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Research Article

Evaluation of life history traits of hymenopteran egg parasitoids *Trichogramma japonicum* Ashmead and *Telenomus dignus* (Gahan) of Yellow Stem Borer *Scirpophaga incertulas* (Walker) in kharif rice

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ABSTRACT: The life history traits; adult longevity (days) and sex ratio (female/male) of hymenopteran egg parasitoids *Trichogramma japonicum* (A.) and *Telenomus dignus* (G.) of Yellow Stem Borer (YSB) in kharif rice was evaluated by collecting the YSB egg masses from the pesticide free rice field at seven days interval from 20 days after transplanting to 55 days after transplanting (20 DAT, 27 DAT, 34 DAT, 41 DAT, 48 DAT and 55 DAT). The naturally parasitised egg masses by the egg parasitoids were checked in the laboratory for two consecutive kharif seasons of 2022 and 2023. The result revealed that the pooled adult longevity of *T. dignus* was 1.99±0.05 days. For *T. japonicum*, the pooled adult longevity was 4.09±0.11 days. The sex ratio of *T. dignus* was 1.06±0.01, while it was 0.55±0.02 for *T. japonicum*. At the end of the trial, it was concluded that adult longevity of *T. japonicum* was reported to be higher than that of *T. dignus,* but the sex ratio (female/male) was found to be higher in the case of *T. dignus* than *T. japonicum* in kharif rice.

KEYWORDS: Adult longevity, egg masses, egg parasitoids, pesticide, sex ratio

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INTRODUCTION

Among the numerous insect pests known to adversely affect rice production and cause significant yield losses, the YSB, *Scirpophaga incertulas* (Walker) (Lepidoptera: Pyralidae), stands out as one of the most destructive and economically important pests. This species is widely recognised for infesting rice plants at multiple growth stages, causing considerable damage that can severely compromise crop productivity and quality across many rice-growing regions (Reuolin & Soundarajan, 2019). It is a widely distributed, monophagous pest that targets rice exclusively, posing a serious threat to its cultivation across various agro-ecological zones. It infests the rice crop throughout its developmental stages, from the early seedling phase through to maturity, thereby exerting continuous pressure on plant health and productivity. Among the approximately 20 insect species identified as potential pests of rice, YSB has emerged as the most prevalent and damaging. Its dominance is attributed to its high reproductive potential, adaptability to diverse environmental conditions, and persistent feeding behaviour. The damage inflicted by YSB can lead to substantial yield reductions, with reported losses ranging from 21% to 51%, depending on the infestation level, crop variety, and management practices employed (Muralidharan & Pasalu, 2006). “Dead hearts” (DHs) are a visible symptom in rice plants resulting from stem borer infestation during the vegetative growth stage. At this stage, the larvae bore into the central shoot, causing it to wither and die, leading to

the characteristic appearance of a "dead heart." In contrast, "white ear heads" (WHs) are symptoms that occur when stem borers attack rice plants during the reproductive stage, specifically when the panicles are forming and developing. This type of damage results in the ear heads turning white and remaining unfilled due to disrupted nutrient flow. While rice plants can often compensate for a low incidence of dead hearts without significant yield loss, the presence of white ear heads is more detrimental. For every 1% increase in white ear head occurrence, it is estimated that overall grain yield will decrease by 1-3%, making WHs a more critical indicator of economic damage in rice production (Rubia *et al.*, 1996).

Egg parasitoids are a group of entomophagous organisms, predominantly hymenopteran insects that oviposit within or upon the eggs of a host arthropod. The developing parasitoid larva exploits the host egg as its sole nutritional resource, completing its entire ontogeny within the host egg and ultimately causing the host to die before embryonic development or hatching. Egg parasitoids of YSB, which parasitise the majority of the egg mass and stop stem borer eggs from developing, are crucial to the population control of this borer pest of rice. Hymenopteran members belonging to the families Mymaridae, Trichogrammatidae, and Platygastridae are exclusively egg parasitoids (Austin *et al.*, 2005). Additionally, several species from chalcid families such as Eulophidae, Encyrtidae, Pteromalidae, and Eupelmidae are also known to parasitise the eggs of other insects and arthropods (Noyes, 2011). Suppression of the YSB population is effectively possible by encouraging promising egg parasitoids together with the limited application of insecticides. Egg parasitoids such as *Tetrasticus schoenobii* Ferriere, *Telenomus rowani* (Gahan), *T. dignus* (Gahan), and *Trichogramma japonicum* Ashmead are widely distributed in rice fields and serve as key biological control agents. Combined natural parasitism of YSB eggs by *Trichogramma*, *Telenomus*, and *Tetrastichus* species can reach up to 95% in rice ecosystems (Lakshmi *et al.*, 2010; Rahaman & Stout, 2019). *T. dignus*, *T. schoenobii*, and *T. japonicum* have also been reported as common YSB egg parasitoids (Prasanthi *et al.*, 2020). *Trichogramma* species are widely used for controlling lepidopteran pests in irrigated rice (Rani *et al.*, 2007), targeting hosts such as the asiatic rice borer (*Chilo suppressalis* Walker), the rice leaf roller (*Cnaphalocrocis medinalis* Guenee), and the YSB (*S. incertulas*) (Hui-fang *et al.*, 2002; Chen *et al.*, 2010; Ko *et al.*, 2014; Gurr *et al.*, 2012). Conducting detailed biological studies of these egg parasitoids across successive generations is essential for understanding their life history traits, reproductive potential, and overall fitness under varying environmental conditions. Such generational studies provide critical insights into their developmental rates, longevity, fecundity, and host-parasitoid interactions, all of which are key determinants of their effectiveness in the field. This information is vital for evaluating and enhancing the field efficacy of these parasitoids in the biological control of lepidopteran pests, ensuring consistency and sustainability in integrated pest management programs. The present study investigates the important biological parameters of two hymenopteran egg parasitoids of YSB under laboratory conditions.

MATERIALS AND METHODS

Layout of field studies

The field experiment was conducted during the kharif season in 2022 and 2023 on uniform 400 m^2 plots to ensure consistent conditions. All treatments, design elements, and

Table 1. Experimental set-up details in the field for biological attributes

Location	:	Teaching Farm, COA, Burdwan (BCKV)
Crop	:	Rice
Variety	:	MTU-7029 (Swarna)
Season	:	*kharif* (2022) and *kharif* (2023)
Field size	:	400 m^2
Spacing	:	20 cm × 15 cm

agronomic practices were standardised to reduce variability and allow reliable statistical analysis. Details of the layout, including treatments, replications, and plot configuration, are provided in Table 1.

Crop and variety

Paddy (*Oryza sativa* L.) variety MTU-7029 ('Swarna') was grown during the 2022 and 2023 kharif seasons. This widely cultivated variety in Purba Bardhaman, West Bengal, was selected to ensure ecological relevance. The study aimed to document the biological parameters and behaviour of hymenopteran egg parasitoids of the rice YSB to allow natural host-parasitoid interactions, no chemical insecticides were used, ensuring accurate observation of parasitoid incidence, emergence, and parasitisation under field conditions.

Parameters studied under this experiment in the laboratory

Adult longevity and sex ratio

YSB egg masses were collected at weekly intervals from 20 to 55 days after transplanting (20, 27, 34, 41, 48, and 55 DAT) in pesticide-free rice fields at the COA (BCKV) teaching farm, Burdwan, during kharif 2022 and 2023. The collected egg masses were kept in glass test tubes covered with muslin cloth to monitor adult parasitoid emergence. Emerged adults were transferred to polythene vials with a honey solution and, after death, placed in Petri plates for identification. The adult lifespan of each hymenopteran egg parasitoid species was recorded for both seasons. In addition, the sex ratio of the parasitoids was determined by examining them under a microscope. Males and females of each parasitoid species were counted, identified by observing the presence or absence of an ovipositor under a microscope and then sex ratios were calculated.

Data analysis

One-way Analysis of Variance (ANOVA) with a subsequent multiple comparison Tukey test ($p<0.05$) was performed to compare the different parameters in different treatments.

RESULTS

Adult longevity of hymenopteran egg parasitoids of yellow stem borer

Two egg parasitoids, *T. dignus* and *T. japonicum,* were found naturally parasitising the YSB egg masses in rice fields. No cases of multiple parasitism or hyperparasitism were observed. The highest adult longevity of *T. dignus* was recorded in kharif 2023 (2.02 ± 0.03 days), while the lowest

Table 2. Adult longevity (days) of *T. dignus* on yellow stem borer egg mass in kharif 2022 and 2023

	Season		
Days	***kharif*, 2022**	***kharif*, 2023**	**Pooled mean**
20	2.03±0.01	1.95±0.02	1.99±0.04
27	1.93±0.03	2.02±0.03	1.98±0.04
34	1.95±0.03	2.05±0.03	2.00±0.05
41	2.00±0.03	2.09±0.04	2.05±0.04
48	1.88±0.02	2.10±0.02	1.99±0.11
55	1.90±0.02	1.92±0.02	1.91±0.01
Mean ± SE	1.95±0.02[a]	2.02±0.03[b]	1.99±0.05
F value	3.68		
CV	0.09		

*Means within columns separated by ANOVA at 5% level of significance

**Means in columns followed by the different letters shown in superscript are significantly different

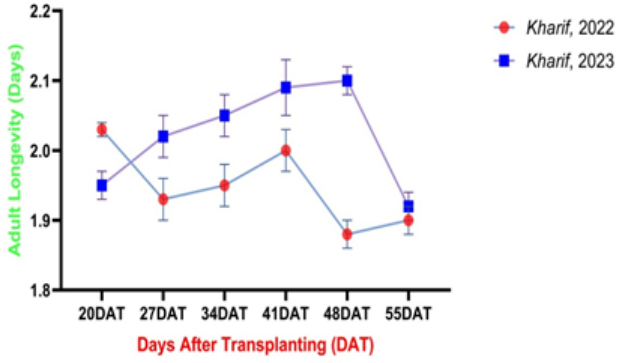


Figure 1. Adult longevity (days) of *T. dignus* on yellow stem borer egg mass in kharif 2022 and 2023.

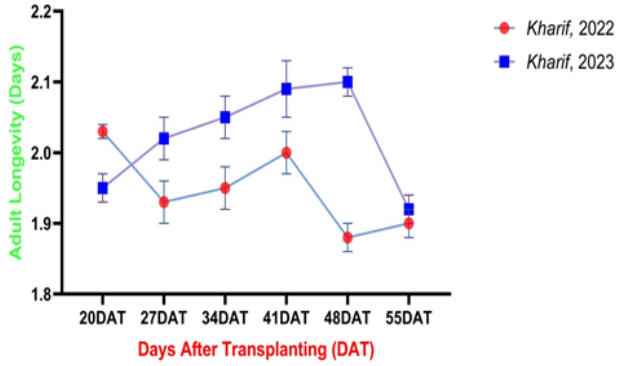


Figure 2. Adult longevity (days) of *T. japonicum* on yellow stem borer egg mass in kharif 2022 and 2023.

occurred in kharif 2022 (1.95 ± 0.02 days). The pooled mean for both seasons was 1.99 ± 0.05 days. Longevity peaked at 41 DAT in 2023 (2.09 ± 0.04 days) and was lowest at 48 DAT in 2022 (1.88 ± 0.02 days). During kharif 2022, values ranged from 1.88 ± 0.02 to 2.03 ± 0.01 days, and in 2023, from 1.92 ± 0.02 to 2.09 ± 0.04 days (Table 2; Figure 1). For *T. japonicum*, the highest average adult longevity occurred in kharif 2023 (4.18 ± 0.03 days), while the lowest was in kharif 2022 (4.01 ± 0.03 days). The pooled mean for both seasons was 4.09 ± 0.11 days. Longevity peaked at 55 DAT in 2023 (4.92 ± 0.03 days) and was lowest at 48 DAT in 2022 (3.91 ± 0.05 days). During kharif 2022, longevity ranged from 3.91 ± 0.05 to 4.12 ± 0.06 days, and in 2023 from 3.92 ± 0.02 to 4.92 ± 0.03 days, showing slightly greater variability and generally longer lifespans (Table 3; Figure 2).

Sex ratio of hymenopteran egg parasitoids of yellow stem borer

The sex ratios of the two dominant egg parasitoids, *T. dignus* and *T. japonicum*, were then calculated. The highest average sex ratio of *T. dignus* occurred in kharif 2023 (1.06 ± 0.03), while the lowest was in kharif 2022 (1.04 ± 0.03). The pooled mean for both seasons was 1.06 ± 0.01. The maximum sex ratio (1.18 ± 0.04) was recorded at 41 DAT in 2023, whereas the minimum (0.96 ± 0.02) occurred at 20 and 48 DAT in 2022. Sex ratios ranged from 0.96 ± 0.02

Table 3. Adult longevity (days) of *T. japonicum* on yellow stem borer egg mass in kharif 2022 and 2023

	Season		
Days	***kharif*, 2022**	***kharif*, 2023**	**Pooled mean**
20	3.94±0.02	4.06±0.04	4.00±0.06
27	4.06±0.03	3.92±0.02	3.99±0.07
34	4.04±0.06	4.00±0.03	4.02±0.02
41	4.12±0.06	4.14±0.03	4.13±0.01
48	3.91±0.05	4.04±0.03	3.98±0.06
55	4.02±0.06	4.92±0.03	4.47±0.45
Mean ± SE	4.01±0.03[a]	4.18±0.03[b]	4.09±0.11
F value	1.14		
CV	0.34		

*Means within columns separated by ANOVA at 5% level of significance

**Means in columns followed by the different letters shown in superscript are significantly different

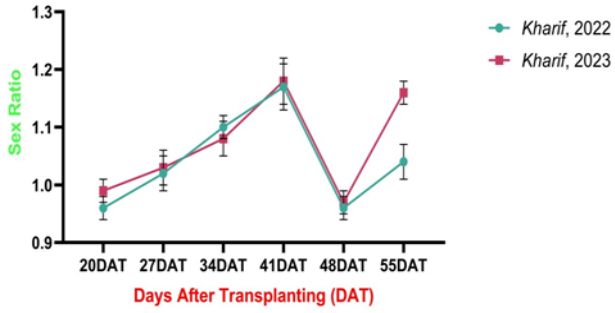


Figure 3. Sex ratio (female/male) of *T. dignus* on yellow stem borer egg mass in kharif, 2022 and 2023.

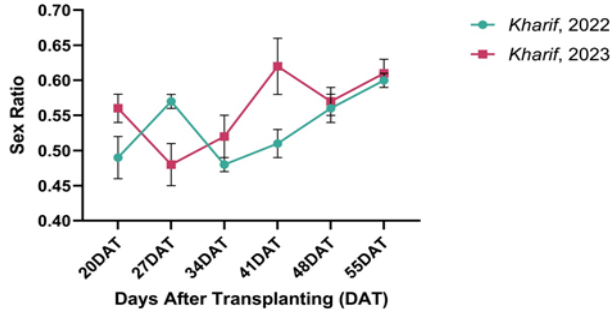


Figure 4. Sex ratio (female/male) of *T. japonicum* on yellow stem borer egg mass in kharif, 2022 and 2023.

Table 4. Sex ratio (female/male) of *T. dignus* on yellow stem

	Season		
Days	***kharif*, 2022**	***kharif*, 2023**	**Pooled mean**
20	0.96±0.02	0.99±0.02	0.98±0.01
27	1.02±0.03	1.03±0.03	1.03±0.05
34	1.10±0.02	1.08±0.03	1.09±0.01
41	1.17±0.04	1.18±0.04	1.18±0.05
48	0.96±0.02	0.97±0.02	0.97±0.05
55	1.04±0.03	1.16±0.02	1.10±0.06
Mean±SE	1.04±0.03[a]	1.06±0.03[b]	1.06±0.01
F value	0.29		
CV	0.11		

*Means within columns separated by ANOVA at 5% level of significance
**Means in columns followed by the different letters shown in superscript are significantly different

Table 5. Sex ratio (female/male) of *T. japonicum* on yellow stem borer egg mass in kharif, 2022 and 2023

	Season		
Days	***kharif*, 2022**	***kharif*, 2023**	**Pooled mean**
20	0.49±0.03	0.56±0.02	0.53±0.03
27	0.57±0.01	0.48±0.03	0.53±0.04
34	0.48±0.01	0.52±0.03	0.50±0.02
41	0.51±0.02	0.62±0.04	0.57±0.05
48	0.56±0.02	0.57±0.02	0.57±0.05
55	0.60±0.01	0.61±0.02	0.61±0.05
Mean±SE	0.53±0.01[a]	0.56±0.02[b]	0.55±0.02
F value	0.72		
CV	0.07		

*Means within columns separated by ANOVA at 5% level of significance
**Means in columns followed by the different letters shown in superscript are significantly different

to 1.17 ± 0.04 in 2022 and from 0.97 ± 0.02 to 1.18 ± 0.04 in 2023 (Table 4; Figure 3). For *T. japonicum*, the highest average sex ratio was 0.56 ± 0.02 in kharif 2023, and the lowest was 0.53 ± 0.01 in kharif 2022, with a pooled mean of 0.55 ± 0.02. The maximum sex ratio (0.62 ± 0.04) occurred at 41 DAT in 2023, and the minimum (0.48 ± 0.01) at 34 DAT in 2022, showing temporal variation. Sex ratios ranged from 0.48 ± 0.01 to 0.60 ± 0.01 in 2022 and 0.48 ± 0.03 to 0.62 ± 0.04 in 2023 (Table 5; Figure 4).

DISCUSSION

Very little work has been reported on *T. dignus* and *T. japonicum* for the parameters discussed, and only a small number of studies exist for the *Telenomus* genus in general. Oktaviani *et al.* (2022) conducted a study in which they focused on various biological parameters, including adult longevity, and they observed that the mean lifespan of adult males and females of *T. remus* was 1.95 days and 2.16 days, respectively. These findings provide valuable insight into the life history traits of this parasitoid species. The general pattern of adult longevity observed by them is consistent with the results obtained in the present study. This suggests a degree of similarity in biological characteristics among species of the same genus, thereby supporting the broader applicability of their findings across different *Telenomus* species. Pomari *et al.* (2013) found that the longevity of *T. remus* adults reared at 34°C varied with the different *Spodoptera* hosts: 2.37 days on *S. frugiperda*, 2.78 days on *S. cosmioides*, and 1.50 days on *S. eridania*. These differences may similarly affect related species like *T. dignus*, whose demographic parameters, especially adult survival, are shaped by temperature and host availability. Longer-lived parasitoids can oviposit more, remain active in the field longer, and ultimately provide more sustained pest suppression, with host nutritional suitability playing a central role (Almeida, 2004). Additionally, Mehendale (2009) discovered that female *T. chilonis* had adult longevity of 4.47 days when fed on a diet of [sorghum + groundnut + powdered yeast] and 1.73 days when fed on sorghum only. He reported that female and male *T. chilonis* lived for 4.03 and 3.00 days, respectively, when fed a 10% honey solution, which aligns with the present findings. Rathi and Ram (2000) examined the adult longevity of *T. chilonis* reared on the commonly used factitious host *Corcyra cephalonica* and reported mean lifespans of 4.6 and 7.8 days for males and females, respectively. This clear sexual dimorphism, with females living longer, reflects typical physiological and reproductive differences in parasitoids. In contrast to other studies conducted under higher temperature regimes, Shirazi (2006) demonstrated that the longevity of *T. chilonis* females was significantly influenced by ambient temperature, with individuals living for an average of 10.08 days at 20°C, while longevity declined markedly to 6.73 days at 30°C. These temperature-dependent variations in lifespan are consistent with the findings of Dileep (2012), who reported that male and female *T. chilonis* emerging from *Spodoptera litura* eggs survived for 3.67 and 5.33 days, respectively, compared to slightly reduced longevities of 3.67 and 4.5 days when reared on *Corcyra cephalonica* eggs. These differences underscore the combined influence of both host species and thermal conditions on the physiological performance of the parasitoid. Firoz (2015) reported that male and female *T. japonicum* lived 3.1 and 4.1 days, respectively, when reared on *C. cephalonica*, emphasising host-related variation. Similarly, Ghosh *et al.* (2017) found that female longevity peaked at 6.6 days at 16°C and declined to 4.6 days at 26°C and 3.0 days at 36°C. Together, these studies support the present findings by showing reduced adult longevity at higher temperatures and the strong influence of host species on trichogrammatid life-history traits.

Qin *et al.* (2018) conducted a field study in China (2013-2014) examining the sex ratio of *T. dignus* emerging from two sugarcane borers, *Scirpophaga intacta* and *Chilo sacchariphagus*. They found that the female-to-male ratio from *S. intacta* increased notably from 1.45 in 2013 to 5.17 in 2014, while the ratio from *C. sacchariphagus* in 2014 was 2.17. Supporting this, Pomari *et al.* (2013) reported that the sex ratio of *T. remus* reared on the factitious host *C. cephalonica* under controlled laboratory conditions at 25 ± 2°C varied between 0.56 and 0.67, illustrating the sensitivity of sex ratio to host and environmental factors. Mehendale (2009) reported significant variability in the sex ratio of *T. chilonis* when parasitising eggs of different host species, with the highest female-to-male ratio observed at 1:4.48 on the eggs of *Samia cynthia ricini*, indicating a strong female bias under these conditions. Conversely, the lowest sex ratio was recorded as 1:1.24 on the eggs of *Earias vittella*, while on *C. cephalonica*, a commonly used factitious host, the

ratio was slightly higher at 1:1.30. These findings underscore the influence of host species on sex allocation strategies in parasitoids, likely reflecting differential host quality and suitability for offspring development. Complementing this, Tang *et al.* (2017) documented sex ratios of 0.71 and 0.62 for *T. japonicum* and *T. chilonis*, respectively, when reared on *S. incertulas* under controlled cage test conditions. These values align closely with the present research, further validating the consistency of sex ratio patterns across diverse experimental setups. However, slight deviations were noted when compared with the findings of Mohapatra and Shinde (2023), who reported a notably higher sex ratio of 2.82 for *T. japonicum* reared on *C. cephalonica*. Such variability in sex ratio across studies and host species suggests that multiple interacting factors, including environmental conditions, host availability, nutritional status, and parasitoid physiological state, play a pivotal role in shaping sex allocation. These temporal and spatial fluctuations emphasise the complex biological and ecological dynamics influencing sex ratio outcomes in parasitoid populations, with important implications for their use in integrated pest management programs where optimising female progeny production is critical for enhancing biocontrol efficacy.

CONCLUSION

A parasitoid selected for biological control should possess high parasitism capacity, viability, and a female-biased sex ratio, as these traits determine its effectiveness and reproductive potential. These parameters are particularly important for assessing parasitoid quality under laboratory conditions and ensuring successful mass rearing and field establishment (Parra & Coelho, 2022). The present study demonstrated that *T. dignus* has a superior potential for parasitising yellow stem borer egg masses compared with *T. japonicum*. The higher sex ratio observed in *T. dignus* further indicates its greater reproductive potential and biological control efficiency. Moreover, *T. dignus* has been confirmed as an effective hymenopteran egg parasitoid of the yellow stem borer. With optimised laboratory rearing and mass multiplication techniques, it can be produced in large quantities for field release. Thus, *T. dignus* represents a promising candidate for incorporation into IPM programmes against yellow stem borer. Its utilisation can contribute to sustainable, eco-friendly, and effective pest management in rice agroecosystems.

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AUTHOR CONTRIBUTIONS

SS prepared the manuscript; LCP checked the manuscript and helped to execute the research work fruitfully. SS was responsible for conducting the experimental work, while SAM carried out the data analysis and interpretation. All authors were actively involved in the development of the manuscript, contributed to its content through critical revisions, and provided their approval for the final version submitted for publication.