Illiciomyia Tokuda,a New Genus for Illiciomyia yukawai sp.n.(Diptera : Cecidomyiidae : Asphondyliini) Inducing Leaf Galls on Illicium anisatum (Illiciaceae) in Japan

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Illiciomyia Tokuda, a New Genus for *Illiciomyia yukawai* sp. n. (Diptera: Cecidomyiidae: Asphondyliini) Inducing Leaf Galls on *Illicium anisatum* (Illiciaceae) in Japan

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Abstract. A new genus, *Illiciomyia* Tokuda, is erected for *Illiciomyia yukawai* sp. n. that induces leaf galls on *Illicium anisatum* (Illiciaceae) in Japan. The new genus belongs to the subtribe Asphondyliina (Diptera: Cecidomyiidae: Asphondyliini) and can be distinguished from other genera by the lack of an apical spur on the first tarsomere on all legs and the shallow constriction of male flagellomeres. In the subtribe Asphondyliina, the genus is considered to have a close relation to the genera *Bruggmanniella* and *Pseudasphondylia* by having common characters such as two separate teeth of gonostylus and transverse rows of rather long spines on the anterior half of dorsal surface of pupal abdominal segment. However, the paramere-like structure of *Illiciomyia* is sclerotized, while paramere of *Bruggmanniella* and *Pseudasphondylia* is not sclerotized. These differences indicate that *Illiciomyia* is phylogenetically apart from *Bruggmanniella* and *Pseudasphondylia.*

Key words: Asphondyliini, Cecidomyiidae, gall midge, new genus, *Illicium anisatum*, *Illiciomyia yukawai*

Introduction

Gall midges belonging to the tribe Asphondyliini are a well-circumscribed monophyletic group sharing unique characters of the adult postabdomen (Gagné, 1994). They exhibit various unique ecological traits; e.g., most species can pierce plant tissue and lay eggs there because they possess a needle-like ovipositor (e.g., Möhn, 1961; Gagné, 1989); some species associate with fungal symbionts and induce ambrosia galls (e.g., Docters van Leeuwen, 1939; Borkent & Bissett, 1985; Bissett & Borkent, 1988);

and at least three species of the genus *Asphondylia* H. Loew, 1850 are known to exhibit seasonal host alternation (Harris, 1975; Orphanides, 1975; Yukawa *et al.*, 2003; Uechi *et al.*, 2004). Therefore, the tribe is one of the most fascinating materials for ecological and evolutionary studies.

At present, the tribe Asphondyliini is divided into two subtribes, Asphondyliina and Schizomyiina, and consists of 41 genera and 460 species in the world (Gagné, 2004). Although the tribe is taxonomically and phylogenetically well-studied group comparing with other tribes of Cecidomyiidae (e.g., Möhn, 1961; Gagné, 1994), there are still many undescribed genera and species. Thus, further taxonomic study is needed to clarify the evolutionary processes of various ecological traits in the tribe. To contribute the taxonomy of the tribe Asphondyliini, a new genus is erected in the tribe for a new species induces leaf galls on *Illicium anisatum* Linnaeus (Illiciaceae) in Japan.

This gall midge was first reported by Shinbo (1913) long ago, but has not been named so far. Growers of *I. anisatum* have been seeking control measures against the gall midge, because gall-free shoots have been increasingly requested in recent years by a religious body as a sacred tree (Yukawa, 1988). Thus, the description of this gall midge has significance also from the aspect of applied entomology.

Illicium anisatum is an evergreen small tree common in Japan (western parts of Honshu, Shikoku, Kyushu, and the Ryukyus) and in the southern tip of the Korean Peninsula (Horikawa, 1976; Hotta *et al.*, 1989).

Materials and Methods

Collection of galls and gall midges

Leaf galls on *I. anisatum* (Fig. 1; Gall No. C-249 in Yukawa & Masuda, 1996) were collected from various localities in Japan. Collectors' names are abbreviated as follows; JY: J. Yukawa; MT: M. Tokuda; NU: N. Uechi. Some of the galls were dissected under a stereoscopic microscope to obtain larval and pupal specimens. When some of the dissected galls contained mature larvae or pupae, the rest of the collected galls were maintained in plastic bags (350 mm x 250 mm in size) to obtain adults and pupal skin. All specimens collected in this study were preserved in 75 % ethanol for morphological studies or in 99.5 % acetone for future DNA analysis.

Morphological studies and terminology

Some of the ethanol-preserved specimens were mounted on slides for microscopic study in Canada balsam using the techniques outlined in Gagné (1989). Drawings were made with the aid of a drawing tube.

Adult morphological terminology, except for that of thoracic plates, follows Mc-

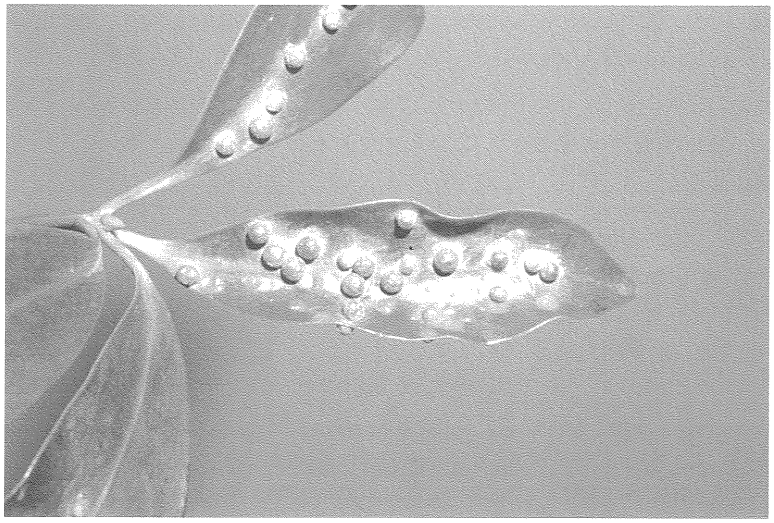

Fig. 1. Leaf galls of *Illiciomyia yukawai* on *Illicium anisatum.*

Table 1. *Illiciomyia yukawai*: frontoclypeal and thoracic setal and scale counts.

Sex	Male			Female		
Specimens exam.	18			22		
	Mean	SD	Range	Mean	SD	Range
Frontoclypeal setae	20.3	3.47	15-26	21.7	2.83	17-25
ADL setae*	23.9	4.17	17-33	27.0	5.44	20-41
PDL setae**	30.5	8.24	24-43	29.6	4.50	25-38
Mesopleural scales	14.8	2.81	10-21	20.2	2.99	16-28
Mesepimeral setae	15.6	3.22	12-25	16.2	3.37	12-25

*ADL: Anterior dorsolateral; ** PDL: Posterior dorsolateral.

Alpine (1981). The terminology of thoracic setae and scales, except those on pteropleuron, follows usage in Panelius (1965) and setae of mesepimeron (= pteropleuron) in Yukawa & Ohsaki (1988). While counting thoracic setae and scales, I noticed that dorsolateral setae are divided into anterior and posterior clusters, so I distinguished them as 'anterior dorsolateral setae' and 'posterior dorsolateral setae', respectively (see Table 1). The counts are actually based on the setal and scale insertions, since many setae and scales become lost through the processes of collection, preservation, or preparation.

Morphological terminology of immature stages generally follows Möhn (1955 & 1961; originally written in German, translated into English in Yukawa, 1971), but the terminology of pupal antennal horn follows Gagné (1994). In addition, the term of 'anterior dorsal papillae' (Tokuda *et al.*, 2004) is applied to pupal papillae that are

situated between the anterior margin of each abdominal segment and the transverse rows of spines on dorsal surface of the segment.

All specimens used in this study are kept in the collection of the Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka, Japan.

Illiciomyia Tokuda, gen. n.

Type species: *Illiciomyia yukawai* sp. n.

Male.

Palpus two-segmented. Antenna with 12 flagellomeres; first and second flagellomeres not fused; flagellomeres gradually shortened distally; circumfila not closely appressed to the flagellomeres (Fig. 2A); flagellomeres, especially the several distal flagellomeres, shallowly constricted into three parts (Fig. 2B).

First tarsomeres without apical spurs (Fig. 2C); claws simple on all legs, bent at obtuse or right angle; empodia as long as or a little shorter than claws; pulvilli much shorter than empodia. Wing densely covered with dark grayish hairs; R_5 joining costa a little beyond wing apex.

Abdominal tergites with anterior pair of trichoid sensilla; first through seventh tergites rectangular, mostly with a single row of posterior setae; anterior portion of eighth tergite sclerotized, without setae; some lateral setae present on first to seventh tergites; elsewhere covered with scales on first through seventh tergites. Abdominal sternites without anterior pair of trichoid sensilla. Genitalia (Fig. 2D): cerci separated deeply by a U-shaped emargination, forming a pair of triangular lobes, without distinct setae; hypoproct deeply incised, forming a pair of lobes, each with usually a single apical seta; gonostylus a little longer than wide, distally with two sclerotized teeth; gonocoxite massive, extending ventrally beyond insertion of gonostylus; aedeagus distally tapering, basally with a small sclerotized paramere-like structure.

Female.

Flagellomeres shortened distally and terminal one subglobular. Ovipositor protractile, slender, aciculate, basally with a bilobed cerci-like structure. Needle part of ovipositor relatively short; minute apical lobe of ovipositor without cilia. Otherwise as in male.

Full-grown larva.

Body color yellow. Cervical papillae without setae. Number and position of spiracles normal. Four dorsal papillae present on thoracic and first to seventh abdominal segments; a pair of elliptical papillae present on anterodorsal portion of first to eighth abdominal segments; terminal papillae not apparent. Sternal spatula distally with three-pointed lobes (Fig. 2E), central lobe longer than two outer lobes; generally five, rarely

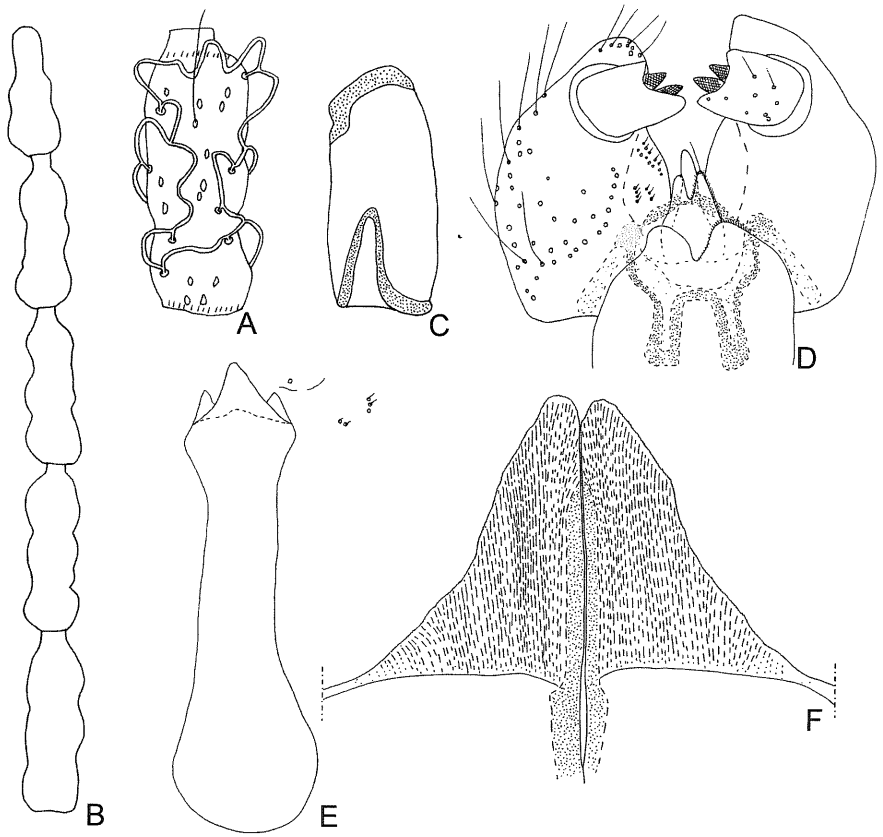

Fig. 2. *Illiciomyia yukawai*, A: Male third flagellomere; B: Male eighth to twelfth flagellomeres; C: Male first tarsomere of mid leg; D: Male genitalia; E: Larval sternal spatula and associated papillae; F: Pupal apical horns.

six, lateral papillae present on each thoracic segment; sternal papillae without setae on prothorax, each with a minute seta on meso- and metathorax; inner pleural papillae not apparent; anterior and posterior ventral papillae not apparent; anal papillae absent; a pair of additional papillae visible on anteroventral portion of meso- and metathorax, each with a minute seta. Anus situated dorsally. Each abdominal segment, except terminal one, ventrally with many transverse rows of minute spines, which are more densely distributed in anterior and posterior thirds and with many small triangular spines ventro- and dorsolaterally.

Pupa.

Pupal skin not pigmented. Apical horn long, acutely pointed with finely denticulate outer margin (Fig. 2F); apical papilla situated on a small protuberance and with a long seta; upper and lower frontal horns absent; prothoracic horn relatively long; stigmatal

tubercles present on second to seventh abdominal segments, those on eighth abdominal segment rudimentary; first abdominal segment with dense minute spines on ventral and dorsal surfaces; second to eighth abdominal segments with dense minute spines on ventral surface and on posterior half of dorsal surface; second to eighth abdominal segments with five to six transverse rows of rather long spines on anterior half of dorsal surface.

Remarks. This genus is easily distinguished from other genera of Asphondyliina by the shallow constriction of male flagellomeres especially in distal several segments, less appressed male circumfila, and the lack of apical spur on first tarsomere of all legs. In addition, the larva differs from other genera by having five lateral papillae as usual and some of them have no setae. Although these features are rather common in the subtribe Schizomyiina, presence of sclerotized teeth on male gonostylus and situation of larval anus indicate that the genus belongs to the subtribe Asphondyliina.

Illiciomyia yukawai sp. n.

Male.

Eye bridge four to five facets long. Frontoclypeal setal count as in Table 1. First palpal segment about 37 μm in length, about 1.7 times as long as basal width; second about as long as first. Scape ventrally with a few setae; pedicel with setae rather sparsely; first flagellomere about 150 μm in length, about 4.0 times as long as wide, 1.1 times as long as second; fifth flagellomere about 120 μm in length, about 3.2 times as long as wide.

Thoracic setal counts as in Table 1. All legs covered with many scales; length of respective segments as in Table 2. Wing length 2.45 to 2.90 mm, about 2.4 times as long as wide.

First through sixth abdominal sternites rectangular, about 0.28 to 0.40 times as long as wide, seventh and eighth sternites rather elongated, 0.55 to 0.68 times as long as wide. Sclerotized teeth of gonostylus rather closely situated one another (Fig. 2D).

Female.

First flagellomere about 1.2 times as long as second, fifth flagellomere about 100 μm, about 2.4 times as long as wide. Seventh sternite about 1.30 times as long as wide; eighth sternite without setae. Needle part of ovipositor 0.40 to 0.51 mm long, about 1.1 times as long as the length of seventh sternite; minute apical lobe of ovipositor without setae.

Full-grown larva.

Body length 1.7 to 2.3 mm. Second antennal segment subglobular, about 9 μm in length, about 1.1 times as long as basal width. Four dorsal papillae usually each with a

minute seta; eighth abdominal segment with two dorsal papillae, each with a minute seta; two pleural papillae present on each side, each with a minute seta. Sternal spatula 225 to 275 μm long; five lateral papillae divided mostly into two inner and three outer clusters (Fig. 2E), usually two papillae of each cluster with a minute seta; in the case of six lateral papillae, they divided usually into three inner and three outer clusters, two papillae of each cluster with a minute seta.

Table 2. *Illiciomyia yukawai*: measurements of legs (μm).

Sex		Male			Female		
Specimens examined		10			10		
		Mean	SD	Range	Mean	SD	Range
Fore leg	Femur	911	97.0	775-1044	842	55.4	774-944
	Tibia	830	65.3	703-930	802	76.9	659-929
	Tarsomere I	128	38.7	62-211	122	18.4	100-163
	Tarsomere II	643	137.2	323-778	609	105.8	422-729
	Tarsomere III	278	39.4	221-366	255	61.6	144-357
	Tarsomere IV	196	37.8	142-285	135	35.1	82-200
	Tarsomere V	132	26.9	97-193	117	20.4	82-145
Mid leg	Femur	852	79.6	740-1030	772	42.0	712-839
	Tibia	761	77.3	667-901	707	46.8	628-785
	Tarsomere I	118	27.2	69-157	114	22.7	88-150
	Tarsomere II	550	94.9	368-703	456	83.4	357-640
	Tarsomere III	299	83.6	210-460	219	73.9	131-385
	Tarsomere IV	197	49.8	162-321	136	17.9	108-165
	Tarsomere V	134	29.6	75-175	119	26.1	80-156
Hind leg	Femur	940	68.9	787-1026	863	110.1	708-1069
	Tibia	797	50.9	735-895	758	68.1	664-855
	Tarsomere I	130	36.5	74-200	125	15.4	98-143
	Tarsomere II	579	34.5	506-622	524	122.7	344-757
	Tarsomere III	304	47.6	247-409	234	47.5	160-344
	Tarsomere IV	188	19.0	160-224	164	32.0	123-224
	Tarsomere V	118	16.5	90-143	124	15.7	95-148

Pupa.

Body length about 2.7 mm (including apical horn). Apical horn 200 to 220 μm long (Fig. 2F); apical papilla with a 100 to 130 μm long seta; a pair of lower facial papillae and a pair of lateral facial papillae present, each usually with a minute seta; prothoracic horn 175 to 200 μm long; stigmatal tubercles on second to seventh abdominal segments 35 to 55 μm long; spines on anterior half of dorsal surface 45 to 55 μm long; eight dorsal papillae present on first to seventh abdominal segments, four (most outer and second inner pairs) of them each with a minute seta; two dorsal papillae present on

eighth abdominal segment, each with a minute seta; two anterior dorsal papillae present on second to eighth abdominal segments; usually two pleural papillae present on each side, each with a minute seta.

Etymology. This species is named in honor of Prof. Junichi Yukawa (Kyushu University, Japan) for his long and distinguished career in taxonomic and ecological studies of gall midges.

Type material. Holotype: male (on a slide, Type No. 3190, Cecido. No. A1401), from gall collected on 8.v.1965 from Mt. Wakasugi, Sasaguri, Fukuoka, Kyushu, JY, and emerged during the period 14 to 22.v.1965. Paratypes (a date after the name of each locality indicates the collecting date of midge galls, unless otherwise mentioned): 11 males, 12 females & 3 pupae (on slides, Cecido. Nos. A1402-1424, A14101-14103), same data as holotype; 1 male & 2 females (on slides, Nos. A1425-1427), Mt. Ichifusa, Kumamoto, Kyushu, 8.v.1965, JY, emerged on 14-22.v.1965 from galls; 2 males, 2 females, 2 pupae & 5 full-grown larvae (on slides, Nos. A1428-1431, A14104-14105, A14201-14205), Mt. Inao, Kagoshima, Kyushu, 2.v.1971, K. Deki, emerged on 10-21.v.1971 from galls, reared by JY; 4 males & 4 females (on slides, Nos. A1432-1439), Futsukaichi, Fukuoka, Kyushu, 1.v.1966, Y. Miyatake, emerged on 6-13.v.1966 from galls, reared by JY; 4 full-grown larvae (on a slide, Nos. A14206-14209), Kurinodake-onsen, Kagoshima, Kyushu, 15.i.1971, JY; 2 males, 3 females & 2 pupae (on slides, Nos. A1440-1444, A14106-14107), Mt. Hiko, Soeda, Fukuoka, Kyushu, 30.iv.1998, MT & JY; 4 full-grown larvae (on a slide, Nos. A14210-14213), Chion-in, Kyoto, Honshu, 15.iii.2000, NU, dissected on 7.iv.2000 by MT; 3 males, 3 females & 4 pupae (on slides, Nos. A1445-1450, A14108-14111), Mt. Yuwan-dake, Uken, Amami-Ohshima Island, Kagoshima, 27.iv.2000, H. Inoue; 3 males, 4 females & 1 pupa (on slides, Nos. A1451-1457, A14112), Shimokawakami, Ohtoh, Wakayama, Honshu, 9.v.2001, M. Shoubu, emerged on 10-15.v. 2001 from galls, reared by MT; 6 full-grown larvae (on slides, Nos. A14214-14219), from Ushiwara, Tosu, Saga, Kyushu, 10.xi.2002, MT & NU.

Distribution. Japan [Honshu, Shikoku, Kyushu, Yakushima Island, and Amami-Ohshima Island (**new distribution rec.**)]

Gall.

Hemiglobular swelling mostly on the upper, sometimes on the lower, surface of *I. anisatum* leaves; surface color is brown while inhabited by the gall midge and turns to brownish black after adult emergence; height 2.3 to 3.2 mm, basal diameter 2.0 to 3.3 mm (Fig. 1; see also Gall No. C-249 in Yukawa & Masuda, 1996).

Biological notes. See Shinbo (1913); Yukawa & Masuda (1996).

Discussion

To date, Asphondyliina has been distinguished from Schizomyiina by such autapomorphies as bilobed cerci-like structure on female ovipositor, the denticles of gonostyli that are fused at least partly to a solid tooth or teeth, and the dorsally situated larval anus (Gagné, 1994). In addition, the presence of apical spur on the first tarsomere is a common character of Asphondyliina, even though one species of Schizomyiina, *Schizomyia vitispomum* (Osten Sacken, 1878), exceptionally shares this feature (Gagné, 1994). However, a genus of Schizomyiina that possesses bilobed cerci-like structure on female ovipositor was discovered recently (Tokuda *et al.*, 2004).

The present study reports, for the first time, the lack of apical spur on the first tarsomere in Asphondyliina. As a consequence, the subtribe Asphondyliina can be defined only by two autapomorphies: the existence of solid tooth or teeth of gonostyli and dorsally situated larval anus, while there are no autapomorphies in the subtribe Schizomyiina as far as I know. This strongly suggests that Schizomyiina is a paraphyletic group of Asphondyliina.

In Asphondyliina, the genus *Illiciomyia* is considered to have close relation to the genera *Bruggmanniella* Tavares, 1909 and *Pseudasphondylia* Monzen, 1955 based on common characters such as two solid teeth of gonostylus and transverse rows of rather long spines on anterior half of pupal dorsal surface (e.g., Yukawa, 1971; Yukawa, 1974; Gagné, 1994). However, as mentioned earlier, *Illiciomyia* has some unique features rather common in Schizomyiina; e.g., the shallow constriction of male flagellomeres, less appressed male circumfilar, and the lack of apical spur on the first tarsomere. In addition, paramere-like structure of *Illiciomyia* is sclerotized, but paramere of *Bruggmanniella* and *Pseudasphondylia* is not sclerotized (e.g., Yukawa, 1971; M. Tokuda & J. Yukawa, unpublished data). These morphological differences indicate that *Illiciomyia* is phylogenetically apart from *Bruggmanniella* and *Pseudasphondylia*.

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