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Trichogramma yousufi sp. nov. employed for the management of *Spodoptera exigua* and *Spodoptera litura* in Indonesia

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Abstract

Trichogramma (Hymenoptera: Trichogrammatidae) are minute polyphagous wasps and endoparasitoids of lepidopteran eggs. The objective of this study was to identify *Trichogramma* species emerging from the eggs of the Asian corn borer, *Ostrinia furnacalis* (Guenée) (Lepidoptera: Crambidae) attacking corn, *Zea mays* L. (Poaceae) in Bunga Raya, Siak, Riau, Sumatra, Indonesia, and individuals from an unidentified species obtained from a commercial laboratory in Jatisari, Karawang, West Java, Java, Indonesia. The emergence rate of *Trichogramma yousufi* sp. nov. Khan & Ikram (Hymenoptera: Trichogrammatidae) on an infestation containing eggs of both pest species, beet armyworm, *Spodoptera exigua* (Hübner), and the tobacco cutworm, *Spodoptera litura* (F.) (both Lepidoptera: Noctuidae), on *Acacia crassiparpa* A. Cunn ex Benth. (Fabaceae) also was evaluated in a nursery in Pangkalan Kerinci, Riau. Two *Trichogramma* species, namely *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) and a new species, *T. yousufi* sp. nov., were recovered from the eggs of *O. furnacalis* in Bunga Raya. *Trichogramma poliae* Nagaraja (Hymenoptera: Trichogrammatidae) was identified as the species reared in the laboratory in Jatisari. *Trichogramma yousufi* sp. nov. was compared and separated from its closer species, *Trichogramma latipennis* Haliday (Hymenoptera: Trichogrammatidae). *Trichogramma* species, recovered from corn crops and 1 that also was reared in the laboratory, successfully parasitized the eggs of *S. exigua* and *S. litura* under controlled conditions. The emergence rate of *T. yousufi* sp. nov. was recorded at 24.79 to 40.82%, with the highest percentage for more adults of this parasitoid released per m² in the nursery, indicating its potential to be employed as a biological control agent of *Spodoptera* in natural conditions.

Key Words: new species; *Ostrinia furnacalis*; parasitism rate

Resumen

Las especies *Trichogramma* (Hymenoptera: Trichogrammatidae) son avispas polífagas diminutas y endoparasitoides de huevos de lepidópteros. El objetivo de este estudio fue identificar las especies de *Trichogramma* que emergen de los huevos del barrenador asiático del maíz, *Ostrinia furnacalis* (Guenée) (Lepidoptera: Crambidae) que ataca al maíz, *Zea mays* L. (Poaceae) en Bunga Raya, Siak, Riau, Sumatra, Indonesia, e individuos de una especie no identificada obtenida de un laboratorio comercial en Jatisari, Karawang, Java Occidental, Java, Indonesia. Se evaluó la tasa de emergencia de *Trichogramma yousufi* sp. nov. Khan & Ikram (Hymenoptera: Trichogrammatidae) en una infestación que tenía huevos de ambas especies de plagas, el gusano del ejército de remolacha, *Spodoptera exigua* (Hübner), y el gusano del tabaco, *Spodoptera litura* (F.) (Lepidoptera: Noctuidae), en *Acacia crassiparpa* A. Cunn ex Benth. (Fabaceae) también en un vivero en Pangkalan Kerinci, Riau. Las dos especies de *Trichogramma*, *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae), y la nueva especie, *T. yousufi* sp. nov., fueron recuperados de los huevos de *O. furnacalis* en Bunga Raya. *Trichogramma poliae* Nagaraja (Hymenoptera: Trichogrammatidae) fue identificada como la especie criada en el laboratorio en Jatisari. *Trichogramma yousufi* sp. nov. fue comparada y separada de su especie más cercana, *Trichogramma latipennis* Haliday (Hymenoptera: Trichogrammatidae). Las especies de *Trichogramma*, recuperadas de cultivos de maíz, y una criada en el laboratorio, parasitaron con éxito los huevos de *S. exigua* y *S. litura* en condiciones controladas. Se registró la tasa de emergencia de *T. yousufi* sp. nov. en 24.79 a 40.82%, con el porcentaje más alto para adultos de este parasitoide liberado por m² en el vivero, lo que indica su potencial para ser empleado como agente de control biológico de *Spodoptera* en condiciones naturales.

Palabras Clave: nuevas especies; *Ostrinia furnacalis*; tasa de parasitismo

The beet armyworm, *Spodoptera exigua* (Hübner) and the tobacco cutworm, *Spodoptera litura* (F.) (both Lepidoptera: Noctuidae) are important polyphagous pests with a cosmopolitan distribution (Li et al.

2015). They are recorded as severe defoliating pests of *Acacia crassiparpa* A. Cunn. ex Benth. (Fabaceae) plantings that are growing in commercial nurseries in Riau, Sumatra, Indonesia (Sulistiyono et al. 2020).

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Spodoptera exigua and *S. litura* possibly migrate to *A. crassiparva* from onion, *Allium cepa* L. (Amaryllidaceae), crops because of the extensive area in which this vegetable is cultivated, which is recorded annually as being infested with these pests in Riau (Sulistiyono et al. 2020).

The minute polyphagous wasps, *Trichogramma* (Hymenoptera: Trichogrammatidae), are endoparasitoids of lepidopteran eggs (Leite et al. 2015, 2017; Pontes et al. 2019). *Trichogramma* could be recovered locally from crops such as corn, *Zea mays* L., and sugarcane, *Saccharum officinarum* L. (both Poaceae), and used in a program to control *S. exigua* and *S. litura* on *A. crassiparva* plantings in nurseries in Sumatra. *Trichogramma* species are not well understood in Indonesia (Yunus 2018). Studies on taxonomy characters and the biology of *Trichogramma* species on the eggs of alternative and natural hosts in Indonesia are important information for the management of lepidopterans in several crops (Jiang et al. 2019; Khan et al. 2019).

The objectives of this study were undertaken to identify the *Trichogramma* species recovered from the eggs of the Asian corn borer, *Ostrinia furnacalis* (Guenée) (Lepidoptera: Crambidae), attacking corn in Bunga Raya, Siak, Riau, Sumatra, Indonesia, and from an established colony in a laboratory in Jatisari, Karawang, West Java, Java, Indonesia. Additionally, to evaluate some biological parameters of these parasitoids on eggs of the rice moth, *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae) (an alternative host), *S. exigua*, and *S. litura* (natural hosts) in the laboratory. Finally, we wanted to discover the parasitism rate of *Trichogramma yousufi* sp. nov. Khan & Ikram (Hymenoptera: Trichogrammatidae) on eggs of a mixed population of *S. exigua* and *S. litura* recovered after a release of this parasitoid in an *A. crassiparva* nursery in Pangkalan Kerinci, Riau.

Materials and Methods

COLLECTION OF *TRICHOGRAMMA* SPECIES

Trichogramma chilonis Ishii (Hymenoptera: Trichogrammatidae) and *T. yousufi* sp. nov. were reared on eggs of *O. furnacalis* collected from a corn field during an exploration at Bunga Raya, Indonesia (0.7500°N, 102.0500°E, 15 masl). *Trichogramma poliae* Nagaraja (Hymenoptera: Trichogrammatidae) was obtained from Balai Besar Peramalan Organisme Pengganggu Tumbuhan, a commercial laboratory in Jatisari, Indonesia (6.3000°S, 107.0000°E, 100 masl), where it had been reared for about 5 yr on eggs of *C. cephalonica* and delivered to farmers to manage lepidopteran pests on sugar cane crops.

LABORATORY REARING

Eggs of *O. furnacalis*, parasitized by *T. chilonis* and *T. yousufi* sp. nov., and of *C. cephalonica* by *T. poliae* were taken to the Entomology Laboratory of PT. Riau Andalan Pulp and Paper in Pangkalan Kerinci, Riau, Indonesia, where they were kept at 26 ± 2 °C, 75 ± 5 % RH, and a 12:12 h (L:D) photoperiod. *Corcyra cephalonica* (Cruz 1980) and *O. furnacalis* (Seo et al. 2014) were identified based on the analysis of the external body morphology of adults. Colonies of these parasitoids were established on *C. cephalonica* eggs in the Entomology Laboratory.

MAINTENANCE OF *TRICHOGRAMMA* COLONIES

Corcyra cephalonica eggs were obtained from oviposition cages in the laboratory. These cages each consisted of a cylindrical PVC tube (12 cm diam × 30 cm high) with its top opening covered by organza fabric. Newly deposited eggs were separated from impurities using a cotton ball and were glued with diluted Arabic gum (90:10% Arabic gum:distilled water) onto sheets of paperboard (10 cm long × 2 cm

wide), totaling around 5,000 *C. cephalonica* eggs per paperboard sheet. Paperboard sheets then were placed on a plastic tray and exposed to ultraviolet light for 1 h in a chamber (40 cm long × 40 cm high × 40 cm wide) equipped with 2 lamps (Gaxindo®, GX-N093, T5-8W, Jakarta, Indonesia; purple light, lamp length = 29 cm, lamp diam = 1.5 cm, lamp wavelength = 28.5 cm, height from lamp to paperboard sheets = 30 cm) to make the *C. cephalonica* embryo unviable. After the inviability process, paperboard sheets were exposed individually to a colony of *T. chilonis*, *T. poliae*, or *T. yousufi* sp. nov. adults in a glass jar (12 cm long × 3 cm wide) for 72 h (3,000–3,500 adults per jar). Drops of honey were placed on the inner surface of the jars daily as food for the *Trichogramma* adults. Steps used to rear the larvae, pupae, and adults of *C. cephalonica* followed Amadou et al. (2019) with slight modifications.

BIOLOGICAL PARAMETERS OF *TRICHOGRAMMA* PARASITIZING *SPODOPTERA* EGGS IN THE LABORATORY

Spodoptera exigua and *S. litura* eggs and larvae were collected manually from an *A. crassiparva* commercial nursery in Pangkalan Kerinci, and taken to the Entomology Laboratory where the larvae were reared on a solid, cube-shaped artificial diet, following fabrication steps described by Tavares et al. (2019). *Spodoptera exigua* and *S. litura* newly deposited eggs, laid on paper sheets used as oviposition substrate in cages as previously described, were exposed to ultraviolet light for 1 h in a chamber to make the *Spodoptera* embryo unviable as previously described. *Spodoptera exigua* or *S. litura* paperboard sheets were prepared by cutting the egg masses from the paper sheets leaving 1 mass per sheet, followed by gluing the egg masses onto sheets of paperboards. Each sheet of paperboard was exposed to a colony of *T. chilonis*, *T. poliae*, or *T. yousufi* sp. nov. adults in a jar for 72 h as previously described (each sheet of paperboard had 6 egg masses exposed to 3,000–3,500 adults per jar). One egg mass had an average of 60 and 75 eggs for *S. exigua* and *S. litura*, respectively.

After subjection to parasitism, 1 sheet of paperboard was placed into a test tube (2 cm diam × 12 cm high), where it was kept until adult *Trichogramma* or larval *Spodoptera* hatched. Individuals of *S. exigua* and *S. litura*, from the same laboratory colony, were recently identified through morphology and confirmed via molecular analysis (Sulistiyono et al. 2020). The design was completely randomized with 9 treatments (each *Trichogramma* species parasitizing 1 of Lepidoptera), and with 25 replicates each with a sheet of paperboard. The following parameters were evaluated: incubation period, life cycle, adult longevity (d), female-biased sex ratio (number of females/number of insects), parasitism, and emergence (%). Blackened eggs, 4 d after subjection to parasitism, were classified as parasitized. Males and females of Trichogrammatidae were identified by dimorphism of their antennae, feathery in males, and nailed in females (Santos et al. 2020). The data were submitted to Analysis of Variance, and averages were compared by the Tukey range test (Tukey 1949) at 5% probability.

PARASITISM RATE OF *SPODOPTERA* BY *TRICHOGRAMMA* *YOUSUFI* SP. NOV. IN THE NURSERY

Trichogramma yousufi sp. nov. sheets of paperboard, consisting of fresh eggs of *C. cephalonica* subjected to parasitism for 72 h, were taken to a commercial nursery of *A. crassiparva* and were infested by about 95% *S. exigua* and 5% *S. litura* in Pangkalan Kerinci. The percentage of *Spodoptera* species was previously evaluated by collecting the moths using light traps. There were 3 treatments each with 5 replicates: 1, 2, or 5 paperboard sheets stapled per 1, 2, or 3 ground sand beds, respectively. Paperboard sheets were stapled on the abaxial surface of a leaf from the middle plant. Each bed (24 m long × 1 m wide) was

planted with 1,280 plantings. The experimental area was visited every d after the trial was established, and all new *Spodoptera* egg masses were eliminated. Five d after the paperboard sheets were stapled, 100 *Spodoptera* egg masses were randomly selected and recovered per treatment by cutting them from the entire leaf using scissors; then they were placed in 500 mL plastic containers (Easiyo®; Pekanbaru, Riau, Indonesia) and taken to the Entomology Laboratory where they were kept under incubation in glass jars (1 mass per jar) until adult *Trichogramma* or larval *Spodoptera* hatched. *Trichogramma* emergence rate was evaluated using the following formula: emergence rate = number of egg masses with adult *Trichogramma* hatched/number of recovered egg masses × 100. The data were submitted to Analysis of Variance, and averages were compared by the Duncan new multiple range test (Duncan 1955) at 5% probability.

TRICHOGRAMMA IDENTIFICATION, DESCRIPTION, PHOTOGRAPHY, AND DEPOSIT

Trichogramma species were identified and described after the external and internal morphology analysis of the male. Photographs were taken under a stereo zoom binocular microscope (ARK-zoom Star-VI, AmScope®; Irvine, California, USA) using a Leitz Labor Lux S (Leica®, Wetzlar, Germany) camera. Body measurements were made with oculometer of different magnification powers (10×, 20×, 40×) in the Leitz Labor Lux S. *Trichogramma yousufi* sp. nov. is deposited under the registration NFIC Accession No.: 22321, Depository: National Forest Insect Collection, Forest Protection Division, Forest Entomology Discipline, Forest Research Institute, Dehradun, Uttarakhand, India 248006.

Results

PARASITISM IN THE LABORATORY

This is the first report of *T. chilonis* and *T. yousufi* sp. nov. parasitizing eggs of *O. furnacalis*. Parasitism of eggs of *C. cephalonica*, *S. exigua*, and *S. litura* was successful using *T. chilonis*, *T. poliae*, and *T. yousufi* sp. nov. The mean incubation period, life cycle, adult longevity, and female-biased sex ratio of *Trichogramma* were similar on eggs of *Spodoptera* and *C. cephalonica* ($P < 5\%$). The parasitism and emergence rates were greater on *C. cephalonica* eggs than on those of *Spodoptera* ($P > 5\%$) (Table 1).

PARASITISM IN THE NURSERY

The emergence rate of *T. yousufi* sp. nov. parasitizing egg masses of a mixed infestation of *S. exigua* and *S. litura* in a commercial nursery of *A. crassiparva* (Fig. 1A, B) was greater with the density of 1 paperboard sheet stapled per ground sand bed ($P > 5\%$; Table 2).

DESCRIPTION OF *TRICHOGRAMMA YOUSUFI* SP. NOV. KHAN & IKRAM (FIG. 2A–F)

MALE. Body length 0.51 mm. Body honey yellow; ocelli and eyes bright red. Antennae pale brown with 32 to 35 thick and pointed hairs on flagellum. Midlobe of mesoscutum and scutellum light brown, forewings hyaline except light infuscation beneath STV; RS1 having 4 setae. Genital capsule longer than combined length of aedeagus and apodemes.

HEAD (Fig. 2E). 1.45× wider than long in facial view (192: 132); ocelli arranged in obtuse triangle; mandible with 3 denticles. Antennae (Fig. 2E) with scape, 3.6× as long as broad (77: 21); pedicel 1.5× as long as wide (35: 23) and slightly wider than scape (21: 23), 2-anelli (A1 and A2) present; flagellum having 31 to 35 thick and pointed hairs, 4.7× as long as broad (151: 65); flagellar setae longest of which about 2× as long as maximum width of flagellum (65: 32).

MESOSOMA. Mid lobe of mesoscutum about as long as wide; scutellum about 2× as wide as long (70: 35); propodeum about 2× longer than dorsellum medially. Forewings (Fig. 2C) about 2× as long as wide (428: 228) having RS1 4 seate (Fig. 2D); discal setae arranged in rows; costal cell narrow; marginal fringe about 1/8th of forewing width (30: 228).

METASOMA. Gaster about 2× longer than mesosoma (Fig. 2A); genital capsule slightly shorter than hind tibia (144: 140); aedeagal length slightly shorter than apodemes, both together slightly shorter than genital capsule (132: 140).

FEMALE (Fig. 2B). Body length 0.50 mm. Same as male except antenna having scape 3.7× as long as wide (85: 23); pedicel 1.7× as long as wide; club 2.4× as long as wide (85: 35). Ovipositor slightly longer than hind tibia (159: 156).

HOST. Eggs of the Asian corn borer, *Ostrinia furnacalis* (Guenée) (Lepidoptera: Crambidae).

TYPE SPECIMEN EXAMINED. Holotype, ♀ (on slide). Bunga Raya, Siak, Riau, Sumatra, Indonesia; 28-29 Nov 2018. Coll. Wagner de Souza Tavares. Ex. Eggs of the Asian corn borer, *Ostrinia furnacalis* (Guenée) (Lepidoptera: Crambidae).

PARATYPES. 2♂ & 2♀, same data as holotype.

DISTRIBUTION. Indonesia: Riau.

ETYMOLOGY. The species name is derived from the name of Dr. Mohd. Yousuf, Scientist-G, Forest Research Institute, Uttarakhand (India), who has provided the major contribution in taxonomy of the world Trichogrammatidae.

REMARKS. *Trichogramma yousufi* sp. nov. is very close to *Trichogramma latipennis* Haliday, but can be distinguished by the male body length of 0.51 mm. Antennae with scape, 3.6× as long as broad; pedicel 1.5× as long as wide; flagellum 4.7× as long as broad; longest hair of flagellum about 2× as long as maximum width of flagellum; flagellum having 31 to 35 thick, pointed hairs. Forewings (Fig. 2C) about 2× as long as wide (428: 228) having RS1 4 setae; discal setae arranged in

Table 1. Biological parameters (mean) of *Trichogramma chilonis*, *Trichogramma poliae*, and *Trichogramma yousufi* sp. nov. (Hymenoptera: Trichogrammatidae) parasitizing egg masses of *Corcyra cephalonica* (CC) (Lepidoptera: Pyralidae), *Spodoptera exigua* (SE), and *Spodoptera litura* (SL) (both Lepidoptera: Noctuidae) in the laboratory.

Parameter	<i>Trichogramma chilonis</i>			<i>Trichogramma poliae</i>			<i>Trichogramma yousufi</i> sp. nov.		
	SL	SE	CC	SL	SE	CC	SL	SE	CC
Incubation period (d)	9 a	9 a	9 a	9 a	9 a	9 a	9 a	9 a	9 a
Life cycle (d)	11 a	11 a	10.5 a	11 a	11 a	10.5 a	11 a	11 a	10.5 a
Adult longevity (d)	4 a	4 a	4 a	4 a	4 a	4 a	4 a	4 a	4 a
Female-biased sex ratio	0.7 a	0.7 a	0.7 a	0.7 a	0.7 a	0.7 a	0.7 a	0.7 a	0.7 a
Parasitism rate (%)	75.5 b	75.5 b	87 a	75.5 b	75.5 b	87 a	75.5 b	75.5 b	87 a
Emergence rate (%)	75 b	75 b	90 a	75 b	75 b	90 a	75 b	75 b	90 a

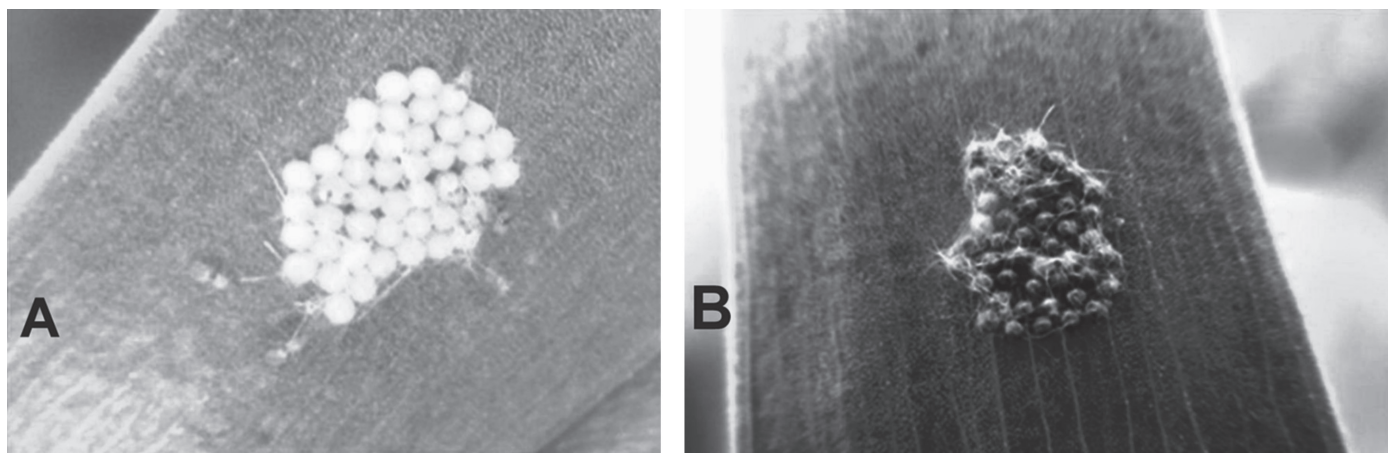


Fig. 1. Adults of *Trichogramma yousufi* sp. nov. (Hymenoptera: Trichogrammatidae) parasitizing an egg mass of *Spodoptera exigua* (Lepidoptera: Noctuidae) (A) and a parasitized egg mass (B) in a commercial nursery of *Acacia crassiparpa* (Fabaceae) in Sumatra, Indonesia.

rows; costal cell narrow; marginal fringe about 1/8th of forewing width (30: 228). FEMALE. Body length 50 mm. Antenna with club more than 2× as long as wide. Ovipositor hidden, slightly shorter than hind tibia.

In *T. latipennis*, male body length 0.42 mm. Antennae with scape, slightly less than 4× as long as broad; pedicel about 2× as long as wide; flagellum 4.7× as long as broad; longest hair of flagellum about 1.5× as long as maximum width of flagellum; flagellum having 41 blunt hairs. Forewings about 2× as long as wide (428: 228) having RS1 4 setae; discal setae arranged in rows; costal cell narrow; marginal fringe about 1/8th of forewing width (30: 228). FEMALE. Body length 41 mm. Antenna with club less than 2× as long as wide. Ovipositor slightly exerted, about as long as hind tibia.

TRICHOGRAMMA CHILONIS ISHII (FIG. 3A)

DIAGNOSIS. *Trichogramma chilonis*. Body about 0.45 mm long, honey yellow; male antennae with 35 to 45 long and tapering flagellar hairs, longest hair about 2.5× as long as maximum width of flagellum; forewings with fringe on tornus about 1/6th the wing width; genitalia having DEG triangular with prominent lateral lobes; chelate structure clearly below the level of gonoforceps; median ventral process broad at base; aedeagus longer than apodemes; both together slightly shorter than hind tibia; female with ovipositor as long as hind tibia.

TRICHOGRAMMA POLIAE NAGARAJA (FIG. 3B)

DIAGNOSIS. *Trichogramma poliae*. Body slightly more than 0.5 mm long, light brownish yellow; male antennae having flagellum with 30 to 35 long tapering hairs, longest hair about 3× the maximum width

of flagellum; forewings with marginal fringe on tornus about 1/6th the wing width; male genitalia having DEG with prominent lateral lobes; CS below the level of GF; MVP large and broad at base; apodemes shorter than aedeagus, both together slightly shorter than hind tibia. Female with ovipositor about as long as hind tibia.

Discussion

The similar incubation period of *Trichogramma* shows the eggs of *Spodoptera* and *C. cephalonica* being able to provide adequate nutrients to the larva of this parasitoid. Eggs of *C. cephalonica* (573.5 µm long × 346.1 µm wide, with a volume of 0.036 mm³) and *Spodoptera* (454.9 µm long and 390.2 µm wide, with a volume of 0.036 mm³), similar in size and volume (Cônsoi et al. 1999), are suitable to allow *Trichogramma* to produce large and vigorous adults, resulting in a standard life cycle period and survival rate (Firake & Khan 2014; Edwin et al. 2016). The higher number of females produced with eggs of both host species is beneficial in laboratory rearing for the release of this parasitoid (Brotodjojo & Walter 2006; Oliveira et al. 2017). The lower parasitism and emergence rate of *Trichogramma* on *Spodoptera* is possibly due to the ability of the eggs of this pest to encapsulate the parasitoid larva (Dorémus et al. 2013) and promote physical protection against parasitoids (Sá & Parra 1994). *Spodoptera* eggs are laid in 2 to 3 layers and are protected with hairs deposited by moths, with the parasitoid ovipositor encountering difficulties reaching those in deeper layers (Cônsoi et al. 1999).

The greater emergence rate of *T. yousufi* sp. nov. with a density of 1:1 (paperboard sheet:ground sand bed) was expected because a higher number of adults of this parasitoid was released per m². Higher densities of *Trichogramma* released per m² are more successful in parasitism (Jin et al. 2019; Mohammadpour et al. 2019). The emergence rate of *T. yousufi* sp. nov. in the current study was greater than that of *Trichogramma japonicum* Ashmead (Hymenoptera: Trichogrammatidae) on eggs of the rice yellow stem borer, *Scirpophaga incertulas* (Walker) (Lepidoptera: Crambidae), by 2.05% in Asian rice, *Oryza sativa* L. (Poaceae), cabbage, *Brassica oleracea* L. (Brassicaceae), corn, and tomato, *Solanum lycopersicum* L. (Solanaceae), crops and of *Trichogramma chilonis* Nagaraja & Nagarkatti (Hymenoptera: Trichogrammatidae) on those of a mixed infestation of the cabbage cluster, *Crociodolomia pavonana* (Fabricius) (Lepidoptera: Crambidae), and *S. litura* by 1.67% on cabbage crops in Solok, West Sumatra, Indonesia (Hidayani et al. 2013).

Table 2. Emergence rate (mean) of *Trichogramma yousufi* sp. nov. (Hymenoptera: Trichogrammatidae) parasitizing egg masses of a mixed population of *Spodoptera exigua* and *Spodoptera litura* (both Lepidoptera: Noctuidae) in a commercial nursery of *Acacia crassiparpa* (Fabaceae) in Sumatra, Indonesia.

Density of paperboards installed per group of ground sand beds	Emergence rate (%)
1:1	40.82 a
1:2	33.34 b
1:5	24.79 c
CV	24.32

Means followed by different letters differ by the Duncan new multiple range test at 5% probability. CV = Coefficient of variation.

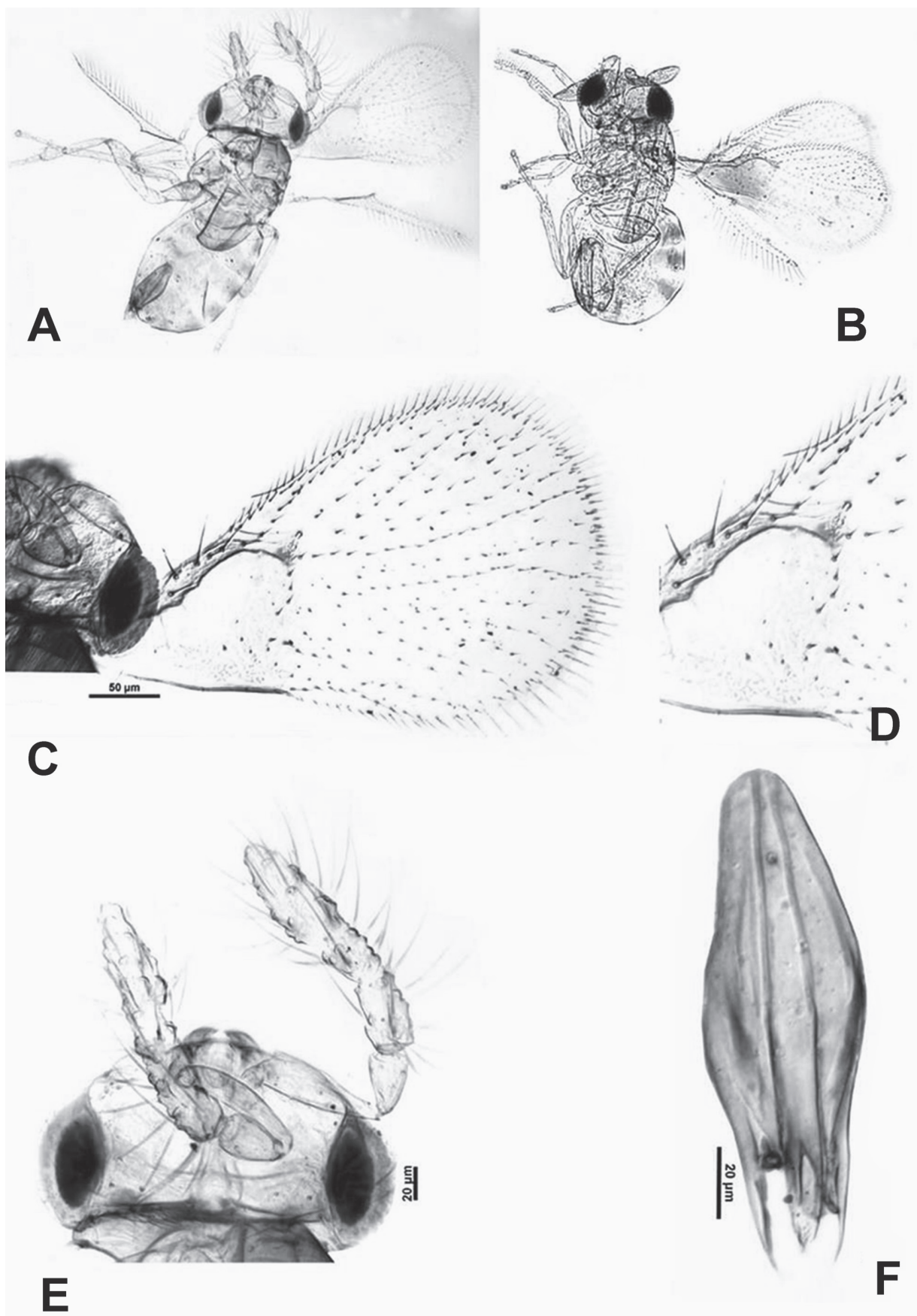


Fig. 2. *Trichogramma yousufi* sp. nov. (Hymenoptera: Trichogrammatidae) adult male (A), adult female (B), fore wing (C), RS1 (D), head with antennae (E), and male genitalia (F).

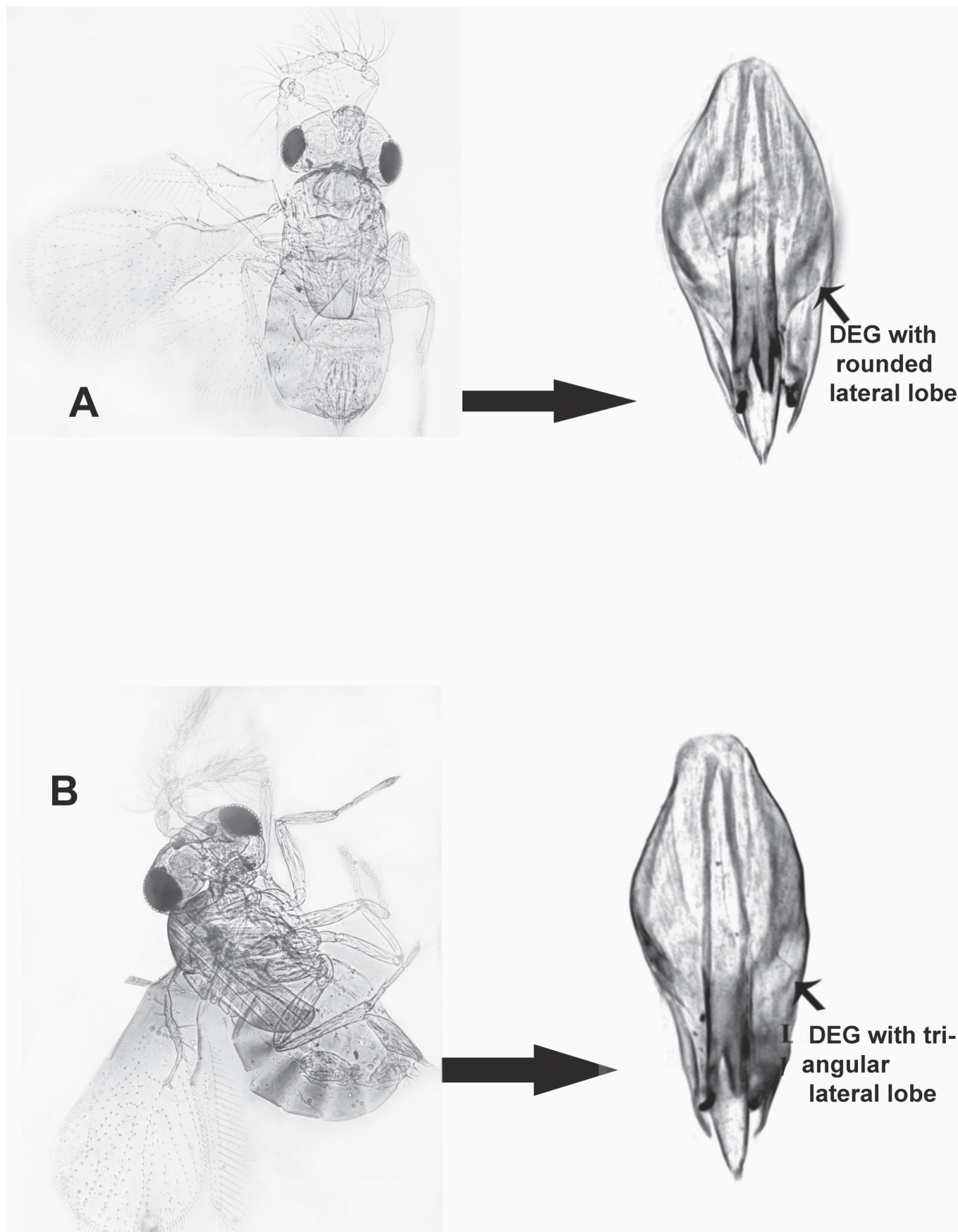


Fig. 3. Genitalic difference between adults of *Trichogramma chilonis* (A) and *Trichogramma poliae* (B) (Hymenoptera: Trichogrammatidae).

In conclusion, *T. chilonis* and the new species, *T. yousufi* sp. nov., were recovered from *O. furnacalis* eggs during a field exploration in Bunga Raya, whereas *T. poliae* was obtained from *C. cephalonica* eggs in a laboratory in Jatisari. The separation of *T. yousufi* sp. nov. from its closer species, *T. latipennis*, has been discussed in greater detail. The taxonomic characters of all 3 *Trichogramma* species have been given precisely. The *Trichogramma* species, recovered from corn crops and reared in a laboratory, successfully parasitized *S. exigua* and *S. litura* eggs under environmentally controlled conditions, with the parasitism rate of *T. yousufi* sp. nov. ranging from 24.79 to 40.82% on the eggs of *S. exigua* and *S. litura* attacking *A. crassiparva* plants in a commercial nursery in Pangkalan Kerinci. It therefore appears from this study that *T. yousufi* sp. nov. may be employed as a biological control agent to manage *Spodoptera* in *Acacia* nurseries.

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