J. HYM. RES.
Vol. 13(1), 2004, pp. 31–47

# *Torymus* Dalman (Torymidae: Hymenoptera) Associated with Coniferous Cones, with Descriptions of Three New Species

E. E. GRISSELL, K. KAMIJO, AND K. R. HOBBS

(EEG) Systematic Entomology Laboratory, PSI, ARS, USDA, % National Museum of Natural History, Washington, DC 20560-0168, USA, email: egrissel@sel.barc.usda.gov;
(KK) Nishi 2 Minami 6-2-41, Bibai, Hokkaido, 072-0025 Japan, email: kamijo@mb.infosnow.ne.jp;
(KRH) 74 673 Zircon Circle East, Palm Desert CA 92260 USA (deceased 2 August 2003)

*Abstract.*—Eight species of *Torymus* Dalman are associated with coniferous cones, including three new species described herein: ***Torymus pseudotsugae*** **Hobbs**, from cones of *Pseudotsuga menziesii* in the United States (California, Idaho) and Canada (British Colombia); ***Torymus hobbsi*** **Grissell**, from cones of *Picea sitchensis* (Bongard) Carriere in the United States (California, Oregon, Colorado); and ***Torymus ezomatsuanus*** **Kamijo**, from larvae of cecidomyiid in seeds of *Picea glehnii* (F. Schmidt) Masters and *P. jezoensis* (Siebold and Zuccarini) Carriere in Japan (Hokkaido). The previously described species are: *T. azureus* Boheman (Holarctic), *T. caudatus* Boheman (Holarctic), *T. festivus* Hobbs (Nearctic), *T. janetiellae* Graham and Gijswijt (Palearctic), and *Torymus tsugae* (Yano) (Palearctic). Of the eight known species, five are reported attacking Cecidomyiidae (Diptera) in coniferous cones, but specific hosts are unknown for the other three. *Torymus tsugae* is recognized and redescribed for the first time since its description in 1918. *Torymus caudatus* is reported for the first time from Japan (Hokkaido, ex cones of *Picea jezoensis,* new host plant) and from the New World (New York, USA, ex cones of *Picea abies* (L.) Karsten); *T. azureus* is reported for the first time from Japan (Hokkaido, ex seeds of *Picea glehnii*). An illustrated key to all species is given.

The hymenopterous family Torymidae contains a number of species associated with coniferous cones. Most of these belong to the genus *Megastigmus* Dalman and are phytophagous within seeds (Grissell 1999). Less well known are species of *Torymus* Dalman that inhabit cones. Although little specific host data are available for these species, it is probable that all are parasitoids of cone-inhabiting gall flies of the family Cecidomyiidae (Fig. 31). It is possible, though unlikely based on known host records for the genus, that some species may be seed-feeders or might be attacking seed-feeding *Megastigmus.* Basically little is known about these *Torymus* other than they occur in coniferous cones. Though they appear to be of little economic importance, they likely play some role in the natural control of cone-infesting cecidomyiids, which in some cases account for loses of up to 80% in seed production (Masters 2003).

In this paper we review the world's known cone-inhabiting *Torymus,* which total eight species, including three new ones described herein. What specific host data are available are discussed under each species and a summary host/parasitoid list is given at the end of this paper. This list encapsulates what is known about host plant, host insect, and the *Torymus* associated with them. We provide distribution and economic data for each species as well as an illustrated key. We report the first New World occurrence of *Torymus caudatus* Boheman, and the first occurrence of that species and *T. azureus* Boheman in Japan.

## METHODS

Our concepts of described Palearctic species are based on specimens determined by Graham and Gijswijt (1998) who designated neotypes for several species (*T. azureus, T. caudatus*) and to M. J. Gijswijt who loaned specimens for examination (*T. caudatus, T. janetiellae* Graham and Gijswijt). Examples of these specimens and of type material of *T. festivus* Hobbs are housed in the National Museum of Natural History, Washington, D.C. The senior author has examined specimens of all taxa, including the new species described herein, and those for the redesciption of *T. tsugae* Yano.

Plant nomenclature and distribution was checked using the *Germplasm Resources Information Network* (GRIN 2000) and *The PLANTS Database* (USDA, NRCS, 2001). *Torymus* names and hosts were determined using Grissell (1995), Graham and Gijswijt (1998), and Noyes (2002). Cecidomyiid host names were checked by Dr. Raymond Gagné, Systematic Entomology Laboratory. The authors' names for all plant and insect hosts are given in the Host Plant/*Torymus* list at the end of this paper.

The following abbreviations are used: OOL = ocellocular distance, POL = postocellar distance, OD = lateral ocellus diameter; square brackets [ ] are used for label data indicating that the information is not on the label and has been added from other sources. The key provides technical morphological characters with which to identify species, but these are often difficult to see, even with series of specimens in excellent condition. Females are the more reliable sex upon which to base determinations.

## KEY TO CONE-INFESTING SPECIES OF *TORYMUS* DALMAN

1 Female: basal cell open behind, cubital vein without setae (Fig. 28, arrow). Both sexes: metacoxa without setae along outer dorsal margin (as in Figs. 10, 11) ***and*** lateral ocellus subequal in length to ocellocular length (Fig. 5); (ex *Tsuga*; Palearctic) ...... ***tsugae* Yano**

– Female: basal cell partially (Fig. 27) to completely (Fig. 26, arrow) closed behind, cubital vein with 2 or more setae. Both sexes: either metacoxa with setae along outer dorsal margin (Figs. 8, 9) ***or*** metacoxa without setae (Figs. 10, 11) and lateral ocellus 0.7× or less length of ocellocular distance (Figs. 1, 23) .................................. 2

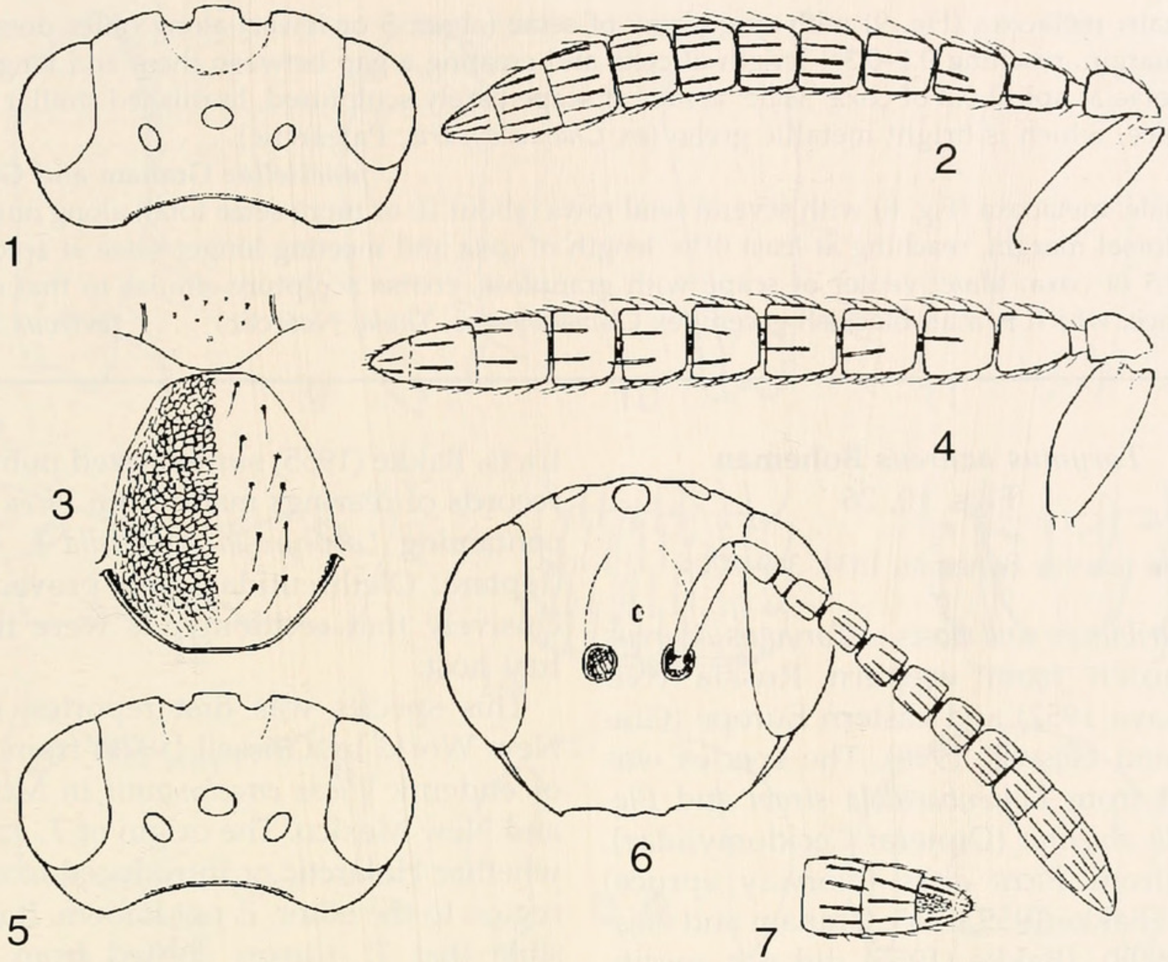
2 Metacoxa without setae along outer dorsal margin (Figs. 10, 11); frenal area of scutellum with (Fig. 3) or without setae ................................................ 3

– Metacoxa with short setae along outer dorsal margin (Figs. 8, 9) [note that these are different from longer setae arising on posterior side of coxa in ventral half]; frenal area of scutellum with setae (as in Fig. 3) ............................................ 5

3 Frenal area of scutellum without setae, glabrous and shiny; area polished compared to anterior of scutellum; interocular distance about 1× eye height in facial view (as in Fig. 6); postgenal area in side view narrow, less than 0.3× eye width. Female: metacoxa narrowly elongate, nearly parallel-sided, over 3× as long as wide (Fig. 10); club without area of ventral micropilosity on any segment; (ex *Picea*; Holarctic) ..... ***azureus* Boheman**

– Frenal area of scutellum sparsely setose, with at least a few setae (Fig. 3) or if setae not apparent then entire scutellum heavily reticulate; interocular distance about 1.5× eye height in facial view (Fig. 17); postgenal area in side view wide, 0.5–0.7× eye width (Fig. 21). Female: metacoxa not elongate, about 2.5–3× as long as wide (as in Figs. 8, 9, 11); at least one club segment with ventral area of micropilosity (as in Fig. 7) ......... 4

4 Toruli 1.5–2× own diameter above ventral eye margin (as in Figs. 6, 16); venter of forewing basal cell essentially bare, with few or no setae. Female: club segment 3 with ventral area of micropilosity (as in Fig. 7); (ex *Picea*; Palearctic) .... ***ezomatsuanus* Kamijo, n. sp.**




Figs. 1–7. *Torymus* spp. 1–4, *T. ezomatsuanus*. 5–7, *T. tsugae*. 1, 5, Female, head, dorsal view. 2, Female, antenna. 3, Female, scutellum. 4, Male, antenna. 6, Female, head, front view. 7, Female, clava, ventral view.

– Toruli less than own diameter above ventral eye margin (Fig. 17); venter of forewing basal cell evenly covered with short setae (Fig. 27). Female: club segments 2 and 3 with ventral area of micropilosity; (ex *Abies*; Nearctic) .................... ***hobbsi* Grissell, n. sp.**

5 Propodeal spiracle about 3 to 4× its own length from posterior margin of propodeum, ca. 0.3× median length of propodeum (Fig. 13). Female: ovipositor 7× length of metatibia (sometimes curling and distorting when dry so that it cannot be measured); (ex *Picea*; Holarctic) .................... ***caudatus* Boheman**

– Propodeal spiracle less than 3× its own length from posterior margin of propodeum, ca. 0.5 to 0.7× median length of propodeum (Fig. 12). Female: ovipositor not more than 4× length of metatibia .................... 6

6 Funicle segments (Fig. 14) at apex without transverse row of outstanding perpendicular setae (cf. Figs. 14, 15); female pro- and metafemora slender, over 4× as long as wide; profemur of male about 3.5× as long as wide. Female: ovipositor less than 3× as long as metatibia. Male: setae on funicle segments recurved above surface, dense (ca. 3–4 rows), obscuring multiporous plate sensilla (Fig. 14) .................... 7

– Funicle segments (Fig. 15; best seen in profile with backlighting) at apex with transverse row of bristles clearly projecting at nearly right angles; female pro- and metafemora slightly enlarged, less than 3.5× as long as wide; profemur of male enlarged, less than 3× as long as wide. Female: ovipositor at least 4× as long as metatibia (but usually distorted and difficult to measure). Male: setae on funicle segments appressed to surface, sparse (ca. 2 rows), multiporous plate sensilla apparent as white, flattened bands (Fig. 15); (ex *Pseudotsuga*; Nearctic) .................... ***pseudotsugae* Hobbs, n. sp.**

7 Female: metacoxa (Fig. 9) with single row of setae (about 5 or fewer) along outer dorsal margin, reaching 0.2–0.3× length of coxa and creating a gap between them and longer setae at apical 0.3 of coxa. Male: venter of scape barely sculptured, burnished similar to face, which is bright metallic green (ex *Chamaecyparis*; Palearctic) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *janetiellae* **Graham and Gijswijt**

– Female: metacoxa (Fig. 8) with several setal rows (about 10 or more setae total) along outer dorsal margin, reaching at least 0.5× length of coxa and meeting longer setae at apical 0.5 of coxa. Male: venter of scape with granulose, coarse sculpture similar to that on face, which is matt blackish green; (ex *Chamaecyparis, Thuja*; Nearctic) . . . . *festivus* **Hobbs**

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### *Torymus azureus* Boheman
Figs. 10, 26

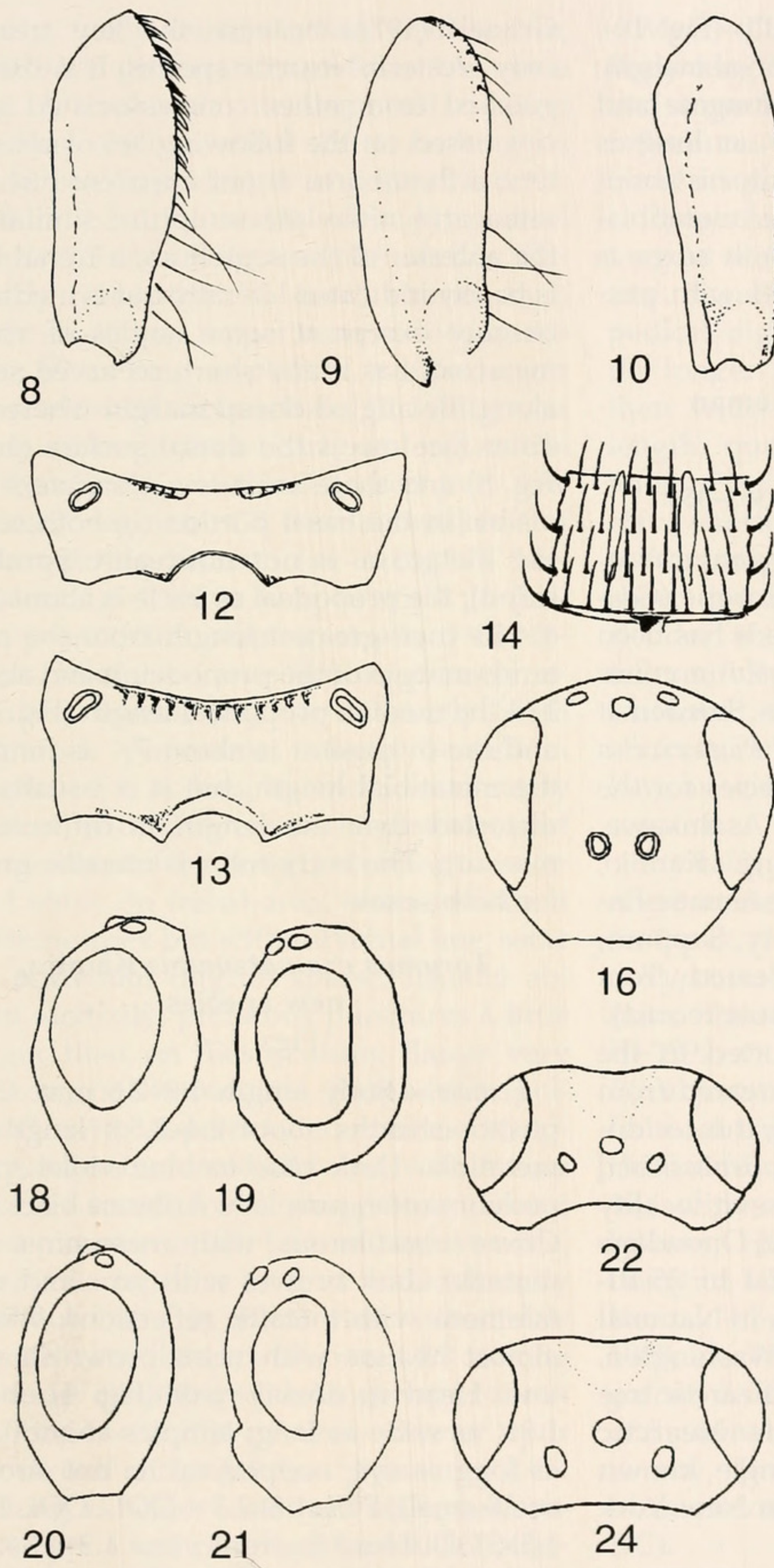
*Torymus azureus* Boheman 1834: 369–370.

*Distribution and hosts.*—*Torymus azureus* is known from western Russia (Nikol'skaya 1952) and eastern Europe (Graham and Gijswijt 1998). The species was reared from *Kaltenbachiola strobi* and *Plemeliella abietina* (Diptera: Cecidomyiidae), both from *Picea abies* (Norway spruce) cones (Bakke 1955, 1963; Graham and Gijswijt 1998). [Bakke (1955) did not specify the *Picea* species, but based on his summary work published in 1963 it may be assumed that he worked only with *Picea abies* in Norway.] Norway spruce is endemic to the Palearctic Region (USDA, NRCS 2001). We have seen 1♂ from Sweden reared from cones of *Picea excelsa* (= *P. abies*). We report *T. azureus* here for the first time from Japan (1♀, Ashoro, Hokkaido, 1956, K. Kamijo; 1♀ Hokkaido (exact locality unknown), 1956, K. Kamijo; 1♀, Tomakomai, Hokkaido, 1956, K. Kamijo). These specimens were reared from *Picea glehnii* (new host record), which is endemic to the Palearctic (Japan and Russia; GRIN 2000).

Bakke (1955) provided a detailed historical overview of *Torymus azureus*, including both its taxonomic confusion with *T. caudatus* (see next species discussion), and its biological habits. According to Bakke (1963) *T. azureus* was common in the lowlands and southern areas of Norway, whereas *T. caudatus* was more common in the higher elevations and northern districts. Bakke (1955) summarized published records of rearings made from *Picea* cones containing *Laspeyresia strobilella* L. (Lepidoptera: Olethreutidae) and proved conclusively that cecidomyiids were the actual host.

This species was first reported in the New World by Grissell (1976) from cones of endemic *Picea engelmannii* in Montana and New Mexico. The origin of *T. azureus*, whether Holarctic or introduced from one region to the other, is not known. It is possible that *T. azureus* shifted from introduced Norway spruce to endemic Englemann's spruce, but so far there are no records of the species from Norway spruce in the New World. The Palearctic cecidomyiid hosts are not known from the New World (Gagné, pers. comm.).

*Discussion.*—This species would be placed in the *varians*-group by Grissell (1976) and in its own species-group by Graham and Gijswijt (1998). Other species known from coniferous cones are members of the *bedeguaris-* or *cingulatus*-groups of *Torymus*. *Torymus azureus* is distinguished from species in these groups based on the following species-group characters: the frenal area is indicated by an absence of setae (remainder of scutellum with sparse, elongate setae) and being almost smooth compared to anterior of scutellum and dorsum of mesosoma, which is feebly aciculate; there is no frenal line. Additional characters that aid in identification are: the metacoxa distally has long setae on the inner (flat) surface, but from an outer (i.e., normal) view these




Figs. 8–25. *Torymus* spp. 8–12, Metacoxa, outer view. 8, *T. festivus*. 9, *T. janetiellae*. 10, *T. azureus*. 11, *T. hobbsi*. 12–13, Propodeum. 12, *T. pseudotsugae*. 13, *T. caudatus*. 14–15, Funicle segment 5. 14, *T. janetiellae*. 15, *T. pseudotsugae*. 16–17, Head, frontal view. 16, *T. pseudotsugae*. 17, *T. hobbsi*. 18–21, Head, side view. 18, *T. festivus*. 19, *T. pseudotsugae*. 20, *T. janetiellae*. 21, *T. hobbsi*. 22–25, Head, dorsal view. 22, *T. pseudotsugae*. 23, *T. hobbsi*. 24, *T. janetiellae*. 25, *T. festivus*.

are usually visible only distally (Fig. 10); there are no setae along the dorsal margin; in females the metacoxa is elongate and parallel-sided being 3 to 3.5× as long as wide (Fig. 10); and the ovipositor is about 4.5 to 5.5× as long as the metatibial length. The body color for both sexes is metallic blue green, sometimes with purplish reflections.

### *Torymus caudatus* Boheman
Fig. 13

*Torymus caudatus* Boheman 1834: 365–366.

*Distribution and hosts.*—*Torymus caudatus* is widespread in eastern Europe (Graham and Gijswijt 1998) where it has been reared from *Kaltenbachiella strobi* in cones of *Picea abies* (Bakke 1955). In Sweden it has been reared from cones of *Picea excelsa* (= *P. abies*). We report the species for the first time from Japan (2♀, 2♂, Asahikawa, Hokkaido, em. 27-VI-1990, K. Kamijo; specimens in Laboratory of Systematic Entomology, Hokkaido University, Sapporo, Hokkaido), where it was reared from cones of *Picea jezoensis* (new host record).

The species is herein reported in the New World for the first time reared from cones of *Picea abies* containing the cecidomyiid *Dasineura* [now = *Kaltenbachiola*] *canadensis* (Felt). The only known locality is New York (8♀, 8♂, Syracuse, Onondage Co., coll. 13-XII-1979, em. 12-I to 25-III-1980, P. J. Sedwick; specimens in National Museum of Natural History, Washington, DC). Because *Picea abies* is a Palearctic tree species introduced into the Nearctic (USDA, NRCS 2001), the single known population of *T. caudatus* from New York was most likely introduced.

*Discussion.*—Bakke (1955, 1963) reviewed the taxonomic history and biology of this species, especially with reference to its early and consistent confusion with *T. azureus*. This species is placed as a member of the *bedeguaris*-group as defined by Grissell (1976) and Graham and Gijswijt (1998). It cannot be placed in the key of Grissell (1976) because the key treated only western Nearctic species. It is distinguished from other cone-associated species based on the following set of characters: a frenal area is not apparent but has setae and reticulate sculpture similar to the anterior of the scutellum; a frenal line is barely indicated laterally but is medially obscure except at some angles of view; metacoxa has many short, recurved setae along the angled dorsal margin where the outer face meets the dorsal surface (as in Fig. 8) and there are a few elongate setae visible in the basal portion (in both sexes the metacoxa is not noticeably parallel-sided); the propodeal spiracle is about 3 to 4× its own greatest length from the posterior margin of the propodeum and about 1/4 the median propodeal length (Fig. 13); and the ovipositor is about 7× as long as the metatibial length, but it is usually so distorted that the length is difficult to measure. The body color is metallic green for both sexes.

### *Torymus ezomatsuanus* Kamijo, new species
Figs. 1–4

*Female.*—Body length 1.9–2.6 mm. Ovipositor sheaths about 2.4–2.5× length of metatibia. Dark blue to blue violet: propodeum often purplish. Antenna blackish. Coxae concolorous with mesosoma, remainder dark brown, with pro- and metafemora with metallic reflections. Wings almost hyaline with veins brownish yellow. Head in dorsal view (Fig. 1) about 1.9× as wide as long; temples about 0.3× as long as eye; occiptal carina not strong; ocelli small, POL 1.8–2.3× OOL, OOL 1.3–1.5× OD. Head in front view 1.2–1.3× as wide as high, genae roundly converging to mouth. Eyes separated by about 1.3× their height, with inner orbits subparallel; malar space about 0.4× eye height; in lateral view genal area about 0.5× eye width. Torulus slightly more than own diameter above ventral eye margin. Clypeus with lower margin almost truncate. Head irregularly, finely reticulate, face with sparse, indistinct piliferous punctures. Antenna (Fig. 2) weakly clavate; scape not reaching median ocellus, about 2.9× as long as wide; combined length of pedicel and flagellum 1.2–1.3× width of head; pedicel nearly 1.5× as long as wide; anellus distinctly transverse; F1 much shorter than pedicel, slightly longer than wide to quadrate; F2 as long as pedicel, a little longer than wide; F4 subquadrate; F7 1.3–1.4× as wide as long; clava nearly as long as F5–F7 combined; sensilla disposed in 1 row on each segment; C3 with a small tuft of micropilosity beneath (as in Fig. 7). Mesosoma 1.6–1.8× as long as wide, in profile propodeum sloping at about 60 degrees. Midlobe of mesoscutum densely reticulate, transversely so anteriorly, with piliferous punctures minute. Scutellum nearly 1.3× as long as wide, moderately convex, with sculpture as in posterior part of mesoscutal midlobe, becoming weaker and shiny on frenal area, often smooth at extreme apex but without frenal line; setae on scutellum (Fig. 3) sparse, usually absent medially, piliferous punctures a little larger than on mesoscutum; flange very narrow, not trabeculate. Propodeum polished, with superficial alutaceous sculpture, smoother medially and with a row of very small fovea along base. Lower mesepimeron small, 1.5× as high as wide. Metacoxa twice as long as wide, dorsally without hairs in basal half, outer side weakly reticulate; metafemur 4.9× as long as wide; metatibia with longer spur about as long as width of tibia, shorter spur about half of longer one. Forewing 2.4× as long as wide; costal cell on upper surface with a row of setae in apical half; basal vein with about 6 setae; basal cell with 1–9 setae, widely open below; speculum of moderate size, narrowly open below; relative lengths of M:PM:ST = 31:9.5:4; ST petiolate. Metasoma a little longer than mesosoma; hypopygium reaching 0.7 to 0.8 of gaster. Ovipositor sheaths as long as metasoma plus half of mesosoma.

*Male.*—Differs from female as follows: Body length 1.7–2.3 mm. Frons and face, and sometimes mesosoma with coppery reflections. Legs more extensively darker. Head in dorsal view fully twice as wide as long. Antenna (Fig. 4): scape 2.3× as long as wide; combined length of pedicel and flagellum 1.3–1.4× width of head; pedicel slightly longer than wide; F1 a little longer than pedicel, slightly longer than wide or quadrate; F2–F5 equal in length, quadrate to slightly longer than wide; F6–F7 usually slightly transverse; clava shorter than F5–F7, C3 without ventral micropilosity; flagellum with rather short decumbent setae. Mesosoma more slender, about 1.8× as long as wide. Scutellum fully 1.3× as long as wide, with scattered setae all over scutellum except on frenal area. Forewing less than 2.3× as long as wide. Metasoma shorter than mesosoma.

*Etymology.*—From "ezomatsu", the Japanese name of *Picea jezoensis,* and the suffix *-anus.*

*Type material.*—Holotype ♀: Chitose (near Shikotsu-ko), Hokkaido, Japan, em. III-1992, ex cecidomyiid larva in seed of *Picea jezoensis,* K. Kamijo (deposited in Laboratory of Systematic Entomology, Hokkaido University). Paratypes: 15♀, 10♂ with same data as holotype; 2♀, Asahikawa, Hokkaido, em. V-1983, ex cecidomyiid larvae in seeds of *P. jezoensis,* F. Komai; 4♀, 1♂, Akan, Hokkaido, em. V-1983, ex cecidomyiid larvae in seeds of *P. glehnii,* F. Komai (deposited in Laboratory of Systematic Entomology, Hokkaido University, Biabi, Hokkaido, and National Museum of Natural History, Washington, DC).

*Distribution.*—Japan (Hokkaido). The host tree is endemic to the Palearctic and is found in China, Japan, and the Russian Federation (GRIN 2000).

*Host.*—Reared from cecidomyiid larvae in seeds of *Picea glehnii* and *P. jezoensis.*

*Discussion.*—*Torymus ezomatuanus* belongs to the *cingulatus*-group of Graham and Gijswijt (1998) or to the *bedeguaris*-group of Grissell (1976), whose definition includes the *cingulatus*-group. This species belongs to the group of species without setae on the dorsum of the metacoxa and is similar in size and color to *T. azureus* from which it differs in having the frenal area sparsely setose (Fig. 3) and sculptured about as for the remainder of the scutellum (i.e., not nearly polished as in *T. azureus*); in females having the metacoxa less than about 2.5× as long as wide (as in Fig. 11, not over 3× as in *T. azureus*, Fig. 10) and antennal club segment 3 with an area of ventral micropilosity (as in Fig. 7). Females have the ovipositor about 2.5× the length of the metatibia. In both sexes the color is metallic blue to blue violet or purplish.

### *Torymus festivus* Hobbs
Figs. 8, 14, 18, 25

*Torymus festivus* Hobbs 1950: 173–175.

*Distribution and hosts.*—This species was reared from *Dasineura* sp. (Diptera: Cecidomyiidae) in seeds of nearctic endemic western red cedar (*Thuja plicata*) and Port Orford cedar (*Chamaecyparis lawsoniana*) (Hobbs 1950). It is known from Oregon, Alaska, and the Northwest Territories (Grissell 1976). As these trees are native to the northwestern Nearctic (USDA, NRCS 2001), *Torymus festivus* should be considered an endemic Nearctic species. Currently this species and *T. pseudotsugae* are the only two species associated with coniferous cones that are thought to be endemic to the New World.

*Discussion.*—*Torymus festivus* is placed in the *bedeguaris*-group based upon Grissell (1976). It is phenotypically similar to *T. janetiellae* in characters associated with the antenna, metafemur, propodeum, and metacoxa, but may be distinguished from it by the few characters given in the key. Additionally, *T. festivus* is known only from the Nearctic whereas *T. janetiellae* is known only from the Palearctic. Females have the ovipositor about 2.7 to 3× as long as the metatibia. In both sexes the body color is metallic blue.

### *Torymus janetiellae* Graham and Gijswijt
Figs. 9, 20, 24

*Torymus janetiellae* Graham and Gijswijt 1998: 115–116.

*Distribution and hosts.*—This species was reared in the Netherlands from cones of *Chamaecyparis lawsoniana* containing *Janetiella siskiyou* (Diptera: Cecidomyiidae) (Graham and Gijswijt 1998). *Chamaecyparis lawsoniana* is an endemic tree native to southern Oregon and northern California (GRIN 2000) and the host cecidomyiid is native to Oregon (Gagné 1989). The fly is introduced and well established in Europe (Gagné 1989), as is the tree. It is likely that *T. janetiellae* is also introduced (Graham and Gijswijt 1998). *Torymus festivus* was reared from *C. lawsoniana* in California and is extremely similar to *T. janetiellae*, suggesting an additional affinity of the latter species to the Nearctic fauna. Graham and Gijswijt (1998) also suggested that *T. janetiellae* could have been introduced from Japan but gave no reasons for this.

*Discussion.*—This species is listed as a member of the *bedeguaris*-group in Graham and Gijswijt (1998) and would key to that group as recognised by Grissell (1976). It is distinguished from its most phenotypic congenitor, *T. festivus*, by characters given in the key. In females the ovipositor is less than 2.5× the length of the metatibial length. In both sexes the body is metallic green.

### *Torymus hobbsi* Grissell, new species
Figs. 11, 17, 21, 23, 25, 27, 29, 30

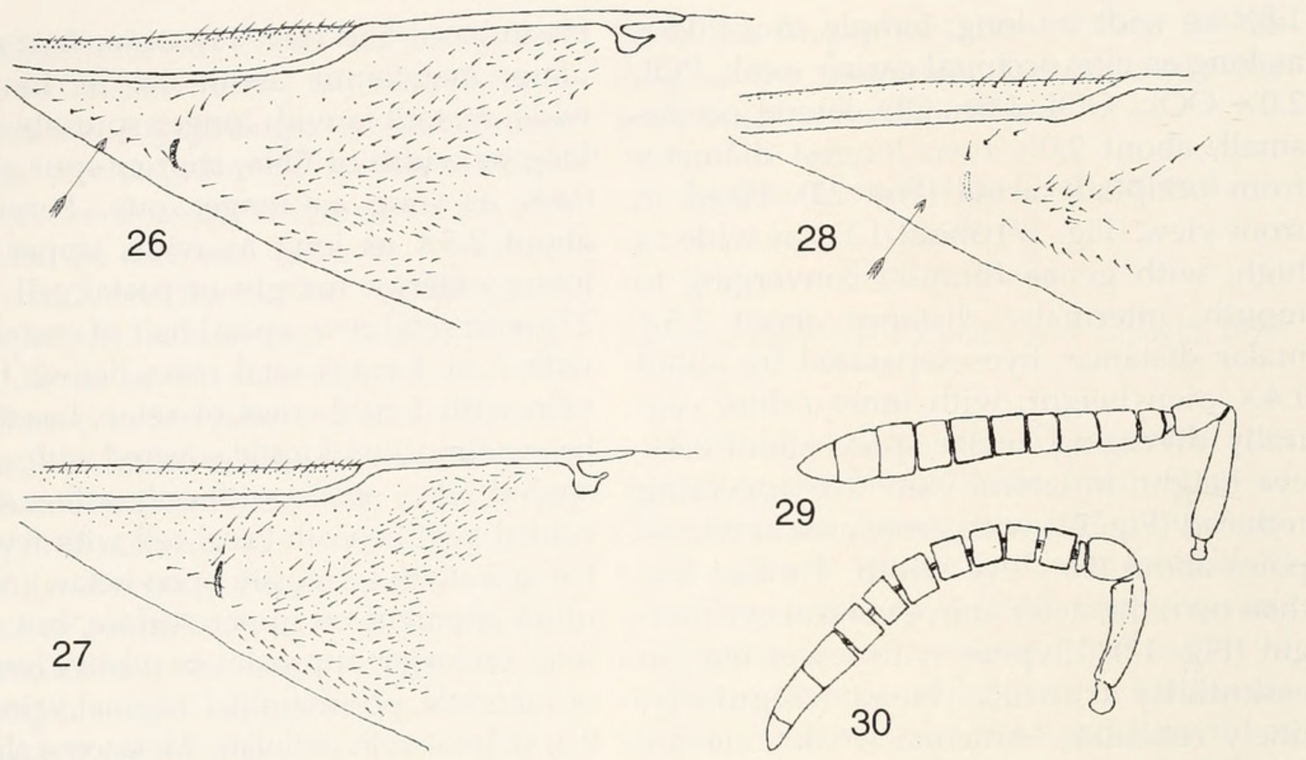
*Female.*—Body length 2.0–2.5 mm; ovipositor sheaths about 4× length of metatibia. Metallic blue black except following weakly brownish yellow: antenna, legs, wing veins, ovipositor sheaths; wings hyaline. Head in dorsal view (Fig. 23) about

1.8× as wide as long; temple about 0.5× as long as eye; occipital carina weak; POL 2.0× OOL, OOL 1.5× OD, lateral ocellus small, about 2.0× own longest diameter from occipital carina (Fig. 23). Head in front view (Fig. 17) about 1.1× as wide as high, with genae roundly converging to mouth; intermalar distance about 2.5× malar distance. Eyes separated by about 1.4× own height, with inner orbits ventrally diverging; malar space about 0.4× eye height; in lateral view eye appearing reduced (Fig. 21) with genal area at widest point about 0.6× eye width. Torulus less than own diameter above ventral eye margin (Fig. 17). Clypeus with lower margin essentially truncate. Head irregularly, finely reticulate. Antenna weakly clavate (Fig. 29); scape not reaching median ocellus, about 3× as long as wide; combined length of pedicel and flagellum about equal to width of head; pedicel in lateral view about 1.2× as long as wide; anellus distinctly transverse; F1 slightly shorter than pedicel, quadrate; F2 slightly longer than pedicel, a little longer than wide; F4 slightly wider than long; F7 about 1.5× as wide as long; clava equal to or longer than F5–F7 combined; sensilla arranged in 1 row on each segment; C3 without micropilosity beneath. Mesosoma ca 1.8× as long as wide, in profile propodeum sloping at about 60 degrees. Entire dorsal surface densely reticulate (transversely so just posterior to pronotum); lateral surfaces in most specimens nearly similarly sculptured (including acropleuron, upper and lower epimeron, and metapleuron), but some nearly smooth on lateral surfaces (see "Variation", below). Scutellum about as long as wide, moderately convex, without frenal line; setae sparse (about as in Fig. 3) to absent; scutellar flange narrow (barely perceptable), with no trace of pits. Propodeum nearly as reticulate as scutellum, with row of small fovea along anterior margin. Lower mesepimeron about 1.8× as high as wide. Metacoxa about 3–3.5× as long as wide, dorsally without setae in basal half (Fig. 11), outer face reticulate; metafemur about 4× as long as wide; metatibia with longer spur about as long as width of tibia, shorter spur about 0.6× as long as longer one. Forewing about 2.5× as long as wide; upper and lower anterior margin of costal cell (Fig. 27) with setal row, apical half of costal cell with 3 or 4 rows setal rows below; basal vein with 1 to 2 rows of setae; basal cell below almost uniformly covered with widespaced setae, above with only a few setae, cubital vein beneath basal cell with few setae apically (i.e., mostly open below); speculum apparent on upper surface, but with setae on lower; approximate relative lengths of marginal : postmarginal : stigmal veins 30: 9:4; stigmal vein petiolate. Metasoma slightly longer than mesosoma; hypopygium about 0.7× length of gaster. Ovipositor sheaths as long as body.

*Male.*—Body length 1.9–2.9 mm. Differing from female as follows: Antenna (Fig. 30): scape about 6× as long as wide; pedicel nearly 2× as long as wide; F1 shorter than pedicel, about as long as width of pedicel; F2–F7 wider than long; clava ventrally flattened, longer than F5–F7, C3 without ventral micropilosity; flagellum with short decumbent setae.

*Variation.*—This species appears to be highly variable in sculpture. In one rearing (Newport) 2 female and 2 males are lightly sculptured and 2 males are heavily sculptured. In an August rearing at Crescent City, 1 female and 1 male are lightly sculptured and 2 females are heavily sculptured, but an October rearing from the same locality has 1 female and 4 males all heavily sculptured. All other characters for these specimens appear to be consistent. In all specimens the torulus varies from slightly to much less than its own diameter above the ventral eye margins (Fig. 17), but this variation appears to be due to slight distortions of the head. (See also discussion section, below.)

*Etymology.*—This species is named in honor of Kenneth R. Hobbs who, long




Figs. 26–30. *Torymus* spp. 26–28, Forewing, basal portion, arrow points to cubital vein. 26, *T. azureus.* 27, *T. hobbsi.* 28, *T. tsugae.* 29–30, *T. hobbsi,* antenna. 29, Female. 30, Male.

ago, played a major role in its describer's pursuit of the torymids. Sadly, Kenny passed away before he could see the publication of this paper.

*Type material.*—Holotype ♀: Crescent City, [Del Norte Co.], California, 17-VIII-[19]14, Paterson, Hopkins No. 12557g, [ex cones] *Picea sitchensis* (deposited in National Museum of Natural History, Washington, DC). Paratypes: 2♀, 1♂, same data as holotype [1♂ Hopkins No. 12577g]; 1♀, 4♂, same data except 3-X-[19]13, P. D. Sergent, Hopkins No. 10850k, [ex cones] *Picea sitchensis* **Colorado**: 1♀, 2♂, Glenwood Springs, [Garfield Co.], 25-X-[19]13, reared IV-[19]14, Hopkins No. 10859e, [ex cones] *Picea sitchensis.* **Oregon**: 2♀, 4♂, Newport, [Lincoln Co.], reared 12-X-[19]15, J. M. Miller, Hopkins No. 13305a, [ex cones] *Picea sitchensis* (all specimens deposited in National Museum of Natural History, Washington, DC).

*Distribution.*—California, Oregon, and Colorado. According to GRIN (2000) the host tree is endemic to the Nearctic and is found in Alaska, British Columbia, Washington, Oregon, and northern California, but no mention is made of Colorado. It is possible that the latter host tree was misidentified.

*Host.*—Reared from cones of *Picea sitchensis.*

*Discussion.*—*Torymus hobbsi* is somewhat difficult to place within a species group. Following Grissell (1976) some specimens would fall within the *varians*-group based on the apparent absence of setae in the frenal area. The setae are sparse at best and may simply be missing. The frenal area is not delimited and the scutellum is heavily sculptured. In the Nearctic key (Grissell 1976) this species runs to couplet 3 in the species group where it could then run either to couplet 4 based on the small ocelli, or couplet 5 based on the higher than wide epimeron. Its round face (Fig. 17), reduced eyes (Fig. 21), and basal cell with numerous setae beneath distinguish it from all four species involved in these two couplets. In the key to Palearctic species (Graham and Gijswijt

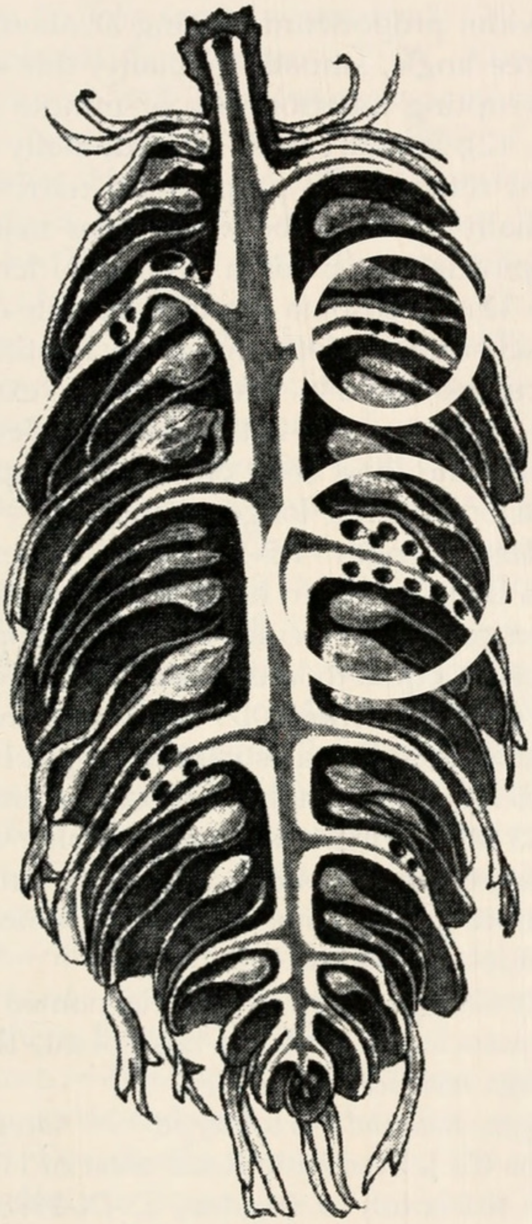


Fig. 31. *Pseudotsuga menziesii* cone. Cross section showing scale galls (white circles) of *Contarinia oregonensis* (Cecidomyiidae) (modified from Gagné 1989, Fig. 356, reprinted by permission).

1998) *T. hobbsi* runs to couplet 4 where it fits neither of the two treated species.

*Torymus hobbsi* differs from other species of *Torymus* reared from cones based upon the basal cell and parastigmal areas, which are nearly uniformly setose on the under side (Fig. 27). It also differs in part in the following respects [exceptions are noted in brackets]: the torulus is less than its own diameter above the ventral eye margin (Fig. 17) [also *ezomatsuanus, caudatus,* and *azureus,* especially when the head is collapsed]; the postgenal area is about 0.6–0.7× the eye width in lateral view (Fig. 21); the interocular distance is about 1.5× the eye height [also *ezomatsuanus*]; female and male *T. hobbsi* have the antennal club equal to or greater in length than the preceeding 3 segments (Figs. 29, 30); male *T. hobbsi* have the club somewhat flattened ventrally and distinctly acuminate at the apex (Fig. 30). Some specimens of *T. hobbsi* differ based upon the heavily sculptured acropleuron, upper and lower epimeron, metapleuron, and propodeum (all other species are essentially polished in these areas). Unfortunately the expression of sculpture in these areas is not consistent on all specimens, even in a single rearing, so that the above characters must be used in combination. In females, the ovipositor is about 4× as long as the metatibia. In both sexes the color is bluish black.

Four specimens reared from the series collected in Crescent City appear to represent either extreme variations of *Torymus hobbsi,* or a different species entirely. These have setae on the dorsum of the metacoxa and on the frenal area, both characters that indicate assignment to a different species group. It will require collection and analysis of new material in excellent condition to determine if more than one species is living in the cones of *Picea sitchensis.*

### *Torymus pseudotsugae* Hobbs, new species

Figs. 12, 15, 16, 19, 22

*Holotype female.*—Body length 2.0 mm; ovipositor sheaths abut 4× length of metatibia. Metallic blue with purple reflections under indirect light, including pedicel, anellus, head, thorax and abdomen; following light amber: scape, except apical 2/3 of dorsal surface dark blue, trochanters, femora at bases and apices, dorso-lateral surfaces of tibiae metallic blue fading to brown on ventral and mesolateral surfaces; protarsal segments nearly uniform brown, mesotarsal segments similar with basitarsus lighter brown, metabasitarsus off white with each segment increasingly brown distally; wing veins light brown basally becoming darker distally, stigmal vein prominently petiolate; areas between postmarginal vein and stigmas vein light brown. Face and dorsal aspects of thorax bearing closely appressed white setae about as long as distance between them; clypeal and apical scutellar hairs twice this length; metacoxa with dorsal setae. Head in dorsal view 1.7× as wide as long; temple 0.3× as long as eye; occipital carina developed; POL 2.5× OOL, OOL 1.6× OD, lateral ocellus 1.7× own longest diameter from occipital carina (Fig. 22). Head in front view (Fig. 16) 1.1× as wide as high, with gena roundly converging to mouth; intermalar distance 2.7× malar distance. Eyes separated by about own height, with inner margins ventrally slightly diverging; malar space 0.3× eye height; in lateral view eye not appearing reduced (Fig. 19; cf Fig. 21, *hobbsi*) with genal area at widest point 0.5× eye width. Torulus about 1.5–2× own diameter above ventral eye margin (Fig. 16). Clypeus with lower margin truncate, slightly recessed relative to ventral margin of head (Fig. 16). Antenna cylindrical (as in Fig. 4), scape not reaching median ocellus, about 4× as long as wide; combined length of pedicel and flagellum about much greater than width of head; pedicel in lateral view 2× as long as broad, anellus quadrate tapering basally, ratio pedicel:anellus:F1 through F7:club as 7:3:4:5:5:5:5:6:3 (Fig. 29); anterior 3/4 of pronotum transversely aciculate, posterior 1/4 finely reticulate as in remainder of dorsal surface of scutum and scutellum; forewing (Fig. 27) relatively bare basally, costal cell in basal 1/4 and apical 1/3 with upper and lower setal rows, lower surface with additional scattered setae behind setal row, basal cell with several setae paralleling submarginal vein, basal vein with 1 or 2 setae, cubital vein entirely setose; frenum and frenal line absent. Mesosoma about 1.6× as long as wide, propodeum sloping at about 60 degree angle, smooth medially, this area interrupting anterior row of minute pits (Fig. 12); laterally with longitudinally oriented reticulation; propodeum narrowed medially, distance between inner margin of spiracles 3× median propodeal length (Fig. 12). Mesosoma evenly reticulate over dorsal surface. Metasoma finely, distinctly reticulate laterally and dorsally except Mt2 smooth, Mt2–Mt5 medially deeply emarginate [best seen on paratype specimens], ovipositor longer than body.

*Male.*—Length 1.5–2.5 mm. Differing from female only in having more metallic green color; ocellocular and ocelloccipital distances equal to lateral ocellus diameter; and epimeron about 0.7× as wide as high.

*Variation.*—Females vary in length from 1.8 to 2.5 mm. with the ovipositor from 2.1 to 2.3 mm. Females are uniform blue with some purple reflections. The males tend to be more green, however, some are nearly as blue as females.

*Etymology.*—This species is named for the association with its host plant, *Pseudotsuga menziesii.*

*Type material.*—Holotype ♀: Oregon, [Coos Co.], Two Mile Road west of Highway 101 south of Bandon, 23-IX-1998, C. Hobbs, B. Baugh and S. Brown coll., reared from cones of *Pseudotsuga menziesii,* emerged in lab 2-II-1999 (deposited in National Museum of Natural History, Washington DC). *Paratypes*: 73♀, 59♂ (in USNM unless otherwise noted): 2♀, 8♂, same data as holotype. USA: **California**: 6♀, 1♂, Santa Cruz Co., Bonnie Doon, 1/2 mi. ne 4600 Smith Grade Road, 23-IX-1998, B. Hobbs, C. Hobbs, K. Hobbs, reared from cones of *Pseudotsuga menziesii,* emerged 8-I to 2-II-1999; 3♀, 1♂, [Siskiyou Co.], Happy Camp, Klamath National Forest, 27-VII-[19]54, Hopkins No. 34018d, *Pseudotsuga taxifolia* (now = *menziesii*); 1♀, Siskiyou Co., Etna, XI-1957, T. W. Koerber, Hopkins No. 34097a, *Pseudotsuga menziesii;* 4♀, 1♂, [Humboldt Co.], Orleans, 12-26-VIII-[19]54, Hopkins No. 34091d, *Pseudo-*

*tsuga taxifolia* (now = *menziesii*); 13♀, 6♂, Humboldt Co., Orleans, T. W. Koerber, Hopkins No. 37500a, *Pseudotsuga menziesii*; 4♀, Trinity Co., Salyer, IX-1957, T. W. Koerber, Hopkins No. 37504a, *Pseudotsuga menziesii*. **Idaho**: 5♀, 6♂, Shoshone Co., 9 mi. nw Kellog, ex cones *P. menziesii*; 18♀, 14♂, Idaho Co., ca. 1.8 mi sse Graves Butte, US Hwy. 12, mi. marker 139. ex. cones *P. menziesii* (specimens deposited in Natural History Museum, London; Canadian National Collection, Ottawa); 7♀, 5♂, Boise Co., 1 mi. e Lowman, T9N, R&E, Sec. 35, 19-VIII-1972, R. W. Clausen, ex cones *P. menziesii*; 1♀, 1♂, McCall, [Valley Co.], 12-VIII-1971, J. Dale, Hopkins No. 14280f, ex Douglas-fir cones. **Oregon**: 1♀, 7♂, [Jackson Co.], Mistletoe, 25-VIII-[19]16, J. E. Patterson, *Pseudotsuga taxifolia* (now = *menziesii*). CANADA: **British Colombia**: 8♀, 9♂, southern Vancouver Island, VIII-1994, R. Bennetem. Spring 1995, ex cones *P. taxifolia* (now = *menziesii*).

*Distribution*.—This species is widely distributed from northern California to southern British Colombia.

*Hosts*.—This species has been reared from seeds and cones of *Pseudotsuga menziesii*. Douglas-fir is endemic to the western United States and Canada (GRIN 2000) and so far has only a single known cecidomyiid species (*Contarinia oregonensis* Foote) that feeds in the cone scales (Fig. 31). It is possible that a seed-feeding cecidomyiid could also be present, but none has been reported (Gagné 1989 and personal communication).

*Discussion*.—*Torymus pseudotsugae* is a member of the *bedeguaris* species group as defined by Grissell (1976) and Graham and Gijswijt (1998). Among western Nearctic *Torymus*, the species would run to *T. coloradensis* (Huber) in the key by Grissell (1976); in the Palearctic Region it would run to *T. hylesini* Graham in Graham and Gijswijt (1998) (neither of these species is associated with coniferous cones). It is distinguished from cone-associated species by the following set of characters: the scutellum has no frenal area, is evenly covered with reticulate sculpture and sparse setae, and has no frenal line; the metacoxa is not elongate but is parallel-sided, with a few long setae distally and many short, recurved setae along the angled dorsal margin where the outer face meets the dorsal surface; the propodeal spiracle is less than 3× its own greatest length from the posterior margin of the propodeum and about 1/2 to 1/3 the median propodeal length (Fig. 12). In males the funicular segements have 2 rows of appressed setae that do not obscure the multiporous plate sensilla (Fig. 15), and in both sexes there is a single row of bristles that project at nearly right angles (Fig. 15). In females the ovipositor is about 4× as long as the metatibial length. In both sexes the body varies from metallic green, blue, or purple, with combinations of blue-green to bluish purple.

Interestingly *Torymus pseudotsugae* has not, until now, been recognized even though Douglas-fir seeds are a valuable crop (Masters 2003) and have been the object of much study (Johnson and Hedlin 1967, Hedlin et al. 1980, Hermann and Lavender 1990, Ministry of Forestry 2003). According to Hermann and Lavender (1990) the most destructive insects include: the Douglas-fir seed chalcid (*Megastigmus spermotrophus* Wachtl) (Hymenoptera), the Douglas-fir cone moth (*Barbara colfaxiana* Kearfott) and the fir cone worm (*Dioryctria abietivorella* Grote) (Lepidoptera), and the Douglas-fir cone gall midge (*Contarinia oregonensis* Foote) and cone scale midge (*C. washingtonensis* Johnson) (Diptera). According to Hedlin et al. (1980) any of these insects may effectively destroy a cone crop in a given location; Masters (2003) reported that cecidomyiid cone gall midges can cause a reduction of up to 80% in seed production. There are at least 5 described species of Cecidomyiidae (Diptera) (Gagne 1989) on *Pseudotsuga*, and it is one or more of these species that is the likely host of *Torymus pseudo-*

*tsugae.* If *Torymus pseudotsugae* is parasitizing one or more of the cecidomyiids, as is most likely based on the other cone-infesting *Torymus* examined in our study, then its value as a biological control agent has been overlooked completely.

**_Torymus tsugae_ (Yano)**
Figs. 5–7, 28

*Callimome tsugae* Yano [in Yano and Koyama] 1918a: 44–45; 1918b: 373.

This species was originally described from specimens reared from seeds of Japanese hemlock, *Tsuga sieboldii.* Yano did not give any other data for the types. Nothing has been published on *T. tsugae* since its description, and we have been unable to locate specimens of this species for comparison. Information about types was requested from Dr. Akihiko Shinohara, National Science Museum, Tokyo, and Dr. Tikahiko Naito, Kobe University, Kobe; both replied that Yano type material is not housed at these institutions. Kamijo (1962), writing of the type material of *Megastigmus cryptomeriae* Yano, *M. inamurae* Yano, and *M. thuyopsis* Yano, stated that it had been "destroyed by fire." Because *Torymus tsugae* was described in the same paper (Yano and Koyama 1918a) as these *Megastigmus,* it is likely that the types of this species were destroyed in the same fire. The following redescription is based on specimens reared from Japanese hemlock, the original host plant, which is native to Japan and Korea (GRIN 2000).

*Female.*—Body length 1.8–2.3 mm; ovipositor sheaths about 3.9× as long as metatibia. Dark blue with a violet or a greenish tinge in places. Scape testaceous, darker apically; pedicel and flagellum blackish. Legs testaceous: coxae and metafemur dark blue; pro- and mesofemora and metatibia medially darkened, usually with metallic reflections. Wings hyaline, with veins yellowish testaceous. Head in dorsal view (Fig. 5) about 1.9× as wide as long; occipital carina not strong. POL 2.2–2.27× OOL, OOL 0.95–1.2× OD. Head in front view (Fig. 6) rounded, 1.16–1.18× as wide as high. Eyes separated by 1.1× their height, with inner orbits subparallel. Malar space about one third height of eye; genae roundly converging towards mouth; in lateral view genal area about 0.3× eye width. Torulus about 1.5× own diameter above ventral eye margin. Clypeus with lower margin truncate or very shallowly emarginate. Both mandibles tridentate. Vertex and frons irregularly, densely reticulate, somewhat granulate, with sparse, rather distinct piliferous punctures. Face finely reticulate; setae on face short, with piliferous punctures indistinct. Antenna (Fig. 6): scape not reaching median ocellus, 3.4× as long as wide; pedicel plus flagellum about 1.3× width of head; pedicel 1.7–1.9× as long as wide, a little longer than F1; flagellum distinctly clavate; anellus slightly transverse to almost as long as wide; F1 quadrate to slightly longer than wide; F2 and F3 equal in length, a little longer than wide; F6 and F7 transverse; clava as long as F5–F7 combined, 2.0–2.25× as long as wide: C3 with a small tuft of micropilosity beneath (Fig. 7); sensilla disposed in 1 row on each funicle segment. Mesosoma nearly 1.7× as long as wide; in profile, propodeum sloping at about 60 degrees. Mid lobe of mesoscutum transversely reticulate, more or less imbricate in anterior half; setae moderately dense, with piliferous punctures shallow and indistinct. Scutellum 1.2× as long as wide, flat in longitudinal axis, reticulate, very densely so anteriorly; frenum indicated by very weak, almost smooth sculpture but frenal line absent; setae on scutellum about as in Fig. 3, with piliferous punctures distinct. Propodeum longitudinally, weakly sculptured, with a row of very small fovea along base. Lower mesepimeron small, 1.5× as high as wide. Metacoxa about 2.5× as long as wide, very weakly sculptured, dorsally with a carina and without setae in basal half; metafemur 4.4–4.7× as long as wide, with sparse, elongate piliferous punctures; metatibia with longer spur as long as width of tibia, shorter spur longer than half of longer one. Forewing 2.5× as long as wide; costal cell on upper surface with a row of setae apically; basal cell bare, open below (Fig. 28); basal vein with a few setae; speculum moderately large, narrowly open below; relative lengths of marginal: postmarginal : stigmal veins = 31:7:3.1; ST petiolate. Metasoma a little longer than mesosoma, compressed; hypopygium reaching about 0.7 of gaster. Ovipositor sheaths slightly longer than body.

*Male.*—Differs from female as follows. Body length 1.6–2.1 mm. Antenna: scape about 2.4× as long as wide; pedicel plus flagellum about 1.4× width of head; pedicel 1.3× as long as wide, a little shorter than F1; anellus distinctly transverse; F1–F2 subquadrate; distal funicle segments weakly transverse; clava without visible tuft of micropilosity. Mesosoma slender, 1.8–1.9× as long as wide. Scutellum 1.3× as long as wide or more, with scattered setae all over scutellum except on frenal area. Metasoma usually shorter than mesosoma.

*Specimens examined.*—6♀, 6♂, Shiga-Kogen, Nagano Pref., Honshu, Japan, em. 10.iv.–4.v.1957, ex seeds of *Tsuga sieboldii,* K. Kamijo (5♀, 5♂, in Laboratory of Systematic Entomology, Hokkaido University; 1♀, 1♂, National Museum of Natural History, Washington, DC).

*Distribution.*—Japan (Honshu). The host tree is endemic to the Palearctic and is known only from Japan and South Korea (GRIN 2000).

*Host.*—Reared from seeds of *Tsuga sieboldii.*

*Discussion.*—This species would be placed in the *bedeguaris*-group by Grissell (1976) and Graham and Gijswijt (1998). *Torymus tsugae* is recognized in females by having a few setae on the frenal area (as in Fig. 3), the ovipositor sheaths less than about 4× as long as hindtibia (4.5 to 5.5× as long in *azureus*), the metacoxa about 2.5× as long as wide and not parallel-sided (about 3.5× as long and parallel-sided in *azureus*), and the absence of setae on the basal vein and along the posterior margin of the basal cell (Fig. 28). In males, there may be a few setae along the basal vein (as in male *T. azureus*), but the speculum is open posteriorly (i.e., there are no setae on the poximal part of the cubital vein, thus leaving a bare path from the speculum to the posterior wing margin (Fig. 28). Other species generally have setae in the area posteriad of the speculum (e.g., Figs. 26, 27). Both sexes of *T. tsugae* are metallic blue to violet with some green tinges.

## HOST PLANT/*TORYMUS* LIST

(All species reared from coniferous cones. Insect hosts, when known, are Cecidomyiidae (Diptera) in cones or seeds.)

*Chamaecyparis lawsoniana* (A. Murray) Parlatore (Port Orford cedar)
- *Dasineura* sp.: *Torymus festivus* Hobbs
- *Janetiella siskiyou* Felt: *Torymus janetiellae* Graham and Gijswijt

*Picea abies* (L.) Karsten (Norway spruce)
- *Kaltenbachiola canadensis* (Felt): *Torymus caudatus* Boheman
- *Kaltenbachiola strobi* (Winnertz): *Torymus azureus* Boheman, *Torymus caudatus* Boheman
- *Plemeliella abietina* Seitner: *Torymus azureus* Boheman

*Picea engelmannii* Parry ex Engelmann (Engelmann spruce)
- unknown host in cones: *Torymus azureus* Boheman

*Picea glehnii* (F. Schmidt) Masters (Sakhalin spruce)
- cecidomyiid in seed: *Torymus azureus* Boheman, *Torymus ezomatsuanus* Kamijo

*Picea jezoensis* (Siebold and Zuccarini) Carriere (ezo spruce)
- cecidomyiid in seed: *Torymus ezomatsuanus* Kamijo

*Picea sitchensis* (Bongard) Carriere (Sitka spruce) unknown host in cones: *Torymus hobbsi* Grissell

*Pseudotsuga menziesii* (Mirbel) Franco (Douglas-fir)

unknown host in seeds and cones: *Torymus pseudotsugae* Hobbs

*Thuja plicata* Donn ex D. Don (western red cedar)

*Dasineura* sp.: *Torymus festivus* Hobbs

*Tsuga sieboldii* Carriere (Japanese hemlock)

unknown host in seeds: *Torymus tsugae* (Yano)

## ACKNOWLEDGMENTS

We thank Dr. Raymond Gagné (Systematic Entomology Laboratory, Washington, DC) for information and help with the nomenclature of cecidomyiid hosts. We also thank M. J. Gijswijt and W. Hogenes for the gift of specimens from the Zoölogisch Museum Amsterdam, Netherlands and Dr. Akihiko Shinohara (National Science Museum, Natural History, Tokyo) and Dr. Tikahiko Naito (Kobe University, Kobe), for help in attempting to find type material of *Torymus tsugae.* Information for Hopkins' Numbers was obtained from the Hopkins' cards on file with the Systematic Entomology Laboratory, National Museum of Natural History, Washington, DC. For reviewing the manuscript and making useful suggestions we thank John Noyes, the Natural History Museum, London, and Michael Gates, David Nickle, and David Smith, all of the Systematic Entomology Laboratory. Figure 31 (this paper) is reprinted from Gagné (1989) by permission of the publisher, Cornell University Press.

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