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[Note]

Influence of abiotic factors on seasonal incidence of pests of tasar Silkworm *Antheraea mylitta* D.

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Abstract

Rearing of tropical tasar silkworm, *Antheraea mylitta* Drury is mainly conducted in outdoor on *Terminalia tomentosa* W. & A. a nature grown primary host plant available in forest and also on raised primary host plant *Terminalia arjuna* Bedd. Temperature, relative humidity and rainfall are the main environmental factors for occurrence of pests (parasites and predators) of tasar silkworm during I, II and III crop rearing in the tropical tasar producing zones. The present study was aimed to study the influence of abiotic factors on prevalence of tasar silkworm pests. The study was conducted at different agro-climatic regions viz., Central Tasar Research &Training Institute, Ranchi, Jharkhand, Regional Extension Centre, Katghora, Chattisgarh and Regional Extension Centre, Hatgamaria during 2010-13 covering 3 seed crop and 6 commercial crops. Data on incidence of tropical tasar silkworm endo-parasitoids like Uzi Fly, *Blepharipa zebina* Walker and Ichneumon fly (Yellow Fly), *Xathopimpla pedator*, Fabricius and Predators such as Stink bug (*Eocanthecona furcellata* Wolf), Reduviid bug (*Sycanus collaris* Fabricius) and Wasp (*Vespa orientalis* Linnaeus) was recorded Weekly. The meteorological data was collected daily. Data was collected from 4 different agro-climatic zones of tasar growing areas. Analysis of the data revealed a significant negative correlation between abiotic factors and incidence of ichneumon fly and uzi fly. Based on the 3 years data on prevalence of pests region-wise pest calendars and prediction models were developed.

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Terminalia arjuna,
Terminalia tomentosa,
Antheraea mylitta.

Introduction

The tasar culture is a cottage, agro-forestry and forestry based industry that provides sustainable livelihood to several rural communities and country to earn foreign exchange. The tasar silk industry generates cocoons through commercial

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rearings along with the collection from natural habitats by many Indian tribal families as tradition since immemorial. *Antheraea mylitta* is a sericigenous, polyphagous insect feeds primarily on *Shorea robusta* (Sal), *Terminalia arjuna* (Arjun), *Terminalia tomentosa* (Asan) besides variety of secondary and tertiary food plants *viz., Zizyphus mauritiana, Terminalia paniculata, Anogeissus latifolia, Syzigium cumini, Careya arborea,* and *Lagerstroemia parviflora, etc.,* (Mahapatra, 2009) available in tropical deciduous forests of West Bengal, Jharkhand, Bihar, Orissa, Chhattisgarh, Madhya Pradesh, Uttar Pradesh Maharashtra and Andhra Pradesh states of India. Earlier the tasar food plants were not extensively cultivated by the rearers. Natural tasar food plants were used for the silkworms rearing. But adaptation of scientific farm techniques led to the intensive cultivation of the food plants in huge acreage which resulted in monoculture which attracted more number of pests of both host plants and silkworm. It is estimated that in conventional rearing about 70-80% of the crop is lost due to these pests and finally the rearers hardly able to harvest 20-30% of the crop. The duration of the developmental stages of silkworm pests cannot be controlled completely in the nature, which further increases the chance of pest and predator attack, thus this peculiar situation in tasar silkworm rearing makes the pest and predator control more difficult.

Abiotic factors alter the survival, development and reproductive capacity of insects. Their activities are mostly dependent on the environmental temperature, prolonged periods of low or high temperatures or sudden change adversely affect the insect development. Similarly humidity and rainfall influence the population of insects (Prasad and Logiswan, 1997). These factors compelled the insects to adapt themselves to the changing climatic conditions or perish (Pedigo, 2004). Among the various physical factors, temperature, humidity and rainfall are considered to be the most important cause of insect population fluctuations.

The pests of tasar silkworm are broadly categoried into predators and parasitoids. Predators cause damage to tasar larvae during early instars and parasitoids during later stages of silkworm rearing. Due to these pests the production of tasar silk is effected considerably.

Keeping in view the above factors, present study was taken up to record the incidence of silkworm pests in different agro-climatic zones to know the influence of abiotic factors on pest prevalence and to prepare a pest calendar as well as to develop prediction model.

Materials and Methods

Data on prevalence of silkworm pests and predators were collected from 4 different agro-climatic zones of tasar growing areas *viz.,* Research Extension Centre, Kathgora, Chattisgarh, Research Extension Centre, Hatgamaria, Jharkhand, Research Extension Centre, Bangriposi, Orissa and Central Tasar Research and Training Institute, Ranchi, Jharkhand along with the recording the data on abiotic factors like temperature (minimum & maximum), relative humidity (minimum & maximum) and rain fall at weekly interval for a period of 3 years (2010 – 2013). For collection of pest incidence data, 5 villages were selected in each centre consisting of 10 farmers/village. In each farmers plot 7 tasar food plants where silkworm rearing was being conducted were selected randomly for data collection. The predators of silkworm were collected by using country made sticky trap and insect catching net. The parasitoid uzi fly was observed based on its symptoms of attack. For the purpose 100 silkworms were randomly collected from each plant and were inspected for symptoms of uzi infestation. For ichneumon fly, after cocoon harvest 500 cocoon/farmers were randomly observed for symptoms of fly emergence. The percent pest incidence was calculated using the following formulae:

Percent incidence of predators =

$$\frac{\text{No.of predators collected per plant}}{\text{No.of silkworms per plant}} \times 100$$

Percent incidence of uzi fly =

$$\frac{\text{No.of uzi infested silkworms/Cocoons}}{\text{No.of silkworms larvae/cocoons observed}} \times 100$$

Percent incidence of ichneumon fly =

$$\frac{\text{No.of ichneumon fly emerged cocoons}}{\text{No.of cocoon observed}} \times 100$$

Results

Prevalence of Pests of silkworm:

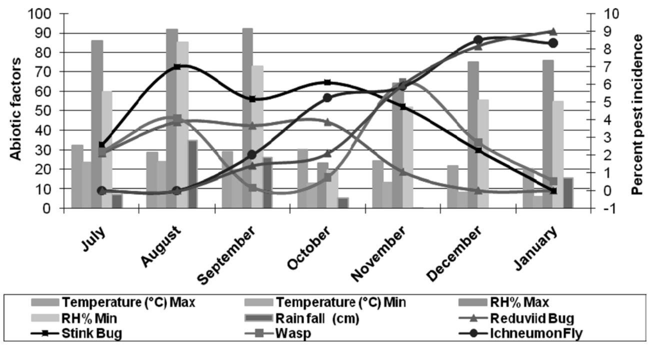

Fig. 1a. Prevalence of silkworm pests during rearing period in CTR&TI, Ranchi

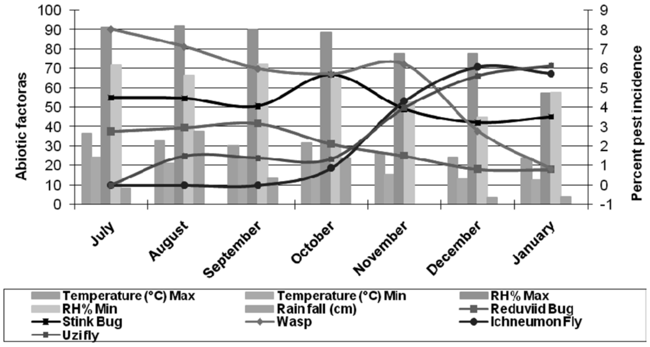

Fig. 1b. Prevalence of silkworm pests during rearing period in REC, Hatgamaria.

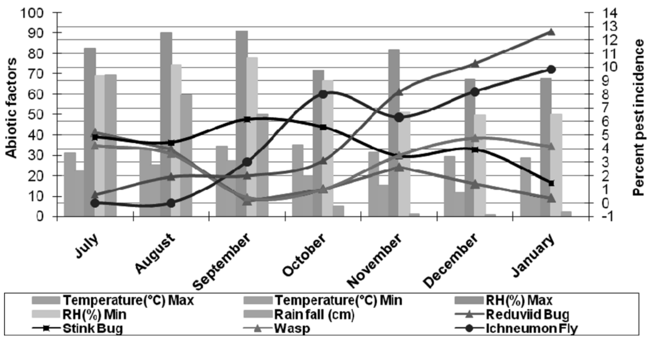

Fig. 1c. Prevalence of silkworm pests during rearing period in REC, Katghora.

The prevalence of major pests of silkworm and abiotic factors at CTR&TI, Ranchi, Jharkhand, REC, Katghora, REC, Hatghmaria and REC, Bangriposi are shown in Fig. 1a – Fig. 1d, respectively. Pest-wise occurrence at different locations and its relation with selected abiotic factors are summarized:

1. Reduviid bug (*Sycanus collaris* Fabricius)

The peak period of incidence of Reduviid bug was recorded

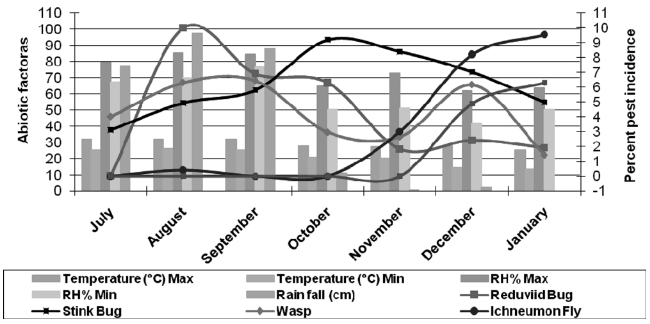

Fig. 1d. Prevalence of silkworm pests during rearing period in REC, Bangriposi.

in July and August months in most of the locations. A significant positive correlation between prevalence of Reduviid bug with maximum temperature (r = 0.853*), minimum temperature (r = 0.932**), maximum relative humidity (r =0.850*), and minimum relative humidity (r = 0.891**) was observed at REC, Hatgamaria. At CTRTI, Ranchi the observed correlation between Reduviid bug and maximum temperature (r = 0.817*) was significant and positive.

2. Stink bug (*Eocanthecona furcellata* Wolf)

The peak period of incidence of Stink bug was recorded in August and November months in most of the locations. A significant positive correlation between prevalence of Stink bug with maximum temperature (r = 0.842*), minimum temperature (r = 0.808*) and minimum relative humidity (r = 0.794*) was found at REC, Katghora.

3. Wasp (*Vespa orientalis* Linnaeus)

The peak period of incidence of Wasp was recorded in the months of August and November in most of the locations. The correlation was significant and positive between prevalence of Wasp with maximum temperature (r = 0.880**), minimum temperature (r = 0.826*) and maximum relative humidity (r =

Table 1. Dependent and Independent variable

Dependent variables (Silkworm pests)	Independent variables (Abiotic factors)
Y1: Reduviid Bug	X1: Maximum Temperature (°C)
Y2: Stink Bug	X2: Minimum Temperature (°C)
Y3: Wasp	X3: Maximum RH (%)
Y4: Ichneumon Fly	X4: Minimum RH (%)
Y5: Uzi Fly	X5: Rain Fall (cm)

Table 2. Correlation coefficient between abiotic factors and silkworm pests

CTR&TI, Ranchi					
	Reduviid bug	Stink bug	Wasp	Ichneumon fly	Uzi fly
Max. Temp.	0.817*	0.592 NS	-0.112 NS	-0.862*	-0.958**
Min. Temp.	0.725 NS	0.588 NS	0.148 NS	-0.994**	-0.936**
Max. RH	-0.104 NS	-0.187 NS	-0.103 NS	-0.418 NS	-0.138 NS
Min. RH	0.106 NS	0.097 NS	0.219 NS	-0.515 NS	-0.263 NS
Rainfall	0.575 NS	0.387 NS	-0.196 NS	-0.586 NS	-0.492 NS
REC, Hatgamaria					
	Reduviid bug	Stink bug	wasp	Ichneumon fly	Uzi fly
Max. Temp.	0.853*	0.707 NS	0.880**	-0.918**	-0.970**
Min. Temp.	0.932**	0.730 NS	0.826*	-0.977**	-0.986**
Max. RH	0.850*	0.600 NS	0.889**	-0.857*	-0.890**
Min. RH	0.891**	0.609 NS	0.633 NS	-0.919**	-0.866*
Rainfall	0.625 NS	0.613 NS	0.430 NS	-0.679 NS	-0.557 NS
REC, Katghora					
	Reduviid bug	Stink bug	wasp	Ichneumon fly	Uzi fly
Max. Temp.	-0.098 NS	0.842*	-0.896**	-0.321 NS	-0.744 NS
Min. Temp.	0.313 NS	0.808*	-0.589 NS	-0.828*	-0.936**
Max. RH	0.397 NS	0.541 NS	0.367 NS	-0.852*	0.736 NS
Min. RH	0.234 NS	0.794*	-0.614 NS	-0.767*	-0.921**
Rainfall	0.609 NS	0.505 NS	-0.103 NS	-0.955**	-0.814*
REC, Bangriposi					
	Reduviid bug	Stink bug	wasp	Ichneumon fly	Uzi fly
Max. Temp.	0.416 NS	-0.535 NS	0.702 NS	-0.755*	-0.666
Min. Temp.	0.479 NS	-0.296 NS	0.453 NS	-0.935**	-0.898**
Max. RH	0.462 NS	-0.489 NS	0.528 NS	-0.726 NS	-0.700 NS
Min. RH	0.457 NS	-0.564 NS	0.467 NS	-0.704 NS	-0.611 NS
Rainfall	0.513 NS	-0.623 NS	0.639 NS	-0.684 NS	0.572 NS

*- Significant at 5% and **- significant at 1%

0.889**) at REC, Hatgmaria. However, at REC, Katghora the correlation between the pest and maximum temperature (r = -0.896**) was significant and negative.

4. Ichneumon fly (*Xanthopimpla pedator* Fabricius)

The peak period of Ichneumon fly incidence was observed in the months of November, December and January in most of the locations. The pest showed significant negative correlation with maximum temperature (r = -0.862*, r = -0.755*) and minimum temperature (r = -0.0.994**, r = -0.935**) at CTR&TI, and REC, Bangriposi, respectively. At REC, Hatgamaria the correlation was significant and negative with maximum temperature (r = -0.918**), minimum temperature (r = -0.977**), maximum relative humidity (r = -0.857*) and minimum relative humidity (r = -0.919**). Similarly, the pest exhibited significant negative correlation with minimum temperature (r = - 0.828*), maximum relative humidity (r = -0.852*), minimum relative humidity (r = -0.767*) and rain fall (r = -0.955**).

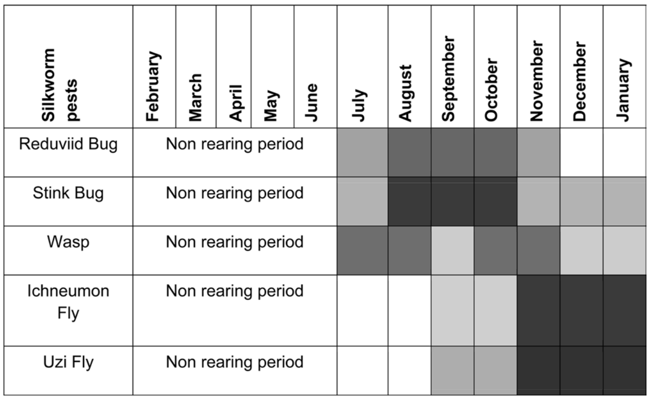

Fig. 2a. Pest Calendar of Tasar Silkworm Pests in CTR&TI, Ranchi.

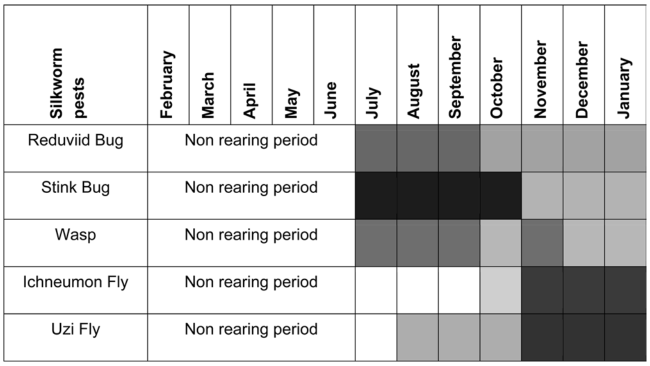

Fig. 2b. Pest Calendar of Tasar Silkworm Pests in REC, Hatgamaria.

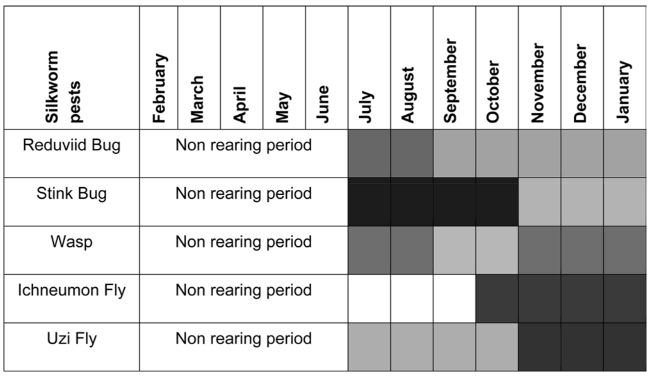

Fig. 2c. Pest Calendar of Tasar Silkworm Pests in REC, Kathgora.

5. Uzi fly (*Blepharipa zebina* Walker)

The correlation was significant and negative between uzi fly and the abiotic factors except rain fall at REC, Hatgamaria. The uzi fly showed significant negative correlation with maximum temperature (r = -0.958**) and minimum temperature (r = -0.936**) at CTR&TI, Ranchi and with minimum temperature (r = -0.898**) at REC,

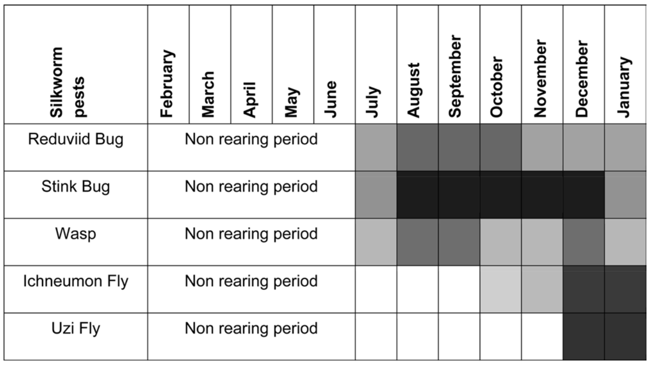

Fig. 2d. Pest Calendar of Tasar Silkworm Pests in REC, Bangriposi. Note: In each row Dark colour indicates the peak prevalence of pest while Light colour indicates moderate occurrence and white colour indicates no occurrence of the pest.

Bangriposi. At REC, Katghora the correlation between the pest and minimum temperature (r = -0.936**), minimum relative humidity (r = -0.921**) and rain fall (r= -0.814*) was significant and negative. Correlation coefficients are furnished in Table 2.

Region wise Pest calendar

The data collected from different locations for a period of three years were pooled and the region wise pest calendars were developed for silkworm pests (Figs. 2a – 2d).

Prediction model

The data for biotic and abiotic factors (Table 1) collected from four location namely CTR&TI Ranchi, REC Katghora, REC Hatgamaria and REC, Bangariposi was analyzed to develop the prediction models for silkworm pests using Multiple linear Regression, Y_i (pests) = a + $b_1 X_1$ (Max.Temp.) + $b_2 X_2$ (Min.Temp.) + $b_3 X_3$ (Max. RH) + b4 X_4 (Min. RH) + $b_5 X_5$ (Rain fall). Prediction models silkworm pests were worked out using Linear Regression Models ($Y = \sum b_i X_i + a$) with backward method (SPSS software). The difference was less between estimated and observed values for silkworm pests (Figs. 3-6). The R^2 (R-Square) estimate in each model indicates total variation explained by predictive variables in getting the pest incidence. Location wise prediction models for silkworm pests are furnished in Table 3.

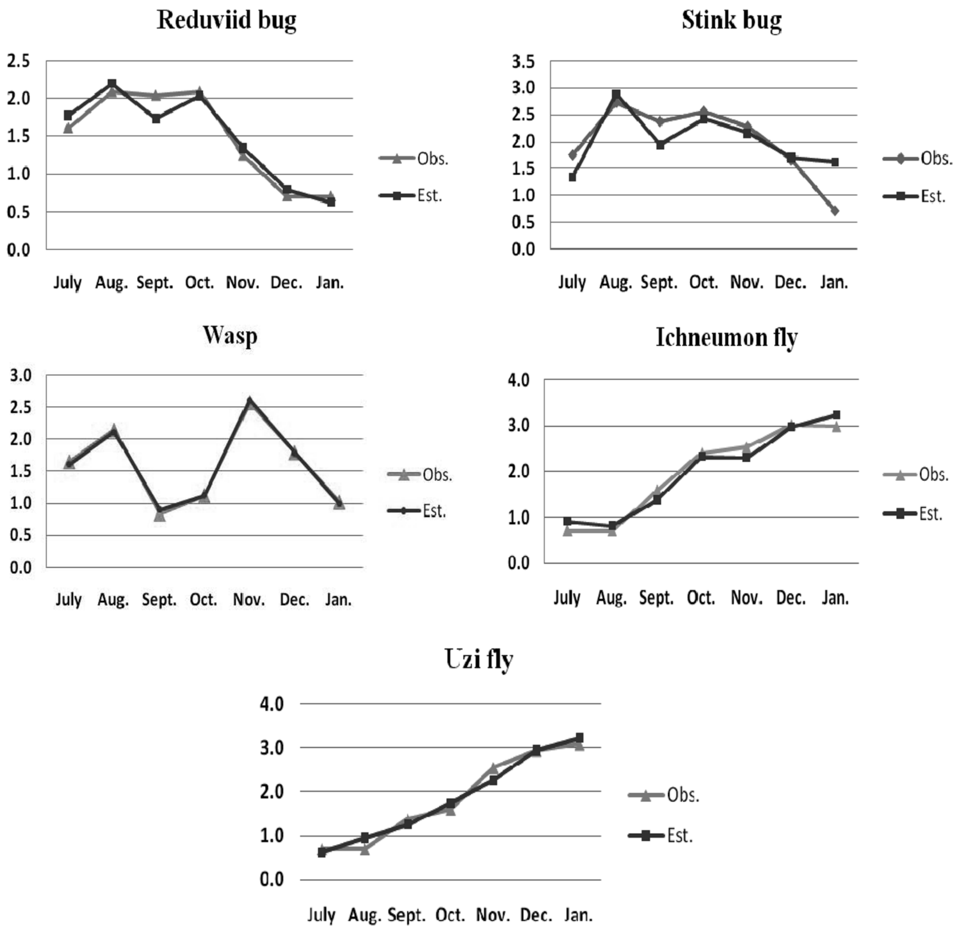

Fig. 3. Observed and Estimated value for Silkworm pests at CTR&TI, Ranchi, (a) Reduviid bug, (b0 Stink bug, (c) Wasp, (d) Ichneumon fly and (e) Uzi fly.

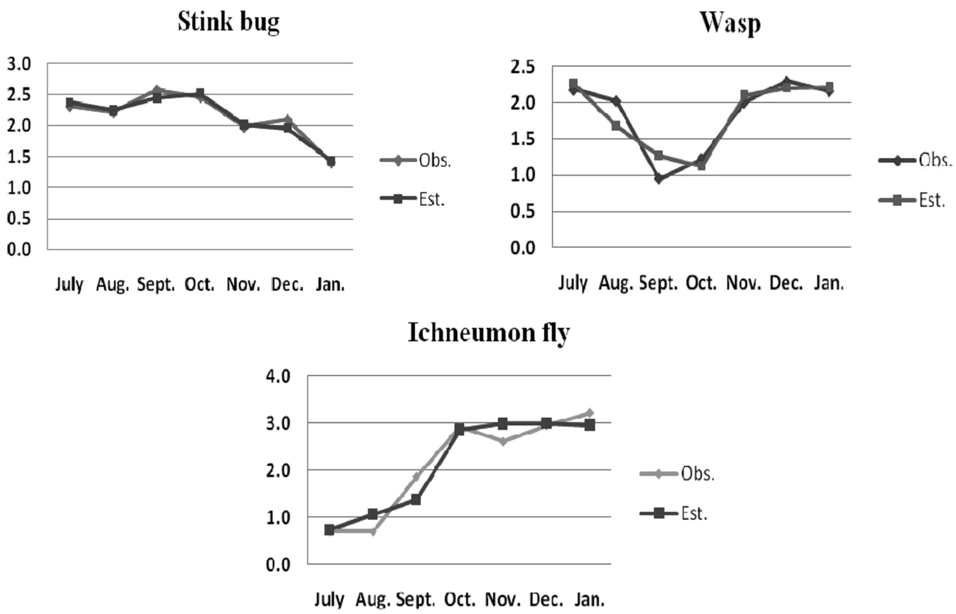

Fig. 4. Observed and Estimated value for Silkworm pests at REC, Katghora, (a) Stink bug, (b) Wasp and (c) Ichneumon fly.

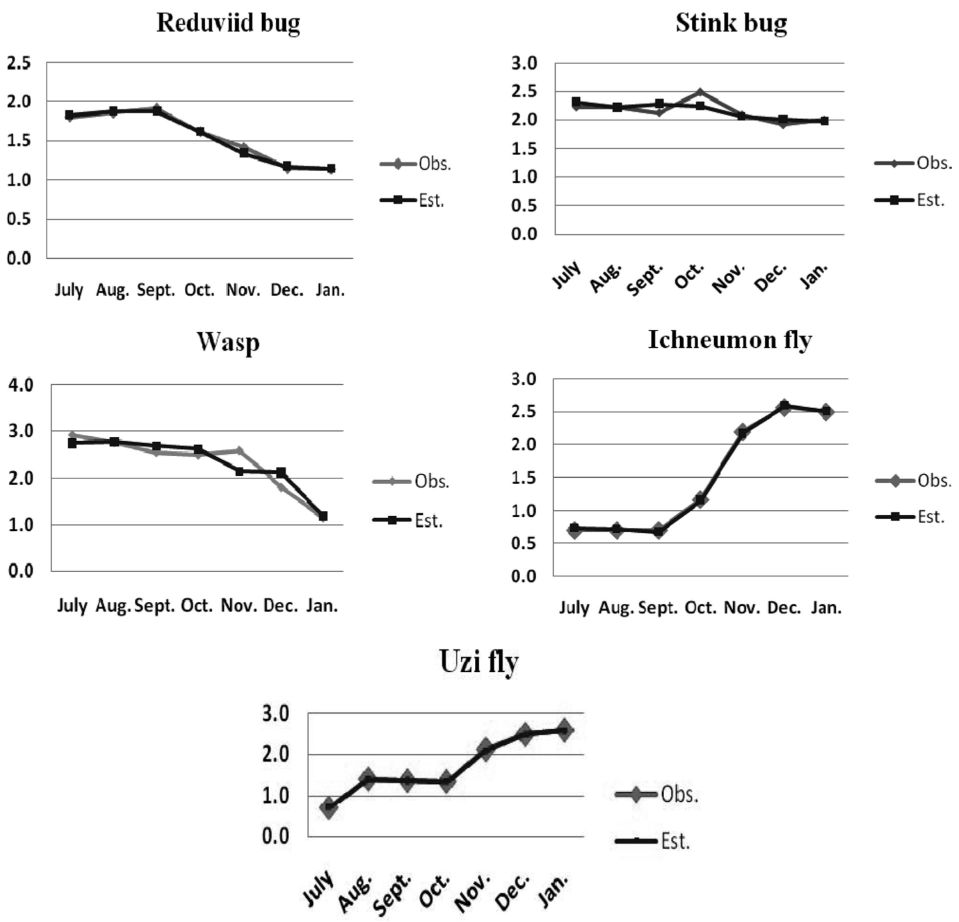

Fig. 5. Observed and Estimated value for Silkworm pests at REC, Hatgamaria, (a) Reduviid bug, (b) Stink bug, (c) Wasp, (d) Ichneumon fly and (e) Uzi fly.

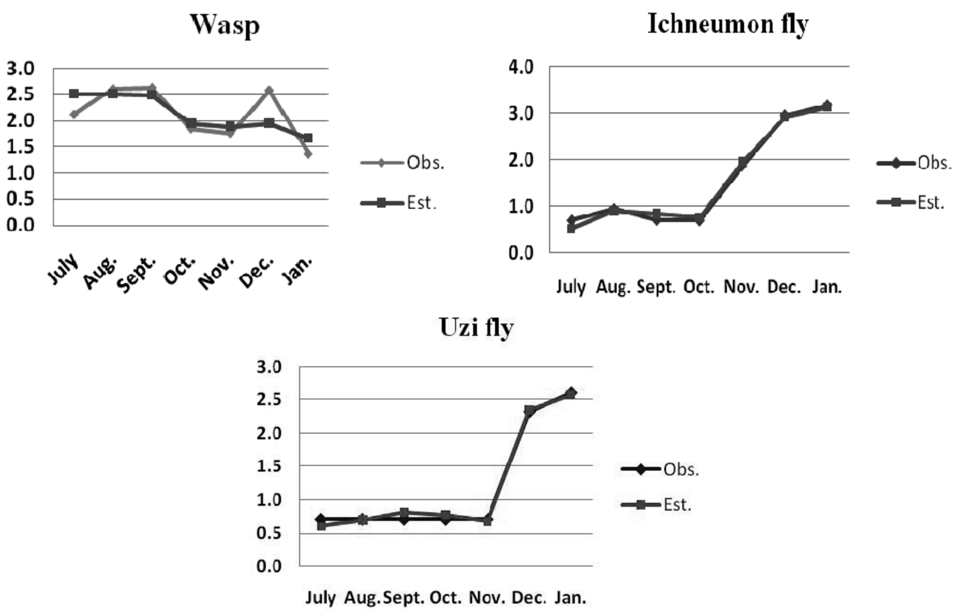

Fig. 6. Observed and Estimated value for Silkworm pests at REC, Bangriposi, (a) Wasp, (b) Ichneumon fly and (c) Uzi fly.

Table 3. Regionwise Prediction models for Tasar Silkworm Pests

Locations	Predictive models	R-square	Reg. F value
CTR&TI Ranchi	Y_1 (Red. Bug) = -1.16 + 0.11 X_1 (Max.Temp) – 0.03 X_3 (Max.RH%) + 0.04 X_4 (Min.RH%)	0.931	13.59**
	Y_2 (Stink Bug) = 2.45 – 0.07 X_3 (Max.RH%) + 0.08 X_4 (Min.RH%)	0.565	2.60NS
	Y_3 (Wasp) = 10.93 – 0.45 X_1 (Max.Temp) + 0.35 X_2 (Min.Temp) – 0.03 X_3 (Max.RH%) – 0.04 X_5 (Rain Fall)	0.996	136.62**
	Y_4 (Ich. Fly) = 4.08 – 0.14 X_2 (Min.Temp)	0.962	126.95**
	Y_5 (Uzi Fly) = 5.65 – 0.09 X_1 (Max.Temp) – 0.08 X_2 (Min.Temp)	0.967	58.31**
REC Katghora	Y_2 (Stink Bug) = 8.52 + 0.34 X_2 (Min.Temp) – 0.07 X_3 (Max.RH%) – 0.11 X_4 (Min.RH%)	0.950	18.13**
	Y_3 (Wasp) = 5.59 – 0.07 X_4 (Min.RH%) + 0.02 X_5 (Rain Fall)	0.846	10.96**
	Y_4 (Ich. Fly) = 3.01 – 0.03 X_5 (Rain Fall)	0.910	51.99**
	Y_5 (Uzi Fly) = 10.42 – 0.50 X_1 (Max.Temp) + 0.04 X_3 (Max.RH%) + 0.10 X_4 (Min.RH%) – 0.06 X_5 (Rain Fall)	0.999	1009.59**
REC Hatgamaria	Y_1 (Red. Bug) = -1.98 – 0.08 X_2 (Min.Temp) + 0.03 X_3 (Max.RH%) + 0.04 X_4 (Min.RH%)	0.983	75.99**
	Y_2 (Stink Bug) = 1.63 + 0.03 X_2 (Min.Temp)	0.560	6.41NS
	Y_3 (Wasp) = -1.44 + 0.05 X_3 (Max.RH%)	0.837	25.69**
	Y_4 (Ich. Fly) = 8.61 + 0.08 X_2 (Min.Temp) – 0.05 X_3 (Max.RH%) – 0.08 X_4 (Min.RH%) – 0.01 X_5 (Rain Fall)	0.999	702.78**
	Y_5 (Uzi Fly) = 5.51 – 0.09 X_1 (Max.Temp) - 0.06 X_2 (Min.Temp) +0.01 X_5 (Rain Fall)	0.999	897.93**
REC Bangariposi	Y_3 (Wasp) = -1.67 + 0.13 X_1 (Max.Temp)	0.525	5.54NS
	Y_4 (Ich.Fly) = 0.89 – 0.36 X_2 (Min.Temp) + 0.14 X_3 (Max.RH%) - 0.04 X_4 (Min.RH%)	0.990	103.45**
	Y_5 (Uzi Fly) = 6.31 – 0.28 X_2 (Min.Temp) + 0.02 X_5 (Rain Fall)	0.994	345.70**

Note: 1. *- significant at 5%, **-significant at 1% and NS-non-significant
2. R^2 = Coefficient of determination, F-test (Regression ANOVA)
Explanatory variable:
X_1 = Max. Temp. (°C), X_2 = Min. Temp (°C), X_3 = Max. RH (%), X_4 = Min. RH (%) and X_5 = Rainfall (mm)
Response variable:
Y_1 = Reduviid bug (%), Y_2 = Stink bug (%), Y_3 = Wasp (%), Y_4 = Ichneumon fly (%) and Y_5 = Uzi fly (%)

Discussion

Major parasitoids of tasar silkworm

The Uzi fly, *Blepharipa zebina* Walker (Diptera: Tachinidae) and the Ichneumon fly, *Xanthopimpla pedator* Fabricius (Hymenoptera: Icheumonidae) are the major endo-parasitoids of tasar silkworm. It is widely distributed in tropical tasar region of India, China, Thailand, Bangladesh and Japan. It is also reported in North – Eastern India infesting Muga silkworm. Several species of lepidopteran caterpillars have been recorded as hosts of *B. zebina*.

The silkworm larvae infested by uzi fly in early instar die before they reach the spinning stage. If the infestation takes place in the late fifth instar, the mature maggot comes out by piercing the cocoon and thereby rendering the cocoon unfit for mass reeling. Infested silkworm can be identified by the presence of black scar on the part of the skin where the maggot penetrates in to the body of the host larvae. Sometimes, an egg shell is left behind in the centre of the black scar. At the initial stage of infestation minute creamy white oval eggs smaller than pinhead are observed on the skin of the larvae.

The ichneumon fly belongs to the order Hymenoptera, family ichneumonidae. The female fly has nearly 1 cm long prominent needle like ovipositor with two long stylets. The female fly lays eggs inside the pre-pupal body by inserting its ovipositor through freshly formed / flimsy cocoon shell. Only one egg is deposited in each host. The maggot after hatching consumes the entire pupal content except the skin and pupates. The adult fly emerges from the cocoon by piercing the cocoon which renders the cocoon unfit for reeling.

Major predators of tasar silkworm

The major predators of silkworm are Stink bug, Reduviid bug, Praying mantis,Wasp and Red ant. The stink bug *Eocanthecona furcellata* Wolf (Hemiptera: Pentatomidae) is the most harmful predator and is responsible for about 15% of the crop loss particularly during early instars (chawki) of silkworms.

On an average single mated female lays 250–350 eggs in batches of 40–70 usually on the under surface of the leaves or on the twigs. Each egg mass consists of four to five rows of 8-15 eggs. The predator lives on the haemolymph of the host, which it sucks by piercing the larval body by its proboscis. It has been observed that single bug can kill 130-225 tasar silkworms of first to third instars throughout its life.

The Reduviid bug, *Sycanus collaris* Fabricius (Hemiptera : Reduviidae) is also most harmful predator particularly during early instars of silkworm in some areas of Chattishgarh, India. The adult bug is black in colour. On an average single mated adult female bug lays about 300 eggs. The nymphs pass through five instars. The entire nymphal period is about 25 days. The nymphs and adults suck the haemolymph of silkworm. A single bug feeds and kills about 200 tasar larvae of first to third instars throughout its life.

The Wasp, *Vespa orientalis* Linnaeus (Hymenoptera : Vespidae) wasp feed on caterpillars, mantids, grasshoppers and other insects. But in a silkworm rearing field defenseless tasar larvae are the choice and they predate silkworm not only for self but also collect and deposit them to their comb cells where large numbers of young ones are developing.

Red ants, *Oecophylla smaragdina* (Hymenoptera : Formicidae) is one of the most damaging predators. It is harmful to all the insects, but the larvae of younger stages of silkworm are more easily affected. They generally attack in groups and carry the younger tasar larvae to their nests. They bite the larvae of advanced ages in an attempt to feed on their appendages including hairs and setae. This leads to swelling, paralysis and finally to death of the worms.

In the present study correlation analysis revealed that the abiotic factor showed significant and positive correlation between maximum temperature and reduviid bug at CTR&TI, Ranchi and REC, Hatgamaria. The results are in consonance with the reports of Joshi and Khalid Zafar *et al.* (2013), Pushpalatha (2008) and Sanjay Kumar (2012) and it differs from Rahman *et al.* (2012), Sardana and Das (2001a, b) who reported significant negative correlation of maximum temperature with the pests.

The minimum temperature showed significant positive correlation with reduviid bug, wasp and stink bug at REC, Hatgamaria and REC, Katghora, respectively. Significant positive correlation of minimum temperature with Jassid population and Jute semilooper was reported by Iqbal *et al.* (2010) and Rahman *et al.* (2012), respectively.

The maximum and minimum Relative Humidity revealed significant negative correlation with ichneumon fly and uzi fly at REC, Katghora and REC, Hatgamaria. The significant negative correlation between pest and RH is in agreement with the reports of Joshi and Sanjay Kumar (2012), Khalid Zafar *et al.* (2013), Pushpalatha (2008) and Sardana and Das (2010a).

The influence of rain fall was significant and negative between ichneumon fly and uzi fly at REC, Katghora. Similar positive influence of rail fall on pest was reported by Ogah *et al.* (2012) and Rahman *et al.* (2012). However, the correlation between the mango hopper and rain fall was reported significant and negative by Pushpalatha (2008).

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