Relative composition of egg parasitoid species of yellow stem borer, *Scirpophaga incertulas* Wlk. in paddy field at Uttar Dinajpur, West Bengal, India

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ABSTRACT

Extent of parasitization of yellow stem borer (YSB), *Scirpophaga incertulas* Wlk. egg masses for three consecutive years (2008-2010) was assessed in insecticide free paddy field at Raiganj, Uttar Dinajpur, West Bengal. *Telonomus rowani*, Gahan (Scelionidae), *Tetrastichus schoenobii*, Ferriere (Eulophidae) and *Trichogramma chilonis*, Ishii (Trichogrammatidae) were the three important YSB egg parasitoids recorded from this area. Activity of YSB egg parasitoids is seasonally allied; egg mass size dependent and paddy growth stage specific. Egg mass was mostly parasitized either by single or by two parasitoid species. Presence of three parasitoids species in a single egg mass is uncommon. Incidence of parasitization by only *Trichogramma* sp., *Telonomus* sp. and *Tetrastichus* sp. was 6.12%, 9.53% and 48.44%, respectively. Parasitization by *Trichogramma* sp. + *Telonomus* sp., *Telonomus* sp. + *Tetrastichus* sp. and *Trichogramma* sp. + *Tetrastichus* sp. were 3.46%, 21.06% and 2.35%, respectively. *Tetrastichus schoenobii* and *Trichogramma chilonis* were active almost throughout the year, while activity of *Telonomus rowani* was recorded from late August to middle of October. Significant positive effect of maximum temperature, minimum temperature and temperature gradient on parasitoid population was noted. Humidity gradient and sunshine hours exerted significant negative effect on all parasitoid population. However, rainfall did not show any significant effect on parasitoids.

KEY WORDS: Egg parasitoids, rice, *Telonomus*, *Tetrastichus*, *Trichogramma*, yellow stem borer

INTRODUCTION

Ecologists tend to think of agricultural systems as distressed, depauperate, and evolutionary (Kiritani et al., 1994). Tropical Asian rice ecosystem, however, has exhibited an essentially exception. Long ecological history of succession, together with widespread geographic distribution and generally consistent warm and wet regional climates, has resulted in an ecosystem unrivaled by any other in the world in consideration of ecological complexity (Kiritani 2005).

The green revolution was literally and metaphorically a ‘technology packaged’ for mass consumption. Such package
included the adoption of high yielding variety of paddy seeds, addition of plenty of nitrogen and phosphate fertilizers, newly formulated insecticides, and fungicides (Shepard et al. 1991). In general the dominant pest-control strategy in tropical rice over the past 30 years has been the use of modern resistant improved paddy varieties and especially the use of newer brand of toxic chemical insecticides (Kiritani et al. 1994). But pest population has developed high levels of resistance against several classes of insecticides, including chlorinated hydrocarbons, organophosphates and nereistoxin analogues, as a result of long-term field application (He et al. 2008; Jiang et al. 2009). Further, most insecticides used in crop protection now, however, show high toxicity to non-target arthropods including parasitoid wasps (Wu et al. 2007, Prasad et al.2007, Jhansi Lakshmi et al. 2010).

The majority of research related to arthropods in tropical rice has been directed towards the small number of ‘pest’ species without examining the biotic linkages to the rest of the system. Modern Integrated Pest Management (IPM) methodology is mainly dependent on the exploitation of the ‘biotic linkage(s)’ especially to the predator and parasites to maximize pest population suppression (Singh, 1999). Biological control with predators and parasitoids is an important component of the IPM programs (Islam, 1990; Kalode, 2005). Considering the paramount importance of natural enemies in rice culture, systematic investigation of pest and parasitoid population in relation to the structure and function of rice-field ecology is long overdue (Lakshmi et al., 1997).

Among the paddy pests, yellow stem borer (YSB), *Scirpophaga incertulas* Walker is distributed throughout India and is regarded as the most dominating and destructive pest species (Banerjee, 1967, Panda et al., 1976). Early destruction of yellow stem borer egg masses by encouraging the field parasitoid population is essential to maximize yield with least toxic chemical input (Gupta et al., 1985). Activity of YSB egg parasitoids is seasonally allied; egg mass size dependent and paddy growth stage specific. Parasitization causes the ‘hallow’ formation within the egg clutch (Fig.1). The egg mass disintegrates and subsequently degenerates. A study was carried out in pesticide untreated conventionally managed field with the cultivar *Swarna mashuri* (MTU 7029) at the ecological conditions of Raiganj [26°35′15″(N) – 87°48′37″(W)], Uttar Dinajpur, West Bengal with a view to ascertain the degree of management of *S. incertulas* by the parasitoids. The present study was taken up to explore the existence of general and consistent patterns of parasitoid population dynamics related to *S. incertulas* or intrinsic levels of biological control and to understand the effect of weather parameters on existing levels of parasitoids.

**MATERIALS AND METHODS**

**Geographic location and agro-climatic conditions:** Raiganj [26°35′15″(N) – 87°48′37″(W)], is the administrative headquarter of the district Uttar Dinajpur, West Bengal. The climate of this zone is sub-tropical humid in nature. The average annual rain fall varies from 2100 to 3000 mm, the maximum rainfall occurs during the rainy months of June to September amounting to more than 80% of the total
rain fall. The annual average day night temperature ranges between 19.7 and 29.9°C with the mercury soaring even as high as 33°C in April and cascading to a low of 5°C in January. The relative humidity at 8:30 hours is 58% and 88% in March and July respectively. The relative humidity in the afternoon at 17:30 hours is 48% and 84% in March and November respectively.

**Experimental layout:**

Field study was conducted by randomized block design (RBD) during three consecutive crop years (2008-2010) in pesticide untreated field of paddy cultivar *Swarna mashuri* (MTU 7029). Transplantation was done with 35-day old seedlings at 15 x 10 cm spacing on 27-28 standard meteorological weeks (SMW). The soil of the experimental field was sandy loam with PH value 6.8 and EC value 0.28 mmhos/cm. N, P2O5 and K2O was 315, 65 and 3452 kg/ha respectively. During land preparation, each plot received 150:60:60 NPK as basal dose. Field management was done following national protocol with befitting modifications.

Simultaneously the seedlings were potted at the rate of 4 seedlings/pot and kept in netted situation. Each pot was 12 cm x 12 cm by volume and encaged with a nylon mesh cage. A white foam plate (1.5 m x 1.0 m) was set below the incandescent light source (100 watt) at night on the ridge of a paddy field of *Swarna mashuri*, every week from 15 days after transplantation to capture YSB females. At each occasion mated female moths from light traps were individually confined to the rice plant cages and allowed to deposit eggs until their death. The plant parts containing YSB egg masses were taken from the cage, kept it in the

paddy fields for different growth stages of paddy in relation to SMW for egg mass parasitization. After 2-3 days the plant parts along with parasitized egg masses were transferred to glass tubes (20 cm long and 2.5 cm wide) with 2.5 cm water to moist the cut portion of the paddy plant. Each tube contained 2 egg masses and for each date there were three tubes. Observation was made for consecutive weeks, so for a single experiment 39 (13 x 3) glass tubes were maintained throughout the observation period. Tubes were arranged in rack and subsequently placed in to green house. The mouth of the tubes were plugged with cotton and allowed necessary time for parasitoids to come out. Egg parasitoids emerged and got trapped in cotton.

**Assessment on parasitoid incidence:** Parasitoids emerged from YSB egg mass were observed under binocular microscope. Assessment of YSB egg mass parasitization was carried out following the procedure of Shen *et al.* (2004) with suitable modifications.

**Correlation analysis:** Weekly noted parasitoid population were correlated with the prevailing weather parameters viz., maximum temperature (Tmax), minimum temperature (Tmin), temperature gradient (Tgr), maximum humidity (RHmax), minimum humidity (RHmin), humidity gradient (RHgr), sunshine hour (Shr), rainfall (Rfall) and rainy days (Rdays).

**RESULTS AND DISCUSSION**

Extent of parasitization of yellow stem borer (YSB), *S. incertulas* egg masses was assessed for three consecutive years (2008-2010) in insecticide untreated rice field at Raiganj, Uttar Dinajpur, West
Bengal. *Telonomus rowani*, Gahan (Scelionidae), *Tetrastichus schoenobii*, Ferriere (Eulophidae) and *Trichogramma chilonis*, Ishii (Trichogrammatidae) were the three important YSB egg parasitoids recorded from this area. The overall results are delineated below:

**Extent of parasitization by different species:**

In consideration of nature of parasitization YSB egg clutches were grossly categorized in two categories, parasitized and non-parasitized (G1). Eggs were parasitized either by single (G2), double (G3) or triple species (G4) of egg parasitoids. Further there are three categories for G2 (a1, a2 and a3) and G3 (a4, a5 and a6) respectively. Number of egg masses without parasitization was very low (5.21%). Incidence of parasitization by only *Trichogramma* sp. (a1), *Telonomus* sp. (a2), and *Tetrastichus* sp. (a3) in separate instances was 6.12%, 9.53% and 48.44% respectively. Parasitization by *Trichogramma* sp. + *Telonomus* sp. (a4), *Telonomus* sp. + *Tetrastichus* sp. (a5) and *Trichogramma* sp. + *Tetrastichus* sp. (a6) were 3.46%, 21.06% and 2.35% respectively. Instances of parasitization by all the three species were 3.83% only. Incidence of two or three species of parasitoids in a single egg clutch were comparatively low than the occurrence of single species. This may due to the fact that the presence of a single parasitoid species mutually excludes the presence of other species. Such exclusion was comparatively higher for *Tetrastichus* sp. However, coexistence of *Telonomus* sp., + *Tetrastichus* sp. was relatively high than other combinations.

![Fig 1: Yellow stem borer egg clutches: 1(a) in natural condition, 1(b) in parasitized condition](image-url)
Table 1: Extent of parasitization in relation to the growth stage of paddy

<table>
<thead>
<tr>
<th>Group</th>
<th>category</th>
<th>Species composition</th>
<th>Number of egg mass</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>G1 (no parasitization)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>G2 (Parasitization By Single species)</td>
<td>a1</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>a2</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>a3</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>G3 (Parasitization By two species)</td>
<td>a4</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>a5</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>a6</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

(+) Present, (-): Absent
A: *Trichogramma* sp., B: *Telonomus* sp., C: *Tetrastichus* sp.

**Parasitization in relation to the growth stages of paddy:**

Incidence of YSB eggs and the extent of parasitization varied considerably as the growth stage of paddy advances (Fig.2). Initially, immediately after seedling transplantation (DAT) the incidence of egg clutches were very low and most of the eggs were parasitized. The incidence of egg masses increased gradually up to 25 DAT. The first peak incidence was noted at about 30 DAT. This then subsided abruptly with a sharp decline. The next peak of moderate range was noted at 45 DAT which persisted for 50 DAT. A gradual fall of egg mass population was then noted. At 55-75 DAT incidence of YSB egg masses were very low. The last peak with restricted incidence of egg mass was noted at 90 DAT. After which the availability of egg masses declined at first gradually and then abruptly. Incidence of egg masses was befitted with the adult YSB incidence. YSB covers nearly two generations in a single crop cycle. The first peak was due to the gravid immigrant adult YSB population. The subsequent peak was due the fresh egg laying of the newly emerged first batch of adult population and the late immigrants from the nearby fields. The last peak was from the eggs of the second batch adults. As the paddy crop is near to mature immigration of adult YSB at this stage was very much restricted. Extent of parasitization in all cases depends on the availability of the YSB egg masses. However it was high at early growth stage but somewhat low at late growth stage of paddy. This may due to the low searching capacity of parasitoid population for YSB eggs in the dense canopy of paddy crop at late growth stage of paddy. In consideration of the nature of parasitization by single or by the combination of different parasitoid species, there were distinct variations (Table 2). However their overall dynamics were
more or less followed a distinct pattern. This pattern was noted in laboratory condition. For all the instances, at 30 standard meteorological weeks (SMW), the incidences were very low and attained the maximum value at 44 SMW.

Table 2: Incidence of different parasitoids by in relation to paddy growth stages (individuals/75 egg clutches)

<table>
<thead>
<tr>
<th>Species combinations</th>
<th>Incidence in relation to SMW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td>A</td>
<td>3.87</td>
</tr>
<tr>
<td>B</td>
<td>5.92</td>
</tr>
<tr>
<td>C</td>
<td>7.67</td>
</tr>
<tr>
<td>B+C</td>
<td>4.12</td>
</tr>
<tr>
<td>A+C</td>
<td>3.21</td>
</tr>
<tr>
<td>A+B+C</td>
<td>1.41</td>
</tr>
<tr>
<td>No parasitization</td>
<td>12.56</td>
</tr>
</tbody>
</table>

A: *Trichogramma* sp., B: *Telonomus* sp., C: *Tetrastichus* sp.

SMW – Standard Meteorological Week

Fig 2: Incidence of yellow stem borer egg masses and the extent of parasitization in relation to paddy growth stage
**Influence of weather parameters on parasitoids:**

Significant positive effect of maximum temperature, minimum temperature and temperature gradient on parasitoid population was noted. Effect of average temperature was significantly positive at high level. Maximum and minimum relative humidity exerted significant positive and significant negative effect, respectively (Table 3). Parasitoid population showed significant negative correlation with humidity gradient and sunshine hours. Effect of rainfall and number of rainy days exerted insignificant negative effect. Variation was noted regarding the extent of effect of the weather parameters in different years. However, their gross effect in consideration of different years did not diverge erratically.

Incidence of *T. schoenobii* was inversely correlated with the temperature, higher the temperature lesser will be the abundance (Chandra mohan *et al.* 1984). But in the present study the effect is significantly positive. Hikim (1979) have noted that emergence of YSB egg parasitoids is restricted after 32°C. Extent of parasitization ranged from 84.6-100% and 28.0-74.7% during wet and dry season respectively (Mohanraj *et al.* 1995). Degree of parasitization mostly depends on the ability of the parasitoids to search YSB eggs. From late tillering growth stage of paddy egg clutches are laid mostly towards the lower part of the mature leaf.

Canopy compactness due to tiller generation affects the searching capability of the parasitoids adversely. *T. schoenobii* was reported to the second best important parasitoid in regulating the late broods of YSB population during winter (Hikim 1988). At Navasari, Gujrat *T. dingus* and *T. schoenobii* were the most abundant parasitoids of YSB eggs (Pandya *et al.* 1995). *T. rowani* was considered the most abundant parasitoids in Karnataka (Rai *et al.* 1977). In occasional cases egg mass parasitism was recorded up to 86.7% at 40 days after seedling transplantation (DAT) where larval parasitism reached 58.3% at 60 DAT (Rao *et al.* 1983).

Parasitization by *T. schoenobii* in Andhra Pradesh, India was 30.6% during *kharif* and 23.7% during *rabi* season. But the rate of parasitization in laboratory condition, extended up to 48% (Gupta *et al.* 1985). *Tetrastichus* sp. was the main egg parasitoid during *kharif* season in Warangal, Haryana (Rao *et al.* 1983). Parasitism by *Telenomus* during October and November was 26.84% (Rao *et al.* 1976). At Kapurthala, Punjab during September, *T. dignoides* was abundant (Sukhija *et al.* 1991). But at Cuttack, Orrisa, maximum activity of *T. dignoides* was noted during *rabi* and *kharif* seasons (Anonymous 1991). This was followed by *T. schoenobii*. While parasitism by *T. japonicum* was very low. Both the incidence of egg mass and the extent of parasitism were more during *rabi* season. But the number of eggs in each egg clutch and the proportion of hatching were more during *kharif*.

*Telenomus dignoides* parasitizes maximum number of egg masses (32.4-63.3%) in all the seasons(Anonymous 1996). Very few egg masses (3.0-13.6%) were parasitized by *T. japonicum* during
kharif season. This was followed by T. schoenobii, T. japonicum in descending order. At Coimbatore, India parasitism due to Tetrastichus sp. T. rowani and T. japonicum was 32%, 24% and 2% respectively. While at Chinchura, West Bengal, the gross value ranged from 15 to 45% (Anonymous 1991). In the Eastern Ghat zone of Orrisa, the average value was 73.6-96.9%. Grossly the extent of parasitism in different parts of India ranges from 4.0 to 97.2% (Senapati et al. 1999). Incidence of parasitism increased following host enrichment by the placement of YSB egg masses in the rice field, when the moth population was low (Anon 1996).

Manju et al. (2002) have noted that abundance of egg population was positively correlated with the extent parasitism at insignificant level. Hikim (1979) have reported that the activity of parasitoids were egg mass density independent. But in the present study extent of parasitization was found to be egg mass size dependent ($r = 0.786$) and was also be fitting with the standing paddy growth stages, high in the early growth stages but low in late growth stages.

High average parasitization at early vegetative stages (63.85%) decreased steadily and remained constant during mid-tillering stage (34.65%), and further declined during the ripening stage (14.67%). At all the growth stages abundance of T. chilonis was maximum and T. schoenobii was minimum In general the parasitoid population followed a linear trend in relation to the availability of the YSB eggs (Ram et al. 1996). Because of the less accessibility of the insecticide formulation in the compact crop canopy at late growth stage of paddy, release of abundant egg parasitoids in relation to the regional agro-climatic conditions is the best possible method to YSB menace (Mathur 1999).

Table 3: Correlation coefficient of incidence of the natural enemies with the climatic factors indicating the level of significance

<table>
<thead>
<tr>
<th>Climatic parameters</th>
<th>Degree of correlation of parasitoid species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichogramma sp.</td>
</tr>
<tr>
<td>Maximum temperature (Tmax)</td>
<td>0.602*</td>
</tr>
<tr>
<td>Minimum temperature (Tmin)</td>
<td>0.567*</td>
</tr>
<tr>
<td>Temperature gradient (Tgr)</td>
<td>0.508*</td>
</tr>
<tr>
<td>Average temperature (Tavg)</td>
<td>0.788</td>
</tr>
<tr>
<td>Maximum humidity(RHmax)</td>
<td>0.545*</td>
</tr>
<tr>
<td>Minimum humidity (RHmin)</td>
<td>-0.765*</td>
</tr>
<tr>
<td>Humidity gradient (RHgr)</td>
<td>-0.578*</td>
</tr>
<tr>
<td>Average humidity (RHavg)</td>
<td>0.211</td>
</tr>
<tr>
<td>Sunshine hours / day(Shr)</td>
<td>-0.513*</td>
</tr>
<tr>
<td>Rainfall (Rfall)</td>
<td>-0.346</td>
</tr>
<tr>
<td>Rainy days (Rdays)</td>
<td>-0.423</td>
</tr>
</tbody>
</table>

Significant at 5% level
CONCLUSION

Observations at Raiganj, Uttar Dinajpur, West Bengal on the extent of parasitization of yellow stem borer (YSB), *Scirpophaga incertulas* Wlk. egg masses for three consecutive years (2008-2010) revealed that *Telonomus rowani*, *Tetrastichus schoenobii* and *Trichogramma chilonis* were the three important YSB egg parasitoids recorded from this area. Incidence of YSB egg parasitoids is seasonally allied; egg mass size dependent and paddy growth stage specific. Egg mass was mostly parasitized either by single or by two parasitoid species. Presence of three parasitoid species in a single egg mass is uncommon. Correlation values showed that maximum temperature, minimum temperature and temperature gradient had significantly positive effect on parasitoid population. Effect of average temperature was significantly positive. Maximum and minimum relative humidity exercised significant positive and significant negative effect, respectively. Humidity gradient and sunshine hours exerted significant negative population on parasitoid population. Effect of average humidity in all instances is insignificantly positive. However, rainfall and number of rainy days did not show any significant effect.

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