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Four new species of Trichogramma Westwood (Trichogrammatidae) from Japan

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**FOUR NEW SPECIES OF *TRICHOGRAMMA*
WESTWOOD (TRICHOGRAMMATIDAE)
FROM JAPAN**

A Thesis

Presented to

The Faculty of the Department of Biological Sciences

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Laurel V. Taylor

December 2002

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ABSTRACT

FOUR NEW SPECIES OF *TRICHOGRAMMA* WESTWOOD (TRICHOGRAMMATIDAE) FROM JAPAN

By Laurel Taylor

Four new species of *Trichogramma* Westwood from Northern and Central Japan are described: *T. oka* Taylor from Fukuoka Prefecture, *T. kurai* Taylor from Shimane Prefecture, *T. yabu* Taylor from Ishikawa Prefecture, all on Honshu Island, and *T. sapporoensis* Taylor from Sapporo Prefecture on Hokkaido Island. Diagrams and scanning electron micrographs are included with the four new species descriptions.

ACKNOWLEDGEMENTS

I am very grateful to Dr. Jeffrey Honda who gave me the opportunity to study entomology and who encouraged me to employ my background as an artist in the pursuit of taxonomy. I am deeply indebted to Josephine Jose for her extraordinary skill in mounting my specimens, for preparing SEMS, and helping in many ways towards this endeavor. Additionally, other members of our lab: Zia Nisani, Stan Vaughan, and Adrienne Brundage were always generous with general support and humor, neither of which I could have done without. Great appreciation is extended to Dr. Rodney Myatt and Dr. Adrian Rodriguez for their thoughtful and invaluable suggestions to improve the manuscript. A very special thanks to Dr. J. Gordon Edwards whose unflagging enthusiasm for entomology kept me inspired. Finally, I can't forget Dr. Gregory Laughlin who set me firmly on the road to becoming a scientist.

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INTRODUCTION

The Trichogrammatidae are cosmopolitan egg parasitoids that rarely surpass a length of 0.7 mm. *Trichogramma* is the largest genus in the family with 180 species presently described worldwide (Pinto 1998). Their parasitoid lifecycle and the ease of rearing them have stimulated much interest in them from the field of biocontrol (Pinto and Stouthamer 1994). However, their minute size and insufficient collections have impeded a thorough knowledge of *Trichogramma* systematics (Pinto 1998).

Undocumented introductions of *Trichogramma* occurred in the nineteenth and twentieth centuries, when they were exported and imported for their reputed value in agriculture, long before any reliable taxonomic characters had been established (Pinto 1998). Relatively large forewings in addition to their tiny body size made natural dispersal by wind inevitable as well, placing them “even on remote islands” (Doutt and Viggiani 1968), and helping to further obscure phylogenetic analysis by biogeography.

Indian researcher, Sudha Nagarkatti, redescribed several known *Trichogramma* species, establishing the central importance of the male genitalia as a diagnostic character (Nagarkatti and Nagaraja 1968, 1971). Her papers provided workers with morphological differences that correlated with reproductive data (Pinto and Stouthamer 1994). Nagarkatti’s redescrptions of some known species (Nagarkatti and Nagaraja 1971) included six species: *Trichogramma evanescens* Westwood (1833), *T. japonicum* Ashmead (1904), *T. jezoensis* Ishii (1941), *T. dendrolimi* Matsumura (1926), *T.*

austrailicum Girault (1912), and *T. chilonis* Ishii (1941) that were previously known from Japan and listed earlier in a 1965 tentative catalogue of insect natural enemies of injurious insects from Japan (Yasumatsu and Watanabe 1965). *Trichogramma evanescens* Westwood was also known to exist throughout the Palearctic and Oriental regions, while *T. chilonis* Ishii and *T. australicum* Girault had been reported in the Oriental region, in Eastern Australia, and on many Pacific Islands (Pinto and Stouthamer 1994).

Even with the advantage of the male genitalia as a character, *Trichogramma* is considered an anatomically conservative group; species discrimination is often based on relatively minor morphological differences (Pinto et al. 1989). As sampling increases, intraspecific variances become more apparent (Pinto 1998). High levels of phenotypic plasticity (Pinto et al. 1989) and the discovery of cryptic species (Pinto 1997) created a motive to employ alternative methods of taxonomy such as comparing allozymes as well as ITS2 DNA sequences.

Additionally, these developments in *Trichogramma* taxonomy made it possible to reassess the known species of Japan. The value of correct species identification of native taxa and the ability to discriminate from introduced exotics is of crucial importance for insects used in augmentation programs (Oatman and Platner 1973). Misidentifications, missing data, and a lack of type specimens undermined the accuracy of Watanabe's original assessment of the diversity of *Trichogramma* species found on the islands of Japan (Oatman et al. 1982). Of the original six species listed, only *T. japonicum* Ashmead, *T. chilonis* Ishii, and *T. dendrolimi* Matsumura are now considered known species of Japan (Oatman et al. 1982). *Trichogramma papilionis* Nagarkatti was

described at a later date (Nagarkatti 1975) from material collected in Fukuoka in 1974. It should also be noted that a lectotype was designated for *T. japonicum* Ashmead in 1982 (Oatman et al. 1982).

Material collected by the Institute of Biological Control (Faculty of Agriculture, Kyushu University, in Fukuoka), from 1989 through 1997, in Sapporo Prefecture on Hokkaido Island, and in Ishikawa, Fukuoka and Shimane Prefectures in Northern and Central Honshu (Fig. 1.) was made available to Dr. Jeff Honda's lab at San Jose State University. Four new species, all morphologically distinct from each other and from all previously known species of Japan, are recognized and described in this paper.

Fig. 1. Distribution of four new species of *Trichogramma* on Honshu and Hokkaido Islands. (Map credit: National Geographic Society, 1999)

MATERIALS AND METHODS

Trichogramma emerging from parasitized egg masses, collected from agricultural areas in Japan, were examined. Field-collected adults and larvae reared in the laboratory under constant climate conditions (30°) were killed and stored in 95% ethanol or wrapped in cotton tissue. Specimen preparation for slide mounting followed protocols described by Platner et al. (1999). After clearing in 10% KOH so the male genitalia were made visible, specimens were warmed at 30–40 C° on a oven for 1.0–4.0 hrs, depending on their degree of sclerotization. The specimens were placed in 10 % ethanol (approx, 10 ml with one drop of Triton X-100®), a warmed on top of a slide-warming oven for approximately 2 hrs and placed in 20% ethanol overnight.

The wasps were then taken through a dehydration series of 40, 60, 80, 95, and 100% ethanol for 45–60 minutes each, with a maximum of one hour at the two highest concentrations. At the final concentration, half of the ethanol was removed and replaced by a few drops of clove oil. As more ethanol evaporated, it was gradually replaced with the oil.

Following complete evaporation, 2–3 more drops of oil were added and left for at least 2 hours before mounting. A clean slide was prepared for the specimen. The insects were then transferred to a drop of Canada balsam that had been formed on a head of a size 1 insect pin. Under 100X magnification, the insect was positioned ventral side up and with all appendages in a single plane clear of obstruction from any other body parts. Most importantly, the male genital capsule (or the female ovipositor) was made as flat as possible to ensure accurate measurement.

After the balsam dried (1-2 weeks on a slidewarmer) a cover slip was prepared with a balsam applicator. A dot of balsam, dipped in xylene, was placed on the 5 mm cover slip and mixed with the applicator, then placed over the specimen. Completed slides were set on a slide warmer at 30 C° for at least two weeks.

Measurements (in millimeters) were adopted from Pinto (1998) and taken with a Zeiss compound microscope fitted with an ocular micrometer. Genitalia, antennae, forewing, and hind wing illustrations were drawn freehand using a Zeiss compound microscope (160X and 400X magnification), graphite, and graph paper. The original pencil drawings were then traced with archival ink Micron pens: 03 mm and .05 mm, on Durafilm® and mounted on Bristol board.

RESULTS

The new material examined is listed in Table 1. Anatomical terminology according to Pinto (1998) and taxonomic abbreviations are listed in Table 2.

The morphological characters studied in the Japanese material allowed recognition of four new species belonging to three cosmopolitan species groups. Two species: *T. kurai* (Figs. 2-4) and *T. yabu* (Figs. 5-7) are placed in the Exiguum Section, as defined by Pinto (1998): Exiguum members are characterized by a posteriorly narrowed genital capsule ($AW/GW < 0.7$). Their paraemes are relatively straight with a slight constriction at their base. The linguiform posterior extension of the dorsal lamina is moderately wide and the curved volsellae are normally of similar width their entire length. The elongate intervolsellar process is more than half the length of the volsellae, and the generally papilliform ventral processes near the base of the intervolsellar process are immediately lateral to the ventral ridge.

One species: *T. sapporoensis* (Figs. 8-10) can be included in the smaller Drepanophorum Section: characterized by a uniformly broad genital capsule (AW/GW usually > 0.7) which narrows apically. Distinctly curved volsellae with sclerotization medially continues anteriorly to the intervolsellar bridge area. On most species a dorsal ridge is apparent, and the parameres narrow and converge. The conical or subconical aedeagus is also typical of this species group (Pinto 1998).

Finally, *T. oka* (Figs. 11-13) is assigned to the Retorridum Section, marked by straight volsellae and a relatively short intervolsellar process.

Table 1. Four new species from Japan, known species they are compared with, and collection data.

New Species	Comparative Species	Author	Species Section	Location	Collector
<i>T. sapporoensis</i>	<i>T. obscurum</i>	Pinto	Drepanophorm	Nishino, Sapporo	Kurosa
<i>T. yabu</i>	<i>T. californicum</i>	Nagaraja & Nagakarti	Exiguum	Kanazawa, Ishikawa	Yabu
<i>T. oka</i>	<i>T. retorridum</i>	Girault	Retorridum	Ikuhashi, Fukuoka	Unknown.
	<i>T. japonicum</i>	Ashmead			
<i>T. kurai</i>	<i>T. ostrinae</i>	Pang & Chen,	Exiguum	Izumo City, Shimane	Murai
	<i>T. pretiosum</i>	Riley			

Table 2. Anatomical terms and abbreviations used in *Trichogramma* taxonomy diagnosis and description.

Antennae		Wings		Genital Capsule	
FL	Flagellum length	FWL	Forewing length	GCL	Genital capsule length
FW	Flagellum width	FWW	Forewing width	GCW	Genital capsule width
FL/FW	*	FSL	Fringe setae length	GW/GL	*
BPS	Basiconic peg sensilla	FWW/L	*	DA	Dorsal aperture
PLS	Placoid sensilla	FSL/W	*	DLA	Dorsal lamina
		HW	Hind wing	DR	Dorsal ridge
Female/Body				IVP	Intervolsellar process
OL	Ovipositor length			PM	Parameres
HTL	Hind tibia			VR	Ventral ridge
OL/HTL	*			VP	Ventral processes
HTL	Hind tibia length			VS	Volsellae
HTW	Hind tibia width			AD	Apical distance
				BD	Basal distance
				AD/GL	*
				AW	Apical width
				AW/GW	*

*indicates ratios

***Trichogramma kurai* Taylor, new species**
(Figs. 2-4)

Diagnosis:

Two widespread Asian and North American species: *T. ostrinae* Pang and Chen and *T. pretiosum* Riley, respectively, are very similar morphologically to *T. kurai* Taylor. Pinto (1998) carefully distinguished *T. pretiosum* and *T. ostrinae* from each other; therefore, the following considerations are listed to compare certain characters of *T. kurai* that may be confused with either or both species.

While the shape of the genital capsule of *T. kurai* is much like *T. ostrinae* and *T. pretiosum*, *T. kurai* is more likely to be mistaken for the Asian species, *T. ostrinae*, because of geographic location, but also because *T. kurai* possesses the same distinct character which distinguishes *T. ostrinae* from *T. pretiosum*: the adenate ventral processes (Pinto 1998). However, in *T. kurai*, the left process is placed distinctly posterior to the one on the right. *Trichogramma kurai*'s DLA originates from a slightly more anterior position than on the other species under consideration. It is deeply notched, has less developed shoulders than the other two species and narrows to apex in a more gradual manner. The intervolsellar process on *T. kurai* more closely resembles *T. pretiosum*'s and is best described as spinose, rather than narrow and subtriangular as is *T. pretiosum*'s, but *T. kurai*'s is also uniquely bifurcate.

Another useful character on the *kurai* genital capsule are prominent subconical volsellar spines which curve in a dorsolateral direction, and which in all the samples that were examined appeared asymmetrical in size and position from their counterpart on the opposing volsellae. Lastly, the scutellum setae are subequal, whereas in *T. pretiosum* and *T. ostrinae* they are of variable length.

Description:

Based on cultured material. Quantitative data taken from seven males (**HTL** = 0.1–0.16) and six females (**HTL** = 0.14–0.16). Forewing 0.18 ± 0.05 mm wide; **FWW/FFWL** = 0.50 ± 0.04 ; 6–8 setae between 4th and 5th vein tracks; longest fringe setae 0.15 ± 0.04 **FWW**, ca. 1.2X **HTW**. Hind wing with 0–3 and 0–6 setae in anterior and posterior track, respectively, the latter attaining 0.2 distance from the hamuli to wing apex. Scutellum with anterior pair of setae subequal to posterior pair.

Male:

Flagellum of antennae slightly curved, 0.17 ± 0.06 , about twice as long as scape. **FL/FW** = $6.1X \pm 0.4$, **FL/HTL** = 1.04–1.25 (N=6); moderately elongate, filliform setae tapers gradually to apex, **FSL/FW** = 3.3 ± 0.4 (3.0–4.0); unsocketed setae absent; **BPS** subglobose. **PS** formula 1-1(2)-1-(0)-1-1; terminal **PLS** does not extend beyond tip of flagellum.

Genital capsule widest at anterior of center of capsule, 0.37 ± 0.05 as wide as long; sides gradually convergent from widest aspect, slightly constricted at base of **IVP**, **PM** relatively straight and acuminate, slightly convergent at apex; **AD/GL** = 0.25 ± 0.01 (N=6); **AW/GW** = 0.59 ± 0.03 ; **DAL/GL** = 0.6 ± 0.05 ; **DLA** originating from anterior third of capsule, with a slight notch that never attains the sides of the capsule and with poorly developed shoulders, gradually tapering to a sublinguiform posterior extension whose width at **IVP** level is $.86 \pm 0.22$ that of aedeagus, and subequal to length of volsellae. **DLA** 1.7 ± 0.10 as long as wide, its length from apex of **DA** 1.28 ± 0.16 X **AD**; **VS** slightly bowed, narrowing apically, occupying 0.59 ± 0.07 **AD**, volsellar spines

prominent, subconical, asymmetrical. typically spine on right **VS** directed more dorsolaterally. longer and more arcuate than spine on opposing volsellae. **IVP** spinose, subequal to **VS**, occupying 0.46 ± 0.10 of **AD**; **VR** elongate, parallel, extends from base of **IVP**, ca. 0.33 of **BD**. **VP** prominent, protuberant, positioned ventrolateral and dorsolateral at base of **IVP**. Aedeagus subequal ± 0.06 **GL**. **AL/HTL** 0.75 ± 0.25 ; apodemes ca. 0.47 ± 0.09 **AL**.

Female: Funicle of antennae typically 1 **BPS** on F1 and F2.

OL/HTL = $1.06X \pm 0.14$.

Types: Holotype, allotype and 6 paratypes. JAPAN. *Shimane Prefecture*: Izumo City; 1990; ex eggs of *Ostrinia furnicalis*; Pyralidae. LEPIDOPTERA

Etymology: Kurai, a Japanese word for “dark.”

Geographic Distribution: Known only in Japan.

Materials Studied: 7 males and 6 females; 13 records.

Fig. 2. *T. kurai* n. sp. (a) Forewing (160X). (b) Antennae (400X). (c) Ventral and dorsal view of the male genital capsule (400X). (d) Hind wing (160X). Bars = 0.05 mm.

Fig. 3. Dorsal view of male genital capsule of *T. kurai* n. sp. (722X). SEM courtesy of Josephine Jose.

Fig. 4. Ventral view of male genital capsule of *T. kurai* n. sp. (612X). SEM courtesy of Josephine Jose.

***Trichogramma yabu* Taylor, new species**
(Figs. 5-7)

Diagnosis:

The genital capsule of *T. yabu* is very similar to the North American species *T. californicum* Nagaraja and Nagarkatti which is distinguished by narrow shoulders of the dorsal lamina that though rounded are less broadly so than in other examples of the Exiguum Section. The notch, evident just below the posterior extension, is definitively shallower in *T. yabu*, with the DLA width slightly broader anterior to the notch. Another exception to their resemblance is whereas *T. californicum*'s DLA is subequal in width to its aedeagus, *T. yabu* is 1.5X greater and the aedeagus/hind tibia ratio of *T. yabu* is at least 0.20 greater than the North American species. The narrow spinose IVP occupies 0.50 ± 0.14 of the AD in the new species in comparison with *T. californicum*'s which occupies only 0.40, but what is more strikingly apparent is that the IVP on *T. yabu* is subequal to the volsellae. Antennae of these species are very close but the forewings and the hind wings are less setose in *T. yabu* than *T. californicum* (see Variation).

Description:

Based on 4 slide-mounted males, 2 slide-mounted females, reported as a mean. Genital capsule data for paratype taken from dissected capsule of cultured individual. Color appearing dark in mounted material. Forewing $0.13 \text{ mm} \pm .13$ wide; FWW/FWL = $0.43 \pm .09$; 8-9 setae between 4th and 5th tracks; longest fringe setae $0.15 \pm .08$ FWW. Hind wing with 2 and 5 setae in anterior and posterior track, respectively, the latter attaining 0.2 distance from the hamuli to wing apex. Scutellum with anterior pair of setae equal in length to posterior pair.

Male:

Flagellum of antennae elongate, slightly curved, 2.6 as long as scape, **FL/FW**= 6.3 ± 1.18 , **FL/HTL** 1.13 ± 0.06 (N=4); moderately elongate, filiform setae tapers gradually to apex. **FSL/FW**= $0.3.90 \pm 0.7$; **BPS** (shape), formula 1-2(1)-1-1(0) -1-1; **PLS** only very slightly curved, terminal **PLS** with apical 0.15 extending beyond flagellum.

Genital capsule moderately broad, 0.36 ± 0.24 as wide as long; slightly constricted at base of **IVP**, **PM** slightly sinuate and acuminate, convergent at apex; **AD/GL** =0.21—0.03; **AW/GW**= $0.59 \pm .06$; **DAL/GL**=0.57—0.58; **DLA** originating from just below center of genital capsule, distinctly notched with rounded shoulders that do not approach sides of **GC**, forming a moderately broad linguiform posterior extension. acuminate at apex, whose width at **IVP** level is 1.5 ± 0.23 X more than that of aedeagus. **DLA** 2.13 ± 0.5 as long as wide, its length from apex of **DA**= 1.5 ± 0.21 **AD** and 0.49 ± 0.06 **GC**; spine of **VS** ovoid, **VS** slightly bowed, occupying $0.65 \pm .06$ of **AD**; **IVP** spinose occupying 0.57 ± 0.14 **AD**; **VR** extremely broad at posterior half, narrowing anteriorly, occupying ca. 0.40 of **BD**. **VP** not obviously protuberant, positioned at base of **IVP**. Aedeagus subequal (0.99 ± 0.06) of **GL**. **AL/HTL** 1.07 ± 0.09 ; apodemes 0.45 ± 0.04 **AL**.

Female: Funicle of antennae 1 and 2 **BPS** on F1 and F2, respectively.

OL/HTL=0.93–1.2X.

Types: Holotype, paratype and allotype. JAPAN. *Ishikawa Prefecture*: Kanazawa; 1997; ex eggs of *Ostrinia furnicalis*; Pyralidae. LEPIDOPTERA

Etymology: Named for the collector, Tetsuo Yabu.

Etymology: Named for the collector, Tetsuo Yabu.

Variation: 1 individual exhibited 17 setae between the 4th and 5th vein tracks.

Geographic Distribution: Known only in Japan

Materials studied. 4 males, 2 females; 6 records. In addition, a dissected genital capsule from a culture originating in Nangoku Kochi, was examined and incorporated into the description.

Fig. 5. *T. yabu* n. sp. (a) Forewing (160X). (b) Antennae (400X). (c) Dorsal and ventral view of the male genital capsule (400X). (d) Hind wing (160X). Bars = 0.05 mm.

Fig. 6. Dorsal view of male genital capsule of *T. yabu* n. sp. (534X). SEM courtesy of Josephine Jose.

Fig. 7. Ventral view of male genital capsule of *T. yabu* n. sp. (600X). SEM courtesy of Josephine Jose.

Trichogramma sapporoensis Taylor, new species
(Figs. 8-10)

Diagnosis:

Trichogramma sapporoensis bears a strong resemblance to a North American species: *T. obscurum* Pinto, another member of the Drepanophorum Section whose genital capsule is not as broad as other members of the group, but many of *T. sapporoensis*' distinguishing characteristics place it firmly within that assemblage. As it does in *T. obscurum*, the broad linguiform posterior extension of the dorsal lamina obscures the volsellae in dorsal view. The volsellae are significantly curved, with heavy sclerotization medially contiguous with the **IVP** and the area immediately anterior to it. The parameres are slender, slightly sinuate, pointed and convergent; and the aedeagus is conspicuously subconical. A short **DR** is weakly apparent at the very anterior end of the capsule—another similarity to *T. obscurum*—but the two can be easily separated by the dorsal lamina which is obviously notched on the anterior end in *T. sapporoensis* but not at all in *T. obscurum*. Other differences include the BPS and PLS formulas, the subequal scutellar setae and the less setose forewings and hind wings in the new species

Description:

Based on 11 slide-mounted males. Quantitative data taken from 11 individuals and reported as a mean (**HTL** = 0.15 ± 0.04). Hind wing and forewing data restricted to 5 or 8 individuals, respectively, due to damage. Genital capsule data taken from 10 individuals.

Color of head and thorax, light yellow, delicately suffused with brown.

Forewing 0.17 ± 0.04 mm wide; **FWW/FWL** = 0.50 ± 0.08 ; 6–9 setae between 4th and 5th tracks; longest fringe setae 0.19 ± 0.05 **FWW**. Hind wing with 0–4 and 0–3 setae in anterior and posterior track, respectively, the latter attaining 0.30 ± 0.02 distance from the hamuli to wing apex. Scutellum with anterior pair of setae long, equal in length to posterior pair.

Male:

Flagellum of antennae elongate, very slightly curved, 0.14 ± 0.04 mm, slightly longer than scape, **FL/FW** = 5.6 ± 0.8 , **FL/HTL** = 0.9 ± 0.3 ; (N=11) filiform setae tapers abruptly at apex, **FSL/FW** = 2.3 ± 0.4 ; unsocketed setae present on F1; **BPS** formula 1(2)-1-1-1 (2)-1 -1; terminal **PLS** extends 0.3 beyond apex of flagellum.

Genital capsule widest at the middle of capsule, 0.38 ± 0.02 as wide as long; sides gradually convergent from widest aspect, slightly constricted at base of **IVP**, **PM** straight and acuminate, very slightly convergent at apex; **AD/GL** = 0.24 ± 0.01 ; **AW/GW** = 0.53 ± 0.12 ; **DAL/GL** = $0.65 \pm .06$; **DR** weakly apparent. **DLA** originating from posterior half, slightly notched at base, forming a very broad linguiform posterior extension whose width at **IVP** level is ca. 1.2X more than that of aedeagus, but slightly less than **AW**. **DLA** 1.7 ± 0.44 as long as wide, its length from apex of **DA** = 1.2 ± 0.33 **AD**; **VS** curved with some medial sclerotization, occupying $0.45 \pm .01$ **AD**; **VS** spines ovoid, some sclerotization on median surface of volsellae, parallel to apex of **IVP**. **IVP** short, subtriangular, less than half the length of **VS**, occupying only 0.21 ± 0.03 of **AD**; **VR** extends from base of **IVP** to 0.26 **BD**. **VP** small, papilliform, positioned anterior to base of **IVP**, lateral to **VR**. Aedeagus 0.92 ± 0.07 length of **GL**. **AL/HTL** 0.88 ± 0.09 ; apodemes ca. $0.59 \pm .09$ **AL**.

base of **IVP**, lateral to **VR**. Aedeagus 0.92 ± 0.07 length of **GL**. **AL/HTL** 0.88 ± 0.09 ; apodemes ca. $0.59 \pm .09$ **AL**.

Female: Unknown.

Types: Holotype and 10 paratypes. JAPAN. Sapporo Prefecture: 1997; ex eggs of *Ivela* sp. LEPIDOPTERA

Etymology: Sapporoiensis named after the capital city of Hokkaido Island.

Geographic Distribution: Known only in Japan.

Materials studied: 11 males; 11 records.

Fig. 8. *T. sapporoiensis* n. sp. (a) Forewing (160X). (b) Antennae (400X). (c) Dorsal and ventral view of the male genital capsule (400X). (d) Hind wing (160X). Bars = 0.05 mm.

Fig. 9. Dorsal view of male genital capsule of *T. sapporoensis* n. sp. (607X). SEM courtesy of Josephine Jose.

Fig. 10. Ventral view of male genital capsule of *T. sapporoensis* n. sp. (446X). SEM courtesy of Josephine Jose.

***Trichogramma oka* Taylor, new species**
(Fig. 11)

Diagnosis:

Trichogramma oka displays all the critical characters which define the Retorridum Section. This small species group is exemplified by straight volsellae and a comparatively short intervolsellar process. As in most of these species, *T. oka*'s hind wings have complete anterior and posterior setal tracks. Like the North American species, *T. retorridum* and *T. gabrielino*, *T. oka* is distinguished by an elongate VR, almost 0.75 of BD, with the ventral processes positioned distinctly anterior of the intervolsellar process and laterally to the ventral ridge. The slender, subsinuate dorsal lamina most closely resembles that of the nominal species but the elliptical DA is not as narrow at its apex as in *T. retorridum*. *T. oka* should not be easily confused with

T. japonicum, also of this group, as the apical distance in *T. japonicum* is a much greater proportion of the genital capsule length, 0.34 compared to 0.22 in *T. oka*. Additionally, the width of the basal portion of the DLA in the new species is not nearly as broad and it abruptly tapers slightly posterior of the widest part of the capsule. Antennal differences include: BPS formula on *T. japonicum* allows for count of 2 on the first 3 antennal segments, whereas in *T. oka*, 2 BPS are only found on F1. Scutellum setae on *T. oka* are of equal length.

Description:

Based on two slide-mounted males and cultured material. Quantitative data taken from two individuals, and reported as a range when data varies. (HTL = 0.16–0.17). Hind wing and genital capsule data for paratype lacking due to damage. Genital capsule

data for the paratype is taken from a dissected capsule of a cultured sibling. Hind wing data taken only from holotype.

Color appearing light grey in mounted material; area of forewing behind venation noticeably darkened. Forewing 0.18 mm wide; **FWW/FWL** = 0.46–0.47; 9–13 setae between 4th and 5th tracks; longest fringe setae 0.02–0.03 **FWW**. Hind wing with 1 and 6 setae in anterior and posterior track, respectively, the latter attaining 0.03 distance from the hamuli to wing apex. Scutellum with anterior pair of setae long, equal in length to posterior pair.

Male:

Flagellum of antennae elongate, very slightly curved, 0.17–0.18 mm, slightly longer than scape, **FL/FW** = 5.8–6.3, **FL/HTL** = 1.02–1.08; moderately elongate, filliform setae tapers abruptly at apex, **FSL/FW** = 2.4 —2.5; unsocketed setae present on F1; formula 2-1-1-1(0)-1(0)-1; terminal **PLS** does not extend beyond apex of flagellum.

Genital capsule widest in anterior half just below center of capsule, 0.35—0.36 as wide as long; sides gradually convergent from widest aspect, moderately constricted at base of **IVP**, **PM** straight and acuminate, very slight convergent at apex; **AD/GL** = 0.22–0.24; **AW/GW** = 0.47–0.50; **DAL/GL** = 0.59–0.61; **DLA** originating from anterior half, not notched at base but immediately narrowing posteriorly, forming a slender linguiform posterior extension whose width at **IVP** level is ca. a half less than that of aedeagus, elongate and subequal to length of volsellae. **DLA** 1.6–1.9 as long as wide, its length from apex of **DA** = 1.0–1.25 **AD**; **VS** subrectangular in shape and truncate, occupying 0.75–0.86 **AD**; **VS** spines oval, some sclerotization on median surface of volsellae, parallel to apex of **IVP**. **IVP** short, subtriangular, less than half the length of

VS, occupying only 0.35–0.47 of **AD**; **VR** elongate, extends from base of **IVP** to 0.75

BD. **VP** papilliform, positioned distinctly anterior to base of **IVP**, lateral to **VR**.

Aedeagus 1.05–1.07X greater than **GL**. **AL/HTL** 0.72; apodemes ca. 0.50—0.57 **AL**.

Female: Unknown..

Types: Holotype and paratype. JAPAN. Fukuoka Prefecture: Ikuhashi; 1997; ex eggs of *Ostrinia furnicalis*, Pyralidae, LEPIDOPTERA.

Etymology: Oka, named after my Japanese-American college chemistry professor, Rodney Oka.

Geographic Distribution: Known only in Japan

Materials studied: 2 males; 2 records. In addition, a dissected genital capsule from a culture originating in Ikuhashi, Japan, was examined and incorporated into the description.

Fig. 11. *T. oka* n. sp. (a) Forewing (160X). (b) Antennae (400X). (c) Dorsal and ventral view of the male genital capsule (400X). (d) Hind wing (160X). Bars = 0.05 mm.

DISCUSSION

Four species of *Trichogramma* were collected from different locations on the islands of Honshu and Hokkaido in Japan (Table 1). These new species were compared for morphological characters against North American species and grouped accordingly within the assemblage sections in which they are best represented. Two species, *T. kurai* and *T. yabu*, are placed in the large Exiguum Section containing the most species of interest to biological control (Pinto 1998), because of the constriction at the base of the parameres, relatively straight parameres and the notched dorsal lamina. One species, *T. sappororiensis*, can be included in the smaller, but better defined (Pinto 1998), Drepanophorum Section characterized by a uniformly broad genital capsule. Finally, *T. oka* is assigned to the Retorridum Section, characterized by straight volsellae, relatively short intervolsellar processes, and setose forewings and hind wings (Pinto 1998).

These phylogenetic species groups are not satisfactorily resolved (Pinto 1998), but species groups serve as an informal category to classify hypothetical relationships in taxonomic problems that exist in a still-early stage of development (Pinto 1998). In *Trichogramma* cladistic analysis, a number of problems prevent definitive resolution of relationships, including relatively few delimiting characters and a certain amount of homoplasy in some of these traits (Pinto et al. 1989). Another important consideration is contrasting conclusions derived from the different contributions of genitalic or non-genitalic character suites (Pinto et al. 1989). Even though genitalic data has proven to be less plastic and more diverse than non-genitalic data, when a large number of species are

analyzed, a level of intermediacy promotes unavoidable arbitrariness in coding of the character states (Pinto 1998). Nevertheless, morphologically derived cladograms define a number of monophyletic assemblages for North American *Trichogramma* species that appear to have cosmopolitan distributions (Pinto 1998). No such consistent analysis and systematic grouping have yet been reliably established for other regions of the world.

Though there is scant evidence that individual species regularly occur in geographically separated areas, overlap emerges considerably at the species-group level (Pinto and Stouthamer 1994). Therefore, considering these new species in relation to the species they most closely resemble morphologically, and whose cladistic alignments have thus been loosely determined, may ultimately be of more value to the field of *Trichogramma* taxonomy than concentrating solely on species that share the same geographic location.

In addition, the literature available on Oriental species, especially on some of those remaining recorded for Japan, was introduced before rigorous and uniform *Trichogramma* taxonomic standards for type specimens were recognized, or the magnitude of conspecific variants was understood (Pinto et al. 1982).

In conclusion, it has been suggested that species of *Trichogramma* be described from limited samples only in cases where significant differences in male genitalia, isozymes, and reproductive incompatibility are readily apparent (Pinto et al. 1989). It is regrettable that two of the four species, *T. oka* and *T. yabu*, were determined from so few male samples, and that the other species examined, *T. kurai* and *T. sapporoensis*, though better fortified in numbers, were also derived from single populations from one locale. The argument to treat them as species, instead of tentatively as races or forms of other

known species that they may resemble, is that molecular DNA evidence clearly suggests their autonomy (Honda unpublished): this paper is offered as supportive confirmation of those findings.

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