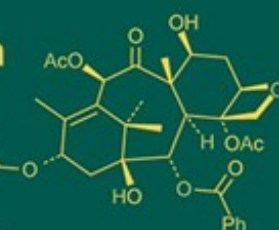
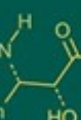
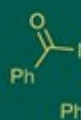
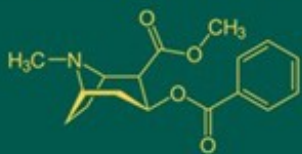


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Biological attributes and morphometric characters of egg parasitoid *Trichogramma chilonis* Ishii on *Corcyra cephalonica* (Stainton)

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ABSTRACT

Trichogramma chilonis Ishii is an important egg parasitoid used in augmentative biological control, and its mass production depends on a suitable factitious host. The present investigation aimed to study the biological attributes and morphometric characters of *T. chilonis* reared on eggs of *Corcyra cephalonica* (Stainton) at 27 ± 1 °C and $70 \pm 5\%$ relative humidity. The egg-larval and pupal periods were 4.85 ± 0.16 and 3.23 ± 0.11 days, respectively, giving a total developmental period of 8.08 ± 0.27 days. Female and male longevity averaged 5.53 ± 1.25 and 4.17 ± 0.83 days. Parasitisation was $87.93 \pm 3.03\%$, adult emergence $90.36 \pm 1.95\%$ and the sex ratio 2.12:1 (female: male). Females were larger than males in all absolute dimensions except antennal length; body length was 466.8 ± 5.3 µm in females and 441.5 ± 4.8 µm in males, whereas the male antenna was longer (209.3 ± 2.7 µm) than the female antenna (134.4 ± 2.5 µm). The results provide baseline biological and morphometric information on *T. chilonis* reared on *C. cephalonica*.

Keywords: *Corcyra cephalonica*, Egg parasitoid, Biological attributes, Morphometry, *Trichogramma chilonis*, Mass rearing

Introduction

Biological control forms an important part of integrated pest management, especially in the management of lepidopteran pests. Among the natural enemies used for this purpose, egg parasitoids of the genus *Trichogramma* Westwood (Hymenoptera: Trichogrammatidae) are widely used because they parasitize the pest before the damaging larval stage develops. Their short generation period, wide host range and suitability for mass production have made them useful in several biological control programmes (Hassan, 1993⁸; Smith, 1996³¹; Pinto, 1999²⁷) [1, 2, 3]. *Trichogramma chilonis* Ishii is one of the commonly used species in India and has been reported against a number of economically important lepidopteran pests.

The rice moth, *Corcyra cephalonica* (Stainton), is widely used as a factitious host for laboratory multiplication of *T. chilonis*. The success of rearing depends on the suitability and quality of the host eggs and the conditions under which the parasitoid is maintained. Funde *et al.* (2020⁶) [4] reported differences in the performance of *T. chilonis* when reared on different hosts. Similarly, Jidung *et al.* (2022) observed changes in parasitisation, adult emergence, longevity and developmental period of *T. chilonis* under different temperature conditions. Ajudia *et al.* (2023¹) [5] recorded 86.50 ± 5.09 per cent parasitisation and 88.30 ± 4.42 per cent adult emergence when *T. chilonis* was reared on *C. cephalonica* eggs under laboratory conditions.

Apart from biological parameters, morphometric characters are useful in studies on *Trichogramma*. The small size of these parasitoids and the similarity between closely related species can make identification difficult based only on general external characters. Khan *et al.* (2018¹⁵) [6] studied morphometric characters of *T. chilonis* and *T. japonicum* and reported differences in several measured characters. Mohapatra and Shinde (2023²⁰) [7] also studied biological and morphometric characters of *T. japonicum*, indicating the usefulness of such measurements for parasitoid characterization.

The performance of *T. chilonis* can vary with host, geographical origin and laboratory conditions. Hence, information on the biological and morphometric characteristics of a culture maintained under a particular rearing system is useful for assessing its performance. In the present study, the biological attributes and morphometric characters of *T. chilonis* reared on *C. cephalonica* eggs were studied under laboratory conditions. Developmental duration, longevity, life cycle, parasitisation, adult emergence and sex ratio were recorded along with measurements of selected morphological characters of the adult parasitoid.

Materials and Methods

Nucleus culture of *T. chilonis* and *C. cephalonica*

The factitious host, *Corcyra cephalonica* (Stainton), and the test insect, *Trichogramma chilonis* Ishii, were maintained at the Biocontrol Laboratory, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, under laboratory conditions of 27 ± 1 °C temperature and $70 \pm 5\%$ relative humidity as per the methodology put forwarded by Naganna and Shinde (2017²³) [8] with slight modification. The nucleus culture of *C. cephalonica* was maintained on a sorghum-based diet and the eggs collected from the culture were used for rearing *T. chilonis*. The nucleus culture of *T. chilonis* was maintained on *C. cephalonica* eggs using parasitized trichocards. Freshly collected *C. cephalonica* eggs were sterilized under ultraviolet radiation and approximately 1 cc of eggs was uniformly pasted on a 15×10 cm card using acacia gum. The cards were allowed to dry for 15 minutes and exposed to adult *T. chilonis* for parasitization. After 24 hours of exposure, the cards were transferred to clean glass bottles (22×11.5 cm) and maintained under laboratory conditions. Adult parasitoids were provided with 5 per cent honey solution as food.

Methodology for biological attributes

Biological attributes of *Trichogramma chilonis* on *Corcyra cephalonica* were studied following the methodology suggested by Mehendale (2009¹⁸) [9]. Freshly laid, UV-sterilized *C. cephalonica*

eggs (100 eggs) were uniformly pasted with diluted acacia gum on white paper strips measuring 5×2 cm and distributed using a pepper sprinkler. The egg strips were air-dried for 15 minutes and placed individually in plastic vials measuring 7.5×4 cm. A total of 30 egg strips were maintained for the study. Each vial was provided with five pairs of freshly emerged *T. chilonis* adults obtained from the laboratory culture. The parasitoids were supplied with 5 per cent honey solution as food, provided as small droplets on a plastic strip fixed inside the vial. The observations on biological attributes were recorded subsequently.

Total developmental period

The total developmental period was considered as the period between parasitization and adult emergence. After 24 hours of exposure to *T. chilonis*, each parasitized egg card was transferred to a clean container for further observations. The cards were observed daily until the parasitized *C. cephalonica* eggs turned black. The time taken from parasitization to blackening of the eggs was recorded in days. The blackened eggs were subsequently observed for adult emergence at 6:00 AM and 6:00 PM, at an interval of 12 hours, to determine the time of adult emergence accurately. The period from egg blackening to adult emergence was recorded in hours and later converted into days. The total developmental period was calculated as:

$$\text{Total developmental period (days)} = \text{Time taken from parasitization to egg blackening (days)} + \text{Time taken from egg blackening to adult emergence (days)}$$

Parasitisation potential

The parasitized eggs turned black after the fourth day of parasitisation, which was counted to calculate the parasitic potential. The actual number of parasitized eggs were obtained by subtracting the number of eggs left over from the total number of exit holes on *C. cephalonica* eggs and the total number of adults emerged from the egg strip.

Adult emergence

After complete emergence of *T. chilonis* adults, the total number of adults emerged from each parasitized egg card was counted irrespective of sex. The observations were further cross-checked by examining the empty *C. cephalonica* eggs under a microscope. Adult emergence was expressed as percentage based on the number of adults emerged from the parasitized eggs.

Time taken for adult emergence after egg blackening (Days).

$$= \frac{\sum (\text{Number of adult emerged} \times \text{Days after blackening of eggs})}{\text{Total no. of emerged adults}}$$

$$\text{Adult Emergence (\%)} = \frac{\text{Total number of adult emerged}}{\text{Total number of black eggs}} \times 100$$

$$\text{Total life cycle (days)} = \text{Total developmental period (days)} + \text{Adult longevity (days)}$$

Morphometrics

Detailed morphometric observations of *T. chilonis* were recorded with maximum accuracy using a stereo-trinocular microscope fitted with a Catcum-130 camera and Power Scope Photo software (Version 3.1). The morphological characters described by Khan et al. (2018¹⁵) [6] were considered for the present study. The measurements included body length and breadth, head capsule length and breadth, antennal length, forewing and hindwing length and breadth, hind tibia length and female ovipositor length. The morphometric observations were recorded as described below.

The male and female body. The body length of *T. chilonis* was measured from the anterior portion of the thorax (prothorax) to the terminal end of the abdomen. The maximum abdominal breadth was considered as the body breadth of the respective sex.

Adult longevity

The adults of *T. chilonis* emerging from parasitized *C. cephalonica* eggs were separated into males and females based on their morphological characters. A total of 30 males and 30 females were maintained individually in separate clean vials. Five per cent honey solution was provided as adult food. Individual parasitoids were observed at 6:00 AM and 6:00 PM until death. The period from adult emergence to adult death was considered as adult longevity, and male and female longevity was calculated separately.

Sex ratio

The adults emerging from the parasitized eggs were counted individually as male and female based on their morphological characters. The sex ratio was calculated from the number of male and female adults emerged from the laboratory culture and expressed as female ratio.

Total life cycle

The duration of the entire life cycle was considered as the period from the date of parasitization to the death of the emerged adult. The total life cycle of male and female *T. chilonis* was calculated separately using the following formula:

Male and female head capsule (frontal view)

The length and breadth of the head capsule were measured after detaching it from the rest of the body. Head capsule length was measured from the vertex to the labium, whereas the maximum breadth near the compound eyes was recorded as the head capsule breadth.

Male and female antenna

The antenna was detached from the head before measurement. Since the antenna was curved, its total length was measured in two parts. First, the length of the scape plus pedicel was measured from the antennifer to the base of the flagellum in males and the club in females. Second, the length of the flagellum in males and the club in females was measured. The total antennal length was calculated by adding these two measurements.

Male and female wing

The forewing length was measured from the base of the wing to the point where the median anterior vein reached the wing margin. The hindwing length was measured from the base of the wing to its terminal end. The maximum width of both forewing and hindwing was recorded as wing breadth.

Male and female hind tibia

The length of the hind tibia was measured from the junction of the femur and tibia to the base of the tarsi.

Female ovipositor

The length of the ovipositor was measured from the basal portion of the first and second valvulae to the tip of the third valvula.

Results and Discussion

Biological attributes of *T. chilonis*

Trichogramma chilonis, a holometabolous hymenopteran wasp, passed through egg, larval, pupal and adult stages. As described for the genus, the immature stages are completed entirely inside the host

egg: the parasitoid egg hatches in about 24 h, the larva passes through three instars, and the host egg darkens by the third instar, roughly 3-4 days after parasitisation, whereas the adult emerges through an exit hole and is free living (Irshad *et al.* 2025^[12] [10]). A clear understanding of this biology is essential for the mass production and field use of the parasitoid. The biological attributes of *T. chilonis* reared on *Corcyra cephalonica* eggs at 27 ± 1 °C and $70 \pm 5\%$ relative humidity are therefore presented in Table 1 and discussed hereunder.

Table 1. Biological attributes of *Trichogramma chilonis* on *Corcyra cephalonica* eggs

Biological attribute	Minimum	Maximum	Mean $\pm$ SD
Egg-larval period (days)	4.56	5.16	4.85 ± 0.16
Pupal period (days)	3.04	3.44	3.23 ± 0.11
Total developmental period (days)	7.60	8.60	8.08 ± 0.27
Female adult longevity (days)	5.00	9.00	5.53 ± 1.25
Male adult longevity (days)	3.00	5.00	4.17 ± 0.83
Female total life cycle (days)	11.90	17.10	13.61
Male total life cycle (days)	10.80	13.70	12.25
Parasitisation (%)	82.00	93.00	87.93 ± 3.03
Adults emerged (number per 100 eggs)	72.00	87.00	79.53 ± 4.39
Adult emergence (%)	86.90	94.50	90.36 ± 1.95
Sex ratio (Female: Male)	1.71:1	2.70:1	2.12:1

Note: Values are mean $\pm$ standard deviation (SD; $n = 30$). Minimum and maximum are the lowest and highest observed values.

3.1.1 Egg-larval, pupal and total developmental period

The egg-larval period, taken as the time required for parasitised *C. cephalonica* eggs to turn black, ranged from 4.56 to 5.16 days with a mean of 4.85 ± 0.16 days, whereas the pupal period, from blackening of the host egg to adult emergence, ranged from 3.04 to 3.44 days with a mean of 3.23 ± 0.11 days. The total developmental period of *T. chilonis* on *C. cephalonica* was therefore 7.60-8.60 days, with a mean of 8.08 ± 0.27 days (Table 1).

The present total developmental period is in close agreement with earlier reports on this parasitoid host combination. Perveen *et al.* (2012^[26] [11]) recorded 8 days for *T. chilonis* on *C. cephalonica* eggs at 28 °C, and Honnayya and Gawande (2018^[11] [12]) likewise noted a developmental period of 8 days on 24hrs, 48hrs and 72hrs old *C. cephalonica* eggs. Anoosha *et al.* (2025^[2] [13]) reported development in about eight days, and Ajudia *et al.* (2023^[1] [5]) documented successful development of the parasitoid on the same host. Perveen *et al.* (2012^[26] [11]) recorded 9.2, 8.0 and 7.2 days on *C. cephalonica* at 24, 28 and 32 °C. The 8.08 days obtained at 27 ± 1 °C thus falls where expected, between the longer periods recorded at lower temperatures and the shorter periods recorded at higher temperatures.

In the present study the host eggs turned black after a mean of 4.85 days, which is longer than the 3-4 days after parasitisation generally described for the genus (Khan *et al.* 2018^[15]; Irshad *et al.* 2025^[12] [6, 10]) and the 4.00 days recorded for *T. japonicum* (Mohapatra and Shinde 2023^[20] [7]). Correspondingly, the pupal period of 3.23 days was shorter than the 4.56 days reported by Mohapatra and Shinde (2023^[20] [7]). Because the totals are close, the differences lie mainly in how development is partitioned between the two phases. This de-

pends on the criterion used to score blackening and on the interval at which egg strips are inspected, so the total developmental period is the more reliable basis for comparison among studies. The slight variation in developmental duration might be attributed to differences in *Trichogramma* species or strain, host species, host egg age, rearing temperature and the prevailing laboratory conditions.

3.1.2 Adult longevity

Female adults survived for 5.00-9.00 days with a mean longevity of 5.53 ± 1.25 days, whereas male longevity ranged from 3.00 to 5.00 days with a mean of 4.17 ± 0.83 days when adults were fed 5% honey solution. Females therefore lived about 1.4 days longer than males (Table 1).

Female longevity in the present study is close to values reported earlier for *T. chilonis*: 5 and 6 days on *Ephesia kuehniella* and *Plutella xylostella* eggs, respectively (Miura and Kobayashi 1995^[19] [14]), 5.6 days on *S. cerealella* at 31 °C (Nadeem *et al.* 2009^[22] [15]), 4.9 days on *C. cephalonica* (Jalali *et al.* 2006^[13] [16]), 4.8 days on *S. cerealella* at 24 °C (Sultan *et al.* 2013^[34] [17]) and 5.70 ± 1.59 days on *C. cephalonica* (Ajudia *et al.* 2023^[1] [5]). Manickavasagam *et al.* (1994^[17] [18]) recorded 5 days for females and 4 days for males, in close agreement with the present female and male means. Male longevity (4.17 days) was lower than the 5.15 ± 1.04 days reported by Ajudia *et al.* (2023^[1] [5]) but similar to the 4.6 days recorded for males by Rathi and Ram (2000^[30] [19]).

The longer survival of females than males agree with the pattern recorded for *T. japonicum* on *C. cephalonica* (4.90 ± 1.12 and 2.63 ± 1.10 days; Mohapatra and Shinde 2023^[20] [7]). Adult longevity is strongly influenced by nutrition. Mehendale (2009^[18] [9]) recorded

4.03 days for females and 3.00 days for males fed 10% honey solution. Temperature and host availability also affect lifespan (Irshad *et al.* 2025¹²; Ghosh *et al.* 2017⁷) [10, 20]. The slight differences in longevity might therefore be due to adult food, the rearing medium of the host, ambient temperature, and the species or strain used. In the present study adults were provided only with 5% honey solution, so the values refer to honey-fed adults.

Total life cycle

The total life cycle of females ranged from 11.90 to 17.10 days with a mean of 13.61 days, whereas that of males ranged from 10.80 to 13.70 days with a mean of 12.25 days (Table 1). The mean female life cycle was 1.36 days longer than that of males, which corresponds to the longer adult longevity of females.

The present life cycles are close to those reported for *T. japonicum* on *C. cephalonica*, 13.46 ± 1.21 days for females and 11.19 ± 1.11 days for males (Mohapatra and Shinde 2023²⁰) [7], the female value being almost identical. Because the life cycle is the sum of the developmental and adult periods, differences among studies may reflect the species tested, the factitious host, temperature, relative humidity and adult food.

Parasitisation

Parasitisation of the 100 *C. cephalonica* eggs offered per strip ranged from 82.00 to 93.00%, with a mean of 87.93 ± 3.03% (Table 1). The present mean is close to the 86.50 ± 5.09% reported by Ajudia *et al.* (2023¹) [5] for *T. chilonis* on *C. cephalonica* eggs and to the 85.33% recorded for *T. pretiosum* on the same host by Moirangthem *et al.* (2022²¹) [21]. It is higher than the 60.67% recorded for *T. japonicum* on *C. cephalonica* eggs by Moirangthem *et al.* (2022²¹) [21]. Anoocha *et al.* (2025²) [13] also reported high parasitisation by *T. chilonis* on *C. cephalonica*, whereas Funde *et al.* (2020⁶) [4] reported lower parasitisation on the same host under their experimental conditions.

The wide differences among studies indicate that parasitisation depends on the parasitoid species and on the host. Moirangthem *et al.* (2022²¹) [21] found white and green trichocards most suitable for mass production of *Trichogramma*, and white card strips were used in the present study, which may have contributed to the high parasitisation recorded. Further variation among studies might reflect host egg age, parasitoid age and density, exposure period, host egg quality, temperature and relative humidity.

Adult emergence

Adult emergence ranged from 86.90 to 94.50% with a mean of 90.36 ± 1.95%, corresponding to 72-87 adults per 100 eggs exposed (mean 79.53 ± 4.39; Table 1). The relatively narrow range among the 30

replicates indicates consistent emergence under the rearing conditions used. Emergence was expressed relative to the number of parasitised eggs, as in Mohapatra and Shinde (2023²⁰) [7], who related adults emerged to blackened eggs, which allows direct comparison.

The present emergence is in line with several earlier reports: 89.4% on *C. cephalonica* and 90.13% on *S. litura* for *T. chilonis* (Dileep 2012⁴) [22], 88.30 ± 4.42% (Ajudia *et al.* 2023¹) [5], 93.3% on *C. cephalonica* (Rathi and Ram 2000³⁰) [19], 92.60% for *T. japonicum* at 26 °C on *C. cephalonica* (Ghosh *et al.* 2017⁷) [20] and 86% for *T. japonicum* on *C. cephalonica* eggs (Pandi *et al.* 2021²⁵) [23]. Higher emergence was recorded for *T. japonicum* on *C. cephalonica* by Mohapatra and Shinde (2023²⁰; 96.67 ± 3.32%) [7], whereas lower emergence was reported by Perveen *et al.* (2012²⁶; maximum 80.3% at 28 °C).

Irshad *et al.* (2025¹²) [10], summarising Srivastava and Singh (2015³³) [24], report that the highest fecundity and emergence of a temperature-tolerant strain of *T. chilonis* occurred at 27 °C within the range 25–31 °C, which is relevant to the 27 ± 1 °C maintained here. Most earlier findings thus support the present result; the slight variation might be due to the different factitious hosts, parasitoid species and the temperature prevailing during the investigations.

Sex ratio

The progeny sex ratio ranged from 1.71:1 to 2.70:1 (female: male) with a mean of 2.12:1 (Table 1). Expressed as male: female, as is common in the literature, this is 1:2.12 (range 1:1.71 to 1:2.70), indicating female-biased progeny.

A similar female bias has been recorded earlier. Dileep (2012⁴) [22] reported 1:2.10 for *T. chilonis* on *S. litura* and 1:1.53 on *C. cephalonica* eggs. Kumari *et al.* (2020¹⁶) [25] recorded 1:2.50 on *C. cephalonica* at 25 °C, and Mohapatra and Shinde (2023²⁰) [7] recorded 1:2.82 (range 1:1.22 to 1:5.33) for *T. japonicum*. Mehendale (2009¹⁸) [9] recorded 1:1.30 on *C. cephalonica* and 1:4.48 on *Samia cynthia ricini*. The present ratio therefore lies within the range of earlier reports. Some discrepancy among studies is expected because the sex ratio changes with the *Trichogramma* species, the host egg used (Mehendale 2009¹⁸; Firoz 2015⁵) [9, 26], host egg age (Dileep 2012⁴) [22], the methodology and the prevailing environmental conditions, so the present value characterises this colony under these rearing conditions.

Morphometric characteristics of *T. chilonis*

Twelve morphometric characters of females and eleven of males of *T. chilonis* are presented in Table 2 and discussed hereunder.

Table 2. Morphometric measurements of adult *Trichogramma chilonis* females & males

Morphometric character	Female (mean ± SD, µm)	Male (mean ± SD, µm)
Body length	466.8 ± 5.3	441.5 ± 4.8
Body breadth	212.4 ± 3.2	199.6 ± 2.8
Head capsule length	138.7 ± 1.9	131.8 ± 1.6
Head capsule breadth	163.7 ± 2.4	154.2 ± 2.1
Antennal length	134.4 ± 2.7	209.3 ± 2.5
Forewing length	413.8 ± 4.7	392.7 ± 4.1
Forewing width	188.1 ± 2.5	177.2 ± 2.2
Forewing L/W ratio	2.20 ± 0.03	2.22 ± 0.03
Hindwing length	277.6 ± 3.6	261.4 ± 3.1
Hindwing width	58.6 ± 0.8	54.2 ± 0.7
Hind tibia length	135.4 ± 1.9	125.1 ± 1.7
Ovipositor length	158.2 ± 1.3	—

Note: Values are mean ± SD; n = 30 for each sex. The forewing length/width (L/W) ratio is dimensionless and was calculated from the measured values, not applicable (ovipositor length is a female-specific character).

(continued on next page)

Females were larger than males in every absolute dimension, by 5.2% (head capsule length) to 8.2% (hind tibia length) when calculated from the means. The forewing L/W ratio was nearly identical in the two sexes (2.20 and 2.22), so the sexual difference lay mainly in overall size and not in wing shape. Larger females than males have been recorded in several *Trichogramma* species, and Mohapatra and Shinde (2023²⁰) [7] concluded that morphometric measurements help to differentiate the sexes of a species as well as the species themselves. Comparison with published values must, however, allow for differences in landmarks, specimen preparation and sample size. The morphology of *Trichogramma* also shows phenotypic plasticity over generations in laboratory culture (Pinto *et al.* 1989²⁸) [27], which can contribute to differences among colonies.

Male and female body

Female body length was 466.8 ± 5.3 μm and male body length 441.5 ± 4.8 μm , while body breadth was 212.4 ± 3.2 μm in females and 199.6 ± 2.8 μm in males, so females were larger than males in both dimensions (Table 2). Larger females than males were likewise reported for *T. chilonis* by Khan *et al.* (2018¹⁵; about 400 and 360 μm) and Yousuf *et al.* (2016³⁶; about 420 and 370 μm), for *T. japonicum* by Khan *et al.* (2018¹⁵) [6] and Mohapatra and Shinde (2023²⁰; about 400 and 370 μm), for *T. plasseyensis* (396 and 378 μm ; Hassan and Yousuf 2007⁹) [28], for *T. achaeae* (543 and 478 μm ; Khan and Yousuf 2017¹⁴) [29] and for *T. australicum* (489 μm long and 177 μm wide in females against 454 μm and 165 μm in males; Dahlan and Gorth 1998³).

The ratio of female to male body length in the present study (1.06) lies within the range of 1.05–1.14 calculated from the means of the above studies. The absolute body lengths recorded here are greater than those given for *T. chilonis* by Khan *et al.* (2018¹⁵) [6] and Yousuf *et al.* (2016³⁶) [30] and closer to those of *T. achaeae* and *T. australicum*, and they fall within the range of 342–640 μm reported for the genus (Hirai and Fursov 1998¹⁰; Sumer *et al.* 2010³⁵) [31, 32]. The slight differences in measurements might be due to species or strain, the nutritional value of the host, and the landmarks used to measure body length.

Male and female head capsule

Head capsule length was 138.7 ± 1.9 μm in females and 131.8 ± 1.6 μm in males, and breadth was 163.7 ± 2.4 and 154.2 ± 2.1 μm , respectively. The head capsule was broader than long in both sexes, as described for *T. japonicum* (Mohapatra and Shinde 2023²⁰) [7], and the greater female head length agrees with the findings of Mohapatra and Shinde (2023²⁰; about 160 and 150 μm), Yousuf *et al.* (2016³⁶; 172 and 150 μm) [30] and Hassan and Yousuf (2007⁹; 159 and 144 μm) [28]. Head breadth was almost the same in the two sexes in those studies (for example 207 and 205 μm ; Yousuf *et al.* 2016³⁶) [30], whereas females were about 6% broader-headed than males here. The head dimensions recorded here are smaller than the values given in the above studies, which might be due to species or strain, orientation of the head in frontal view, and the landmarks used.

Male and female antenna

Antennal length was 209.3 ± 2.7 μm in males and 134.4 ± 2.5 μm in females (Table 2). In *Trichogramma* the male antenna bears a long flagellum with long tapering hairs, whereas the female antenna ends in a short club, so the male antenna is the longer. The same pattern was recorded by Mohapatra and Shinde (2023²⁰) [7], who reported total antennal lengths of about 210 μm in male and 130 μm in female *T. japonicum*. The present values are close to theirs, and the male antenna was about 1.55 times as long as the female antenna. Antennal length was thus the only character in which males exceeded females. For diagnostic purposes, separate measurement of the female club and male flagellum is recommended, together with the length and number of flagellar hairs, which separated *T. chilonis* (0.06–0.08 mm; 33–45 hairs) from *T. japonicum* (0.08–0.10 mm; 26–35 hairs) in males (Khan *et al.* 2018¹⁵) [6].

Male and female forewing and hindwing

Female forewing length and width were 413.8 ± 4.7 and 188.1 ± 2.5 μm , against 392.7 ± 4.1 and 177.2 ± 2.2 μm in males, giving L/W ratios of 2.20 ± 0.03 and 2.22 ± 0.03 . Hindwing length and width were 277.6 ± 3.6 and 58.6 ± 0.8 μm in females and 261.4 ± 3.1 and 54.2 ± 0.7 μm in males. In earlier studies forewing length was nearly the same in the two sexes, at 510 and 500 μm for female and male *T. chilonis* (Khan *et al.* 2018¹⁵) [6], 503 μm in both sexes (Yousuf *et al.* 2016³⁶) [30] and 500 and 490 μm in *T. japonicum* (Mohapatra and Shinde 2023²⁰) [7].

The forewing L/W ratio recorded here (2.20–2.22) lies within the range given by Khan *et al.* (2018¹⁵) [6] for *T. chilonis* (1.83–2.52; mean 2.01) and is close to their means for *T. japonicum* (2.27 in males and 2.34 in females), so wing proportion alone would not separate the two species in this colony. Khan *et al.* (2018¹⁵) [6] found fore and hindwing width useful for separating *T. chilonis* from *T. japonicum*. The absolute wing values recorded here (forewing 393–414 μm long, hindwing 261–278 μm long) are smaller than those in the studies cited above. The differences are most probably due to the strain, the host and the way the wings were mounted and measured, and the present values should be taken as baseline values for the colony studied.

Male and female hind tibia

Hind tibia length was 135.4 ± 1.9 μm in females and 125.1 ± 1.7 μm in males, so that females had the longer tibia (Table 2). The same pattern was recorded in *T. japonicum* (about 160 and 140 μm ; Mohapatra and Shinde 2023²⁰) [7] and *T. chilonis* (175 and 170 μm ; Yousuf *et al.* 2016³⁶) [30], although Khan *et al.* (2018¹⁵) [6] recorded equal tibia lengths (about 180 μm) in the two sexes of *T. chilonis*. The values obtained here are shorter than those for *T. chilonis* in the above studies and nearer to those of *T. japonicum*. Because hind tibia length is used as the reference length in several diagnostic ratios (Nagaraja and Nagarkatti 1973²⁴; Sorokina 1984³²) [33, 34], the difference might be due to the landmarks used, specimen mounting, host and strain, and it is advisable to follow a fixed landmark definition when ratios are compared among laboratories.

Female ovipositor

Ovipositor length of females was 158.2 ± 1.3 μm (Table 2). This lies within the range of about 150–200 μm (mean about 180 μm) given for *T. chilonis* by Khan *et al.* (2018¹⁵) [6] and is somewhat shorter than the 178 μm recorded by Yousuf *et al.* (2016³⁶) [30], whereas it is clearly shorter than the about 220–230 μm reported for *T. japonicum* (Mohapatra and Shinde 2023²⁰; Khan *et al.* 2018¹⁵) [7, 6]. The ratio of ovipositor length to hind tibia length is a recognised taxonomic character (Nagaraja and Nagarkatti 1973²⁴; Sorokina 1984³²) [33, 34]. It was 0.90–1.16 (mean 1.01) in *T. chilonis* and 1.24–1.57 (mean 1.43) in *T. japonicum* in Khan *et al.* (2018¹⁵) [6], and the ovipositor was about 1.37 times the hind tibia in *T. japonicum* (Hirai and Fursov 1998¹⁰; Mohapatra and Shinde 2023²⁰) [31, 7]. The ratio calculated from the present means is 1.17, which is just above the upper limit given for *T. chilonis* and well below the range given for *T. japonicum*, so the colony is closer to *T. chilonis* in this character.

The slightly higher ratio is consistent with the shorter hind tibia recorded here (Section 3.2.5), because hind tibia length is the reference length of the ratio. It might also reflect the point from which the ovipositor was measured, the mounting of the specimen (whole mounts compared with dissected slide mounts; Platner *et al.* 1999²⁹) [35], and strain or host effects, and the value should be treated as colony-specific baseline information and not as a diagnostic range for the species.

Conclusion

Trichogramma chilonis completed development on *Corcyra cephalonica* eggs in about 8 days (8.08 ± 0.27 days) at 27 ± 1 °C and $70 \pm 5\%$ RH, with high parasitisation ($87.93 \pm 3.03\%$) and adult emergence ($90.36 \pm 1.95\%$). Progeny were female-biased (2.12:1),

and females lived longer than males (5.53 vs 4.17 days), which favours colony productivity. Females were larger than males in all absolute dimensions except antennal length, where males were longer (209.3 vs 135.4 μm). These results confirm *C. cephalonica* as a suitable factitious host and give baseline biological and morphometric data for this laboratory colony.

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