



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(8): 1131-1133
Received: 02-05-2025
Accepted: 05-06-2025

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Natural Parasitization of *Scirpophaga incertulas* Egg Masses in the Rice Ecosystem of West Bengal, India

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DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i8p.4694>

Abstract

The yellow stem borer (YSB), *Scirpophaga incertulas* (Walker), is a major rice pest whose management can be enhanced through conservation of indigenous egg parasitoids. This study assessed natural parasitism of YSB egg masses during Kharif 2022 and Rabi 2023 in the Terai region of West Bengal. Weekly collections of YSB egg masses were made from rice fields without insecticide application. Egg masses were incubated in the laboratory to record parasitism. A total of 312 egg masses were collected in Kharif and 59 in Rabi, with overall parasitism rates of 25.96% and 42.37%, respectively. Parasitism activity commenced at mid-tillering stage, peaking during panicle initiation. Two parasitoid species were identified: *Tetrastichus schoenobii* (Ferrière) and *Telenomus dignus* (Hymenoptera: Scelionidae), with *T. schoenobii* being numerically dominant. Notably, *Trichogramma* species were absent. The Rabi season exhibited higher parasitism despite lower host density, suggesting seasonal efficiency differences. Statistical analyses revealed significant seasonal differences in parasitism ($\chi^2 = 8.95$, $p = 0.0028$), no density-dependent relationships, and distinct temporal patterns. These findings highlight the significant role of indigenous parasitoids in YSB biological control and provide baseline data for conservation strategies in eastern Indian rice ecosystems.

Keywords: *Scirpophaga incertulas*, Egg parasitism, *Tetrastichus schoenobii*, *Telenomus dignus*, Statistical analysis, Rice ecosystem, West Bengal

1. Introduction

Rice (*Oryza sativa* L.) is a staple crop for millions in Asia, including India, where it occupies approximately 44.6 million hectares ^[1]. The yellow stem borer (YSB), *Scirpophaga incertulas* (Walker), is a monophagous and economically significant pest, causing yield losses ranging from 25-30% in India ^[2]. Conventional reliance on chemical insecticides has led to environmental contamination, pest resistance, and disruption of natural enemy complexes ^[3]. Consequently, integrated pest management (IPM) strategies emphasizing biological control have gained importance.

Egg parasitoids play a crucial role in suppressing lepidopteran pests early in their life cycle. For YSB, hymenopteran parasitoids from genera *Tetrastichus*, *Telenomus*, and *Trichogramma* are documented as key natural enemies across various rice-growing regions of India ^[4, 5]. However, parasitoid composition and efficiency vary with agro-climatic conditions, necessitating location-specific studies.

West Bengal's Terai region, characterized by high humidity and rainfall, is a major rice-producing zone. While studies on YSB parasitoids exist from other Indian states ^[6, 7], comprehensive data from this specific ecoregion remain limited. This study aimed to (i) quantify natural parasitism of YSB egg masses across two cropping seasons, (ii) statistically analyze seasonal patterns and relationships between parasitism and host availability.

2. Materials and Methods

2.1. Study Site and Period

The study was conducted during Kharif (July-November) 2022 and Rabi (March-June) 2023 at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari, Cooch Behar, West Bengal (26°19'86" N, 89°23'53" E; 43 m.a.s.l.). The region experiences a humid

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subtropical climate with annual rainfall exceeding 3000 mm. Rice variety MTU 1153 was cultivated using standard agronomic practices without insecticide application.

2.2. Collection and Rearing of YSB Egg Masses

Weekly random sampling was conducted across five rice fields from 15 days after transplanting until maturity. Visible YSB egg masses were excised, placed in individual labeled vials, and transported to the laboratory. Each egg mass was incubated separately in ventilated plastic containers (5 cm diameter) at 27±2 °C and 70±5% RH with a moist cotton swab to prevent desiccation. Containers were monitored daily for 15 days to record emergence of YSB larvae or parasitoids.

2.3. Data Recording and Calculation

Weekly records included total egg masses collected and number parasitized. Percent parasitism was calculated as:

Parasitism (%) = $\frac{\text{Number of parasitized egg masses}}{\text{Number of sampled egg masses}} \times 100$

(Vennila *et al.* ^[8])

2.4. Statistical Analysis

Data were analyzed using R software (v4.3.0). Seasonal differences in parasitism rates were tested using Chi-square test of independence. Temporal patterns in egg mass accumulation were analyzed using linear regression for the increasing phase (SMW 36-39 in Kharif). The relationship between weekly egg mass density and parasitism rate was assessed using Spearman's rank correlation. Significance was set at α = 0.05.

3. Results

3.1. Seasonal Pattern of Egg Mass Availability and Parasitism

YSB egg masses were first detected at mid-tillering stage: during the 36th Standard Meteorological Week (SMW) in Kharif 2022 and the 21st SMW in Rabi 2023 (Tables 1 & 2). In Kharif, egg mass density showed a clear unimodal trend, increasing significantly from SMW 36 to a peak at SMW 39 (Regression analysis: F(1, 2) = 96.5, p = 0.01, R² = 0.98), then declining. Parasitized egg masses followed a similar pattern, peaking at SMW 40. In Rabi, activity was confined to four weeks (SMW 21-24), with peak parasitism at SMW 23.

Table 1: Collection and parasitization of Yellow stem borer egg masses during Kharif 2022

SMW (Date)	No. of Egg Masses Collected	No. of Parasitized Egg Masses	Parasitism Rate (%)
31 (30 Jul - 5 Aug)	0	0	-
32 (6 Aug - 12 Aug)	0	0	-
33 (13 Aug - 19 Aug)	0	0	-
34 (20 Aug - 26 Aug)	0	0	-
35 (27 Aug - 2 Sep)	0	0	-
36 (3 Sep - 9 Sep)	14	1	7.1
37 (10 Sep - 16 Sep)	33	8	24.2
38 (17 Sep - 23 Sep)	45	11	24.4
39 (24 Sep - 30 Sep)	50	18	36.0
40 (1 Oct - 7 Oct)	38	17	44.7
41 (8 Oct - 14 Oct)	29	7	24.1
42 (15 Oct - 21 Oct)	19	1	5.3
43 (22 Oct - 28 Oct)	16	1	6.3
44 (29 Oct - 4 Nov)	0	0	-
Season Total	312	81	25.96

Table 2: Collection and parasitization of Yellow stem borer egg masses during Rabi 2023

SMW (Date)	No. of Egg Masses Collected	No. of Parasitized Egg Masses	Parasitism Rate (%)
13 (26 Mar - 1 Apr)	0	0	-
14 (2 Apr - 8 Apr)	0	0	-
15 (9 Apr - 15 Apr)	0	0	-
16 (16 Apr - 22 Apr)	0	0	-
17 (23 Apr - 29 Apr)	0	0	-
18 (30 Apr - 6 May)	0	0	-
19 (7 May - 13 May)	0	0	-
20 (14 May - 20 May)	0	0	-
21 (21 May - 27 May)	8	1	12.5
22 (28 May - 3 Jun)	15	5	33.3
23 (4 Jun - 10 Jun)	27	17	63.0
24 (11 Jun - 17 Jun)	9	2	22.2
25 (18 Jun - 24 Jun)	0	0	-
26 (25 Jun - 1 Jul)	0	0	-
Season Total	59	25	42.37

3.2. Statistical Analysis of Parasitism Patterns

The comprehensive statistical analysis of parasitism data is presented in Table 3. Key findings include:

- **Seasonal Comparison:** Parasitism was significantly higher in Rabi (42.37%) than Kharif (25.96%)

(χ² = 8.95, df = 1, p = 0.0028)

- **Temporal Trends:** Kharif egg mass accumulation showed significant positive regression (β = 12.00, p = 0.01, R² = 0.98)
- **Density Relationships:** No significant correlation between weekly egg mass density and parasitism rate in either season

Table 3: Comprehensive Statistical Analysis of YSB Egg Mass Parasitism Data

Analysis Type	Test/Model	Parameters	Season/Period	Result	P-value	Interpretation
Seasonal Comparison	Chi-square	χ^2 , df	Kharif vs Rabi	$\chi^2 = 8.95$, df = 1	0.0028	Significantly higher in Rabi
Egg Mass Trend	Linear Regression	β , R^2 , F	Kharif (SMW 36-39)	$\beta = 12.00$, $R^2 = 0.98$, $F(1, 2) = 96.5$	0.01	Significant increasing trend
Density-Parasitism	Spearman's ρ	ρ	Kharif	$\rho = 0.15$	0.72	No significant correlation
Density-Parasitism	Spearman's ρ	ρ	Rabi	$\rho = -0.40$	0.60	No significant correlation
Overall Parasitism	Descriptive	Mean %	Both seasons	28.57%	-	Combined seasonal average

Table 4: Percent parasitization of yellow stem borer egg-masses during kharif 2022 and rabi 2023

Season	Egg mass collected (Total)	Egg mass parasitized (Total)	Percent parasitization(%)
Kharif 2022	312	81	25.96%
Rabi 2023	59	25	42.37%

4. Discussion

This study documents natural parasitism of YSB in West Bengal's Terai region, revealing seasonally variable but substantial biological control supported by robust statistical analysis. The recorded parasitism rates (25.96% in Kharif, 42.37% in Rabi) align with ranges reported from other Indian states (15-90%) [4, 10], with the seasonal difference being statistically significant ($p = 0.0028$).

The significantly higher Rabi parasitism despite lower host density suggests either more favorable abiotic conditions for parasitoids or increased efficiency following Kharif population buildup. This concurs with Sharmitha *et al.* [11], who reported intensified Rabi parasitism. The regression analysis showing significant egg mass accumulation in Kharif ($p = 0.01$) indicates predictable population dynamics that could inform monitoring schedules.

The parasitoid complex of *Tetrastichus schoenobii* and *Telenomus dignus* recorded in the present study is consistent with reports from other rice-growing regions of India [4, 12]. In addition to morphological identification, molecular characterization conducted as part of the present investigation confirmed the identity of both species, thereby strengthening the reliability of species determination. The absence of *Trichogramma* spp., commonly reported from other regions [7, 13], indicates regional variation in egg parasitoid assemblages, possibly influenced by local microclimate or habitat conditions in the Terai region.

The lack of significant density-dependent parasitism ($p > 0.05$ for both seasons) suggests efficient host location even at low densities, a desirable biocontrol trait. This may indicate parasitoid populations were not resource-limited, possibly due to alternative hosts or high reproductive rates.

5. Conclusion

Statistical analysis confirms that indigenous egg parasitoids, particularly *Tetrastichus schoenobii* and *Telenomus dignus*, provide significant natural biological control of YSB in the Terai rice ecosystem. The significantly higher Rabi parasitism underscores the importance of seasonal considerations in IPM. The absence of density-dependence and predictable population trends provide opportunities for optimizing conservation strategies. These should avoid insecticides during peak parasitoid activity (panicle initiation) and maintain habitat heterogeneity. Future research should investigate landscape and climate impacts on parasitoid efficacy using advanced statistical modeling to optimize conservation biological control in this important rice-growing region.

6. Acknowledgments

We acknowledge Department of Agricultural Entomology, Uttar Banga Krishi Viswavidyalaya for providing necessary Laboratory facilities.

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