



## Research Article

## Three new species of *Trichogramma* (Hymenoptera: Trichogrammatidae) from southern India

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**ABSTRACT:** Three species of *Trichogramma*, *T. rabindraii*, *T. pieridis* and *T. giriensis* have been described as new. The first species was reared from the eggs of a sphingid on a marshy weed bordering paddy fields at Someshwar and Saligrama in Udupi District, the second one from those of a pierid on *Cassia fistula* at Balehonnur, Chickamagalur District (both Karnataka) and the third from unidentified lepidopterous eggs on bamboo leaves at Tusharagiri (Kerala). The taxonomic significance of scutellar bristles, RS1 row of setae in the forewings and setal arrangement in the hind wings are discussed. A key to differentiate the three newly described species from other closely resembling ones has been included.

**KEY WORDS:** New species, *Trichogramma*, *T. rabindraii*, *T. pieridis*, *T. giriensis*, RS1 row of setae, scutellar bristles, Pieridae, Pyralidae, Sphingidae, Lepidoptera, *Cassia fistula*, biosystematics, dendrogram, biological control

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### INTRODUCTION

The survey was carried out in Someshwar and Saligrama in Karnataka, S. India near the West coast of Udupi district and Balehonnur in Chickamagalur district for collection of trichogrammatids in 2007. At Someshwar, below Agumbe ghat and at Saligrama a new species of *Trichogramma* was collected from the eggs of an unidentified sphingid (*Agrius convolvuli* (L.)?) (Lepidoptera: Sphingidae) on a marshy weed lining the paddy fields. This species produced a small percentage (less than 5%) of apterous males. The second species was collected from the eggs of a pierid (*Catopsilia pyranthe* (L.)?) (Lepidoptera: Pieridae) on leaflets of *Cassia fistula* along the banks of a river at Balehonnur. The third species emerged from unidentified lepidopterous eggs on bamboo leaves at Tusharagiri, near Palghat, Kerala. These three species are distinctly different from other known *Trichogramma* and have been described in this paper as new. Additionally, the importance of scutellar bristles, RS1 setae in the forewings and setal rows in the hind wings have been discussed.

A key to distinguish these newly described species from other closely resembling species has been included based on the illustrations and descriptions in Sorokina

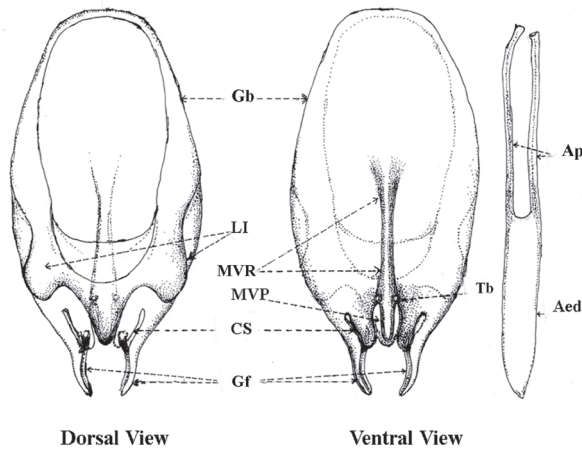
(1993), Polaszek *et al* (2002), Gibbs. *et al.* (2004), Yousuf and Hassan (2008a,b) and Pang and Chen (1974).

### MATERIALS AND METHODS

Adults of *T. rabindraii* which emerged at NBAIL, Bangalore could not be cultured in the laboratory since it failed to parasitize the eggs of the laboratory host *Corcyra cephalonica* Stn. (Lepidoptera, Pyralidae). It however accepted eggs of a local unidentified sphingid, which were laid on *Catharanthus roseus* (= *Vinca rosea*). But these eggs were not continuously available resulting in the dying down of this culture. The adults of the other two species readily parasitized eggs of *C. cephalonica* and hence cultures could be established in the laboratory for further studies.

For mounting specimens on slides the dead specimens were treated in Glacial Acetic acid for 24 hrs for clearing. They were then treated for 3 – 24 hrs in a mixture of Phenol and Glacial Acetic acid at 1: 1. When the specimens were cleared and dehydrated they were mounted on slides in a mixture of Phenol and Canada Balsam at 1: 1. The slides were then dried in a hot air oven for 1–2 hrs and outside. Drawings were made using a *camera lucida*.

The terminology used in the description of male genitalia is detailed in Fig. 1.



**Fig. 1.** Male genitalic structures of taxonomic significance (Aed – aedeagus; Ap – apodemes; CS – chelate Structure; DEG – dorsal Expansion of gonobase; Gb – gonobase; Gf – gonoforceps; LI – lateral lobes; MVP – median ventral projection; MVR – median ventral ridge; Tb – tubercles)

**Description of new species**

***Trichogramma rabindrai* sp. nov. (Fig. 2)**

Male: Length: 0.52 (0.45 – 0.67; N = 10) mm; width across head: 0.21 (0.17 – 0.27N = 10) mm.

Colour: Head light yellow; ocelli dark pink; eyes brick red; antenna light greyish yellow, hairs dark. Thorax light yellow except for greyish prothorax and mesoscutum; legs light yellow. Gaster with grey shades especially at the apex.

Antenna with flagellum length x 3.75 the width, x 3.5 the pedicel and x 1.7 the scape with 30–32 short hairs, longest measuring less than two times the maximum width of flagellum. Forewing length about two times width, fringe setae on tornus about 0.13 the width of wing, basal infuscation up to stigma, RS1 with 2–5 setae.

Scutellum with anterior bristles small, measuring about 0.33 of posterior bristles, sensory pits lying in between the bristles, nearer to posterior bristles.

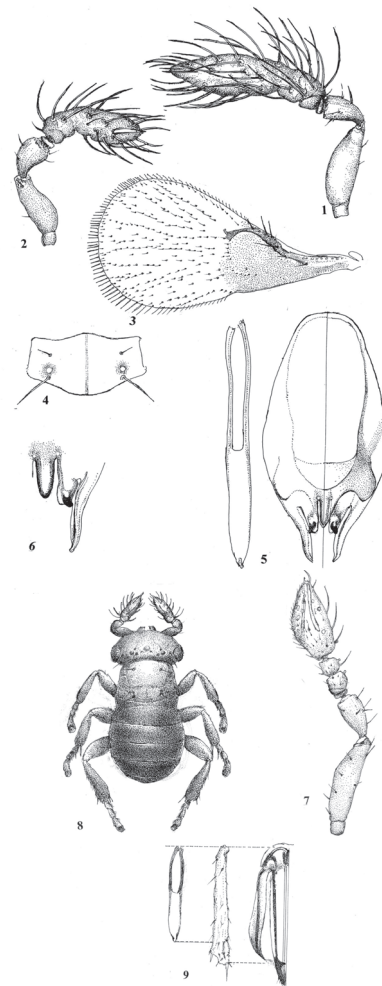
Length of genital capsule about x 2 its width, DEG with very distinct lateral lobes pointing diagonally with distinct notches behind. GF converging towards median line. CS below GF at 0.10 of length of genital capsule. MVP distinct, not pointed, reaching to about 0.75 level of CS, lateral tubercles at the base of MVP. Aedeagus as long as apodemes, both together as long as genital capsule and about 0.86 of hind tibia. Ventral ridge (VR) running nearly half the length of genital capsule.

Apterous male: Length 0.43 (0.36–0.46; N = 7) mm; width across head 0.15 (0.13–0.18; N = 7) mm. Colour light yellow, with dark red ocelli and brick red eyes and greyish abdomen. Antenna with short flagellum, length x 3 of width, x 1.9 of pedicel and x 1.3 of scape and with

18-20 short hairs, longest measuring less than x 2 the maximum width of flagellum. Genitalia as in alate male.

Female: Length 0.58 (0.48–0.67; N = 10) mm and width across head 0.22 (0.20–0.24; N = 10) mm.

Colour: Head light yellow, ocelli dark pink, eyes brick red, antennae light yellow. Thorax light yellow but for greyish prothorax and anterior mesoscutum; legs light yellow. Gaster with anterior terga blackish followed by light yellowish mid-abdomen and blackish tip.



**Fig. 2.** *Trichogramma rabindrai* sp. nov. (1. male antenna (Alate); 2. male antenna apterous); 3. forewing; 4. scutellum; 5. male genitalia with aedeagus drawn separately; 6. terminal portion of male genitalia (part enlarged); 7. female antenna; 8. apterous ale; 9. relative lengths of aedeagus, hind tibia and ovipositor)

Antennae with club length x 2.2 of width x 1.9 of funicle, x 1.9 of pedicel and about 0.78 of scape Ovipositor about x 1.15 the length of hind tibia.

Holotype: Male: Slide with male specimen with following particulars: Ex Egg of unidentified sphingid on a marshy weed growing along the border of paddy field. Someshwar. Udupi District, Karnataka. Coll.: Prashanth Mohanraj and H. Nagaraja, July, 2007.

Paratypes: (i) Apterous male (ii) Alate male, and (iii) Female with above particulars as well as from Saligrama, (Udupi District).

Holotype and Paratypes (two each of alate and apterous males and females) with above particulars also from another locality, Saligrama (Udupi District) are deposited in the Museum of National Bureau of Agriculturally Important Insects, Bangalore.

Holotype deposited in NBAII (ICAR), Bangalore and Paratype males and females at NBAII (one each) and IARI, New Delhi (one alate male and one female).

**ETYMOLOGY:** *T. rabindrai* is named after Dr. R. J. Rabindra, Director, NBAII, Bangalore.

**Comments:** *T. rabindrai* is a distinct species with alate and apterous males. Apterous males are also produced in *T. semblidis* (Aur.) which is morphologically different from *T. rabindrai*. In *T. semblidis* the apterous antennal flagellum in males is segmented while it remains unsegmented in *T. rabindrai*. Based on the structure of the male genitalia *T. rabindrai* falls into the *T. chilonis* group. Other species in this group include *T. poliae* Nag., *T. dendrolimi* Mats., *T. bactrianum* Sugonjaev and Sorokina (Sorokina, 1993), *T. nubilale* Ertle and Davies (Ertle and Davis, 1975), *T. manicobai* Brun, Moraes and Soares (Brun *et al.*, 1984), *T. ivalae* Pang and Chen (Pang and Chen, 1974) and *T. closterae* Pang and Chen (Pang and Chen, *op.cit.*). However, the distinct lateral lobes of the DEG are pointed diagonally in *T. rabindrai* (as well as *T. manicobai*, see key) rather than laterally as in *T. chilonis*. Additionally, the male antenna in *T. rabindrai* has very short hairs, 2 times or less than the maximum width of flagellum. Moreover the apex of the DEG is narrow and short.

***Trichogramma pieridis* sp. nov. (Fig. 3)**

Male: Length 0.53 (0.38–0.60; N = 15) mm; Width 0.22 (0.15–0.27; N = 15) mm.

Colour: Head light dull yellow; ocelli dark pink, eyes brick red, antennae light; sensory pits below anterior bristles, nearing posterior ones. Thorax light yellow with prothorax and anterior portion of mesoscutum greyish. Gaster light dull yellow with anterior-most terga blackish.

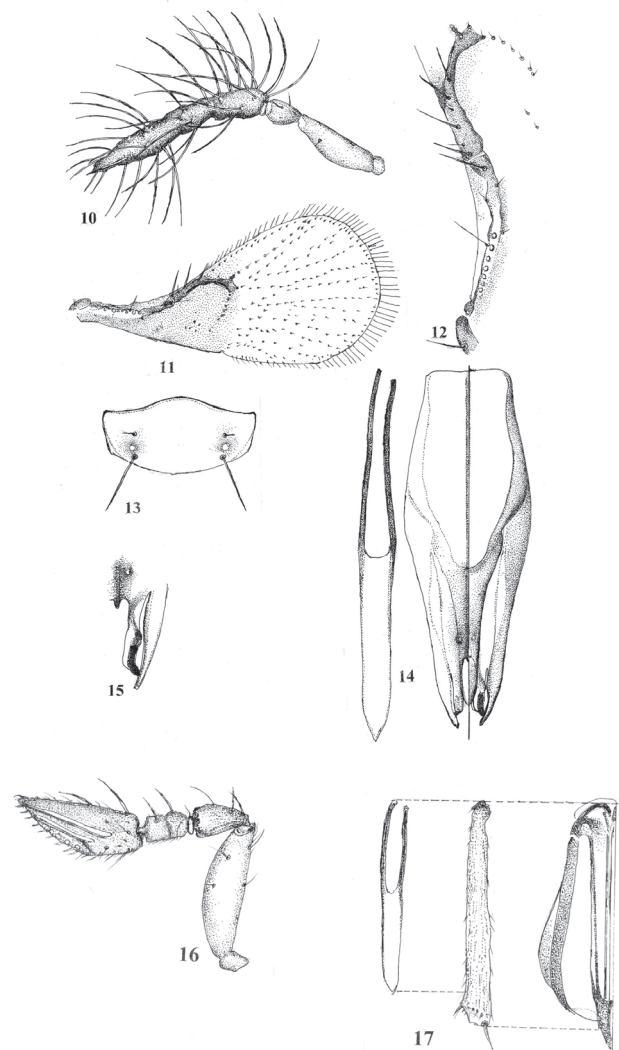
Antenna with flagellum length x 7 the width, and x 5 the pedicel and x 1.8 the scape with 31–35 long hairs, longest being nearly x 3.5 the maximum width of flagellum. Forewing with width slightly less than x 0.5 the length. Fringe setae on tornus about 0.13 the width of wing. Basal infuscation extending up to the level of stigma, RS1 tract with 3–7 setae. Scutellum with anterior bristles about 0.16 the length of posterior bristles; sensory pits below anterior bristles, nearing posterior ones.

Genitalia: Length x 2.7 of width. DEG without lateral lobes, narrow, both sides nearly parallel, reaching slightly below the level of CS with indistinct notches behind DEG;

CS slightly below level of GF. MVP very minute, lateral tubercles far below the MVP. Aedeagus with equally long apodemes, both together somewhat longer than the genital capsule and about 0.85 the length of hind tibia. Ventral ridge broader till the middle, but narrower till MVP.

Female: Length 0.59 (0.53–0.69; N = 10) mm; Width 0.24 (0.22–0.26; N = 10) mm.

Colour: Head light yellow, ocelli dark pink; eyes brick red; antennae light dull light yellow. Thorax light yellow with prothorax and mesoscutum dark greyish, legs light yellow. Abdomen light yellow with anterior-most terga blackish.



**Fig. 3. *Trichogramma pieridis* sp. nov. (10. male antenna; 11. forewing; 12. basal portion of forewing showing pre-marginal, marginal and stigmal regions of vein and the recurrent vein track; 13. scutellum; 14. male genitalia with aedeagus drawn separately; 15. terminal portion of male genitalia (part enlarged); 16. female antenna; 17. relative lengths of aedeagus, hind tibia and ovipositor)**

Antenna with club length nearly x 2 of width, about x 2.8 the funicle, x 2.4 the pedicel and slightly shorter than scape. Ovipositor about x 1.11 the length of hind tibia.

Holotype: Male: Ex eggs of pierid *Catopsilia pyranthe?* on leaves of *Cassia fistula* on the bank of a river at Balehonnur, Chickmagalur District, Karnataka. Coll: H. Nagaraja and Prashanth Mohanraj; July, 2007.

Paratypes: Males and Females with above particulars.

Holotype deposited in NBAII (ICAR), Bangalore and Paratype males and females at NBAII (one male and one female) and IARI (ICAR), New Delhi (one male and one female).

**ETYMOLOGY:** *T. pieridis* is named after the unidentified host of the family Pieridae.

**Comments:** *T. pieridis* is a species resembling *T. achaeae* Nag. and Nagar., *T. kankerensis* Yousuf and Hassan (Yousuf and Hassan, 2008a), *T. gicai* Pintureau and Stefanescu (Pintureau, *et al.*, 2000; Gibbs *et al.*, 2004) and also *T. raoi* Nag. (Nagaraja, 1973). The differences in males from *T. achaeae* are as follows: (01) CS is markedly below the level of GF, while it reaches the level of GF in *achaeae* (02) Aedeagus with apodemes as long as the length of genital capsule in *pieridis* while it is shorter in *achaeae*; (03) longest antennal hair nearly 3.5 times the maximum width of flagellum while it is about 2.5 times in *achaeae*. The present species differs from *T. raoi* in (01) the length of aedeagus with apodemes being as long as genital capsule in *pieridis* while it is slightly shorter in *raoi*; (02) ovipositor in *pieridis* is slightly longer than hind tibia (1:1.11, N = 19) while they are equal in *raoi*; (03) apex of DEG reaching to about 0.75 the level of CS in *pieridis* while it is 0.5 the said level in *raoi*. The MVP is minute in *pieridis* while it is longer, although not reaching CS, in *gicai*. With *kankerensis* the present species differs in the length of antennal hairs measuring 2 times the width of flagellum while in *pieridis* it is 3.5 times as long as the same. These differences are shown in the key.

***Trichogramma giriensis* sp. nov. (Fig. 4)**

Male: Length: 0.57(0.43-0.64; N=12) mm; Width: 0.23 (0.17-0.26; N=12) mm.

Colour: Head light yellow, ocelli and eyes bright brick red; antennae light yellow, hairs darker. Thorax lemon yellow, legs light dull yellow. Abdomen dark grey, more so the anterior-most terga.

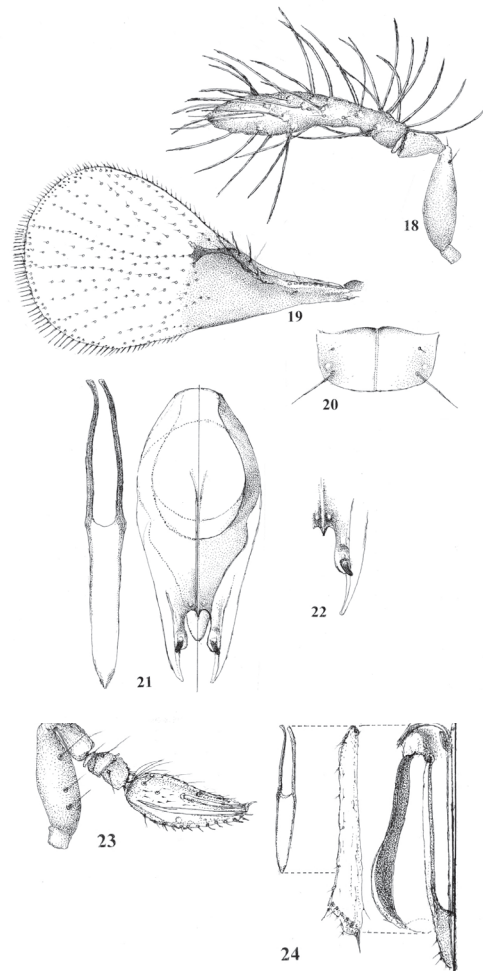
Antenna with flagellum length about x 4.6 the width, about x 1.54 the scape, x 4.6 the pedicel and x 1.7 the scape with moderately long hairs, longest being about x 2.5 the maximum width of flagellum. Thorax with two pairs of scutellar bristles, anterior ones short, the posterior ones long, about x 7 of the anterior ones; sensory pits below anterior bristles, near the posterior ones.

Forewing width more than half the length; fringe setae about 0.10 of wing width; RS1 tract with 2–4 setae. Basal infuscation up to level of stigma.

Genitalia: Length nearly x 2.5 the width; DEG with rounded sides, apex nearly reaching the level of CS; CS far below the level of GF, at about 0.90 the length of genital capsule. Median notch holding MVP at about 0.24 level of genital capsule. MVP small, far below and at less than 0.25 the length of CS. Aedeagus slightly longer than apodemes, both together very slightly longer than genital capsule, and about 0.70 of hind tibia. Ventral ridge running till 2/3 the length becoming faint till MVP.

Female: Length 0.53 (0.40–0.62; N = 12) mm; Width 0.21 (0.19–0.23; N = 12) mm.

Colour: Head light lemon yellow; ocelli and eyes bright brick red, antennae light yellow. Thorax lemon yellow. Abdomen lemon yellow with anterior-most terga and the tip blackish.



**Fig. 4.** *Trichogramma giriensis* sp. nov. (18. male antenna; 19. forewing; 20. scutellum; 21. male genitalia with aedeagus drawn separately; 22. terminal portion of male genitalia (part enlarged); 23. female antenna; 24. relative lengths of aedeagus, hind tibia and ovipositor)



Antenna with club length x 2.67 the width, x 2.67 the funicle and x 2.5 the pedicel and about 0.93 the length of scape. Ovipositor about x 1.2 the length of hind tibia.

Holotype: Male mounted on slide with following particulars: Ex. Lepidopterous eggs on bamboo leaves. Tusharagiri, Kerala. Coll: K. Rajeshwari.

Paratypes: Males and females with particulars as above.

Holotype: Deposited in the collections of NBAIL, Bangalore; Paratype Males & Females deposited at NBAIL (one male and one female) and IARI (ICAR), New Delhi (one male and one female).

**ETYMOLOGY:** *T. giriensis* is named after terminal part of the name of the type locality, Tusharagiri.

Comments: *T. giriensis* is a unique species in India which somewhat resembles *T. bruni* Nagaraja, described from Brazil (Nagaraja, 1983). But it differs mainly in the length of ovipositor which is distinctly longer in *T. giriensis*. It also resembles *T. zahiri* Polaszek (Polaszek *et al.*, 2002) and *T. plasseyensis* Nag. But its minute MVP makes it different from *plasseyensis* and the level of CS to that of GF makes it different from *T. gicai*.

#### Additional diagnostic characteristics

##### 01. Observation on the number of setae on the RS1 vein track

In the forewing of some trichogrammatids, the vein track RS1 with setae is found below stigma on a broad inwardly curved line. This track is absent in the genera *Trichogrammatoidea*, *Lathromeris*, *Abelloides*, etc. (Doutt and Viggiani, 1968). Although this track is present in *Trichogramma*, the number of setae in the track is not strictly specific. The range in their numbers could in some cases be considered specific. This difference (in both male and female) is found in *T. pieridis* which has a range of 3–7 while in *T. rabindraii* it is 2–5 and *giriensis*, 2–4. The particulars are shown in Table 1. Amongst the other *Trichogramma* spp. studied, *T. japonicum* for example has a much larger number (5–8) of RS1 setae.

There is no difference between the sexes in the distribution of setae along the RS1 vein track in these

species. *T. pieridis* has larger number of setae as compared to the other two. The standard deviation shows wide variation within each species. Although the numbers of these setae are by no means species specific characters, they could aid in the identification of species like *T. pieridis*.

##### 02. Bristles on scutellum

The scutellum in mesothorax contains two pairs of bristles, the anterior ones being smaller than the posterior ones. This is the general rule in most of the species examined, with the anterior bristles being short to extremely short and slender as in *T. pretiosum* Riley while they are long, about  $\frac{3}{4}$  the length of the posterior ones, as in *T. japonicum* Ashm. and *T. pallidiventris* Nag. The posterior bristles are always longer, as long as the ones found on the mesoscutum. There are some species in which the anterior bristles may be longer, but they are generally shorter than in *T. japonicum*, etc.

##### 03. Setae on hind wing

Hind wing in *Trichogramma*, as shown by Pinto (1997) has limited setal arrangement. There is one median line containing highest number of setae, another sparsely arranged line below/posterior to the median and a very sparsely arranged line of setae above /anterior to the median line. However, *T. japonicum* has the highest number of anterior, median as well as posterior lines of setae. Setal arrangement on the hind wings of the three species dealt with in this paper are compared with that of *T. japonicum* in Table 2. *T. rabindraii* has the largest number of anterior setae.

The other characters, not always dependable, include length of wing fringe in the fore wing, as compared with wing width. This, to a great extent, depends on the size of adults, the larger adults having a shorter wing fringe and *vice versa* (Nagaraja, 1996). Hence, the length of fringe setae and the size of the adults are inversely proportional to each other. The size of adults again depends on the size of the host egg within which it developed and also the number of individuals developing in a single host egg. Relative to other species however, *T. japonicum* and *T. pallidiventris* have the longest wing fringe.

**Table 1. Number of setae along RS1 in the forewings of *T. rabindraii*, *T. pieridis* and *T. giriensis***

Species	Nos. examined		Mean nos. of Rw + Lw		Range		SD	
	Male	Female	Male	Female	Male	Female	Male	Female
<i>T. rabindraii</i>	6	21	4	3.6	3-5	3-5	0.58	1.02
<i>T. pieridis</i>	27	20	4.9	5.3	4-6	4-7	1.04	0.07
<i>T. giriensis</i>	12	15	3.25	3.4	3-4	3-4	1.01	1.01

RW – Right wing; LW – Left wing; SD – Standard Deviation

**Table 2. Number of hind wing setae in four species of *Trichogramma***

Species	N	Median setae			Anterior setae			Posterior setae		
		N	Range	SD	N	Range	SD	N	Range	SD
<i>T. japonicum</i>	Male 6	23	22–26	1.16	8	6–10	1.37	12	10–13	1.14
	Female 11	23	18–26	2.37	8	6–9	1.37	11	9–15	2.00
<i>T. rabindrai</i>	Male 6	20	15–23	2.44	2.5	2–3	0.47	8	7–9	0.69
	Female 16	23	19–25	1.54	3	2–4	0.73	9	7–12	2.32
<i>T. pieridis</i>	Male 8	21	18–24	2.18	0.5	0–4	1.18	8	5–9	1.05
	Female 9	19	15–21	2.18	0.1	0–1	0.03	7	5–7	1.18
<i>T. giriensis</i>	Male 6	20	16–21	1.57	0.2	0–1	0.34	8	5–9	1.5
	Female 10	20	17–22	1.82	0.2	0–1	0.40	7	5–8	0.98

*Key to differentiate the present species from other closely resembling species*

- 01. DEG with lateral lobes; MVP distinct; CS well below level of GF .....02  
 DEG without lateral lobes; other characters varying ..... 11
- 02. DEG with lateral lobes diagonally pointed; male antennal hair less than x 2 the flagellar width .....03  
 DEG with lateral lobes laterally pointed, male antennal hair not like above .....04
- 03. MVP distinct, reaching 0.67 of CS; male antennal hairs less than 2 times the maximum width of flagellum ..... ***T. rabindrai* sp. nov.**  
 MVP small, reaching at about 0.25 of CS .....  
 ..... *T. manicobai* Brun, Moraes and Soares\*
- 04. DEG with lateral lobes sharply notched posteriorly .....*T. ivelae* Pang and Chen\*  
 DEG different ..... 05
- 05. DEG with lateral lobes broadly rounded, without marked constrictions or notches posteriorly .....*T. dendrolimi* Matsumura  
 DEG with lateral lobes different ..... 06
- 06. DEG with lateral lobes narrow ..... 07  
 DEG with lateral lobes not as narrow as above .....08
- 07. DEG with blunt apex; MVP broadly triangular .....*T. poliae* Nagaraja  
 DEG with pointed apex; MVP narrow and pointed .....*T. sibericum* Sorokina\*
- 08. DEG with distal end long, almost reaching CS ....09  
 DEG with distal end not reaching CS .....  
 .....*T. bactrianum* Sugonjaev and Sorokina\*
- 09. MVP narrow, not reaching level of CS .....  
 .....*T. closterae* Pang and Chen\*  
 MVP different ..... 10
- 10. MVP broad, but not reaching level of CS .....  
 ..... *T. chilonis* Ishii  
 MVP narrow, reaching CS .....  
 .....*T. nubilale* Ertle and Davis\*
- 11. CS close to GF .....12  
 CS far below GF .....13
- 12. MVP minute .....14  
 MVP longer ..... *T. gicai* Pintureau and Stefanescu
- 13. MVP very short; antennal hairs 2.5 x flagellar width .....  
 .....***T. giriensis* sp. nov.**  
 MVP minute; antennal hairs less than 2.0 x flagellar width .....*T. zahiri* Polaszek\*
- 14. Male antennal hair more than 3.5 x flagellar width .....  
 .....***T. pieridis* sp. nov.**  
 Male antennal hair about 2 x or less than flagellar width .....  
 .....*T. kankerensis* Yousuf and Hassan

\* The comparative measurements mentioned in these couplets are based on the illustrations and descriptions given in the published papers by the respective authors.

**DISCUSSION**

Pioneering work on the biosystematics of *Trichogramma* (Nagarkatti and Nagaraja, 1968), stimulated a new awareness in the classification of the species of the genus resulting in the discovery of a number of species. Discoveries made all over the world since then suggest that there could now be well over 250 valid species.

Following the lead provided by Nagarkatti and Nagaraja (1977), Voegelé and Pintureau (1982) constructed a dendrogram to group the then known species based on the structure of the male genitalia. This grouping is an

aid to identification as the number of species keeps growing with increasing interest on *Trichogramma* diversity from various parts of the world.

It needs to be stressed that *Trichogramma* can provide further information on the evolutionary trends of diverging populations of known species, as well as hitherto unknown ones. The knowledge of such populations, each having discrete ecological requirements, could effectively be exploited for biological control of lepidopterous pests. The present authors have in their possession a few such populations. Investigations on them are in progress.

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