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修士論文

Female genitalia of some tabanids inhabiting Hokkaido, Japan
(Diptera: Tabanidae)

北海道に生息するアブ科雌成虫の外部生殖器
(双翅目：アブ科)

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Introduction

Tabanids are members of the order Diptera, one of the large orders of the class Insecta. According to the shapes of antennae, the order Diptera can be separated into three suborders, namely, Nematocera, Brachycera, and Cyclorrhapa. Tabanids belong to the suborder Brachycera (Oldroyd, 1952; Murdoch and Takahasi, 1969). This is the primary and important point of tabanids classification to separate from other suborders (Oldroyd, 1952; Murdoch and Takahasi, 1969). As is known to all, tabanids are called horsefly, deerfly, or cleg commonly (Strother, 1999). And they are well known to the people who have livestock or engage in outdoor activities.

The adult body size ranges from approximately 6-30mm, some species even bigger. Tabanids are robust insects, with a yellow to black body in deerfly, dark brown or black body in horsefly. They are consisted of head, thorax, and abdomen, with various appendages inserted on the three parts. Paired prominent compound eyes constitute the large portion of the face, separated in female, but touched in male; in female, a strip between the eyes called frons bears one or more bare, shining calli, which is used in specific classification; antennae originate on the subcallus, and are composed of three segments, and the third segment called flagellum is consisted of basal portion and terminal annulations, having species difference. Thorax usually has some stripes on dorsal, and has wings, legs on lateral; forewings are membranous, with three types of mottled pattern, banded pattern, clear pattern, hind wings are vestigial to halter; all tabanids have spur in mid-leg, but presence or absence in hind leg depending on subfamilies. Abdomen is dorso-ventrally compressed and oval-shaped, also has 3 types: (1) a mid-dorsal stripe with or without lateral spots on at least terga 1 to 3; (2) wide showy bands on the apex of each tergum; (3) no definite color pattern (Murdoch and Takahasi 1969; Oldroyd, 1952; Strother, 1999).

The eggs are spindle-shaped, brown to black. The larvae are white to tan, with a slender, cylindrical body that is slightly tapered at the head. The head contains two sharp, slender mandibles that possess a hollow canal. The pupae have a hard chitinous covering and rings of backward pointing spines on each abdominal segment (Murdoch and Takahasi 1969; Oldroyd, 1952; Strother, 1999). Tabanids are holometabolous insects. Therefore, they go through the life stages of egg, larva, pupa and adult. Usually, eggs are laid in large, layered clusters of 100-1000 on vegetation or other objects overlying water or moist soil. The larvae are aquatic, semi-aquatic, or terrestrial. When they hatch from the

eggs, they quickly drop to the water or soil below where they become voracious predators of other invertebrates or small vertebrates. The larvae undergo several molts as they grow and depending on the species, the larval stage may last a several months or as long as two to three years. Once the larvae are fully developed, they move into drier soil beneath the ground surface to pupate. Depending on the species, the pupal stage lasts approximately 5-21 days, and then the adult flies emerge from the soil. Mating occurs shortly when they step into the adult stage (Strother, 1999).

And not laying eggs until the female get a blood meal (Strother, 1999). Blood meal is important to female tabanids for breeding the next generation. To obtain the nutrition of the growth of ovary, the female of many species acts one of the most blood-sucking pests in the world. Because of its large amount of the blood meal, they like continuing to attack hosts and ignore the defense of hosts, till they satisfy their gut full. Therefore, their feeding behavior will cause the hosts to bring the mechanical transmission of many kinds of disease pathogens, such as virus, bacteria, protozoa and filarial nematode (Krinsky, 1976). Those pathogens cause around 25 different types of animal diseases (Foil, 1989), such as, trypanosomiasis, equine infectious anemia, bovine leukemia virus etc. The feeding behavior of the fly also affects the decrease of milk production of dairy cattle and daily gain of livestock. Tabanids transmit the filarial parasite named *Loa Loa* to human in West Africa. Their attacks cause strong pain to both humans and livestock. So they are regarded as the medical and veterinary important insects in human society (Sasaki and Watanabe, 2016; Murdoch and Takahasi 1969; Xu and Sun, 2013).

It is necessary to identify what species they are, to control them absolutely. Up to the present, about 4500 tabanids species have been recorded in the world, and are classified into three subfamilies, nine tribes and 137 genera (Xu and Sun, 2013). Within the species, 9 genera 99 species can be found in Japan and 38 species of 7 genera are recorded from Hokkaido (Sasaki and Watanabe, 2016). Usually, researchers use female tabanids as the research object. The reason is that females are easier encountered and captured than males. This is a quite difference, comparing with others groups of this order, which the researchers always use male to be the material for classification.

Reviewing the research history about the morphology on its female genitalia of tabanids, it was not evaluated highly at first. The primary opinion of many scholars was useless on taxonomy (Ovazza and Taufflieb, 1954). Brygoo (1950) thought it was not worth researching further after he dissected several species. According to the study on three species of female *Theriopectes*, Collin (1940)

indicated that the cercus and the sternite may be useful for classification. After that, Oldroyd (1952) thought on certain features can be used in some species (Ovazza and Taufflieb, 1954). Murdoch and Takahasi (1959) stated that primary characteristics showing greatest variability are the shape of the sternite 10, cerci, and the shape of the genital fork; characteristics showing less variation but still of taxonomic value are tergites 8 and 9, spermathecae, and the mushroom-shaped ends of the spermathecal ducts after they dissected and compared the *Tabanus amaenus* Group (Murdoch and Takahasi, 1959). Deep discussion about the morphology on its genitalia of Tabanidae is considered to become more and more necessary with development of further study.

Up to now, the systematic study on it is still incomplete. In this context, I did a study about the female genitalia of 6 genera and 24 species of tabanids inhabiting Hokkaido, Japan. This is the first report on the female genitalia of tabanids inhabiting Hokkaido. Further, we try to evaluate that it is usefulness of the morphology of female genitalia for the identification according the common and different among the subfamilies, genera, and species.

Materials and Methods

Tabanids belonging to 3 subfamily, 6 genera and 24 species, namely *Tabanus trigonus* Coquillett, 1898, *T. nipponicus* Murdoch et Takahasi, 1969, *T. rufidens* (Bigot, 1887), *T. sapporoensis* Shiraki, 1919, *T. iyoensis* Shiraki, 1918, *T. kinoshitai* Kono et Takahasi, 1939, *T. mandarinus* Coquillett, 1898, *T. katoi* Kono et Takahasi, 1940, *T. chrysurus* Loew, 1858, *T. fulvivedioides* Shiraki, 1918, *T. palliliventrif* Olsoufieff, 1937, *Hybomitra distinguenda* (Verrall, 1909), *H. hirticeps* (Loew, 1858), *H. tarandina* (Linnaeus, 1758), *H. olsoi* Takahasi, 1962, *H. montana* (Meigen, 1820), *Haematopota tristis* Bigot, 1891, *Hae. tamerlani* Szilady, 1923, *Atylotus horvathi* (Szilady, 1926), *Chrysops suavis* Loew, 1858, *C. japonicus* Wiedemann, 1828, *C. nigripes* Zetterstedt, 1840, *C. vanderwulpi* Krober, 1929 and *Stonemyia yezoensis* (Shiraki, 1918) were examined (Plate. 26-29). All specimens were collected in Hokkaido, Japan by myself and H. Sasaki by the means of Nzi trapping and hand netting method. Captured flies were preserved with 70% Ethyl Alcohol in micro vials till the dissection. Some specimens examined were pinned and dried specimens, and were macerated with physiological saline just before dissection.

Specimens with physiological saline were dissected in the petri dish with needle and tweezers under the binocular microscope. Sternite 8, tergite 9, tergite 10, cercus, genital fork, spermathecae and spermathecal duct were removed from the body and separated, then their shapes were drawn. Terminology will be shown at Plate. 1.

Results

General characters of female genitalia of Tabanidae

The tergite 9 is divided into two pieces and usually widely separated each other and much smaller than tergite 10. That of Pangoniinae is a transverse bar and not divided and that of some species of this subfamily is larger than tergite 10 (Mackerras, 1956, 1960), but in Tabaninae and Chrysopsinae, it is divided and widely separated triangular plates. The shape of most species is triangle or crescent shape.

Tergite 10 is elongated transversely and divided into two pieces which are closed or connected each other. The shape is commonly rectangle or trapezoid in Tabaninae and Pangoniinae, but in Chrysopsinae it is triangle.

Cercus is simple forming with only 1 segment, shape is generally scale-like, and its width is around as long as the length commonly (Iwata and Nagatomi, 1976), among the subfamilies, it is hard to obtain a result from morphology.

Sternite 8 is called star-like by Iwata and Nagatomi (1976). But it is better to describe the shape as alike to ancient Chinese bronze pottery. Two star-like processes exist at the both sides of Sternite 8 in Tabaninae. Sternite 8 of Chrysopsinae is the shape of a water vat, and that of Pangoniinae is hexagon.

Genital fork is tongs-like and having two pieces of crescent moon- or peltate-like membranes at each side of it. The mid-distal part of genital fork is not elongated to apex, rather it elongates toward the base of abdomen.

Spermathecal duct is usually elongated and tenuous, but only that of Chrysopsinae is short and loose. The basal part of spermathecal duct of Pangoniinae and Chrysopsinae has no expansion, but that of Tabaninae has mushroom-like expansion.

The shape of spermatheca is usually fusiform but that of some species shows band form (Table 1).

Description

Subfamily Pangoniinae

Genus *Stonemiya* Brennen, 1935

Stonemyia yezoensis (Shiraki, 1918) (Plate. 2)

Tergite 9 not divided into a pair but connected together at middle, and right angled triangle shape, all darken; tergite 10 trapezoid and with inner margin shorter than outer margin, all darken; cercus scale-like, posterior margin pointed bluntly to some extent, all darken; sternite 8 wider than length clearly, widest at middle, hexagon-like, with the anterior margin nearly straight, and posterior margin concave distinctly, darken at some area; spermathecae expanding into circular, darken; spermathecal duct is a little stout at apical, and turning slender into basal, no expansion at the end, transparent; genital fork tong-like, with small peltate-like membranes at both sides.

Specimen examined: 1♀, stored in alcohol, Ebetsu, Hokkaido, Aug. 11 2016, C. Yang.

Subfamily Chrysopsinae

Genus *Chrysops* Meigen, 1803

The common features in the 4 species of this genus: *Chrysops suavis*, *C. japonicus*, *C. nigripes*, *C. vonderwulpi*, are as followed: tergite 9 is quite separated from each other, tapering inward and the anterior margin appears to be concaved, except *Chrysops vonderwulpi*; tergite 10 is roughly triangular but not so sharply pointed at the apical, this is a significant distinguish to other two subfamily; the posterior margin of cercus is rounded; sternite 8 is like water vat, widest near base; the apical of spermathecal duct is as fat as spermatheca, and turn slender into basal, no expansion at end of base; genital fork is tong-like, with two big peltate-like membranes.

Chrysops suavis Leow, 1858 (Plate. 3):

Tergite 9 separated and concaved distinctly at its anterior margin, crescent shape, all darken; tergite 10 triangle with the a dull apical tapering outward, all darken; cercus scale-like, rounded at posterior margin, all darken; sternite 8 looked like vat, gently convex at anterior margin and lightly concaved at posterior margin, widest at basal, darken in some extent, having individual difference by observed; spermatheca big comparing the whole size of spermathecal duct, and turn slender into basal, no expansion at end of base; genital fork is tong-like, with small angle at each antelateral part and two big peltate-like membranes at basal part,.

Specimens examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Jul. 17 2015, Jul. 15, Aug. 11 2016, C. Yang.

Chrysops japonicus Wiedemann, 1833 (Plate. 4):

Tergite 9 and 10 similar to that of *C. suavis*, all darken; cercus is comparatively short, rounded and darken; sternite 8 also vat-like, but anterior part is wider than posterior part, rounded smoothly at anterior margin, no concaved at posterior margin, but distinctly concaves at middle of the outer margin; spermathecae sharp at apical, big size and longer than the other three species; spermathecal duct slender from apical to basal, no expansion at the end; genital fork the same with *Chrysops suavis*, no angle.

Specimen examined: 1♀, stored in alcohol, Tsukigata, Hokkaido Jun. 18 2015, H. Sasaki; 1♀, dried, Tobetsu, Hokkaido, Jun. 6 1985, H. Sasaki.

Chrysops nigripes Zetterstedt, 1840 (Plate. 5):

Tergite 9 comparatively small in size, all darken slightly; tergite 10 sharper at outer margin, lightly darken; cercus comparatively long, lightly darken; sternite 8 vat-like, anterior margin little pointed, posterior margin concaved gently, the base of outer margin straight, mid-distal part slightly concave, darken in some extent; spermathecae and spermathecal duct are similar to *C. suavis*; genital fork also same with *C. suavis*, but no angle at antelateral.

Specimen examined: 1♀, dried, Tsurui, Hokkaido, Jul. 30 1975, H. Sasaki.

Chrysops vonderwulpi Krober, 1885 (Plate. 6):

Tergite 9 small triangle shape, quite separated from each other, all yellowish; tergite 10 triangle shape, outer angle dull, all yellowish; cercus comparatively long and round at posterior margin, all yellowish; sternite 8 close to square at the front-mid part, absolutely concaved at basal lateral margin and posterior margin; spermathecae big and long, all black; spermathecal duct turning slender into basal, no expansion at end; genital fork is tong-like, pointed at antelateral part and concaved at anterior margin.

Specimen examined: 1♀, dried, Okushiri, Hokkaido, Aug. 2 1986, H. Sasaki.

Subfamily Tabaniinae

Genus *Atylotus* Osten-Sacken, 1876

Atylotus horvathi (Szilady, 1926) (Plate. 7):

Tergite 9 small triangle, and quite separated with each other, all yellowish; tergite 10 around rectangle, with some long hair, all lightly darken; cercus

scale-like, comparatively long, lightly darken at the inner angle of the basal and posterior margin pointed distinctly, other part yellowish; sternite 8 star-like, with two processes darken, the anterior margin distinctly straight, and posterior margin rounded and concaved at middle, other part yellowish; spermathecae slightly expansion, fusiform and darken; spermathecal duct long and slender, forepart lightly darken, posterior part transparent and having mushroom-shaped expansion at end; genital fork tong-like, concaved at anterior margin, with two angles at antelateral and two crescent shape membranes at both sides.

Specimen examined: 2♀, stored in alcohol, Shizunai, Hokkaido, Jul. 29 2016, Aug. 15 2016, C. Yang.

Genus *Haematopota* Meigen, 1803

Haematopota tristis Bigot, 1891 (Plate. 8):

Tergite 9 roughly triangle, tapering inward, a little dark at inner angle, other part yellowish; tergite 10 roughly oval, with distinctly hair, all yellowish; cercus scale-like, with posterior margin processed clearly, all yellowish; sternite 8 processed at apical angles, darken at both lateral parts, and the other portion yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, with forepart is lightly darken, posterior part transparent, and having mushroom-shaped expansion at end; genital fork is tong-like, anterior margin concaved, with crescent shape membrane at beside.

Specimen examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Aug. 15 2015, Aug. 11 2016, Aug. 11 2016, C. Yang.

Haematopota tamerlani Szilady, 1923 (Plate. 9):

Tergite 9 triangle, tapering inward, but comparatively slender, all lightly darken; tergite 10 trapezoid, outer margin wider than inner margin, all lightly darken; cercus smooth rounded, with a light stripe at middle, and darken at apical and basal; sternite 8 star-like, comparatively short, with distinctly concave at anterior margin, lateral margin and posterior margin, around little darken, but central yellowish; spermathecal, spermathecal duct and genital fork are fail to be observed.

Specimen examined: 2♀, dried, Kiyosato, Hokkaido, Jul. 19 1989. H. Sasaki.

Genus *Hybomitra* Enderlein, 1922

Hybomitra hirticeps (Loew, 1858) (Plate. 10):

Tergite 9 triangle, tapering inward sharply, all darken; tergite 10 around

rectangle, all darken; cercus wider than long, roughly rectangle, all darken; sternite 8 star-like, anterior, lateral of forepart and posterior margins concave in some extent, and darken, the other part lightly darken, with two stripes through middle; spermathecae expanding to fusiform, all darken; spermathecal duct is long and slender, having mushroom-shaped expansion at end, all lightly darken; genital fork is tong-like, with two crescent shape membranes, but rather slender.

Specimen examined: 1♀, stored in alcohol, Tsukigata, Hokkaido, Jun. 18 2015, H. Sasaki

Hybomitra distinguenda (Verrall, 1909) (Plate. 11):

Tergite 9 triangle, outer margin rounded, all yellowish; tergite 10 around rectangle, with dull angle at apical of inner margin, all yellowish; cercus scale-like, processed at posterior margin, yellowish with some black spots at apical; sternite 8 comparatively stout, star-like, distinctly concaved at anterior margin and posterior margin, darken at lateral and slightly darken at central; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, all transparent, having mushroom-shaped expansion at end; genital fork is tong-like, with two boat-shaped membranes.

Specimen examined: 2♀, stored in alcohol, Shizunai, Hokkaido, Jul. 16 2015, Jul. 14 2016, C. Yang.

Hybomitra montana (Meigen, 1920) (Plate. 12):

Tergite 9 triangle, tapering inward sharply, posterior margin smoothly rounded, all yellowish; tergite 10 roughly trapezoid, apical of outer margin concaved distinctly, all yellowish; cercus scale-like, posterior margin rounded, all yellowish; sternite 8 star-like, with two dull angle at forepart, anterior margin concaved but nearly straight, posterior margin concaved lightly, darken at both lateral parts, the others yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, transparent, with mushroom-shaped expansions at end; genital fork is tong-like, little stout, with two stout crescent shape membranes.

Specimen examined: 1♀, dried, Matsuyama Moor Bifuka, Hokkaido, Aug. 20 2006, H. Sasaki.

Hybomitra olsoi Takahasi, 1962 (Plate. 13):

Tergite 9 triangle, comparatively small, outer margin darken, other part lightly darken; tergite 10 around rectangle, with apical of outer margin and

inside of posterior margin concaved slightly, all darken lightly; cercus comparatively long, scale-like, posterior part darken extending to outside of anterior margin, other part darken lightly; sternite 8 star-like, with anterior margin and posterior margin concaved, and darken at lateral part, little darken at anterior part and central part; spermathecae expanding to fusiform, darken extending to part of spermathecal duct; spermathecal duct long and slender, transparent, with mushroom-shaped expansion at end; genital fork is tong-like.

Specimen examined: 1♀, dried, Matsuyama Moor Bifuka, Hokkaido, Aug. 20 2006, H. Sasaki.

Hybomitra tarandina (Linnaeus, 1758) (Plate. 14):

Tergite 9 triangle, but anterior margin nearly straight, with lightly darken, posterior margin slanting inward, yellowish; tergite 10 roughly parallelogram, all darken slightly; cercus comparatively short, rounded at posterior margin, inner angle of anterior part lightly darken, other part yellowish; sternite 8 star-like, apical angle bluntly pointed, little darken, anterior margin concaved and straight, lateral part darken, has a darken stripe at central, posterior margin concaved distinctly, other part yellowish; it is fail to observe spermatheca, spermathecal duct, and genital fork.

Specimen examined: 1♀, dried, Mt. Taisetsu, Hokkaido, Jul. 26 1983, H. Sasaki.

Genus *Tabanus* Linnaeus, 1758

Tabanus chrysurus Leow, 1858 (Plate. 15):

Tergite 9 comparatively stout, roughly triangle, little darken at anterior part and deeper darken at posterior part; tergite 10 around triangle, tapering outward, concaved at posterior margin, all darken slightly; cercus circular, all lightly darken; sternite 8 star-like, with apical angle pointed sharply, anterior and posterior margin concaved, darken at lateral part, other part lightly darken; spermathecae expanding to fusiform, darken; spermathecal duct is long and slender, forepart darken lightly, posterior part transparent, with mushroom-shaped expansion at end; genital fork tong-like, with two crescent shape membranes.

Specimen examined: 2♀, stored in alcohol, Shizunai, Hokkaido, Aug. 15 2015, Aug. 11 2016, C. Yang.

Tabanus iyoensis Shiraki, 1918 (Plate. 16):

Tergite 9 around right angled triangle shape, all darken lightly; tergite 10

rectangle, posterior margin concaved, all slightly darken; cercus scale-like, posterior margin rounded, all slightly darken; sternite 8 comparatively long, anterior margin arc-like concaved lightly, posterior margin concaved distinctly, lateral parts darken, other part yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, transparent, with mushroom-shaped expansion at end; genital fork is tong-like, with two membranes.

Specimen examined: 2♀, stored in alcohol, Shizunai, Hokkaido, Aug. 12 2015, Aug. 11 2016, C. Yang.

Tabanus trigonus Coquillett, 1898 (Plate. 17):

Tergite 9 triangle shape, tapering inward, all lightly darken; tergite 10 around trapezoid, outer margin smoothly curved downward, all darken slightly; cercus scale-like, with posterior margin bluntly processed, all lightly darken; sternite 8 comparatively long and slender, anterior margin and posterior margin concaved distinctly, lightly darken at central anterior part, and darken at lateral parts, other parts yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, lightly darken at anterior part, and transparent at posterior margin, with mushroom-shaped expansion at end; genital fork is tong-like.

Specimen examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Jul. 17 2015, Jul. 15 2016, C. Yang.

Tabanus katoi Kono et Takahashi, 1940 (Plate. 18):

Tergite 9 triangle shape, with dull angles, all yellowish; tergite 10 trapezoid, slanting downward, little concaved at posterior margin, all yellowish; cercus around rounded, all yellowish; sternite 8 comparatively long and slender, anterior margin deeply concaved, posterior margin distinctly concaved, lateral parts darken, other part yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, transparent, with mushroom-shaped expansion at end; genital fork tong-like, membranes comparatively small.

Specimen examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Aug. 13 2015, Aug. 11 2016, C. Yang.

Tabanus sapporoensis Shiraki, 1918 (Plate. 19):

Tergite 9 triangle shape, tapering inward sharply, all yellowish; tergite 10 roughly trapezoid, anterior margin concaved, outer margin wider than inner

margin, all yellowish; cercus scale-like, with posterior margin processed, all yellowish; sternite 8 star-like, with anterior margin straight, and two small angles at apical, posterior part bigger than anterior part, and concaved, lateral parts darken, other part yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, transparent, with mushroom-shaped expansion at end; genital fork tong-like.

Specimen examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Aug. 15 2015, Aug. 11 2016, Aug. 12 2016, C. Yang.

Tabanus fulvemediodes Shiraki, 1918 (Plate. 20):

Tergite 9 triangle, with dull angles, posterior part lightly darken, anterior part yellowish; tergite 10 around triangle, tapering inward bluntly, all slightly darken; cercus scale-like, with posterior margin dull pointed, all yellowish; sternite 8 star-like, with anterior margin straight, posterior margin concaved deeply, lateral part darken, with three stripes at central part, posterior part little darken, other part yellowish; spermathecae not expanding to fusiform, belonged a part of spermathecal duct; spermathecal duct comparatively long, slender, forepart darken, posterior part transparent, with mushroom-shaped expansion at end; genital fork is tong-like, comparatively slender, and membranes comparatively big.

Specimen examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Jul. 17 2015, Jul. 14 2016, Aug. 12 2016, C. Yang.

Tabanus kinoshitai Kono et Takahashi, 1939 (Plate. 21):

Tergite 9 triangle shape, tapering inward sharply, and the middle of anterior margin little pointed, all darken lightly; tergite 10 around parallelogram, with apical part of outer margin little concaved, all slightly darken; cercus scale-like, with anterior margin concaved and posterior margin processed, all lightly darken; sternite 8 star-like, comparatively short and small, with anterior margin straight, posterior margin concaved distinctly, lateral part darken, other part yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct comparatively short, transparent, with mushroom-shaped expansion at end; genital fork tong-like, comparatively big, with two crescent shape membranes.

Specimen examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Jul. 3 2015, Jul. 1 2016, Jul. 1 2016, C. Yang.

Tabanus mandarinus Schiner, 1868 (Plate. 22):

Tergite 9 triangular, tapering inward sharply, with little darken at central anterior margin, other part yellowish; tergite 10 roughly trapezoid, with anterior margin and posterior margin concaved, outer margin wider than inner's, all darken slightly; cercus circular, scale-like, all darken lightly; sternite 8 star-like, apical angles processed obviously, anterior margin and posterior margin concave clearly, almost part darken but forepart lightly darken, with two stripes throughout the middle part; spermathecae expandind to fusiform, all darken; spermathecal duct long and slender, with forepart lightly darken, posterior part transparent, and with mushroom-shaped expansion at end; genital fork tong-like.

Specimen examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Jul. 16 2015, Jul. 15 2016, Jul. 15 2016, C. Yang.

Tabanus nipponicus Murdoch et Takahashi, 1969 (Plate. 23):

Tergite 9 triangle shape, with sharp angles obviously, all yellowish; tergite 10 roughly trapezoid, outer margin wider than inner margin, with edges of the anterior margin processed gently, all yellowish; cercus scale-like, posterior margin processed inward, and posterior part lightly darken, other part yellowish; sternite 8 comparatively long and slender, anterior margin deeply concaved, and apical angles processed obviously, posterior margin also concaved, darken at lateral part and posterior part, other part yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, darken at forepart, transparent at posterior part, with mushroom-shaped expansion at end; genital fork tong-like.

Specimen examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Jul. 16 2015, Jun. 30 2016, Aug. 11 2016, C. Yang.

Tabanus pallidiventris Olsufjev, 1937 (Plate. 24):

Tergite 9 triangle shape, all yellowish; tergite 10 around trapezoid, with edges of anterior margin processed obviously, posterior margin concaved gently, outer margin wider than inner margin, all yellowish; cercus scale-like, with posterior part little darken, other part yellowish; sternite 8 comparatively long, especially the anterior part, anterior margin deeply concaved, and apical angles processed obviously, posterior margin also concaved, darken at lateral part and posterior part, other part yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, all transparent, with mushroom-shaped expansion at end; genital fork tong-like.

Specimen examined: 1♀, dried, Shizunai, Hokkaido, Jul. 28 1990, H. Sasaki.

Tabanus rufidens (Bigot, 1887) (Plate. 25):

Tergite 9 triangular, with outer margin darken lightly, other part yellowish; tergite 10 roughly rectangle shape, with outer margin, anterior margin and posterior margin concaved distinctly, all yellowish; cercus circular, all yellowish; sternite 8 comparatively long and stout, anterior margin deeply concaved, and apical angles processed obviously, posterior margin also concaved, darken at lateral part and angle part, other part yellowish; spermathecae expanding to fusiform, all darken; spermathecal duct long and slender, all transparent, with mushroom-shaped expansion at end; genital fork tong-like.

Specimen examined: 3♀, stored in alcohol, Shizunai, Hokkaido, Aug. 15 2015, Aug. 11 2016, Aug. 11 2016, C. Yang.

Discussion

In this paper, I describe the shapes and its pigmented areas of tergite 9, tergite 10, cercus, spermatheca, spermathecal duct, and genital fork of the female tabanids inhabiting Hokkaido Japan. Based on the differences of these structures, it is intelligible to make a distinction among the subfamilies of Tabanidae.

Tergite 9 of the subfamily Pangoniinae is quite different from the subfamily Chrysopsinae, and Tabaninae. That of Pangoniinae is connected with each other, but those of the other two subfamilies are separated away, these results are same with Mackerras (1956, 1960). The other difference is found in the shape of sternite 8, its lateral part is big and projected, and at lateral margin it is not concave. The last obvious difference is that the shape of spermathecae is circular.

The subfamily Chrysopsinae also has several differences that can distinguish from the other two subfamilies. One is that the shape of tergite 10 is roughly triangle with outer angle dull. The second point is that the shape of sternite 8 is looked like a water vat, its upper margin is widest, and without visible process at lateral margin. Next difference is that spermathecae is comparatively big, and connect with spermathecal duct smoothly, and with no expansion. The last place is that the shape of genital fork membranes, of the subfamily are peltate-like. These results confirmed Iwata and Nagatomi (1976).

The differences of the subfamily Tabaninae are the shape of lateral part of sternite 8, shape of spermatheca, shape of the end of spermathecal duct and shape of genital fork membrane. Lateral part of sternite 8 is always pointed; and spermatheca expands fusiformly, except in *Tabanus fulvimedoides*. The end of spermathecal duct has mushroom-like expansion; and genital fork membrane is roughly crescent shape. Great variabilities of cercus and genital fork are not showed in this study compared with the conclusion of Murdoch and Takahasi (1959). Instead, tergite 10, spermathecae, and mushroom-shaped ends of the spermathecal ducts are showing more variation in taxonomic value.

Among the genera, it is hard to get the common points to distinction. Among species, only in the genus *Chrysops* the species are similar to each other; in others genera, the species are very different in structures. The same conclusion was shown by Mackerras (1956). On the one hand, tergite 9, tergite 10, sternite 8, spermatheca and genital fork membrane can be basis to separate subfamilies of Tabanidae of Hokkaido. However, the further studies are needed to identify the genera and species of Tabanidae by the feature of female genitalia.

Abstract

Only a few studies on the morphological characteristics of female genitalia of tabanids are found in the past 60 years. And no reports about the tabanids inhabiting Hokkaido can be seen in this respect. In this study, I reported the main features of female genitalia of some tabanids of Hokkaido, Japan. I examined 24 species out of 3 subfamilies and 6 genera of tabanids of Hokkaido. The examined parts are tergite 9, tergite 10, cercus, sternite 8, spermathecae, spermathecal duct and genital fork. The results show that: both right and left tergite 9 of species of the subfamily Pangoniinae tied each other, but those of the species of the subfamily Tabaninae and Chrysopsinae are not connected; the shape is roughly triangular in the subfamily Pangoniinae and Tabaninae and *Chrysops vanderwulpi*, and those of the subfamily Chrysopsinae are crescent shape. In the subfamily Chrysopsinae, tergite 10 is triangular shape tapering outward; the other two subfamilies are not like that. Sternite 8 of the subfamily Tabaninae is star-like, and those of the subfamily Chrysopsinae and Pangoniinae are like vats and hexagon. Spermathecae of the subfamily Pangoniinae is circle, but stout and big in the subfamily Chrysopsinae, and the subfamily Tabaninae, except of band shaped *Tabanus fulvimediodes*, spermathecae is fusiform. Spermathecal duct of the subfamily Chrysopsinae is comparatively short and stout at apical part, and at the base is slender, but that of the subfamily Tabaninae is comparatively long, except *Tabanus kinoshitai* species of the subfamily Tabaninae have a mushroom-shaped expansion at the end, but no expansion is seen in the subfamily Chrysopsinae and Pangoniinae. Membranes of genital fork of the subfamily Tabaninae are fan-shaped or crescent shape, but in the subfamily Chrysopsinae and Pangoniinae, it is peltate. These are the differences of subfamily level. To the genus and species level classification, to combine the characteristics of tergite 9, tergite 10, cercus, sternite 8, spermathecae, spermathecal duct and genital fork is required.

Key word: Tabanidae, Diptera, female genitalia, morphology, Hokkaido.

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和文摘要

分類の基準が雌成虫の形態に置かれているにもかかわらず、双翅目アブ科の雌生殖器の形態は、過去 60 年以上にわたってあまり調査されていなかった。そこで、北海道に生息する 3 亜科 6 属 24 種の第 9 背板、第 10 背板、尾角、第 8 腹板、受精囊、受精囊管、生殖叉器を精査し、亜科、属、種レベルの分類に用いることが可能か否かの検討を行った。その結果、マルガタアブ亜科の第 9 背板は左右に連結しているが、アブ亜科とキンメアブ亜科の種類では繋がっていない、マルガタアブ亜科、アブ亜科とキンメアブ亜科のヨスジキンメアブの第九背板はほぼ三角形だが、キンメアブ亜科は三日月形、第 10 背板はキンメアブ亜科では三角形で、外に向かって鈍くとがるが、他の 2 亜科ではそうならない、アブ亜科の第 8 腹板は星状だが、キンメアブ亜科とマルガタアブ亜科では壺状か六角形、受精囊はマルガタアブ亜科では丸型、キンメアブ亜科は肥厚して大きくて、アブ亜科は帯状のキスジアブを除いて紡錘状、受精囊管はキンメアブ亜科では先端が相対的に肥厚し短く底部は先細り、アブ亜科はキノシタシロフアブを除いて相対的に長く受精囊管の後ろにきのこ形の拡張体を付属するが、キンメアブ亜科とマルガタアブ亜科では拡張体が見られない、生殖叉器の膜はアブ亜科では扇形か三日月形だが、キンメアブ亜科とマルガタアブ亜科では盾状など、亜科レベルでは区別が可能であった。また、属、種レベルの分類では、これらの形態的特徴を組み合わせることで分類することが可能であることが判った。以上の結果から、北海道に生息するアブ類の分類に雌生殖器の形態を用いることの有用性が明らかとなった。

Plate. 1

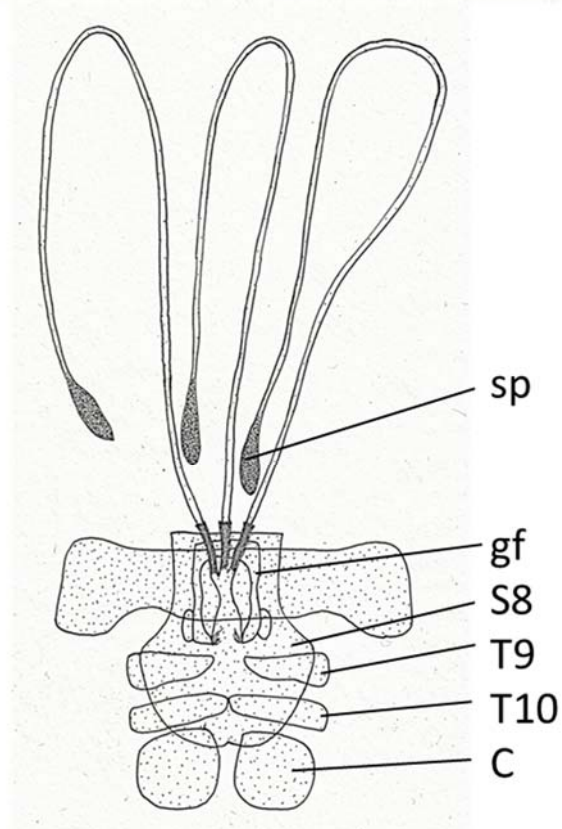
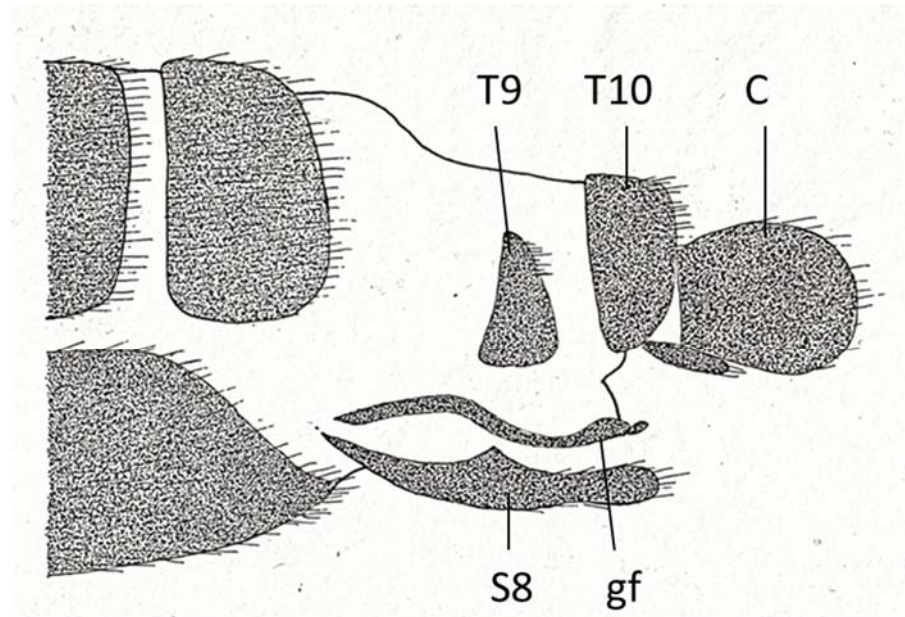


Plate. 1: T9: tergite 9, T10: tergite 10, C: cercus, S8: sternite 8, sp: spermathecae, gf: genital fork (explanation of the abbreviations are common with Plate. 2-25).

Plate. 2

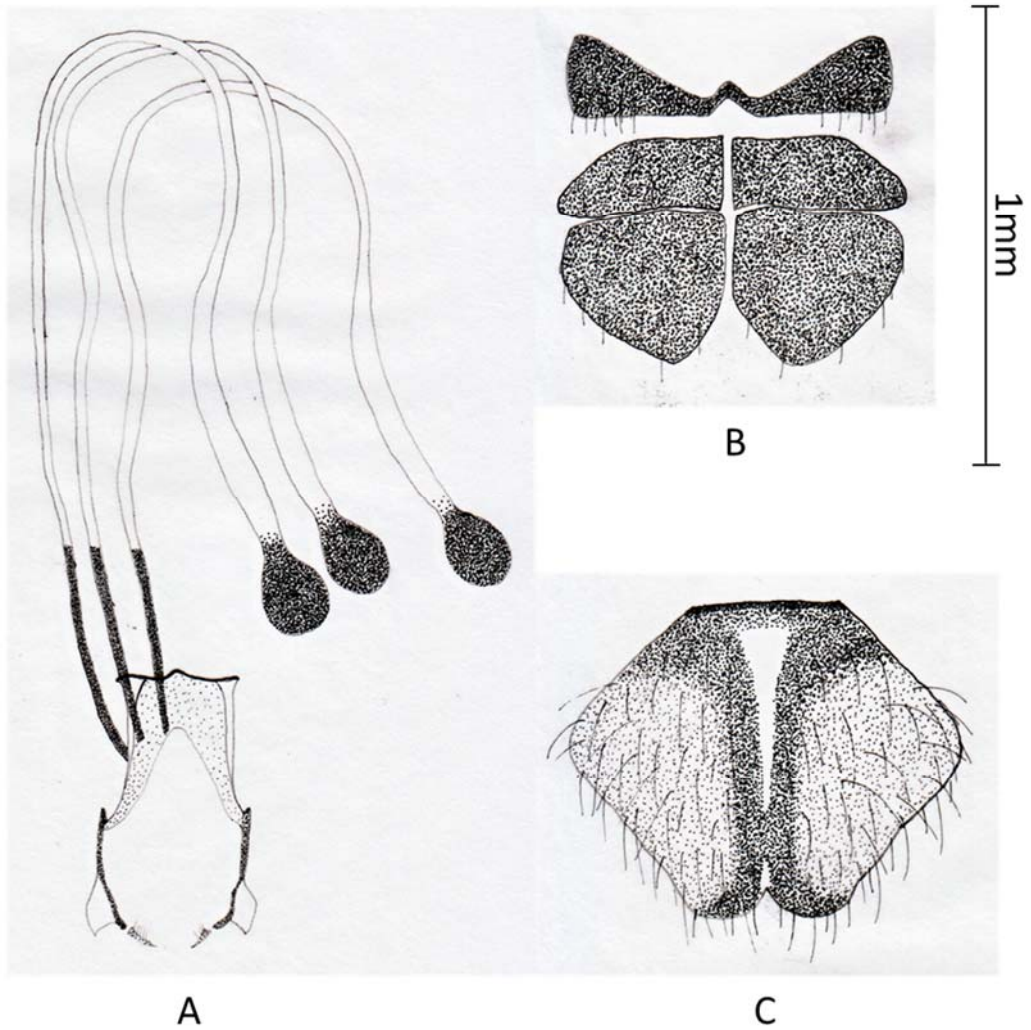
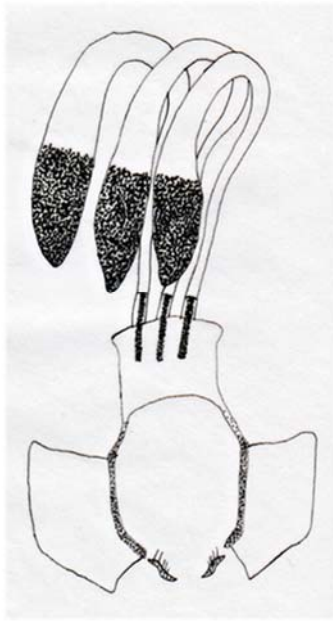
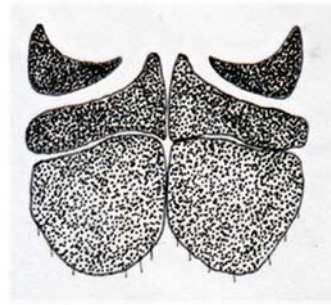


Plate. 2: *Stonemyia yezoensis* (Shiraki, 1918) ♀
A: sp and gf; B: T9-10, and C; C: S8

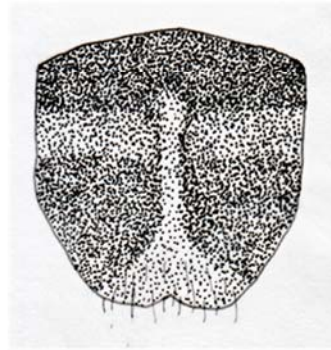
Plate. 3



A



B



C

Plate. 3: *Chrysops suavis* Leow, 1858 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 4



A



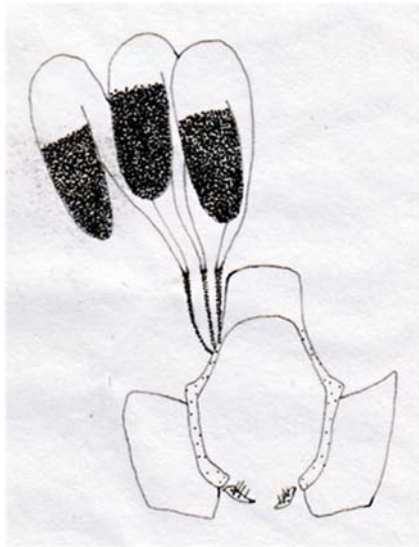
B



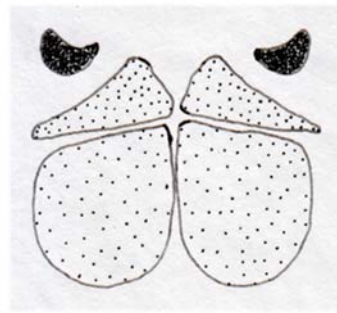
C

Plate. 4: *Chrysops japonicus* Wiedemann, 1833 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 5



A



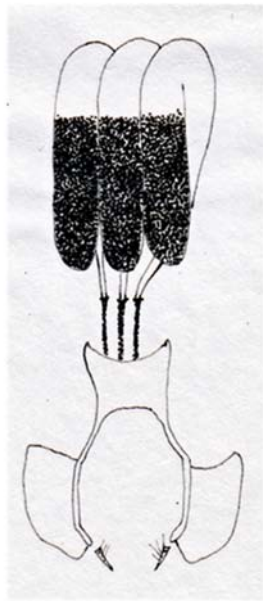
B



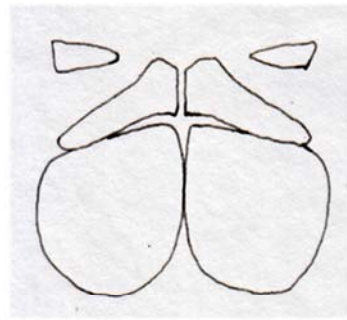
C

Plate. 5: *Chrysops nigripes* Zetterstedt, 1840 ♀
A: sp and gf; B: T9-10, and C: C: S8

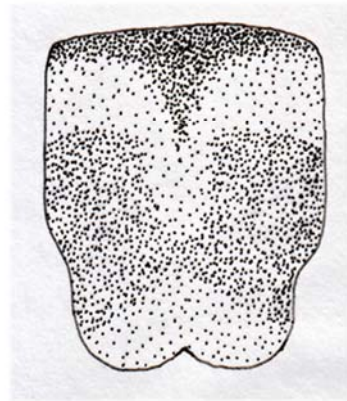
Plate. 6



A



B



C

Plate. 6: *Chrysops vanderwulpi* Krober, 1885 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 7

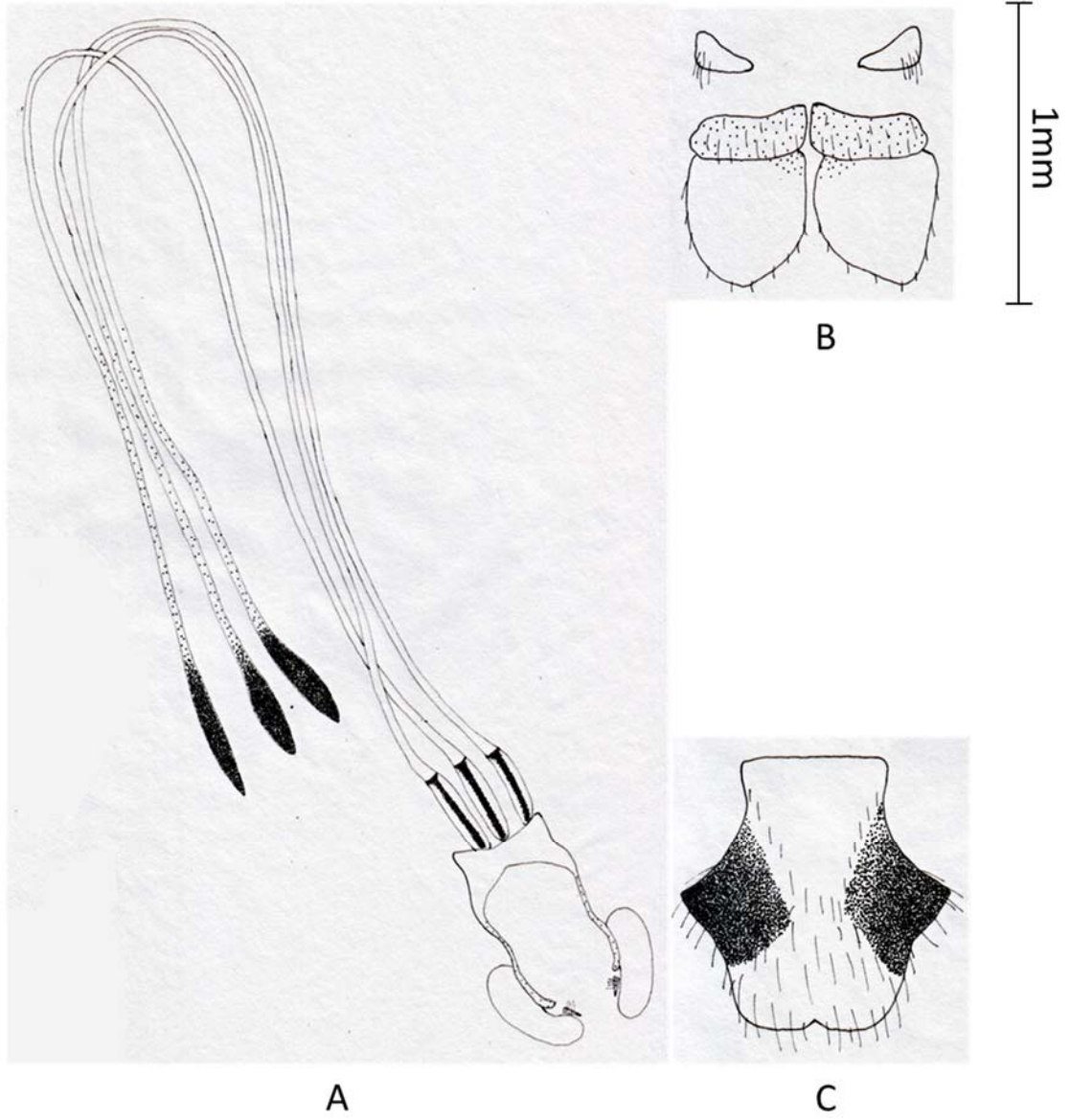
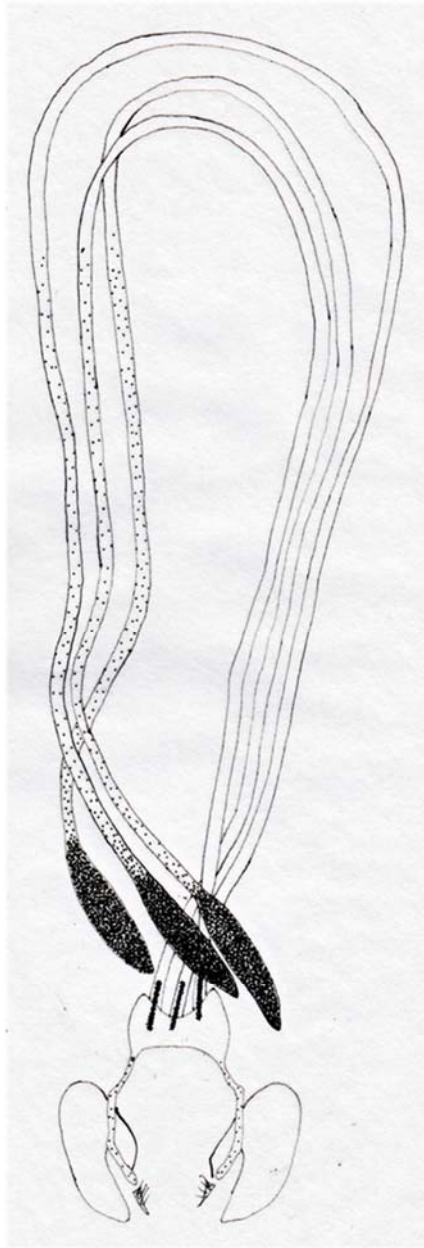


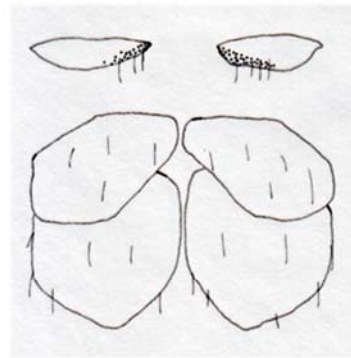
Plate. 7: *Atylotus horvathi* (Szilady, 1926) ♀

A: sp and gf; B: T9-10, and C: C: S8

Plate. 8



A



B

1mm

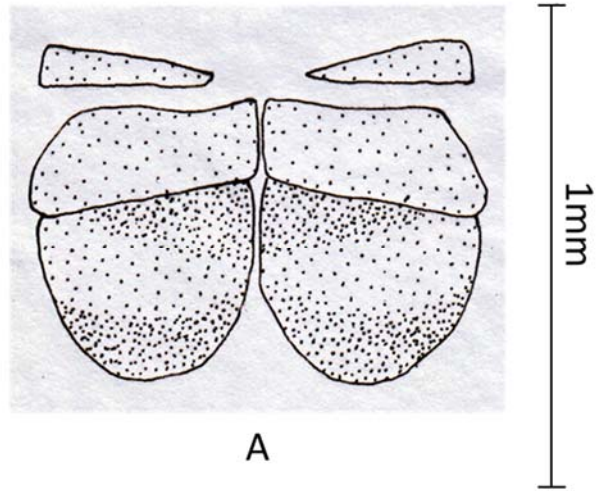


C

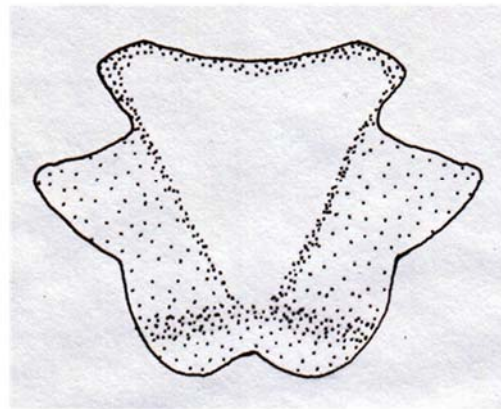
Plate. 8: *Haematopota tristis* Bigot, 1891 ♀

A: sp and gf; B: T9-10, and C: C: S8

Plate. 9



A

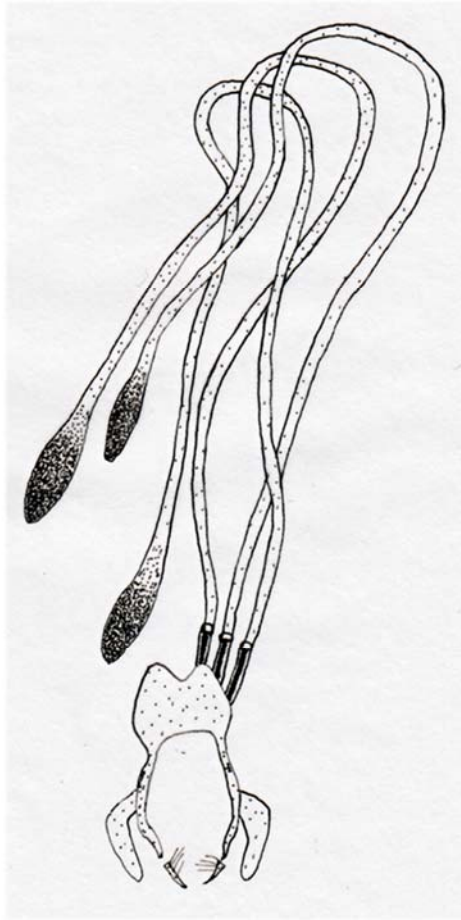


B

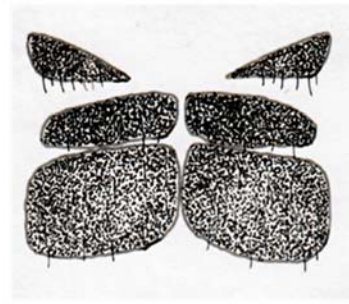
Plate. 9: *Haematopota tamerlani* Szilady, 1923 ♀

A: T9-10, and C; B: S8

Plate. 10

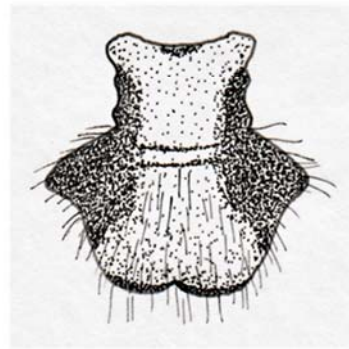


A



B

1mm



C

Plate. 10: *Hybomitra hirticeps* (Loew, 1858) ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 11

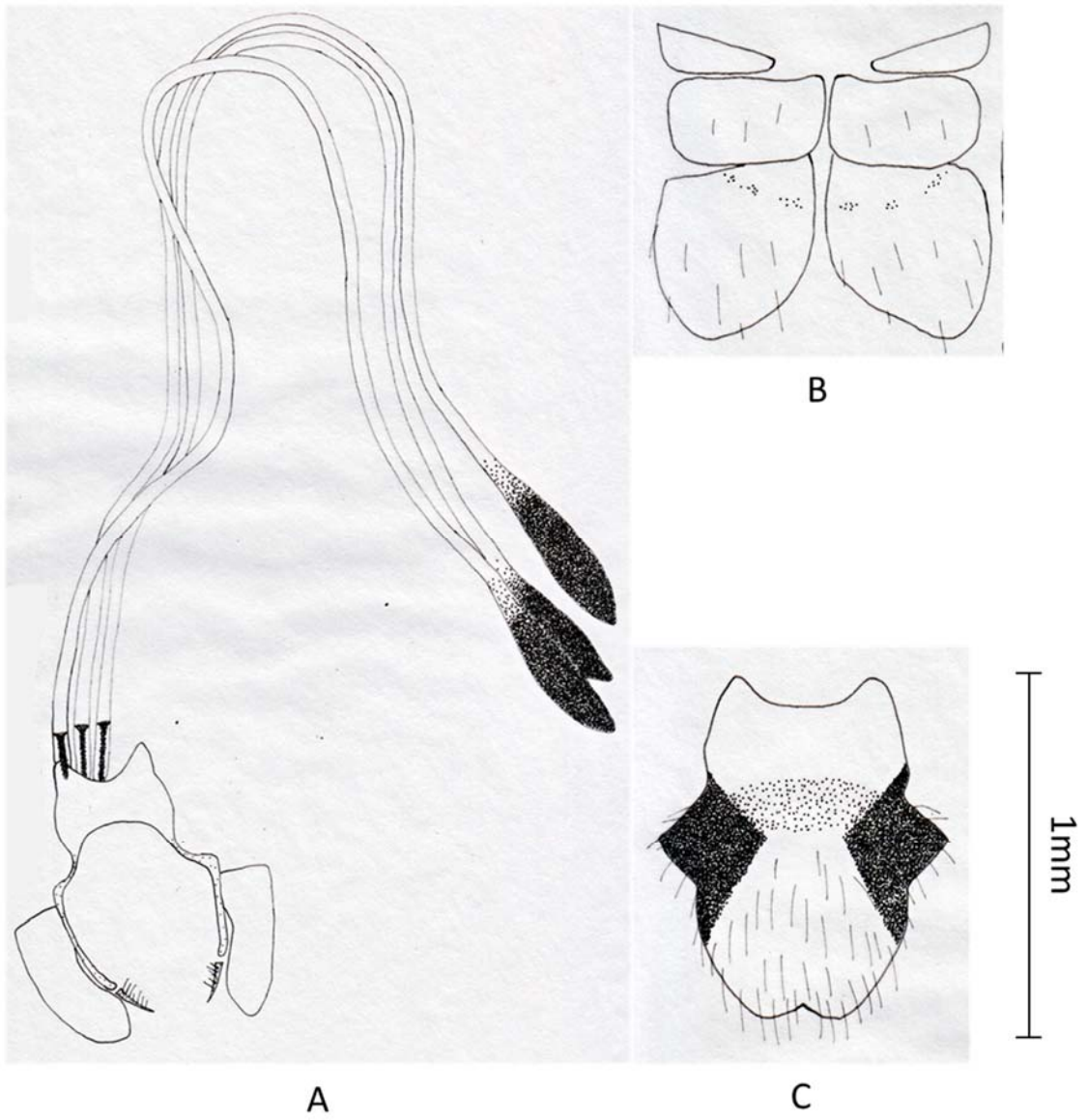
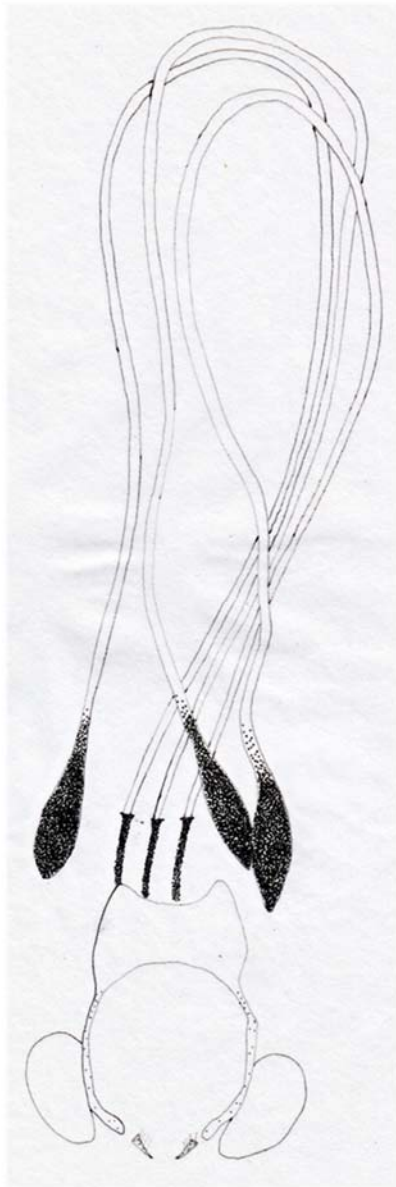
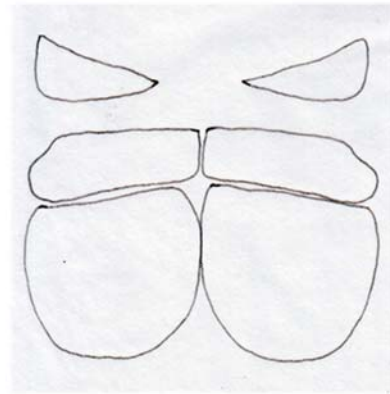


Plate. 11: *Hybomitra distinguenda* (Verrall, 1909) ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 12



A



B



C

Plate. 12: *Hybomitra montana* (Meigen, 1920) ♀

A: sp and gf; B: T9-10, and C: C: S8

Plate. 13

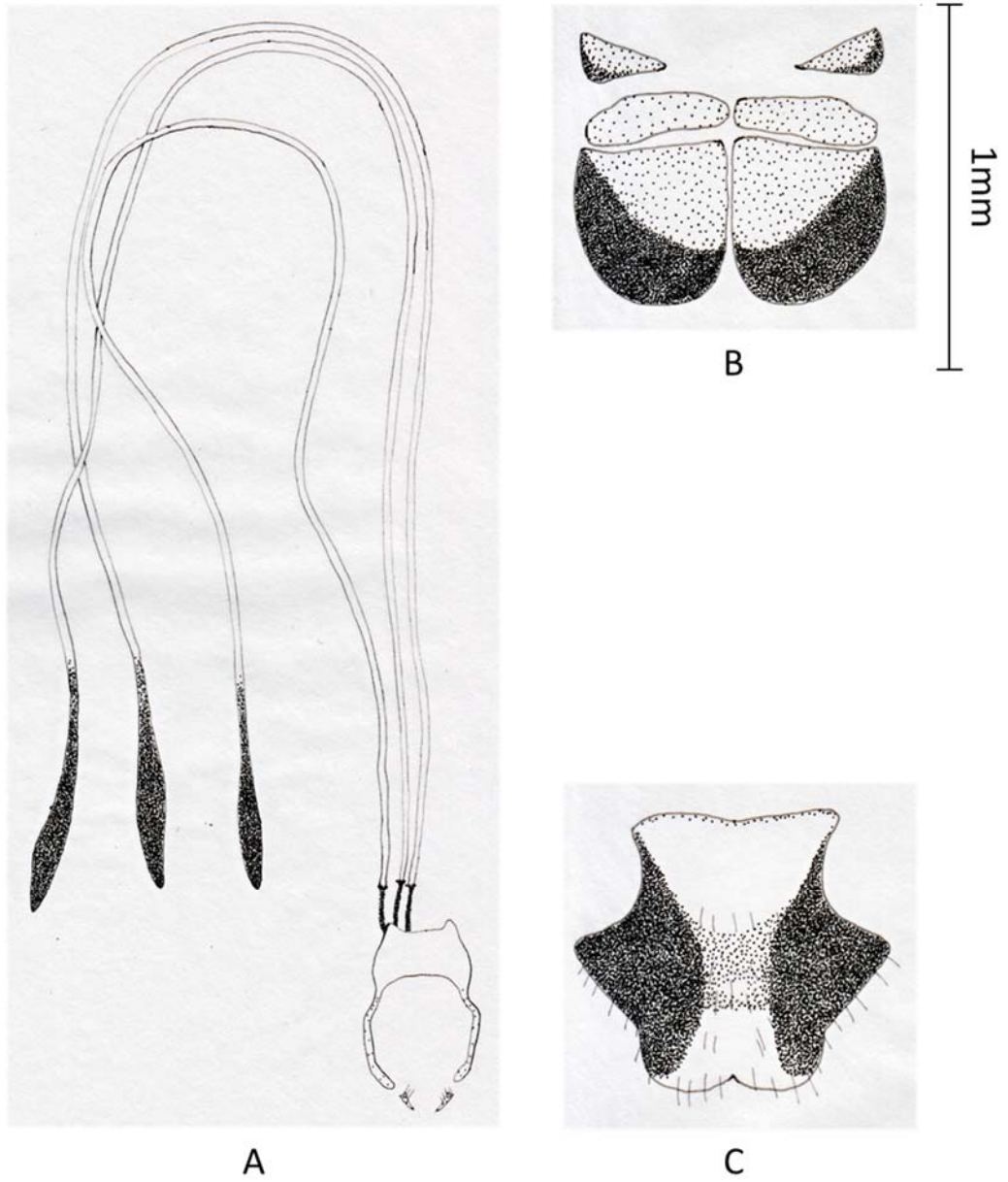


Plate. 13: *Hybomitra olsoi* Takahasi, 1962 ♀
A: sp and gf; B: T9-10, and C; C: S8

Plate. 14

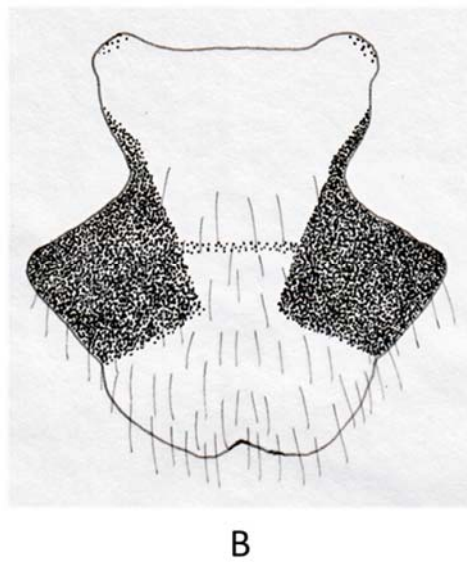
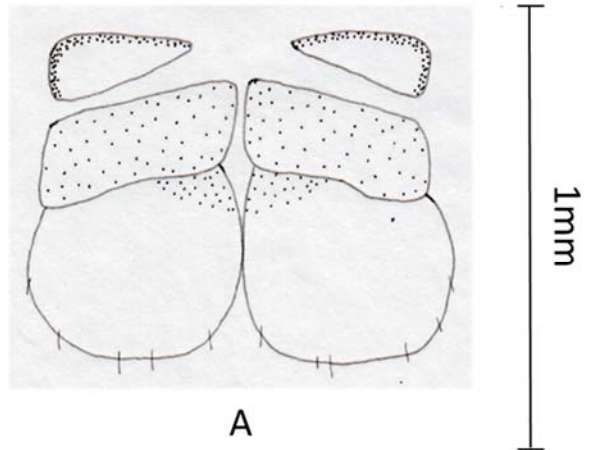


Plate. 14: *Hybomitra tarandina* (Linnaeus, 1758) ♀
A: T9-10, and C; B: S8

Plate. 15



Plate. 15: *Tabanus chrysurus* Leow, 1858 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 16

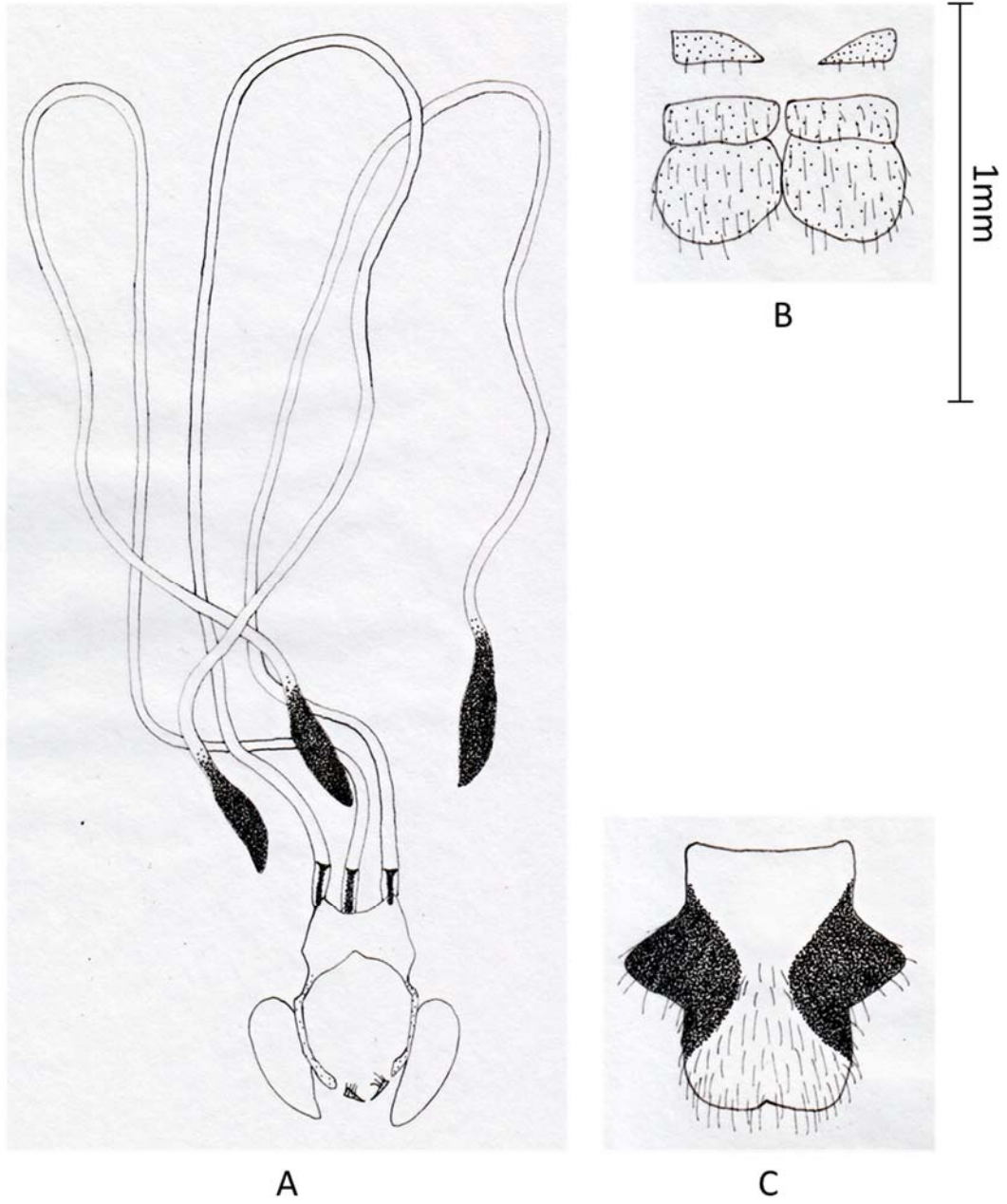
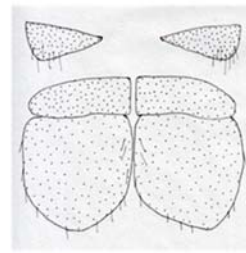


Plate. 16: *Tabanus iyoensis* Shiraki, 1918 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 17



A



B



C

Plate. 17: *Tabanus trigonus* Coquillett, 1898 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 18

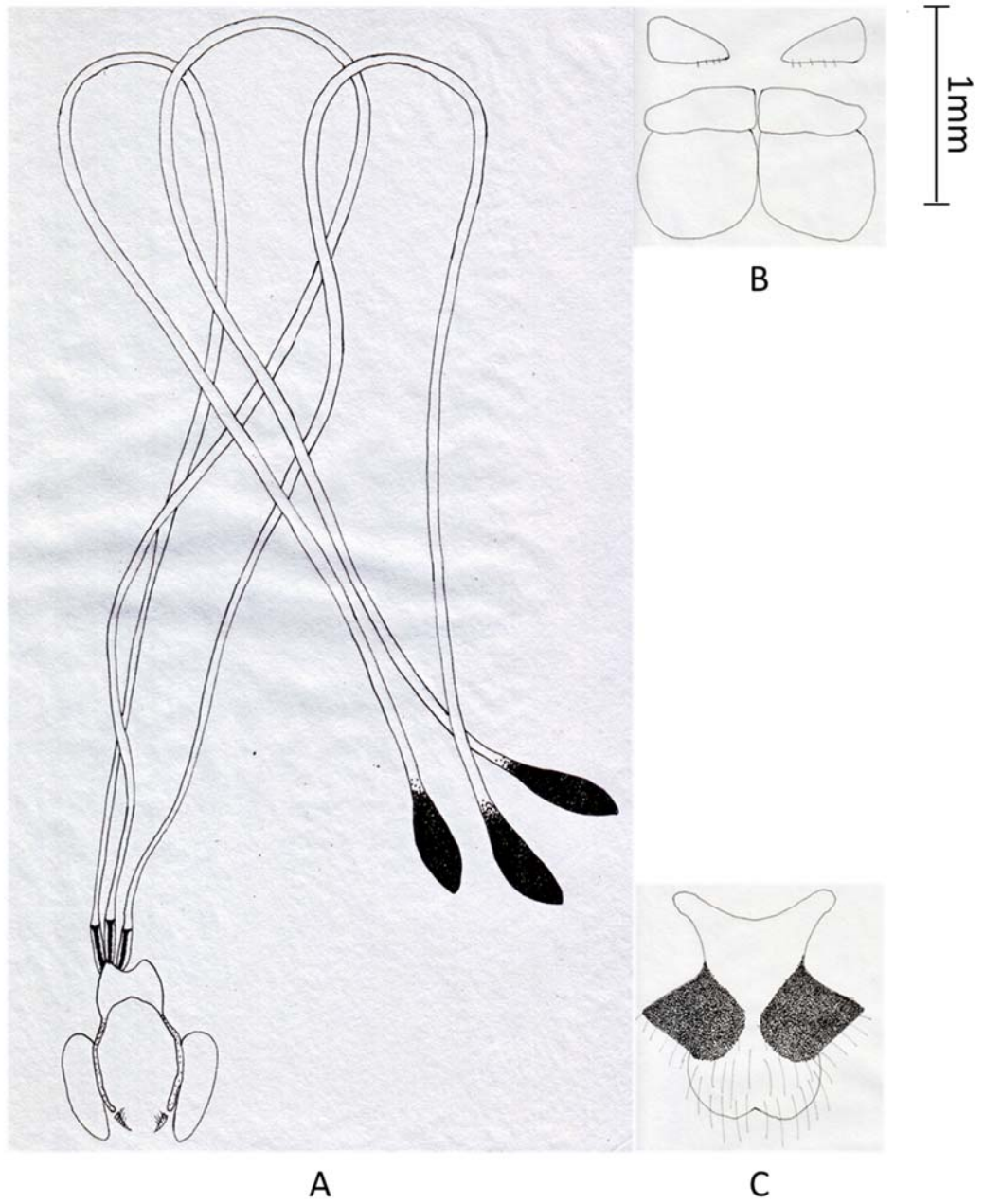


Plate. 18: *Tabanus katoi* Kono et Takahashi, 1940 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 19

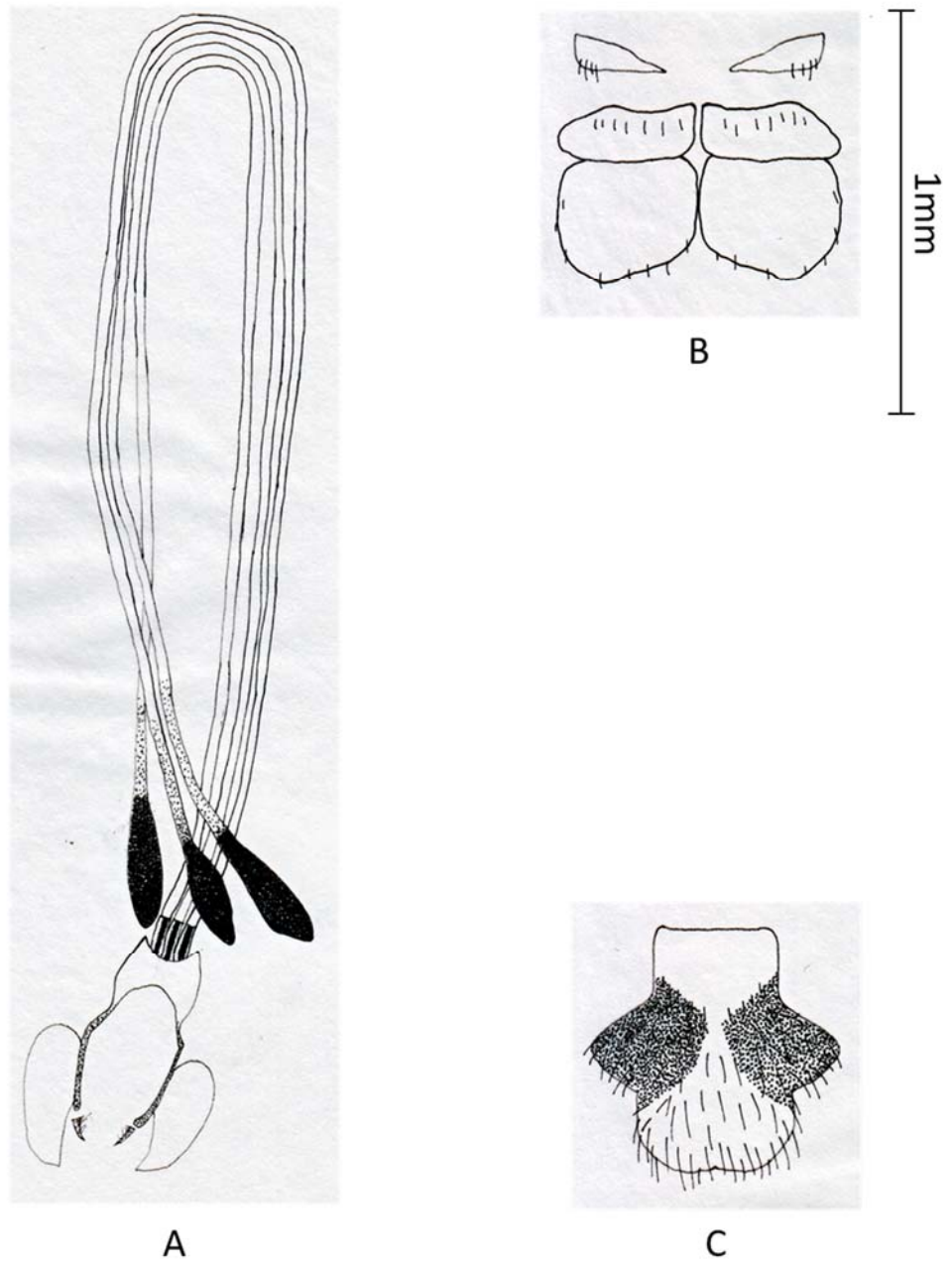


Plate. 19: *Tabanus spporoensis* Shiraki, 1918 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 20

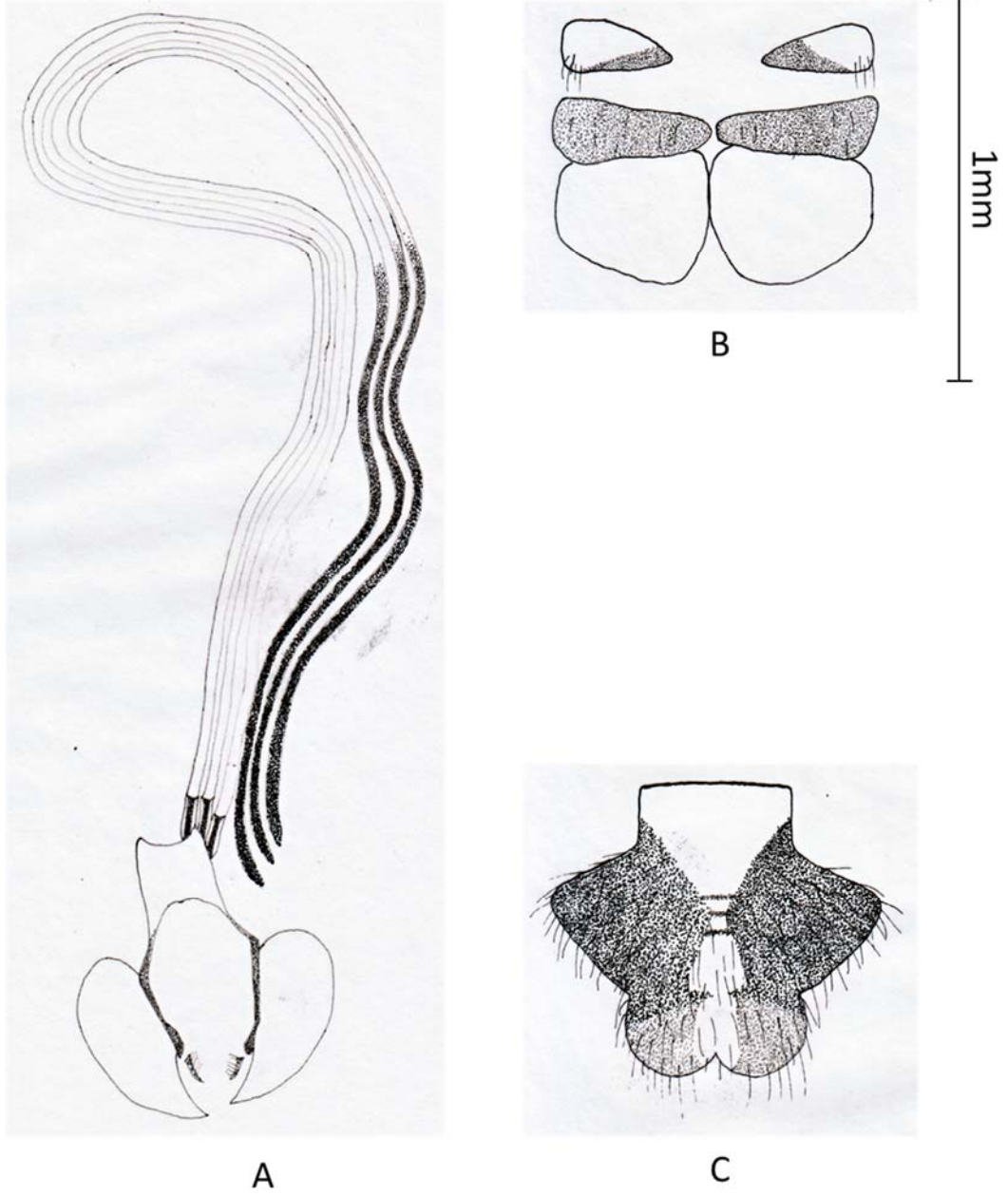


Plate. 20: *Tabanus fulvemediodes* Shiraki, 1918 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 21

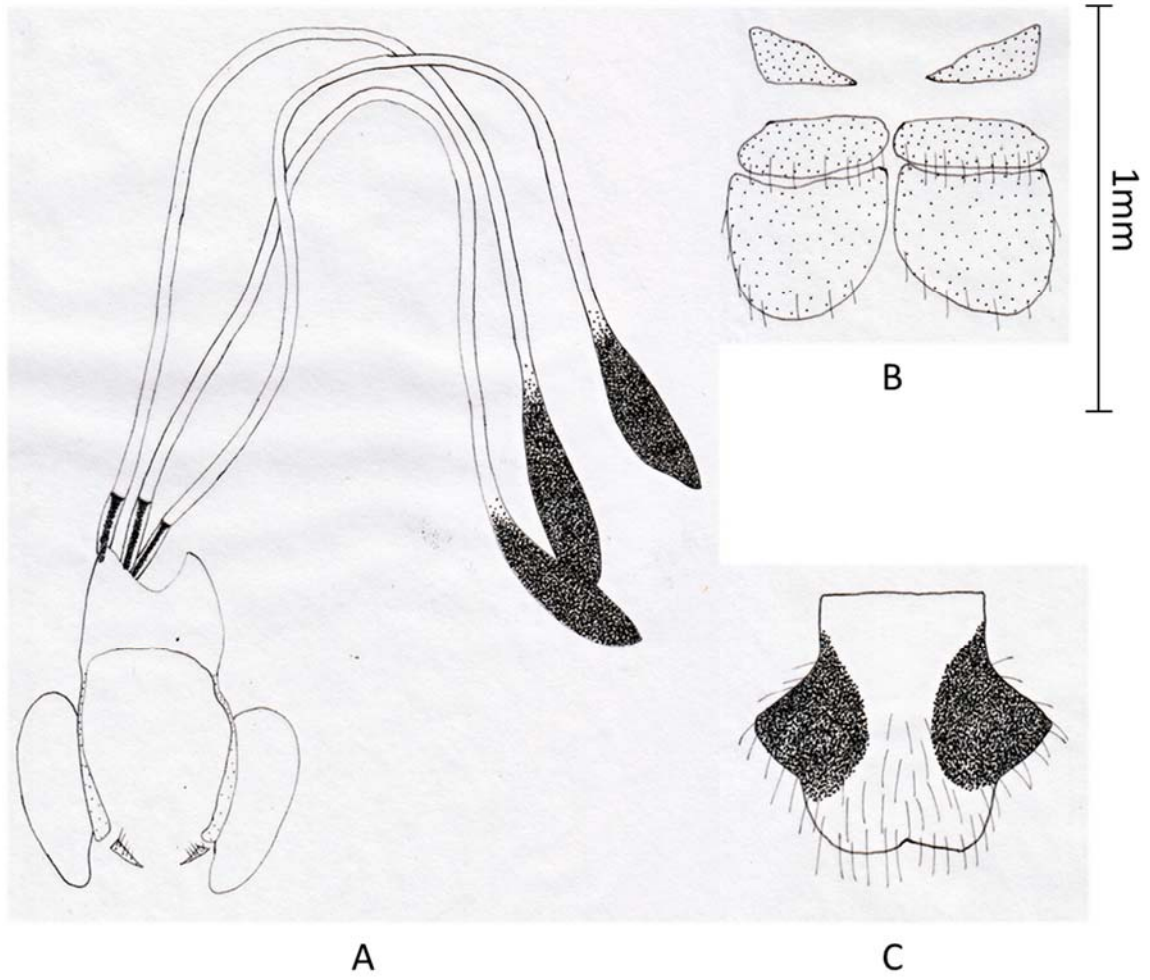


Plate. 21: *Tabanus kinoshitai* Kono et Takahashi, 1939 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 22

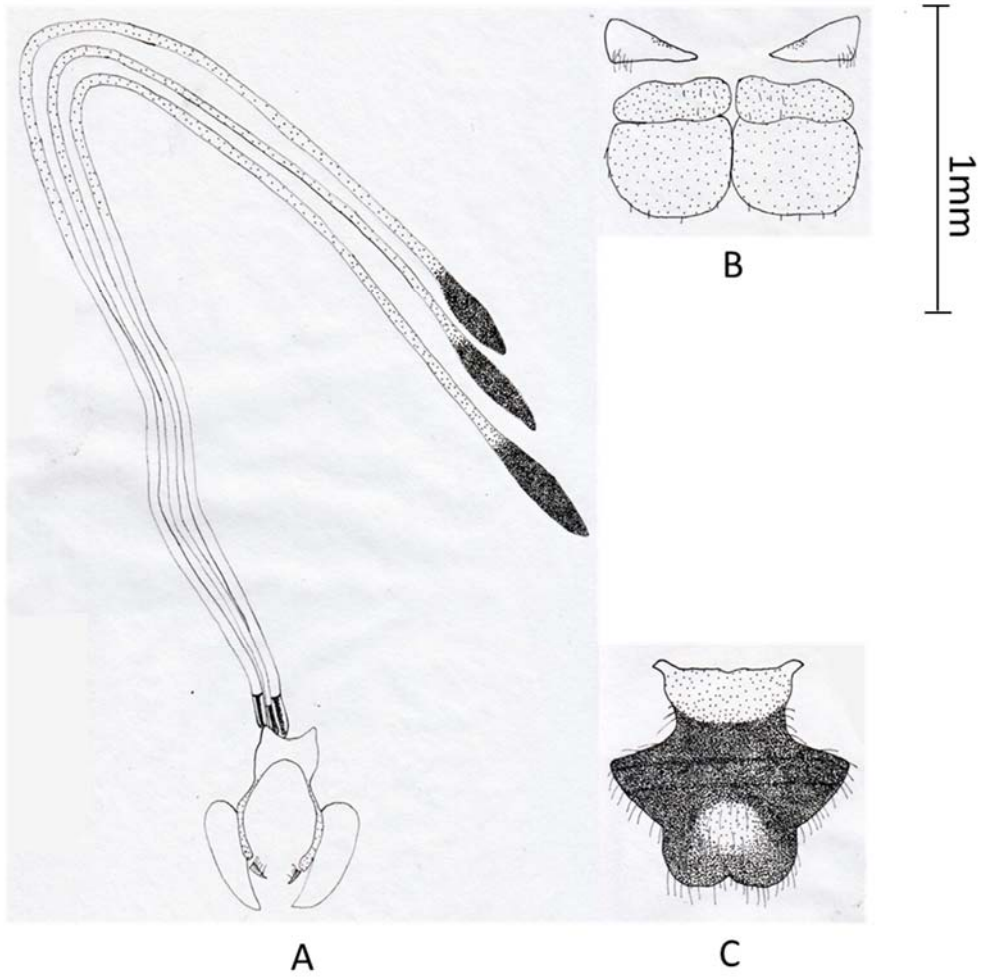


Plate. 22: *Tabanus mandarinus* Schiner, 1868 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 23

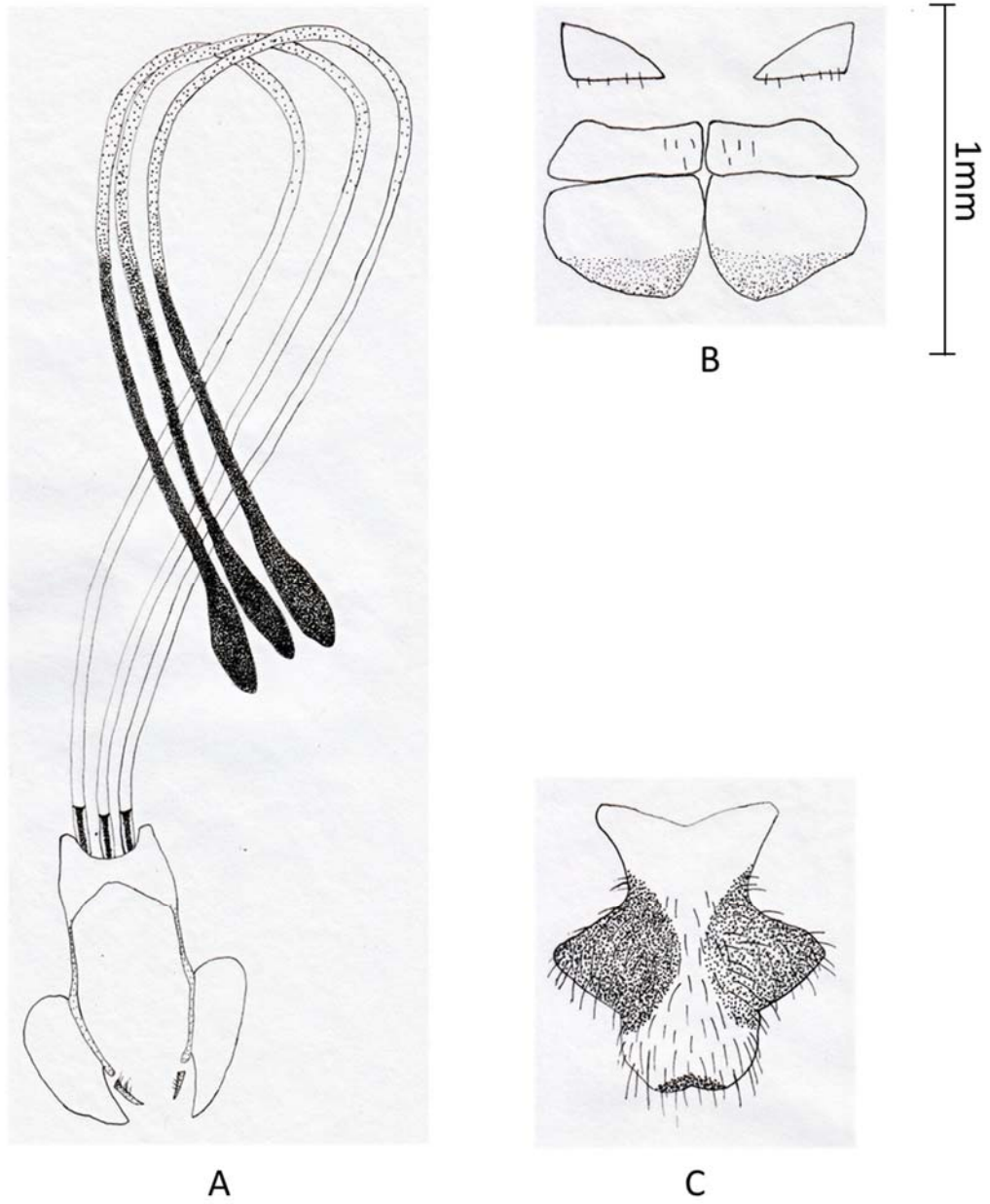


Plate. 23: *Tabanus nipponicus* Murdoch et Takahashi, 1969 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 24

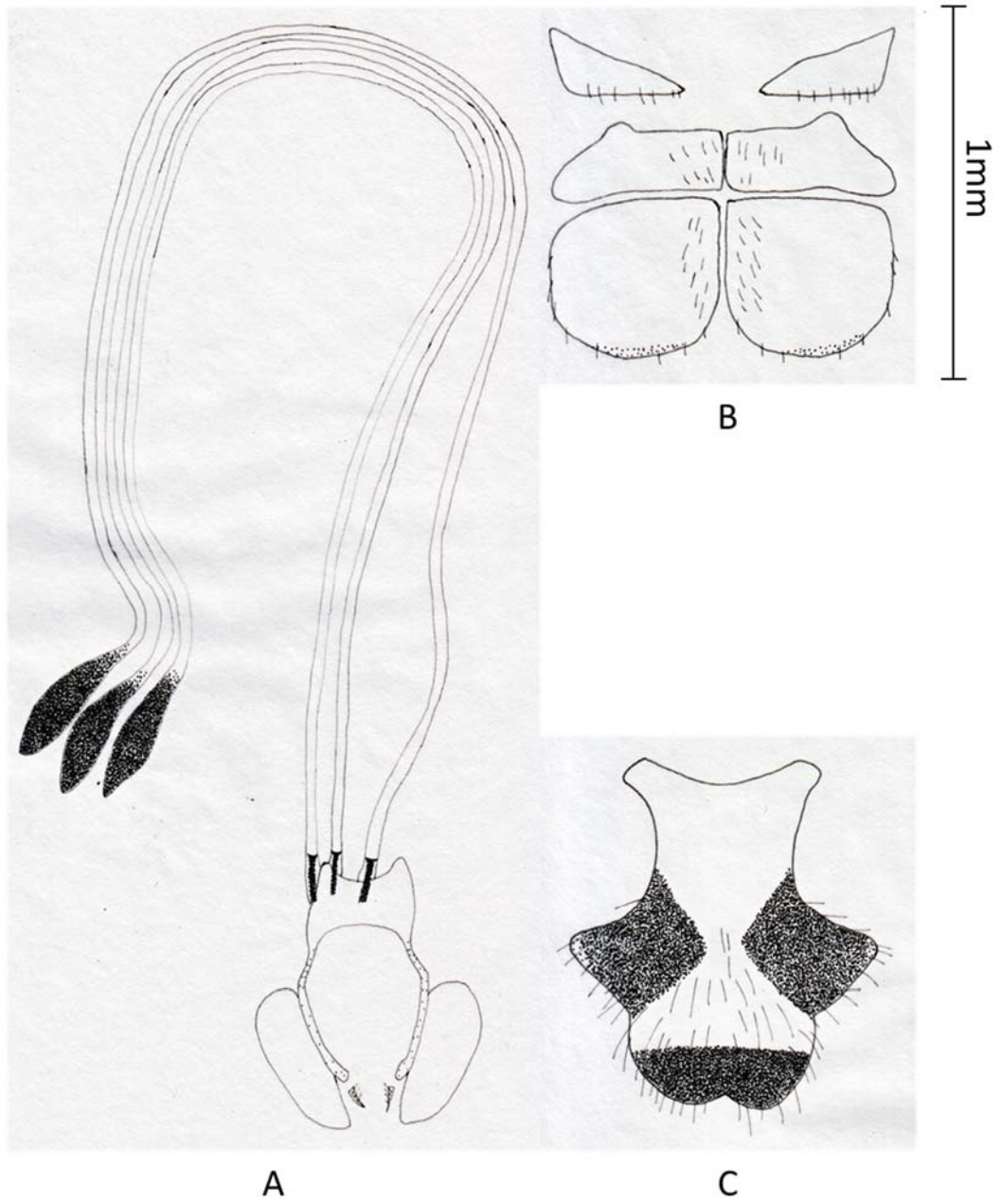


Plate. 24: *Tabanus pallidiventris* Olsufjev, 1937 ♀
A: sp and gf; B: T9-10, and C: C: S8

Plate. 25

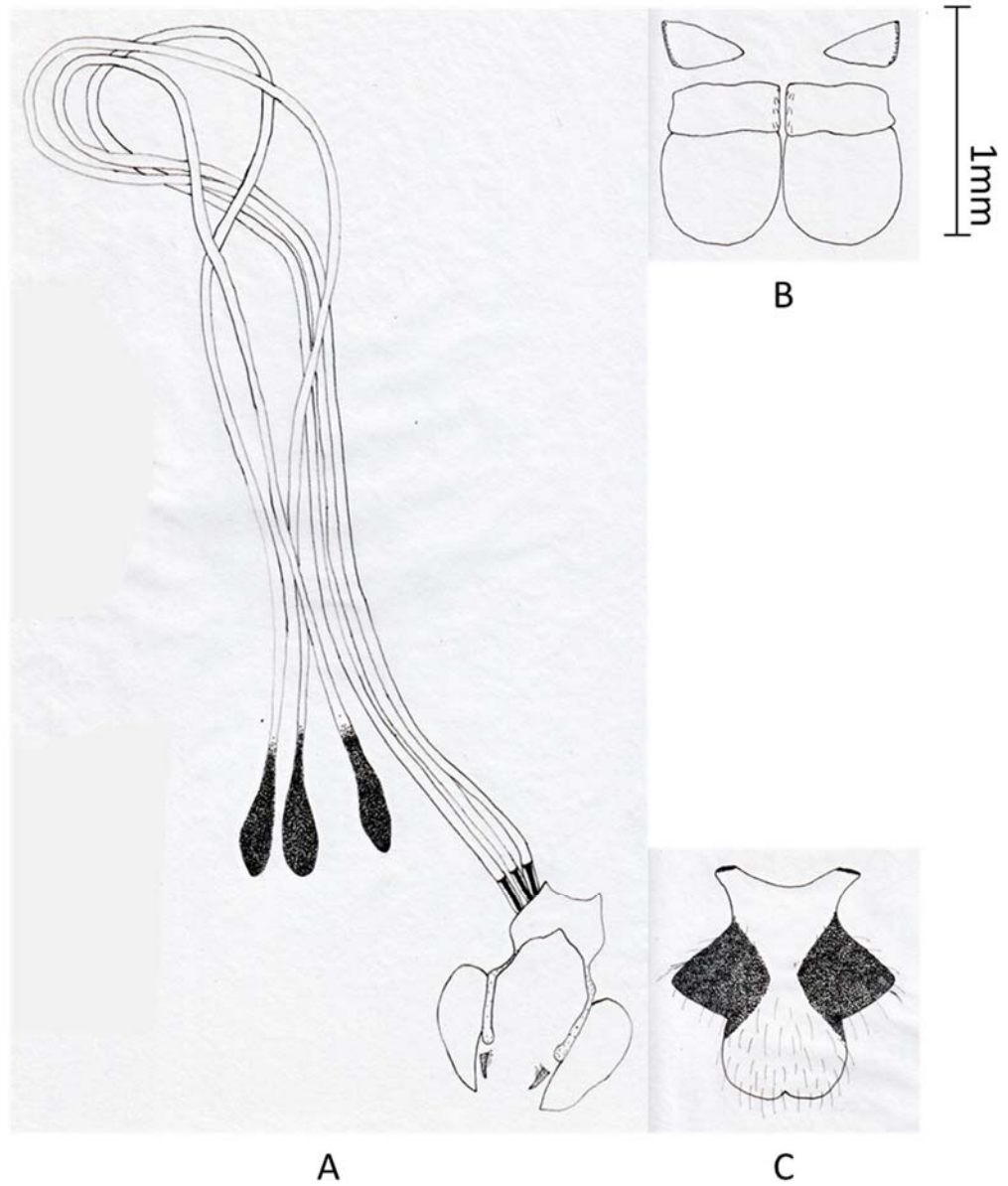


Plate. 25: *Tabanus rufidens* (Bigot, 1887) ♀
A: sp and gf; B: T9-10, and C: C: S8

Explanation of plates

- Plate. 26: *Stonemyia yezoensis* Shiraki, ♀ (a, b); *Chrysops suavis* Leow, ♀ (c, d); *Chrysops japonicus* Wiedemann, ♀ (e, f); *Chrysops nigripes* Zetterstedt, ♀ (g, h); *Chrysops vonderwulpi* Krober, ♀ (i, j); *Atylotus horvathi* Szilady, ♀ (k, l); *Haematopota tristis* Bigot, ♀ (m, n); *Haematopota tamerlani* Szilady, ♀ (o, p); *Hybomitra hirticeps* Loew, ♀ (q, r); *Tabanus spporoensis* Shiraki, ♀ (s, t); *Tabanus iyoensis* Shiraki, ♀ (u, v); *Tabanus fulvimediodes* Shiraki, ♀ (w, x); *Tabanus kinoshitai* Kono et Takahashi, ♀ (y, z); *Tabanus nipponicus* Murdoch et Takahashi, ♀ (A, B).
- Plate. 27: *Hybomitra distinguenda* Verrall, ♀ (a, b); *Hybomitra montana* Meigen, ♀ (c, d); *Hybomitra olsoi* Takahasi, ♀ (e, f); *Hybomitra tarandina* Linnaeus, ♀ (g, h); *Tabanus mandarinus* Schiner, ♀ (i, j); *Tabanus pallidiventrus* Olsufjev, ♀ (k, l); *Tabanus chrysurus* Leow, ♀ (m, n).
- Plate. 28: *Tabanus trigonus* Coquillett, ♀ (a, b); *Tabanus katoi* Kono et Takahashi, ♀ (c, d); *Tabanus rufidens* Bigot, ♀ (e, f).

Plate. 26

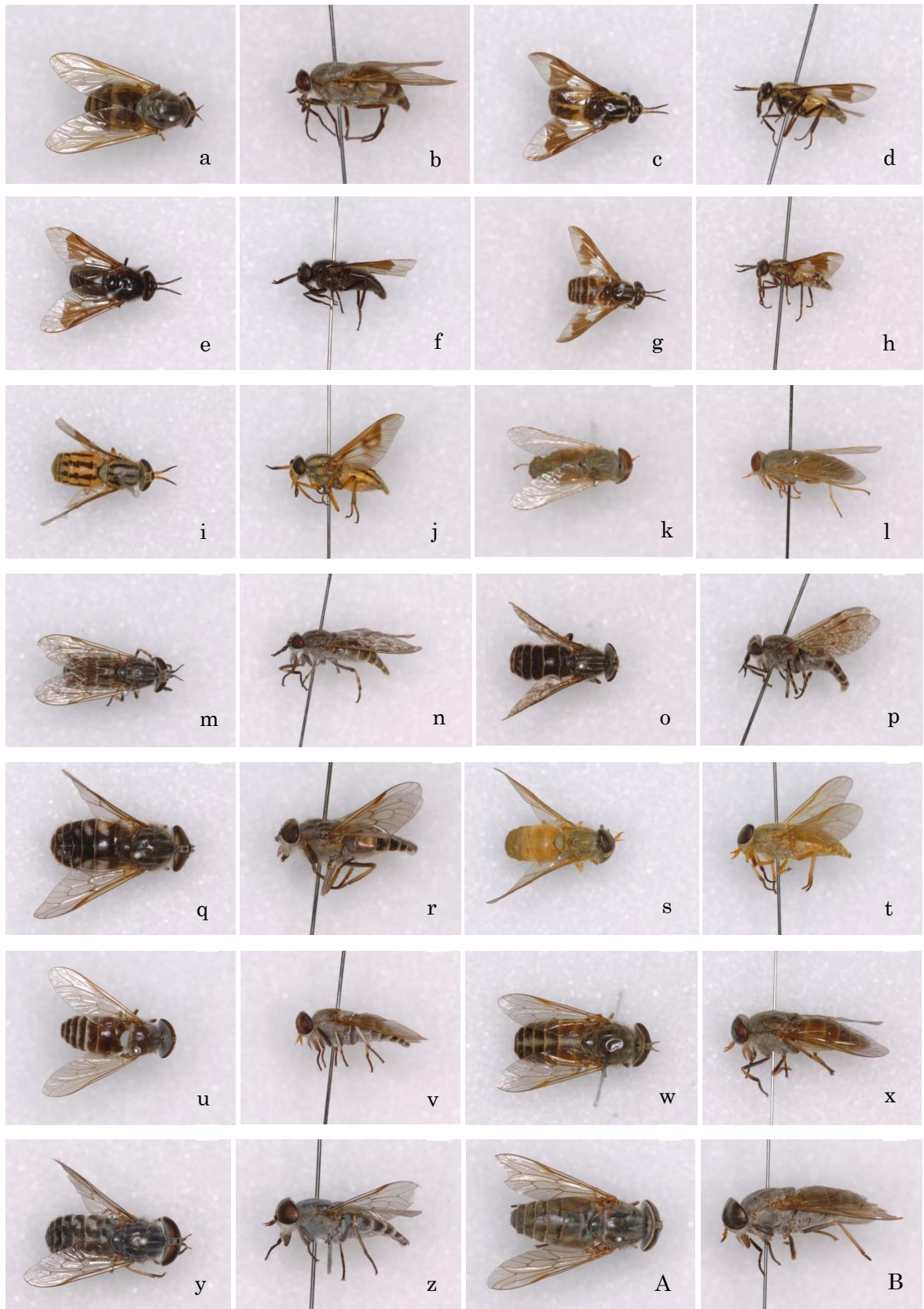


Plate. 27



Plate. 28

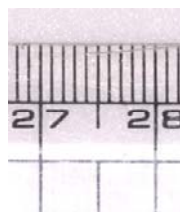


Table 1. Features of 3 subfamilies of Tabanidae

	Tergite 9	Tergite 10	cercus	Stermite 8	spermatheca	Spermathecal duct	Genital fork
Pangoniinae	Connected, right angled triangle, all darken	Separated, trapezoid, all darken	Separated, scale-like, all darken	Anterior margin straight, posterior margin concaved, lateral part processed, hexagon	Circular, all darken	Forepart stout, posterior part slender, no mushroom-shape expansion at end	Tong- like, membrane peltate-like
Chrysopinae	Separated, crescent shape or triangle, all darken or yellowish	Separated, triangle with dull outer angle, all darken, lightly darken, or yellowish	Separated, scale-like, all darken, , lightly darken, or yellowish	Anterior margin processed or straight, posterior margin concaved, upper wider than lower	Stout, and long, all darken	Forepart stout, posterior part slender, no mushroom-shape expansion at end	Tong- like, membrane peltate-like
Tabaninae	Separated, leaves-like, or triangle	Separated, rectangle, trapezoid, and triangle,	Separated, scale-like,	Anterior margin concaved or straight, posterior margin concaved, lateral part pointed, and almost darken	Almost fusiform, all darken	Long and slender, mushroom-shape expansion at end	Tong- like, membrane crescent shape