than male; stem of M obviously longer than fork of M; C = 2/3 w. All other characteristics as in male.

Body length: 1.9 ~ 2.3 mm

Material examined. Korea, 45 males: Jinbu–Myeon, Pyeongchang–gun, GW, 29 males, 18.viii.2009, Leg. S. Shin.; Jeongam–ri, Hoengseong–gun, GW, 1 male, 16.v.2008, Leg. S. Shin.; *ditto*, 2 males, 23.iv.2009, Leg. S. Shin.; *ditto*, 1 male, 14.vii.2009, Leg. S. Shin.; *ditto*, 1 male, 23.iv.2009 ~ 25.v.2009, malaise trap, Leg. S. Shin.; *ditto*, 1 male, 25.v.2009, Leg. S.

Shin.; Sanghyo–dong, Seoguipo–si, JJ, 1 male, 07.v.2009, Leg. S. Shin.; Jangheung–gun, JN, 9 males, 16.v.2009, Leg. S. Shin.

Habitats. The adult flies have been found on glasshouses, laboratories, fields, and mushroom houses (*Agaricus bisporus*, *A. blazei* and *Lentinula edodes*). The larvae were found on the stems and roots of young plants (*Antirrhinum* spp, beans, carnations, carrot, chrysanthemums, cucumbers, cyclamen, freesias, garlic, geraniums, hydrangea, lettuce, lilies, lucerne, lupins, maize, melon, peas, pelargonia, poinsettia, potatoes, radish, *Saintpaulia*, *Schlumbergera*, strawberries, sugarbeet, sweetpepper, sweetpotato). ruderal land, in deciduous (beech, copper beech, oak) or coniferous (pine, spruce) woods. The species has also been found on moorland (on peat moss) and in gardens (on ornamental plants).

Distribution. Korea, Azerbaijan, Brazil, Czech Republic, Finland, Germany, Great Britain, Italy, Japan, Latvia, Netherland, Russia, South Africa, Spain, Switzerland, USA.

Remarks. *B. difformis* is easily recognized by the very short, compressed Flgm. of the males.

Bradysia fungicola (Winnertz 1867) (Plate A–23)

Sciara fungicola Winnertz (1867): 137–138.

Sciara fera Winnertz 1867: 136–137.

Sciara ingrata Winnertz 1867: 143–144.

Sciara hercyniae Winnertz 1869: 663–664.

Sciara sylvicola Winnertz 1869: 664–665.

Sciara incana Strobl 1910: 236–237.

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. brown, with coarse hair; Flgm. IV (Plate A–23E) about 2.5 times as long as wide; bristles about 1/2 times as long as width of Flgm. basal. Maxillary palpus (Plate A–23D) three–segmented; basal segment with 2 ~ 4 bristles, without patch of sensillae; sensilla short and fine; third segment about 1.5 times as long as 2nd.

Thorax: brown, with coarse and long hairs. Posterior pronotum without bristles. Wings (Plate A–23C) bright; posterior veins and wing membrane clearly without macrotrichia; stem of M longer than M–fork; x = y, bare; stem of CuA = 2/3 x; R_1 = 5/6 R; R_5 dorsally with macrotrichia; length of C = 2/3 w. Halteres yellow. Legs pale; apex of fore tibia with comb–like row bristles (Plate A–23F); claws toothed.

Abdomen: genitalia (Plate A–23A) dark, wider than high and without basal lobe or hairs; base of gonocoxite emarginated v–shaped. Gonostylus (Plate A–23B) long about 2.9 times as long as wide, apical bristles coarse and variable; apex of gonostylus with short tooth and 5 ~ 8 spines as long as tooth. Tegmen as wide as high, broadly rounded; aedeagus slender, and moderately long

Body length: 3.0 mm

Material examined. Germany, 1 male: Garten, Koln–Poll (Nrw), 1 male, 9.iv.2002, Leg. Franzen.

Habitats. Common in broad–leaved and carr woodland; grassland (including calcareous); gardens; old hedges; coastal clay cliffs. Reared from fallen beech trunk and rotten wood (Menzel et al., 2006)

Distribution. Korea (north), Palaeartic region (Mohrig et al., 1992).

Remarks. Mohrig et al. (1992) recorded this species in North Korea; however, I could not examine this species due to the lack of specimens.

Bradysia hilariformis Tuomikoski 1960 * (Plate A–24)

Bradysia hilariformis Tuomikoski (1960): 127–128.

Description. *Male*. Head: eye bridge 4 facets wide. Ant. dark brown, with coarse hairs; necks distinctly bi–colored; Flgm. IV (Plate A–24E) about 3.0 times as long as wide; bristles about as long as width of Flgm. basal. Maxillary palpus (Plate A–24D) three–segmented; basal segment with 2 ~ 5 bristles, and without patch of sensillae; sensilla short and fine; third segment about 1.5 times as long as 2nd.

Thorax: yellowish brown, with coarse and long hairs. Posterior pronotum without bristles. Wings (Plate A–24C) bright; posterior veins and wing membrane clearly without macrotrichia; stem of M longer than M–fork; x = y, bare; stem of CuA = 4/5 ~ 1/1 x; R_1 = 4/5 R; R_5 dorsally with macrotrichia; length of C = 3/4 w. Halteres dark. Legs pale yellow; apex of fore tibia with comb–like row bristles (Plate A–24F); claws toothed.

Abdomen: genitalia (Plate A–24A) dark, as high as wide, and without basal lobe or hairs; base of gonocoxite emarginated v–shaped. Gonostylus (Plate A–24B) long about 2.5 times as long as wide, apical bristles coarse and variable; apex of gonostylus with tooth and 4 ~ 5 spines as long as tooth. Tegmen wider than higher, broadly rounded; aedeagus slender, and moderately long.

Body length: 1.9 mm

Female. Unknown.

Material examined. Korea, 1 male: Micheongol–Nat. Park, Seo–myeon, Yangyang–gun, GW, 1 male, 15.vii.2010, light trap, Leg. S. Shin.

Habitats. Widespread in broad–leaved woodland; also found in bogs; lakeshore; basin mire (Menzel et al., 2006).

Distribution. New to Korea *, Germany.

Remarks. This species is easily recognized by 3 ~ 4 spines on sub apical spines and slightly narrowed apex of gonostylus within *hilaris* species group.

Bradysia hilaris (Winnertz 1867) (Plate A–25)

Sciara hilaris Winnertz (1867): 106–107.

Neosciara betuleti Lengersdorf 1940: 25.

Description. *Male*. Head: eye bridge 2 ~ 4 facets wide. Ant. dark brown, with coarse hairs; necks distinctly bi–colored; Flgm. IV (Plate A–25E) about 3.8 ~ 4.5 times as long as wide; bristles about as long as width of Flgm. basal. Maxillary palpus (Plate A–25D) three–segmented; basal segment with 6 ~ 7 bristles, with patch of sensillae; sensilla short and fine; third segment about 1.2 ~ 1.5 times as long as 2nd.

Thorax: dark brown, with coarse hairs. Posterior pronotum without bristles. Wings (Plate A–25C) bright; posterior veins and wing membrane clearly without macrotrichia; stem of M slightly longer than M–fork; x = y, bare; stem of CuA = 2/3 ~ 1/1 x; R_1 = 4/5 R; R_5 dorsally with macrotrichia; length of C = 1/2 w. Halteres brown. Legs pale yellow; apex of fore tibia with comb–like row bristles (Plate A–25F); claws untoothed.

Abdomen: genitalia (Plate A–25A) dark, as high as wide, and without basal lobe or hairs; base of gonocoxite emarginated v–shaped. Gonostylus (Plate A–25B) short about 2.3 ~ 2.5 times as long as wide, apical bristles coarse and variable; apex of gonostylus with tooth and 2 pairs of strong spines longer than tooth. Tegmen as high as wide, broadly rounded; aedeagus slender, and moderately long.

Body length: 1.8 ~ 2.0 mm

Female. Unknown.

Material examined. China, 3 males: Maoershan Forest, Shangzhi City, Heilongjiang Province, 3 males, 19.viii.2010, sweeping, black mushroom farm, Leg. S. Shin.

Habitats. Widespread in broad–leaved woodland

Distribution. Korea (north), Germany, Palaeartic region (Mohrig et al., 1992).

Remarks. Mohrig et al. (1992) recorded this species in North Korea; however, I could not examine Korean specimens.

Bradysia lapponica (Lengersdorf 1926) (Plate A–26)

Sciara lapponica Lengersdorf (1926): 129.

Neosciara quinquedentata Lengersdorf 1936: 3–4.

Neosciara nigerrima Lengersdorf 1940: 27–28.

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. dark brown, with coarse hairs; necks distinctly unicolored; Flgm. IV (Plate A–26E) about 3.0 times as long as wide; bristles about as long as width of Flgm. neck. Maxillary palpus (Plate A–26D) three–segmented; basal segment with 2 ~ 3 bristles, and with broad patch of sensillae; sensilla short and fine; third segment about 1 ~ 1.5 times as long as 2nd.

Thorax: dark brown, with coarse and long hairs. Posterior pronotum without bristles. Wings (Plate A–26C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M as long as M–fork; x = y, bare; stem of CuA = 4/5 x; R_1 = 4/5 R; R_5 dorsally with macrotrichia; length of C = 1/2 w. Halteres brown. Legs pale; apex of fore tibia with comb–like row bristles (Plate A–24F); claws toothed.

Abdomen: genitalia (Plate A–24A) brown, as high as wide, and without basal lobe or hairs; base of gonocoxite emarginated v–shaped. Gonostylus (Plate A–24B) long about 2.1 times as long as wide; apex of gonostylus with strong tooth and 5 ~ 6 sub apical spines, which spines are 2.0 ~ 2.5 times longer than tooth. Tegmen wider than higher, broadly rounded; aedeagus slender, and moderately long

Body length: 2.0 mm

Material examined. China, 1 male: Maoershan Forest, Shangzhi City, Heilongjiang Province, 1 male, 18.viii.2008, Leg. S. Shin.

Habitats. Collected in woodland; riverbank with alders (Menzel et al., 2006).

Distribution. Korea (north), China (New record), Germany, Palaeartic region, (Mohrig et al., 1992).

Remarks. Mohrig et al., 1992 recorded this species in North Korea, however, I could not examine Korean specimens.

Bradysia longimentula (Sasakawa 1994) (Plate A–27)

Paractenosciara longimentula Sasakawa (1994): 674.

Bradysia longimentula Sasakawa: Menzel and Mohrig 2000: 170.

Description. *Male*. Head: eye bridge 3 facets wide. Flgm. IV (Plate A–27E) about 3.5 times as long as wide, with distinct bi–colored neck, extensive dense hairs that are little longer than width of basal part of Flgm. Maxillary palpus (Plate A–27D) three–segmented; basal segment with 8 ~ 13 bristles and patch of sensillae. Clypeus with 2 ~ 3 hairs.

Thorax: brownish black. Posterior pronotum bare. Mesonotum with dark and moderately short central and prescutellar hairs. Scutellum with 2 strong bristles with short hairs. Wings (Plate A–27C) smoky; R_1 = R; R_5 long, with dorsal and ventral macrotrichia along its whole length; M–stem strongly visible and with macrotrichia; fork of M with dorsally macrotrichia; branches of CuA without macrotrichia; y = x; C = 1/2 w. Halteres darkened. Legs dark–brown; fore tibia with comb–like row of bristles at inner apex (Plate A–27F); spurs of mid and hind tibiae equal, shorter than diameter of apex; claws untoothed.

Abdomen: tergal and sternal hairs short. Genitalia (Plate A–27A) ventrally sparse long–haired, also inner margin of gonocoxite. Gonostylus (Plate A–27B) swollen, with hair–like short subapical spines. Tegmen pyramid–shaped and laterally swinging, apical part is sclerotized. Aedeagus long.

Body length: 3.2 mm

Female. Differs from male in following points: antenna 2.7 mm long; Flgm. IV 0.2 mm long, 5 times as long as wide, with neck 1/8 ~ 1/10 whole length of segment; basal segment of maxillary palpus with 30 ~ 31 sensillae; fore metatarsus 3/5 length of tibia; wing 4.7 mm long; R_1 longer than that of male, ending at level of forking point of M.

Material examined. Korea, 17 males: Jeongam–ri, Hoengseong–gun, GW, 6 males, 25.v.2009, Leg. S. Shin.; *ditto*, 5 males, 04.vi.2009, Leg. S. Shin.; *ditto*, 6 males, 25.v.2009, Leg. S. Shin.

Habitats. The adult flies have been found on spadix of *arisaema serratum* and mushroom houses (*Lentinula edodes*) (Sasakawa, 1994; Shin et al., 2012)

Distribution. Korea (South). Japan.

Remarks. *B. longimentula* is easily recognized by the some bristles on M fork, then Flgm. with bi–color necks.

Bradysia ocellaris (Comstock 1882) * (Plate A–28)

Sciara ocellaris Comstock (1882): 202–204.

Sciara tritici Coquillett 1895: 408.

Lycoria prothalliorum De Meijere 1946: 5–6.

Bradysia (*Chaetosciara*) *rubicundula* Frey 1948: 64, 82.

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. with lighter basal segments; scape and pedicel seldom uniform brown, but often brighter whitish–yellow (usually areas of first to third Flgm. also bright colored), Flgm. IV (Plate A–28E) about 2.2 ~ 2.5 times as long as wide and with rough surface, hairs on Flgm. strongly curved and relatively close together, hairs light brown and about one–half as long as segment width, necks short, distinct, and bicolored. Maxillary palpus (Plate A–28D) moderately long, three–segmented; basal segment with 2 ~ 3 bristles and with deep sensory pit. Prefrons and clypeus with strong and dark bristles.

Thorax: light to red brown. Posterior pronotum bare. Mesonotum with dark strong hairs and long lateral bristles. Scutellum with two long and two short marginal bristles. Wings (Plate A–28C) slightly brown; R_1 = 0.5 ~ 0.7 R; R_5 only dorsally with macrotrichia; 1.3 ~ 1.5 y = x, bare; C = 3/4 w. Halteres brown with short stalk. Legs yellow; inner side of fore tibia with comblike row of 6 ~ 9 bristles (Plate A–28F); spurs of mid and hind tibiae sub equal, slightly longer than diameter of apex; claws untoothed.

Abdomen: yellow to reddish–brown; tergal and sternal hairs moderately fine. Genitalia (Plate A–28A) ventral inner side without basal lobe or group of hairs; inner side of gonocoxite with very short, fine, and pale hairs. Gonostylus (Plate A–28B) longish–narrow, 2.5 ~ 3.0 times as long as wide. Apex of gonostylus with thicker and coarser bristles, with distinctly raised, thin, and hooked apical tooth; upper half of gonostylus on inner side slightly emarginate and with 4 ~ 6 strong bristles; all spines on gonostylus dark, sub equal in length, and evenly curved ventromedially. Tegmen wider than high, membranous, and trapezoid; tip of tegmen flattened; tooth field coarse and with strong single–tipped teeth. Aedeagus moderately long, narrow and with weakly sclerotized base.

Body length: 2.0 ~ 2.5 mm

Female. Flgm. shorter and narrower than male; all segments (including scape and pedicel) dark brown; Flgm. IV 1.7 ~ 3.5 times as long as wide; basal parts of Flgm. almost smooth, with finer and paler hairs; necks almost as dark as basal part and therefore not so strikingly bicolored as in male. Palpus three segmented; basal segment with larger sensory pit and with larger number of sensilla. Bristle comb on fore tibia narrower, about one–third as wide as tibial tip. Wing larger and longer; x = 1.0 ~ 1.2 y; R_1 = 0.7 ~ 0.9 R. All other characteristics as in male.

Body length: 2.7 ~ 3.0 mm.

Material examined. Korea, 1 male: Pyeongtaek–si, GG, 1 male, 14.v.2009, Leg. S. Shin.

Habitats. Found in glasshouses, commercial mushroom houses (*Agaricus brunnescens*, *Agaricus bitorquis*, *Pleurotus cystidiosus*, *Pleurotus ostreatus* and *Auricularia* spp.), other dwellings, in gardens (on ornamental plants), in deciduous woods (acacia, lime, oak, red maple), and on stream banks (in reeds and moss). larvae were found feeding on the roots and/or stems of campanula, carnations, corn, cucumbers, geraniums, lettuce, nasturtiums, young orchid plants, peas, pineapple, poinsettia, potato tubers, primula seedlings, sugar cane, wheat, and also in the soil around cactus plants. This species was also found in waste disposal facilities in Germany (Menzel et al., 2003).

Distribution. New to Korea *, Australia, Brazil, Bulgaria, China, Ecuador, Finland, Germany, Great Britain, India, Indonesia, Ireland, Panama, Russia, Spain, Taiwan, Thailand, The Netherlands, United states, Zimbabwe (Menzel et al., 2003).

Remarks. The species belongs to the *B. amoena* group. The yellow–white base of the male Ant. is very characteristic. The pale color is always found at least on the scape and pedicel, but the first two Flgm. are also often yellow. *B. ocellaris* differs from all the other species in the *B. amoena* group by the characteristic arrangement of 4 ~ 6 strong spines on the upper third of the gonostylus. Only two of these spines are arranged as a pair at the inner angle of the tip of the gonostylus. The other spines (2 ~ 4) are somewhat isolated on the ventral inner side of the gonostylus. This typical arrangement of the spines readily distinguishes this from other species.

Bradysia procera (Winnertz 1868) (Plate A–29)

Sciara procera Winnertz (1868): 535–536.

Phytosciara neofusca Mohrig and Krivosheina 1982: 173–174.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Flgm. IV (Plate A–29E) about 2.8 times as long as wide, with distinct bi–colored neck, extensive dense hairs are as long as width of basal part of Flgm. Maxillary palpus (Plate A–29D) three–segmented; basal segment with 2 bristles and patch of sensillae.

Thorax: brownish black. Posterior pronotum bare. Mesonotum with dark and moderately short central and prescutellar hairs. Scutellum with 2 strong bristles with short hairs. Wings (Plate A–29C) smoky; R_1 = R; R_5 long, with dorsal and ventral macrotrichia along its whole length; M–stem strongly visible and without macrotrichia; fork of M without macrotrichia; branches of CuA without macrotrichia; y = x; C = 1/2 w. Halteres darkened. Legs dark–brown; fore tibia with comb–like row of bristles at inner apex (Plate A–29F); spurs of mid and hind tibiae equal, shorter than diameter of apex; claws toothed.

Abdomen: genitalia (Plate A–29A) ventrally sparse long and strong hairs, also inner margin of gonocoxite. Gonostylus (Plate A–29B) swollen, apical rounded and densely furred with hair–like short subapical spines; inner side of gonostylus emarginated. tegmen pyramid–shaped and laterally swinging, apical part is sclerotized. Aedeagus long.

Material examined. Korea, 2 male: Taebaeksi, GW, 1 male, 01.ix.2008, collected from ginseng farm, Leg. T. Hong.; Youngin–si, GG, 1 male, 22.v.2009, collected from ginseng farm, Leg. S. Lee.

Habitats. Larvae feeding stem of ginseng; and in laboratory, reared by chinese cabbage (Lee et al., 2010). Usually adult collected wet oak forest (Metzner and Menzel, 1996).

Distribution. Korea, Germany, Russia, Ukraine (Menzel et al., 1990; Metzner and Menzel, 1996).

Remarks. This species similar with *B. longimentula* but differs in toothed claws and without macrotrichia on rear wing veins.

Bradysia protohilaris Mohrig and Krivosheina 1983 * (Plate A–30)

Bradysia protohilaris Mohrig et al. (1983): 6-7.

Description. *Male*. Head: eye bridge 4 facets wide. Ant. dark, with rough surface; Flgm. IV (Plate A–30E) about 2.5 ~ 3.0 times as long as wide, with distinct bi–colored neck, extensive dense hairs that are shorter than width of basal part of Flgm. Maxillary palpus (Plate A–30D) three–segmented; basal segment with several bristles and patch of sensillae. Clypeus with very short hairs.

Thorax: dark brown. Posterior pronotum bare. Mesonotum with very fine brown hairs. Scutellum without strong bristles. Wings (Plate A–30C) heavily tanned; R slightly longer than R_1; R_5 long, only dorsally with macrotrichia; y = x, bare; Cu1 stem shorter than x; C = 2/3 w. Halteres short and dark. Legs brown; fore tibia with comb–like row of 8 distinct bristles at inner apex (Plate A–30F); spurs of mid and hind tibiae equal, slightly longer than diameter of apex; claws untoothed.

Abdomen: tergal and sternal hairs sparse and moderately long; without basal lobe; genitalia (Plate A–30A) ventrally sparse long haired, also inner margin of gonocoxite. Gonostylus (Plate A–30B) about 2.5 times as long as wide and moderately swollen, without apical spines, apically covered with short dense hairs, subapical with 3 ~ 4 short spines. Tegmen small, rounded, with teeth. Aedeagus moderately long.

Body length: 3.0 ~ 3.5 mm

Female. Unknown.

Material examined. Korea, 10 males: SNU-CALS-garden, Seodun–dong, Suwon– si, GG, 10 males, 29.iv.2009, Leg. S. Shin.

Distribution. New to Korea *, Russia (Gebiet Chabarowsk, Bytschycha, Naturschutzgebiet Chechtzyr), Palaeartic region.

Remarks. *B. protohilaris* also very dark species make it differs by the distinct bi–colored neck of the Flgm. Specific diagnosis is long and very fine hairs on the ventral section of the gonocoxite and the 3 ~ 4 subapical spines on gonostylus.

Bradysia trispinifera Mohrig and Krivosheina 1979 (Plate A–31)

Bradysia trispinifera Mohrig et al. (1979): 586–587.

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. slightly rough with long neck (longer than width of link); Flgm. IV (Plate A–31E) about 2.6 ~ 3.1 times as long as wide, with slightly bi–colored neck, bristle–like hairs longer than width of Flgm. IV. Maxillary palpus (Plate A–31D) three–segmented; basal segment with 1 or 2 bristles with patch of sensillae. Clypeus bare.

Thorax: dark brown. Posterior pronotum bare. Mesonotum with bright hairs, strong central bristles, and 3 ~ 4 strong lateral hairs. Scutellum hairs with 3 strong bristles. Wings (Plate A–31C) light brown with well–developed anal area; rear wing veins poorly developed; stem of M is not visible; length of R_1 = 3/5 R; R_5 with dorsal macrotrichia; length of y = 5/4 x, bare; length of C = 3/5 ~ 3/4 w. Halteres short. Legs yellowish–brown; fore tibia with comb–like row of 3 ~ 4 bristles at inner apex (Plate A–31F); spurs of mid and hind tibiae equal, longer than diameter of apex; claws untoothed.

Abdomen: genitalia (Plate A–31A) with sparse long–hairs ventrally and also on inner margin of gonocoxites. Gonostylus (Plate A–31B) about 2.3 ~ 2.8 times as long as wide and moderately swollen with apical 3 strong and long spines; apical spine longer and thicker than others. Tegmen broader than high and trapezoid shape with patch of fine teeth. Aedeagus moderately short, without sclerotized base.

Body length: 1.2 ~ 1.5 mm.

Female. Unknown.

Material examined. Korea, 6 males: Jeongam–ri, Hoengseong–eup, Hoengseong–gun, GW, 1 males, 17.iv.2009, Leg. S. Shin.; *ditto*, 1 male, 14.vii.2009, Leg. S. Shin.; *ditto*, 4 males, 17.viii.2009 ~ 07.ix.2009, Leg. S. Shin.

Habitats. According to Mohrig et al. (1979) larvae were collected in rotting brown alder. Adult flies have also been found in Shiitake mushroom house.

Distribution. New to Korea *, Russia.

Remarks. This species is easily recognized by the apical long spines on the gonostylus. According to Mohrig et al. (1979) this species has 2 bristles on basal segment of maxillary palpus. However, in this study 3 specimens have 1 bristle and 2 specimens have 2 bristles on basal segment of maxillary palpus.

Bradysia bilobata Mohrig and Kozánek 1992

Bradysia bilobata Mohrig and Kozánek (1992): 21.

Distribution. Korea (north) (Mohrig et al., 1992).

Remarks. Mohrig et al. (1992) recorded this species in North Korea; however, I could not examine this species due to the lack of specimens.

Bradysia scabricornis Tuomikoski 1960

Bradysia scabricornis Tuomikoski (1960): 117-118.

Habitats. Common in ancient oak and beech forest, broad–leaved woodland; wetlands including wet meadow with peat, *Juncus* and *Glyceria*, fens, ombrotrophic mire, reed and sedge beds; grassland and scrub with stream; calcareous grassland. Reared from mole nest (Menzel et al., 2006).

Distribution. Korea (north), Finland, Germany, Nepal, Slovakia (Mohrig et al., 1992).

Remarks. Mohrig et al., 1992 recorded this species in North Korea; however, I could not examine Korean specimens.

Bradysia globulifera (Lengersdorf 1934)

Neosciara globulifera Lengersdorf (1934): 58.

Distribution. Korea (north), Finland, Russia, Sweden, Israel (Mohrig et al., 1992; Salmela and Vilkamaa, 2005).

Remarks. Mohrig et al., 1992 recorded this species in North Korea; however, I could not examine this species due to the lack of specimens.

Genus *Ctenosciara* Tuomikoski 1960

Type species: *Ctenosciara hyalipennis* (Meigen 1804): *Sciara hyalipennis* Meigen 1804

Ctenosciara insolita (Sasakawa 1994) * (Plate A–32)

Phytosciara (*Dolichosciara*) *insolita* Sasakawa (1994): 670–671.

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. dark brown, with coarse hair; neck district; Flgm. IV (Plate A–32E) about 2.6 ~ 2.7 times as long as wide; bristles about 3/4 times as long as the width of Flgm. basal. Maxillary palpus bright yellow, long and three–segmented (Plate A–32D); basal segment with 4 ~ 5 bristles (one of them much longer), and without patch of sensillae; sensilla short and fine; second segment elongated, third segment about 1.5 times as long as 2nd.

Thorax: dark, with coarse and long hairs. Posterior pronotum without bristles. Wings (Plate A–32C) brown; posterior veins with macrotrichia and wing membrane clearly without macrotrichia; stem of M longer than M–fork; x = 1.1 ~ 1.2 y, bare or distal 1/2 with bristles; stem of CuA = 4/5 ~ 1/1 x; R_1 = 4/5 ~ 1/1 R; R_5 dorsally and ventral with macrotrichia; length of C = 2/3 w. Halteres yellow and short. Legs pale yellow; apex of fore tibia with comb–like row bristles slightly arched (Plate A–32F); claws toothed.

Abdomen: genitalia (Plate A–32A) dark, higher than wide and without basal lobe or hairs; base of gonocoxite emarginated v–shaped. Gonostylus (Plate A–32B) long about 2.5 times as long as wide, apical bristles coarse and variable; apex of gonostylus with tooth and 7

~ 9 spines as long as tooth; upper half inside emarginated. Tegmen wider than higher, broadly rounded. Aedeagus slender, and moderately long

Body length: 2.9 mm

Female. Similar to male, but Flgm. more long and smooth; cercus is little longer than tergite 10 and slightly shorter than half of hypogynal valve (Menzel and Mohrig, 2000).

Body length: 3.2 ~ 3.9 mm

Material examined. Korea, 4 males: Mt. Homyeong, Cheongpyeong–ri, Gapyeong–gun, GG, altitude 220 m, 4 males, 18~31.iv.2009, Malaise trap, Leg. J. Lim.

Distribution. New to Korea *. Japan.

Remarks. This species is easily recognized by CuA_2 wing vein with macrotrichia.

Ctenosciara nudata Mohrig and Kozánek 1992

Ctenosciara nudata Mohrig et al. (1992): 20–21.

Distribution. Korea (north), Nepal, Russia Primorsky Krai (Menzel and Martens, 1995; Mohrig et al., 1992).

Remarks. Mohrig et al., 1992 recorded this species in North Korea; however, I could not examine this species due to the lack of specimens.

Genus *Phytosciara* Frey 1942

Type species: *Phytosciara* (s. str.) *halterata* (Lengersdorf 1926): *Sciara halterata* Lengersdorf 1926

Key to species of the genus *Phytosciara* in the Korean Peninsula

1. Gonostylus elongated, more than twice as long as wide, apex without bristles, and subapical spines short, posterior wing veins always with macrotrichia. 2

– Gonostylus short and stocky, apex with 4 ~ 5 spines, subapical with significant sub apical lobus very large with 4 ~ 6 spines. 4

2. only in sub apical (upper 1/5) inside of gonostylus with hyaline spines (Plate A–33B). .... *Ph.* (*Dolichosciara*) *flavipes*

– inside of gonostylus (upper 2/3) filled with spines. 3

3 inside of gonostylus (upper 2/3) filled with 9 ~ 12 spines, with basal lobus (Plate A–34B). . ... *Ph.* (*Dolichosciara*) *semiferruginea* *

– inside of gonostylus (upper 2/3) filled with 5 ~ 7 spines, without basal lobes (Plate A–35B). .... *Ph.* (*Dolichosciara*) *koreansis* sp. nov. *

4. Sub apical lobus on gonostylus clearly split at the end with 6 (2 + 4) strong, blade like spines, and the base of gonocoxite with basal lobus (Plate A–36A). .... *Ph.* (*Prosciara*) *ussuriensis* *

Phytosciara (Dolichosciara) flavipes (Meigen 1804) (Plate A–33)

Sciara flavipes Meigen (1804): 487.

Sciara fugax Grzegorzek 1884: 263–264.

Sciara flavipes var. *nigrithorax* Strobl 1898: 280.

Description. *Male*. Head: eye bridge 3 facets wide. Ant. dark brown; Flgm. 1 ~ 2 segments usually yellowish bright; Flgm. IV (Plate A–33E) more than 3 times as long as wide; Flgm. bristles dense and short more than 1/2 times as long as wide of neck; neck bicolored and short. Maxillary palpus (Plate A–33D) three–segmented; basal segment slender with several bristles and without deep sensillae pit; sensilla fine; 2nd segment slightly shorter than basal member; 3rd slender and much longer than 2nd segment.

Thorax: yellow with dark spots. Posterior pronotum bare. Mesonotum "mosquito–like" arched, ventrally with dark stripe, and dark haired; lateral and scutellum bristles strong. Wings (Plate A–33C) brown; posterior veins with strong macrotrichia; stem of M little longer than M–fork; M_1 and M_2 are nearly parallel; x = 1/2 y, macrotrichia on distal half of y; stem of CuA = 1.3 x; R_1 = 4/5 R; length of C = 1/2 w. Halteres dark brown and short stalked. Legs, coxae and femora whitish yellow; apex of fore tibia with single comb–like row spines (Plate A–33F); claws toothed.

Abdomen: genitalia (Plate A–33A) yellow, ventral base of gonocoxite with fine hairs; apical of ventral gonocoxite with 3 ~ 4 strong bristles. Gonostylus (Plate A–33B) long, apex narrowed; densely fur and dark on apex; dorsal of sub apical with 5 ~ 8 hyaline spines. Tegmen as high as wide and apically rounded; with large toothed area. Aedeagus short.

Body length: 3.5 ~ 5.2 mm

Female. Flgm. shorter than male; Flgm. IV 2.2 ~ 2.5 times as long as wide; neck is very short and dark.

Body length: 3.2 ~ 5.5 mm

Material examined. China, 4 males: Mt. Paekdusan, Jilin–seong, 4 males. 20.vi.2009.

Leg. S. Shin.

Habitats. Very common in broad–leaved, mixed and carr–woodland; arboretum of conifers; grazed wet heath land; wetlands especially fen and bog; also reed and sedge beds, valley and basin mire, pond and lakeside marshes; former gravel workings; calcareous grassland; parkland (Menzel et al., 2006).

Distribution. Korea (north), America (California), Britain, China (New record), Europe, Greenland, Nepal, North Africa, Russia, Taiwan (Menzel et al., 1990; Tuomikoski, 1960).

Remarks. This species is easily recognized from the other species in *Dolichosciara* by, light base of Flgm; slightly curved basal lobes and tegmen rounded, not longer than wide. I do not examined Korean specimens, because, lack of specimens.

Phytosciara (Dolichosciara) semiferruginea Menzel 1995 * (Plate A–34)

Phytosciara (Dolichosciara) semiferruginea Menzel (1995): 110–111.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. dark brown; Flgm. IV (Plate A–34E) about 3.2 ~ 4.0 times as long as wide; Flgm. bristles short and strong 1/2 ~ 2/3 times as long as wide of neck; neck bicolored and short; Flgm. I bright. Maxillary palpus (Plate A–34D) yellow to light brown and very long with three–segmented; basal segment slender as long as about 2nd segment with 7 ~ 8 bristle without deep sensillae pit; fine sensilla in large area; 3rd segment 1.3 ~ 1.5 times as long as basal segment.

Thorax: reddish brown. Posterior pronotum bare. Mesonotum with coarse and dark hairs; lateral and scutellum bristles rough and long. Wings (Plate A–34C) brown; posterior veins with strong macrotrichia; stem of M little longer than M–fork; M_1 and M_2 are nearly parallel; x = 1/2 y, both bare; stem of CuA = 1.3 x; R_1 = R; length of C = 2/5 ~ 1/2

w. Halteres dark brown and short stalked. Legs, coxae and femora whitish yellow; apex of fore tibia with broad single comb–like row dark spines (Plate A–34F); claws toothed.

Abdomen: genitalia (Plate A–34A) yellow to reddish brown; higher than wide; entire gonocoxite bristles strong and coarse; gonocoxite with basal lobes and with side bristles; inside of gonocoxite with thick and short to moderately long hairs. Gonostylus (Plate A–34B) slender, about 3.5 times longer than wide and apex slightly curved; apex of gonostylus dark with dense bristles; inside of gonostylus (upper 2/3) filled with 9 ~ 12 spines. Tegmen as high as wide and apically rounded; toothed area with fine tooth. Aedeagus very short.

Body length: 4.2 ~ 4.8 mm

Female. Eye bridge 3 facets wide. Flgm. much shorter and smoother than male; Flgm. IV about 2.4 times as long as wide; base segment of Flgm. dark

Body length: 4.0 mm

Material examined. Korea, 20 males: Mt. Taehwa, Sanglim–ri, Docheok–myeon, Kwangju–si, GG, 7 males, 25.vii.2009, Leg. S. Shin.; Mt. yongmun, Yongmun–myeon, Yangpyeong–gun, GG, 6 males, 16 ~ 30.vi.2009, malaise tarp, Leg. J. Lim.; Doradaedae, Munsan–eup, Paju–si, GG, 1 male, 21.vii.2008, Leg. S. Shin.; Kwanak–Arboretum, Manan–gu, Anyang–si, 1 male, 4.vii.2009, Leg. S. Shin.; Baekyangsa Temple, Bukha–myeon, Jangsung–gun, JN, 4 males, 17.vi.2010, Leg. S. Shin.; Seoguipo– Nat. park, Seoguipo–si, JJ, 1 males, 12.vii.2011, Leg. S. Shin.

Distribution. New to Korea *, Nepal, Thailand (Menzel and Martens, 1995).

Remarks. *Ph. semiferruginea* similar with *Ph. orcina* but recognized by very long Flgm. segments, long R_1, dark halteres and on a larger number of sub apical gonostylus spines.

Phytosciara* (*Dolichosciara*) *koreansis sp. nov. * (Plate A–35)

Diagnosis. This species recognized by 5 ~ 7 spines on inside of gonostylus.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. dark brown; Flgm. IV (Plate A–35E) about 3.0 times as long as wide; Flgm. bristles short and strong 1/2 ~ 2/3 times as long as wide of neck; neck gradated bicolored. Maxillary palpus (Plate A–35D) yellow to light with three–segmented and 3rd segment very long; basal segment as long as about 2nd segment with 4 ~ 5 bristles without deep sensillae pit; sensilla fine in large area; 3rd segment more than 2.0 times as long as basal segment.

Thorax: reddish brown. Posterior pronotum bare. Mesonotum with coarse and dark hairs; lateral and scutellum bristles rough and long. Wings (Plate A–35C) brown; posterior veins with strong macrotrichia; stem of M little longer than M–fork; M_1 and M_2 are nearly parallel; x = 2/3 y, both bare; stem of CuA = 1 x; R_1 = 1.3 R; length of C = 2/5 ~ 1/2 w. Halteres brown and short stalked. Legs, coxae and femora whitish yellow; apex of fore tibia with broad single comb–like row dark spines (Plate A–35F); claws toothed.

Abdomen: genitalia (Plate A–35A) yellow to reddish brown; slightly higher than wide; entire gonocoxite bristles strong and coarse; gonocoxite with basal lobes and with side bristles; inside of gonocoxite with thick and short to moderately long hairs. Gonostylus (Plate A–35B) slender, about 3.5 times longer than wide and apex slightly curved; apex of gonostylus dark with dense bristles; inside of gonostylus (upper 2/3) filled with 5 ~ 7 spines. Tegmen as high as wide and apically rounded; toothed area with fine tooth. Aedeagus very short.

Body length: 2.7 ~ 3.0 mm

Material examined. *Holotype male*. Gwanak–Abr., Manan–gu, Anyang–si, GG, Korea, altitude 175 m, 23 ~ 29.vii.2007, Malaise trap, Leg. J. Lim. *Paratype*. Geojehuyangrim, Guchon–ri, Dongbu–myeon, Geoje–si, GN, 1 male, 25.viii.2008, Light trap, Leg. S. Shin.

Distribution. Korea *

Remarks. This new species similar with *Ph. semiferruginea*, but recognized by differs in characters as follows: less spine numbers inner side of gonostylus. And in wing vein, R_1 is shorter than R, length of CuA and x are same.

Phytosciara* (*Prosciara*) *ussuriensis Antonova 1977 * (Plate A–36)

Phytosciara (*Prosciara*) *ussuriensis* Antonova (1977): 110–112.

Phytosciara (*Prosciara*) *lobata* Antonova 1977:111–112.

Description. *Male*. Head: eye bridge 3 facets wide. Ant. bright and rough; Flgm. IV (Plate A–36E) about 2.5 times as long as wide; Flgm. bristles 2/3 times as long as wide of neck; neck tanned; Flgm. I bright. Maxillary palpus (Plate A–36D) three–segmented; basal segment slander with long bristles (as long as 3rd segment); without sensillae pit; sensilla short and fine; second segment with 6 ~ 8 short bristles

Thorax: dark brown. Posterior pronotum with bristles. Mesonotum with dark hairs; and lateral, central and scutellum with several bristles. Wings (Plate A–36C) brown; posterior veins with macrotrichia, usually up to half filled with macrotrichia; stem of M as long as M–fork; x = 0.8 y, 2 ~ 3 bristles on y; stem of CuA = 1/2 ~ 1.0 x; R_1 = 4/5 R; R_5 dorsal and apex of ventral with macrotrichia; length of C = 2/3 w. Halteres dark. Legs, coxae and femora yellow; apex of fore tibia with single comb–like row bristles (Plate A–36F); claws untoothed.

Abdomen: genitalia (Plate A–36A) light brown, and base of ventral gonocoxite with dense hairy basal lobe; inner side covered with short bristles. Gonostylus about 2.5 times as long as wide, apically narrow and dorsally with split sub apical lobes; bristles on apex of gonostylus thick and dark; sub apical lobe with 6 pair spines. Tegmen slightly higher than wide; toothed area with large tooth. Aedeagus short

Body length: 2.5 ~ 3.0 mm

Female. Unknown.

Material examined. Korea, 1 male: Mt. Yongmun, Yongmun–myeon, Yangpyeong–gun, GG, altitude 324 m, 1 male, 26.vi ~ 16.vii.2009, Malaise trap, Leg. J. Lim.

Distribution. New to Korea *, Russia (Mohrig and Menzel, 1994, 1997).

Remarks. This species is easily recognized by unique character of sub apical lobe on gonostylus. According to Menzel and Mohrig (2000) *Ph. lobata* is differs only length of basal lobe. However that kind of character can be changed by position of preparation.

Genus *Scatopsciara* Edwards 1927

Type species: *Scatopsciara vitripennis* (Meigen 1818): *Sciara quinquelineata* Macquart 1834 [*Sciara* (*Scatopsciara*) *unicalcarata* (Edwards 1927) (= *Sciara vitripennis* Meigen 1818)]

Scatopsciara camptospina Mohrig and Mamaev 1990 (Plate A–37)

Scatopsciara camptospina Mohrig et al. (1990): 19.

Description. *Male*. Head: eye bridge 2 facets wide. Flgm. IV (Plate A–37E) about 2.5 times as long as wide, with unicolor distinct neck, extensive dense hairs are little longer than width of basal part of Flgm. Maxillary Palpus (Plate A–37D) three–segmented; basal segment with 1 bristle and weak patch of sensillae. Clypeus with 2 ~ 3 hairs.

Thorax: dark brown. Posterior pronotum bare. Mesonotum dark and moderately short central and prescutellar hairs. Scutellum with 3 strong bristles with some short hairs. Wings (Plate A–37C) smoky; length of R_1 = 1/2.5 R; R_5 only dorsally with macrotrichia; length of y = 1/3 x, both bare; length of C = 2/3 w; all posterior veins without macrotrichia. Halteres long. Legs yellowish–brown; apex of fore tibia without distinctly arranged bristles (Plate A–37F); spurs of mid and hind tibiae unequal, longer than diameter of apex; claws untoothed.

Abdomen: genitalia (Plate A–37A) ventrally sparse short–haired, also inner margin of gonocoxites. Gonostylus (Plate A–37B) swollen, with strongly curved apical tooth, 9 ~ 10 longer subapical spines, and two strong spear–like spines at middle of inner side. Tegmen pyramid–shaped, apical part is not strongly sclerotized. Aedeagus moderately long.

Body length: 1.1 mm.

Female. Unknown.

Material examined. Korea, 1 male: Jeongam–ri, Hoengseong–eup, Hoengseong–gun, GW, 1 male, 23.iv ~ 25.v.2009, malaise trap, Leg. S. Shin.

Habitats. The adult flies have been found in malaise trap in shiitake mushroom houses.

Distribution. New to Korea *, Russia (Primorsky Krai) (Mohrig et al., 1990).

Remarks. *S. camptospina* is easily recognized by the gonostylus, strongly curved apical tooth, and 9 ~ 10 longer subapical spines and two strong spear–like spines at middle of inner side

Scatopsciara buccina Mohrig and Mamaev 1985

Scatopsciara buccina Mohrig et al. (1985a): 309

Distribution. Sweden, Russia, Latvia, Korea (north) (Mohrig et al., 1992).

Remarks. Mohrig et al., 1992 recorded this species in North Korea; however, I could not examine Korean specimens.

Scatopsciara nacta (Johannsen 1912)

Sciara nacta Johannsen (1912): 132.

Distribution. Korea (north), Czech, Sweden, (Mohrig et al., 1992).

Remarks. Mohrig et al., 1992 recorded this species in North Korea; however, I could not examine Korean specimens.

Scatopsciara postgeophila Mohrig and Menzel 1992

Scatopsciara postgeophila Mohrig et al. (1992): 32.

Distribution. Korea (north), Austria, Taiwan (Mohrig et al., 1992; Rudzinski, 1994).

Remarks. Mohrig *et al*., 1992 recorded this species in North Korea; however, I could not examine this species due to the lack of specimens.

Genus *Zygoneura* Meigen 1830

Type species: *Zygoneura sciarina* Meigen 1830

Key to species of the genus *Zygoneura* in the Korean Peninsula

1. Apical parts of R_5 wing vein with single sided dorsal macrotrichia (Plate A–40 C); base of bell–shaped fork of M swollen and very high [basal part of M_1 right–angled from base of stem of M; M_1 very strongly s–shaped] (Plate A–40 C); spurs of fore tibia twisted, narrow, and spike–like (Plate A–40 F); neck of 4th-flagellomere at least as long as basal part (Plate A–40 E); apex of gonostylus with dense hairs and without apical spine; all spines set on ventral side; gonostylus with 2 or 3 spines (Plate A–40 A, B). 2

– Apical half of R_5 wing vein with widely spaced dorsal and ventral macrotrichia; bell–shaped fork of M only slightly angled and therefore really flat [basal part of M_1 obtuse from stem of M; M_1 relatively weakly arcuate and s–shape flat]; spurs of fore tibia flattened and dagger–like; neck of 4th flagellomere at most 1/2 as long as basal part; apex of gonostylus distinctly tapered, narrow and with 4–5 apical spines; apical hairs sparse. ....
.... SG *Allozygoneura* Menzel and Mohrig 1998 (unknown in Korea)

2 Flgm. with long bristles of similar shape as the fine ground setae on the same basal parts (Plate A–40E); basal segment of maxillary palpus usually with 2 bristles (Plate A–40D); dense patch of bristles on the apex of fore tibia present (Plate A–40F); ventral base of gonocoxites with two weak, reduced groups of bristles (Plate A–40A); eye bridge 3–4 facets wide; apex of gonostylus widely rounded and always with 3 spines (Plates A–40A, B). ....
.... 3. SG *Zygoneura* Meigen 1830

– Flgm. long, with whorled bristles in a crown near to the necks only, the bristles distinctly longer than the fine ground setae (Plates A–38E, 1–39E); basal segment of maxillary palpus usually with one bristle (Plate A–38D); patch of bristles on apex of fore tibia almost in a row (Plate A–39F); ventral base of gonocoxites with 2 bristle lobes (Plates A–38A, 1–39A) [very rarely reduced]; eye bridge 4–5 facets wide; outer side of gonostylus bevelled and usually with 2 spines (Plates A–38B, 1–39B). .... 4. SG *Pharetratula* Mamaev 1968

3. Gonostylus oblong with 3 strong spines (Plate A–40B) [one spine apically and one sub apically, position of third spine varying]. .... *Z.* (s. str.) *sciarina*

4 Genitalia as high as wide, with two dark spines in middle of gonostylus; spines on high

sockets and standing on a shared lobe; tegmen wider than high, highly arched and broadly rounded (Plate A–38A, 39B). .... *Z.* (*Pharetratula*) *bidens* *

– Genitalia wider than high, with two erect dark spines in middle of gonostylus; spines on high sockets and each standing on a lobe; tegmen higher than wide, highly arched and oval (Plate A–39A, B). .... *Z.* (*Pharetratula*) *flavicornis*

Zygoneura* (*Pharetratula*) *bidens (Mamaev 1968) * (Plate A–38)

Pharetratula bidens Mamaev (1968): 610–611.

Pharetratula sinica Zhang and Yang 1990: 267, 273, 268.

Description. *Male*. Head: eye bridge 4 ~ 5 facets wide. Ant. rough and brown; neck of Flgm. I lighter than others (sometimes Flgm. II gradate yellowish to brown apex), up to the first row of bristles of basal part of Flgm. I–V yellow (Flgm. III–V variable and sometimes yellowish brown or dark coloured); Flgm. IV (Plate A–38E) about 3.2 ~ 3.5 times as long as wide, neck elongated and 1.6 ~ 1.8 times as long as basal length; basal of Flgm. with rough and long projecting hairs and near of neck with remarkably long bristles crown; bristles 4.2 ~ 4.5 times as long as diameter of Flgm. including short and fine hairs. Maxillary palpus (Plate A–38D) brown, three–segmented; basal segment with 1 bristle, and without patch of sensillae; sensilla long and curved, third segment about 1.5 times as long as 2nd. Clypeus with dark bristles.

Thorax: dark brown, with sparse dark hairs. Posterior pronotum bare. Mesonotum with sparse dark hairs. Scutellum with 2 long marginal bristles. Katepisternum slightly extended and short. Wings (Plate A–38C) brown and M–fork slightly distended bell shaped; posterior veins and wing membrane clearly without macrotrichia; stem of M as long as M–fork; basis of M_1 high arched and almost vertical reached in stem of M; x = 1.2 y, bare; stem of CuA =

0.5 ~ 1.0 x; R_1 = 1/2 ~ 2/3 of R and ahead of M–fork, length of C = 3/4 w. Halteres short stalked and yellow. Legs pale yellow; apex of fore tibia almost single row like bristles (Plate A–38F); spurs of mid tibiae short pin like, each one usually shortens significantly; claws finely toothed.

Abdomen: genitalia (Plate A–38A) dark brown and as high as wide; base of gonocoxite with bristle groups on two lobes (central area of gonocoxite near inner edge bristle lobes sclerotized very weak); basal bristle group is small and short, each consisting of 2 ~ 5 bristles; inside of gonocoxite emarginate semi–circular and basally up to half un hairy; gonocoxite base flat. Gonostylus (Plate A–38B) long and swollen, apical bristles densely furred, with two dark spines in middle of gonostylus and ventral surface bare; spines on high sockets and standing on shared lobe. Tegmen as high as wide, highly arched and rounded broadly. Aedeagus moderately long, very slender and small.

Body length: 2.3 ~ 3.0 mm

Female. Ant. shorter than in male; flagellomere with short necks; basal parts of flagellomere with irregular and dense short bristles; basal part of 4th flagellomere about 2.0 times as long as wide, neck of 4th flagellomere shorter than basal width; ovipositor moderately long, telescopic, with two "3–segmented" [correctly 2–segmented] cerci at the end; last segment of cercus with strong bristles; spermathecae sclerotized, one of them bucket–shaped, the other strongly reduced (Mamaev, 1968).

Material examined. Korea, 3 males. Jeongam–ri, Hoengseong–eup, Hoengseong–gun, GG, 37°29'35.15"N, 128°1'10.09"E, altitude 140 m, 1 male, 18. ~ 24.vi.2010, Leg. S. Shin.; *ditto*, 1 male, 24.vi ~ 02.vii.2010, malaise trap, Leg. S. Shin.; Kwaneun temple, Ara–dong, Jeju–si, JJ, 33°25'22.98"N, 33°25'22.98"N, altitude 600 m, 1 male, 12.v.2008, Leg. S. Shin.

Habitats. The adult flies have been caught by the malaise traps in shiitake mushroom house.

Distribution. New to Korea *, China, Russia (Mamaev, 1968; Zhang, 1990).

Remarks. This species has been recorded in Russia and China(Mamaev, 1968; Menzel and Mohrig, 2000; Zhang, 1990)It can be easily recognized by two dark spines on shared lobe in middle of gonostylus. Korean samples with moderately long bristles on body.

Zygoneura* (*Pharetratula*) *flavicornis Mamaev 1968 (Plate A–39)

Pharetratula flavicornis Mamaev (1968): 611.

Description. *Male*. Head: eye bridge 4 ~ 5 facets wide. Ant. rough and light brown; neck of Flgm. I–II lighter than other segments; up to the first row of bristles of basal part of Flgm. I–IV yellow (5th–6th Flgm. variable and sometimes yellowish–brown or dark coloured); neck of Flgm. III dark yellow; Flgm. IV (Plate A–39E) about 2.8 ~ 3.0 times as long as wide, neck elongated and 1.3 ~ 1.4 times as long as basal length; basal of Flgm. with rough projecting hairs and near of neck remarkably long bristles crown; bristles 4.0 times as long as diameter of Flgm. including short and fine hairs; maxillary palpus (Plate A–39D) brown, three–segmented; basal segment with 1 ~ 2 bristles, and without patch of sensillae; sensilla long and curved, third segment as long as 2nd. Clypeus with dark bristles.

Thorax: dark brown, with sparse, long and dark hairs. Posterior pronotum bare. Mesonotum with sparse dark hairs without long lateral bristles. Scutellum with 2 long marginal bristles. Katepisternum slightly broad and rounded. Wings (Plate A–39C) bright brown and M–fork distended bell shaped; posterior veins and wing membrane clearly without macrotrichia; stem of M as long as M–fork and almost invisible; basis of M_1 high arched and vertical reached on stem of M; x = 1.5 y, bare; stem of CuA = 1.0 x; R_1, = 1/2 ~ 2/3 R and ahead of M–fork, length of C = 3/4 w. Halteres short stalked and yellow. Legs pale yellow; apex of fore tibia almost single row like bristles (Plate A–39F); spurs of mid tibiae very short pin like, each one usually shortens significantly; claws finely toothed.

Abdomen: genitalia (Plate A–39A) dark brown; base of gonocoxite two lobes bristle groups (central area of gonocoxite near inner edge bristle lobes sclerotized very weak); basal bristle group is small and short, each consisting of 2 ~ 3 bristles; inside of gonocoxite emarginate semi–circular and basally almost bare; gonocoxite base flat. Gonostylus (Plate A–39B) little long and swollen, apical bristles densely furred, with two dark spines on high sockets each. Tegmen higher than wide, highly arched and oval shaped. Aedeagus moderately long, slender and small.

Body length: 2.0 mm

Material examined. Korea, 1 male. Doradaedae, Gunnae–myeon, Munsan–eup, Paju–si, GG, 37°54'58.88"N, 126°42'6.38"E, altitude 34 m, 1 male, 21.vii.2008, Leg. S. Shin.

Distribution. Korea, Russia (Mamaev, 1968; Mohrig et al., 1992).

Remarks. This species has been recorded in Russia (Mamaev, 1968) and North Korea (Mohrig et al., 1992). It can be easily recognized by gonostylus, two dark spines on high sockets each.

Zygoneura* (*Zygoneura*) *sciarina Meigen 1830 (Plate A–40)

Zygoneura (*Zygoneura*) *sciarina* Meigen (1830): 305.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. uniform dark brown; basal parts of Flgm. very rough, with long bristles and fine hairs; bristles 1.5 ~ 2.5 times as long as diameter of Flgm. and Fine sensory hairs as long as diameter of Flgm. basal; Flgm. IV about 3.3 ~ 3.8 times as long as wide (Flgm. X: Plate A–40E), length of neck as long as basal length and Flgm. segments narrowed and smaller towards apex. Maxillary palpus (Plate A–40D) pale yellow, three–segmented; basal segment with 2 bristles (rarely with one bristle), and without patch of sensillae; sensilla long and curved, third segment about 1.5 times as long as 2nd. Clypeus with strong and dark bristles.

Thorax: dark brown, with sparse dark hairs. Posterior pronotum bare. Mesonotum with only sparse, short and fine hairs without vigorous lateral and central bristles. Scutellum with 2 little bit long and strong marginal bristles. Katepisternum extended wedge–shaped. Wings (Plate A–40C) lightly browned; posterior veins and wing membrane clearly without macrotrichia; stem of M longer than M–fork; M–fork wide, and bell–shaped bulge; M_1 at bottom bulged strongly; M_2 evenly curved; x as long as 1 ~ 1.5 y, both bare or no more than half of 1 ~ 3 macrotrichia; stem of CuA = 0.6 x; CuA_2 and CuA_1 initially almost parallel extended; CuA_1 in back half evenly curved, nearly vertical reached in wing margin, R_1 = 1/2 ~ 2/3 R and very far ahead of M–fork reached in C, length of C = 4/5 w. Halteres short stalked and light brown. Legs pale yellow, very long and slender; apex of fore tibia coarse and thick bristle patch without curved boundary (Plate A–40F); spurs of mid tibiae short pin like, each one usually shortens significantly; claws toothed.

Abdomen: tergal and sternal hairs moderately long. Genitalia (Plate A–40A) yellow to brown, bristles coarse and without basal lobe; base of gonocoxites margin with two weak settled and dense bristle groups; gonocoxites inside flat semicircular emarginate with short hairs; gonocoxites base high, not closed. Gonostylus (Plate A–40B) about 2.5 times as long as wide, apically rounded and furry hairs, upper half of ventral gonostylus deeply emarginated and filled with 3 strong spines on apex of sockets (Two apical and subapical spines approached outside edge of gonostylus, and third spine at edge of cavity end of gonostylus; position of third spine usually varying). Tegmen flattened tip trapezoid and wider than high, apical part is not strongly sclerotized, teeth small and band–shaped narrowed, with fine pointedness tooth. Aedeagus moderately long and slender.

Body length: 2.7 ~ 3.5 mm.

Female. Antennal Flgm. IV 2.7 ~ 3.0 times as long as wide, bristles at most 1.5 times as long as diameter of Flgm. basal part; neck short, about 1/4 times as long as basal length; x sometimes longer than 2 y; stem of CuA = 1/2 x. Body length: 2.8 ~ 3.0 mm.

Material examined. Korea, 1 male: Kwaneun temple, Ara–dong, Jeju–si, JJ, 33°25'22.98"N, 33°25'22.98"N, altitude 600 m, 1 male, 12.v.2008, Leg. S. Shin.

Distribution. Korea, China, Finland, Germany, Sweden (Heller et al., 2009; Mamaev, 1968; Menzel and Mohrig, 2000; Mohrig et al., 1992; Vilkamaa et al., 2007; Zhang et al., 2010).

Remarks. This species was recorded in Germany and known widely distributed in Europe (Heller et al., 2009; Mamaev, 1968; Menzel and Mohrig, 2000; Vilkamaa et al., 2007), also reported from in China (Heilongjiang) and North Korea (Mohrig et al., 1992; Zhang et al., 2010). It can be easily recognized by 3 strong spines on gonostylus. Korean samples with moderately long bristles on body, and spurs of hind tibiae equal.

Subfamily Sciarinae Billberg 1820

Type genus: *Sciara* Meigen 1803

Diagnosis. Neck parts of the Flgm. usually with seamless transition to the basal [neck of Flgm. bottle–shaped neck, base to the basal part do not clearly separated (Plates A–42D, 45D)]; wing membrane and rear wing veins usually with macrotrichia (Plates A–45C, 49C); apex of fore tibia without margin and comblike bristles (Plate A–42F) (some species of genus Sciara have incomplete margin; Plate A–48F).

Key to genera of the subfamily Sciarinae in the Korean Peninsula

1. Apex of gonostylus without tooth (Plate A–50B). .... *Trichosia* *
– Apex of gonostylus with strong tooth. 2

2. Gonostylus longer than wide; inner side of gonostylus without lobe like structure (Plate A–41A, 42A); spine–like structure at the apex of fore tibia. .... *Leptosciarella*
– Gonostylus usually wide and variable shaped; inner side of gonostylus usually with lobe like structure (Plate A–48A, 49A); bristle–like structure at the apex of fore tibia. .... *Sciara*

Genus *Leptosciarella* Tuomikoski 1960

Type species: *Leptosciarella* (s. str.) *scutellata* (Staeger 1840): *Sciara elegans* Winnertz 1867 [= *Sciara scutellata* Staeger 1840]

Key to species of the genus *Leptosciarella* in the Korean Peninsula

1. Apex of gonostylus beak–like tooth with sharp bristle like spines (Plate A–41B). 2

– Apex of gonostylus truncated and position of tooth variable, with coarse spines. 3

2. Bristles on the tergite 1 ~ 4 bright. .... *Le*. (s. str.) *trochanterata* *

– Bristles on the tergite 1 ~ 4 dark. .... *Le*. (s. str.) *rejecta* *

3. Truncated area of gonostylus as broad as diameter of gonostylus (Plate A–43B). ....

.... *Le*. (*Leptospina*) *dentate* *

– Truncated area of gonostylus as broad as 1/2 diameter of gonostylus (Plate A–44B). ....

.... *Le*. (*Leptospina*) *subdentata*

Leptosciarella* (s. str.) *trochanterata (zetterstedt 1851) * (Plate A–41)

Sciara trochanterata zetterstedt (1851): 3721–3722.

Sciara coarctata Winnertz 1867: 31–32.

Sciara prisca Winnertz 1867: 132–133.

Sciara splendens Winnertz 1867: 140.

Sciara saltuum Winnertz 1868: 534–535.

Sciara hirsutissima Strobl 1895: 131–132.

Description. *Male*. Head: eye bridge 4 ~ 5 facets wide. Flgm. IV (Plate A–41E) about 1.8 ~ 2.3 times as long as wide; Flgm. bristles dense and shorter than wide of neck; neck short and conical. Maxillary palpus (Plate A–41D) three–segmented; basal segment narrow with dense bristles and sensilla; second segment about 1/2 times as long as 3rd segments.

Thorax: dark brown. Posterior pronotum with bristles. Mesonotum with dark strong hairs; lateral and central with fine bristles. Scutellum with several strong bristles. Wings

(Plate A–41C) light; posterior veins with macrotrichia, usually up to half filled with macrotrichia; stem of M as long as M–fork; x = 0.8 y, bristles on half of y; stem of CuA = 1/4 x; R_1 = 1.3 ~ 1.5 R; R_5 dorsally and apex of ventral with macrotrichia; length of C = 2/3 w. Halteres dark and short stalked. Legs, yellow, or yellow–brown. Hind coxae of same colour as femora, or darkened; apex of fore tibia with dark and short bristles group without margin (Plate A–41F); claws untoothed.

Abdomen: gonocoxites (Plate A–41A) broadly separated; covered with short hairs. Gonostylus (Plate A–41B) 2.5 ~ 3.5 times longer than wide; apex equally rounded, or with one obtuse angle; Inner margin straight. Apical tooth is strong. Awl–like spines short. Tegmen broader than high; rectangular with rounded edges; with dark and strong edges. Aedeagus moderately long.

Body length: 3.1 ~ 4.1 mm

Female. Eye bridge wide, 4 rows. Flgm. IV link 2.2 times longer than wide. Palpus 3 segmented; basal segment with fine bristles and sensilla. Thorax hairs as the male. Abdomen covered with bright short hairs, often extended to all segments. Body length: 3.8 ~ 4.7 mm.

Material examined. Korea, 9 males: Mt. Homyeong, Cheongpyeong–ri, Gapyeong–gun, GG, altitude 220 m, 9 males, 18 ~ 31.iv.2009, Malaise trap, Leg. J. Lim.

Habitats. Very common in all types of woodland; ancient woodland with oak, hazel and bramble; heath land; wetlands including fen, water meadows and wooded river bank; former gravel workings; dunes; old hedges; parkland with rough grassland and scrub; grassland with pingo pools; disused railway cutting; gardens; open montane habitat. Reared from rotting pine stump, from nests of blackbird and song thrush (form with dark coxae only) (Menzel et al., 2006).

Distribution. New to Korea *, Austria, Bulgaria, Czech Republic, France, Ireland, Latvia, Russia, Switzerland (Menzel and Mohrig, 2000; Mohrig and Menzel, 1997).

Remarks. This species is easily recognizable by the conspicuous white hairs of the abdominal segments 3 ~ 4 and the white bristles of the mesonotum in both sexes.

Leptosciarella* (s. str.) *rejecta (Winnertz 1867) * (Plate A–42)

Sciara rejecta Winnertz (1867): 53–54.

Sciara elongata Winnertz 1867: 49–50.

Sciara hispida Winnertz 1871: 847–849.

Sciara echinata Lengersdorf 1926: 126.

Description. *Male*. Head: eye bridge 4 facets wide. Flgm. IV (Plate A–42E) about 2.2 ~ 2.4 times as long as wide; Flgm. bristles dense and shorter than wide of neck; neck short and conical. Maxillary palpus (Plate A–42D) three–segmented; basal segment slander and sensilla fine; second segment about 2/3 times as long as 3rd segments.

Thorax: dark brown. Posterior pronotum with bristles. Mesonotum with strong hairs; lateral, central and scutellum bristles strong. Wings (Plate A–42C) light brown; posterior veins with macrotrichia, usually all veins filled with macrotrichia; stem of M as long as M–fork; x = 0.8 ~ 1.0 y, bristles on half of y; stem of CuA = 1/2 x; R_1 = 1.5 R; R_5 dorsally and apex of ventral with macrotrichia; length of C = 2/3 w. Halteres dark. Legs, coxae and femora pale; tibiae and tarsi dark brown; apex of fore tibia with short bristles group without margin (Plate A–42F); claws untoothed.

Abdomen: genitalia (Plate A–42A) base with moderately long hairs; inside of gonocoxite with sparse hairs. Gonostylus (Plate A–42B) twice as long as wide, apex of gonostylus weakly flattened, with densely covered fine spines; apical tooth strong and sharp beak–shaped. Tegmen, typical with fine teeth. Aedeagus moderately long

Body length: 2.3 ~ 4.0 mm

Female. Eye bridge 4 rows; Flgm. IV 2.2 times as long as wide, wings usually browned clearly stated and all other same as male.

Body length: 4.0 ~ 4.5 mm

Material examined. Korea, 1 male: Seoguipo Natural Recreation Forest, Daepo–dong, Seoguipo–si, JJ, 1 male, 14.v.2008, Leg. S. Shin.

Habitats. Very common in all types of woodland; wetlands including fen, sedge beds, reed beds, bogs and water meadows; gravel pits; old hedges; neutral and calcareous grassland; gardens (Menzel et al., 2006).

Distribution. New to Korea *. Croatia, France, Great Britain, Germany, Latvia, Russia, Turkmenistan, Ukraine (Mohrig and Menzel, 1997).

Remarks. *Le*. *rejecta* slightly truncated gonostylus, whose upper edges are more or less angular to round. The crash area is densely covered with spines significantly wider than the half width of the stylus, unlike *Le*. *subpilosa*. and *Le*. *scutellata* with short neck and bristly hair similar but difference in gonostylus top third of the outside slanted and not nearly square. *Le*. *Brevior*, *Le*. *fuscipalpa* and *Le*. *melanoma* differs from the general area of the crash gonostylus tip.

Leptosciarella* (*Leptospina*) *dentata (Mohrig and Krivosheina 1979) * (Plate A–43)

Trichosia (*Leptosciarella*) *dentata* Mohrig et al. (1979): 573–574.

Description. *Male*. Head: eye bridge 4 facets wide. Ant. light and smooth; Flgm. IV (Plate A–43E) about 3.1 ~ 3.5 times as long as wide, bristles bright and 2/3 times as long as wide of neck; neck very short and smooth. Maxillary palpus (Plate A–43D) three–segmented; basal segment slander with 3 ~ 4 bristles, and without deep patch of sensillae; sensilla fine; basal and third segments same as long, second segment about 2/3 times as long as other two segments.

Thorax: dark. Posterior pronotum with bristles. Mesonotum pale and haired; lateral, central and scutellum bristles long. Wings (Plate A–43C) brown; posterior veins and wing membrane clearly without macrotrichia; stem of M as long as M–fork; x = 4/5 y, bristles on half of y; stem of CuA = 2/3 x; R_1 = R; R_5 dorsally and apex of ventral with macrotrichia; length of C = 3/5 w. Halteres pale and short stalked. Legs pale long and narrow; apex of fore tibia dense bristles group without margin (Plate A–43F); claws untoothed.

Abdomen: genitalia (Plate A–43A) wider than high; inside of gonocoxite covered with short and sparse hairs. Gonostylus (Plate A–43B) strong, broad–square–shaped, apex of gonostylus truncate and anteriorly oblique angled, subapical slim with apical tooth; inside of truncate area bare and rounded with about more than 10 spines, 1 or 2 spines under apical tooth. Tegmen, wider than high and laterally swigging; tooth area higher than wide, with few teeth. Aedeagus short and slender, with strong base.

Body length: 3.5 mm

Female. Unknown.

Material examined. Korea, 15 males: Mt. Homyeong, Cheongpyeong–ri, Gapyeong–gun, GG, altitude 220 m, 15 males, 18 ~ 31.iv.2009, Malaise trap, Leg. J. Lim.

Distribution. New to Korea *. Russia

Remarks. This species is easily recognized by the broad area of hollow truncated–shaped on apex of gonostylus, with tooth. In dorsal part lobe like *Le*. *lobodentata* is missing.

The y wing vein with some macrotrichia. The halteres are as bright as the bristles of the Mesonotum and Scutellum. The Flgm. are quite strong. The Flgm. IV is more than 3 times as long as wide, with very short neck. The Flgm. bristles are dense, fine and shorter than the link of width.

Leptosciarella* (*Leptospina*) *subdentata (Mohrig and Menzel 1992) (Plate A–44)

Trichosia (*Leptosciarella*) *subdentata* Mohrig et al. (1992): 19–20.

Description. *Male*. Head: eye bridge 4 facets wide. Flgm. IV (Plate A–44E) 3.0 ~ 3.5 times as long as wide with bright hairs; bristle–like hairs 2/3 times as long as width of Flgm. Maxillary palpus (Plate A–44D) three–segmented and bright; basal segment with 1 bristle without patch of sensillae. Clypeus with 3 hairs.

Thorax: brown. Posterior pronotum with some bristles. Mesonotum bright and long central, prescutellar hairs; 1 strong lateral hair. Scutellum with 2 ~ 3 strong bristles and some short hairs. Wings (Plate A–44C) smoky; length of R_1 = R; R_5 only dorsally with macrotrichia; length of y = x, y with 1 macrotrichia; length of C = 3/5 w; posterior veins bare. Halteres bright. Legs light–brown; fore tibia at inner apex with strong triangular patch of bristles (Plate A–44F); spurs of mid and hind tibiae equal, shorter than diameter of apex; claws untoothed.

Abdomen: genitalia (Plate A–44A) ventrally sparse haired, inner margin of gonocoxites hairs short and sparse. Gonostylus (Plate A–44B) truncated, apically cut anterior oblique with strong spines, naked crash area with 10 ~ 11 strong thorns, extended to outside, apical toothed. Tegmen small, broader than high and laterally swinging. Aedeagus short and slender, strong base.

Body length: 1.5 mm.

Female. Unknown.

Material examined. Korea, 1 male: Jeongam–ri, Hoengseong–eup, Hoengseong–gun, GG, 1 male, 3.iv ~ 25.v.2009, malaise trap, Leg. S. Shin.

Habitats. The adult flies have been found in malaise trap in Shiitake mushroom houses.

Distribution. New to Korea *, Japan.

Remarks. This species is very similar to *L. dentate*, but can be distinguished by the long Flgm., only one macrotrichia on y–vein, and relatively weak spines at the tip of the gonostylus.

Genus *Sciara* Meigen 1803

Type species: *Sciara hemerobioides* (Scopoli 1763): *Tipula thomae* Linnaeus 1767 [in Meigen1803, *Hirtea thomae* Fabricius; = *Tipula hemerobioides* Scopoli 1763]

Key to species of the genus *Sciara* in the Korean Peninsula

1. Wing membrane with macrotrichia or rarely bare; posterior pronotum with bristles; dorsal surface of gonocoxite deeply concave (Plate A–45, 46, 47). 2

– Wing membrane and posterior pronotum bare; dorsal surface of gonocoxite shallowly concave (Plate A–48, 49). 4

2. Inner side of gonocoxite without long bristles; concavity of dorsal surface of gonocoxite does not reach its basal half. 3

– Inner side of gonocoxite with rows of long bristles; concavity of dorsal surface of gonocoxite reaches its basal half (Plate A–46). .... *S. ruficauda* *

3. Thorax yellowish brown. Gonostylus without spines (Plate A–45B). .... *S. helvola*

– Thorax dark brown. Gonostylus without spines (Plate A–47B). .... *S. mendax*

4. Each gonostylus with more than 10 spines (Plates A–48B). .... *S. multispinulosa*

– Each gonostylus with less than 10 spines (Plates A–49B). .... *S.humeralis* *

Sciara helvola Winnertz 1867 (Plate A–45)

Sciara helvola Winnertz (1867): 30-31.

Description. *Male*. Head: eye bridge 3 facets wide. Scape, pedicel,1st and 2nd Flgm. yellowish brown; 3rd ~ 14th Flgm. brown; Flgm. IV (Plate A–45E) 4.0 ~ 4.2 times as long as wide, hairs yellowish, about 1.2 ~ 1.3 times as long as width of Flgm. Maxillary palpus (Plate A–45D) yellowish brown or brown, three–segmented basal segment with 5 ~ 8 bristles.

Thorax: yellowish or orange brown. Posterior pronotum with few bristles. Dorsocentral and dorsolateral bristles on mesonotum dark brownish. Scutellum with hairs, 2 ~ 4 bristles longer than others. Wings (Plate A–45C) with brownish anterior veins and light brownish posterior veins; wing membrane with bare or 1 ~ 8 macrotrichia mainly on marginal between

M_1 and M_2; M_1, M_2, CuA_1 and CuA_2 with dorsal macrotrichia, stem of M bare or with few dorsal macrotrichia; stem of M 1.1 ~ 1.2 times longer than M–fork; x = 0.6 ~ 1.0 y, bare; stem of CuA very short and almost absent; R_1 = 7/10 R; R_5 dorsally and apex of ventral with macrotrichia; length of C = 4/5 w. Halteres yellowish brown. Legs yellowish brown, tarsi dark brown; hind tibial vestiture with some differentiated spine–1ike short bristles; fore tibia with only bristle group without margin (Plate A–45F).

Abdomen: genitalia (Plate A–45A) nearly quadrate, ventroproximal part with median cleft, dorsal surface deeply concave. Gonostylus (Plate A–45B) nearly pyriform shapes, inner apex slightly swollen, truncate, and darkened with many short conical bristles. Tegmen membranous and quadrate shaped; almost as long as or slightly shorter than wide, minute tooth located at basal. Aedeagus narrow with 2 long forks.

Body length: 3.3 ~ 4.0 mm

Female. Ddifferent from male in following characters. Flgm. I with 5 ~ 6 brownish bristles among yellowish hairs; Flgm. IV 2.3 ~ 2.5 times as long as wide, hairs about 1.0 ~ 1.2 times as long as width of Flgm.

Material examined. Korea, 3 males, 5 females: Kwaneun tample, Ara–dong, Jeju–si, JJ, 1 male, 3 females, 12.v.2008, Leg. S. Shin.: chunwang tample, Nohyoung–dong, JJ, 1 male, 1 female, 15.v.2008, Leg. S. Shin.; Seoguipo Natural Recreation Forest, Daepo–dong, Seoguipo–si, JJ, 1 male, 1 female, 13.v.2008, Leg. S. Shin.

Distribution. Korea, Czech and Slovak Republics (Bohemia), Finland, Germany, European part of Russia, Switzerland, Sweden, Japan, (Heller et al., 2009; Lengersdorf, 1928–30; Mohrig et al., 1992; Sutou and Ito, 2004; Tuomikoski, 1960).

Remarks. *S. he1vola* is easily distinguished by the structure of gonostylus lacking distinct spines and light colored body, especially yellowish–orange brown thorax and brownish abdomen.

Sciara ruficauda Meigen 1818 * (Plate A–46)

Sciara ruficauda Meigen (1818): 280.

Sciara boleti Winnertz 1867: 19–21.

Sciara vigilax Winnertz 1867: 33–34.

Sciara mamaevi Antonova 1978 : 182, 186.

Description. *Male*. Head: eye bridge 3 ~ 4 facets wide. Ant. smooth; Flgm. IV (Plate A–46E) 4.0 times as long as wide, all Flgm. segments long; hairs light and coarse; hairs about as long as width of neck, neck short without sharp margin [all parts neck flask–shaped]. Maxillary palpus (Plate A–46D) three–segmented and browned; basal segment narrow and 1.4 ~ 1.6 times as long as second; patch of sensillae simple [without boundary or pitted depression]; basal segment with numerous long bristles, sensilla very fine; very long and slender 3rd segment, about 1.7 times as long as second and 1.2 times as long as basal.

Thorax: brown to dark brown, laterally with yellowish brown, abdomen little lighter. Posterior pronotum with bristles. Mesonotum hairs fine and bright, with strong and long lateral bristles. Scutellum with 4 ~ 5 strong bristles with several short bristles. Wings (Plate A–46C) large, tanned and with well developed anal area; posterior veins with strong macrotrichia; wing membrane in top part with some macrotrichia; M_1, M_2, CuA_1 and CuA_2 with dorsal macrotrichia, stem of M bare; stem of M only slightly longer than M–fork; x = y, both bare; stem of CuA = 1/4 x; R_1 = R; length of C = 3/4 w. Halteres short–stalked, and pale yellow. Legs pale, long and slender; apex of fore tibia with only bristles group without margin (Plate A–46F); claws untoothed.

Abdomen: genitalia (Plate A–46A) large, about as high as wide and bright yellowish brown; ventral genital basis without basal lobes or basal hair; gonocoxite inside hairs very sparse, fine and light; symmetrically in upper half gonocoxite with 2 arranged bristle groups [those consisting of very long and converging bristles]. Gonostylus (Plate A–46B) long and curved, outside bristles long; apex of gonostylus with nipple–shaped flat lobe; in this area short hairs with numerous short spines; inner side of gonostylus with slightly bulbous and short haired. Tegmen is much higher than broad, strongly sclerotized and flattened quadrangular; apex of tegmen several times shortly emarginate, with coarse teeth. Aedeagus short, sclerotized and with long funnel–shaped base.

Body length: 4.5 mm.

Material examined. Korea, 5 males: Mt. Jeambong Nat. park, Kilin–myeon, Injae–gun, GW, 1 male, 24.viii.2011, Leg. H. Choi.; Eongddo Water Fall, Gangjung–dong, Seoguipo–si, JJ, 1 male, 14.v.2008, Leg. S. Shin.; *ditto*, Seoguipo Nat. park, JJ, 1 male, 12.vii.2011, Leg. S. Shin.; Bongrae Water fall, Jeodong–ri, Ulleung–eup, KB, 1 male, 30.viii.2010, Leg. S. Shin.; Suraksan, Sanggye–dong, Noweon–gu, Seoul, 1 male, 25 ~ 31.viii.2007, Leg. J. Lim.

Habitats. Found in broad–leaved woodland

Distribution. New to Korea *, Britain, Germany, Taiwan, Denmark, Sweden (Heller et al., 2009; Menzel et al., 2006; Petersen, 2001; Rudzinski, 2005).

Remarks. This species is easily recognized by unique character: very long bristles on upper side of gonocoxite.

Sciara mendax Tuomikoski 1960 (Plate A–47)

Sciara mendax Tuomikoski (1960): 13.

Trichosia modesta Winnertz 1867: 286

Sciara nursei Freeman 1983: 161, 162

Sciara marginata Mohrig and Krivosheina 1983: 2, 3

Sciara urichi Menzel and Mohrig 1998: 373

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. brown, pedicel brown, Flgm. brown; Flgm. IV (Plate A–47E) 2.5 times as long as wide, hairs yellowish brown and almost as long as width of Flgm. basal. Maxillary Palpus (Plate A–47D) brown, three–segmented with 5 ~ 6 bristles 3rd segment narrow, twice as long as 2nd.

Thorax: brown. Posterior pronotum with bristles. Dorsocentral with 2 long bristles with short hairs on mesonotum. Scutellum with 4 rough bristles. Katepisternum brown. Wings (Plate A–47C) veins brownish except for light brownish stem of M; wing membrane with macrotrichia; M_1, M_2, CuA_1, and CuA_2 with dorsal macrotrichia, stem of M with 1 ~ 4 dorsal macrotrichia, x, y bare; stem of M 0.8 times longer than M–fork; x = y; stem of CuA 0.5 x ; $R_1 = 1.2$ R; R_5 dorsally and apex of ventral with macrotrichia; C = 0.6 w. Halters brown, with many bristles. Legs yellow, tibiae and tarsi light brown; apex of fore tibia with only bristles group without margin (Plate A–47F).

Abdomen: genitalia (Plate A–47A) ventrally rounded. Gonostylus (Plate A–47B) rounded and curved on apex with short bristles; dorsal inner side with strong 3 ~ 5 spines, which are dark and long, these spines stand on same lobe, bristles on inner side are as long as spines. Tegmen rounded, with membranous margin. Aedeagus strong sclerotized

Body length: 2.5 ~ 3.0 mm

Distribution. Korea, Austria, Russia, Sweden, Taiwan. UK (Heller et al., 2009; Mohrig et al., 1992).

Material examined. Korea, 1 male: Mt. Yeogi, Seodun–dong, Gwonseon–gu, Suwon–si, GG, 1 male, 8.v.1995, malaise trap, Leg. H. Lee.

Remarks. Mohrig et al. (1992) recorded this species in North Korea (*Sciara marginata* Mohrig and Krivosheina 1983); this species is easily recognized by unique character: gonostylus rounded, and very long and strong 3 ~ 5 spines on inner side of gonostylus.

Sciara multispinulosa Mohrig and Kazanek 1992 (Plate A–48)

Sciara multispinulosa Mohrig et al. (1992): 19.

Description. *Male*. Head: eye bridge 3 facets wide. Ant. scape and pedicel brown; Flgm. brown; Flgm. IV (Plate A–48E) 3.6 ~ 4.0 times as long as wide, hairs yellowish brown and almost as long as width of Flgm. Maxillary palpus (Plate A–48D) yellowish brown, basal segment with 4 ~ 6 bristles mainly on outer side and with indistinct brownish sensory area bearing minute sensilla.

Thorax: color predominantly dark brown. Posterior pronotum bare. Mesonotum with short dorsocentral hairs, and long dorsolateral. Scutellum bristles dark brownish and long.

Wings (Plate A–48C) with brownish anterior veins and light brownish posterior veins; membrane without macrotrichia; M_1, M_2, CuA_1, and CuA_2 with dorsal macrotrichia, stem of M with 3 ~ 7 dorsal macrotrichia, x bare or with few dorsal macrotrichia, y with 4 ~ 5 dorsal macrotrichia; x = 1.1 ~ 1.3 y; stem of CuA very short or absent; R_1 = 9/10 R; R_5 dorsally and apex of ventral with macrotrichia; C = 7/10 w. Halter yellowish brown. Legs predominantly yellowish brown, tarsi brown; each tibial vestiture without differentiated spine–like short bristles; apex of fore tibia with only bristles group without margin (Plate A–48F).

Abdomen: genitalia (Plate A–48A) forming narrow bridge, dorsal surface shallowly concave. Gonostylus (Plate A–48B) nearly triangular, with characteristic 13 ~ 15 strong spines and tongue–1ike inner process bearing many short conical bristles. Tegmen (Plate A–48A) membranous, slightly longer than wide, minute tooth located on proximal and central area. Aedeagus slender with 2 long forks.

Body length: 1.9 ~ 2.2 mm

Female. Different from male in following characters: Flgm. I with 4 ~ 6 brownish bristles among yellowish hairs; Flgm. IV 2.1 ~ 2.7 times as long as wide. Second segment of palpus with 12 ~ 15 bristles. Stem of M with 4 ~ 11 dorsal macrotrichia; distal 1/3 ~ 1/2 of R_5 with both dorsal and ventral macrotrichia; y with 7 ~ 10 dorsal macrotrichia; length of x = 0.8 ~ 1.1 y; R_1 long, ending well beyond branching point of M.

Material examined. Korea 4 males, 1 female: Nari, Buk–myeon, Ulleung–gun, KB, 3 males, 1 female, 30.viii.2010, Leg. S. Shin.; Micheongol–Nat. Park, Seo–myeon, Yangyang–gun, GW, 1 male, 15.vii.2010, Leg. S. Shin.

Distribution. Korea, Japan (Mohrig et al., 1992; Sutou, 2004).

Remarks. *S. multispinulosa* is characterized by 13 ~ 15 strong spines on the gonostylus (Plate A–48B). The bare wing membrane and bare posterior pronotum indicate that this species belongs to the *S. humeralis* species group.

Sciara humeralis Zetterstedt 1851 * (Plate A–49)

Sciara humeralis Zetterstedt (1851): 3718.

Description. *Male*. Head: eye bridge 2 ~ 3 facets wide. Ant. scape brown, pedicel brown, Flgm. brown; Flgm. I with 2 ~ 5 brownish bristles among yellowish hairs; Flgm. IV (Plate A–49E) 2.6 ~ 2.9 times as long as wide, hairs yellowish brown and almost as long as width of Flgm. basal. Maxillary Palpus (Plate A–49D) yellowish brown, three–segmented with 3 ~ 6 bristles mainly on its outside and with indistinct brownish sensory area bearing minute sensilla.

Thorax: dark brown. Posterior pronotum bare. Dorsocentral with short and dorsolateral with long bristles on mesonotum. Scutellum with various length of bristles. Katepisternum brown. Wings (Plate A–49C) veins brownish except for light brownish stem of M; wing membrane without macrotrichia; M_1, M_2, CuA_1, and CuA_2 with dorsal macrotrichia, stem of M with 1 ~ 4 dorsal macrotrichia or rarely without macrotrichia, x bare, y with 2 ~ 5 dorsal macrotrichia; stem of M 0.8 ~ 1.0 times longer than M–fork; x = 0.7 ~ 1.2 y; stem of CuA almost absent or 0.1 ~ 0.3 x ; R_1 = 0.7 ~ 0.9 R; R_5 dorsally and apex of ventral with macrotrichia; C = 0.7 w. Halters brown, knob with many bristles. Legs predominantly yellowish brown, tibiae and tarsi brown; each tibial vestiture without differentiated short and spine like bristles; apex of fore tibia with only bristles group without margin (Plate A–49F).

Abdomen: genitalia (Plate A–49A) ventrally narrow bridge, dorsal surface shallowly concaved. Gonostylus (Plate A–49B) nearly triangular shaped with tongue–shaped inner lobe bearing many short bristles, and apically with horn–like process, apex is split into 3 ~ 5 spines, besides them, 1 ~ 4 spines located dorsally, these spines variable. Tegmen membranous, longer than wide and weakly attenuated apically, minute tooth located basally. Aedeagus with two long branches.

Body length: 4.0 ~ 4.2 mm

Female. Different from male in following characters: Flgm. IV 2.0 ~ 2.5 times as long as wide, hairs about 0.8 times as long as width of Flgm. basal. Wing membrane bare or sometimes with few macrotrichia; distal l/3 ~ 1/2 of R_5 with both dorsal and ventral macrotrichia; y with 2 ~ 9 dorsa1ly macrotrichia; R_1 = 0.8 ~ 1.0 R; x = 0.8 ~ 1.3 y; R_1 ending well beyond branching point of M. Abdomen unicolored, brown or dark brown.

Material examined. Korea, 5 males. Kwanak arboretum, Anyang–si, GG, 1 male, 09.vii.2008, Leg. S. Shin.; Jogok–ri, Hoengseong–eup, Hoengseong–gun, GW, malaise trap, 1 male, 23 ~ 29.vii.2007, malaise trap, Leg. S. Shin.; *diito*, 1 male, 17.viii ~ 7.ix.2009, Leg. S. Shin.; Hamyang–gun, KN, 1 male, 26.vii.2011, Leg. H. Choi.; Mt. Jung, sicheon–myeon, Sancheong–gun, KN, 1 male, 29.vi.2011, Leg. H. Choi.

Remarks. *S. humeralis* is well characterized by the presence of horn–like large process on the gonostylus (Plates A–49 A, B) and the shapes of tegmen. The horn–like process on the gonostylus of this species is somewhat peculiar in having split apex. Menzel and Mohrig (2000) pointed out the morphological variation of the male genitalia of *S. humeralis*. They categorized them into two types: examples from Europe and USA having 3 ~ 4 dorsal spines and relatively short horn–like apical process on their gonostylus; examples from Taiwan, southern China and northern Vietnam having only one dorsal spine and relatively long horn–like apical process on their gonostylus. Sutou (2004) suggested two types of *S. humeralis* (Holoarctic type, Oriental type) could be independent species or subspecies status for the Oriental type.

Genus *Trichosia* Winnertz 1867

Type species: *Trichosia splendens* Winnertz 1867

Trichosia confusa Menzel and Mohrig 1997 * (Plate A–50)

Trichosia confusa Menzel and Mohrig (1997a): 9, 14–15.

Male. **Head**: eye bridge 4 ~ 5 facets wide. Ant. dark brown and very thick; Flgm. IV (Plate A–50E) about 3 times as long as wide; bristles about 2/3 times as long as width of Flgm. basal. Maxillary palpus brown and short, three–segmented (Plate A–50D); basal segment with 3 ~ 4 bristles, and without patch of sensillae; sensilla fine; basal segment as long as 3rd. frons with 5 ~ 6 longer and several shorter hairs.

Thorax: dark. Posterior pronotum with bristles. Mesonotum with very short haired. Wings posterior veins with macrotrichia and wing membrane clearly without macrotrichia; stem of M slightly longer than M–fork; x = 3/4 y, macrotrichia on y; stem of CuA = 1/3 x; R_1 = 1.5 R; R_5 dorsal and ventral with macrotrichia; length of C = 2/3 w. Halteres short stalked and yellow. Legs pale yellow; apex of fore tibia with strong bristles group without curved margin (Plate A–50F); claws untoothed.

Abdomen: genitalia (Plate A–50A) dark, inside of ventral gonocoxite hairs moderately long, base of gonocoxite bare. Gonostylus relatively short, outside evenly rounded and inside of middle with strong spine socket group, top half triangular (apex of gonostylus narrowed, but slightly rounded); middle of gonostylus inside with 5 ~ 6 strong spines. Tegmen flat, triangular, membranous; with fine teeth. Aedeagus short and wide.

Body length: 3.0 mm

Female. Unknown.

Material examined. Korea, 8 males: Gwanak Abr., Anyang–si, Manan–gu, GG, 7 males, altitude 140 m, 16.v ~ 07.vi.2007, Malaise trap, Leg. J. Lim.; Mt. Homyeong, Cheongpyeong–ri, Gapyeong–gun, GG, altitude 220 m, 1 male, 18 ~ 31.viii.2009, Malaise trap, Leg. J. Lim.

Habitats. Very common in all types of woodland; fen; water meadows by river; gravel pits; old hedges; calcareous grassland and scrub; dunes; gardens; in house. Reared from rotten wood (Menzel et al., 2006).

Distribution. New to Korea *. Austria, Ukraine, Russia, Germany (Menzel et al., 2006).

Remarks. *T. confusa* differs in the gonostylus shape and spines between *T. morio* and *T. acrotricha*. *T. acrotricha* differs by the lack of macrotrichia on apex of wing membrane, antennal flagellum shorter, halteres small and hairy, shorter gonostylus with thin hair on the inside of gonostylus and smaller size. *T. morio* differs by the smaller apex of gonostylus and the much finer hairs inside the gonostylus.

PART II. DNA barcoding of *Bradysia* (Diptera: Sciaridae) for the identification of larval stages on agriculture plants.

ABSTRACT

The applicability of mitochondrial cytochrome c oxidase (COI) DNA barcode of genus *Bradysia* is studied as the first step towards a COI DNA barcode database for the genus *Bradysia*. Although, the larvae of some species in this genus are pest, the immature stages are hardly identified due to the lack of morphological key characters. Thus, the partial sequences of COI gene are constructed for 25 species of *Bradysia* with the identified voucher specimens. The mean Kimura two–parameter (K2P) interspecific divergence of genus *Bradysia* was 16.78 %, and mean K2P intraspecific divergence was 0.52 %. Comparing these data, *Bradysia difformis*, *B. peraffinis*, *B. procera*, and *B.* sp. 1 are identified from the larval specimens by molecular COI universal region; thus the larvae inhabits in paprika, oak sawdust, ginseng, and scallion are confirmed respectively. Therefore, DNA barcodes are proved to be an available tool for species identification as well as definition of the species within genus *Bradysia*.

Keywords : Genus *Bradysia*, DNA barcode, pest, molecular identification, COI.

2–1. Introduction

The family Sciaridae is one of the most commonly found flies in residential environments as well as agricultural ecosystem. The genus *Bradysia* is the most species rich group, and they have a wide range of the larval habitats within the family Sciaridae (Menzel & Mohrig 2000; Menzel et al., 2003; Menzel et al., 2006). Habitats of genus *Bradysia* are known as forest, greenhouse, and flowerpot for feeding on diverse organic materials, such as dead woods, leaf litters, humus, and living plants in larval stage (Steffan 1973; Menzel & Mohrig 2000; White et al., 2000; Menzel et al., 2003; Sutou & Ito 2004; Menzel et al., 2006; Shin et al., 2012). Especially, larvae of *Bradysia difformis* and *B. ocellaris* were reported as the pest of plants (e.g. carrots, cucumbers, garlic, melon, potatoes, strawberries, sweet potato) (Menzel et al., 2003), and *B. procera* larvae was reported as a pest of ginseng (Shin et al., 2008; Lee et al., 2010; *Phytosciara procera* is a wrong record of *Bradysia procera*).

Those pest species have been reported by reared males from damaged plants, because identification of the larval stage is almost impossible (Steffan 1981; Sutou et al., 2011). However, it is hard to confirm of the pest species from damaged plants, if more than one species collected when the adult flies emerged. Therefore, direct confirmation of the Sciaridae larvae from damaged plants could be an important element for ecological study of the sciarids as a pest.

In the previous studies, the genus *Bradysia* are known as the most controversial group within Sciaridae (Menzel & Mohrig 2000; Menzel et al., 2003), because the infraspecific variation of them has been studied based on the morphological characters (Menzel & Mohrig 2000; Menzel et al., 2003). Especially, Menzel et al. (2003) reported, even though the genital sturucture is within the range of infraspecific variation, the male of *B.*

ocellaris from Australian region have a difference in ratio of antennal segment, compared with males from other zoogeographic regions, (Menzel et al., 2003). Thus, I interested in the matching of DNA barcoding region as well as morphological characters of voucher specimens.

The DNA barcoding is one of the reasonable methods for species identification, as well as quarantine and forensic entomology (Armstrong & Ball 2005; Ball et al., 2005; Ball & Armstrong 2006; Rivera & Currie 2009). Within Sciaridae, the genus *Sciara* has been studied for confirmation of "Armyworm" species in Japan by by COI barcoding region (Sutou et al., 2011). They reported each species of *Sciara* showed an independent cluster. Further, the maximum intraspecific distance was 1.6%, and the minimum interspecific distance was 4.8% in the genus *Sciara*. Intraspecific distance was significantly lower than interspecific distance, and therefore they suggesting that species identification of the genus *Sciara* using COI barcoding region can be a useful tool. Other DNA barcodes of Sciaridae have been studied for genetic diversity of *B. difformis* and *Lycoriella ingenue* (Bae et al., 2001; Hurley et al., 2010). As a consequence of all, the genetic diverse of intraspecific K2P distance has been reported lower than 1.6% (*B. difformis*: 1.52 %; *Sciara*: 1.6%); further, the interspecific K2P distances were more than 4.8%: (between *Sciara kitakamiensis* and *S. humeralis*) within genus level. Also I expect that the genus *Bradysia* could be an identifiable taxon with COI DNA barcoding methods.

The main aim of our study is an examination of DNA barcode applicability for *Bradysia* species identification, through confirmation of barcoding gap between inter– and intraspecific K2P distances. DNA database of identified male specimens was constructed, then that of female and larval specimens matched with identified male species. Therefore, we confirmed the species of female and larval stages by DNA barcode based method. And direct identification of pest larvae were studied by COI database. Consequently, I identified the sciarid larvae from stem of ginseng, scallion, and paprica; and 23 species of COI database is newly reported.

2–2. Materials and methods

2–2–1. Taxon sampling

All of the examined larvae were collected from damaged parts of agriculture plants (Stem of Scallion, and Ginseng) and mushroom bed (Shiitake) (Fig. 2–1A, B), for collecting emerged flies from scallion, pot of scallion has been reared in isolated acrylic cage. To collect adults in various habitats, malaise traps and sweeping net were used. Samples were stored in 99% ethanol, which were used for extraction of genomic DNA (Table 2–1). The identification of each *Bradysia* species was based on the male exterior morphologies of the slide–mounted specimens. All of the samples and voucher specimens were preserved in the Insect Collection of the College of Agriculture and Life Sciences, Seoul National University, Korea. DNA sequences for the COI barcode region were obtained from a total of 176 individuals. Of these, 126 specimens of males were identified to the species–level based on their morphology. Among them, twenty–five species of genus *Bradysia* has been identified by morphological characteristics of male specimens. The remaining specimens (43 adult females, 7 larvae) were used to reexamine the DNA barcode dataset to ensure that all species of concern in this particular habitat could be identified based on their COI sequences.

Therefore, two plant pest species of larvae were confirmed as genus *Bradysia* for species level matching of the COI barcoding region, and those larvae were collected from the damaged parts of ginseng (*B. procera*) and scallion (*B.* sp. 1) respectively.

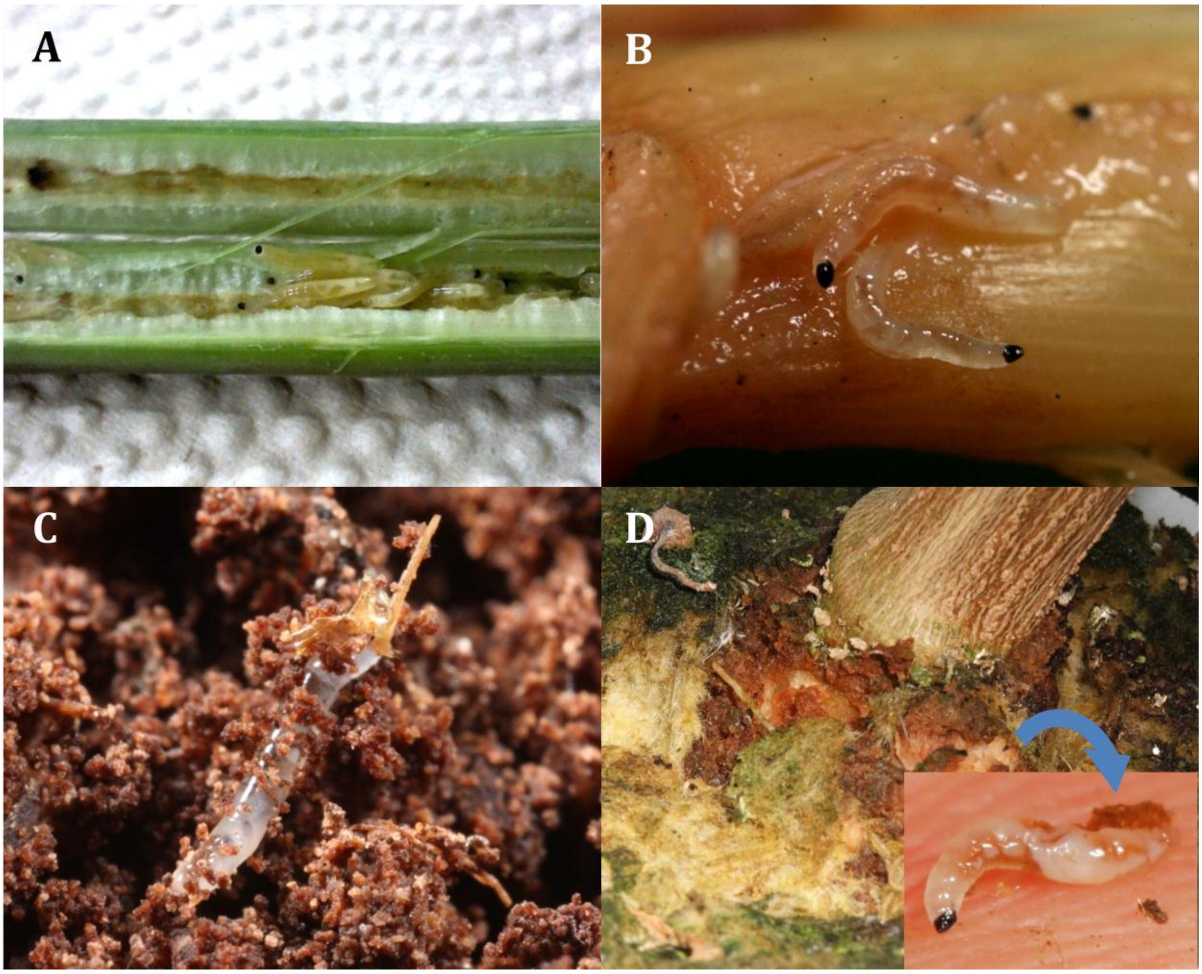

Figure 2–1. A: Larvae of *Bradysia procera* feed on stem of ginseng; B: Larvae of *Bradysia* sp. 1 feeding on stem of scallion; C: Larva of *Bradysia peraffinis* reared from oak sawdust medium; D: Larva of *Bradysia difformis* live on root of paprika.

2–2–2. DNA extraction, PCR amplification, and sequencing

Total genomic DNA was extracted from single individuals using a DNeasy® Blood and Tissue kit (QIAGEN, Inc). All genomic templates were stored at –35℃. For making voucher specimens from the DNA–extracted samples, I used a nondestructive DNA extraction protocol slightly modified from the method of Favret (2005) and Kim et al. (2010).

Before extraction, head, wings, and genitalia were dissected and mounted onto microscope slide respectively. The thorax and abdomen left in the lysis buffer with proteinase K solution at 56℃ for 6 h. After incubation, the cleared cuticle was dehydrated and mounted with other mounted parts onto a microscope slide. The DNA fragments to be analysis were amplified using AccuPower PCR PreMix, a total of 20 µl reaction mixture contained 1 unit of *Top* DNA polymerase (BIONEER, Corp., Daejeon, Korea), 250 µM of dNTPs, 10 mM of Tris–HCl, 30 mM of KCl and 1.5 mM of $MgCl_2$, 1 µl of each primers (10 pmole) and 5–20 ng of template DNA. PCR was performed using a PTC–100 thermocycler (MJ Research Inc., United States of America). I used the following thermal cycle parameters for the 20 µl amplification reactions: initial denaturation at 95℃ for 5 min, followed by 35 cycles of 95℃ for 30 s, annealing temperature of 45℃ for 40 s, and extension at 72℃ for 50 s, with a final extension at 72℃ for 10 min. The PCR products were visualized by electrophoresis on a 2% agarose gel and stained with Ethidium Bromide, and purified using a QIAquick PCR purification kit (QIAGEN, Inc.), and directly sequenced at Macrogen, Inc (Geumcheon–Gu, Seoul, Republic of Korea). The partial sequences of mitochondrial cytochrome c oxidase subunit I (COI) gene was amplified using primer pairs LCO1490 (5'–GGTCAACAAATCATAAAGATATTGG–3'; Folmer et al., 1994) / HCO2198 (5'–TAAACTTCAGGGTGACCAAAAAATCA–3'; Folmer et al., 1994). The sequences generated in this study were all deposited to the National Center for Biotechnology Information (NCBI) (Table 2–1), and *Masakimyia pustulae* (Diptera: Cecidomyiidae) species was employed as an out–group taxon, Genbank Number: JQ613784.

2–2–3. **Sequence alignment and data analyses**

The character sets used for the analyses, 658 bp of COI Raw sequences were examined and corrected using SeqMan II (ver. 5.01, 2001; DNA–star). Alignments conducted by using MAFFT (Katoh et al., 2002; Katoh et al., 2005; Katoh & Toh 2008) via the online sever (ver. 6; http://mafft.cbrc.jp/ alignment/software/). COI sequences had no indels and were aligned using the FFT–NS–I strategy implemented by the MAFFT online server using the default setting.

Pairwise distances, number of substitutions, and nucleotide compositions for COI were obtained using MEGA 5.0 (Tamura et al., 2011) based on the Kimura two–parameter (K2P) model. Neighbor–joining (Saitou & Nei 1987) bootstrap support analysis (1000 replicates) was performed using MEGA 5.0 (Tamura et al., 2011). The K2P model of nucleotide substitution (Kimura 1980), was selected for the analyses, which is the most widely used model for DNA barcoding analyses.

Table 2–1. List of specimens.

Sample number	Species name	country	DNA number	Habitat	Genbank Accession No.	state
PP1002 male–j2	*Bradysia procera*	Korea	100113 –j2	Ginseng farm	JX418169	Male
090516–SKJ–012–3	*Bradysia difformis*	Korea	100113 –S3	Shiitake farm (sawdust bed)	JX418035	Male
090525–SKH–012–1	*Bradysia longimentula*	Korea	100113 –S4	Shiitake farm (log bed)	JN378630	Male
090525–SKH–012–2	*Bradysia longimentula*	Korea	100113 –S5	Shiitake farm (log bed)	JN378631	Male
090525–SKH–012–3	*Bradysia longimentula*	Korea	100113 –S6	Shiitake farm (log bed)	JN378632	Male
090525–SKH–012–5	*Bradysia longimentula*	Korea	100113 –S8	Shiitake farm (log bed)	JN378634	Male
090818–SKP–001–2–1	*Bradysia difformis*	Korea	100113 –S9	Shiitake farm (sawdust bed)	JN378638	Male
090818–SKP–001–2–3	*Bradysia difformis*	Korea	100113 –S11	Shiitake farm (sawdust bed)	JN378640	Male
090818–SKP–001–2–4	*Bradysia difformis*	Korea	100113 –S12	Shiitake farm (sawdust bed)	JN378641	Male
090818–SKP–001–2–5	*Bradysia difformis*	Korea	100113 –S13	Shiitake farm (sawdust bed)	JN378642	Male
090818–SKP–001–2–6	*Bradysia difformis*	Korea	100113 –S14	Shiitake farm (sawdust bed)	JN378643	Male
090818–SKP–001–2–7	*Bradysia difformis*	Korea	100113 –S15	Shiitake farm (sawdust bed)	JN378644	Male
090818–SKP–001–2–9	*Bradysia difformis*	Korea	100113 –S16	Shiitake farm (sawdust bed)	JN378645	Male
090818–SKP–001–2–10	*Bradysia difformis*	Korea	100113 –S17	Shiitake farm (sawdust bed)	JN378646	Male
090818–SKP–001–2–11	*Bradysia difformis*	Korea	100113 –S18	Shiitake farm (sawdust bed)	JN378647	Male
090818–SKP–001–2–12	*Bradysia difformis*	Korea	100113 –S19	Shiitake farm (sawdust bed)	JN378648	Male
090818–SKP–001–2–13	*Bradysia difformis*	Korea	100113 –S20	Shiitake farm (sawdust bed)	JN378649	Male
090818–SKP–001–2–14	*Bradysia difformis*	Korea	100113 –S21	Shiitake farm (sawdust bed)	JN378650	Male
090818–SKP–001–3–1	*Bradysia difformis*	Korea	100113 –S22	Shiitake farm (sawdust bed)	JN378651	Male
090818–SKP–001–3–2	*Bradysia difformis*	Korea	100113 –S23	Shiitake farm (sawdust bed)	JN378652	Male
090818–SKP–001–3–3	*Bradysia difformis*	Korea	100113 –S24	Shiitake farm (sawdust bed)	JN378653	Male
090818–SKP–001–3–6	*Bradysia difformis*	Korea	100113 –S27	Shiitake farm (sawdust bed)	JN378656	Male
090818–SKP–001–5	*Bradysia difformis*	Korea	100113 –S28	Shiitake farm (sawdust bed)	JN378657	Male
090514–SKP–011–2	*Bradysia nomica*	Korea	100126 –S36	Chinese cabbage greenhouse	JX418036	Male
090805–SKW–S2–1	*Bradysia fugaca*	Korea	100126 –S39		JX418037	Male
090805–SKW–S2–2	*Bradysia fugaca*	Korea	100126 –S40		JX418038	Male
090429–SKS–011–1–1	*Bradysia subaprica*	Korea	100126 –S43		JX418039	Male

090429–SKS–011–1–3	*Bradysia protohilaris*	Korea	100126 –S45		JX418040	Male
090429–SKS–011–1–6	*Bradysia protohilaris*	Korea	100126 –S46		JX418041	Male
090429–SKS–011–1–7	*Bradysia protohilaris*	Korea	100126 –S47		JX418042	Male
090429–SKS–011–1–9	*Bradysia protohilaris*	Korea	100126 –S48		JX418043	Male
090429–SKS–011–1–13	*Bradysia protohilaris*	Korea	100126 –S49		JX418044	Male
090429–SKS–011–1–14	*Bradysia protohilaris*	Korea	100126 –S50		JX418045	Male
090429–SKS–011–2–1	*Bradysia protohilaris*	Korea	100126 –S52		JX418046	Male
090429–SKS–011–2–2	*Bradysia protohilaris*	Korea	100126 –S53		JX418047	Male
090429–SKS–011–2–3	*Bradysia aprica*	Korea	100126 –S54		JQ613785	Male
090529–SKB–3	*Bradysia protohilaris*	Korea	100126 –S60		JX418048	Male
090731–SKH–4	*Bradysia protohilaris*	Korea	100113 –S66		JX418049	Male
090820–HR	*Bradysia alpicola*	Korea	100113 –S73		JQ613787	Male
090622–SKC–S1–1	*Bradysia protohilaris*	China	100113 –S79		JX418050	Male
090622–SKC–S1–3	*Bradysia cuneiforma*	China	100113 –S81		JX418051	Male
090504–SKP–011–1	*Bradysia nomica*	Korea	100226 –S106	Chinese cabbage greenhouse	JX418052	Male
090504–SKP–011–3	*Bradysia nomica*	Korea	100226 –S107	Chinese cabbage greenhouse	JX418053	Male
090504–SKP–011–5	*Bradysia nomica*	Korea	100226 –S108	Chinese cabbage greenhouse	JX418054	Male
090622–SKC–04–1	*Bradysia quadrispinistylata*	China	100226 –S113		JX418055	Female
090622–SKC–04–2	*Bradysia quadrispinistylata*	China	100226 –S114		JQ613794	Male
100330 s–4	*Bradysia difformis*	Korea	100113 –S119	Onion farm	JX418056	Male
100330 s–7	*Bradysia difformis*	Korea	100113 –S120	Onion farm	JX418057	Male
100330 s–8	*Bradysia difformis*	Korea	100113 –S121	Onion farm	JX418058	Male
100330 s–9	*Bradysia difformis*	Korea	100113 –S122	Onion farm	JQ613795	Male
100330 s–10	*Bradysia difformis*	Korea	100113 –S123	Onion farm	JX418059	Male
100330 s–13	*Bradysia nomica*	Korea	100113 –S124	Onion farm	JX418060	Male
100330 s–16	*Bradysia difformis*	Korea	100113 –S125	Onion farm	JX418061	Male
100330 s–17	*Bradysia nomica*	Korea	100113 –S126	Onion farm	JX418062	Male
100330 s–19	*Bradysia nomica*	Korea	100113 –S127	Onion farm	JX418063	Male
100330 s–20	*Bradysia difformis*	Korea	100113 –S128	Onion farm	JX418064	Male
100330 s–21	*Bradysia difformis*	Korea	100113 –S129	Onion farm	JX418065	Male
100330 s–24	*Bradysia nomica*	Korea	100113 –S130	Onion farm	JX418066	Male
080901–SKT	*Bradysia procera*	Korea	100126 –S131	Ginseng farm	JX418067	Female
090128 SKH–1	*Bradysia sp. 1*	Korea	100126 –S132	Stem of Scallion	JX418068	Larva

Sample number	Species name	country	DNA number	Habitat	Genbank Accession No.	state
090128 SKH–2	*Bradysia atracornea*	Korea	100126 –S133	Scallion farm	JQ613796	Male
090128 SKH–3	*Bradysia atracornea*	Korea	100126 –S134	Scallion farm	JX418069	Female
pp1003 LAV–2	*Bradysia procera*	Korea	100126 –S145	Stem of Ginseng	JX418070	Larva
PP1005 LAV–3	*Bradysia procera*	Korea	100126 –S146	Stem of Ginseng	JX418071	Larva
PP1002 male–1	*Bradysia procera*	Korea	100126 –S147	Ginseng farm	JQ613797	Male
PP0001 LAV–4	*Bradysia procera*	Korea	100126 –S148	Stem of Ginseng	JX418072	Larva
PP0001 LAV–5	*Bradysia procera*	Korea	100126 –S149	Stem of Ginseng	JX418073	Larva
090516–SKJ–012–02–2	*Bradysia difformis*	Korea	100126 –S157	Shiitake farm (log bed)	JX418074	Female
090616–SKC–04–1	*Bradysia quadrispinistylata*	China	100113 –S161		JX418075	Male
090616–SKC–04–2	*Bradysia quadrispinistylata*	China	100113 –S161		JX418076	Male
090902 SKC–3–10	*Bradysia peraffinis*	Korea	100113 –S168	Shiitake farm (log bed)	JX418077	Female
090902 SKC–3–11	*Bradysia difformis*	Korea	100113 –S169	Shiitake farm (log bed)	JN378659	Female
090516–SKJ–012–1	*Bradysia difformis*	Korea	100113 –S176	Shiitake farm (log bed)	JX418078	Male
090516–SKJ–012–3	*Bradysia difformis*	Korea	100113 –S178	Shiitake farm (log bed)	JX418079	Male
101007–SKB–1	*Bradysia peraffinis*	Korea	100113 –S184	Shiitake log bed	JX418080	Female
101007–SKB–2	*Bradysia peraffinis*	Korea	100113 –S185	Shiitake log bed	JX418081	Female
101007–SKB–3	*Bradysia peraffinis*	Korea	100113 –S186	Shiitake log bed	JX418082	Female
101007–SKB–4	*Bradysia peraffinis*	Korea	100113 –S187	Shiitake log bed	JX418083	Female
101007–SKB–5	*Bradysia peraffinis*	Korea	100113 –S188	Shiitake log bed	JX418084	Male
101007–SKB–6	*Bradysia peraffinis*	Korea	100113 –S189	Shiitake log bed	JX418085	Male
101007–SKB–7	*Bradysia peraffinis*	Korea	100113 –S190	Shiitake log bed	JX418086	Male
101000–SKB–8	*Bradysia peraffinis*	Korea	100113 –S191	Shiitake log bed	JX418087	Male
101007–SKB–9	*Bradysia peraffinis*	Korea	100113 –S192	Shiitake log bed	JX418088	Male
101007–SKB–10	*Bradysia peraffinis*	Korea	100113 –S193	Shiitake log bed	JX418089	Female
101007–SKB–11	*Bradysia peraffinis*	Korea	100113 –S194	Shiitake log bed	JX418090	Female
101007–SKB–14	*Bradysia peraffinis*	Korea	100113 –S197	Shiitake log bed	JX418091	Larva
101007–SKB–15	*Bradysia peraffinis*	Korea	100113 –S198	Shiitake log bed	JX418092	Larva
090516–SKJ	*Bradysia difformis*	Korea	100113 –S199	Shiitake farm (log bed)	JN378661	Male
090508–SKJ–009–2	*Bradysia peraffinis*	Korea	110504 –S206	Shiitake farm (log bed)	JQ613799	Male
090508–SKJ–009–3	*Bradysia peraffinis*	Korea	110504 –S207	Shiitake farm (log bed)	JX418093	Male

090508–SKJ–009–4	*Bradysia peraffinis*	Korea	110504 –S208	Shiitake farm (log bed)	JX418094	Male
090508–SKJ–009–5	*Bradysia peraffinis*	Korea	110504 –S209	Shiitake farm (log bed)	JX418095	Male
090508–SKJ–009–6	*Bradysia peraffinis*	Korea	110504 –S210	Shiitake farm (log bed)	JX418096	Female
090508–SKJ–009–7	*Bradysia peraffinis*	Korea	110504 –S211	Shiitake farm (log bed)	JX418097	Female
080903–SKP–1 f	*Bradysia protohilaris*	Korea	110517 –S224		JX418098	Female
080723 SKG –b1	*Bradysia longimentula*	Korea	110517 –S232		JN378635	Male
080723 SKG –b2	*Bradysia protohilaris*	Korea	110517 –S233		JX418099	Female
080723 SKG –b3	*Bradysia protohilaris*	Korea	110517 –S234		JX418100	Female
080723 SKG –b1	*Bradysia protohilaris*	Korea	110517 –S240		JX418101	Male
080723 SKG –b2	*Bradysia protohilaris*	Korea	110517 –S241		JX418102	Female
080723 SKG –s6	*Bradysia fugaca*	Korea	110517 –S247		JX418103	Female
080722 SKB –5	*Bradysia protohilaris*	Korea	110517 –S252		JX418104	Female
080721 SKD e3	*Bradysia protohilaris*	Korea	110517 –S266		JX418105	Female
080723 SKG–2	*Bradysia protohilaris*	Korea	110517 –S270		JX418106	Female
080825 SKG–1	*Bradysia longimentula*	Korea	110517 –S285		JN378636	Female
080825 SKG–5	*Bradysia alpicola*	Korea	110517 –S289		JX418107	Male
080825 SKG–10	*Bradysia longimentula*	Korea	110517 –S294		JN378637	Female
080701 SKI–2	*Bradysia subaprica*	Korea	110517 –S298		JX418108	Female
080701 SKI–3	*Bradysia trispinifera*	Korea	110517 –S299		JQ613806	Female
080721 SKD–019–2	*Bradysia protohilaris*	Korea	110517 –S307		JX418109	Female
080514 SKJ–3	*Bradysia difformis*	Korea	110530 –S343		JN378662	Female
080709–SKA–2–2	*Bradysia protohilaris*	Korea	110530 –S346		JX418110	Male
080709–SKA–2–6	*Bradysia protohilaris*	Korea	110530 –S350		JX418111	Female
080709–SKA–2–2–2	*Bradysia protohilaris*	Korea	110530 –S352		JX418112	Male
110125–S3N–25	*Bradysia ocellaris*	Cambodia	110728 –S419		JX418113	Male
110125–S3N–29	*Bradysia ocellaris*	Cambodia	110728 –S423		JX418114	Female
100817–SKC–H2–17	*Bradysia cuneiforma*	China	110728 –S528		JX418115	Male
100817–SKC–H2–20	*Bradysia subaprica*	China	110728 –S531		JX418116	Male
100818–SKC–H5–6	*Bradysia hilaris*	China	110728 –S538		JX418117	Female
100818–SKC–H5–10	*Bradysia lapponica*	China	110728 –S542		JX418118	Female
100818–SKC–H5–12	*Bradysia lapponica*	China	110728 –S544		JX418119	Female
110629–HRK–2	*Bradysia tilicola gr 1*	Korea	110807 –S576		JX418120	Male
100817–CS4–2	*Bradysia aprica*	China	110807 –S589		JX418121	Male

Sample number	Species name	country	DNA number	Habitat	Genbank Accession No.	state
100818–CS7–12	*Bradysia lapponica*	China	110807 –S604		JX418122	Female
100818–CS7–23	*Bradysia lapponica*	China	110807 –S607		JQ613820	Male
100818–CS7–28	*Bradysia hilaris*	China	110807 –S612		JX418123	Male
100819–CS8–11	*Bradysia hilaris*	China	110807 –S624	Blackmusroom farm	JQ613822	Male
100819–CS8–13	*Bradysia hilaris*	China	110807 –S626	Blackmusroom farm	JX418124	Male
100819–CS8–16	*Bradysia subaprica*	China	110807 –S629	Blackmusroom farm	JX418125	Female
101013–SKL–1	*Bradysia protohilaris*	Korea	110807 –S633		JX418126	Male
101013–SKL–2	*Bradysia protohilaris*	Korea	110807 –S634		JX418127	Male
101013–SKL–3	*Bradysia protohilaris*	Korea	110807 –S635		JX418128	Male
100830–SKUN–2	*Bradysia Sachalinensis*	Korea	110807 –S641		JX418129	Male
100830–SKUN–3	*Bradysia Sachalinensis*	Korea	110807 –S642		JX418130	Male
100830–SKUN–4	*Bradysia Sachalinensis*	Korea	110807 –S643		JQ613824	Male
100830–SKUN–7	*Bradysia Sachalinensis*	Korea	110807 –S646		JX418131	Male
101013–SKL–2–2	*Bradysia longimentula*	Korea	110807 –S651		JX418132	Female
100830–SKUN–2–3	*Bradysia alpicola*	Korea	110807 –S654		JX418133	Male
100830–SKUN–2–4	*Bradysia alpicola*	Korea	110807 –S655		JX418134	Male
100830–SKUN–2–5	*Bradysia Sachalinensis*	Korea	110810 –S656		JX418135	Male
100514–SKJ–6	*Bradysia protohilaris*	Korea	110810 –S668		JX418136	Male
100514–SKJ–7	*Bradysia protohilaris*	Korea	110810 –S669		JX418137	Male
100514–SKJ–8	*Bradysia protohilaris*	Korea	110810 –S670		JX418138	Male
100514–SKJ–9	*Bradysia protohilaris*	Korea	110810 –S671		JX418139	Male
100514–SKJ–10	*Bradysia protohilaris*	Korea	110810 –S672		JX418140	Male
090128–SKH–2–1	*Bradysia atracornea*	Korea	110810 –S674	Scallion farm	JX418141	Female
090128–SKH–2–2	*Bradysia atracornea*	Korea	110810 –S675	Scallion farm	JX418142	Female
090128–SKH–2–3	*Bradysia atracornea*	Korea	110810 –S676	Scallion farm	JX418143	Female
090128–SKH–2–4	*Bradysia atracornea*	Korea	110810 –S677	Scallion farm	JX418144	Female
090128–SKH–2–5	*Bradysia atracornea*	Korea	110810 –S678	Scallion farm	JX418145	Male
090128–SKH–2–6	*Bradysia atracornea*	Korea	110810 –S679	Scallion farm	JX418146	Male
090128–SKH–2–7	*Bradysia atracornea*	Korea	110810 –S680	Scallion farm	JX418147	Male
090128–SKH–2–8	*Bradysia atracornea*	Korea	110810 –S681	Scallion farm	JX418148	Male

090507–SKJ–011–015	*Bradysia difformis*	Korea	110810 –S682		JX418149	Male
090128–SKH–2–8	*Bradysia atracornea*	Korea	110810 –S683	Scallion farm	JX418150	Male
PP1002–1	*Bradysia procera*	Korea	110810 –S693	Ginseng farm	JX418151	Male
PP1002–2	*Bradysia procera*	Korea	110810 –S694	Ginseng farm	JX418152	Female
100617–SKB–1	*Bradysia procera*	Korea	110810 –S695		JX418153	Male
100715–SKM–2N–8	*Bradysia aprica*	Korea	110807 –S716		JX418154	Male
100715–SKM–2N–9	*Bradysia aprica*	Korea	110807 –S717		JX418155	Male
100715–SKM–2N–16	*Bradysia hilariformis*	Korea	110807 –S724		JQ613827	Male
100715–SKM–2N–28	*Bradysia chlorocornea*	Korea	110807 –S736		JQ613828	Male
100617–SKY–M–1	*Bradysia difformis*	Korea	110807 –S739		JX418156	Male
100617–SKY–M–2	*Bradysia difformis*	Korea	110807 –S740		JX418157	Female
100617–SKY–2–1	*Bradysia difformis*	Korea	110807 –S741		JX418158	Male
100617–SKY–2–2	*Bradysia difformis*	Korea	110807 –S742		JX418159	Male
110726–HRHS–1	*Bradysia difformis*	Korea	110807 –S746	Paprika greenhouse	JX418160	Male
110726–HRHS–2	*Bradysia difformis*	Korea	110807 –S747	Paprika greenhouse	JX418161	Male
110726–HRHS–3	*Bradysia difformis*	Korea	110807 –S748	Paprika greenhouse	JX418162	Female
110824–HRD–2	*Bradysia alpicola*	Korea	110902 –S753		JX418163	Male
110824–HRD–11	*Bradysia aprica*	Korea	110902 –S760		JX418164	Male
110822–HRY–4	*Bradysia subaprica*	Korea	110902 –S774		JX418165	Male
090431–JOG–62	*Bradysia boitsovoensis*	Korea	110903–S860		JQ613846	Male
SW1	*Bradysia vernalis*	Sweden	111020 –S944		JQ613859	Male
SW1380–1	*Bradysia brunnipes*	Sweden	111020 –S992		JX418166	Male
SW1380–2	*Bradysia brunnipes*	Sweden	111020 –S993		JX418167	Male
SW1380–3	*Bradysia brunnipes*	Sweden	111020 –S994		JX418168	Male
SW1734–7	*Bradysia cinerascens*	Sweden	111020 –S1036		JQ613879	Male

SNU, Seoul National University; CALS: College of Agricultural and Life Sciences; CN, Chungcheongnam–do; GG, Gyeonggi–do; GN, Gyeongsangnam–do; GW, Gangwon–do; JB, Jeollabuk–do; JN, Jeollanam–do; JJ, Jeju–do.

2–3. Results

2–3–1. Characteristics of the COI barcoding gene fragments in genus *Bradysia*

COI dataset comprised 658 aligned base pairs (bp). Among the dataset, 280 bp were variable and 264 bp were parsimony informative. The average of the uncorrected sequence divergence among taxa for cytochrome c oxidase subunit I (COI) was 15.1%, and the average proportions of T:C:A:G were 38:16:30:15. None of the sequences from this study had indels.

2–3–2. Distance analysis

The intraspecific K2P distance range of the genus *Bradysia* was 0.0% ~ 3.1% (mean 0.5%). The interspecific distance range was 11.2% ~ 22.4% (mean 16.0%). Consequently, the significant "barcoding gap" (Hebert et al., 2004) was occurred (Fig. 2–2). One of the most common pest species *B. difformis* has been analyzed as 2 haplotypes that K2P distance range was 2.0% ~ 2.2%, but there are no differences in habitats or localities between two groups (Fig. 2–3, Table 2–1; Supporting information Fig. S2–1). The *B. procera* larvae divided as 2 groups, which were collected in same colony. The K2P distance between two *B. procera* groups was 2.8% ~ 3.1%. However, the minimum of interspecific K2P distance was magnitude larger than intraspecific distance of maximum K2P distance, and the adult male of those COI variable species were confirmed as same in morphological characters (Fig. S2–3, Supporting information).

Phylogenetic relationships of COI Barcoding region, analyzed by NJ (Fig. 2–3), method was discriminated for species due to significant barcoding gap (Fig. 2-2). The species level clades were strongly supported due to high bootstrap values. Therefore, the COI barcoding region verified useful for species identification of the genus *Bradysia*.

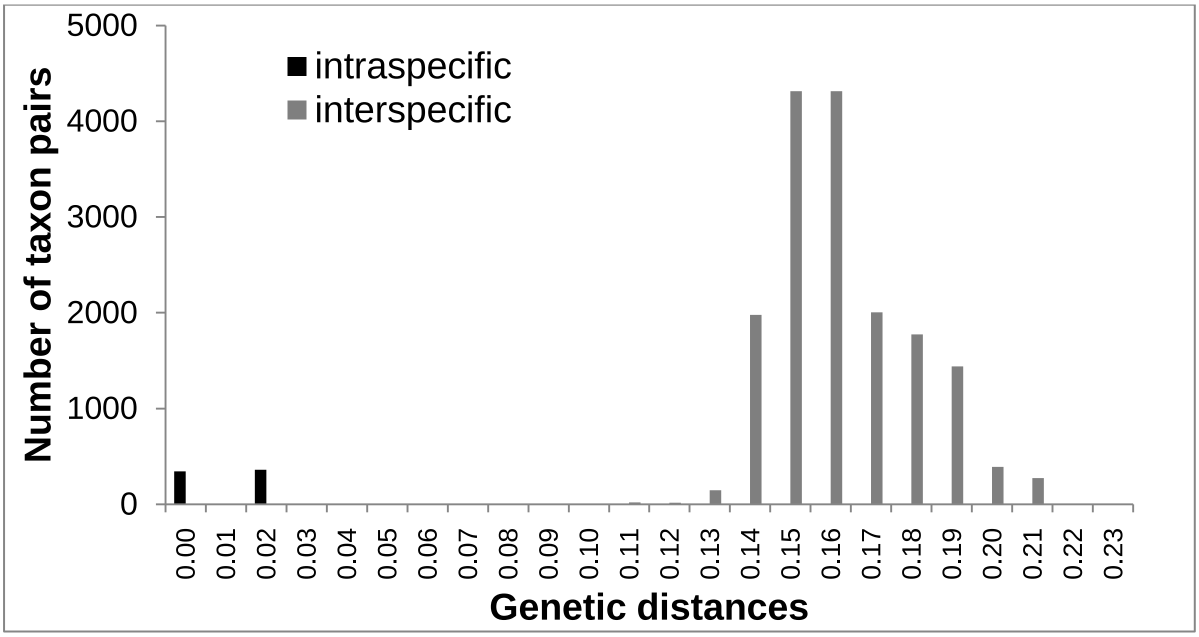

Figure 2–2. Interspecific and interspecific K2P distance of COI Barcoding region among genus *Bradysia*

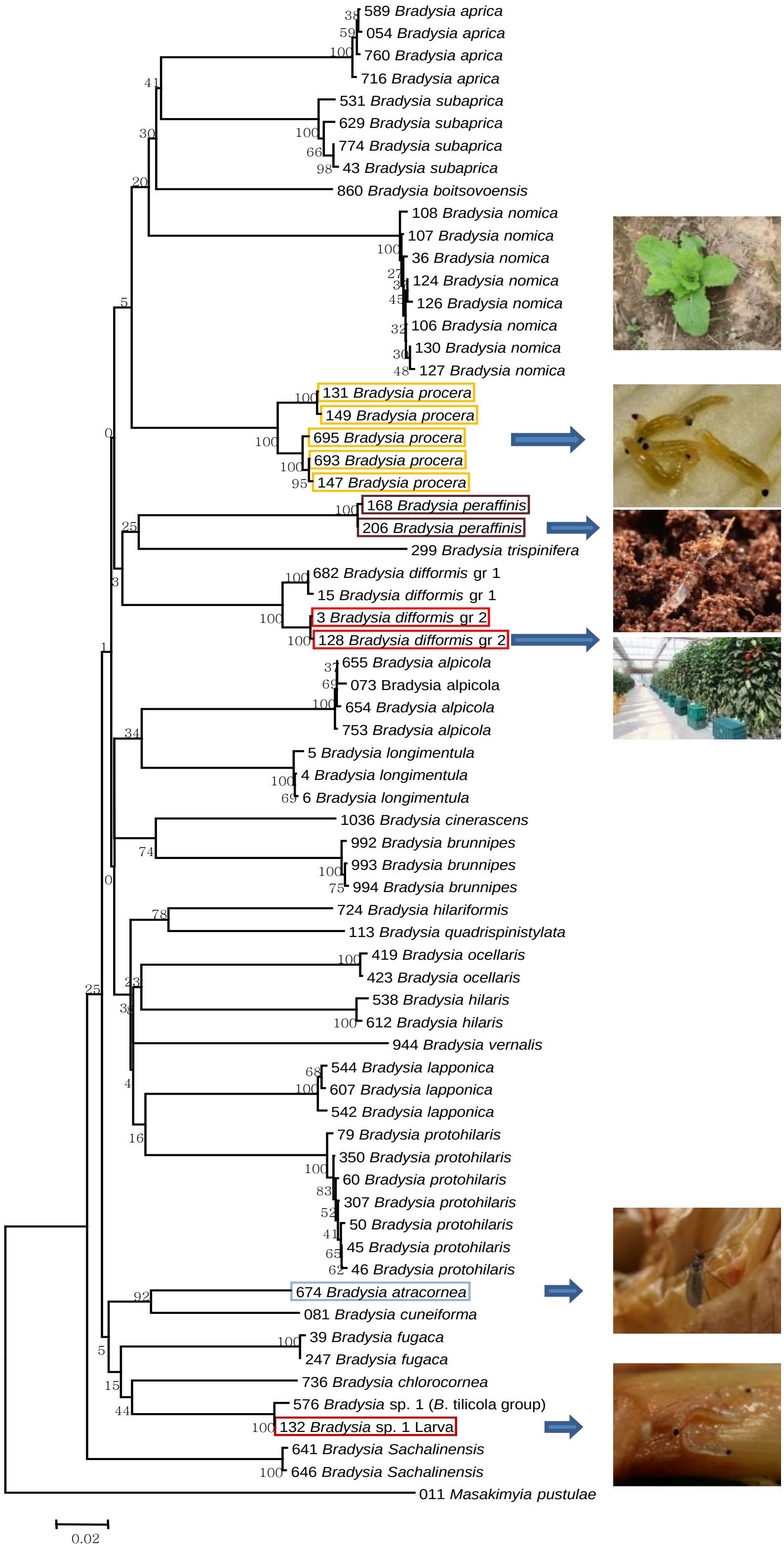

Figure 2–3. Partial neighbor-joining trees based on Kimura 2-parameter genetic distances. Bootstrap support for nodes containing test sequences based on 1,000 replications. The scale bar indicates branch length (NJ tree of total sequences are shown in Fig. S2-1, Supporting information).

2–3–3. Molecular identification using COI for pest species

The pest larval species from damaged parts were identified. From ginseng 4 individuals of larvae specimens were examined (Fig. 2–1A), and they were matched with adult male of *B. procera*. Those samples collected in the same locality in ginseng farm (Yongin–si, GG), and 3 species were collected from Taebaek–si ginseng farm, GW, and forest, in Jangseong–gun, JN. Interspecific K2P distance was 0.0% ~ 3.1% and average was 1.6%. I collected 2 species of *Bradysia* from isolated cultivation of scallion in acrylic cage. Emerged species was identified to *B. atracornea*, but larvae from damaged parts of scallion (Fig. 2–1B) were matched with *B.* sp. 1 (species group *tilicola*) collected by light trap from Mt. Jung, sicheon–myeon, Sancheong–gun, KN. The *B. difformis* collected various habitats in this study. And 3 larval samples from paprika were 100 % matched with *B. difformis* Gr. 1 (Fig. 3). Therefore, COI region of 3 larval pest species were confirmed.

2–4. Discussion

The COI barcoding region were clearly discriminated the clade of each species by highly support in NJ analyses due to significant barcoding gap. Hence, the species identification by COI barcoding could be a useful tool for the genus *Bradysia*. Also, the larval habitats are able to confirm by those methods.

Larval habitats of the genus *Bradysia* is most biologically diverse within Sciaridae (Menzel & Mohrig 2000; Menzel et al., 2003; Shin et al., 2012). Additionally, some species were known as pests for feeding on living plants (Menzel et al., 2003; Menzel et al., 2006; Shin et al., 2008). Until now, the pest species of *Bradysia* have been studied by larval rearing methods for identification (Pobozsny 1976; Park et al., 1999; Meers & Cloyd 2005; Kim et al., 2000). The isolated rearing is one of the reasonable and popular methods for confirmation of pest species. According to Lee et al. (2010), *B. procera* was reported as a pest, because they feed under the first layer as well as root of ginseng (Fig. 2–1A). In this study, the pest larvae from ginseng were matched with *B. procera* by COI barcoding region also. Nevertheless, if more than two species emerged out, it is hard to clarify the host of each species. For example, although the *B. atracornea* mainly emerged from scallion pot, the *B.* sp.1 (*tilicola*-Group) (collected from light trap) has been matched with pest larvae from damaged part of scallion. Thus, the larval habitat of *B.* sp. 1 (*tilicola* G) were confirmed as feeding the first layer of scallion stem with slightly decaying condition (Fig. 2–1B). But, the larval habitat of *B. atracornea* is ambiguous yet, they could have the potential to live on the root of scallion or soil.

In this study, I could not identify the species *B.* sp.1, due to the morphological complex in this species-group (*B. tilicola*-group: formerly *B. amoena*-group). The *B. tilicola*-group is distinguish by the combination of morphological characters such as, the basal segment of antenna is yellow-white color; apex of gonostylus densely bristled, with a claw-shaped short apical tooth and sub-apical spines; tegmen trapezoid (Menzel and Mohrig, 2000; Menzel et al., 2006). The key character of species identification is position and number of sub-apical spines on gonostylus. However, most of species are very similar in this character and the number and position are slightly variable even if same species. Thus, the *B. tilicola*-group was known as one of the ambiguous species group with *B. fungicola*-group within the genus *Bradysia*. The DNA barcode is one of the key characters of species identification, when we have the database of same species. But in this case, I could not found the COI sequences of this species due to the lack of DNA information as well as morphological complex. Therefore, further studies are needed for construction of DNA database with identified voucher specimens in this complex group.

The COI barcoding gene is useful for identifying genus *Bradysia*, but if the morphological information of species is ambiguous, it is hard to use the biological and taxonomical information. In other words, both of morphological and genetical informations are important for DNA barcoding in criptic group such as genus *Bradysia*. The DNA barcode can be a useful tool for the taxonomical definition in intra- interspecific variation within complex group. Further, database construction of COI barcoding gene of genus *Bradysia* is important for confirmation of pest species.

2–5. **Conclusion**

The genus *Bradysia* is hard to identifying group within Sciaridae. Furthermore, most species have possibility of pest (Menzel & Mohrig, 2000). The DNA barcode will be a useful tool, if the COI database constructed with morphological studies in species level. Through the construction of COI database, the host and larval feeding habits would be more clearly confirmed. In other words, ecological bioinformation of genus *Bradysia* be able to construct by DNA based methods.

PART III. **Molecular phylogeny of black fungus gnats (Diptera**: **Sciaroidea**: **Sciaridae) and the evolution of larval Habitats**

ABSTRACT

The phylogeny of the family Sciaridae is reconstructed, based on maximum likelihood, maximum parsimony, and Bayesian analyses of 4,809 bp from two mitochondrial (COI and 16S) and two nuclear (18S and 28S) genes for 100 taxa including the outgroup taxa. According to the present phylogenetic analyses, Sciaridae comprise five subfamilies: Sciarinae, *Chaetosciara* group, Cratyninae, and *Lycoriella* group + Megalosphyinae. Our molecular results are largely congruent with one of the former hypotheses based on morphological data with respect to the monophyly of genera and subfamilies (Sciarinae, Megalosphyinae, and part of postulated "new subfamily") (Menzel and Mohrig, 2000). However, the subfamily Cratyninae sensu Menzel and Mohrig (2000) is shown to be polyphyletic, and the genera *Bradysia*, *Corynoptera*, *Leptosciarella*, *Lycoriella*, and *Phytosciara* are also recognized as non–monophyletic groups. While the ancestral larval habitat state of the family Sciaridae, based on Bayesian inference, is dead plant material (plant litter + rotten wood), the common ancestors of *Phytosciara* and *Bradysia* are inferred to living plants habitat. Therefore, shifts in larval habitats from dead plant material to living plants may have occurred within the Sciaridae at least once. Based on the results, I discuss phylogenetic relationships within the family, and present an evolutionary scenario of development of larval habitats.

Keywords. Black fungus gnats, Sciaridae, Systematics, Molecular phylogeny, Larval habitats, Ancestral character states.

3–1. Introduction

The family Sciaridae comprises tiny and mostly dark colored flies, called as “Black fungus gnats” and “Dark winged fungus gants” because the body color and wing membrane is normally darkened, with more than 2,000 species described worldwide (Amorim, 1992; Menzel and Mohrig, 1997b, 2000; Mohrig, 2003; Mohrig and Menzel, 2009; Mohrig et al., 2004; Steffan, 1966, 1981). Most sciarid larvae are decomposers: the genera *Corynoptera* Winnertz, 1867, *Epidapus* Haliday, 1851, *Scatopsciara* Edwards, 1927, and *Bradysia* Winnertz, 1867 feeding upon diverse organic matter in the soil and plant litter (Menzel and Mohrig, 2000; Pobozsny, 1976); *Trichosia* Winnertz, 1867, *Scythropochroa* Enderlein, 1911, *Xylosciara* Tuomikoski, 1957, and *Zygoneura* Meigen, 1830 living in decaying tree stumps or dead tree trunks (Edwards, 1915a, b; Frey, 1948; Mohrig and Antonova, 1978; Shin et al., 2012; Shinji, 1938; Steffan, 1968, 1973; Sutou and Ito, 2004; Tuomikoski, 1957, 1960). However, some larvae of *Bradysia* (*B. fungicola* and *B. hilaris* groups) and *Phytosciara* Frey, 1942 mine in living stems or leaves, or live under the bark of live trees. Some species of *Bradysia* [*B.* difformis Frey, 1948; *B. ocellaris* (Comstock, 1882)] and *Lycoriella* Frey, 1942 [*L. castanescens* (Lengersdorf, 1940); *L. ingenua* (Dufour, 1839)] are known as pests in mushroom and plant cultivation (Forbes, 1896; Gerbachevskaja, 1963; Hafidh and Kelly, 1982; Hopkins, 1895; Kim et al., 2000; Kim and Hwang, 1996; Kim and Choi, 1999; Lee et al., 1999; Lewandowski et al., 2004; Menzel and Mohrig, 2000; Menzel et al., 2003; Park et al., 1999; Shin et al., 2012; White et al., 2000; Yi et al., 2008).

In earlier systematic studies of the infra–order Bibionomorpha (Blaschke–Berthold, 1994; Hennig, 1973, 1981; Oosterbroek and Courtney, 1995; Wood and Borkent, 1989), the monophyly of Sciaridae has been generally accepted, based on the morphological characteristics in the larval head, however, the relationships within the family Sciaridae are still controversial (Hippa and Vilkamaa, 2004, 2005, 2006; Hippa et al., 2003; Menzel and Mohrig, 2000; Vilkamaa, 2000; Vilkamaa and Hippa, 2004, 2005). Three subfamilies were proposed based on the wing venation (Enderlein, 1911) (Fig. 3–1A): Cratyninae, Lestremiinae, and "Lycoriinae" (= Sciarinae); however, the Lestremiinae sensu Enderlein (1911) included Cecidomyiidae and Scatopsidae along with two genera of Sciaridae (*Gephyromma* and *Zygoneura*) because these taxa share the same larval habits (xylophagous, without forming the plant gall). Based on the wing venation (Fig. 3–1B), Lengersdorf (1928–30) proposed that Sciaridae involve four subfamilies: Cratyninae, "Lycoriinae" (= Sciarinae), Megalosphyinae, and Zygoneurinae. However, Frey (1942) downgraded the rank of the four subfamilies to three genus groups, including fossil species (Fig. 3–1C), using the number of maxillary palp segments and macrotrichia on Cu and M wing veins as the main characters for his classification. Röschmann and Mohrig (1995) reconstructed a phylogeny using fossil genera of Sciaridae and suggested two groups of genera, which almost correspond to Sciarinae and Cratyninae + *Lycoriella* group (Fig. 3–1D). Recently, Menzel and Mohrig (2000) recognized four subfamilies based on morphological cladistic analysis (Fig. 3–1E, Table 2–1): Sciarinae, Megalosphyinae, Cratyninae, with the inclusion of Zygoneurinae, and a "new subfamily" by Menzel and Mohrig (2000: 650) as "clade of *Pseudolycoriella* group – *Corynoptera* s. l. group". Vilkamaa and Hippa (2004) suggested the Sciaridae is hard to be reconstructed using morphological cladistic analysis, due to the homoplasy. And Hippa and Vilkamaa 2005, 2006 recognized the system of the superfamily Sciaroidea, they suggest the traditional Sciaridae treated as a subfamily Sciarinae with fossil taxa; however their systems also do not supported due to the homoplasy.

Evolutionary transitions in larval habitats of Sciaridae are poorly known, although some larval habitats have been studied in various genera. The genera *Trichosia* and *Leptosciarella* Tuomikoski, 1960 have been reported primarily on decomposing woods under moist conditions in the forests, especially rotten beech and birch bark (Menzel and Mohrig, 2000; Menzel et al., 2006). Except for a few reports of xylophagous (living on decomposing wood) spp. [*Cratyna* (s. str.) *ambigua* (Lengersdorf, 1934); *Cratyna* (s. str.) *nigerrima* (Mohrig and Krivosheina, 1979)] (Menzel and Mohrig, 2000), the genera *Cratyna* Winnertz, 1867 and *Corynoptera* are mostly found on plant litter. Menzel et al. (2006) also reported some *Cratyna* and *Corynoptera* species living in plant litter, such as sedge beds [*Cratyna* (*Spathobdella*) *nobilis* (Winnertz, 1867); *Corynoptera subtilis* (Lengersdorf, 1929)] and *Cladium* beds with tufa [*Corynoptera* vagula Tuomikoski, 1960]. The genus *Xylosciara* is xylophagous. The genus *Pseudolycoriella* Menzel and Mohrig, 1998 may be closely associated with living plants as the probably very closely related *Eugnoriste* Coquillett, 1896 species feed on flowers (Steffan, 1966). According to Rulik et al. (2008), some species of *Pseudolycoriella* are phytosaprophagous and their adults are frequently found in *Aristolochia pallida* Willd. flowers (Aristolochiaceae). Most *Lycoriella* s. str. species are associated with fungi and decaying materials, feeding on the mycelium of mushrooms (Lee et al., 1999; Menzel and Mohrig, 2000; Shin et al., 2012). The genus *Ctenosciara* Tuomikoski, 1960 is mainly phytosaprophagous (Sutou and Ito, 2003) as *Ctenosciara hyalipennis* (Meigen, 1804) has been reared from decaying vegetable matter (Menzel et al., 2006). At least a few Palaearctic species of the genus *Scatopsciara* are also phytosaprophagous (Buck et al., 1997; Menzel and Mohrig, 2000; Menzel et al., 2006), as *Scatopsciara* (s. str.) *atomaria* (Zetterstedt, 1851) reared from mushrooms and deadwood. In contrast, the genus *Phytosciara* s. l. and part of the genus *Bradysia* s. l. live in the tissues of living plants (Lee et al., 2010; Menzel and Mohrig, 2000). Some *Bradysia* species were also reported as pollinators of *Octomeria* and

Lepanthes (Orchidaceae, Pleurothallidinae) (Barbosa et al., 2009; Blanco and Barboza, 2005), and the genus *Zygoneura* is associated with both woody and herbaceous plants. The subgenus *Allozygoneura* is known as a plant miner (Sasakawa, 1997; Tuomikoski, 1960), and some species as xylophagous (Menzel and Mohrig, 2000). Consequently, the larval habitats of Sciaridae can be divided into three types: rotten wood, plant litter, and living plants (see 3–2–6).

The main aims of this study are to reconstruct, for the first time, the molecular phylogenetic relationships of the family Sciaridae and clarify the previous classifications using molecular data (Enderlein, 1911; Frey, 1942, 1948; Lengersdorf, 1928–30; Menzel and Mohrig, 2000). Based on our phylogenetic results, I propose an evolutionary history of the larval habitats of the Sciaridae.

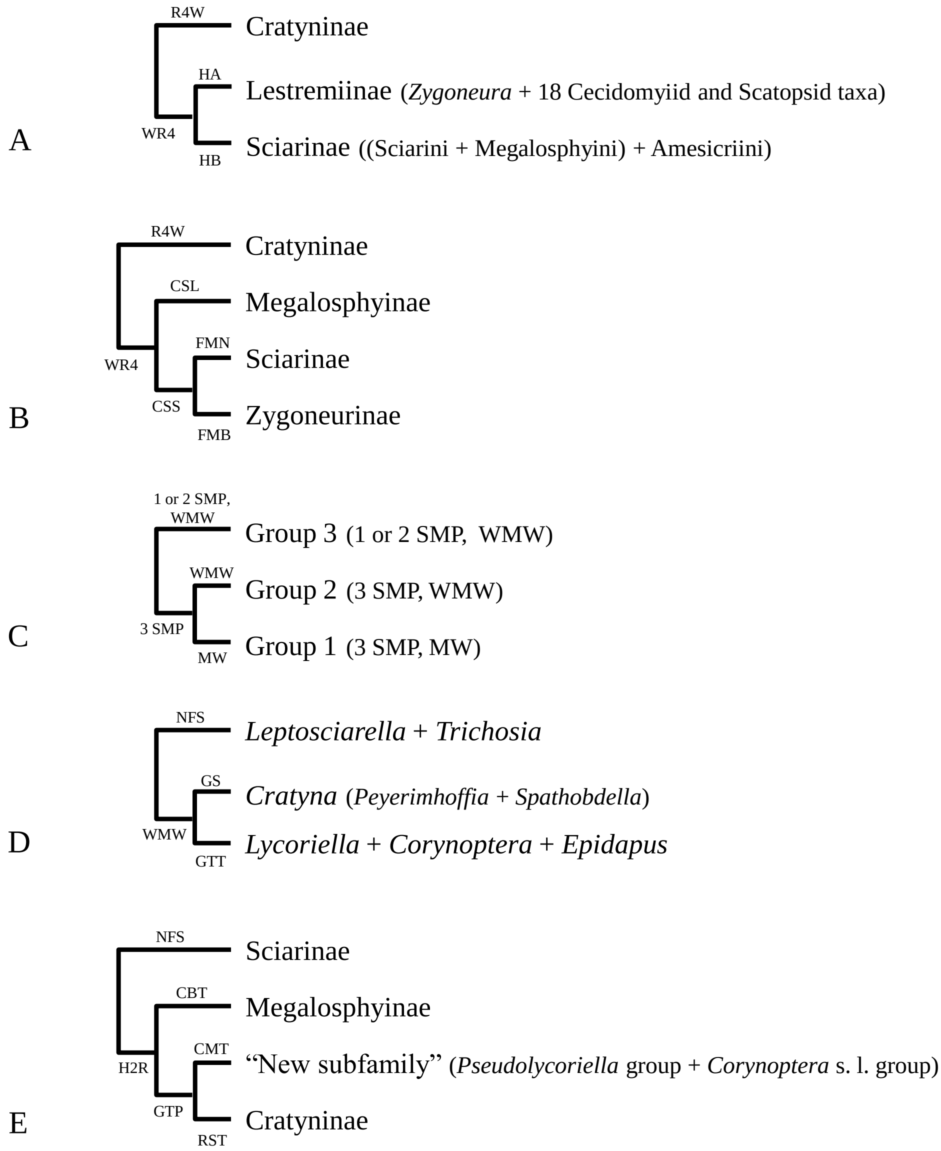

Figure 3–1. Current hypotheses about relationships within the family Sciaridae. (A) Cladogram after Enderlein (1911); (B) Cladogram after Lengersdorf (1928–30); (C) Cladogram after Frey (1942); (D) Cladogram after Röschmann and Mohrig (1995); (E) Cladogram after Menzel and Mohrig (2000) and their classification system. Abbreviations: CBT = comb–like row of bristles on the apex of the fore tibia; CMT = curved margin on the apex of the fore tibia; CSL = CuA–stem long; CSS = CuA–stem short; CST = without–crown spines on the apex of the hind tibia; FMB = Fork of M bell–shaped; FMN = Fork of M normally shaped; GS = Gonostylus of male genitalia compact; GTP = Gonostylus tip tapered and pointed; GTT = Gonostylus apex of male genitalia with strong tooth; H2R = Halteres with only 1 or 2 rows of bristles; HA = Living plants larval habitat; HB = Rotten wood larval habitat; MW = Macrotrichia on Cu and M wing veins; NFS = Neck of flagellomere short; R4P: Wing vein R_4 present; SMP = Segment of maxillary palpus; WMW = Without macrotrichia on Cu and M wing veins; WR4 = Without R_4 wing vein.

Table 3–1. Various classifications of family Sciaridae.

Enderlein (1911)	**Lengersdorf (1928–30)**	**Frey (1942)**	**Menzel and Mohrig (2000)**	**This study**
Cratyninae	**Cratyninae**	**Group 1**	**Cratyninae**	**Cratyninae**
Cratyna s. str. (in part)	*Cratyna* (in part)	*Merianina*	*Allopnyxia*	*Corynoptera* s. str.
		Metangela	*Cratyna*	*Cratyna*
Sciarinae		*Phytosciara* (in part)	*Epidapus*	*Epidapus* s. str.
Amesicriini		*Pseudosciara*	*Hermapterosciara*	
Amesicrium		*Sciara*	*Hyperlasion*	**Megalosphyinae**
		Trichomegalosphys	*Parapnyxia*	*Bradysia* s. l.
		Trichosia	*Pnyxia*	*Ctenosciara*
Megalosphyini	**Megalosphyinae**		*Pnyxiopsis*	*Phytosciara*
Megalosphys	*Bradysia* (in part)	**Group 2**	*Trichodapus*	*Scatopsciara*
Metangela	*Phytosciara*	*Bradysia* (in part)	*Xylosciara*	*Zygoneura*
Phytosciara s. str.	*Scythropochroa* (in part)	*Chaetosciara*	*Zygoneura*	*Co. vagula*–group
Scythropochroa		*Cratyna* (in part)		
Trichomegalosphys		*Eugnoriste*	**Megalosphyinae**	**Sciarinae**
		Hybosciara	*Bradysia* s. l.	*Leptosciarella* s. str.
Sciarini	**Sciarinae**	*Phytosciara* (in part)	*Ctenosciara*	*Le.* (*Leptospina*)
Aniarella	*Bradysia* (in part)	*Rhynchosciara*	*Phytosciara*	*Sciara*
Apelmocreagris	*Corynoptera*	*Scaptosciara*	*Scatopsciara*	*Trichosia* s. str.
Bradysia	*Cratyna* (in part)	*Schwenckfeldina*		
Ceratiosciara	*Epidapus* s. str.	*Scythropochroa* (in part)	**Sciarinae**	***Chaetosciara* group**
Corynoptera	*Hyperlasion*		*Chaetosciara*	*Chaetosciara*
Cratyna s. str. (in part)	*Pnyxia*	**Group 3**	*Leptosciarella*	*Schwenckfeldina*
Epidapus s. str.	*Rhynchosciara*	*Bradysia* (in part)	*Schwenckfeldina*	*Scythropochroa*
Euricrium	*Scatopsciara*	*Ceratiosciara*	*Sciara*	*Mouffetina*
Hybosciara	*Sciara*	*Corynoptera*	*Scythropochroa*	
Odontosciara	*Scythropochroa* (in part)	*Cratyna* (in part)	*Trichosia*	***Pseudolycoriella* group**
Rhynchosciara	*Trichosia*	*Dodecasciara*		*Bradysiopsis*
Sciara		*Epidapus*	**New subfamily (undescribed)**	*Camptochaeta*
Trichosia		*Hyperlasion*	*Bradysiopsis*	*Dichopygina*
Zygomma		*Lycoriella*	*Camptochaeta*	*Keilbachia*
		Peniosciara	*Corynoptera* s. l.	*Lycoriella* s. str.
Lestremiinae		*Scatopsciara*	*Keilbachia*	*Ly.* (*Hemineurina*)
Lestremiini	**Zygoneurinae**	*Scythropochroa* (in part)	*Lycoriella*	*Pseudolycoriella*
Gephyromma	*Zygomma*	*Zygomma*	*Mohrigia*	*Xylosciara*
Zygoneura s. str.	*Zygoneura* s. str.	*Zygoneura*	*Pseudolycoriella*	*Co. boletiphaga*–group

Co. = *Corynoptera* ; *Le.* = *Leptosciarella*; *Ly.* = *Lycoriella*.

3–2. Materials and methods

3–2–1. Taxon sampling

A total of 100 species, including seven outgroup species, were selected for molecular analysis (Table 3–2). The families Cecidomyiidae, Mycetophilidae, and Bibionidae were included as outgroup taxa since they are closely related to Sciaridae (Sciaridae + Cecidomyiidae + Mycetophilidae + Bibionidae + Pachyneuridae) based on molecular result (Bertone et al., 2008), and the family Scatopsidae as a sister group to the other families (Bertone et al., 2008; Hippa and Vilkamaa, 2005; Yeates and Wiegmann, 1999)

Because the classification and the taxon rank of Sciaridae are controversial (Table 3–1; Supporting information Table S3), 93 species were selected from four postulated subfamilies sensu Menzel and Mohrig (2000) as ingroup taxa (Sciarinae, Megalosphyinae, Cratyninae, and a undescribed "new subfamily") (Table 3–2). All slide voucher samples are deposited in the Insect Collection of the College of Agriculture and Life Sciences (Seoul National University, Korea).

3–2–2. DNA extraction, PCR amplification, and sequencing

Total genomic DNA was extracted from single individuals using a DNeasy® Blood and Tissue kit (QIAGEN, Inc). All genomic templates were stored at –35℃. To make voucher specimens from the DNA–extracted samples, I used a nondestructive DNA extraction protocol slightly modified from the method of Favret (2005) and Kim et al. (2010). Before extraction, head, wings, and genitalia were dissected and mounted on microscope slides. The thorax and abdomen were left in the lysis buffer with proteinase K solution at 56℃ for 6 h. After incubation, the cleared cuticle was dehydrated and mounted with the other mounted parts on a microscope slide. PCR was performed using the *TaKaRa Ex Taq* system (Takara Bio Inc, Japan), and the reactions were performed in 50 μl volumes containing 2 μl of each primer, (2.5 mM each) 10 mM dNTPs, 10x *Ex Taq* Buffer (20 mM Mg^{2+}plus), 5U/μl *TaKaRa Ex Taq* polymerase, and 3 μl genomic DNA template. The thermal cycling program consisted of 38 cycles of 98℃/10 sec, 45–50℃/30 sec, and 72℃/50–90 sec, followed by a final extension at 72℃/10 min. The PCR products were cleaned using a QIAquick® PCR purification kit (QIAGEN, Inc.) and directly sequenced at Macrogen, Inc (Geumcheon–Gu, Seoul, Republic of Korea). The partial sequences of the mitochondrial cytochrome c oxidase subunit I (COI) gene, nuclear 18S ribosomal gene, 28S ribosomal gene, and a portion of the mitochondrial 16S ribosomal gene were chosen as molecular markers. These genes have been widely used in molecular systematics, especially within the Bibionomorpha (Insecta: Diptera), and were selected due to their relative ease of amplification and the possibility of integrating data into a broader framework within Diptera (Bertone et al., 2008; Friedrich and Tautz, 1997b, a; Martinsson et al., 2011; Rindal et al., 2009a, b). The mitochondrial cytochrome C Oxidase subunit I (COI) gene was amplified using primer pair LCO1490 (5'–GGTCAACAAATCATAAAGATATTGG–3'; Folmer et al., 1994)/HCO2198 (5'–TAAACTTCAGGGTGACCAAAAAATCA–3'; Folmer et al., 1994). The annealing temperature was 45℃. The partial fragment of the mitochondrial 16S rRNA was amplified using primer pair 16SAR–L (5'–CGCCTGTTTATCAAAAACAT–3') and 16SBR–H (5'–CCGGTCTGAACTCAGATCACGT–3') (Palumbi et al., 1991). The annealing temperature was 45℃. The complete 18S rRNA gene was amplified using primer pair 18S–1 (5'–CTGGTTGATCCTGCCAGTAGT–3')/18S–4 (5'–GATCCTTCTGCAGGTTCACC–3')

(Campbell et al., 1995) and sequenced using the internal primers 18S–2 (5'–AGATACCGCCCTAGTTCTAACC–3') and 18S–3 (5'–GGTTAGAACTAGGGCGGTATCT–3') with 18S–1 and 18S–4, respectively. The annealing temperature was 48–50℃. The 28S D4–D7 rRNA gene was amplified using primer pair 28S–A (5'–GACCCGTCTTGAAGCACG–3') Whiting et al. (1997) and 28S–rD7b1 (5'–GACTTCCCTTACCTACAT–3') Friedrich and Tautz (1997a); Whiting et al. (1997) and sequenced using the internal primers 28s–rD5b (5'– CCACAGCGCCAGTTCTGCTTAC–3') and 28s–Rd48a (5'– ACCTATTCTCAAACTTTAAATGG–3') Whiting et al. (1997) with 28S–A and 28S–rD7b1, respectively. The annealing temperature was 48–50℃.

3–2–3. Alignment and characterization of gene fragments

The character sets used for the analyses were 1971 bp of 18S rRNA, 1457 bp of 28S rRNA, 723 bp of 16S rRNA, and 658 bp of COI, for a total of 4809 bp of sequence. Raw sequences were examined and corrected using SeqMan II (ver. 5.01, 2001; DNA–star). Alignments for rRNA genes were conducted by using MAFFT (Katoh et al., 2005; Katoh et al., 2002; Katoh and Toh, 2008) separately by gene partitions (COI, 16S, 28S, and 18S) via the online server (ver. 6; http://mafft.cbrc.jp/ alignment/software/). The Q–INS–I strategy was chosen for the rRNA genes using the default setting (gap opening penalty = 1.53 and offset value = 0.00), which considers RNA secondary structure and small data sets (<200) (Katoh et al., 2005). COI sequences had no indels and were aligned using the FFT–NS–I strategy implemented by the MAFFT online server using the default setting.

Table 3–2. Taxa used in this study, employing Menzel and Mohrig (2000)'s classification (Genbank accession numbers in supporting information Table S3–5). Larval habitat corded: A = living plants; B = rotten wood; C = plant litter; DR = Direct confirmation by rearing in laboratory; – = Missing code.

DNA #	Family	Species	Locality country	Larval habitat	reference
	Cecidomiiydae				
013		*Camptomyia corticalis*	Korea	B	Shin et al., 2011, DR
012		*Camptomyia heterobia*	Korea	B	Shin et al., 2011, DR
011		*Masakimyia pustulae*	Korea	A	Yukawa and Sunose, 1976, DR
	Mycetophilidae				
942		*Acomoptera* sp. 1	Korea	-	
943		*Megophthalmidia* sp. 1	Korea	-	
	Scatopsidae				
905		*Coboldia fuscipes*	China	C	McAlpine 1981
	Bibionidae				
941		*Plecia* sp. 1	Korea	C	McAlpine 1981
	Sciaridae				
073		*Bradysia alpicola*	Korea	-	
054		*Bradysia aprica*	Korea	C	Menzel et al., 2006
133		*Bradysia atracornea*	Korea	-	
860		*Bradysia boitsovoensis* i. l.	Korea	-	
736		*Bradysia chlorocornea*	Korea	-	
T36		*Bradysia cinerascens*	Sweden	-	
122		*Bradysia difformis*	Korea	A	Menzel et al., 2003; Menzel et al., 2006; Shin et al., 2012; DR
724		*Bradysia hilariformis*	Korea	-	
624		*Bradysia hilaris*	China	-	
607		*Bradysia lapponica*	China	-	
232		*Bradysia longimentula*	Korea	-	
443		*Bradysia ocellaris*	Cambodia	A, C	Menzel et al., 2003; Menzel et al., 2006; DR
206		*Bradysia peraffinis*	Korea	-	
147		*Bradysia procera*	Korea	A	Lee et al., 2010, DR
114		*Bradysia quadrispinistylata*	China	-	
643		*Bradysia sachalinensis*	Korea	-	
299		*Bradysia trispinifera*	Korea	B	Mohrig et al., 1979; Shin et al., 2012
944		*Bradysia vernalis*	Sweden	-	
948		*Bradysiopsis vittigera*	Sweden	C	Menzel and Mohrig 2000
972		*Camptochaeta camptochaeta*	Sweden	C	Menzel and Mohrig 2000
566		*Camptochaeta tenuipalpalis*	Korea	C	Menzel and Mohrig 2000

DNA #	Family	Species	Locality country	Larval habitat	reference
153		*Chaetosciara* sp. 1	China	B	Menzel and Mohrig 2000
888		*Chaetosciara* sp. 2	Korea	B	Menzel and Mohrig 2000
216		*Chaetosciara* sp. 3	Korea	B	Menzel and Mohrig 2000
261		*Chaetosciara umbalis*	Korea	B	Menzel and Mohrig 2000
955		*Corynoptera blanda*	Sweden	B	Buck et al., 1997
995		*Corynoptera boletiphaga*	Sweden	-	
792		*Corynoptera micula*	Korea	-	
594		*Corynoptera primoriensis*	China	-	
876		*Corynoptera saetistyla*	Korea	-	
T34		*Corynoptera subtilis*	Sweden	C	Menzel et al., 2006
959		*Corynoptera vagula*	Sweden	C	Menzel et al., 2006
964		*Cratyna* (*Peyerimhoffia*) *vagabunda*	Sweden	C	Menzel et al., 2006
777		*Cratyna* (s. str.) *ambigua*	Korea	B	Menzel and Mohrig 2000
781		*Cratyna* (s. str.) *nigerrima*	Korea	B	Menzel and Mohrig 2000
999		*Cratyna* (*Spathobdella*) *nobilis*	Sweden	C	Menzel et al., 2006
255		*Ctenosciara angustistylata*	Korea	C	Menzel and Mohrig; 2000Sutou and Ito 2003
T08		*Ctenosciara hyalipennis*	Sweden	A, C	Menzel and Mohrig 2000; Sutou and Ito 2003; Menzel et al., 2006;
803		*Ctenosciara insolita*	Korea	C	Menzel and Mohrig 2000; Sutou and Ito 2003;
947		*Dichopygina aculeata*	Sweden	-	
977		*Epidapus* (s. str.) *atomarius*	Germany	C	Menzel and Mohrig 2000
890		*Keilbachia subacumina*	Korea	C	Menzel and Mohrig 2000
841		*Leptosciarella* (*Leptospina*) *dentata*	Korea	-	
810		*Leptosciarella* (*Leptospina*) sp. 1 (near *L. dentata*)	Korea	-	
820		*Leptosciarella* (*Leptospina*) sp. 2 (near *L. dentata*)	Korea	-	
907		*Leptosciarella* (*Leptospina*) sp. 3	Korea	-	
819		*Leptosciarella* (*Leptospina*) *subdentata*	Korea	-	
333		*Leptosciarella* (s. str.) *rejecta*	Korea	B	Menzel et al., 2006
952		*Leptosciarella* (s. str.) *scutellata*	Sweden	B	Menzel et al., 2006
785		*Leptosciarella* (s. str.) sp. 1	Korea	-	
852		*Leptosciarella* (s. str.) sp. 2	Korea	-	
957		*Leptosciarella* (s. str.) *subpilosa*	Sweden	B	Menzel et al., 2006
831		*Leptosciarella* (s. str.) *trochanterata*	Korea	B	Menzel et al., 2006
062		*Lycoriella* (*Hemineurina*) *flavicornis*	Korea	C	Menzel and Mohrig 2000
601		*Lycoriella* (*Hemineurina*) *gerbatshevskayae*	China	C	Menzel and Mohrig 2000
692		*Lycoriella* (s. str.) *castanescens*	Korea	C	Menzel et al., 2006
229		*Lycoriella* (s. str.) *ingenua*	Korea	C	Menzel et al., 2006; Shin et al., 2012, DR
088		*Phytosciara* (*Dolichosciara*) *flavipes*	China	-	

595	*Phytosciara* (*Dolichosciara*) *orcina*	China	-	
220	*Phytosciara* (*Dolichosciara*) *semiferruginea*	Korea	-	
883	*Phytosciara* (*Prosciara*) *ussuriensis*	Korea	A	Menzel et al., 2006
074	*Pseudolycoriella horribilis*	Korea	C	Menzel and Mohrig 2000
586	*Pseudolycoriella kutzscheri* i. l.	Korea	C	Menzel and Mohrig 2000
640	*Pseudolycoriella longisetaria* i. l.	Korea	C	Menzel and Mohrig 2000
084	*Pseudolycoriella* sp. 1	China	C	Menzel and Mohrig 2000
090	*Scatopsciara* (s. str.) *curviforceps*	China		
981	*Scatopsciara* (s. str.) *atomaria*	Germany	C	Buck et al., 1997; Menzel et al., 2006
623	*Scatopsciara* (s. str.) *necopinata*	China	C	Menzel and Mohrig 2000
902	*Scatopsciara* (s. str.) sp. 1 (near *S. amplituda)*	Korea	-	
978	*Scatopsciara* (s. str.) sp. 2 (*S. atomaria* G)	Germany	-	
112	*Scatopsciara* (s. str.) *vitripennis*	China	C	Menzel et al., 2006
887	*Schwenckfeldina* sp. 1 (near *S. custodiata*)	Korea	B	Menzel and Mohrig 2000
097	*Sciara antonovae*	China	C	Sutou 2004
313	*Sciara helvola*	Korea	C	Sutou 2004
320	*Sciara humeralis*	Korea	C	Sutou 2004; Menzel et al., 2006
653	*Sciara multispinulosa*	Korea	C	Sutou 2004
306	*Sciara ruficauda*	Korea	C	Sutou 2004
T29	*Sciara* sp. 1	Tanzania	-	
780	*Scythropochroa radialis*	Korea	B	Sutou and Ito 2004; Menzel et al., 2006
778	*Scythropochroa* sp. 1 (near *S. quercicola*)	Korea	B	Sutou and Ito 2004; Menzel et al., 2006
900	*Mouffetina* sp. 1	Korea	-	
838	*Trichosia* (s. str.) *confusa*	Korea	B	Menzel et al., 2006
T39	*Trichosia* (s. str.) *edwardsi*	Sweden	B	Menzel and Mohrig 2000
945	*Trichosia* (s. str.) *morio*	Sweden	B	Menzel and Mohrig; 2000; Menzel et al., 2006
858	*Trichosia* (s. str.) sp. 1 (near *T. borealis*)	Korea	B	Menzel and Mohrig 2000
814	*Trichosia* (s. str.) sp. 2 (near *T. flavicoxa*)	Korea	B	Menzel and Mohrig 2000
805	*Trichosia* (s. str.) sp. 3 (near *T. morio*)	Korea	B	Menzel and Mohrig 2000
970	*Trichosia* (s. str.) *splendens*	Sweden	B	Menzel and Mohrig 2000
230	*Xylosciara* (s. str.) *inornata*	Korea	B	Menzel and Mohrig 2000; DR
950	*Xylosciara* (s. str.) *betulae*	Sweden	B	Menzel and Mohrig 2000
312	*Zygoneura* (*Pharetratula*) *bidens*	Korea	B	Menzel and Mohrig 2000
300	*Zygoneura* (*Pharetratula*) *flavicornis*	Korea	B	Menzel and Mohrig 2000
311	*Zygoneura* (s. str.) *sciarina*	Korea	B	Menzel and Mohrig 2000

Code of larval habitats mainly follows Menzel and Mohrig (2000) and Menzel et al. (2006), and various references regarding specific habitats for exceptional cases at the species level. Abbreviations: A = living plants; B = rotten wood; C = plant litter; DR = Direct confirmation by rearing in laboratory.

3–2–4. Saturation tests

Given that nucleotide saturation can result in incorrect phylogenetic inferences (Swofford et al., 1996), uncorrected pairwise sequence distances were plotted against the numbers of transition and transversion substitutions using MEGA 4.0.2 (Kumar et al., 2007) to estimate the extent to which the DNA sequences were saturated.

3–2–5. Phylogenetic analyses

Maximum parsimony (MP) analysis was implemented in PAUP* 4.0b10 (Swofford, 1998) using a heuristic search procedure, tree–bisection–reconnection (TBR) branch swapping, and 1,000 random sequence additions with 10 trees held at each pseudoreplicate. Gaps were coded by the simple indel coding method (Simmons and Ochoterena, 2000) as implemented in IndelCoder 0.5 in the SeqState 1.40 program (Müller, 2005, 2006). All characters were treated as unordered and equally weighted for MP analysis. One thousand MP bootstrap replicates were performed using a heuristic search procedure, with a maximum tree setting of 200 trees. Decay index (DI) values (Bremer, 1988) were also calculated to determine branch support using TreeRot V3 (Sorenson and Farnzosa, 2007).

For maximum likelihood (ML) analysis, MODELTEST version 3.06 (Posada and Crandall, 1998) was used to select the best–fitting nucleotide substitution model; consequently, the GTR + I + G model was used for each gene partition. ML analyses were performed with RAxML version 7.2.8 (Stamatakis, 2006; Stamatakis et al., 2005) for the single and combined datasets. The data were partitioned into COI, 16S, 18S, and 28S segments. One thousand bootstrap replications were performed using the thorough bootstrap algorithm.

Bayesian phylogenetic (BP) analysis was implemented in MRBAYES version 3.1.2 (Ronquist and Huelsenbeck, 2003) for the single and combined datasets. I analyzed the combined dataset using partitioned Bayesian analysis, in which the data were partitioned into COI, 16S, 18S, and 28S segments, with BP performed using a partition scheme that maximized the likelihood based on the GTR + I + G model for each gene region (see above). For the BP analyses, four chains (three heated and one cold) were run, starting from a random tree and proceeding for 10 million Markov chain Monte Carlo (MCMC) generations, sampling the chains every 100th cycle. To ensure that the distribution had stabilized, Tracer version 1.5 (Rambaut and Drummond, 2008) was used to view the graphical representation of MCMC chain mixing. Burn–in was set at 10% of the sampled number of trees. Convergence was confirmed by graphically monitoring likelihood values. A 50% majority–rule consensus tree was constructed from the remaining trees to estimate posterior probabilities (PP).

3–2–6. Reconstruction of ancestral larval habitats

Larval habitat types were coded mainly according to Menzel and Mohrig (2000) and Menzel et al. (2006) with the information on the larval habitat patterns available for species and genera (Buck et al., 1997; McAlpine et al., 1981; Mohrig et al., 1979; Shin et al., 2012; Steffan, 1981; Sutou, 2004; Sutou and Ito, 2003; Sutou and Ito, 2004). The exceptional habitats were excluded, for example of *Scatopsciara* (s. str.) *atomaria*, which lives in mouse nests (Baumann, 1977; Hackman, 1967) and wasp nests (O'Toole, 1978). General habitats were coded as follows: A, living plants (larvae mining plant root, stem, or leaf); B, rotten wood (larvae living on dead wood and/or under bark); C, plant litter (larvae living in soil fractions such as humus or leaf litter); –, missing (unknown) (Table 3–2).

The ancestral larval habitats of Sciaridae were inferred based on the extant taxa. Table 3–2 indicates the larval habitats for each species used in this study. Although plant litter habitat often includes rotten wood, I treated these as separate because the presence of larvae in rotten wood or plant litter could be related to oviposition habitat selection (Meers and Cloyd, 2005; Vilkamaa and Hippa, 1999). Some species in *Scatopsciara* s. str., *Corynoptera* s. l., and *Bradysia* s. l., which have various habitats, were placed according to the information for each species. Furthermore, the larval habitat of all *Sciara*, *Pseudolycoriella*, *Lycoriella* (*Hemineurina*), *Keilbachia* Mohrig, 1987, and *Camptochaeta* Hippa and Vilkamaa, 1994 species was treated as plant litter, and of *Chaetosciara* Frey, 1942, *Cratyna* s. str., *Schwenckfeldina* Frey, 1942, *Trichosia*, *Xylosciara*, and *Zygoneura* species as rotten wood (Menzel and Mohrig, 2000).

A Bayesian approach, as implemented in the BayesTraits (PC version 1.0.) software package (Pagel and Meade, 2007; Pagel et al., 2004), was used to reconstruct the ancestral larval habitat character states for selected nodes in the molecular phylogeny. BayesTraits uses reversible–jump MCMC methods to derive the posterior probabilities and the values of traits at ancestral nodes of the phylogeny (Pagel et al., 2004). BayesMultiState was selected as the model of evolution with MCMC selected as the method of analysis. Because some higher taxa had mixed habitats, I used the multiple character–state option of BayesMultiState. First, the phylogenetic trees were reconstructed by BP (Fig. 3–2), and a set of the 10,000 best trees found by MRBAYES (representing the last 1,000,000 generations of the BP) was used in the BayesMultiState analysis. The polytomies in each tree were resolved to modify branch length 0.0 in mesquite (Maddison and Maddison, 2007). The rate deviation was set to 10. A hyper prior approach was employed with an exponential prior seeded from a uniform prior in the interval 0–10; thus, acceptance rates in the preferred range of 20–40% were achieved as recommended (Pagel and Meade, 2007; Pagel et al., 2004). A total of 10^8 generations were run for each analysis with the first 10^7 samples discarded as burn–in, with sampling every 1000th generation. Because the posterior probabilities for ancestral larval habitat patterns of the single runs differed slightly, I calculated the arithmetic means of all samples to reconstruct ancestral larval habitat types. I used the BP consensus topology tree as a reference tree to obtain the ancestral character states.

3–2–7. Summary of abbreviations

General abbreviations: BP – Bayesian phylogenetic; DI – Decay index; G – species group; i. l. – in litteris (in correspondence, communicated in writing; used for unpublished names of undescribed new species); ML – Maximum likelihood; MP – Maximum parsimony; MYA – Million years ago; PP – posterior probabilities; s. l. – sensu lato; s. str. – sensu stricto; SG – subgenus; † – fossil specimens only. *Characteristics and characters*: BNS – Basal part of the neck clearly separated; CBT – Comb–like row of bristles on the apex of the fore tibia; CMT – Curved margin on the apex of the fore tibia; CSL – CuA–stem long; CSS – CuA–stem short; CST – Without crown spines on the apex of the hind tibia; DBT – Dense bristles on the apex of the fore tibia; FMB – Fork of M bell–shaped; FMN – Fork of M normally shaped; GS – Gonostylus of male genitalia compact; GTP – Gonostylus tip tapered and pointed; GTT – Gonostylus apex of genitalia with strong tooth; H2R – Halteres with only 1 or 2 rows of bristles; MW – Macrotrichia on Cu and M wing veins; MWG – Mesiocentral whiplash seta on the gonostylus; NF – Neck of flagellomere; NFS – Neck of flagellomere short; R4P – Wing vein R_4 present; SMP – Segments of maxillary palpus; VSR – Ventral setae missing on R_5 and R_1 wing veins; WMW – Without macrotrichia on Cu and M wing veins; WR4 – Without R_4 wing vein.

3–3. Results

3–3–1. Characteristics of the four gene fragments

The mitochondrial cytochrome c oxidase subunit I (COI) dataset comprised 658 aligned base pairs (bp), 379 bp variable and 338 bp parsimony–informative. The average of the uncorrected sequence divergence among taxa for cytochrome c oxidase subunit I (COI) was 38.5%, and the average proportions of T:C:A:G were 39:17:30:15. The mitochondrial 16S rRNA dataset comprised 723 bp of aligned sequences, 371 bp variable and 285 bp parsimony–informative. The average of the uncorrected sequence divergence among taxa for 16S rRNA was 11.9%, and the average proportions of T:C:A:G were 42:8:36:13. The observed AT richness is characteristic of insect mitochondrial DNA sequences (Crozier and Crozier, 1993; Tauz et al., 1988). The nuclear 18S rRNA dataset comprised 1,971 bp of aligned sequences, 386 bp variable and 233 bp parsimony–informative. The average of the uncorrected sequence divergence among taxa for 18S rRNA was 2.0%, and the average proportions of T:C:A:G were 29:20:28:24. For the nuclear 28S D4–D7 rRNA dataset, 1457 bp were aligned with 324 bp variable and 208 bp parsimony–informative. The average uncorrected sequence divergence of the 28S rRNA gene among taxa was 2.4%, whereas the average proportions of T:C:A:G were 28:18:30:24.

3–3–2. Substitution patterns

Uncorrected *P*–distances were plotted against the number of transitions (Ts) and transversions (Tv). Tests were performed for four single–gene datasets and the combined dataset. All single–gene datasets and the combined dataset were free of saturation; Ts and Tv values increased linearly according to increasing uncorrected *P*–distances. Therefore, all data were used in subsequent phylogenetic analyses.

3–3–3. Phylogenetic analyses

3–3–3–1. Analyses of the single–gene datasets

Single datasets were analyzed by BP and ML using the GTR + I + G model, which is the best–fit model for each of the four single–genes evaluated by MODELTEST. For the individual–level phylogenetic analysis of the four single–gene datasets (COI/16S/18S/28S; Supporting information Figs S3–1, 2, 3, 4, 5, 6, 7, 8), the branch support values were insufficient to resolve relationships between lower taxa, but major nodes subtending family and some subfamily clusters were highly supported. The monophyly of the Sciaridae was robustly supported in all ML and BP analyses (Supporting information Figs S3–1, 2, 3, 4, 5, 6, 7, 8), and the monophyly of the subfamily Sciarinae was clearly supported in 18S BP and ML analyses (Supporting information Figs S3–3, 7). Additionally, the monophyly of the *Chaetosciara* group was supported by the 18S dataset in both analyses and the 16S dataset in ML (Supporting information Figs S3–2, 3, and 7). The subfamily Cratyninae (except *Epidapus* (s. str.) *atomarius*) was supported by both analyses of the 28S dataset (Supporting information Figs S3–4, 8). However, the monophyly of Megalosphyinae and the *Lycoriella* group was not supported in all analyses (Supporting information Figs S3–1, 2, 3, 4, 5, 6, 7, 8).

The monophyly of the subgenus *Leptospina* and genus *Zygoneura* was clearly supported by all analyses (Supporting information Figs S3–1, 2, 3, 4, 5, 6, 7, 8). The monophyly of *Leptosciarella* s. str., *Trichosia* s. str. (only 16S in ML), and *Sciara* Meigen, 1803 were supported by BP and ML analyses of 16S/18S/28S (rRNA) datasets (Supporting information Figs S3–2, 3, 4, 6, 7, and 8). The genera *Ctenosciara* and *Chaetosciara* were supported by the 16S dataset in the BP and ML analyses (Supporting information Figs S3–2, and 6), and *Chaetosciara* was further supported by the 18S BP analysis (Supporting information Fig. S3–7). The monophyly of the genera *Corynoptera* s. str. (*C. micula*, *C. primoriensis*, *C. subtilis*, *C. saetistyla*), *Cratyna*, and *Phytosciara* were supported by the 28S dataset (Supporting information Figs S3–4, and 8), and *Cratyna* was also supported by the 18S dataset (Supporting information Figs S3–3, and 7). Finally, the genera *Scatopsciara* and *Pseudolycoriella* were supported in both analyses of the 18S dataset (Supporting information Figs S3–3, and 7).

3–3–3–2. **Analysis of the combined dataset**

For the combined dataset, MP analysis yielded four equally parsimonious trees with a tree length of 11,642. The MP bootstrap and DI values (Supporting information Fig. S3–9) are shown in Table 3–3. For ML analysis, the GTR + I + G model was used as the most appropriate for the combined dataset evaluated by MODELTEST. ML analysis constructed a tree that was almost identical to the post–burn–in consensus tree from BP, based on the GTR + I + G model of the combined dataset. Bootstrap *P*–values (PL) for nodes in the ML tree (ln

L = –51489.136215) and BPs of the MrBayes analysis are presented in Table 3–3. The BP topology and PP for the major nodes are marked by numbers in Fig. 3–2 and Table 3–3. In the ML and BP analyses, grouping at the subfamily level is almost identical, but polytomies occurred in the BP analysis within some genera and in part of the *Lycoriella* group (Fig. 3–2). The Sciarinae, and *Chaetosciara* group, were supported in all analyses, but the other three groups (Cratyninae, *Lycoriella* group, and Megalosphyinae) were supported only in BP, and unsupported in the other (ML and MP) analysis due to lack of bootstrap support values.

Based on the results of MP, DI, BP, and ML analyses, the monophyly of the family Sciaridae was supported by high *P*–values (Fig. 3–2; Table 3–3, node 1). The subfamily Sciarinae (excluding the genera *Scythropochroa*, *Schwenckfeldina*, and *Chaetosciara*) was well supported in all analyses (Fig. 3–2; Table 3–3, node 8). Furthermore, the monophyly of clade with *Scythropochroa*, *Schwenckfeldina*, *Chaetosciara*, and *Mouffetina* sp. 1 was strongly supported (Fig. 3–2; Table 3–3, node 11). Consequently, the monophyly of Sciarinae sensu Menzel and Mohrig (2000) was poorly supported in all analyses (Fig. 3–2; Table 3–3, node 2) because the genera *Scythropochroa*, *Schwenckfeldina*, and *Chaetosciara* formed a sister clade (Fig. 3–2; Table 3–3, node 11) to Cratyninae, *Lycoriella* group, and Megalosphyinae (Fig. 3–2; Table 3–3, node 3).

The subfamily Cratyninae sensu Menzel and Mohrig (2000) was reconstructed as a polyphyletic group by all analyses. The monophyly of the genus *Cratyna* (subgenera *Cratyna* s. str., *Peyerimhoffia*, and *Spathobdella*) was strongly supported by the BP and ML analyses (Fig. 3–2; Table 3–3, node 22), but some genera within Cratyninae sensu Menzel and Mohrig (2000) were included in other groups (*Zygoneura* in the subfamily Megalosphyinae, and *Xylosciara* s. str. in the *Lycoriella* group) (Fig. 3–2). Additionally, *Epidapus* (s. str.) *atomarius* (De Geer, 1778) formed a sister clade to the remaining Cratyninae (four species of

Cratyna and four species of *Corynoptera* s. str.) (Fig. 3–2; Table 3–3, node 12). However, the support for *Epidapus* being sister to node 12 was weak (BP = 0.52, without ML and MP support), as a possible alternative relationship could be to the *Lycoriella* group + Megalosphyinae.

In all analyses, the monophyly of the remaining species from the new subfamily sensu Menzel and Mohrig (2000) was not supported (Fig. 3–2; Table 3–3, node 4, except node 6). Furthermore, *Corynoptera* s. l. and *Lycoriella* appeared polyphyletic in the BP, ML and MP analyses (Fig. 3–2; Table 3–3, nodes 5, 15, and 21).

The monophyly of the Megalosphyinae (Fig. 3–2; Table 3–3, node 6) was moderately supported with the inclusion of the genus *Zygoneura*. Finally, the paraphyly of *Bradysia* s. l. and the polyphyly of *Phytosciara* s. l. was supported by the all analyses (Fig. 3–2; Supporting information Fig. S3–9; Table 3–3, nodes 6, 7).

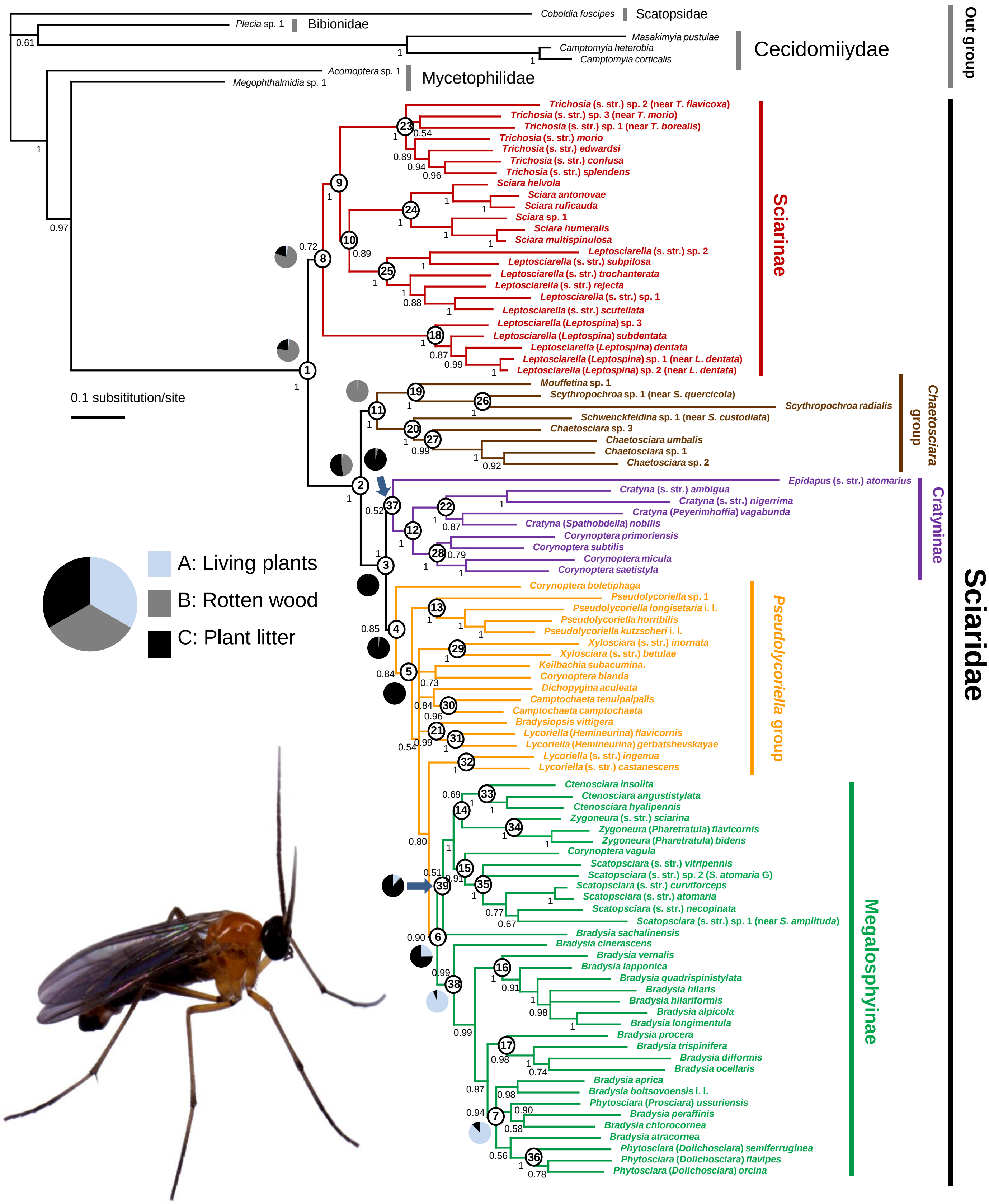

Figure 3–2. Phylogenetic relationships inferred from Bayesian analysis based on a GTR + I + G model with specific model scores for each gene partition with posterior probabilities (PP) under nodes. Numbers on the nodes refer to nodes discussed in the text. Support values from other analyses are provided in Table 3–3. Results of the BayesMultiState analysis of ancestral habitat–type reconstructions are indicated as pie charts showing the relative likelihoods of each habitat type at the respective nodes.

3–3–4. Bayesian ancestral character–state reconstructions

The ancestral larval habitats of sciarids were estimated at the subfamily and genus levels with some complex groups [e.g. node 7: *Bradysia* + *Phytosciara* + *B. boitsovoensis* i. l. in the 39 nodes, shown in the BP tree (Fig. 3–2, Table 3–3, Supporting information Fig. S3–10). BayesMultiState analysis allowed for free rates of larval habitat type exchange among the three types (Table 3–2). The reconstructed probability for the B + C (rotten wood + plant litter: based on dead trees and dead leaves) larval habitats at the root of the family Sciaridae (stem node for Sciaridae; Fig. 3–2; Table 3–3, node 1) was more than 95% (rotten wood 73% + plant litter 25%) based on Bayesian analysis. The ancestral larval habitats on the nodes representing Sciaridae, except Sciarinae, were reconstructed as B + C with a probability of more than 95% (plant litter 54% + rotten wood 45%) (Fig. 3–2; Table 3–3, node 2). The ancestral larval habitats for the *Chaetosciara* group were reconstructed as completely rotten wood with a probability of more than 95% (Fig. 3–2; Table 3–3, node 11). The origins of larval habitat types for the Cratyninae and *Lycoriella* group were strongly reconstructed as plant litter, with probabilities of more than 90% (Fig. 3–2; Table 3–3, nodes 3, 4, 5, 12, 13, and 15). In contrast, the larval habitats for the ancestral character states for the ancestor of the Megalosphyinae (Fig. 3–2, node 6) suggest that a mixture of A + C (living plants 18% and plant litter 81%) was the ancestral feeding type for the main lineages of Megalosphyinae. Although the ancestral larval habitats of the other Megalosphyinae were reconstructed as plant litter with probabilities of more than 90% (Fig. 3–2, node 39), the analysis indicated that living plants, with probabilities of more than 95% (Fig. 3–2; Table 3–3, node 38) was more likely the habitat type of the common ancestor of *Bradysia* (excluding *Bradysia sachalinensis* Mohrig and Krivosheina, 1989) and *Phytosciara* (Fig. 3–2, node 38). Therefore, ancestral habitat transition of larvae has occurred at least once in the evolution of Sciaridae (from dead plant (rotten wood and/or plant litter) to living plants) as determined by the BayesMultiState analysis, and each lineage split into two or three different feeding propensities.

Table 3–3. Clade recovered in the three analyses, Bayesian estimation, Maximum likelihood, Maximum parsimony.

Taxa Clades	**Node on fig. 3**	**MrBayes**	**RAxML**	**PAUP**		**BayesTraits PP of Ancestral larval habitat**		
				MP	**DI**	**A**	**B**	**C**
Sciaridae	1	1	100	100	14	1.49%	**76.18%**	22.33%
Sciaridae except Sciarinae	2	1	100	98	18	1.99%	45.24%	**52.77%**
Sciaridae except (Sciarinae + *Chaetosciara* group)	3	1	98	59	2	0.41%	0.35%	**99.24%**
Lycoriella group + Megalosphyinae	4	0.85	43	-	4	0.87%	0.79%	**98.34%**
Lycoriella group (except *Corynoptera boletiphaga*) + Megalosphyinae	5	0.84	35	-	-	0.20%	0.22%	**99.58%**
Megalosphyinae	6	0.9	34	-	-	24.03%	0.83%	**75.14%**
Bradysia (in part)+ *Phytosciara* + *B. boitsovoensis* i. l.	7	0.94	34	-	-	**87.73%**	0.40%	11.88%
Sciarinae	8	0.72	53	74	-	3.37%	**77.11%**	19.53%
Trichosia (s. str.) + *Sciara* + *Leptosciarella* (s. str.)	9	1	89	69	3	1.64%	**80.75%**	17.60%
Sciara + *Leptosciarella* (s. str.)	10	0.89	67	-	-	3.66%	**52.99%**	43.35%
Chaetosciara group	11	1	90	59	2	1.13%	**97.61%**	1.26%
Corynoptera (s. str.) + *Cratyna*	12	1	83	-	-	1.74%	4.76%	**93.50%**
Pseudolycoriella	13	1	72	-	-	1.37%	1.06%	**97.58%**
Ctenosciara + *Zygoneura*	14	0.69	48	-	-	2.25%	19.99%	**77.76%**
Scatopsciara (s. str.) + *Corynoptera vagula*	15	0.91	59	-	-	0.62%	0.44%	**98.93%**
Bradysia 1 (in part)	16	1	76	-	6	33.33%	33.33%	33.33%
Bradysia 2 (in part)	17	0.98	46	-	-	**94.24%**	0.93%	4.84%
Leptosciarella (SG *Leptospina*)	18	1	100	100	41	33.33%	33.33%	33.33%
Mouffetina sp. 1 + *Scythropochroa*	19	1	99	-	2	8.74%	**81.22%**	10.04%
Schwenckfeldina + *Chaetosciara*	20	1	96	80	8	0.94%	**98.03%**	1.03%
Lycoriella (SG *Hemineurina*) + *Bradysiopsis vittigera* (*vittata* G)	21	0.99	81	-	-	0.51%	0.35%	**99.14%**

Cratyna	22	1	94	-	-	2.81%	19.41%	**77.77%**
Trichosia (s. str.)	23	1	100	100	25	0.14%	**99.73%**	0.14%
Sciara	24	1	100	100	28	0.96%	0.70%	**98.34%**
Leptosciarella (s. str.)	25	1	100	100	17	0.60%	**98.75%**	0.65%
Scythropochroa	26	1	99	78	2	2.62%	**94.39%**	2.99%
Chaetosciara	27	0.99	94	61	1	1.17%	**97.51%**	1.32%
Corynoptera (s. str.)	28	1	88	-	6	9.67%	8.07%	**82.26%**
Xylosciara (s. str.)	29	1	78	73	2	1.86%	**96.03%**	2.12%
Camptochaeta	30	0.96	52	-	-	0.97%	0.71%	**98.33%**
Lycoriella (SG *Hemineurina*)	31	1	74	68	6	0.77%	0.56%	**98.67%**
Lycoriella (s. str.)	32	1	98	100	19	0.96%	0.70%	**98.34%**
Ctenosciara	33	1	92	52	2	1.43%	0.33%	**98.24%**
Zygoneura	34	1	100	100	26	0.38%	**99.20%**	0.42%
Scatopsciara	35	1	85	-	5	1.12%	0.83%	**98.05%**
Phytosciara (SG *Dolichosciara*)	36	1	86	84	6	33.34%	33.33%	33.33%
Cratyninae	37	0.52	-	-	-	1.59%	2.25%	**96.17%**
Bradysia (except *B. sachalinensis*) + *Phytosciara*	38	0.99	49	-	-	**93.38%**	0.77%	5.85%
Megalosphyinae except node 38	39	0.51	16	-	-	10.55%	2.08%	**87.37%**

Blanks (–) indicate that a particular clade is supported by bootstrap values in < 50% of the MP analysis, or not recovered in those analyses. Posterior probabilities (PP) of larval habitats character states for nodes in the Bayesian consensus tree. The observed character state for each node is in bold type (≥ 50%). Abbreviations: A = living plant; B = rotten wood; C = plant litter; G = Species group; SG = Subgenus; PP = Posterior probabilities; MP = Maximum parsimony; DI = Decay index.

3–4. Discussion

The suprageneric classification of the family Sciaridae has been contradictory, because homoplasy has been common in various datasets used in analyses (Hippa and Vilkamaa, 2004, 2005, 2006; Hippa et al., 2003; Menzel and Mohrig, 2000; Vilkamaa and Hippa, 2004). Enderlein (1911) suggested three subfamilies (Fig. 3–1A; Table 3–1): Cratyninae Enderlein, 1911 (only one genus *Cratyna*); Lestremiinae Rondani, 1840 (genus *Zygoneura* with the current Cecidomyiidae and a part of Scatopsidae), and "Lycoriinae Speiser, 1909" (= Sciarinae Billberg, 1820). The subfamily "Lycoriinae" sensu Enderlein (1911) included all of the remaining Sciaridae taxa with three tribes: "Lycoriini" (= Sciarini), Amesicriini, and Megalosphyini. Later, Lengersdorf (1928–30) suggested four subfamilies (Fig. 3–1B; Table 3–1): only Cratyninae sensu Enderlein (1911) was retained, the subfamily "Lycoriinae" (= Sciarinae) was divided into two subfamilies as Sciarinae and Megalosphyinae, and a new subfamily Zygoneurinae (*Zygoneura* s. str. and *Zygomma*) was proposed. However, Frey (1942) downgraded the rank of subfamilies sensu Lengersdorf (1928–30) and reconstructed three specialization levels (Fig. 3–1C; Table 3–1), which have been generally accepted with respect to disregarding the subdivision into subfamilies and tribes (Menzel and Mohrig, 2000). Since that time, Röschmann and Mohrig (1995) discussed the relationships, using morphological phylogenetics, for 12 genus–group names of Sciaridae, including fossils. Interestingly, the grouping of the genera was almost identical to the molecular phylogenetic analyses in this study. The genera *Leptosciarella*, *Trichosia* s. str., *Palaeotrichosia* †, and *Archaeosciara* † were proposed as a monophyletic group based on the character, which is neck of 4th flagellomere short (NFS) (current Sciarinae). Seven other genus–group names were clustered by the character of ventral setae missing on R_5 and R_1

wing veins (VSR) (*Cratyna* s. l. + (*Lycoriella* s. l. + *Epidapus* s. l.)). Within this group, two subgenera of *Cratyna* (*Peyerimhoffia* + *Spathobdella*) were monophyletic, and two groups of the remaining taxa formed clades: (*Protolycoriella* † + *Lycoriella* s. str.) + (*Corynoptera* + [*Epidapus* s. str. + "*Vimmeria*"; misidentification, = *Pseudoaptanogyna*]) (with the genera *Lycoriella*, *Corynoptera* and *Epidapus* as part of Cratyninae) (Fig. 3–1D). Hypotheses regarding subfamily groups and genera based on morphological cladistic analyses were suggested for the Sciaridae (Hippa and Vilkamaa, 2005; Menzel and Mohrig, 2000; Vilkamaa, 2000; Vilkamaa and Hippa, 2005; Vilkamaa et al., 2004). Menzel and Mohrig (2000) conducted a cladistic analysis for all of the proposed subfamily groups using 161 morphological characters (including 48 valid genus–group names in 28 genera with Palaearctic distribution, and four newly defined subfamilies), and suggested a subfamily system largely similar to the current molecular study (Figs 3–1E and 2; Table 3–1).

With regard to the subfamilies of Menzel and Mohrig (2000: 648–550), the present molecular phylogenetic results support the subfamily Sciarinae (Fig. 3–2, node 8) and the subfamily Megalosphyinae (Fig. 3–2, node 6) sensu Menzel and Mohrig (2000), with the exception or inclusion of some genera below, but the subfamily Cratyninae and the "new subfamily" sensu Menzel and Mohrig (2000) (clade of *Pseudolycoriella* group + *Corynoptera* s. l. group) were poorly supported by molecular data. Within Sciarinae sensu Menzel and Mohrig (2000), the genera *Mouffetina*, *Scythropochroa*, *Schwenckfeldina*, and *Chaetosciara* (Fig. 3–2, node 11) are separated as the *Chaetosciara* group. Therefore, I propose a new grouping of five subfamilies (Sciarinae, *Chaetosciara* group, Cratyninae, and *Lycoriella* group + Megalosphyinae) within Sciaridae (Fig 3–2; Table 3–1).

3–4–1. New definitions the Sciaridae

3–4–1–1. Subfamily Sciarinae

As suggested by Menzel and Mohrig (2000), the subfamily Sciarinae includes six genera (Table 3–1; Supporting information Table S3). According to our molecular analyses, the constitution of Sciarinae sensu Menzel and Mohrig (2000) (Fig. 3–2, node 1, except node 3) was poorly supported (Table 3–3). Therefore, I suggest the subfamily Sciarinae as reconstructed at node 8 (*Sciara* + *Trichosia* s. str. + *Leptosciarella* including the subgenus *Leptospina*). The monophyly of the genera *Trichosia* s. str. and *Sciara* was strongly supported, but the genus *Leptosciarella* is polyphyletic because the subgenus *Leptospina* is the sister group of *Trichosia* s. str., *Sciara*, and *Leptosciarella* s. str. Neverthless, the monophyly of *Leptosciarella* s. str. was strongly supported, and the subgenus *Leptospina* was also monophyletic (Fig. 3–2; Table 3–3, node 18). Therefore, the subgenus *Leptospina* is proposed as separate from *Leptosciarella* due to the separation at node 18.

Molecular analyses supported the status of *Scythropochroa*, *Schwenckfeldina*, *Chaetosciara*, and *Mouffetina* as a separate group from the subfamily Sciarinae (Fig. 3–2; Table 3–3, node 8). *Mouffetina* sp. 1 formed the sister taxon of two *Scythropochroa* (Fig. 3–2, node 19). *Schwenckfeldina* sp. 1 (near *S. custodiata* Rudzinski, 2005) formed the sister taxon of four species of *Chaetosciara*, as strongly supported by high *P*–values (Fig. 3–2; Table 3–3, node 20). The cluster of those two clades (Fig. 3–2; nodes 19 and 20) was well supported in all analyses (Fig. 3–2; Table 3–3, node 11).

3–4–1–2. *Chaetosciara* group

In the subfamily Sciarinae, Frey (1942) suggested group 1 (Table 3–1, Fig. 3–1) sharing the following characters: three segments of the maxillary palpus (SMP) and macrotrichia on Cu and M wing veins (MW). However, Menzel and Mohrig (2000) excluded the genus *Phytosciara* based on the characters 'NF long, and comb–like row of bristles on the apex of the fore tibia (CBT)'. Additionally, *Scythropochroa*, *Schwenckfeldina*, and *Chaetosciara* were included as the sister group of the genus *Trichosia* s. str. because of the NFS. According to our present results, the morphological characters uniting the subfamily Sciarinae are densely placed bristles on the apex of the fore tibia (DBT), and the number of SMP 'mostly three' (Menzel and Mohrig, 2000); although some *Leptosciarella* known as 2–segmented palpus, only 3 segmented species are used in this analyses. In contrast, the *Chaetosciara* group has stronger and sparser bristles on the apex of the fore tibia (some species have almost comb–like apical bristles), the basal part of the neck clearly separated (BNS), and the number of SMP variable (*Scythropochroa*: 1 SMP, *Mouffetina*: 2 ~ 3 SMP). Therefore, I propose a separate *Chaetosciara* group, including the genera *Chaetosciara*, *Schwenckfeldina*, *Scythropochroa*, and *Mouffetina*.

3–4–1–3. Subfamily Cratyninae

The Cratyninae comprise 11 genera (Menzel and Mohrig, 2000) (Table 3–1). Four genera (*Cratyna*, *Epidapus* s. str., *Xylosciara* s. str., and *Zygoneura*) are included in our molecular analysis. The monophyly of *Cratyna* had strong support (Fig. 3–2; Table 3–3, node 22) and four species of the genus *Corynoptera* s. str. formed the sister clade (Fig. 3–2, node

12). In contrast, *Xylosciara* s. str. and *Zygoneura* are clustered in the clades *Lycoriella* group, and Megalosphyinae respectively. Morphologically the Cratyninae has been considered to be a sister group of the "new subfamily" sensu Menzel and Mohrig (2000) with reducted crown spines on the apex of the hind tibia (CST). Vilkamaa and Hippa (2005) also suggested that the genus *Cratyna* formed a clade with part of *Corynoptera* and *Epidapus* by VSR. According to our analysis, *Epidapus* (s. str.) *atomarius* was a sister of the remaining Cratyninae group (Fig. 3–2, node 37). Therefore, I define the subfamily Cratyninae including the taxa [genera and subgenera] *Cratyna*, *Corynoptera* s. str., and *Epidapus* s. str.

3–4–1–4. ***Lycoriella* group**

The monophyly of the "new subfamily" sensu Menzel and Mohrig (2000) was poorly supported (Fig. 3–2; Table 3–3, node 4, except node 6) because it gives rise to the large subfamily Megalosphyinae (Fig. 3–2, node 6). Only the monophyly of the genus *Pseudolycoriella* had strong support, and this formed the sister clade of the remaining species (Fig. 3–2, node 13), except for *Corynoptera boletiphaga* (Lengersdorf, 1940). The genera *Corynoptera* and *Lycoriella* were revealed as polyphyletic groups. *Corynoptera blanda* (Winnertz, 1867) formed different groupings, depending on the method of analysis (with *Keilbachia* in BP and with *Lycoriella* s. str. in MP and ML). Besides, *C. boletiphaga* was the sister taxon of all the remaining members of the *Lycoriella* group (Fig. 3–2, nodes 4 and 13). It must be excluded from *Corynoptera* s. str. as proposed by Hippa et al. (2010) and should be treated as a distinct genus together with some related species (*C. boletiphaga* group). The monophyly of the genus *Lycoriella* s. str. was well supported, but the subgenus *Hemineurina* clustered together with *Bradysiopsis vittigera* (Zetterstedt, 1851) was highly supported by MP, BP, and ML (Fig. 3–2; Table 3–3, node 21). Consequently, the subgenus *Hemineurina* could be a separate genus from *Lycoriella* s. l. due to the separation at node 31. Therefore, all analyses supported the conclusion that the two subgenera of *Lycoriella* do not form a monophyletic group, but the subgenus *Lycoriella* s. str. is the sister group of the Megalosphyinae group (Fig. 3–2, node 6). Additionally, *Dichopygina aculeata* Vilkamaa, Hippa and Komarova, 2004 is the sister group of two *Camptochaeta* species.

Those groups were characterized by the curved margin on the apex of the fore tibia (CMT) and/or mesiocentral whiplash seta on the gonostylus (MWG). According to cladistic analyses of Menzel and Mohrig (2000), the genus *Xylosciara* has been included in the Cratyninae due to the lack of CMT. However, Hippa et al. (2003) suggested that the genus *Xylosciara* should be grouped with *Camptochaeta* and *Keilbachia* by MWG. Additionally, phylogenetic studies of the genus *Xylosciara* have been presented by morphological cladistic analysis (Hippa and Vilkamaa, 2004). Interestingly, our ML analysis supports *Xylosciara* s. str. as the sister clade of *Keilbachia* + *Dichopygina* + *Camptochaeta* + *Bradysiopsis* + *Hemineurina* + *Corynoptera blanda*. Thus, *Xylosciara* (s. str.) *betulae* Tuomikoski, 1960 and *Xylosciara* (s. str.) *inornata* Mohrig and Krivosheina, 1979 (all species without CMT; with MWG) are included in the *Lycoriella* group.

In this context, I propose the *Lycoriella* group, including *Xylosciara* s. str. and excluding *Corynoptera* s. str. Because the “new subfamily” sensu Menzel and Mohrig (2000) has not yet been described and the position of *Lycoriella* s. str. is closer to that of Megalosphyinae than to that of the remaining genera, I propose the *Lycoriella* group, including the genera *Lycoriella*, *Pseudolycoriella*, *Xylosciara*, *Dichopygina*, *Camptochaeta*, *Keilbachia*, and *Bradysiopsis*.

3–4–1–5. Subfamily Megalosphyinae

The main part of the Megalosphyinae includes four Palaearctic genera (Menzel and Mohrig, 2000) (Table 3–1). In our molecular results, the monophyly of the subfamily was well supported (Fig. 3–2; Table 3–3, node 6). The monophyly of the genus *Ctenosciara* had strong support in BP and ML, and the genus *Scatopsciara* s. str. also had strong support. The genus *Bradysia* s. l. was paraphyletic. *B. sachalinensis* was the sister taxon of *Ctenosciara*, *Scatopsciara* s. str., *Zygoneura*, and *Corynoptera vagula*. The genus *Phytosciara* forms a clade with *Bradysia* (Fig. 3–2, node 7). *Bradysia atracornea* Mohrig and Menzel, 1992 formed a sister clade with subgenus *Phytosciara* (*Dolichosciara*), and *Phytosciara* (*Prosciara*) *ussuriensis* Antonova, 1977 formed a sister clade with two *Bradysia* species (*B. peraffinis* Tuomikoski, 1960; *B. chlorocornea* Mohrig and Menzel, 1992). Therefore, *Phytosciara* was also discovered to be a polyphyletic group.

The subfamily Megalosphyinae was classified distinctly by strict CBT. This character also played a key role in the definition of Megalosphyinae sensu Menzel and Mohrig (2000). Previously, the genus *Zygoneura* was included in the subfamily Lestremiinae with parts of the families Cecidomyiidae and Scatopsidae due to the length of the CuA stem (Fig. 3–1A) (Enderlein, 1911). Later, the genera *Zygoneura* and *Zygomma* were grouped as the subfamily Zygoneurinae (Fig. 3–1B) due to the bell shape M fork of wing venation (Lengersdorf, 1928–30). Frey (1942) included parts of *Zygoneura* in his group 3 due to the possession of two SMP (Fig. 3–1C). Recently, Menzel and Mohrig (2000) suggested the genus *Zygoneura* should be included in Cratyninae and formed a sister group with the genus *Xylosciara* s. l. based on the hind tibia structure and xylophagous larva. Nevertheless, members of the genus *Zygoneura* have CBT with finely serrated tarsal claws; furthermore, those characters could be a synapomorphy with the genus *Ctenosciara*. In our analyses, *Zygoneura* was composed of three species [*Z.* (s. str.) *sciarina* Meigen, 1830; *Z.* (*Pharetratula*) *flavicornis* (Mamaev, 1968); *Z.* (*Pharetratula*) *bidens* (Mamaev, 1968)] and monophyletic, with strong support for *Zygoneura* as the sister group of *Ctenosciara* (Fig. 3–2, node 14). *Corynoptera vagula* has been recorded as sharing CBT with some related species (*C. vagula*–group) (Vilkamaa and Hippa, 2006). The CBT of *C. vagula* was on a narrow lobe structure, which might represent a synapomorphy with the genus *Scatopsciara* s. str. Based on the new results, I propose that the subfamily Megalosphyinae includes the taxa [genera and species the su *Bradysia*, *Ctenosciara*, *Phytosciara*, *Scatopsciara*, *Zygoneura*, and *C. vagula*–group.

3–4–2. Morphological evolutionary hypothesis of fossil Sciaridae

Using the 161 morphological characters proposed for cladistic analysis by Menzel and Mohrig (2000), the fossil material (Röschmann and Mohrig, 1995) has been referred to three groups (*Leptosciarella* + *Trichosia*) + ((*Cratyna* + *Epidapus*) + (*Lycoriella* + *Corynoptera*)) (Menzel and Mohrig, 2000). Interestingly, the generic relationships of the Baltic amber fossils [35–50 MYA, Eocene] were identical to our molecular phylogenetic results, except for the Megalosphyinae, of which fossil species have not been discovered in Europe (Mohrig and Röschmann, 2005). Although the genus *Bradysia* is presently the most species–rich group, only three species have been found in Dominican amber [20–23 MYA, Oligocene] (Mohrig and Röschmann, 2005). The strict CBT (synapomorphy of Megalosphyinae) might have appeared in subfamily Megalosphyinae after divergence from the *Lycoriella* group (Mohrig and Röschmann, 2005).

With regard to the morphological characters of fossil groups, (*Leptosciarella* + *Trichosia*) group have NFS, distinct from other genera, and the remaining group (Cratyninae + *Lycoriella* group) formed a clade, with the BNS and the gonostylus tip tapered and pointed (GTP). These groups (Cratyninae + *Lycoriella* group) are divided by the characters on the apex of tibial spines: *Cratyna* + *Epidapus* s. str. + *Pseudoaptanogyna* without CST, whereas *Lycoriella* s. str. + *Corynoptera* s. l. with CMT. This character may be related to CBT because the molecular phylogenetic results indicated that *Lycoriella* s. str. is closely related to Megalosphyinae as a sister group, and some *Lycoriella* s. str. species have alike CBT–shaped with CMT. The strict CBT appears only in Megalosphyinae (Menzel and Mohrig, 2000). Additionally, CMT is present in the plant litter habitat group (some spp. of *Sciara*, Cratyninae, and the *Lycoriella* group), but most of the rotten wood habitat group (Sciarinae and the *Chaetosciara* group) is without CMT and CBT. Therefore, CMT could be a homoplasious character and may be related to adaptation to living on plant litter, and CBT could be a synapomorphy of Megalosphyinae as an adaptation to living on herbaceous plants. Further studies on the autecology and morphology of Sciaridae are needed to refine the interpretation of these general trends.

3–4–3. Evolutionary history of the larval Habitats of Sciaridae

The phylogeny obtained by genetic analysis is also reflected in the ecology of certain genera, at least along general lines, but not much is known about the autecology of certain species of Sciaridae. I found that the hypothesized larval habitat of Sciaridae shifted during the course of evolution from dead plant (plant litter, and rotten wood) to living plants (Fig. 3–2; Table 3–3). The subfamily Megalosphyinae, which is evolutionarily the youngest group of Sciaridae, may be more associated with plants than other groups because the larvae of *Phytosciara* s. l. and some species of *Bradysia* are known to live on the tissue of living plants (Lee et al., 2010; Menzel and Mohrig, 2000). And some *Bradysia* species are pollinators of *Octomeria* and *Lepanthes* (Orchidaceae, Pleurothallidinae) (Barbosa et al., 2009; Blanco and Barboza, 2005).

The common ancestor of Sciarinae probably lived on plant litter and rotten wood (Fig. 3–2; Table 3–3, node 8), especially in moist forests. The ancestral stem of Sciaridae, is likely to have retained this dead plant habitat (Fig. 3–2; Table 3–3, node 1). The habitat of the common ancestor of the *Chaetosciara* group (Fig. 3–2, node 11) shifted from mixed dead plant material to rotten wood only (under the bark of dead wood) (Fig. 3–2, node 2). Thus, habitat patterns suggest that species in the subfamily Sciarinae have a relatively broader larval habitat range than species in the *Chaetosciara* group because the *Chaetosciara* group inhabits only rotten wood (Menzel et al., 2006; Sutou and Ito, 2004), especially various broad–leaved trees. On the other hand, the common ancestor habitat of Cratyninae, Megalosphyinae, and the *Lycoriella* group might have evolved to plant litter (humus and/or soil) (Fig. 3–2, node 3) from an ancestral type of mixed dead plants (Fig. 3–2, node 2). The common ancestor habitat of *Phytosciara* and part of *Bradysia* (excluding *B. sachalinensis*) (Fig. 3–2, node 38) might have shifted to living plants (larvae can live on the roots, stems, and leaves of living plants which were attacked by fungi) from mixed habitat (Fig. 3–2, node 6).

The records of larval habitats together with molecular phylogenetic analysis suggest that evolution within Sciaridae is a result of habitat adaptation to the decaying organic materials associated with fungi (Mohrig and Röschmann, 2005). Most sciarid larvae live on different stages of decomposing organic matter (the living plants habitat is also associated with decomposing fungi). More concretely, the subfamily Sciarinae and the *Chaetosciara* group are saproxylic, usually in woodland forest. In comparison, the most diverse group of sciarids (such as *Bradysia*) is mainly phytosaprophagous, and collected in more variable moist habitats, including forests, moorland, mushrooms, and greenhouses etc. In fact, some Sciarinae and *Chaetosciara* group larvae (*Sciara* and *Chaetosciara*) have gregarious habits and are known as 'armyworms' (Amorim, 1992; Becker, 1914; Craik et al., 2005; Menzel and Mohrig, 2000; Pratt, 1899; Shaw and Shaw, 1950; Steffan, 1972; Sutou et al., 2011). Although the reason and the function are not known yet, Craik et al. (2005) suggested that the gregarious behaviour could be a response to local overpopulation. Following our analysis of ancestral larval habitats, I propose that such migratory abilities could have evolved from habitat selection, as a response to environment changes such as humidity, acidity, or stage of decomposition of plant matter (food change) during the larval stage. Because they are found to be strictly saproxylic (and therefore dependent on wood or forest), it is impossible for them to survive without organic matter from woody plants. In contrast, *Bradysia*, the most abundant group in Megalosphyinae, is the genus that adapts most successfully to environmental changes, as indicated by the records of diverse larval habitats (dead plant material as well as living plants). The ancestral habitat of the subfamily Megalosphyinae may be closely related to the rise of forests with herbaceous ground cover and the high soil fertility, as their fossil record is from the Oligocene (not Eocene), which coincided with the expansion of grasslands. Based on the fossil record of the subfamily Megalosphyinae, only three species of *Bradysia* have been found in Oligocene amber (Mohrig and Röschmann, 2005), even though *Bradysia* s. l. is the most abundant group in the current fauna. This differs from other groups (Sciarinae, *Chaetosciara* group, Cratyninae, and *Lycoriella* group), which are found in Eocene amber (Mohrig and Röschmann, 2005; Röschmann, 1994; Röschmann and Mohrig, 1995). Consequently, more than other taxa, the subfamily Megalosphyinae such as genus *Bradysia* could have diversified together with the new and expanding grasslands during the Oligocene (Edwards et al., 2010).

3–4–4. **Final Discussions and Outlook**

I am aware that this study is not comprehensive for all genera of Sciaridae. In particular, taxa from the Neotropical and Australian Regions are missing; nevertheless, I am confident that the main features of the present cladistic results will prove stable even with the inclusion of other genera and species groups. Certain genera, such as *Zygoneura*, have been defined on the basis of quite aberrant species and they are now known to be related to genera with a less unusual appearance. Therefore, the DNA analyses are enormously helpful in illuminating the the phylogeny of certain taxa, in which relationships are difficult to infer on the basis of their morphology. Future analyses will hopefully refine the present taxonomic model and show the placement of the currently the currently analyzed genera.

Conclusions

In the Korean peninsula, 15 genera 61 species of the family Sciaridae are recognized. Among them 29 species are newly recorded including 3 new species. The DNA database with voucher specimens of the Sciaridae is constructed, based on the morphology and molecular studies. I also found that the COI barcoding region is one of the key characters for identifying cryptic male species as well as female and immature stage of the Sciaridae. The new concept of subfamilies within Sciaridae is suggested by present phylogenetic and taxonomic results. The genera *Mouffetina*, *Scythropochroa*, *Schwenckfeldina*, and *Chaetosciara* are separated as the subfamily Chaetosciarinae subfam. nov. from the Sciarinae sensu Menzel and Mohrig (2000). Therefore, I proposed five subfamilies (Sciarinae, Chaetosciarinae, Cratyninae, Lycoriellinae, and Megalosphyinae) within Sciaridae.

The DNA barcode will be a useful tool for the taxonomic as well as ecological researches. In this study, I used the universial region of COI for study of the DNA barcode of genus *Bradysia*, which is the most complex group within the family Sciaridae. I found that the taxonomical definition in intra- interspecific variation within complex group could be possible with the combination of DNA barcode and taxonomic research. The DNA barcode could be one of the most reasonable tools for direct confirmation of pest larval samples from damaged parts for confirmation of the biological habitat information.

I analyzed the tendency of ancestor larval habitats trasitions in the family Sciaridae. The common ancestor of Sciarinae probably lived on plant litter and rotten wood, especially in moist forests. The common ancestor habitats of Cratyninae, Megalosphyinae, and the Lycoriellinae might have evolved to plant litter from an ancestral type of mixed dead plants. Finally, the common ancestor habitat of *Phytosciara* and part of *Bradysia* might have shifted to living plants from mixed habitat. The records of larval habitats together with molecular phylogenetic analysis suggest that evolution within Sciaridae is one of the results of habitat adaptation to the decaying organic materials associated with fungi. Futher, in connection with the study of the fossils, the part of subfamily Megalosphyinae such as genus *Bradysia* and *Phytosciara* could have diversified together with the new and expanding grasslands during the Oligocene.

In this study, I reconstructed the new taxonomic key characters for systematics of sciarids, according to the molecular and taxonomic results. Therefore, the subfamily relationship is redefined. And, the rules of agricultural and ecological importance of Sciaridae are studied by direct identification of the larval stages using COI barcode. And the evolutionally hypothesis of the larval habitats transition is analyzed as shifts in larval habitats from dead plant to living plants may have occurred within the Sciaridae.

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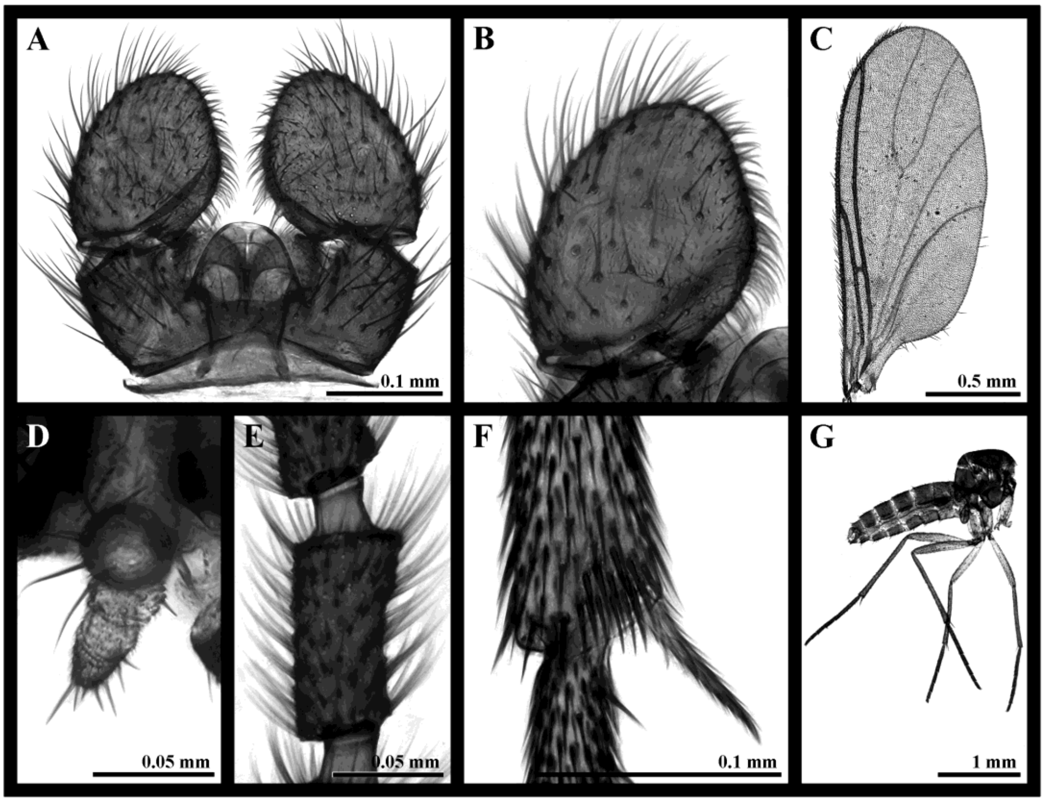


Plate A–1. Male of ***Cratyna* (s. str.) *ambigua*** (Lengersdorf 1934) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

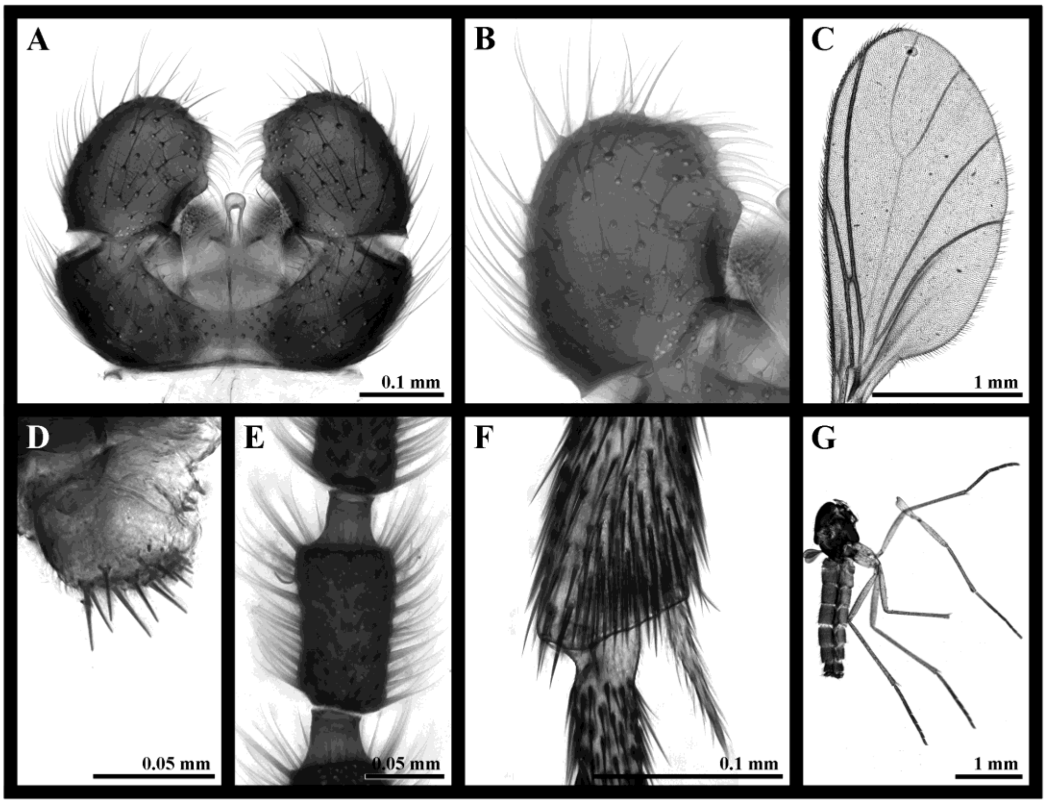


Plate A–2. Male of ***Cratyna* (s. str.) *nigerrima*** (Mohrig and Krivosheina 1979) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

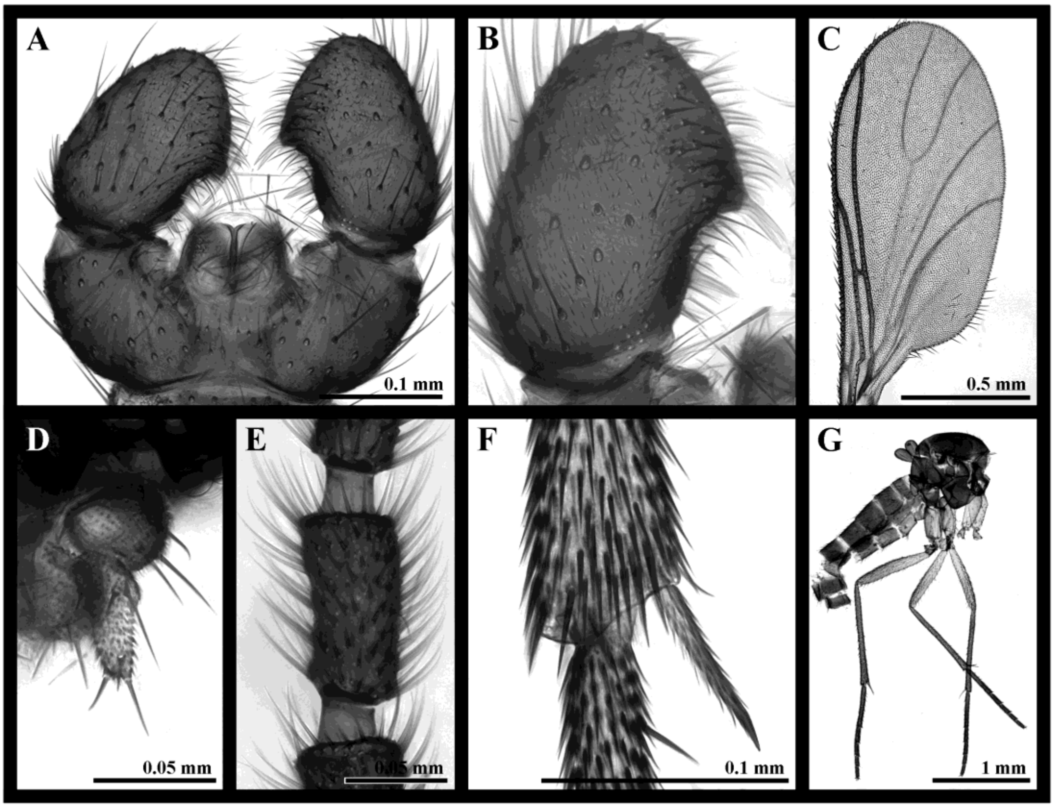


Plate A–3. Male of ***Cratyna* (s. str.) *suwonensis*** sp. nov. * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

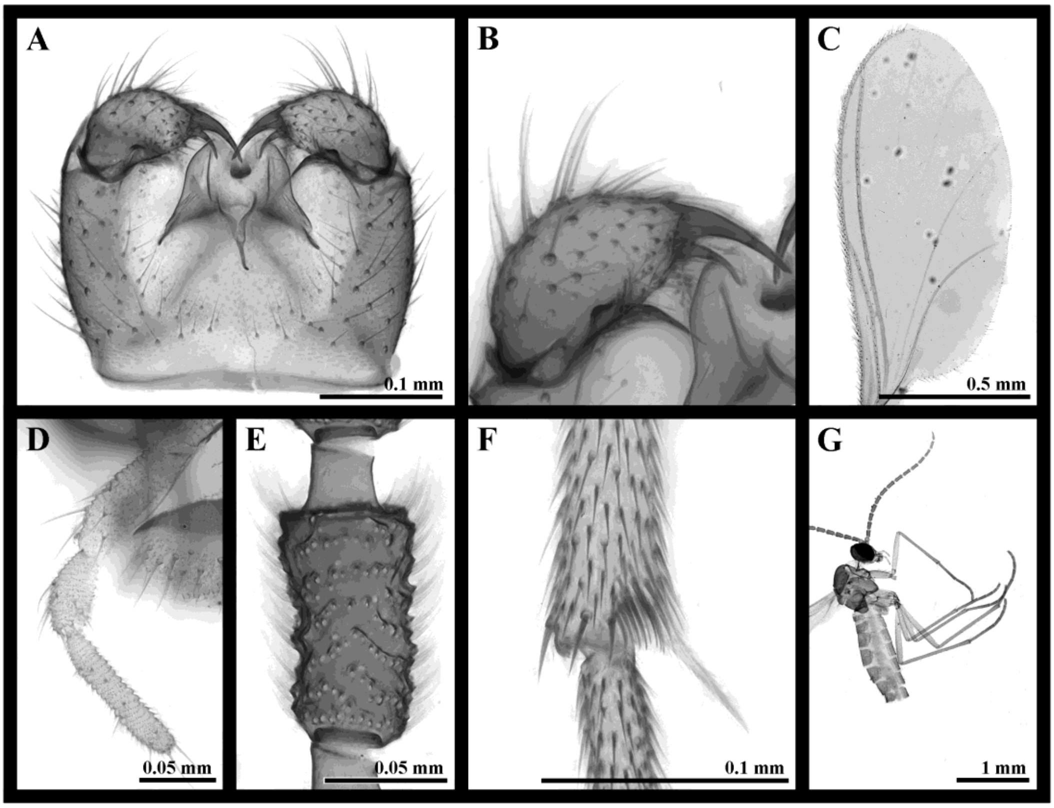


Plate A–4. Male of ***Cratyna* (*Diversicratyna*) *salomonis*** (Mohrig and Mamaev 1985) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

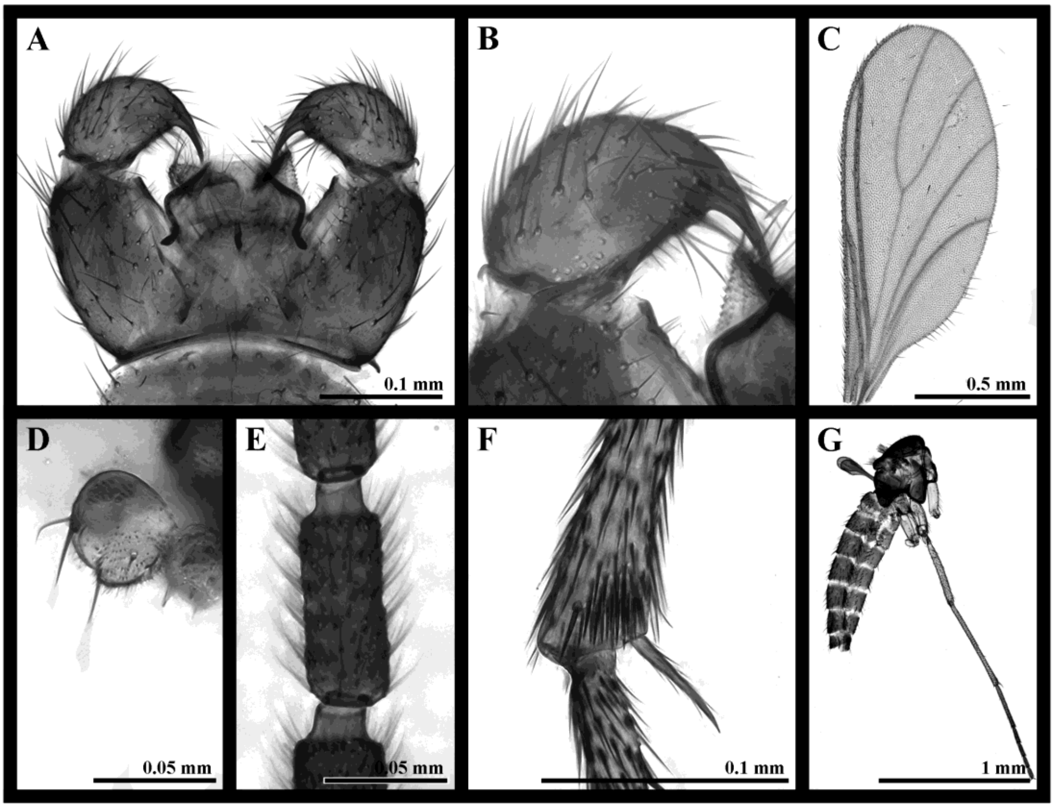


Plate A–5. Male of ***Cratyna* (*Peyerimhoffia*) *vagabunda*** (Winnertz 1867) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

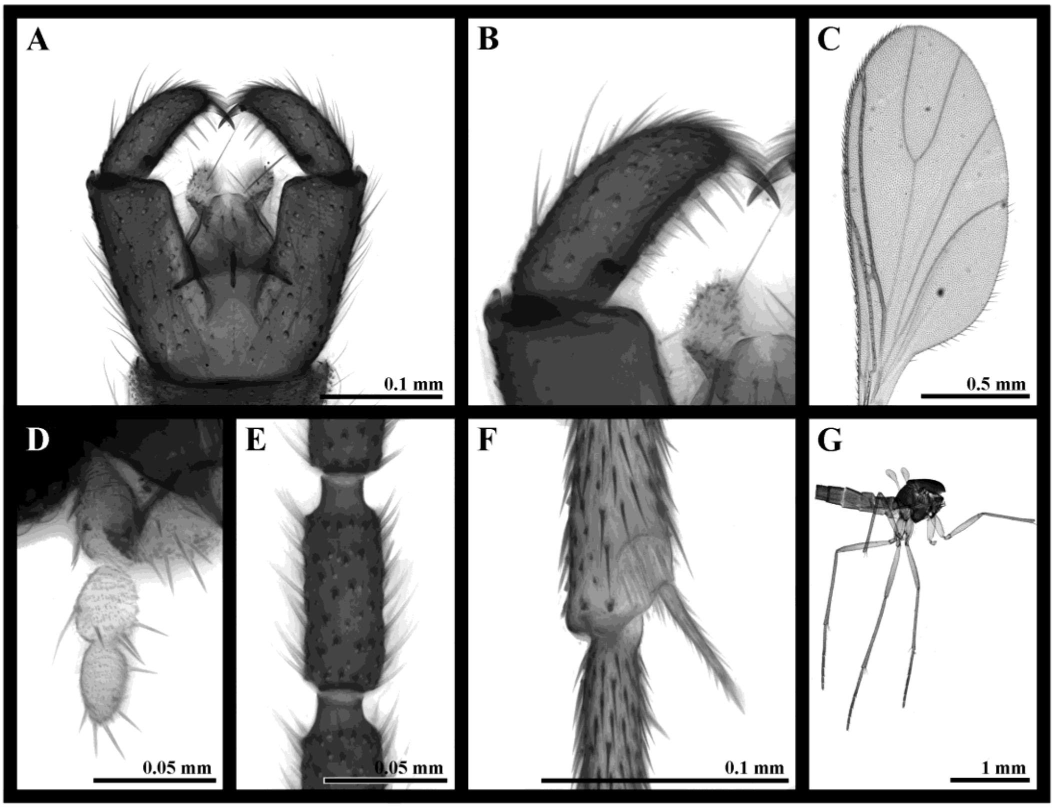


Plate A–6. Male of ***Corynoptera blanda*** (Winnertz 1867) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

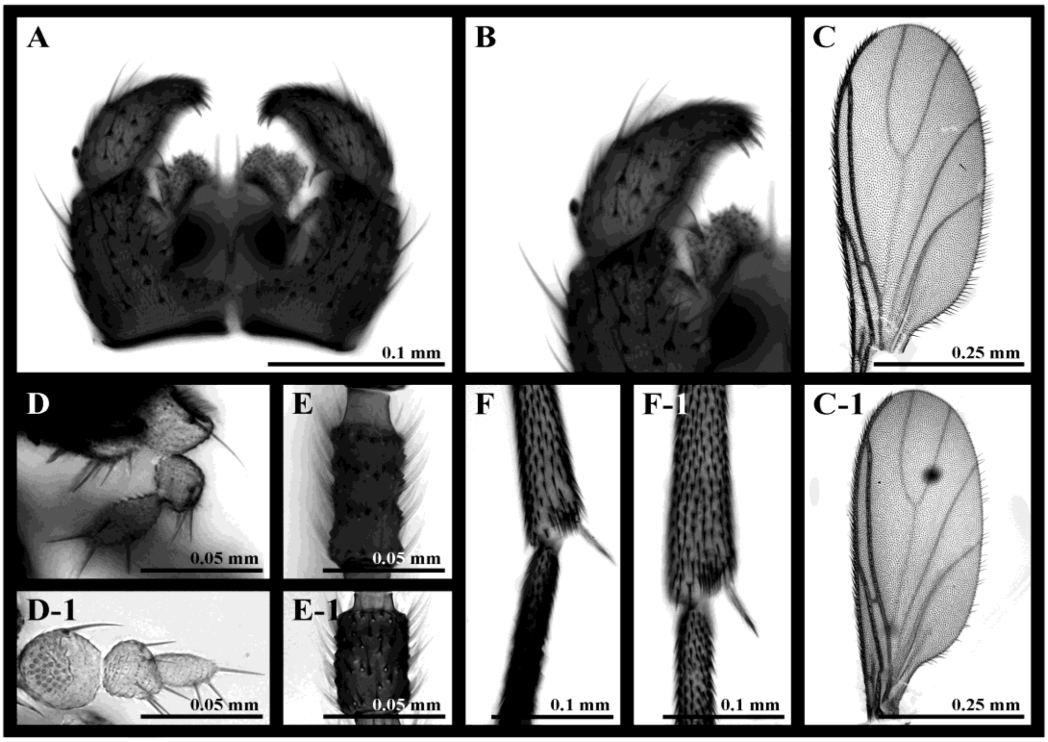


Plate A–7. Male and female adults of ***Corynoptera dentata*** (Bukowski and Lengersdorf 1936) (A–F) A: genitalia, ventral view. B: gonocoxite. C: wing (male). C–1: wing (female). D: maxillary palpi (male). D–1: maxillary palpi (female). E: Flgm. IV segment (male). E–1: Flgm. IV segment (female). F: fore tibia bristles at inner apex (male). F–1: fore tibia bristles at inner apex (female).

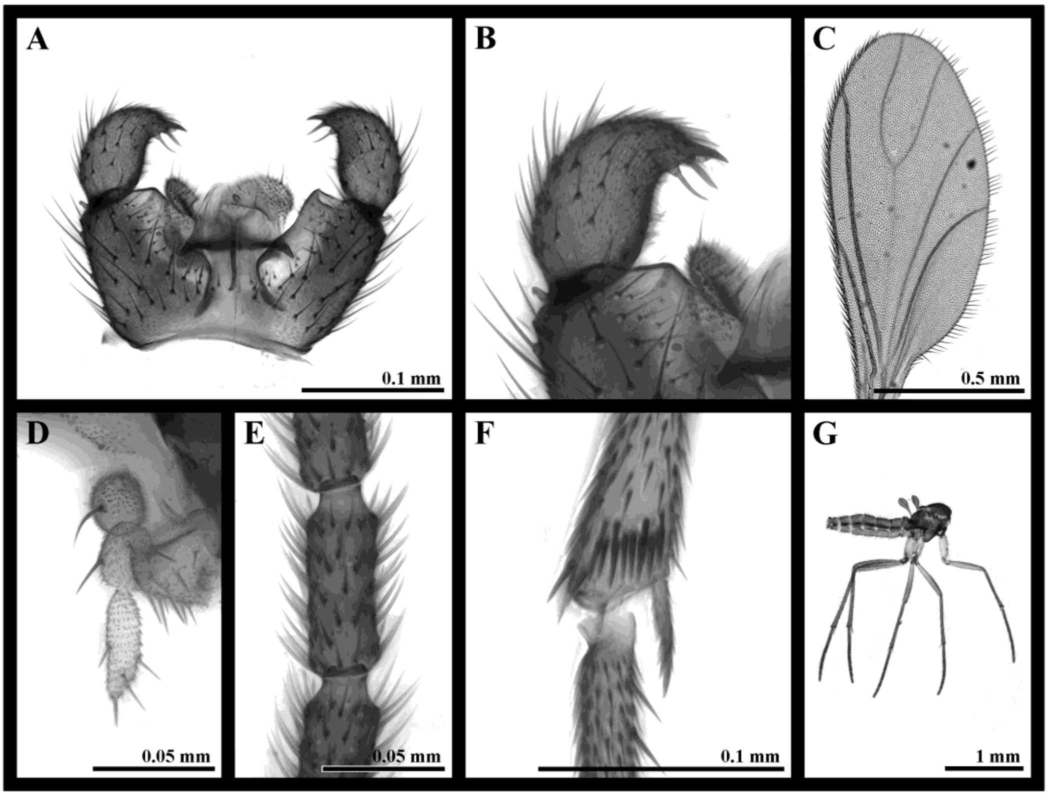


Plate A–8. Male of ***Corynoptera micula*** Hippa, Vilkamaa and Heller 2010 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

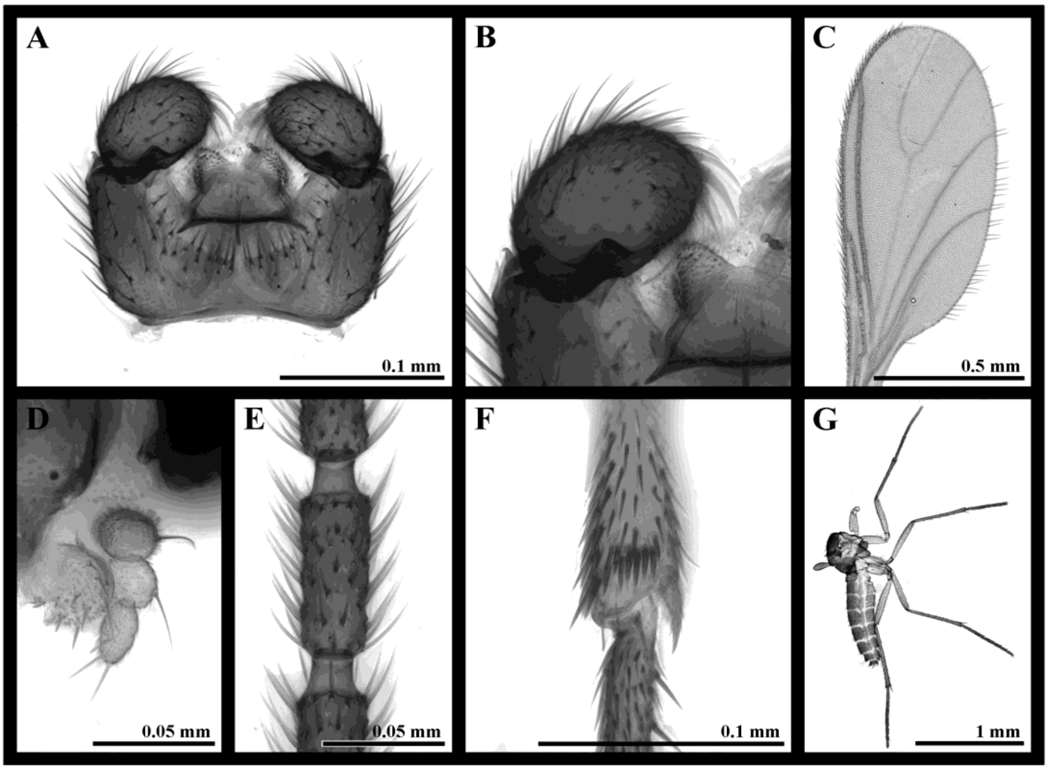


Plate A–9. Male of ***Corynoptera saetistyla*** Mohrig and Krivosheina 1985 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

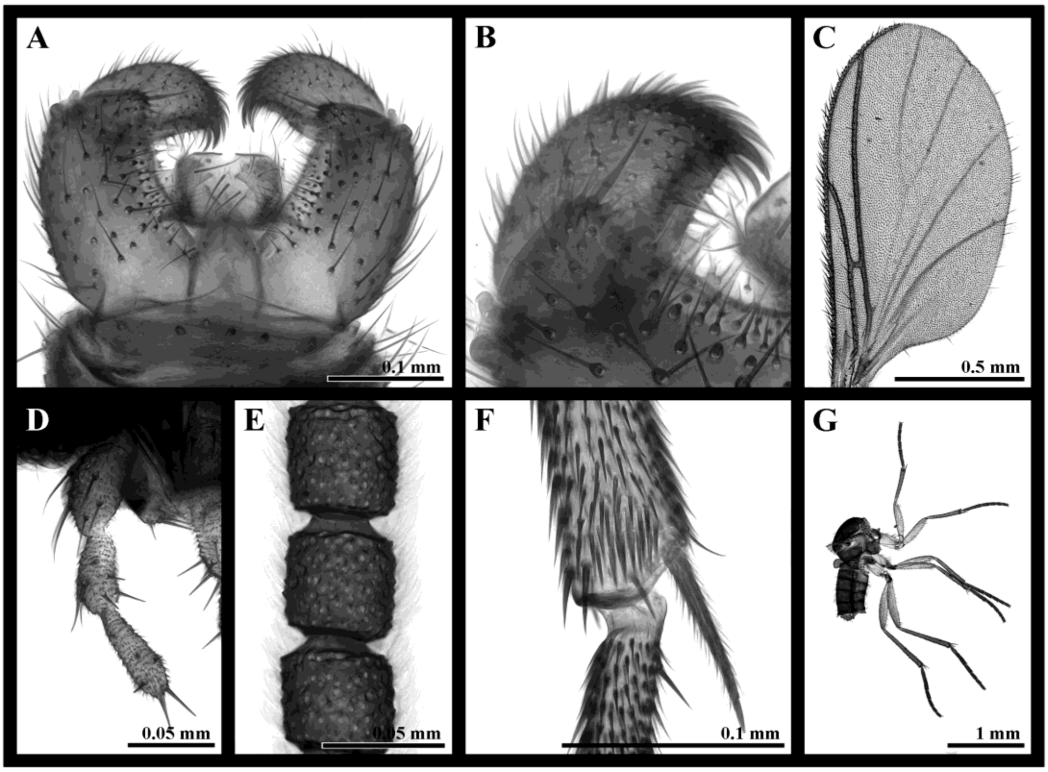


Plate A–10. Male of ***Chaetosciara umbalis*** Mohrig and Krivosheina 1990 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

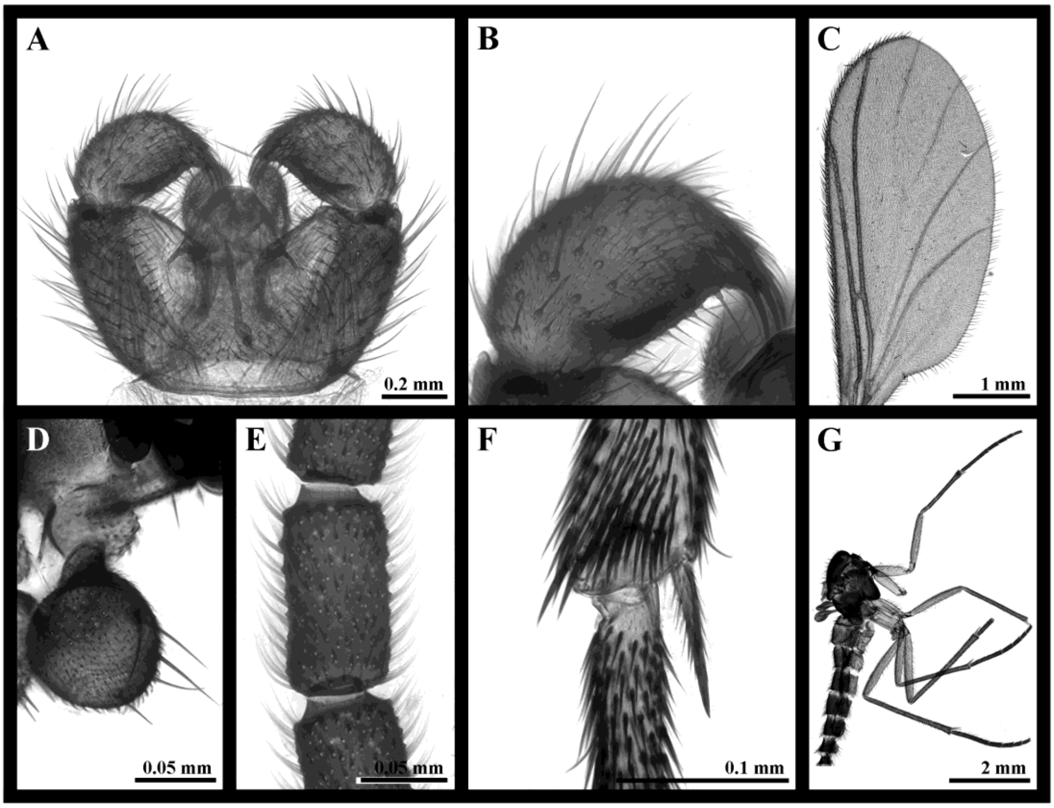


Plate A–11. Male of ***Scythropochroa radialis*** Lengersdorf 1926 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

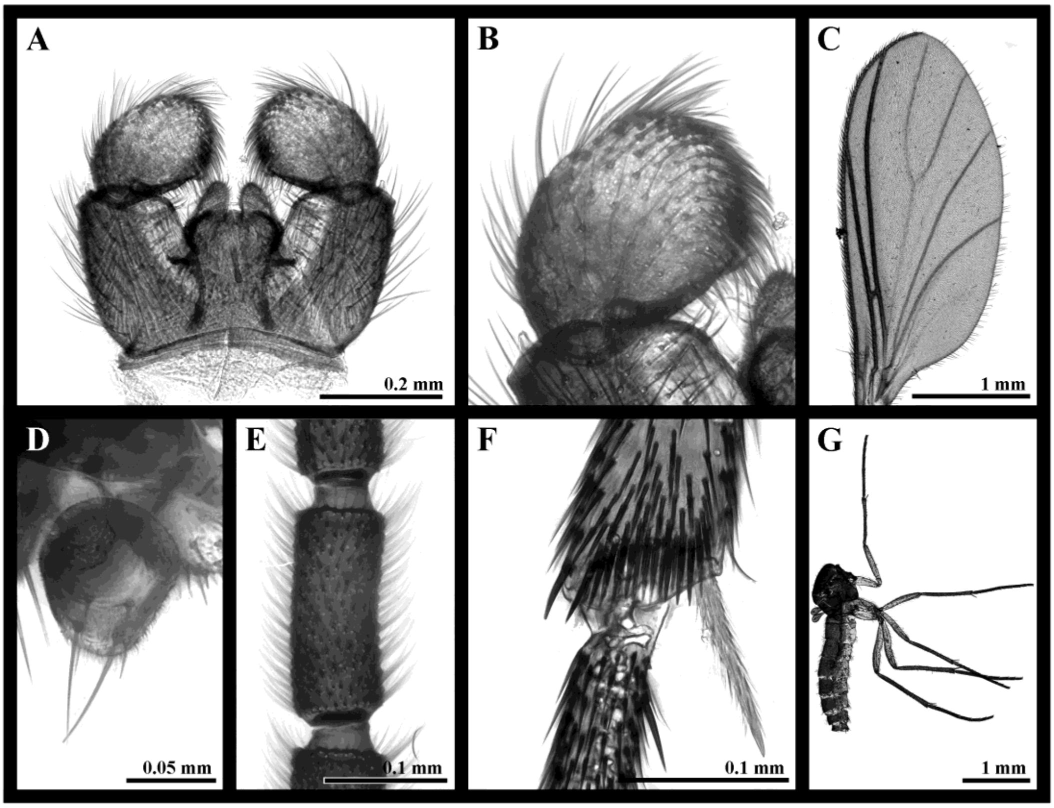


Plate A–12. Male of ***Scythropochroa pseudoquercicola*** sp. nov. * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

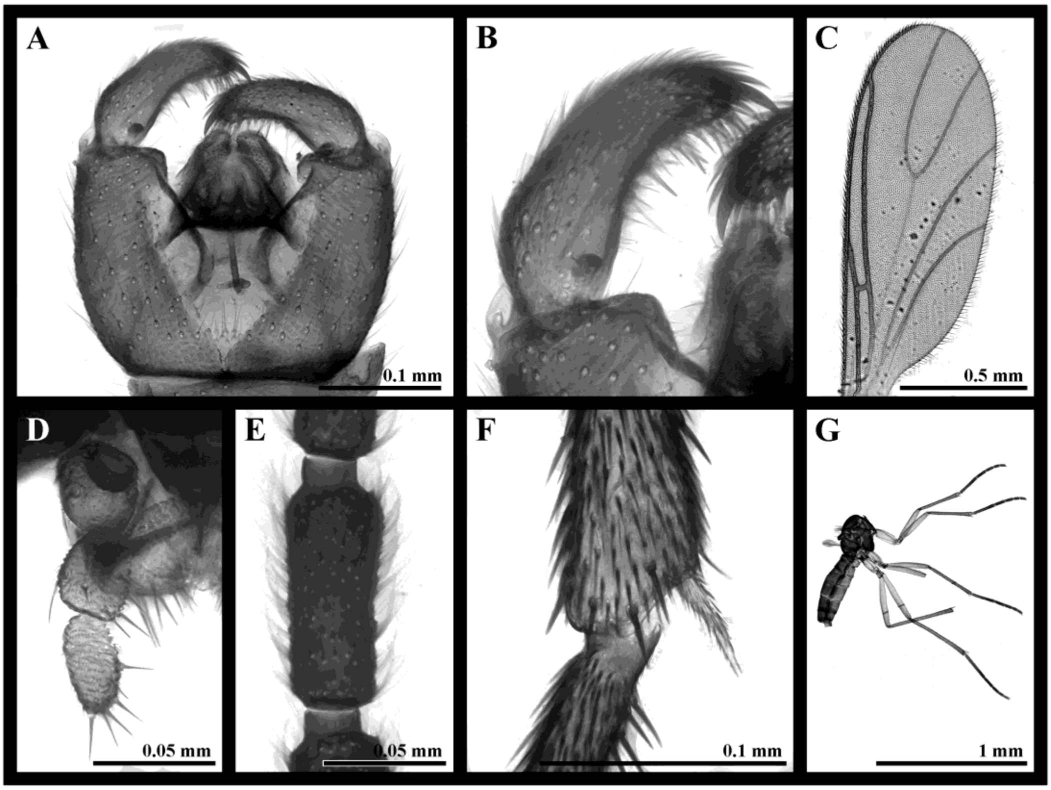


Plate A–13. Male of ***Lycoriella*** **(s. str.)** ***castanescens*** (Lengersdorf 1940) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

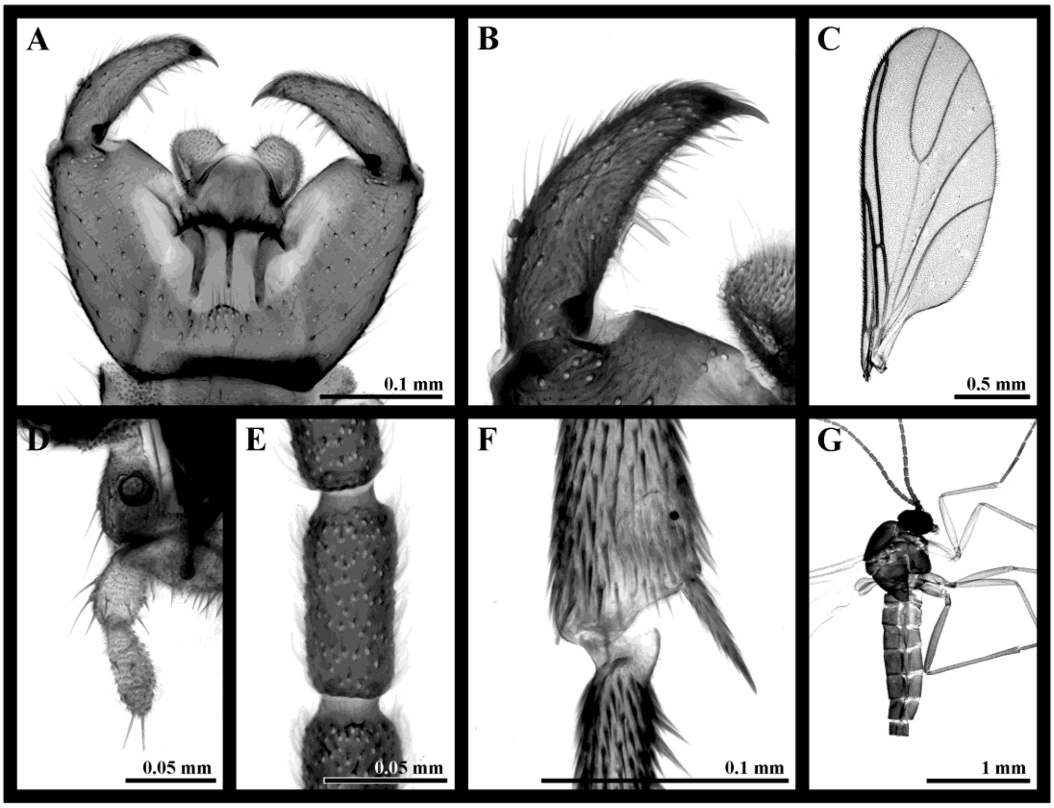


Plate A–14. Male of ***Lycoriella*** **(s. str.)** ***ingenua*** (Dufour 1839) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

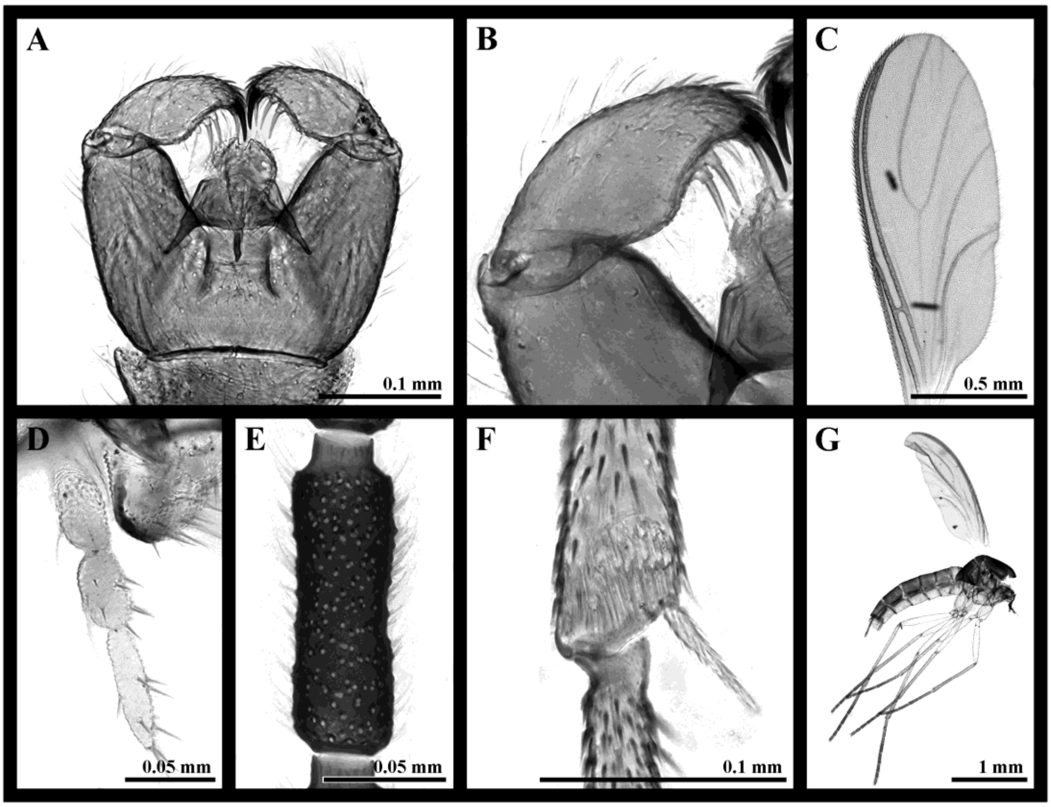


Plate A–15. Male of ***Lycoriella (Hemineurina) flavicornis*** Mohrig and Mamaev 1985 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

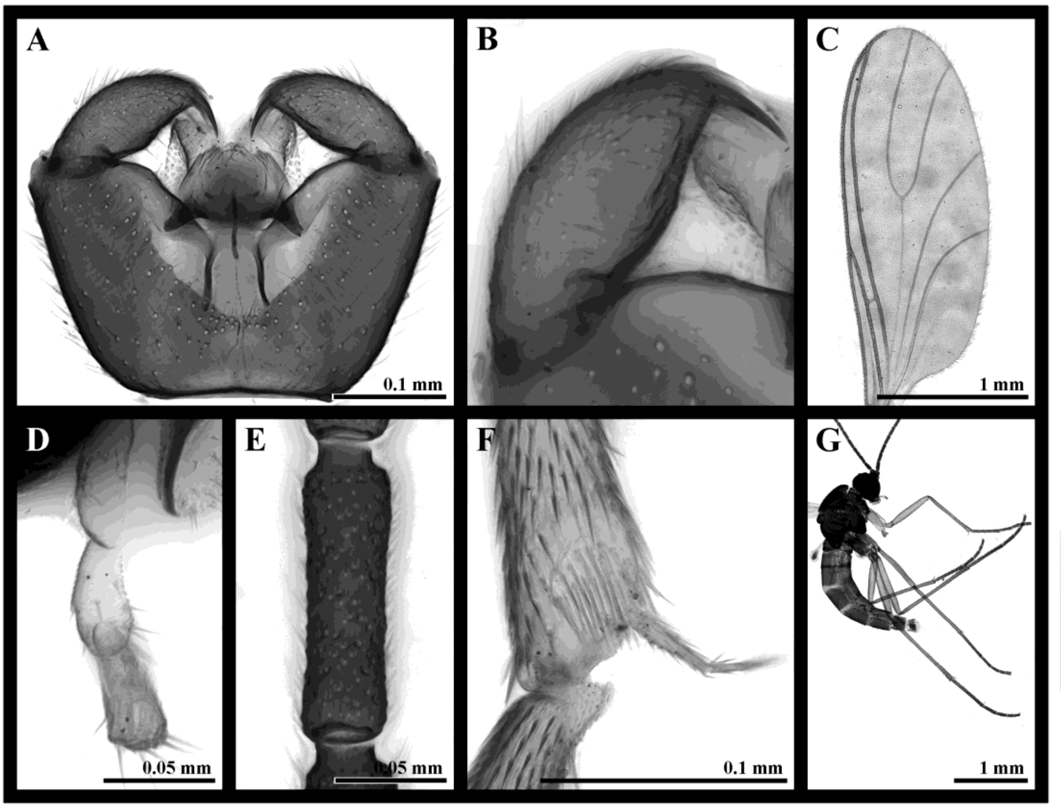


Plate A–16. Male of ***Lycoriella* (*Hemineurina*) *venosa*** (Staeger 1840) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

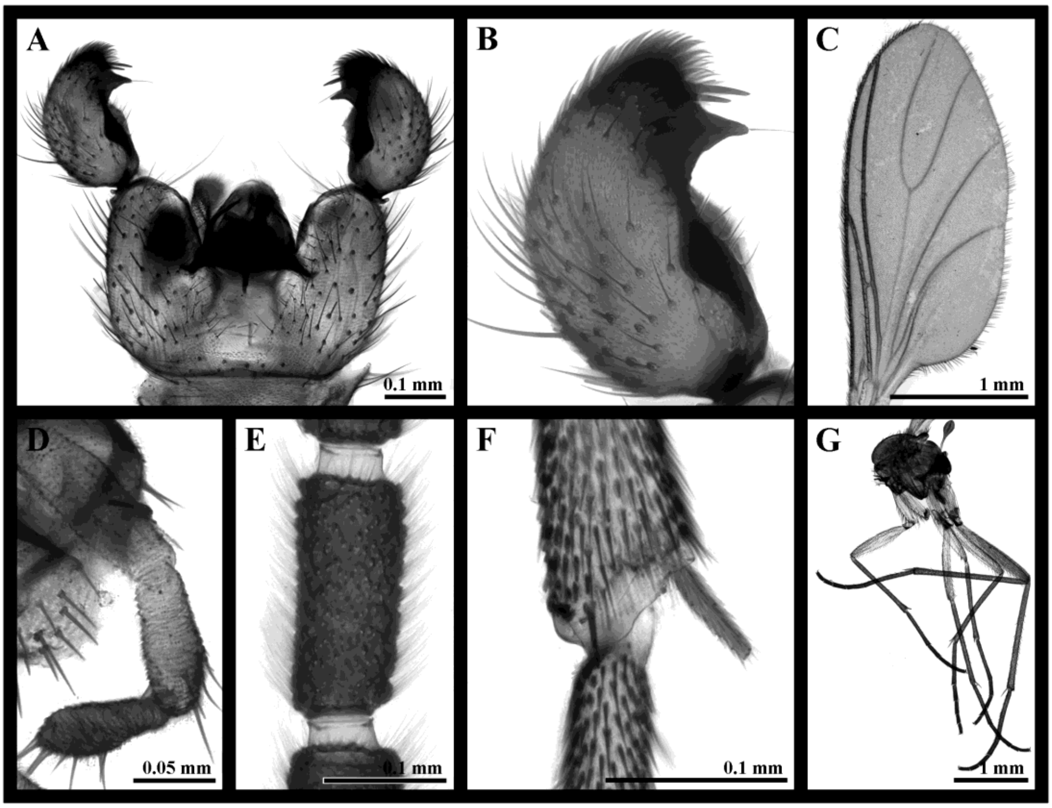


Plate A–17. Male of ***Pseudolycoriella horribilis*** (Edwards 1931) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

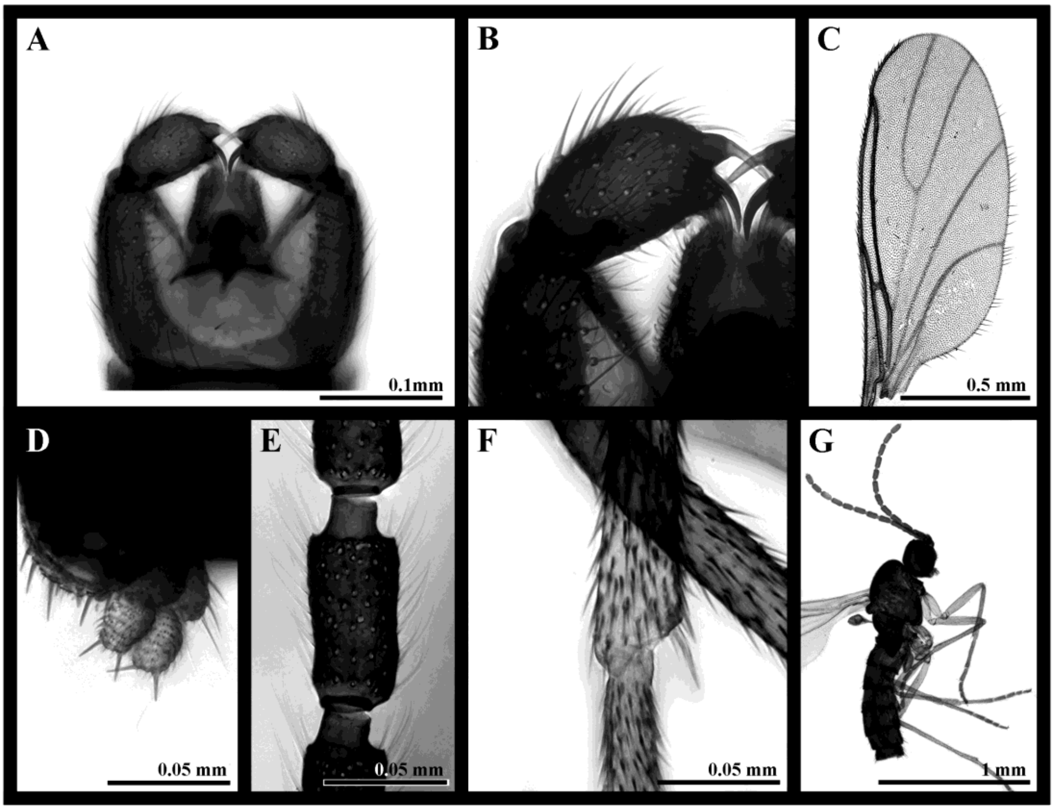


Plate A–18. Male of ***Xylosciara inornata*** Mohrig and Krivosheina 1979 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

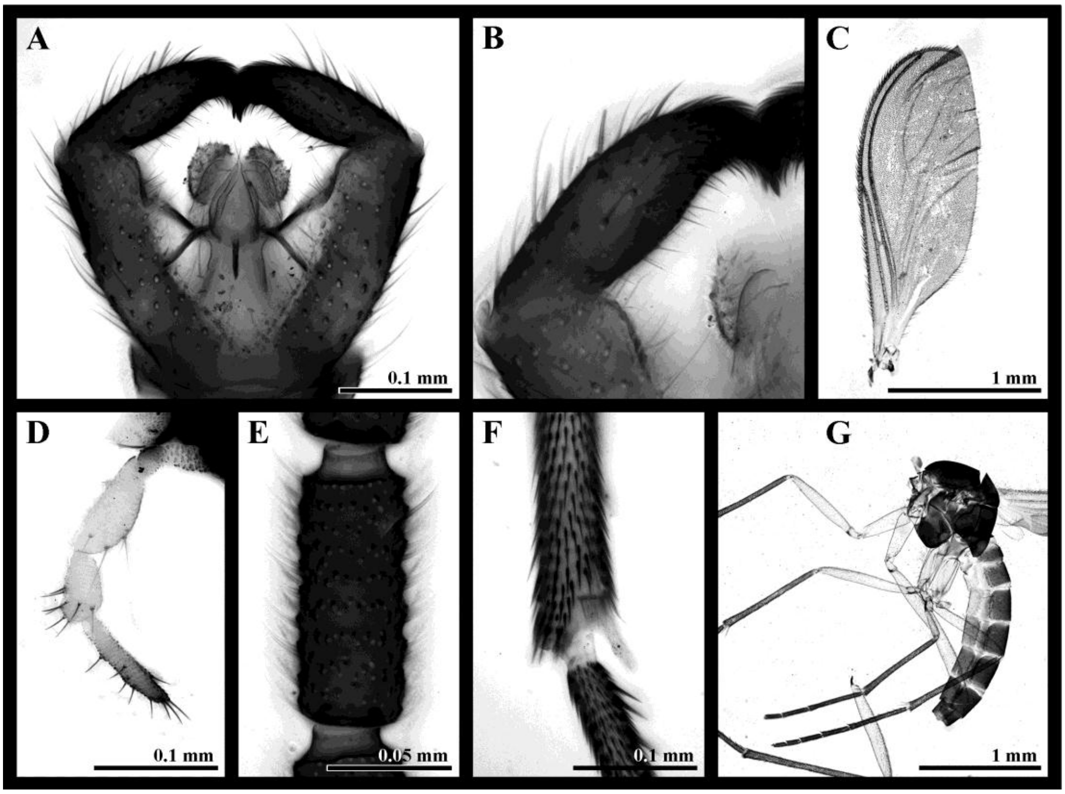


Plate A–19. Male of ***Bradysia aprica*** (Winnertz 1867) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

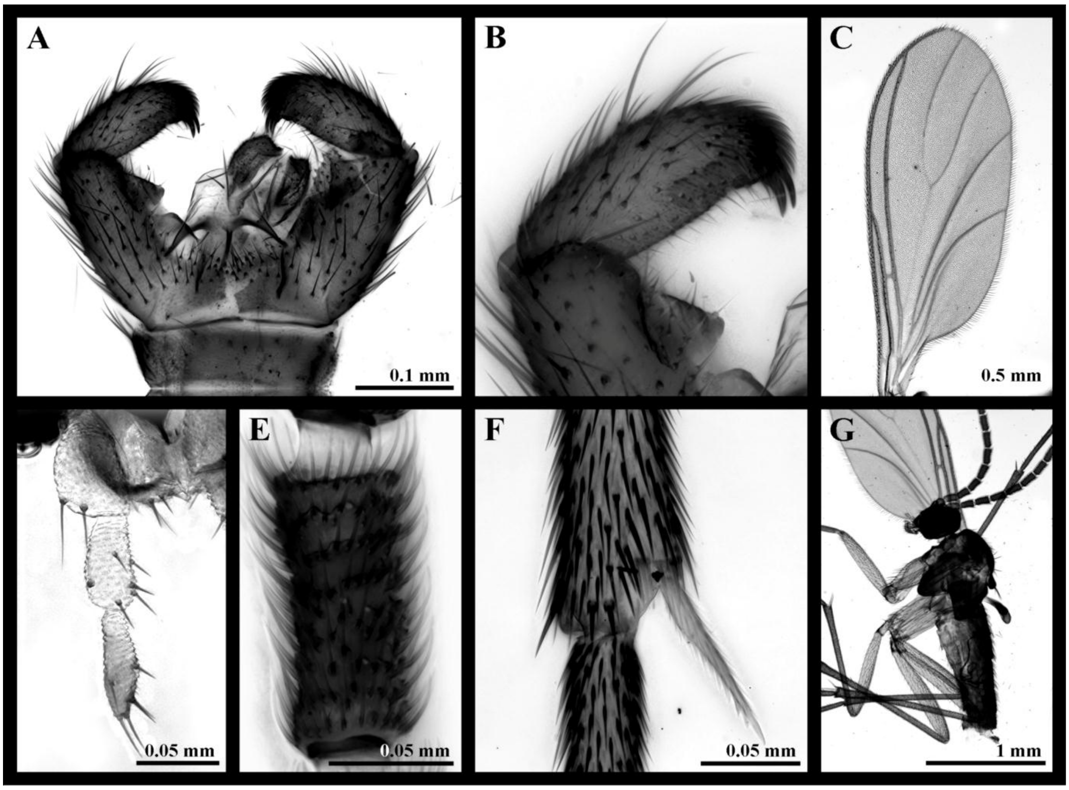


Plate A–20. Male of ***Bradysia atracornea*** Mohrig and Menzel 1992 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

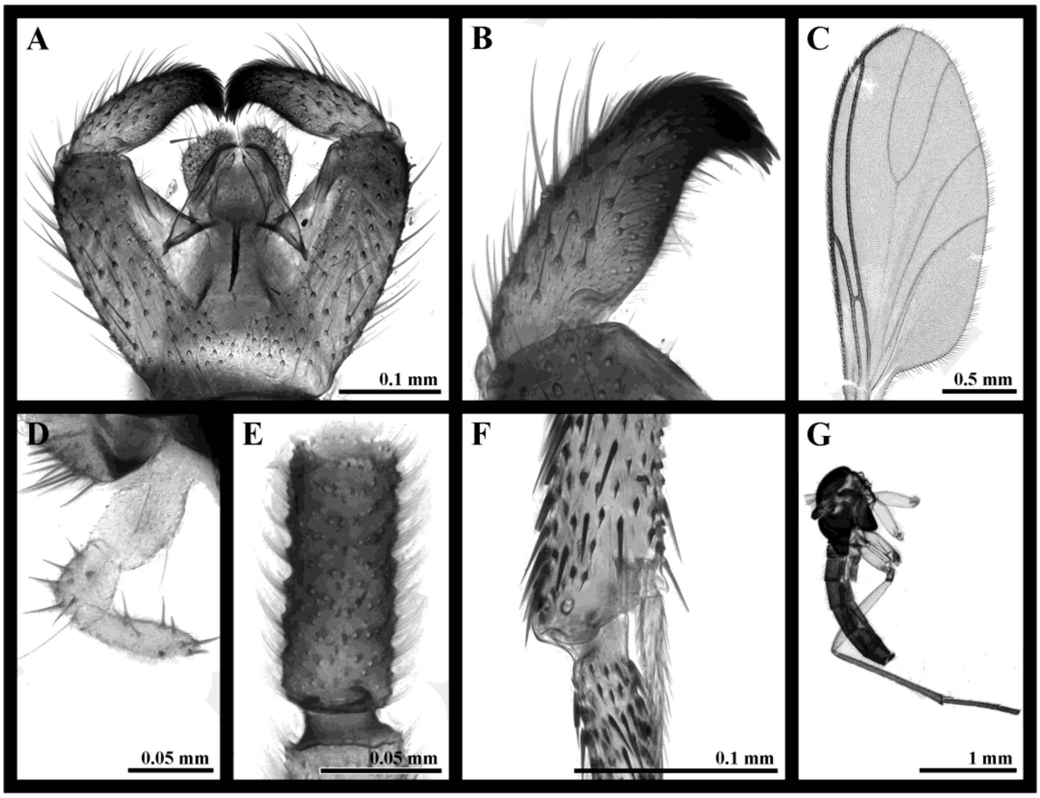


Plate A–21. Male of ***Bradysia chlorocornea*** Mohrig and Menzel 1992 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

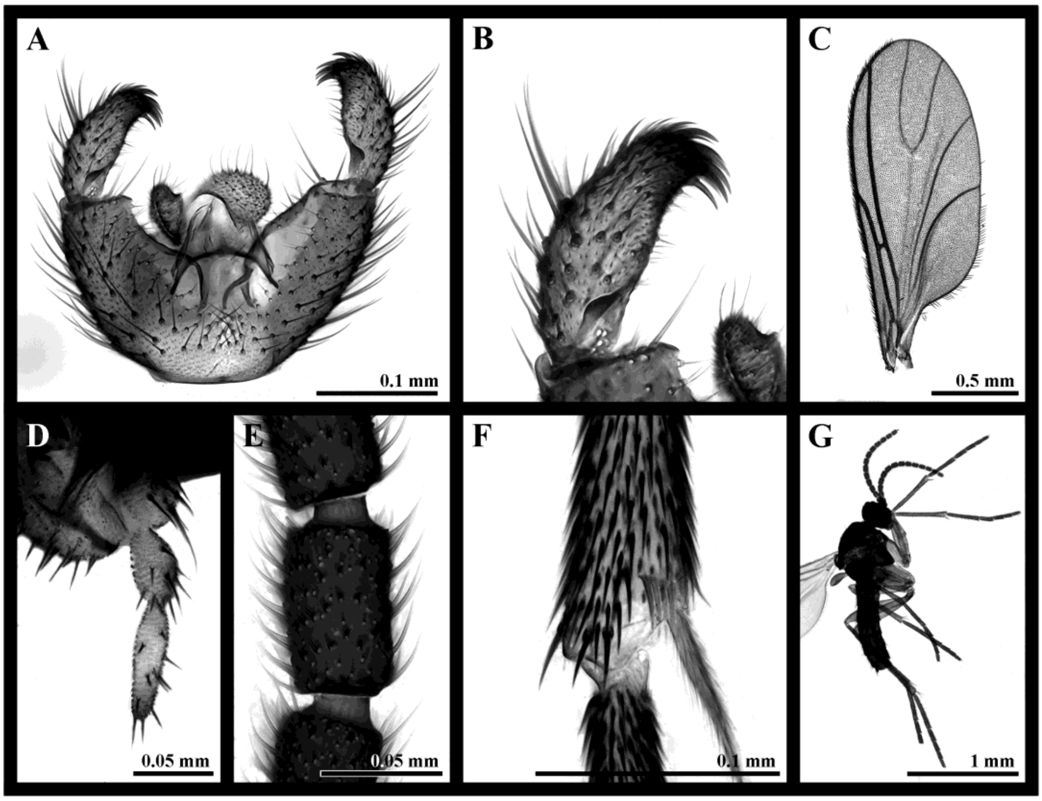


Plate A–22. Male of ***Bradysia difformis*** Frey 1948 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

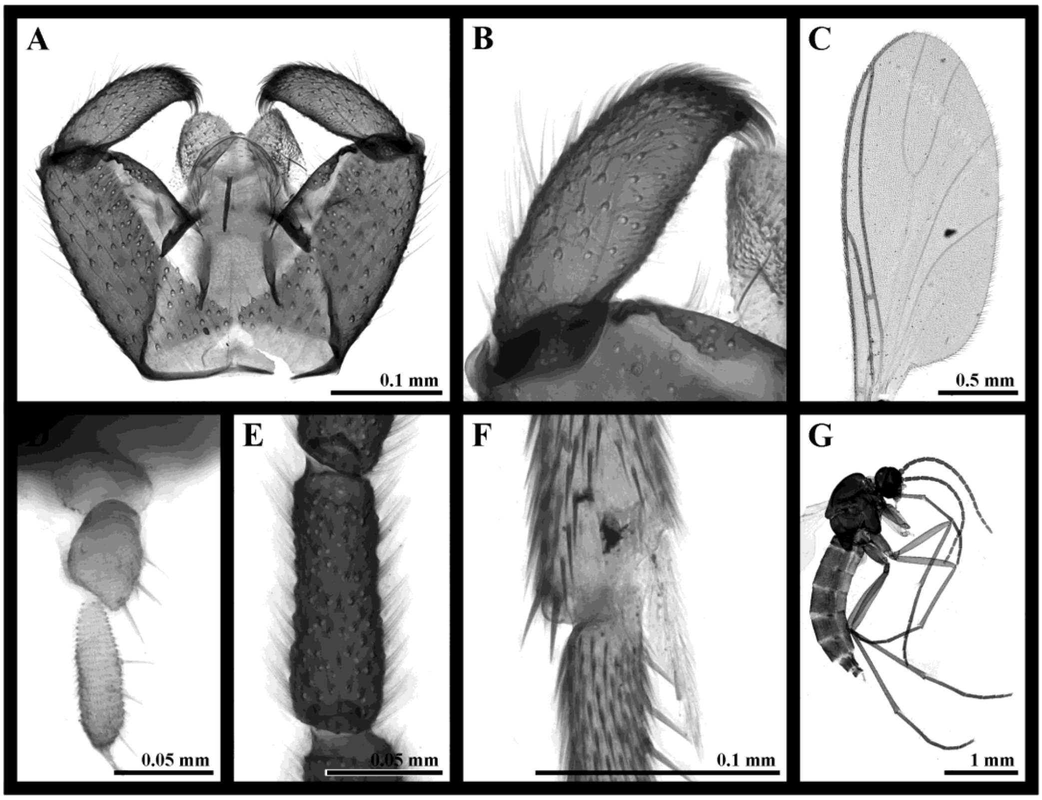


Plate A–23. Male of ***Bradysia fungicola*** (Winnertz 1867) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

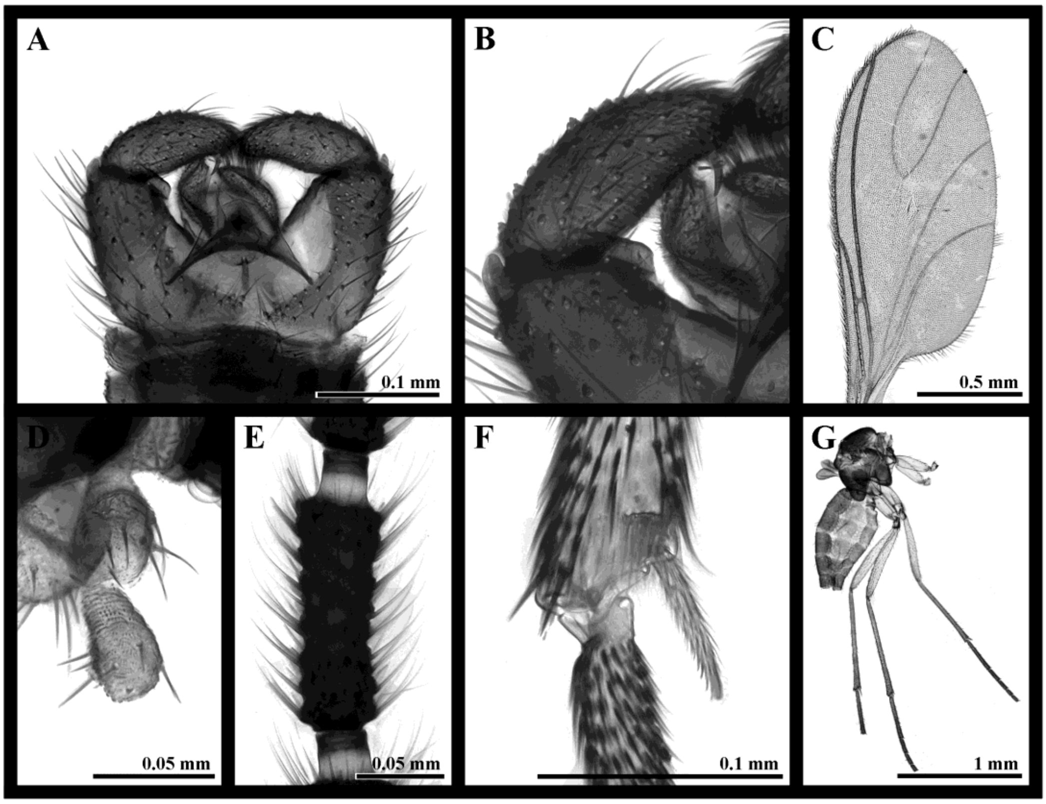


Plate A–24. Male of ***Bradysia hilariformis*** Tuomikoski 1960 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

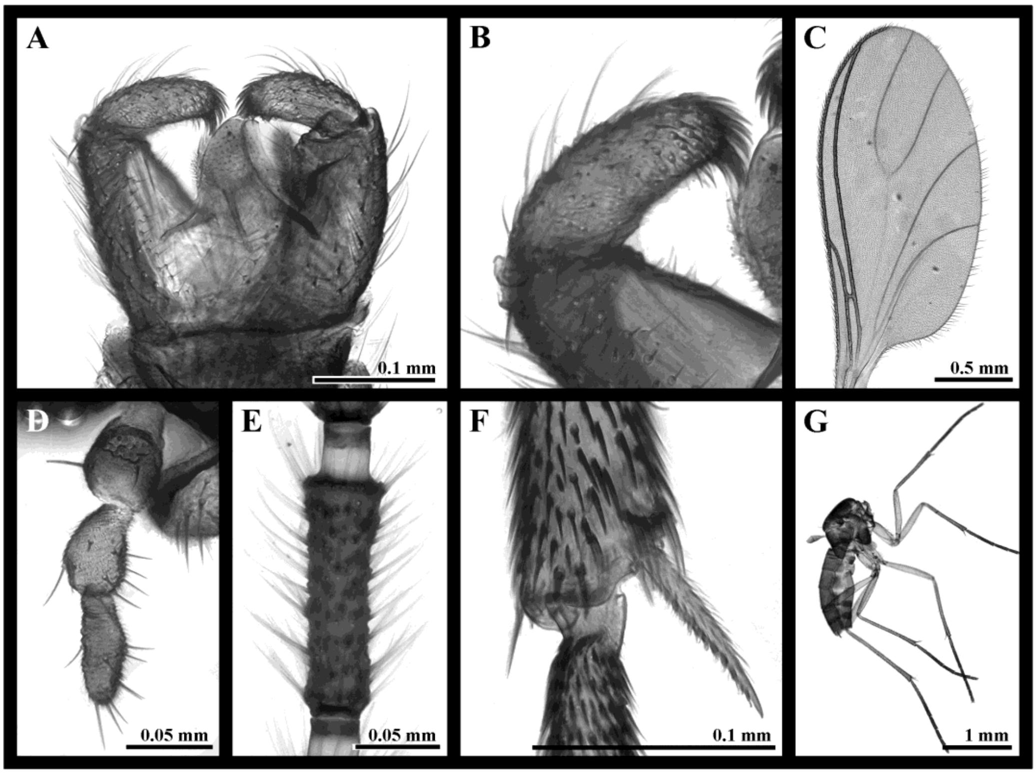


Plate A–25. Male of ***Bradysia hilaris*** (Winnertz 1867) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

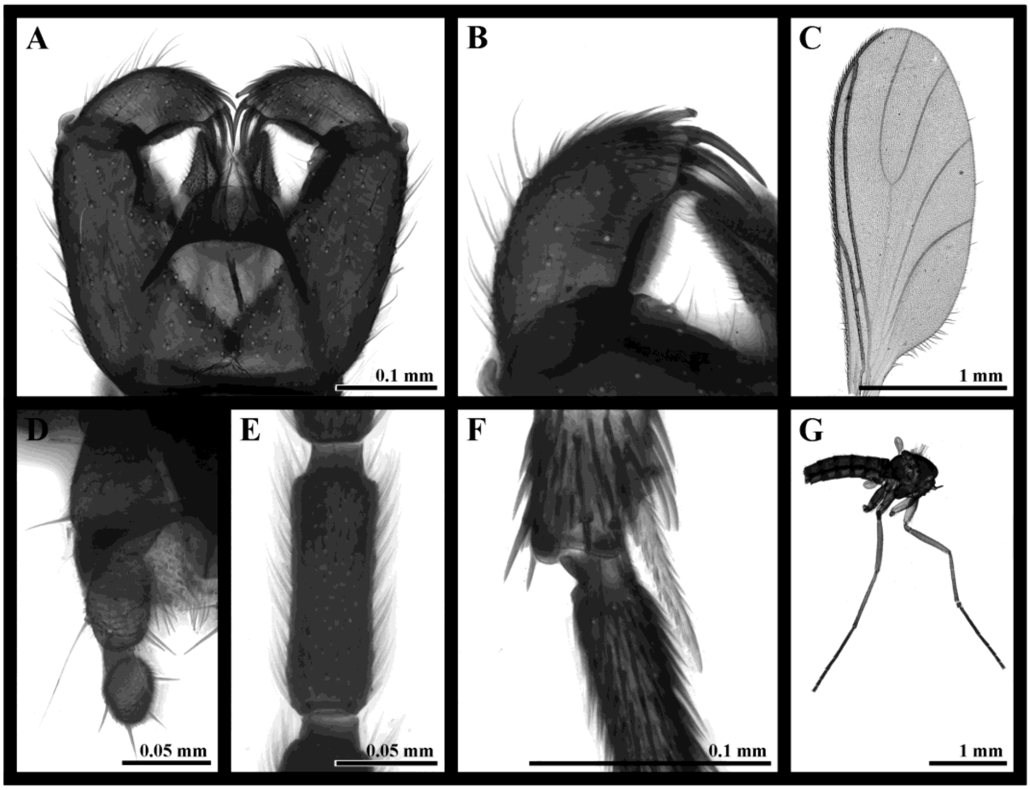


Plate A–26. Male of ***Bradysia lapponica*** (Lengersdorf 1926) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

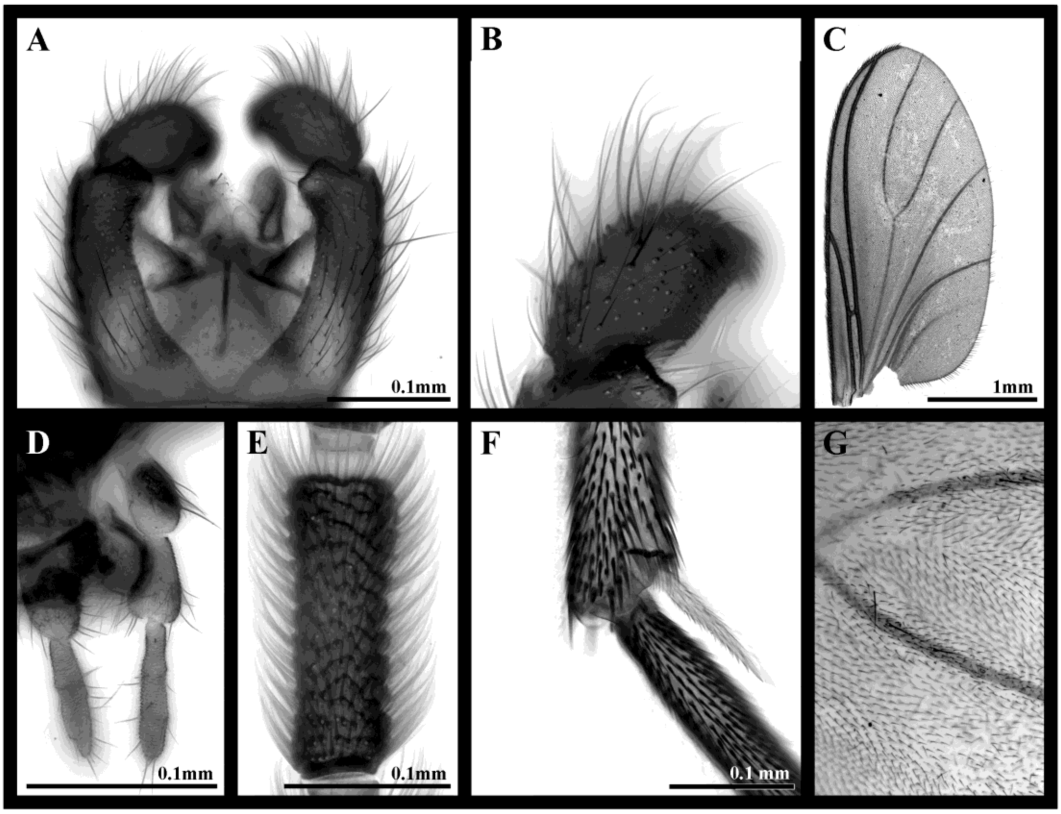


Plate A–27. Male of ***Bradysia longimentula*** (Sasakawa 1994) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

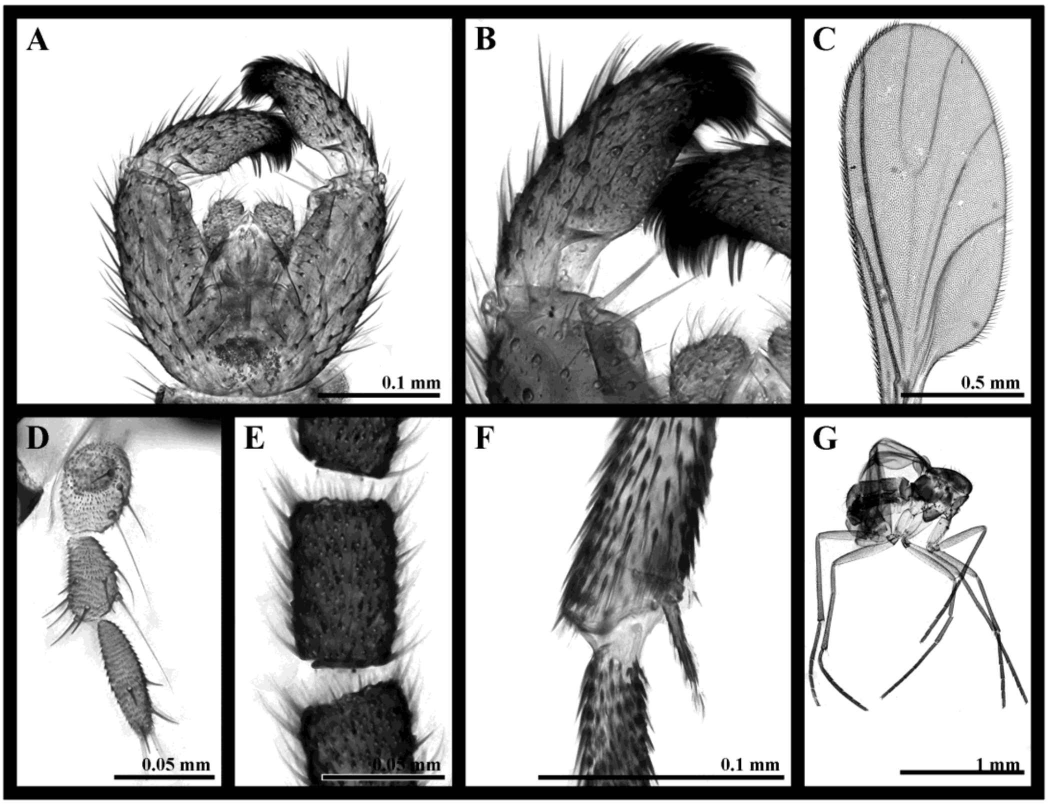


Plate A–28. Male of ***Bradysia ocellaris*** (Comstock 1882) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

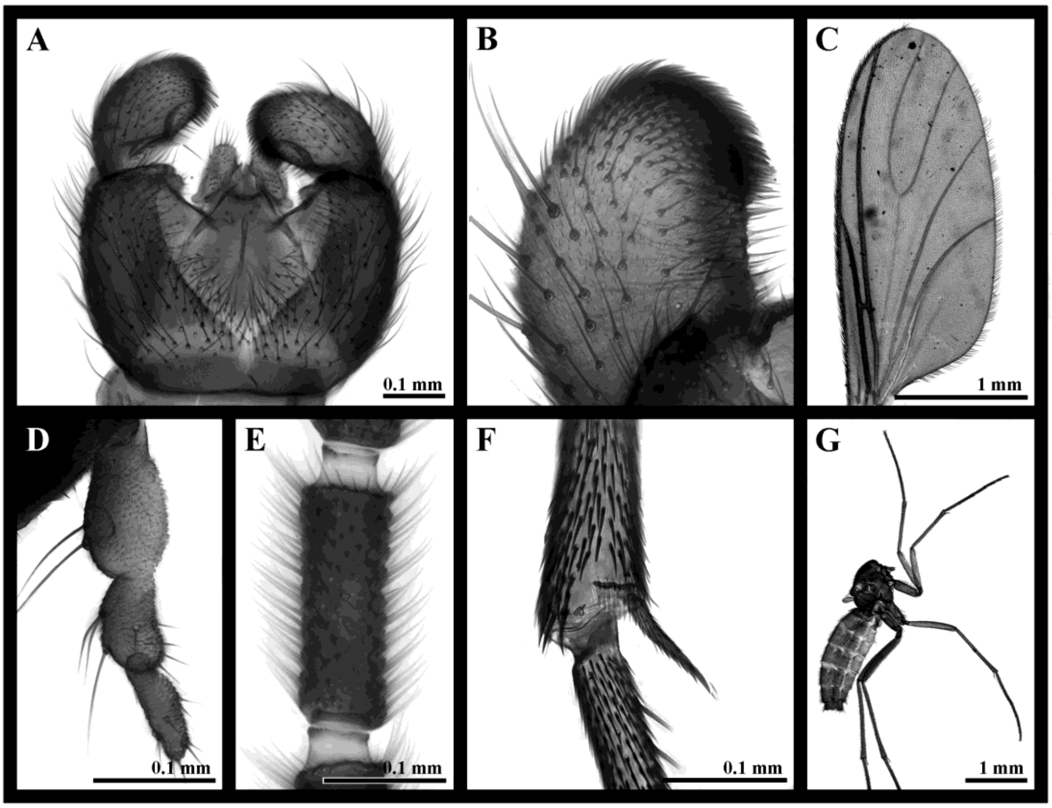


Plate A–29. Male of ***Bradysia procera*** (Winnertz 1868) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

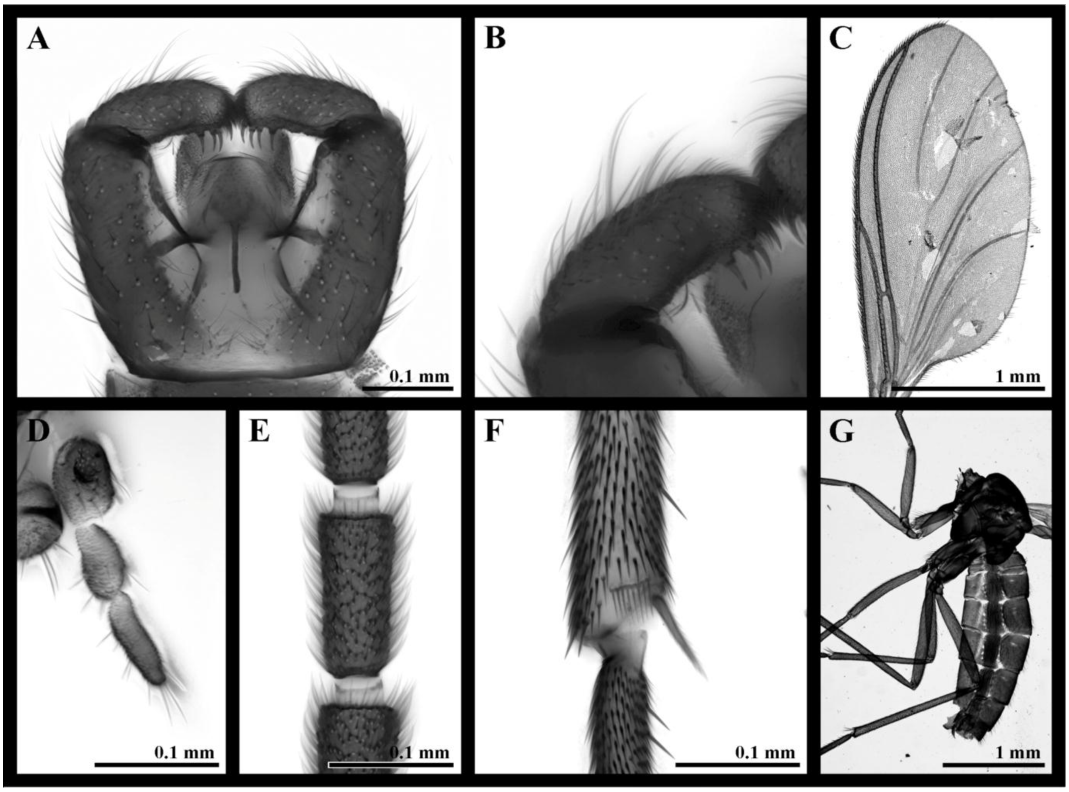


Plate A–30. Male of ***Bradysia protohilaris*** Mohrig and Krivosheina 1983 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

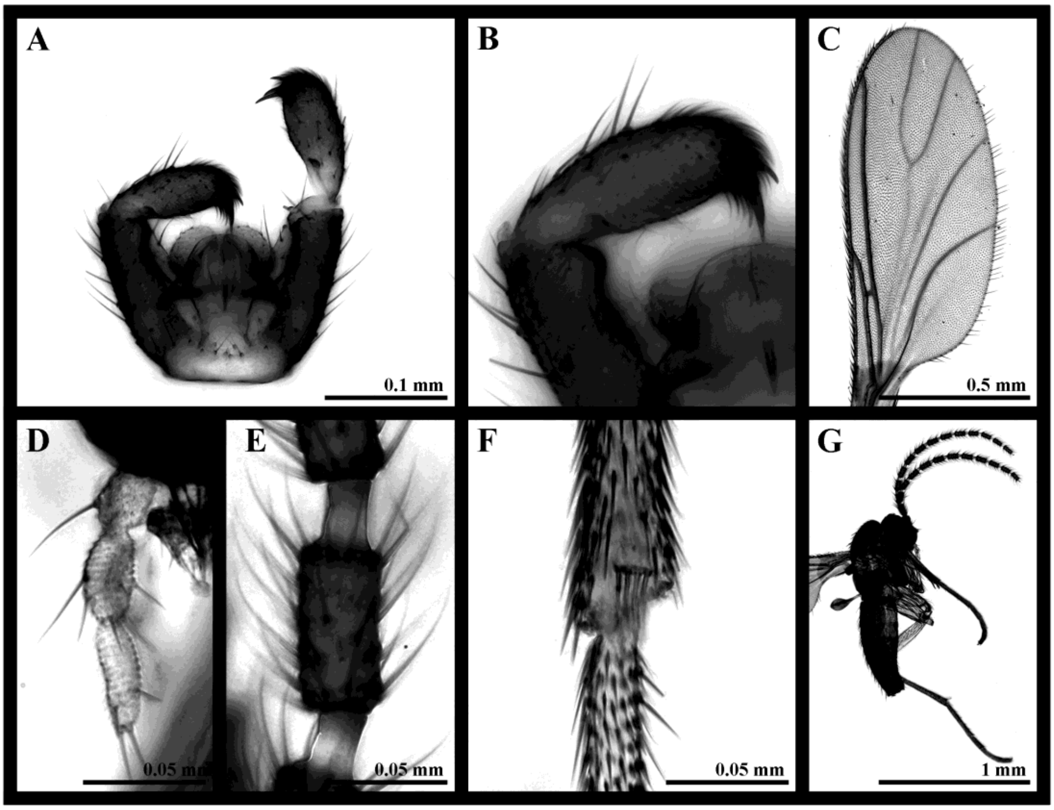


Plate A–31. Male of ***Bradysia trispinifera*** Mohrig and Krivosheina 1979 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

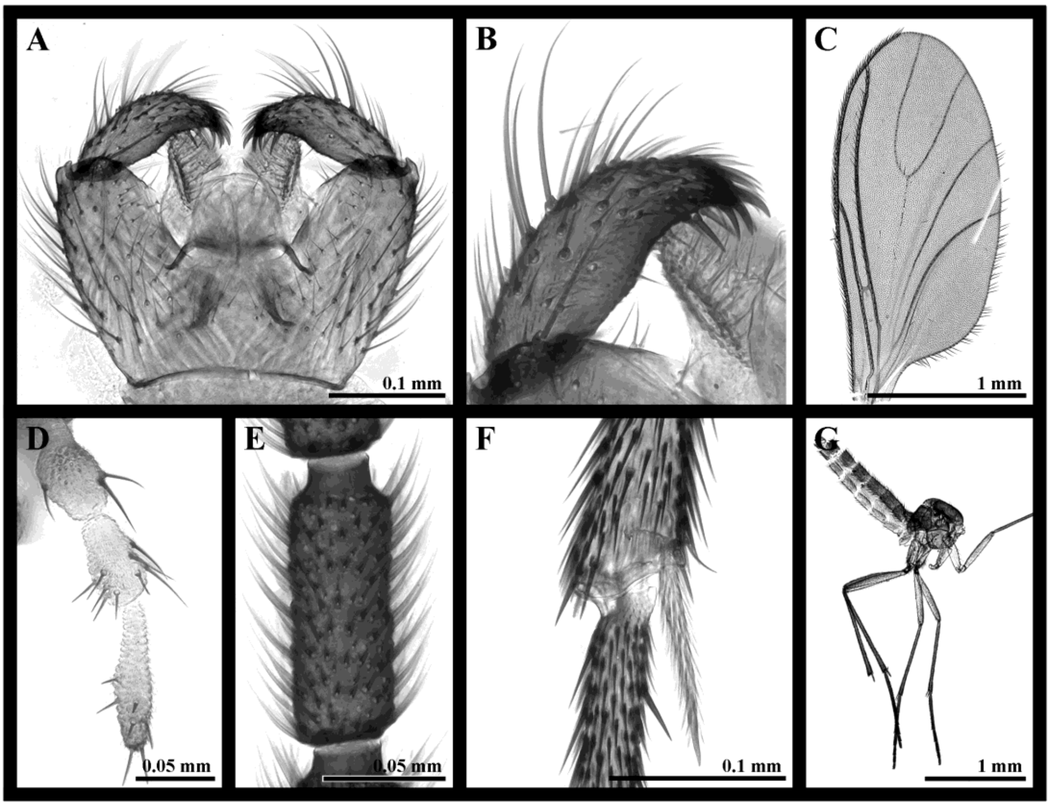


Plate A–32. Male of ***Ctenosciara insolita*** (Sasakawa 1994) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

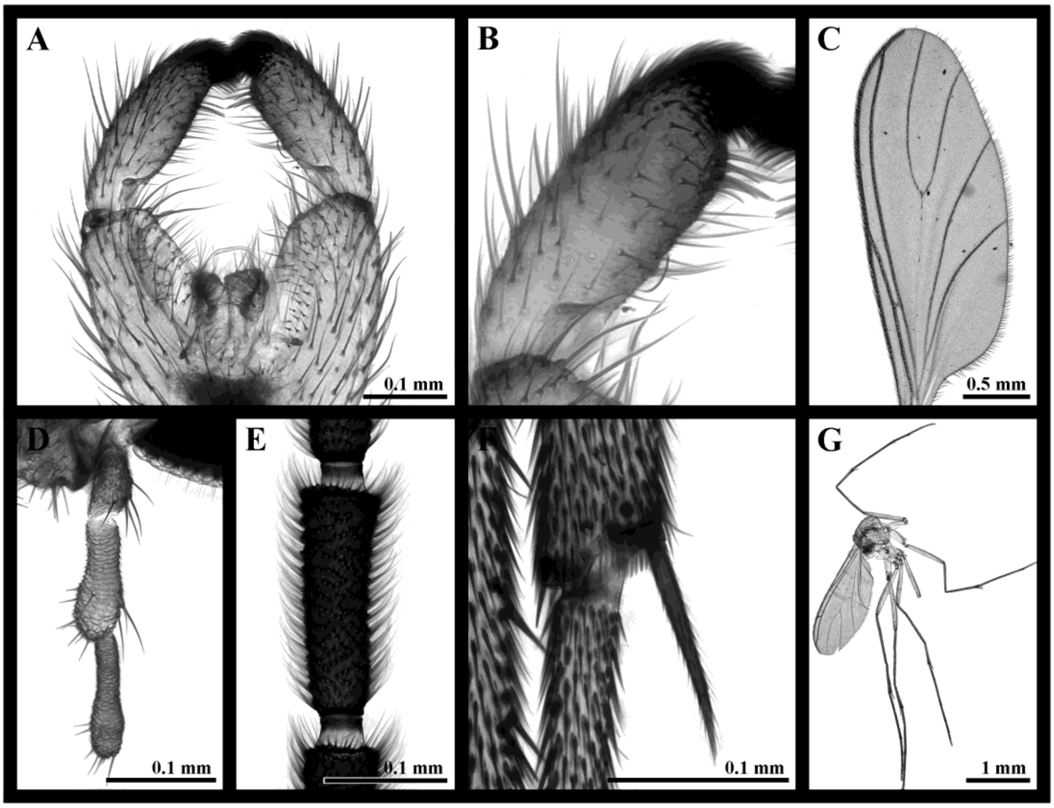


Plate A–33. Male of ***Phytosciara (Dolichosciara) flavipes*** (Meigen 1804) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

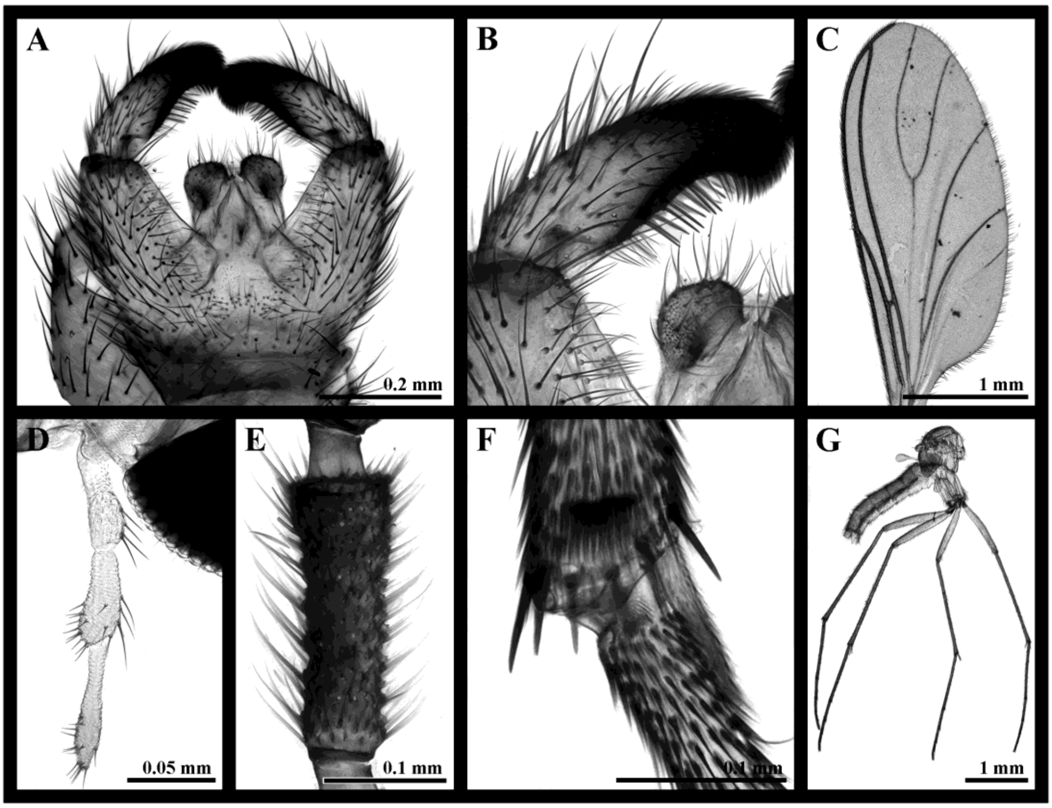


Plate A–34. Male of ***Phytosciara (Dolichosciara) semiferruginea*** Menzel 1995 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

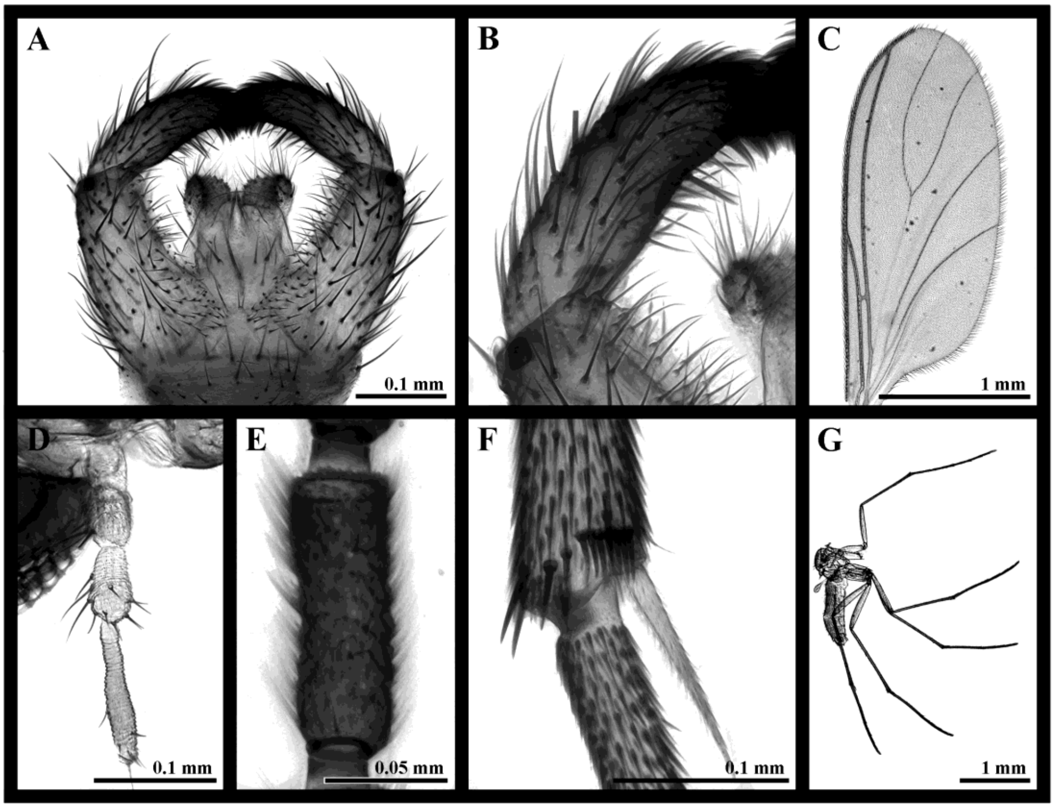


Plate A–35. Male of ***Phytosciara* (*Dolichosciara*) *koreansis*** sp. nov. * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

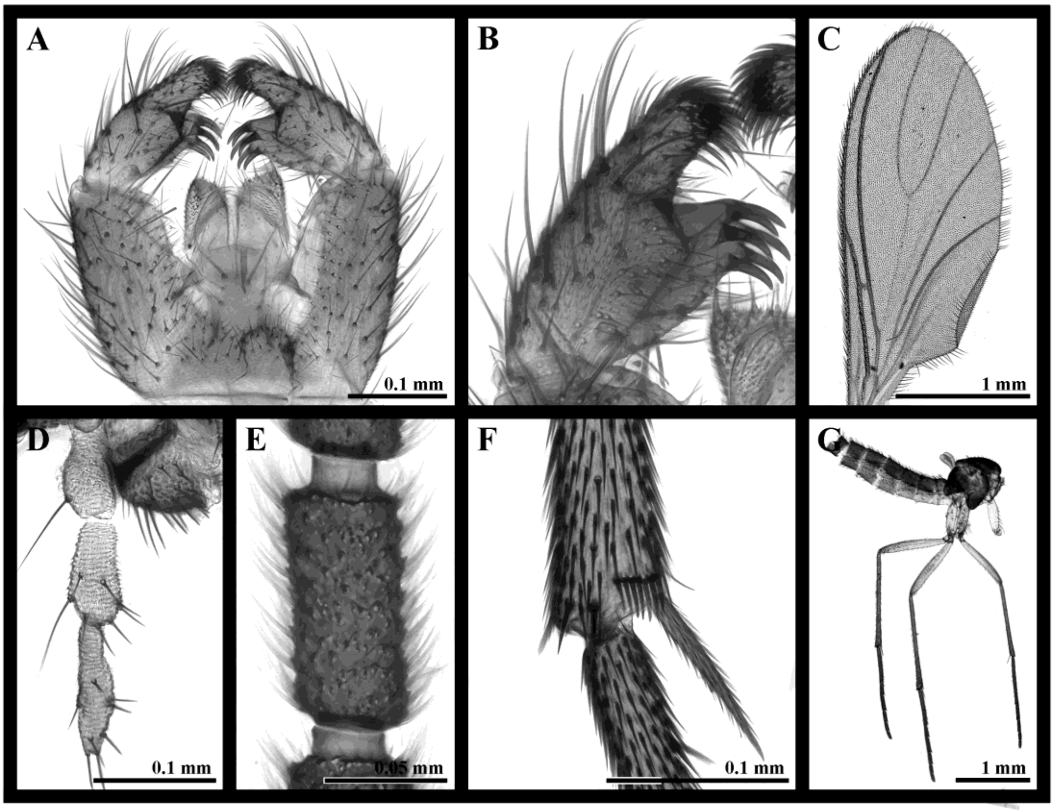


Plate A–36. Male of ***Phytosciara* (*Prosciara*) *ussuriensis*** Antonova 1977 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

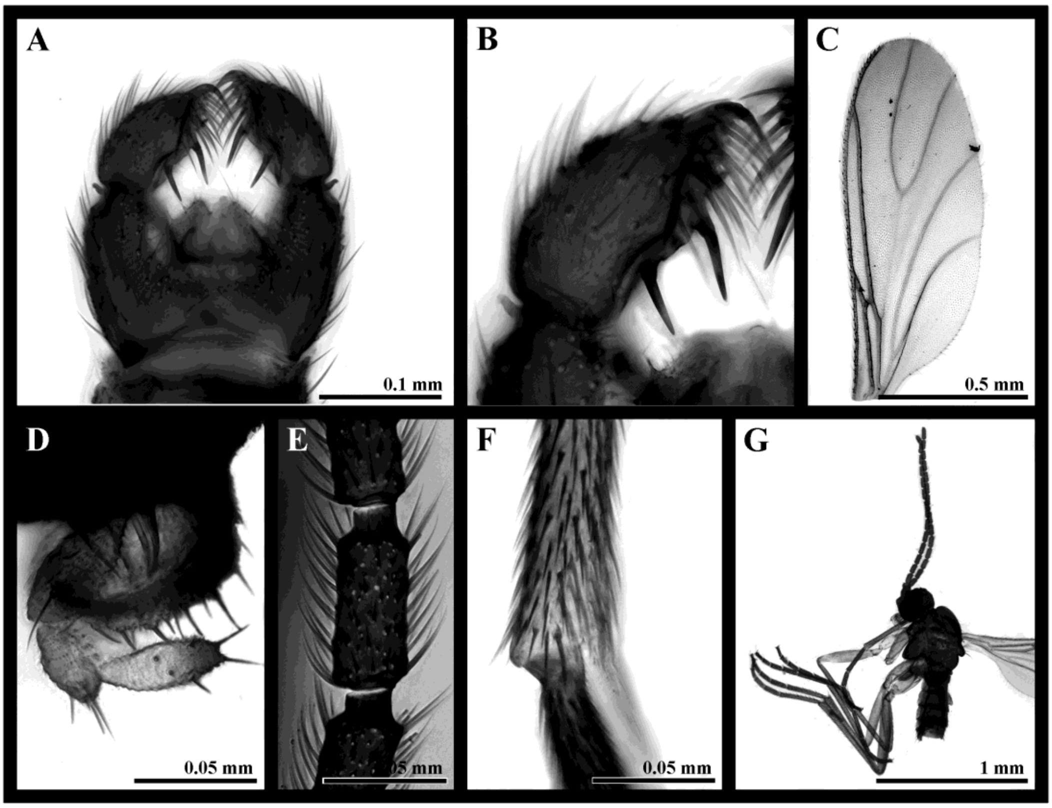


Plate A–37. Male of ***Scatopsciara camptospina*** Mohrig and Mamaev 1990 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

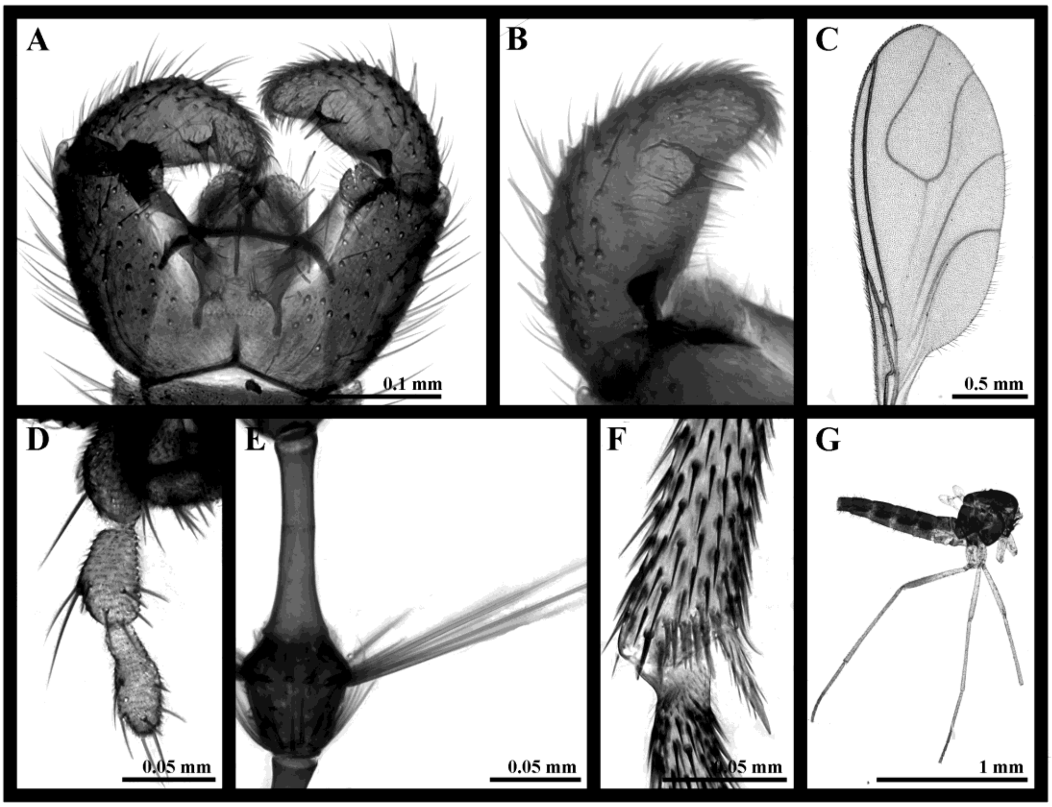


Plate A–38. Male of ***Zygoneura* (*Pharetratula*) *bidens*** (Mamaev 1968) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

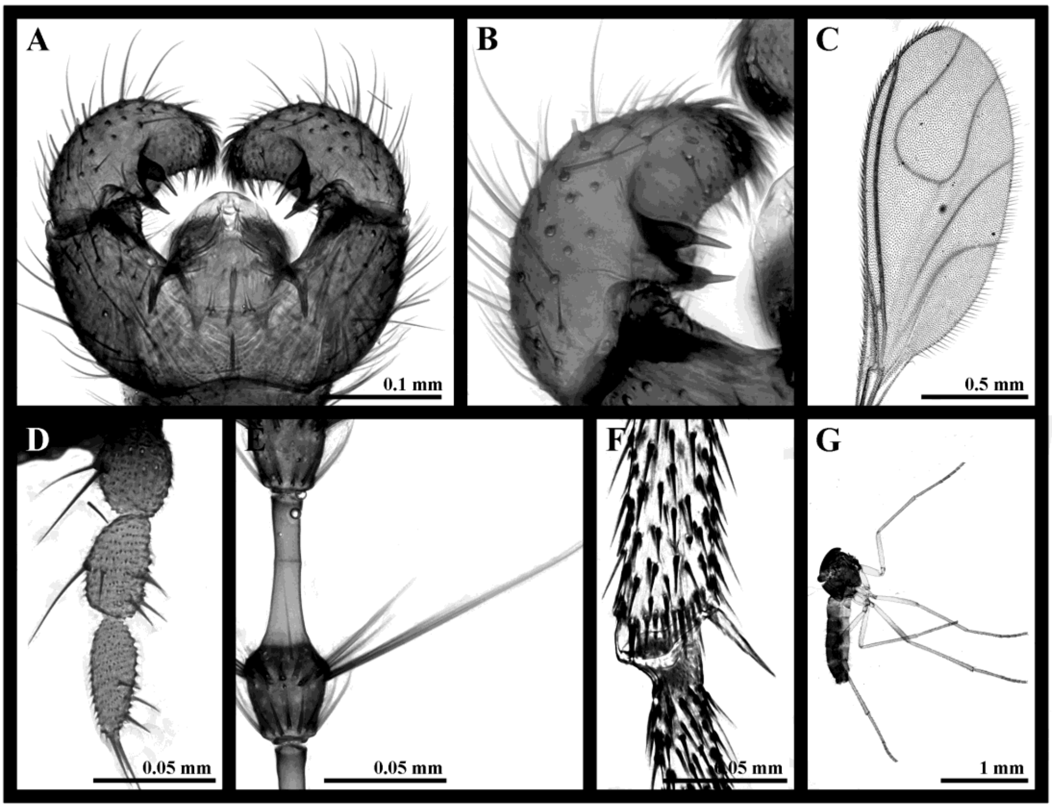


Plate A–39. Male of ***Zygoneura* (*Pharetratula*) *flavicornis*** Mamaev 1968 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

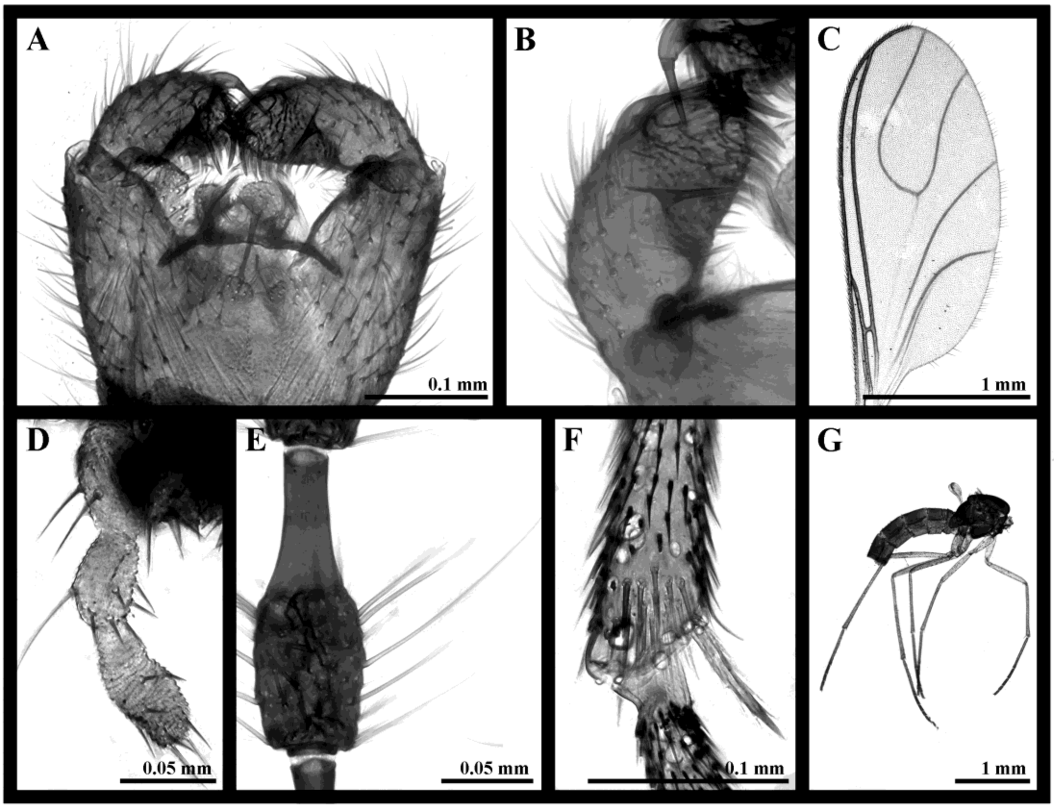


Plate A–40. Male of ***Zygoneura* (*Zygoneura*) *sciarina*** Meigen 1830 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

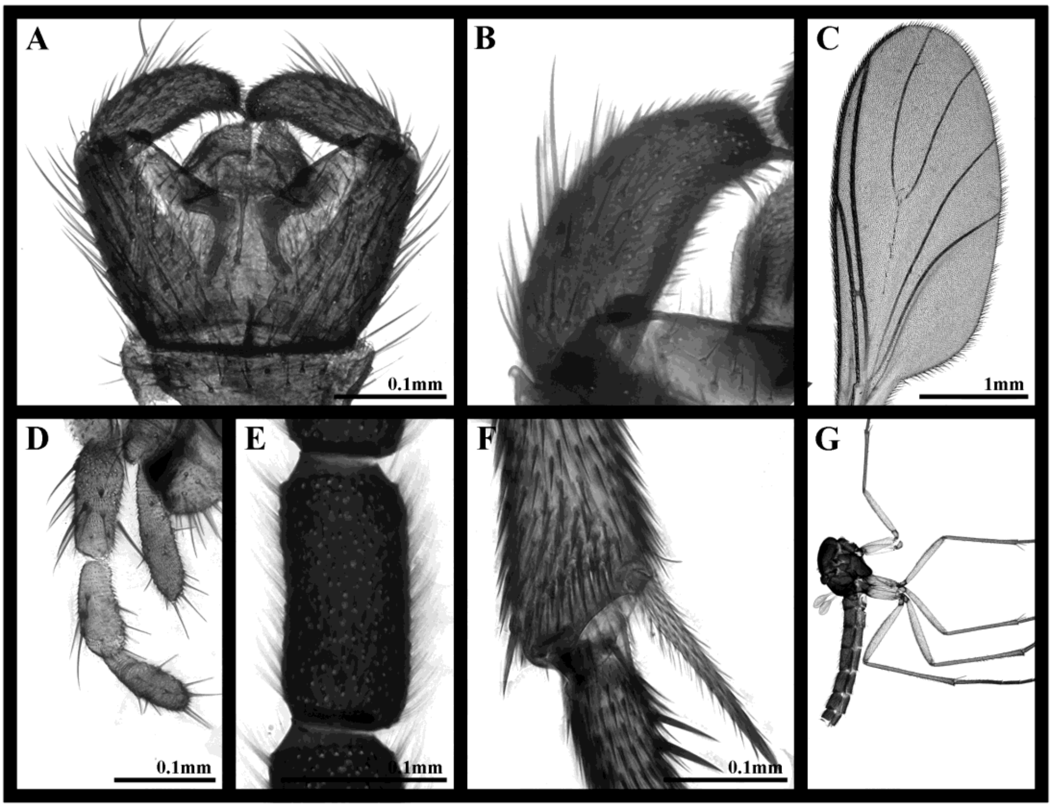


Plate A–41. Male of ***Leptosciarella* (s. str.) *trochanterata*** (zetterstedt 1851) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

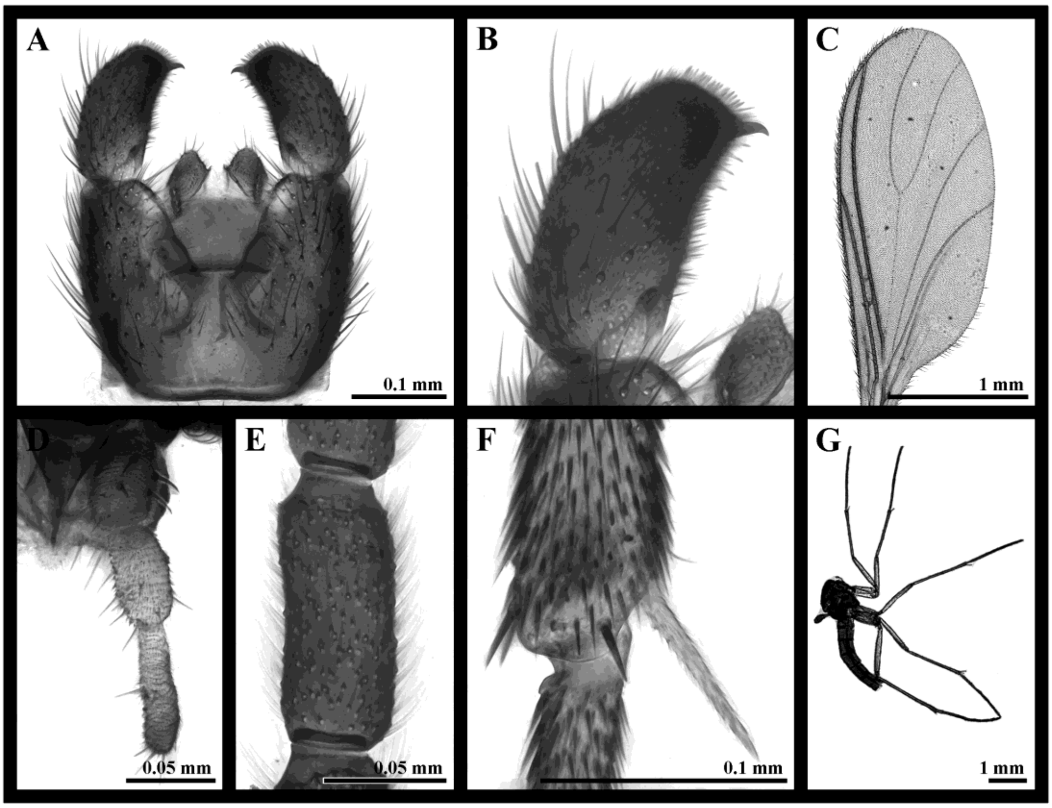


Plate A–42. Male of ***Leptosciarella* (s. str.) *rejecta*** (Winnertz 1867) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

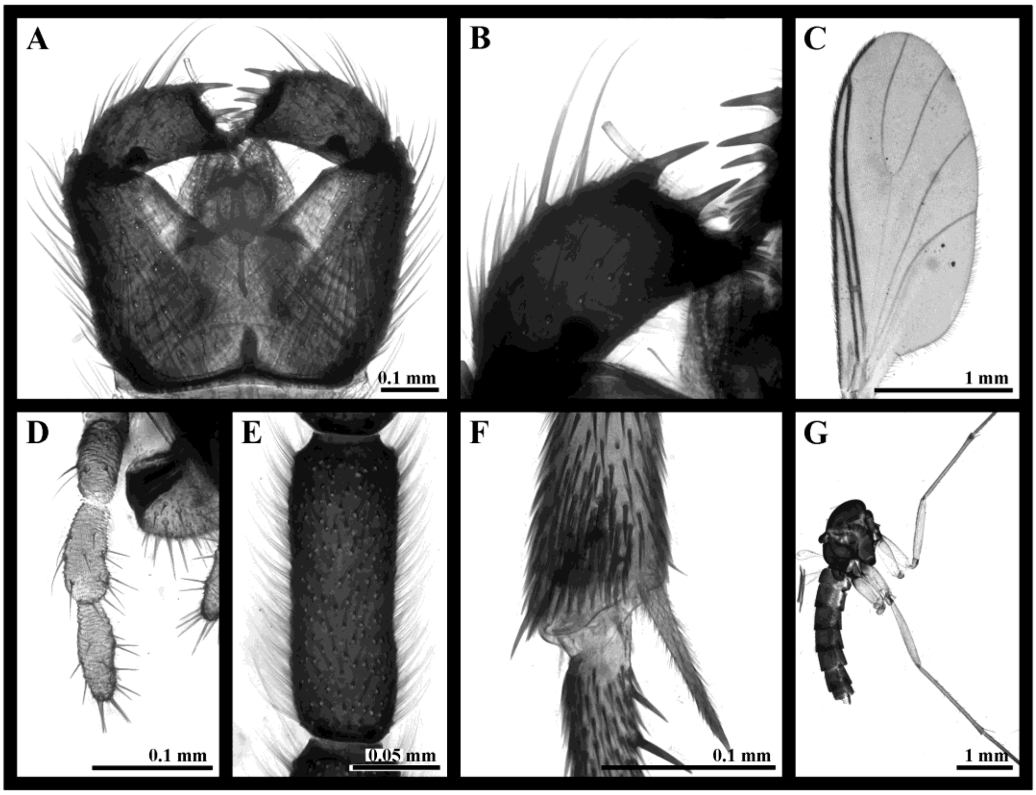


Plate A–43. Male of ***Leptosciarella* (*Leptospina*) *dentata*** (Mohrig and Krivosheina 1979) * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

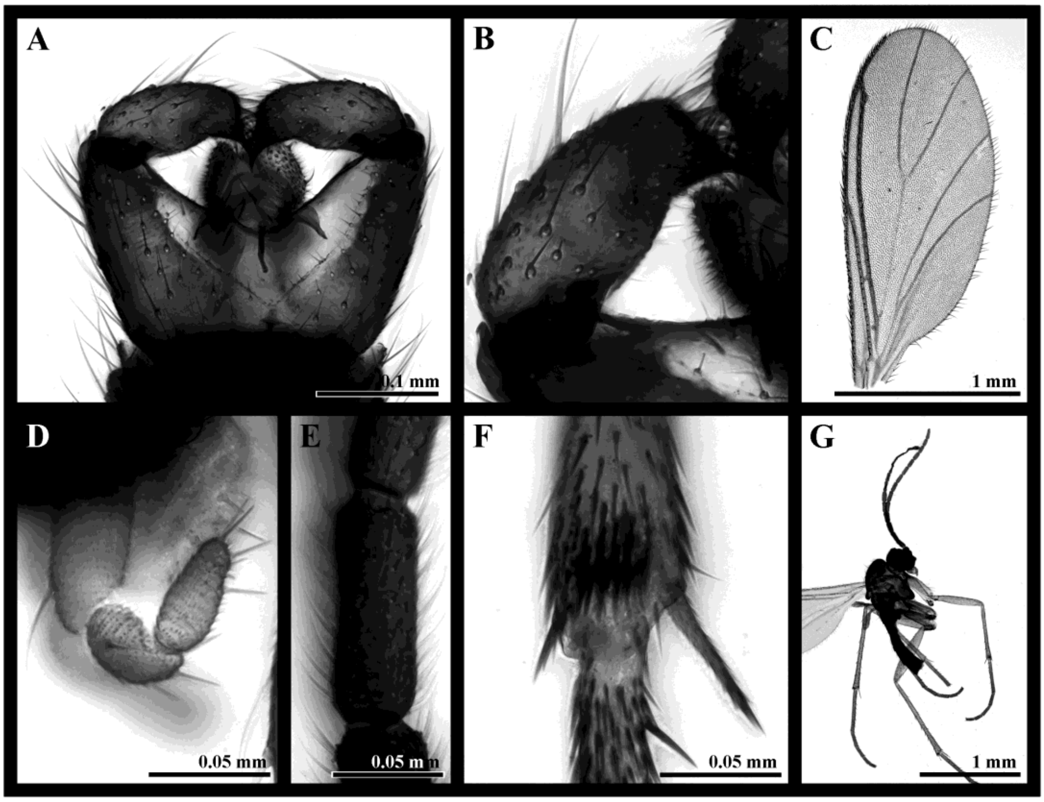


Plate A–44. Male of ***Leptosciarella* (*Leptospina*) *subdentata*** (Mohrig and Menzel 1992) (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

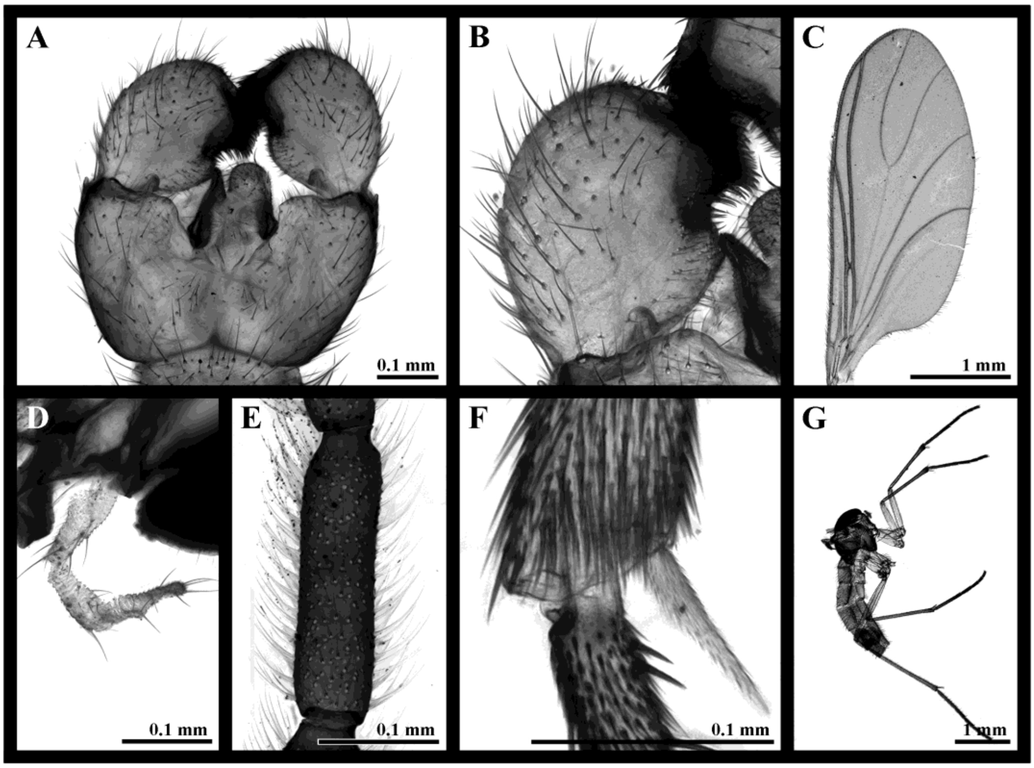


Plate A–45. Male of ***Sciara helvola*** Winnertz 1867 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

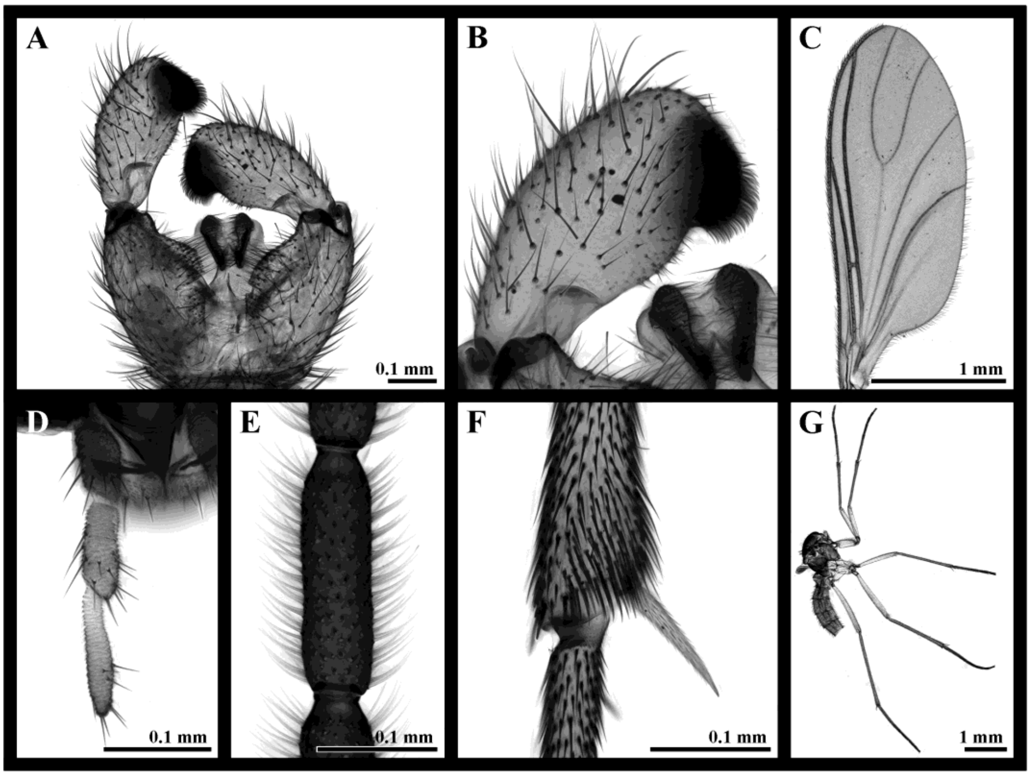


Plate A–46. Male of ***Sciara ruficauda*** Meigen 1818 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

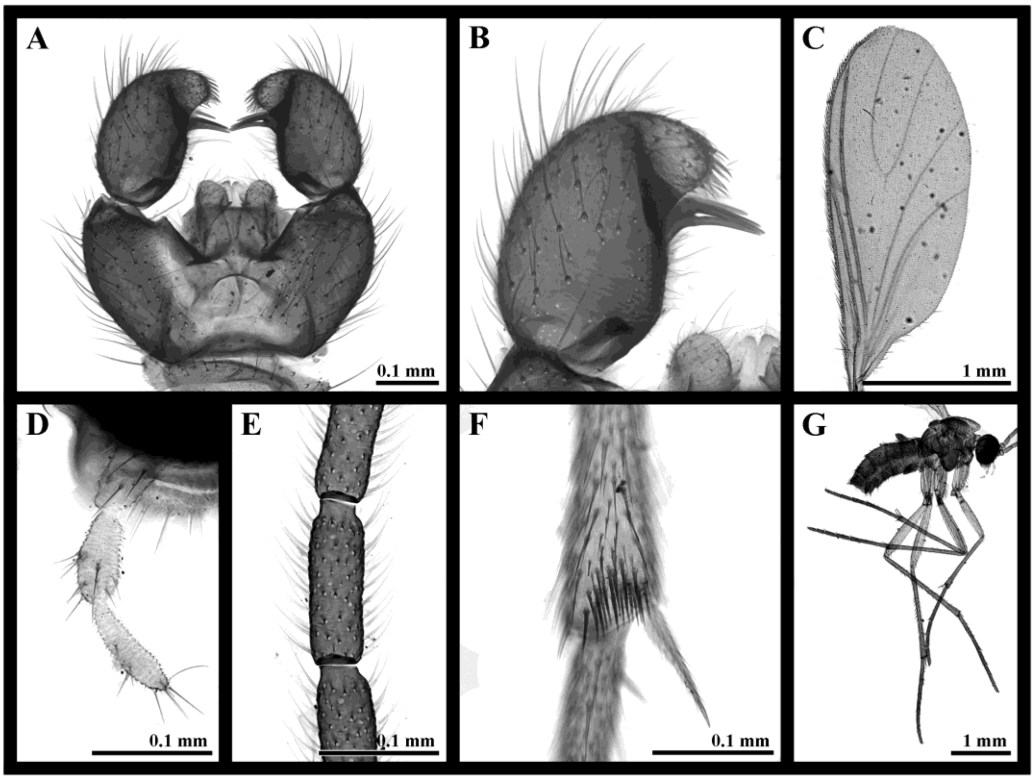


Plate A–47. Male of ***Sciara mendax*** Tuomikoski 1960 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

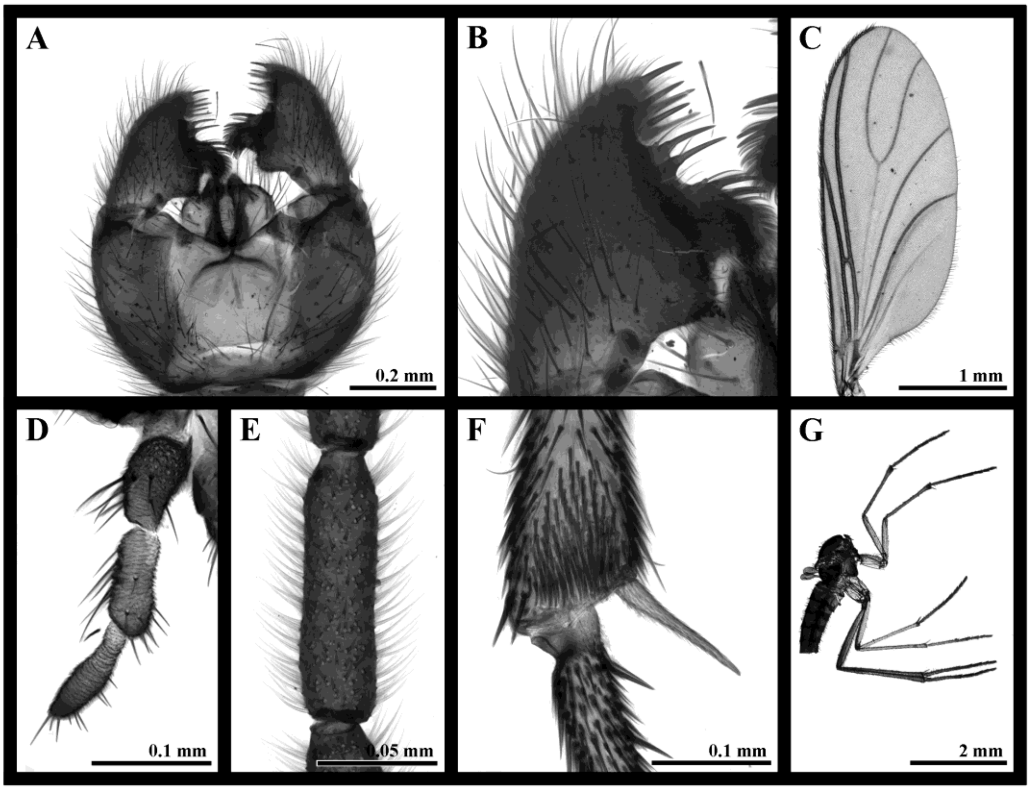


Plate A–48. Male of ***Sciara multispinulosa*** Mohrig and Kazanek 1992 (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

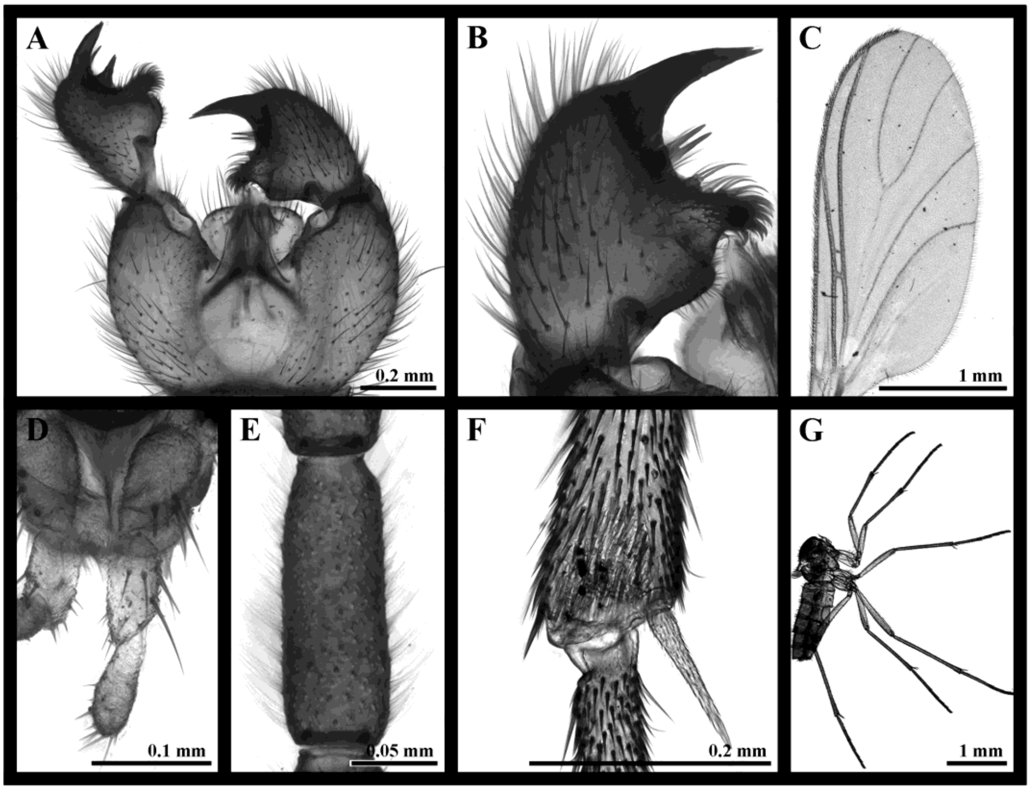


Plate A–49. Male of ***Sciara humeralis*** Zetterstedt 1851 * (A–G) A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

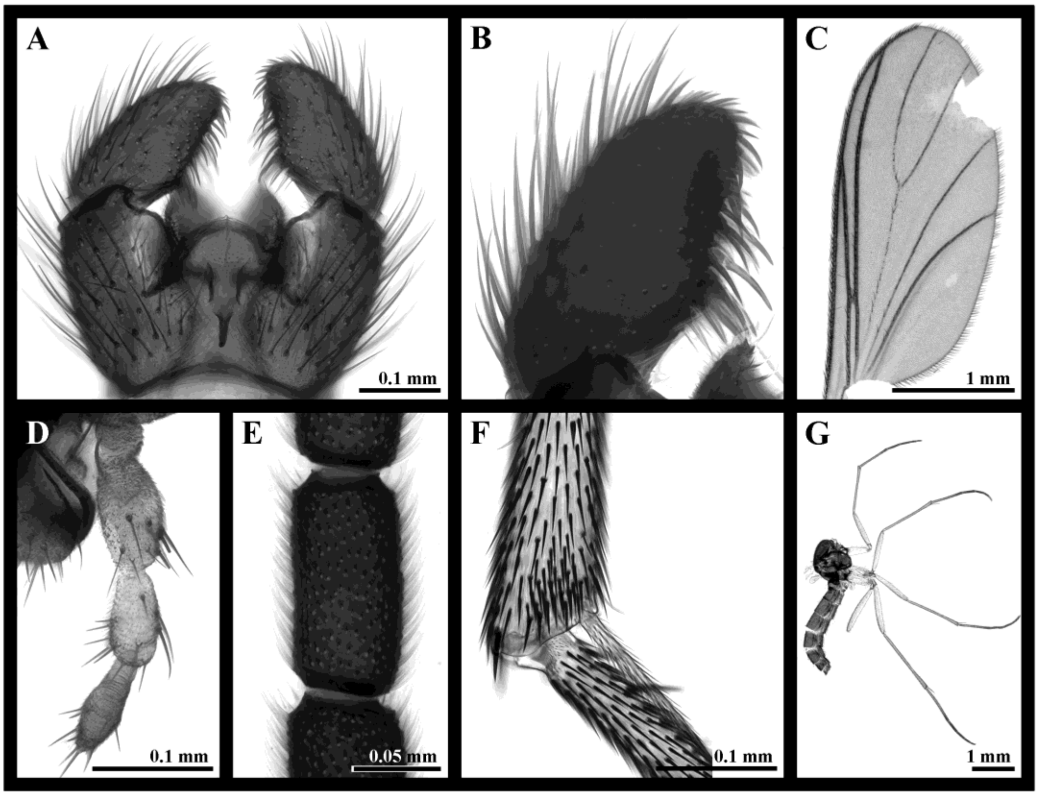
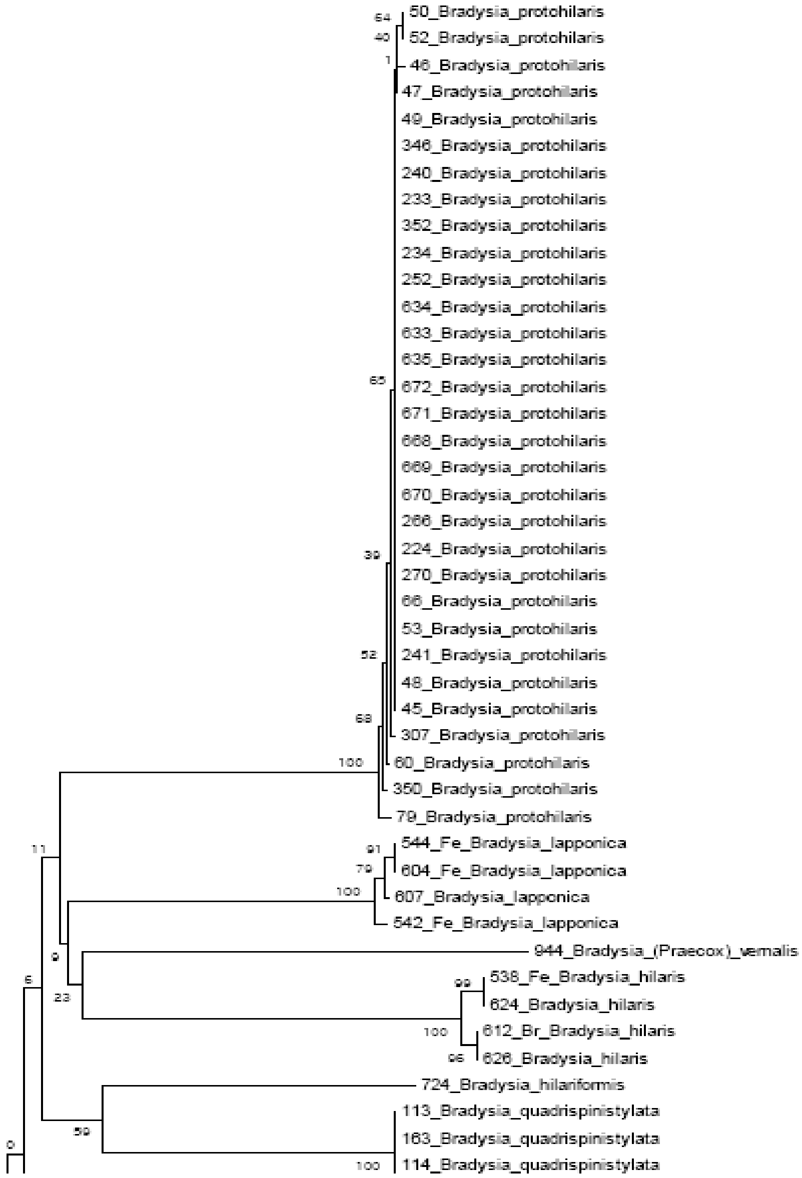
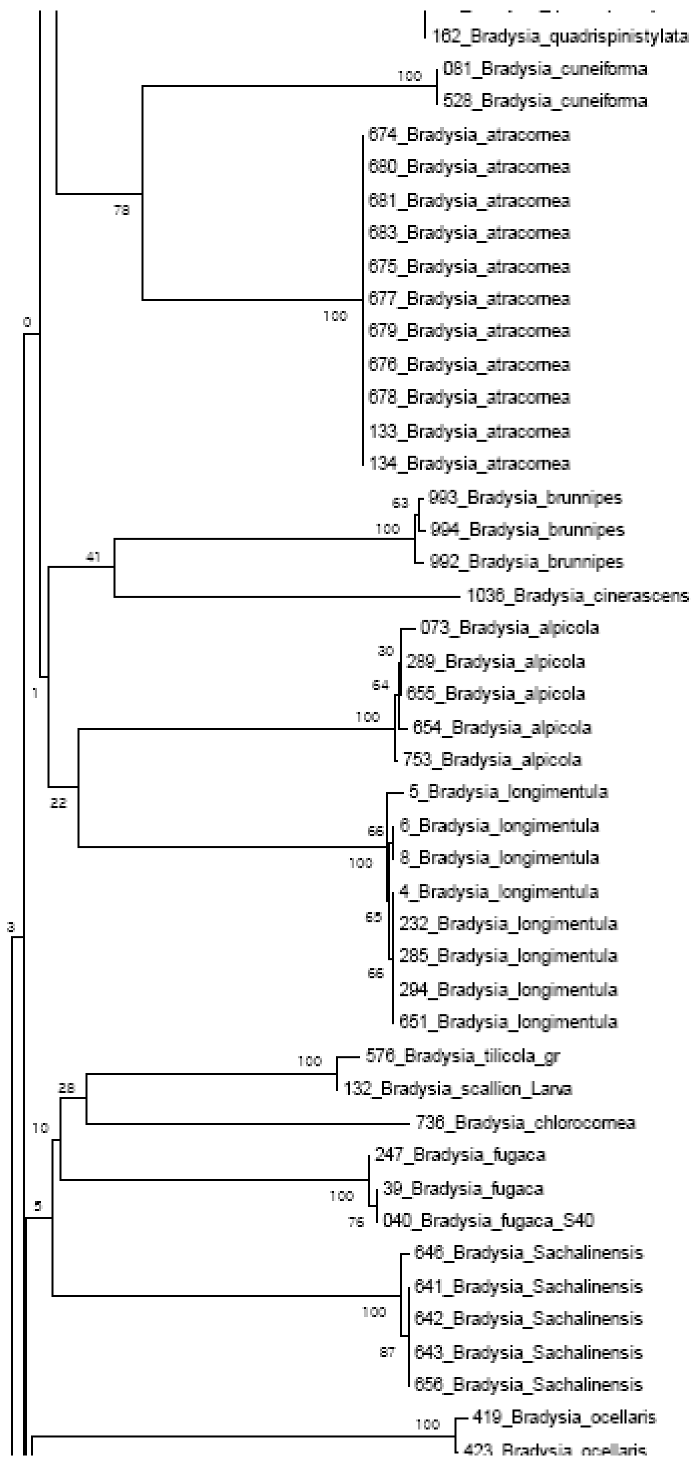


Plate A–50. Male of ***Trichosia confusa*** Menzel and Mohrig 1997 * (A–G). A: genitalia, ventral view. B: gonostylus. C: wing. D: maxillary palpus. E: Flgm. IV segment. F: fore tibia bristles at inner apex. G: body.

Supporting information Figure 2–1. Neighbor–joining trees (based on Kimura 2–parameter genetic distances). Bootstrap support for nodes containing test sequences based on 1,000 bootstrap replications. Numbers on branches represent NJ support values. The scale bar indicates branch length.

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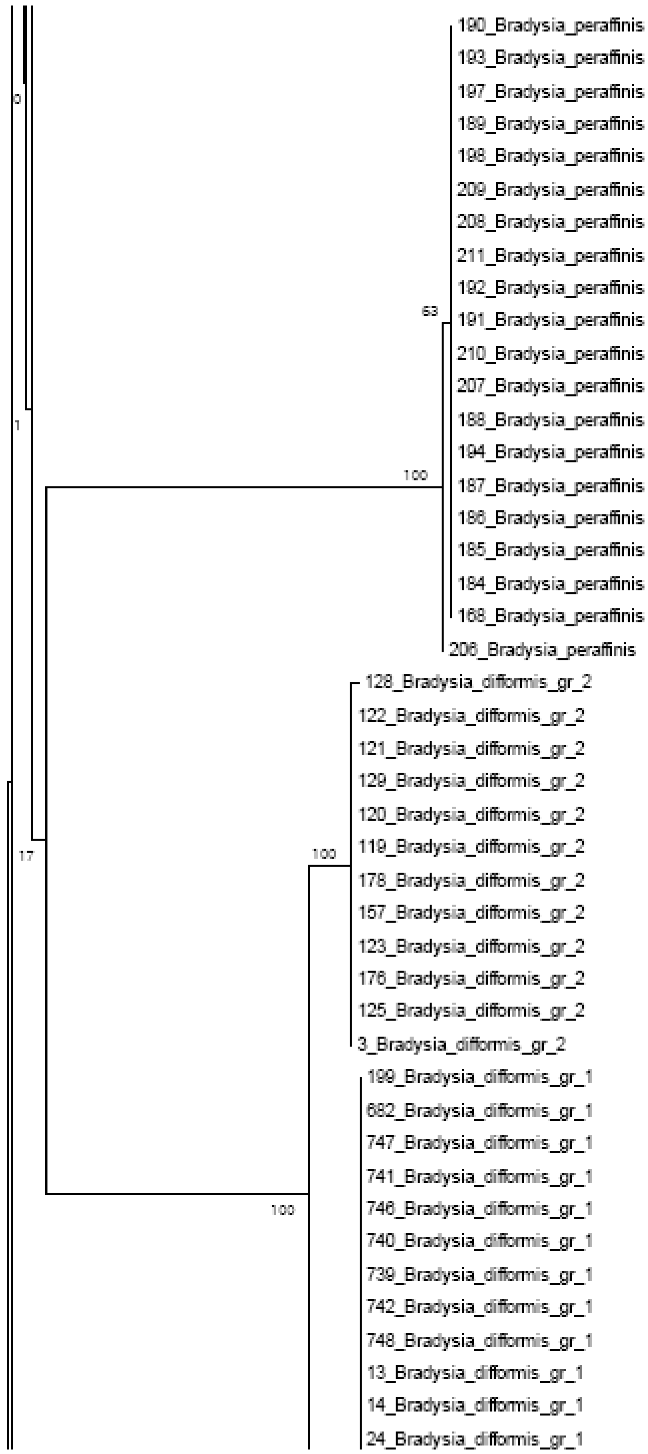
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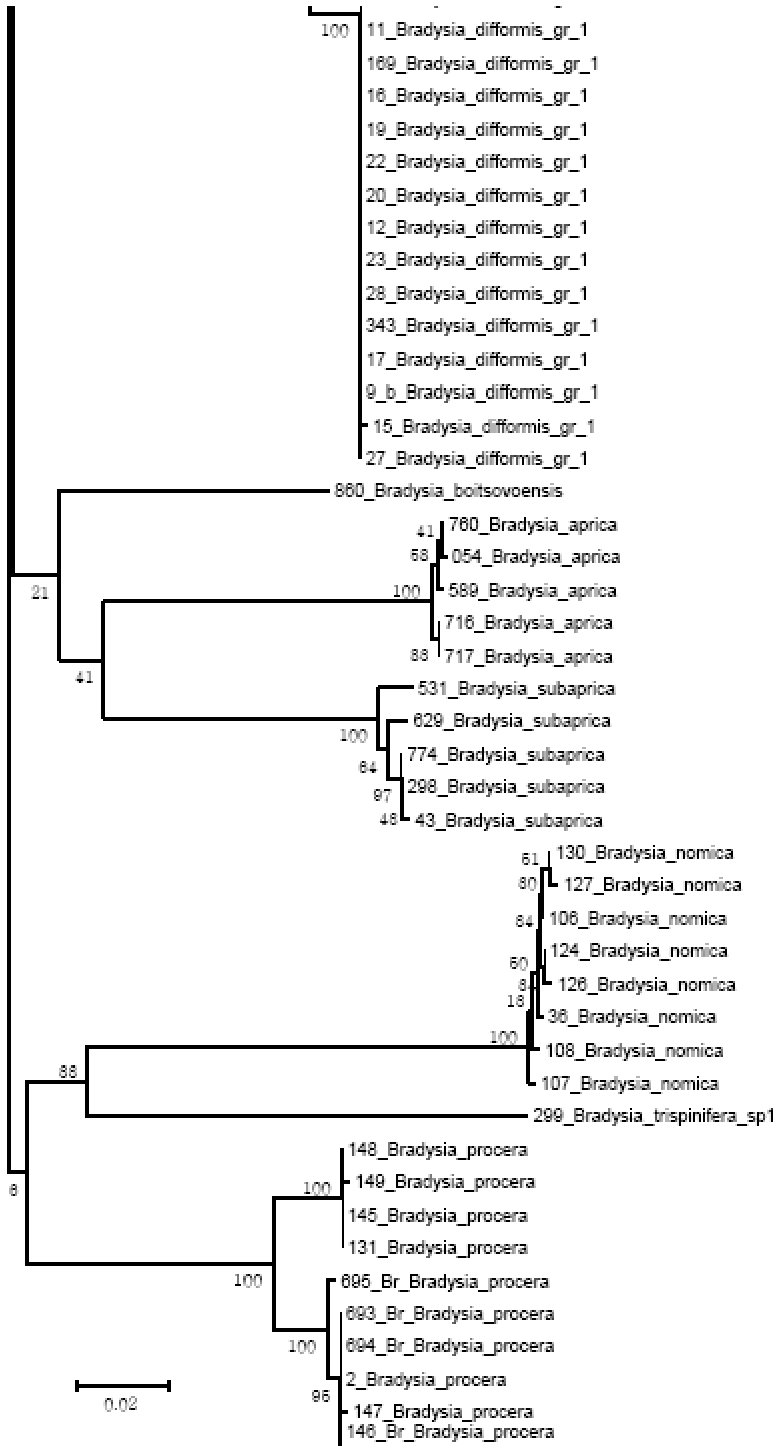
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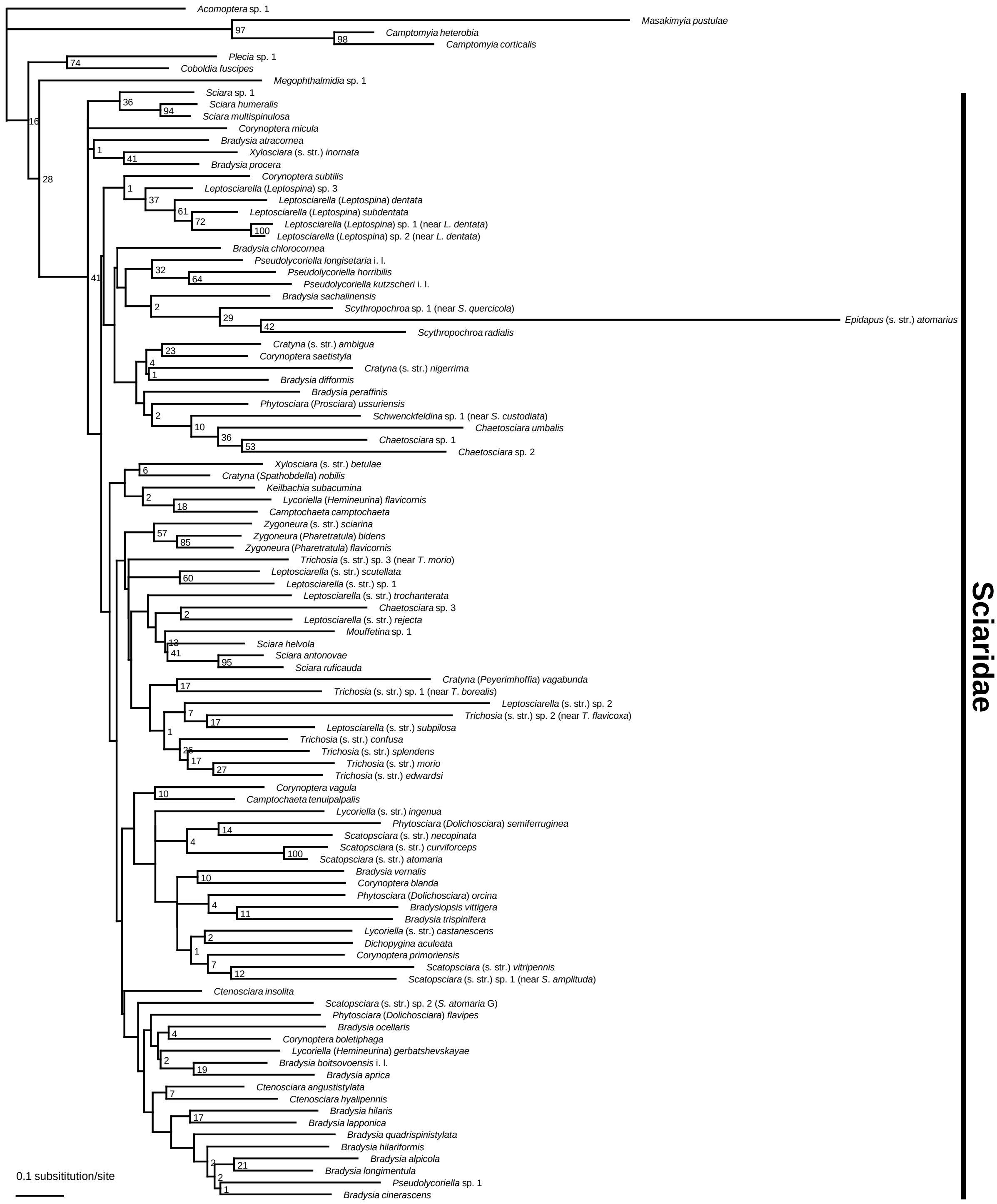
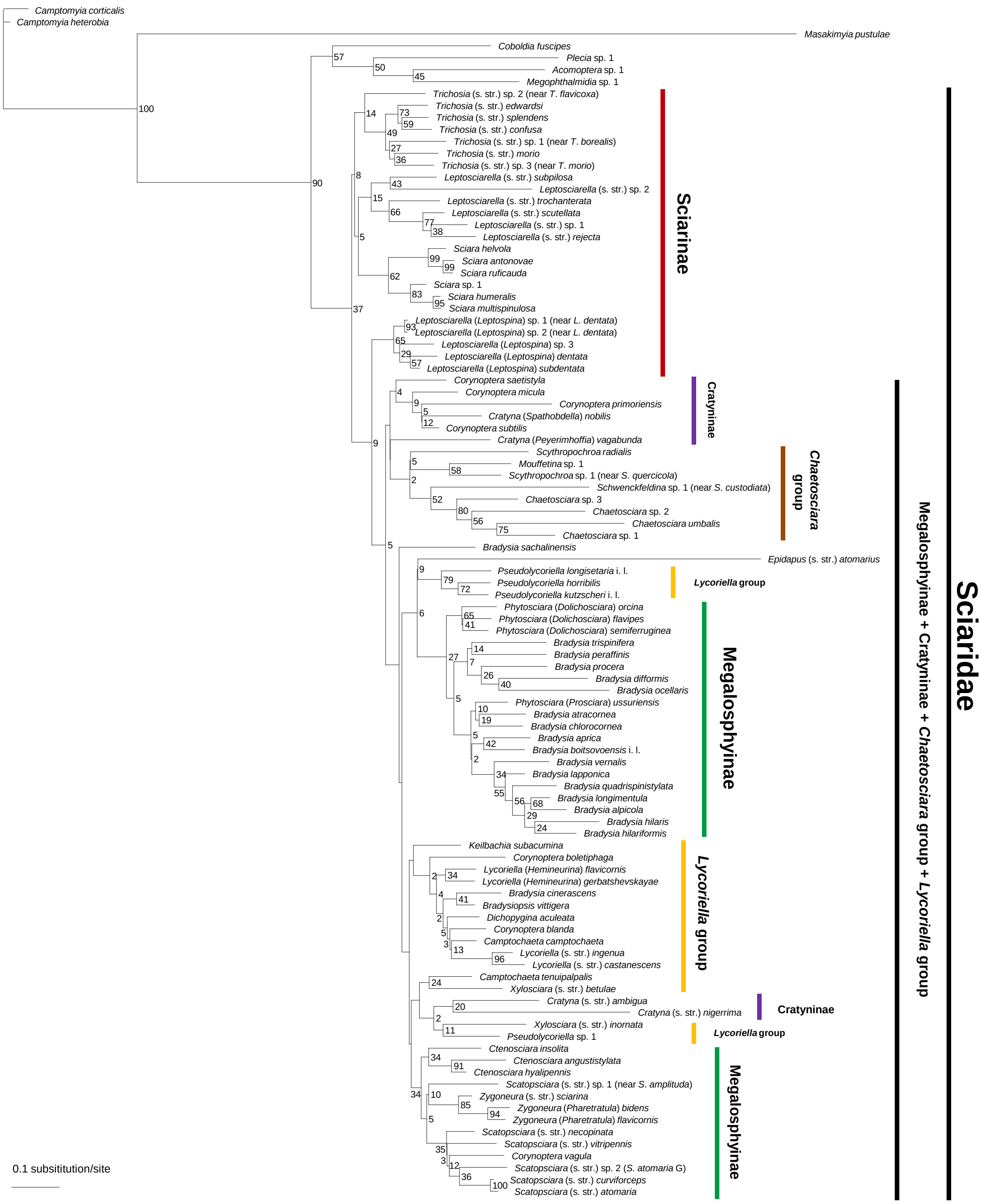
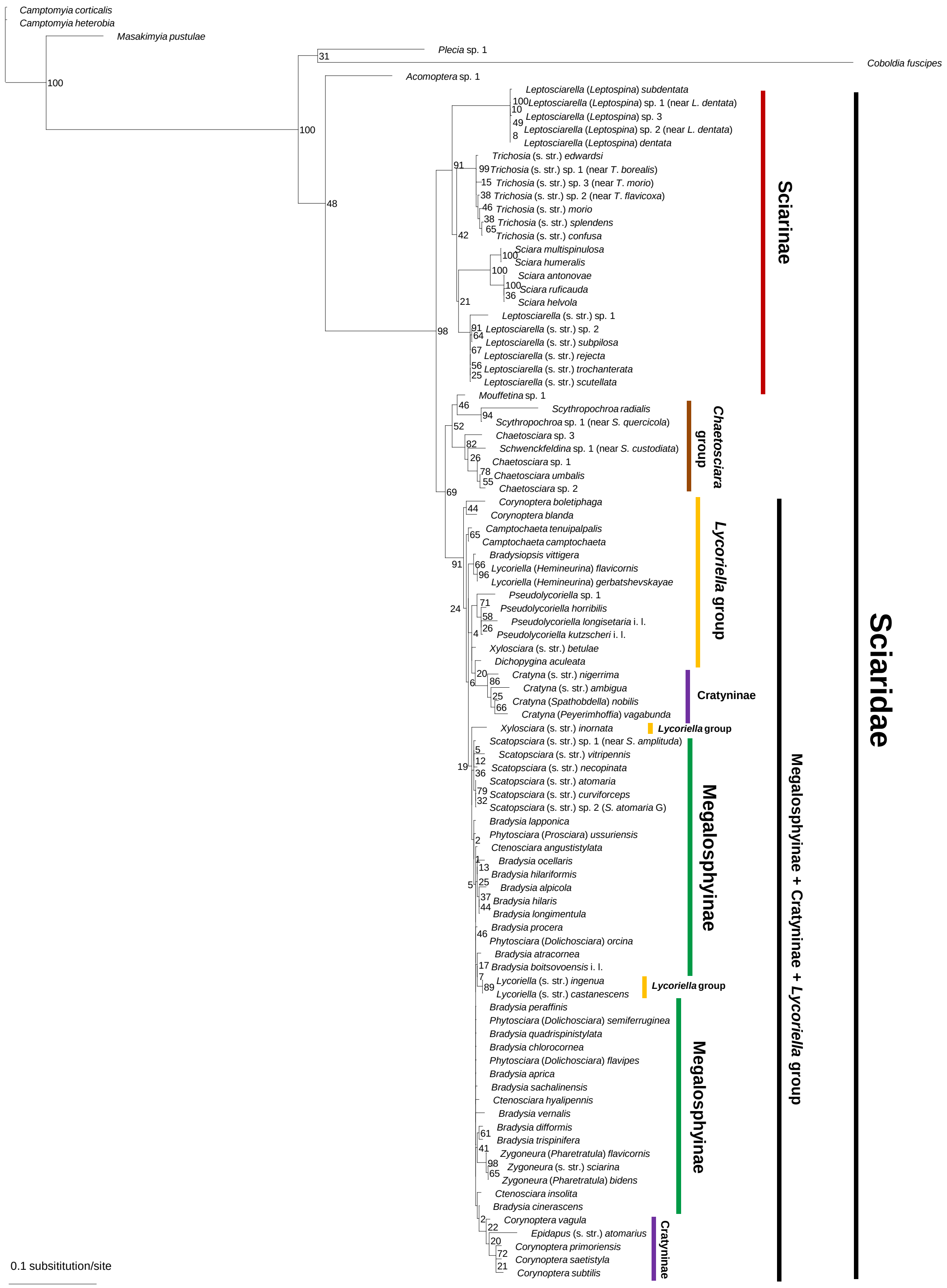
Supporting information Figure 3–1. Phylogenetic relationships inferred from maximum likelihood based on a GTR + I + G model of the COI gene fragment with bootstrap values under nodes.



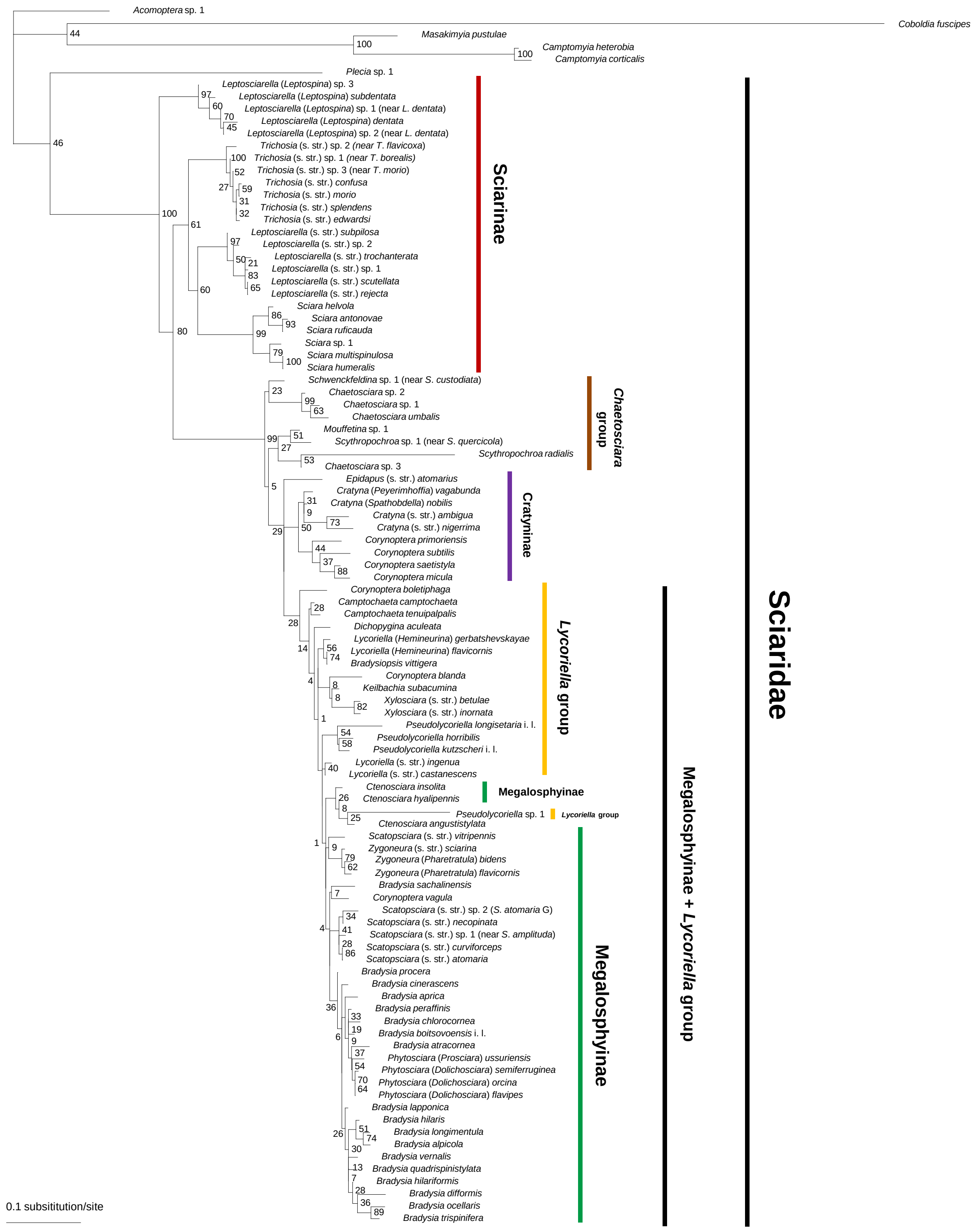
Supporting information Figure 3–2. Phylogenetic relationships inferred from maximum likelihood based on a GTR + I + G model of the 16S rRNA gene fragment with bootstrap values under nodes.



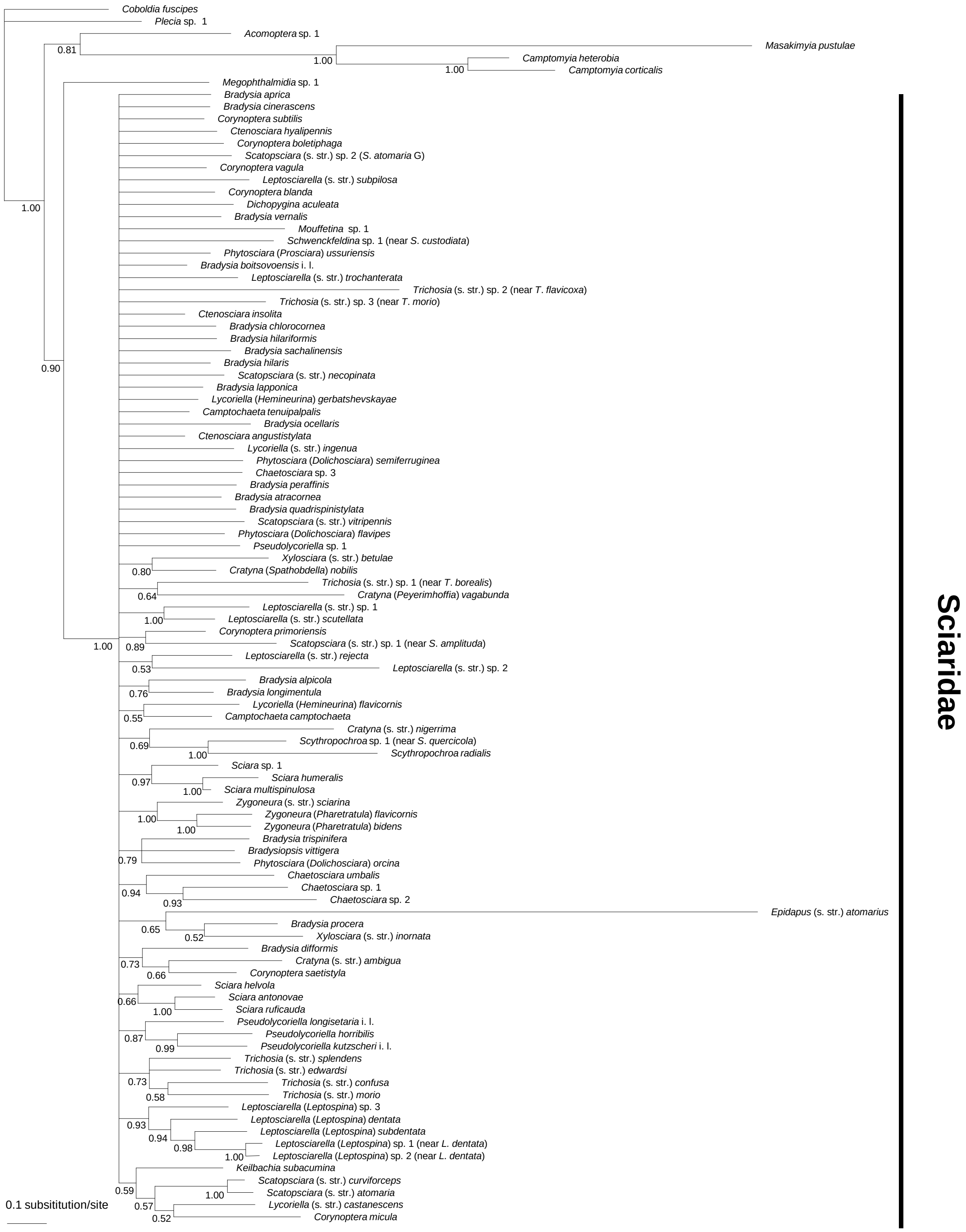
Supporting information Figure 3–3. Phylogenetic relationships inferred from maximum likelihood based on a GTR + I + G model of the 18S rRNA gene fragment with bootstrap values under nodes.



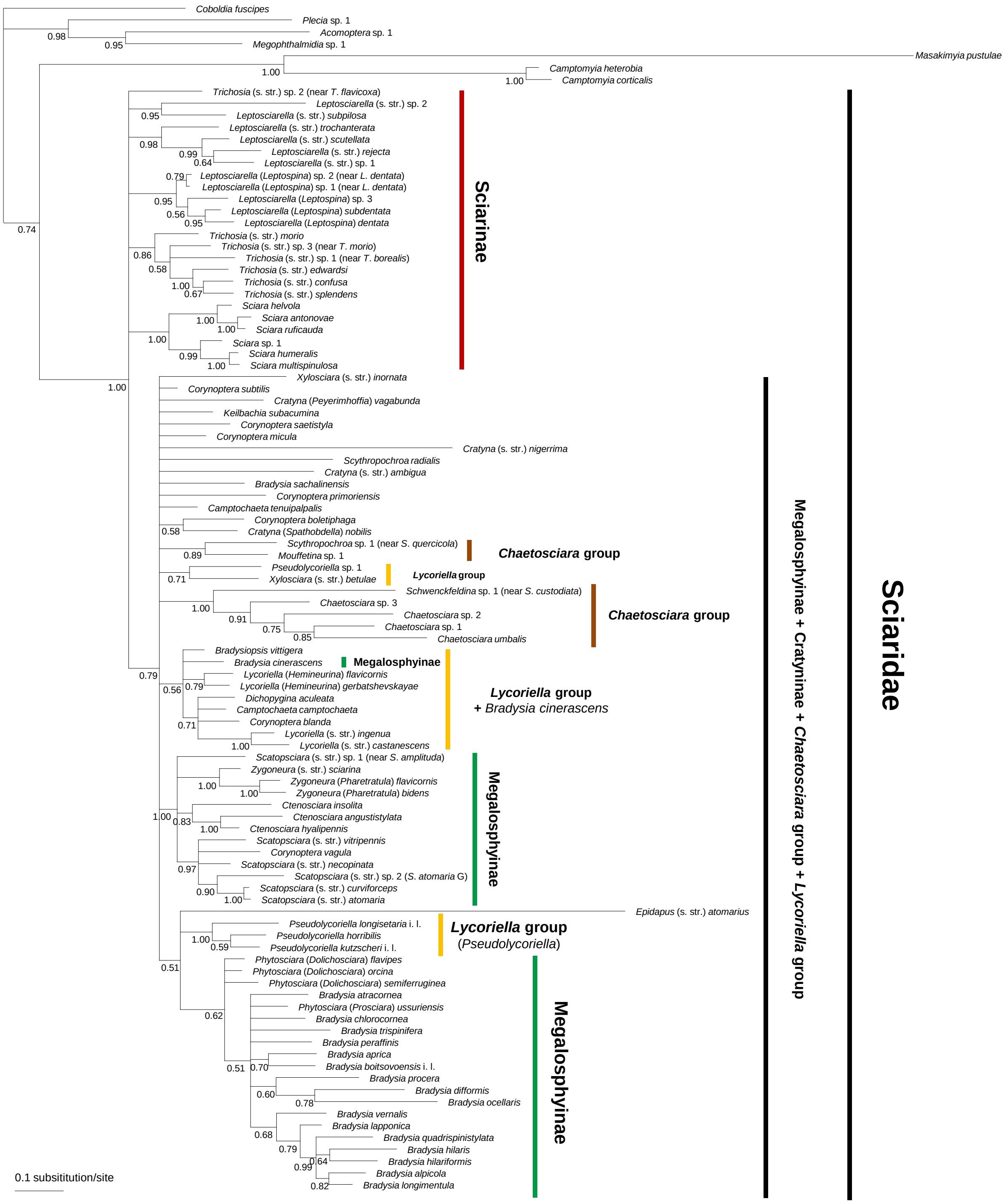
Supporting information Figure 3–4. Phylogenetic relationships inferred from maximum likelihood based on a GTR + I + G model of the 28S rRNA gene fragment with bootstrap values under nodes.



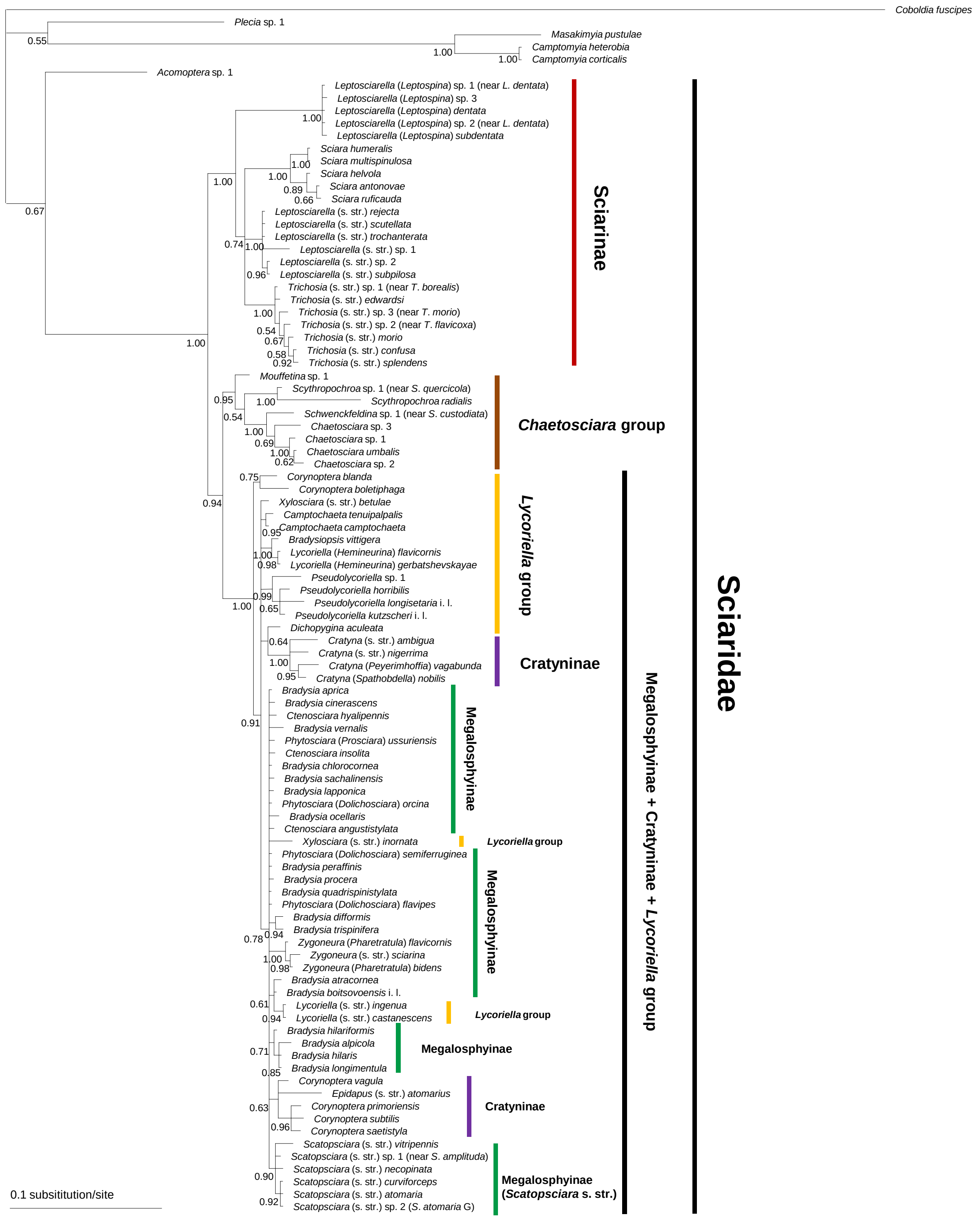
Supporting information Figure 3–5. Phylogenetic relationships inferred from Bayesian analysis based on a GTR + I + G model of the COI gene fragment with posterior probabilities under nodes.



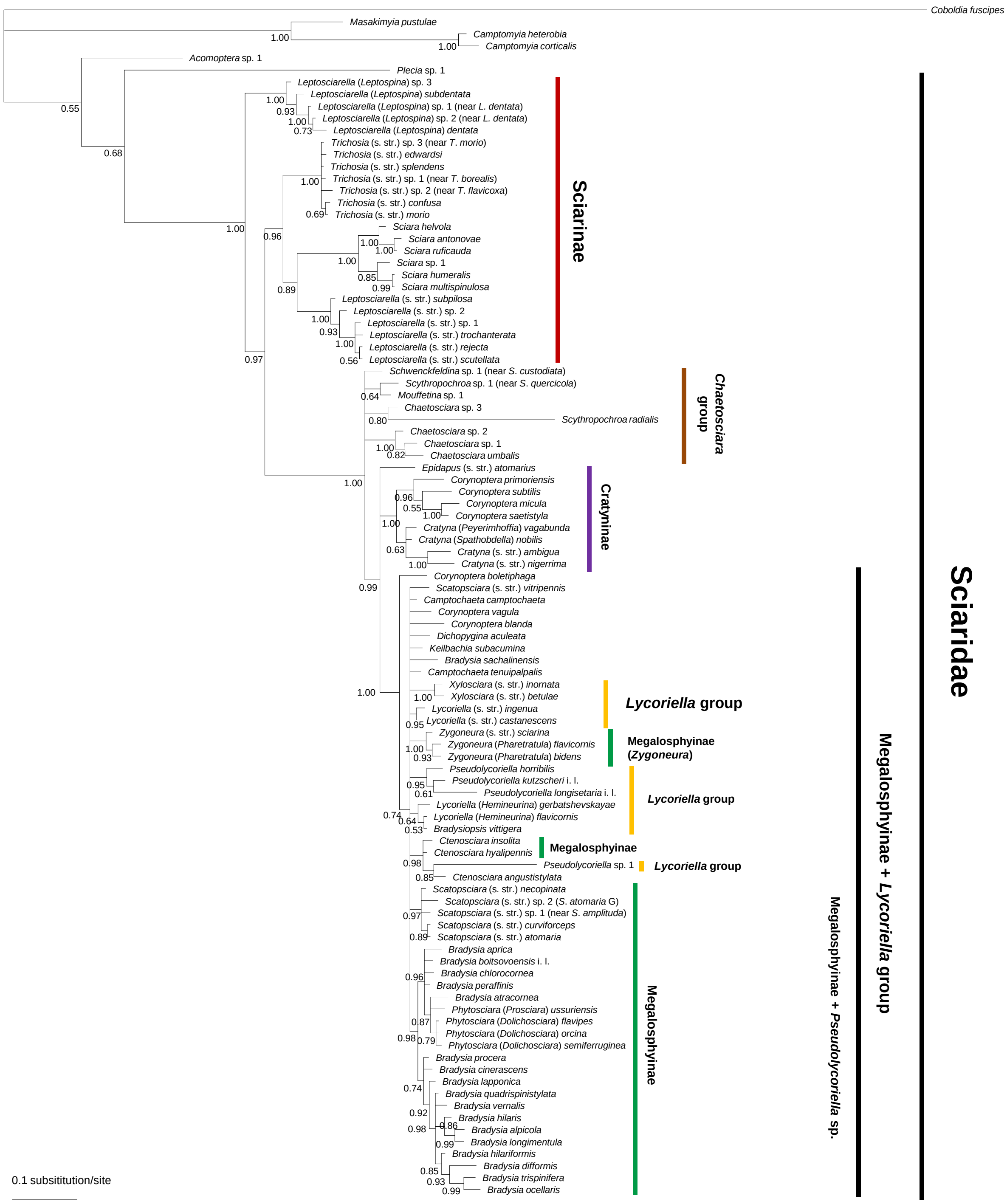
Supporting information Figure 3–6. Phylogenetic relationships inferred from Bayesian analysis based on a GTR + I + G model of the 16S rRNA gene fragment with posterior probabilities under nodes.



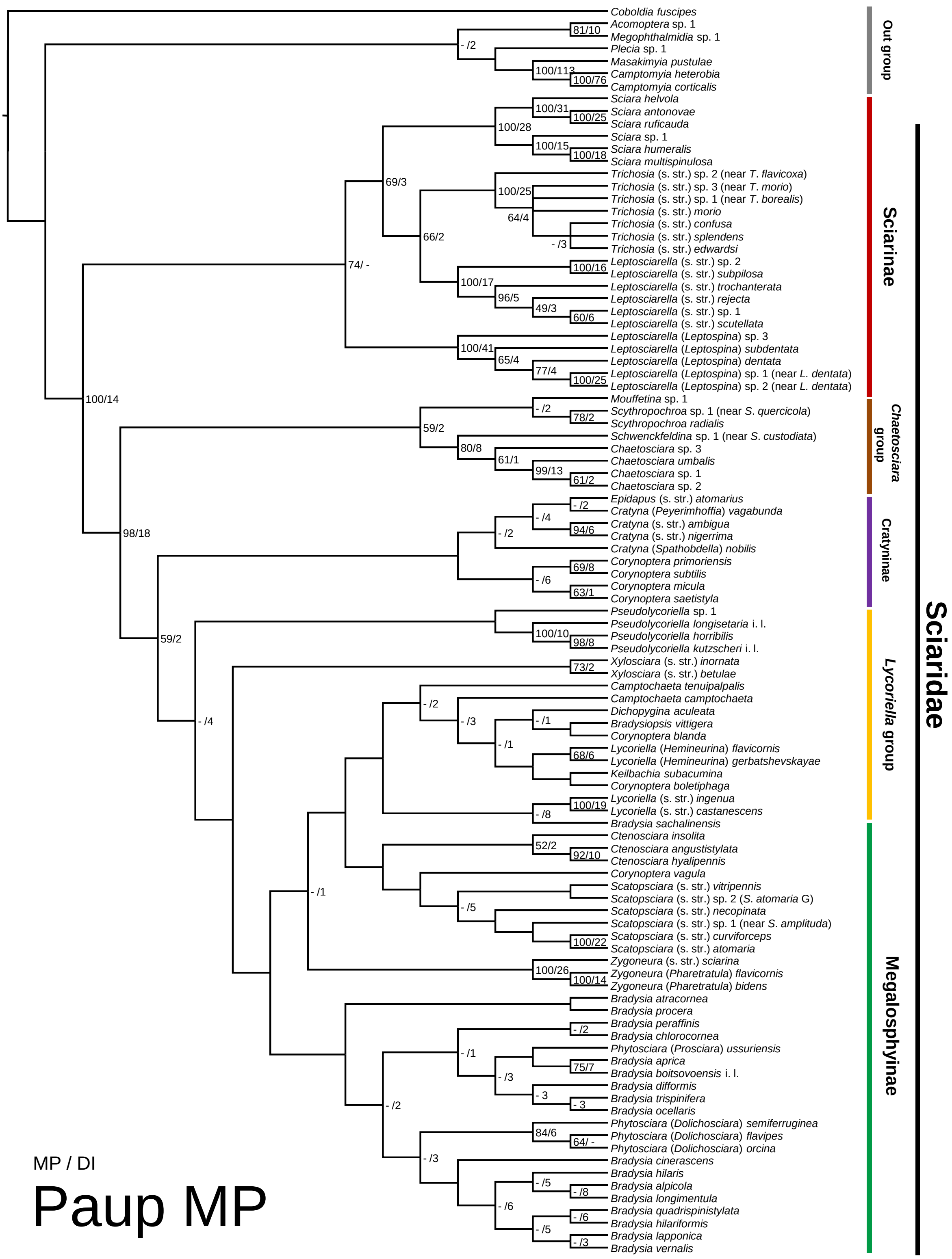
Supporting information Figure 3–7. Phylogenetic relationships inferred from Bayesian analysis based on a GTR + I + G model of the 18S rRNA gene fragment with posterior probabilities under nodes.



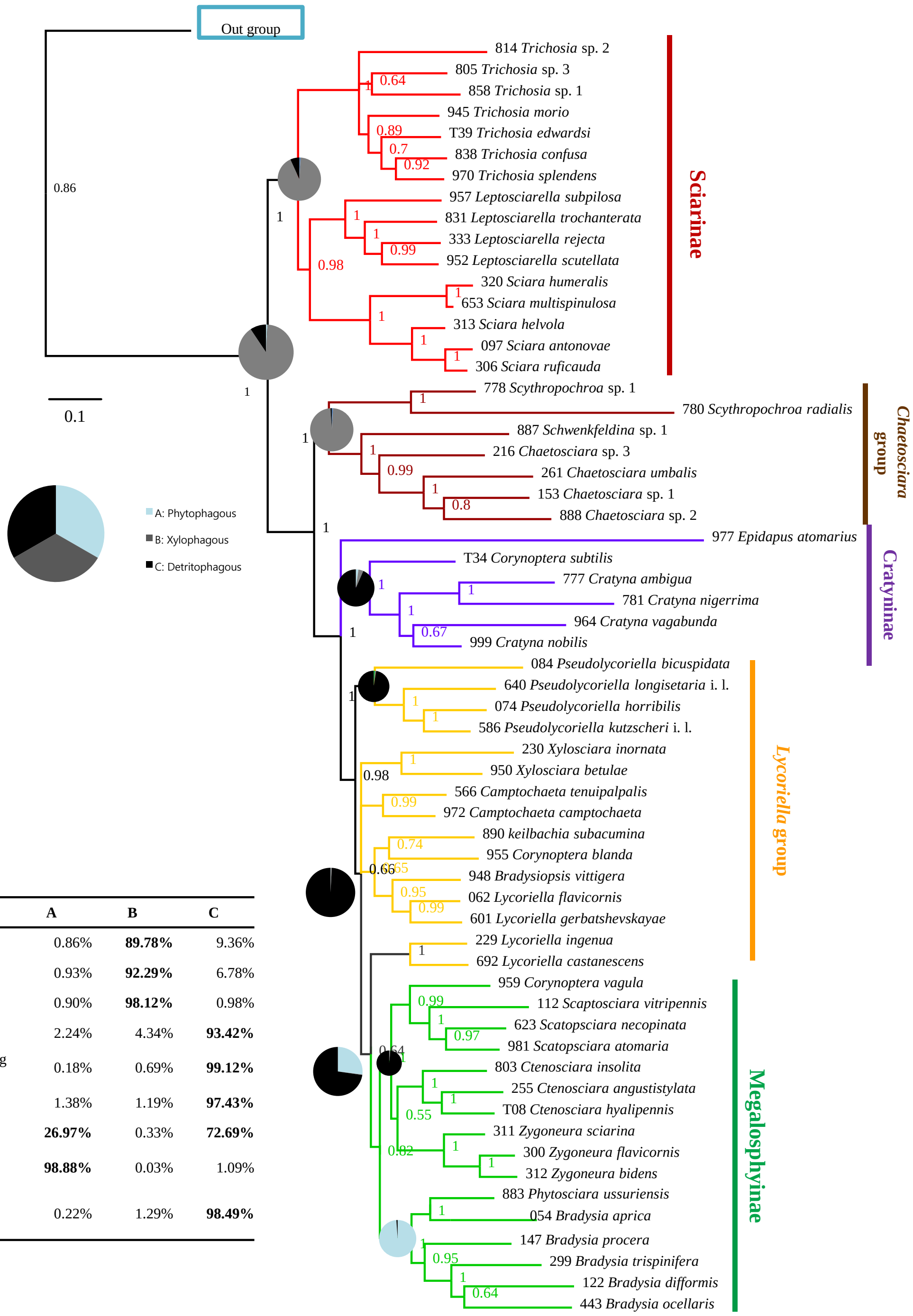
Supporting information Figure 3–8. Phylogenetic relationships inferred from Bayesian analysis based on a GTR + I + G model of the 28S rRNA gene fragment with posterior probabilities under nodes.



Supporting information Figure 3–9. A strict consensus tree of 4 most parsimonious trees, inferred from the combined dataset analysis. Numbers below the branches indicate MP bootstrap and DI support values respectively.



Supporting information Figure 3–10. Phylogenetic relationships inferred from Bayesian analysis with only habitat known species. Posterior probabilities (PP) under nodes. Results of the BayesMultiState analysis of ancestral habitat–type reconstructions are indicated as pie charts showing the relative likelihoods of each habitat type at the respective nodes.



	A	B	C
Sciaridae	0.86%	**89.78%**	9.36%
Sciarinae	0.93%	**92.29%**	6.78%
Chaetosciara group	0.90%	**98.12%**	0.98%
Cratyninae	2.24%	4.34%	**93.42%**
Lycoriella group + Megalosphyinae	0.18%	0.69%	**99.12%**
pseudolycoriella	1.38%	1.19%	**97.43%**
Megalosphyinae	**26.97%**	0.33%	72.69%
Phytosciara + *Bradysia*	**98.88%**	0.03%	1.09%
Scaptosciara +*Ctenosciara* + *ygoneura*	0.22%	1.29%	**98.49%**

Supporting information Table S3–1. Detailed list of Table 3–1 (Various classifications of family Sciaridae). System by Enderlein (1911).

System by Enderlein (1911) for the sciarids of the World

Subfamily	Tribe	Genus	Subgenus	Genus by Enderlein (1911)
Cratyninae Enderlein, 1911				
		Cratyna Winnertz, 1867	*Cratyna* Winnertz, 1867 s. str. (in part)	*Cratyna* Winnertz, 1867
Sciarinae Billberg, 1820 (= Lycoriinae Speiser, 1909)				
	Amesicriini			
		Amesicrium Enderlein, 1911		*Amesicrium* Enderlein, 1911
	Megalosphyini			
		Megalosphys Enderlein, 1911		*Megalosphys* Enderlein, 1911
		Metangela Rübsaamen, 1894		*Metangela* Rübsaamen, 1894
		Phytosciara Frey, 1942	*Phytosciara* Frey, 1942 s. str.	*Psilomegalosphys* Enderlein, 1911
		Scythropochroa Enderlein, 1911		*Scythropochroa* Enderlein, 1911
		Trichomegalosphys Enderlein, 1911		*Trichomegalosphys* Enderlein, 1911
	Sciarini (= Lycoriini)			
		Aniarella Enderlein, 1911		*Aniarella* Enderlein, 1911
		Apelmocreagris Enderlein, 1911		*Apelmocreagris* Enderlein, 1911
		Bradysia Winnertz, 1867		*Bradysia* Winnertz, 1867; *Dasysciara* Kieffer, 1903
		Ceratiosciara Enderlein, 1911		*Ceratiosciara* Enderlein, 1911
		Corynoptera Winnertz, 1867		*Corynoptera* Winnertz, 1867; *Psilosciara* Kieffer, 1909
		Cratyna Winnertz, 1867	*Cratyna* Winnertz, 1867 s. str. (in part)	*Plastosciara* Berg, 1899
		Epidapus Haliday, 1851	*Epidapus* Haliday, 1851 s. str.	*Aptanogyna* Börner, 1903: *Epidapus* Haliday, 1851; *Mycosciara* Kieffer, 1903
		Euricrium Enderlein, 1911		*Euricrium* Enderlein, 1911
		Hybosciara Rübsaamen, 1894		*Hybosciara* Rübsaamen, 1894
		Odontosciara Rübsaamen, 1908		*Odontonyx* Rübsaamen, 1894
		Rhynchosciara Rübsaamen, 1894		*Rhynchosciara* Rübsaamen, 1894
		Sciara Meigen, 1803		*Lycoria* Meigen, 1800
		Trichosia Winnertz, 1867		*Trichosia* Winnertz, 1867
		Zygomma Enderlein, 1911		*Zygomma* Enderlein, 1911
Lestremiinae Rondani, 1840 (incl. other genera of Cecidomyiidae and Scatopsidae)				
	Lestremiini			
		Gephyromma Enderlein, 1911		*Gephyromma* Enderlein, 1911
		Zygoneura Meigen, 1830	*Zygoneura* Meigen, 1830 s. str.	*Zygoneura* Meigen, 1830

Supporting information Table S3–2. Detailed list of Table 3–1 (Various classifications of family Sciaridae). System by Lengersdorf (1928–30).

System by Lengersdorf (1928–30) for the Palaearctic sciarids

Subfamily	Genus	Subgenus	Genus by Lengersdorf (1928–30)
Cratyninae Enderlein, 1911			
	Cratyna Winnertz, 1867	*Cratyna* Winnertz, 1867 s. str. (in part)	*Cratyna* Winnertz, 1867
Megalosphyinae Enderlein, 1911			
	Bradysia Winnertz, 1867 (in part)		*Fungivorides* Lengersdorf, 1926
	Phytosciara Frey, 1942	*Dolichosciara* Tuomikoski, 1960	*Phorodonta* Coquillett, 1910 sensu Edwards
	Phytosciara Frey, 1942	*Phytosciara* Frey, 1942 s. str.	*Psilomegalosphys* Enderlein, 1911
	Scythropochroa Enderlein, 1911 (in part)		*Scythropochroa* Enderlein, 1911
Sciarinae Billberg, 1820 (= Lycoriinae Speiser, 1909)			
	Bradysia Winnertz, 1867 (in part)		*Bradysia* Winnertz, 1867; *Dasysciara* Kieffer, 1903
	Corynoptera Winnertz, 1867		*Geosciara* Kieffer, 1919; *Psilosciara* Kieffer, 1909
	Cratyna Winnertz, 1867	*Peyerimhoffia* Kieffer, 1903	*Peyerimhoffia* Kieffer, 1903
	Cratyna Winnertz, 1867	*Cratyna* Winnertz, 1867 s. str. (in part)	*Plastosciara* Berg, 1899
	Epidapus Haliday, 1851	*Epidapus* Haliday, 1851 s. str.	*Aptanogyna* Börner, 1903: *Epidapus* Haliday, 1851; *Mycosciara* Kieffer, 1903
	Hyperlasion Schmitz, 1918		*Hyperlasion* Schmitz, 1918
	Pnyxia Johannsen, 1912		*Allostoomma* Schmitz, 1915
	Rhynchosciara Rübsaamen, 1894		*Rhynchosciara* Rübsaamen, 1894
	Scatopsciara Edwards, 1927		*Heterosciara* Lengersdorf, 1930; *Scatopsciara* Edwards, 1927
	Sciara Meigen, 1803		*Lycoria* Meigen, 1800
	Scythropochroa Enderlein, 1911 (in part)		*Sciaraneura* Lengersdorf, 1926
	Trichosia Winnertz, 1867		*Trichosia* Winnertz, 1867
Zygoneurinae Lengersdorf, 1930			
	Zygomma Enderlein, 1911		*Zygoneura* Meigen, 1830
	Zygoneura Meigen, 1830	*Zygoneura* Meigen, 1830 s. str.	*Zygoneura* Meigen, 1830

Supporting information Table S3–3. Detailed list of Table 3–1 (Various classifications of family Sciaridae).

System by Frey (1942)

System by Frey (1942) for the sciarids of the World

Specialization group	**Genus**	**Subgenus**	**Genus by Frey (1942)**	**Subgenus by Frey (1942)**
Group 1 (near Sciarinae)				
	Merianina Frey, 1942		*Merianina* Frey, 1942	
	Metangela Rübsaamen, 1894		*Metangela* Rübsaamen, 1894	
	Phytosciara Frey, 1942	*Phytosciara* Frey, 1942 s. str.	*Phytosciara* Frey, 1942	
	Phytosciara Frey, 1942	*Dolichosciara* Tuomikoski, 1960	*Phorodonta* Coquillett, 1910 sensu Edwards	
	Pseudosciara Schiner, 1868		*Pseudosciara* Schiner, 1868	
	Sciara Meigen, 1803		*Sciara* Meigen, 1803	
	Trichomegalosphys Enderlein, 1911		*Trichomegalosphys* Enderlein, 1911	
	Trichosia Winnertz, 1867	*Trichosia* Winnertz, 1867 s. str.	*Leptosciara* Frey, 1942; *Lestremioides* Frey, 1942; *Trichosia* Winnertz, 1867	
	Trichosia Winnertz, 1867	*Mouffetina* Frey, 1942	*Mouffetina* Frey, 1942	
Group 2 (near Cratyninae and Megalosphyinae)				
	Bradysia Winnertz, 1867 (in part)		*Neosciara* Pettey, 1918	*Neosciara* Pettey, 1918 s. str.; *Semnomyia* Frey, 1942
	Chaetosciara Frey, 1942		*Neosciara* Pettey, 1918	*Chaetosciara* Frey, 1942
	Cratyna Winnertz, 1867	*Cratyna* Winnertz, 1867 s. str.	*Decembrina* Frey, 1942; *Neosciara* Pettey, 1918; *Plastosciara* Berg, 1899	*Dendrosciara* Frey, 1942 [as SG of *Neosciara* Pettey]
	Eugnoriste Coquillett, 1899		*Eugnoriste* Coquillett, 1896	
	Hybosciara Rübsaamen, 1894		*Hybosciara* Rübsaamen, 1894	
	Phytosciara Frey, 1942	*Prosciara* Frey, 1942	*Neosciara* Pettey, 1918	*Prosciara* Frey, 1942
	Rhynchosciara Rübsaamen, 1894		*Rhynchosciara* Rübsaamen, 1894	
	Scaptosciara Edwards, 1927		*Scaptosciara* Edwards, 1927	
	Schwenckfeldina Frey, 1942		*Neosciara* Pettey, 1918	*Schwenckfeldina* Frey, 1942
	Scythropochroa Enderlein, 1911		*Sciaraneura* Lengersdorf, 1926	
Group 3 (near Megalosphyinae and Zygoneurinae)				
	Bradysia Winnertz, 1867 (in part)		*Bradysia* Winnertz, 1867; *Dasysciara* Kieffer, 1903	
	Ceratiosciara Enderlein, 1911		*Ceratiosciara* Enderlein, 1911	
	Corynoptera Winnertz, 1867		*Psilosciara* Kieffer, 1909	
	Cratyna Winnertz, 1867	*Peyerimhoffia* Kieffer, 1903	*Cosmosciara* Frey, 1942; *Peyerimhoffia* Kieffer, 1903	
	Dodecasciara Edwards, 1928		*Dodecasciara* Edwards, 1928	
	Epidapus Haliday, 1851	*Epidapus* Haliday, 1851 s. str.	*Aptanogyna* Börner, 1903; *Calcaromyia* Vimmer, 1926; *Epidapus* Haliday, 1851; *Mycosciara* Kieffer, 1903; *Soudekia* Vimmer, 1928	
	Epidapus Haliday, 1851	*Pseudoaptanogyna* Vimmer, 1926	*Caenosciara* Lengersdorf, 1941	
	Hyperlasion Schmitz, 1918		*Scythropochroa* Enderlein, 1911 (in	

		part)	
Lycoriella Frey, 1942	*Lycoriella* Frey, 1942 s. str.	*Lycoriella* Frey, 1942	*Lycoriella* Frey, 1942 s. str.
Lycoriella Frey, 1942	*Hemineurina* Frey, 1942	*Lycoriella* Frey, 1942	*Hemineurina* Frey, 1942
Peniosciara Frey, 1942		*Peniosciara* Frey, 1942	
Scatopsciara Edwards, 1927	*Scatopsciara* Edwards, 1927 s. str.	*Heterosciara* Lengersdorf, 1930; *Lycoriella* Frey, 1942 (in part); *Uddmania* Frey, 1942	*Diorychophthalma* Frey, 1942 [as SG of *Lycoriella* Frey]
Scythropochroa Enderlein, 1911		*Scythropochroa* Enderlein, 1911	
Zygomma Enderlein, 1911		*Zygoneura* Meigen, 1830	
Zygoneura Meigen, 1830		*Zygoneura* Meigen, 1830	

Supporting information Table S3–4. Detailed list of Table 3–1 (Various classifications of family Sciaridae).

System by Menzel and Mohrig (2000)

System by Menzel and Mohrig (2000) for the Palaearctic sciarids

Subfamily	Genus	Subgenus
Sciarinae Billberg, **1820** (= Lycoriinae Speiser, 1909)		
	Chaetosciara Frey, 1942	
	Leptosciarella Tuomikoski, 1960	*Leptosciarella* Tuomikoski, 1960 s. str.
	Leptosciarella Tuomikoski, 1960	*Hirtipennia* Mohrig & Menzel, 1997
	Leptosciarella Tuomikoski, 1960	*Leptospina* Mohrig & Menzel, 1997
	Leptosciarella Tuomikoski, 1960	*Trichosiopsis* Tuomikoski, 1960
	Schwenckfeldina Frey, 1942	
	Sciara Meigen, 1803	
	Scythropochroa Enderlein, 1911	
	Trichosia Winnertz, 1867	*Baeosciara* Tuomikoski, 1960
	Trichosia Winnertz, 1867	*Mouffetina* Frey, 1942
	Trichosia Winnertz, 1867	*Trichosia* Winnertz, 1867 s. str.
Cratyninae Enderlein, **1911** (= Zygoneurinae Lengersdorf, 1930)		
	Allopnyxia Freeman, 1952	
	Cratyna Winnertz, 1867	*Cratyna* Winnertz, 1867 s. str.
	Cratyna Winnertz, 1867	*Diversicratyna* Menzel & Mohrig, 1998
	Cratyna Winnertz, 1867	*Peyerimhoffia* Kieffer, 1903
	Cratyna Winnertz, 1867	*Spathobdella* Frey, 1948
	Epidapus Haliday, 1851	*Cornepidapus* Menzel & Mohrig, 2000
	Epidapus Haliday, 1851	*Epidapus* Haliday, 1851 s. str.
	Epidapus Haliday, 1851	*Pseudoaptanogyna* Vimmer, 1926
	Epidapus Haliday, 1851	*Pseudoepidapus* Mohrig, 1982
	Hermapterosciara Mohrig & Mamaev, 1970	
	Hyperlasion Schmitz, 1918	
	Parapnyxia Mohrig & Mamaev, 1970	*Parapnyxia* Mohrig & Mamaev, 1970 s. str.
	Parapnyxia Mohrig & Mamaev, 1970	*Xenopnyxia* Mohrig & Mamaev, 1970
	Pnyxia Johannsen, 1912	
	Pnyxiopsis Tuomikoski, 1960	
	Trichodapus Mohrig & Menzel, 1997	
	Xylosciara Tuomikoski, 1957	*Protoxylosciara* Tuomikoski, 1960
	Xylosciara Tuomikoski, 1957	*Xylosciara* Tuomikoski, 1957 s. str.
	Zygoneura Meigen, 1830	*Allozygoneura* Menzel & Mohrig, 1998
	Zygoneura Meigen, 1830	*Pharetratula* Mamaev, 1968
	Zygoneura Meigen, 1830	*Zygoneura* Meigen, 1830
"New subfamily"(named as "*Pseudolycoriella* group + *Corynoptera* s. l. group")		
	Bradysiopsis Tuomikoski, 1960	
	Camptochaeta Hippa & Vilkamaa, 1994	
	Corynoptera Winnertz, 1867 s. l.	
	Keilbachia Mohrig, 1987	
	Lycoriella Frey, 1942	*Coelostylina* Tuomikoski, 1960
	Lycoriella Frey, 1942	*Hemineurina* Frey, 1942
	Lycoriella Frey, 1942	*Lycoriella* Frey, 1942 s. str.
	Mohrigia Menzel, 1995	
	Pseudolycoriella Menzel & Mohrig, 1998	

Megalosphyinae Enderlein, 1911		
	Bradysia Winnertz, 1867 s. l.	
	Ctenosciara Tuomikoski, 1960	
	Phytosciara Frey, 1942	*Dolichosciara* Tuomikoski, 1960
	Phytosciara Frey, 1942	*Phytosciara* Frey, 1942 s. str.
	Phytosciara Frey, 1942	*Prosciara* Frey, 1942
	Scatopsciara Edwards, 1927	*Scatopsciara* Edwards, 1927 s. str.
	Scatopsciara Edwards, 1927	*Xenopygina* Frey, 1948

Supporting information Table S3–5. GenBank accession numbers for studied taxa in part 3.

DNA #	Family	Species	GenBank Accession Number			
			COI	16S	18S	28S
	Cecidomiiydae					
013		*Camptomyia corticalis*	JN378593	JQ613883	JQ613591	JQ613687
012		*Camptomyia heterobia*	JN378666	JQ613882	JQ613590	JQ613686
011		*Masakimyia pustulae*	JQ613784	JQ613881	JQ613589	JQ613685
	Mycetophilidae					
942		*Acomoptera* sp. 1	JQ613857	JQ613957	JQ613663	JQ613761
943		*Megophthalmidia* sp. 1	JQ613858	JQ613958		
	Scatopsidae					
905		*Coboldia fuscipes*	JQ613854	JQ613954	JQ613660	JQ613758
	Bibionidae					
941		*Plecia* sp. 1	JQ613856	JQ613956	JQ613662	JQ613760
	Sciaridae					
073		*Bradysia alpicola*	JQ613787	JQ613886	JQ613594	JQ613690
054		*Bradysia aprica*	JQ613785	JQ613884	JQ613592	JQ613688
133		*Bradysia atracornea*	JQ613796	JQ613895	JQ613603	JQ613699
860		*Bradysia boitsovoensis* i. l.	JQ613846	JQ613946	JQ613653	JQ613750
736		*Bradysia chlorocornea*	JQ613828	JQ613928	JQ613636	JQ613732
T36		*Bradysia cinerascens*	JQ613879	JQ613979	JQ613683	JQ613782
122		*Bradysia difformis*	JQ613795	JQ613894	JQ613602	JQ613698
724		*Bradysia hilariformis*	JQ613827	JQ613927	JQ613635	JQ613731
624		*Bradysia hilaris*	JQ613822	JQ613922	JQ613630	JQ613726
607		*Bradysia lapponica*	JQ613820	JQ613920	JQ613628	JQ613724
232		*Bradysia longimentula*	JN378635	JQ613903	JQ613611	JQ613707
443		*Bradysia ocellaris*	JQ613814	JQ613914	JQ613622	JQ613718
206		*Bradysia peraffinis*	JQ613799	JQ613898	JQ613606	JQ613702
147		*Bradysia procera*	JQ613797	JQ613896	JQ613604	JQ613700
114		*Bradysia quadrispinistylata*	JQ613794	JQ613893	JQ613601	JQ613697
643		*Bradysia sachalinensis*	JQ613824	JQ613924	JQ613632	JQ613728
299		*Bradysia trispinifera*	JQ613806	JQ613906	JQ613614	JQ613710
944		*Bradysia vernalis*	JQ613859	JQ613959	JQ613664	JQ613762
948		*Bradysiopsis vittigera*	JQ613862	JQ613962	JQ613667	JQ613765
972		*Camptochaeta camptochaeta*	JQ613870	JQ613970	JQ613675	JQ613773
566		*Camptochaeta tenuipalpalis*	JQ613815	JQ613915	JQ613623	JQ613719
153		*Chaetosciara* sp. 1	JQ613798	JQ613897	JQ613605	JQ613701
888		*Chaetosciara* sp. 2	JQ613850	JQ613950	JQ613657	JQ613754
216		*Chaetosciara* sp. 3	JQ613800	JQ613899	JQ613607	JQ613703
261		*Chaetosciara umbalis*	JQ613805	JQ613905	JQ613613	JQ613709
955		*Corynoptera blanda*	JQ613865	JQ613965	JQ613670	JQ613768
995		*Corynoptera boletiphaga*	JQ613874	JQ613974	JQ613679	JQ613777
792		*Corynoptera micula*	JQ613834	JQ613934		JQ613738
594		*Corynoptera primoriensis*	JQ613817	JQ613917	JQ613625	JQ613721
876		*Corynoptera saetistyla*	JQ613847	JQ613947	JQ613654	JQ613751
T34		*Corynoptera subtilis*	JQ613878	JQ613978	JQ613682	JQ613781
959		*Corynoptera vagula*	JQ613867	JQ613967	JQ613672	JQ613770
964		*Cratyna* (*Peyerimhoffia*) *vagabunda*	JQ613868	JQ613968	JQ613673	JQ613771

777	*Cratyna* (s. str.) *ambigua*	JQ613829	JQ613929	JQ613637	JQ613733
781	*Cratyna* (s. str.) *nigerrima*	JQ613832	JQ613932	JQ613640	JQ613736
999	*Cratyna* (*Spathobdella*) *nobilis*	JQ613875	JQ613975	JQ613680	JQ613778
255	*Ctenosciara angustistylata*	JQ613804	JQ613904	JQ613612	JQ613708
T08	*Ctenosciara hyalipennis*	JQ613876	JQ613976	JQ613681	JQ613779
803	*Ctenosciara insolita*	JQ613835	JQ613935	JQ613642	JQ613739
947	*Dichopygina aculeata*	JQ613861	JQ613961	JQ613666	JQ613764
977	*Epidapus* (s. str.) *atomarius*	JQ613871	JQ613971	JQ613676	JQ613774
890	*Keilbachia subacumina*	JQ613851	JQ613951		JQ613755
841	*Leptosciarella* (*Leptospina*) *dentata*	JQ613843	JQ613943	JQ613650	JQ613747
810	*Leptosciarella* (*Leptospina*) sp. 1 (near *L. dentata*)	JQ613837	JQ613937	JQ613644	JQ613741
820	*Leptosciarella* (*Leptospina*) sp. 2 (near *L. dentata*)	JQ613840	JQ613940	JQ613647	JQ613744
907	*Leptosciarella* (*Leptospina*) sp. 3	JQ613855	JQ613955	JQ613661	JQ613759
819	*Leptosciarella* (*Leptospina*) *subdentata*	JQ613839	JQ613939	JQ613646	JQ613743
333	*Leptosciarella* (s. str.) *rejecta*	JQ613813	JQ613913	JQ613621	JQ613717
952	*Leptosciarella* (s. str.) *scutellata*	JQ613864	JQ613964	JQ613669	JQ613767
785	*Leptosciarella* (s. str.) sp. 1	JQ613833	JQ613933	JQ613641	JQ613737
852	*Leptosciarella* (s. str.) sp. 2	JQ613844	JQ613944	JQ613651	JQ613748
957	*Leptosciarella* (s. str.) *subpilosa*	JQ613866	JQ613966	JQ613671	JQ613769
831	*Leptosciarella* (s. str.) *trochanterata*	JQ613841	JQ613941	JQ613648	JQ613745
062	*Lycoriella* (*Hemineurina*) *flavicornis*	JQ613786	JQ613885	JQ613593	JQ613689
601	*Lycoriella* (*Hemineurina*) *gerbatshevskayae*	JQ613819	JQ613919	JQ613627	JQ613723
692	*Lycoriella* (s. str.) *castanescens*	JQ613826	JQ613926	JQ613634	JQ613730
229	*Lycoriella* (s. str.) *ingenua*	JQ613802	JQ613901	JQ613609	JQ613705
088	*Phytosciara* (*Dolichosciara*) *flavipes*	JQ613790	JQ613889	JQ613597	JQ613693
595	*Phytosciara* (*Dolichosciara*) *orcina*	JQ613818	JQ613918	JQ613626	JQ613722
220	*Phytosciara* (*Dolichosciara*) *semiferruginea*	JQ613801	JQ613900	JQ613608	JQ613704
883	*Phytosciara* (*Prosciara*) *ussuriensis*	JQ613848	JQ613948	JQ613655	JQ613752
074	*Pseudolycoriella horribilis*	JQ613788	JQ613887	JQ613595	JQ613691
586	*Pseudolycoriella kutzscheri* i. l.	JQ613816	JQ613916	JQ613624	JQ613720
640	*Pseudolycoriella longisetaria* i. l.	JQ613823	JQ613923	JQ613631	JQ613727
084	*Pseudolycoriella* sp. 1	JQ613789	JQ613888	JQ613596	JQ613692
090	*Scatopsciara* (s. str.) *curviforceps*	JQ613791	JQ613890	JQ613598	JQ613694
981	*Scatopsciara* (s. str.) *atomaria*	JQ613873	JQ613973	JQ613678	JQ613776
623	*Scatopsciara* (s. str.) *necopinata*	JQ613821	JQ613921	JQ613629	JQ613725
902	*Scatopsciara* (s. str.) sp. 1 (near *S. amplituda)*	JQ613853	JQ613953	JQ613659	JQ613757
978	*Scatopsciara* (s. str.) sp. 2 (*S. atomaria* G)	JQ613872	JQ613972	JQ613677	JQ613775
112	*Scatopsciara* (s. str.) *vitripennis*	JQ613793	JQ613892	JQ613600	JQ613696
887	*Schwenckfeldina* sp. 1 (near *S. custodiata*)	JQ613849	JQ613949	JQ613656	JQ613753
097	*Sciara antonovae*	JQ613792	JQ613891	JQ613599	JQ613695
313	*Sciara helvola*	JQ613811	JQ613911	JQ613619	JQ613715
320	*Sciara humeralis*	JQ613812	JQ613912	JQ613620	JQ613716
653	*Sciara multispinulosa*	JQ613825	JQ613925	JQ613633	JQ613729
306	*Sciara ruficauda*	JQ613808	JQ613908	JQ613616	JQ613712
T29	*Sciara* sp. 1	JQ613877	JQ613977		JQ613780
780	*Scythropochroa radialis*	JQ613831	JQ613931	JQ613639	JQ613735

778	*Scythropochroa* sp. 1 (near *S. quercicola*)	JQ613830	JQ613930	JQ613638	JQ613734
900	*Mouffetina* sp. 1	JQ613852	JQ613952	JQ613658	JQ613756
838	*Trichosia* (s. str.) *confusa*	JQ613842	JQ613942	JQ613649	JQ613746
T39	*Trichosia* (s. str.) *edwardsi*	JQ613880	JQ613980	JQ613684	JQ613783
945	*Trichosia* (s. str.) *morio*	JQ613860	JQ613960	JQ613665	JQ613763
858	*Trichosia* (s. str.) sp. 1 (near *T. borealis*)	JQ613845	JQ613945	JQ613652	JQ613749
814	*Trichosia* (s. str.) sp. 2 (near *T. flavicoxa*)	JQ613838	JQ613938	JQ613645	JQ613742
805	*Trichosia* (s. str.) sp. 3 (near *T. morio*)	JQ613836	JQ613936	JQ613643	JQ613740
970	*Trichosia* (s. str.) *splendens*	JQ613869	JQ613969	JQ613674	JQ613772
230	*Xylosciara* (s. str.) *inornata*	JQ613803	JQ613902	JQ613610	JQ613706
950	*Xylosciara* (s. str.) *betulae*	JQ613863	JQ613963	JQ613668	JQ613766
312	*Zygoneura* (*Pharetratula*) *bidens*	JQ613810	JQ613910	JQ613618	JQ613714
300	*Zygoneura* (*Pharetratula*) *flavicornis*	JQ613807	JQ613907	JQ613615	JQ613711
311	*Zygoneura* (s. str.) *sciarina*	JQ613809	JQ613909	JQ613617	JQ613713

한반도산 검정날개버섯파리과 (파리목: 버섯파리상과)의 계통분류 및 유충서식처 진화 연구

서울대학교 대학원

농생명공학부 곤충학 전공

신승관

국문초록

본 연구는 검정날개버섯파리류에 대한 분류학적 연구를 기반으로 한, 계통 및 서식처 진화 연구로서 총 세가지 부분으로 구성되어 있다. 첫째: 한반도에 서식하는 검정날개버섯파리류의 분류학적 검토, 둘째: 검정날개버섯파리과의 DNA 바코드 연구, 특히 *Bradysia* 속에 대한 유충의 종동정 및 서식처 확인, 셋째: 분자지표를 이용한 검정날개버섯파리과의 계통분석과 유충의 서식처 변화에 따른 진화가설 연구이다. 첫번째 부분에서는 국내에 서식하는 검정날개버섯파리류의 분류학적, 형태학적 연구를 바탕으로 이들 아과에 대한 새로운 가설을 제시하였다. 전체 61종 중, 신종 및 미기록종 29종을 국내에 새롭게 보고하였고, 아과 및 속에 대한 분류검색표를 작성하였다. 두 번째 부분은 검정날개버섯파리과의 DNA 바코드 연구로서 특히 종 동정이 어렵고 비교적 많은종이 해충으로 알려져 있는 *Bradysia* 속의 종동정을 위하여 국내뿐 아니라 국외 종을 포함하여 총 25종에 대한 COI 영역의 자료를 구축하였고, 이들의 종간, 종내 변이율을 비교함으로써 종동정의 가능성을 확인하였다. 이를 바탕으로 채집된 유충의 정확한 종과 서식처를 확인할 수 있었다. 세 번째 부분은 앞부분

에서 다룬 내용을 바탕으로, 다양한 국내외의 표본을 이용하여 계통학적인 분석을 하였고 이에 대한 진화적인 추론을 하였다. 본 연구에서는 기존에 정립되지 않은 아과 개념에 대한 분자생물학적 증명과 함께, 새로운 계통관계를 유추하였다. 특히, 화석기록과 계통학적 조상 분류군의 서식처 추측을 통해, 살아있는 식물로의 유충 서식처 이동에 대한 진화적 추론을 이끌어 내었다. 이 결과를 바탕으로 검정날개버섯파리류의 진화적 가설을 고찰하였고 조상형질을 추론하여 이에 따른 서식처의 변화와 진화적인 연관성을 연구하였다. 본 연구를 통하여 국내 검정날개버섯파리과에 대한 재검토뿐 아니라 새로운 아과 정립과 함께 분자생물학적 관계를 제시함으로써 기존에 정립되지 않은 과내 관계를 처음으로 증명하였다. 또한 이들의 진화적인 관계 파악을 통하여 유충의 서식처 이동에 대한 가설을 처음으로 밝혀내었다. 이러한 연구들을 통하여 기존에 정립되지 않았던 계통 관계뿐 아니라 새로운 아과에 대한 분류학적 재정의를 제시 하였고 검정날개버섯파리의 농업 해충으로서의 중요성과 생태계에서의 역할에 대한 고찰을 하였다.

주요어: **검정날개버섯파리**, **조상형질탐색**, **계통학**, **신종**, **미기록종**, **진화**.

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