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Studies on Larval mortality: Diseases, Pest and Predator menace in Outdoor and Indoor reared Tasar Silkworm, *Antheraea mylitta* Drury (Daba TV)

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Abstract

The rearing of Tasar silkworm, Antheraea mylitta D., conducted in outdoor conditions by the tribal people on the forest grown Terminalia arjuna trees resulted in 80-90% crop loss due to pests, predators, natural calamities and diseases. There are several predators of tasar silkworm like Ichneumon fly, Canthecona bug, reduvid bug, Hicrodulla bipapilla (Praying mantis) etc., which are natural enemies in abundance in the rearing field resulting in low yield of cocoons. During traditional rearing the Tasar silkworms are also facing four serious diseases like Virosis, Bacteriosis, Microsporidiosis and Mycosis which in turn add to heavy crop loss. In order to stabilize tasar silk production and increase income from tasar culture, tasar silkworm rearing methods need considerable improvement. In the present study, the tasar silkworms in outdoor (nylon netted) and indoor (innovative) conditions reared simultaneously is envisaged and mortality due to various causes was comparatively evaluated. The Effective Rate of Rearing (by number) has shown occasional increase in some of the crops in the three years of indoor rearing. The most significant finding of the present studies is that the loss due to pests is minimal to nil and due to rainfall is nonexistent in the indoor rearing.

Key words: Tasar silkworm, *Antheraea mylitta*, pests, predators, virosis, bacteriosis.

Introduction

Tasar culture a forest-based industry reared mostly by tribal population involves crop loss due to parasites, predators and climatic vagaries. The Tasar silkworm, *Antheraea mylitta* Drury (Daba TV) is a commercial and wild sericigenous insect, exists in nearly 17 states of our country in the form of 44 ecological populations (ecoraces) or biotypes, *viz.,* Daba (Jharkhand), Munga (Jharkhand), Modal (Orissa), Sukinda (Orissa), Bhopalpatnam (Chhattisgarh), Piprai (Madhya Pradesh), Tira (West Bengal), Bankura (West Bengal), Monga (Uttar Pradesh), Tesera (Rajasthan), Jiribam (Manipur), Raily (Chhattisgrah), Boko (Assam), Andhra (Andhra Pradesh), Sukinda, Bagai, Sarihan (Jharkhand), Medipatho (Meghalaya) and Bhandara (Maharastra) etc.[1].

The tasar silkworm, *Antheraea mylitta* Drury is a trivoltine (three crops/year) polyphagous insect feeding on a host of food plants but primarily feeding on *Terminalia arjuna, Terminalia tomentosa* and *Shorea robusta*. The secondary food plants are *Terminalia paniculata, Tectona grandis, Terminalia catappa, Shorea roxburghii, Bauhinia variegata, Lagerstroemia indica, Melostoma malabathricum, Carissa carandas, Ficus religiosa, Bombax ceiba, Dodonaea viscose and Madhuca indica etc.*[2].

The traditional rearing of *Antheraea mylitta* D., tasar silkworm on forest grown trees resulted in 80-90% crop loss due to pests, predators, natural calamities and diseases[3]. The majority of crop loss in tasar silkworm rearing is resulting due to viral disease. As the rearing is conducted completely outdoors in the forest, there is no control over the climatic conditions (temperature and humidity) and thereby the rearing of tasar silkworms are subjected to many fluctuations in the climatic conditions that often lead to viral attacks. There are several predators of tasar silkworm like *Ichneumon* fly, *Canthecona* bug, *reduvid* bug, *Hicrodulla bipapilla* (Praying mantis) *etc.*, which are natural enemies in abundance in the rearing field which cause crop loss[4].

Recently, certain biological control measures like IPM package (Integrated pest management package) against Uzi fly was developed at Central Tasar Research and Training institute, Ranchi, India, which involves implementation of mechanical, chemical (use of bleaching powder solution as ovicide) and biological (*Nosolynx thymus* which is a parasite of Uzi fly, attacking immature stages of Uzi fly) means, which resulted in 75.31% reduction and effective controlling of Uzi fly infestation in the tropical tasar silkworm[5], an appropriate rearing technology needs to be adopted in order to prevent the pest and predator hazard during tasar silkworm rearing.

Numerous insects thrive on tasar silkworm, of these *Xanthopimpla* (hymenoptera), *Blepharipa* (Diptera) are pupal and larval parasites, *Sycanus, Cantherona,* (hemiptera), *Hierodulla bipapilla* (dictyoptera), *Polistes* and *Oecophylla* (hymenoptera) are predators of different age groups of tasar silkworms. The cumulative effect of these results in 30 - 40% tasar crop loss. Diverse groups of animals like frogs, bats, birds, snakes, lizards etc and parasitic nematodes (*Hexamormis sp.*), further increase the extent of tasar larval damage. Pest

complex of tasar food plants *T. arjuna* and *T. tomentosa* include *Coleoptera* and *Chrysomelids* which are chlorophyll suckers and root destroyers. Lepidopteran caterpillars are the major defoliaters. There are also certain gall-forming insects (*Trioza fletcheri*). These pests can be controlled to some extent by using pesticides like carbamates *etc*. [6].

Electron microscopic studies of posterior silk gland of Tasar silkworm, *Antheraea mylitta* Drury revealed that the presence of bacteria, nuclear polyhydrosis and spores in the cells cause significant reduction in total protein concentration when compared to that of healthy larvae. However, no significant changes were found in larvae suffering with microsporidiosis[7].

In order to stabilize tasar silk production and increase income from tasar culture, tasar silkworm rearing methods need considerable improvement, as outdoor rearing of wild silkworm exposes the larvae to the vagaries of climatic conditions and also make them more vulnerable to pests and diseases. Young age (chawki) silkworms suffer extensive damage to predators as cited above. A surer way of preventing silkworm crop loss is to conduct indoor rearing of the wild/ forest grown silkworm. Earlier, many endeavours were made to conduct indoor rearing of tasar silkworm but did not yield the desired result. Akai *et al.,* [8] in National Institution of Sericultural and Entomological Sciences, Japan have developed some artificial diet for tropical tasar silkworm comprising asan leaf powder, the principal food plant of that particular race and has achieved success to some extent.

Several workers made efforts towards chawki rearing (rearing of first III instars) to prevent the loss of early age of tasar silkworms[9-12]. Domestication of silkworm *i.e.,* the *indoor rearing technique* at the laboratory level has already been successful and is been adopted by many scientists to carry out their research works on nutritional ecology[13-15]. Certain works have also demonstrated that silkmoths can be bred successfully under confinement and the tasar caterpillars can be successfully reared indoor, for years, on standardized methodology[16,17].

A recent attempt on total indoor rearing of *Antheraea mylitta* Drury (Andhra local ecorace) has revealed a decrease in loss of worms under total indoor conditions and also a considerable increase in crop yield has been observed[18].

Material and Methods

The rearing of Tasar silkworm, *A. mylitta* D., is conducted a in the indoor and outdoor conditions in Sericulture Lab and *T.arjuna* plantation respectively, located in K.U. campus during three seasons per year for three years by taking 400 young worms (except 1st year crop I(200) and crop II (300) worms) in each and calculated accordingly.

Outdoor rearing method: The outdoor method of rearing was conducted in the *Terminalia arjuna* (arjun) plantation, raised at Sericulture Unit, Kakatiya University, which was well maintained at pruned at regular intervals. The selected trees were covered by nylon net to protect from attacking predators. The brushing of newly hatched silkworms were shifted on to the tender twigs of *T.arjuna* plants with the help of paint brush/feather. They were left undisturbed until the most of the leaves were consumed by feeding caterpillars and later shifted to new host plant Measures were taken for the prevention of entry of red ants etc., by painting grease on the tree trunk and bleaching powder around the surroundings (figure 1a).

Indoor rearing method: The indoor rearing of *Antheraea mylitta* was done in the lab from hatching to cocoon formation on the cut branches of *Terminalia arjuna* leaf[19]. During the rearing period fresh and selected twigs (tender leaves for I and II instar caterpillars; semi-mature leaves for III and IV instar and mature leaves for V instar) of *T. arjuna* plant were fed to the tasar silkworm caterpillars.

Indoor rearing set-up consisted of earthen-pots or conical flasks or wide-mouth bottles rather, any water containers which can ensure constant water supply to the inserted branches for the foraging silkworms. The mouth of the conical flask or bottle was plugged with cotton to protect larvae from drowning and also to check any increase in humidity due to evaporation of water. The average number of worms on twigs of conical flask for I, II, III, IV and V instars were 100, 75, 50, 25 and 15 respectively. A paraffin paper was used to gather the faecal pellets and to maintain cleanliness and healthy environment in the rearing set[7]. This rearing set-up was surrounded by *vetifera* curtains to maintain more relative humidity in the indoor rearing environment[18,20] for the late age-worms (figure. 1b).

During the rearing period, care was taken to remove the dead and diseased silkworms, and bury them away from the rearing area. Based on the symptoms of the diseases and damage caused by the pests and predators, (figure 2 and 3, table 1) The mortality chart was prepared accordingly.

Bacteriosis: The Bacteriosis exhibits three typical symptoms *viz*., sealing of anal lips, chain type excreta and rectal protrusion. The anal lips were closed by sticky semi fluid excreta and larvae shrink lengthwise[21]. In chain type excreta the faecal beads were excreted out as jelly like substance in the form of chain and hangs. The rectum protrudes out of the anal opening in the form of transparent bag filled with haemolymph[22] (figure 2A (i, ii, iii)).

Virosis: The polyhedrosis virus infects the larvae which turn pale and sluggish and legs lose their hold from the host twig except claspers, with help of which it hangs its head downwards after death. As a result of infection there was complete disintegration of tissue. It is caused by polyhedral inclusion bodies (PIB) virus. Integument turns opaque and brownish and skin becomes fragile and blackish. Degenerated tissues ooze out from its mouth in the form of dark brownish fluid which gives obnoxious odour (figure 2B (i))

Figure1a
The outdoor rearing and 1b The indoor rearing set-up of tasar silkworm, *Antheraea mylitta* D (Daba TV)

Microsporidiosis: It caused by protozoan parasite *Nosema milittensis*[23]. In the infected larvae the black spots appear all over the integument (figure 2B(ii)). The infected larvae are so affected that they are irregular in moulting and their growth is jeopardized. Larvae infected with *Nosema* sp. show extended development period, reduced size and larval weight in comparison to uninfected ones[24].

Mycosis: It is caused by fungi *Penicillium citriinum*. Larval body becomes hard and bends dorsally. Body covered with white powdery spores of fungus and gets laterally compressed, dry, hard and mummified[25] (figure 2B (iii)).

Results and Discussion

The Mortality by parasites, pests and rain fall of tasar silkworm, *Antheraea mylitta* Drury (Daba TV) during three years of outdoor and indoor rearing of are presented in the table 2, 3 and 4.

During the first year, in crop I, loss in outdoor rearing due to bacterial viral, Fungal, Pebrine, Pests, rainfall, and loss due to shifting, were (18), (23), (3), (Nil), (17), (12) and (15) respectively (total loss of 44%), while that in indoor rearing were (15), (19), (6), (nil), (2), (nil) and (18) respectively (total loss 30%); in the crop II, mortality were (28), (42), (5), (6), (18), (10) and (30) respectively, (total loss of 46%) loss), while in indoor rearing loss of worms were (13), (34), (6), (5), (nil), (nil), (35) respectively (total loss of 31%); in the crop III, loss of worms in outdoor rearing were (34), (51), (16), (nil), (24), (27) and (35) respectively (total loss of 46.75%), while that in the indoor rearing were (20), (42), (5), (nil), (2), (nil) and (41) respectively (Percent loss 27.25%).

During the second year, in crop I, loss in outdoor rearing due to bacterial viral, Fungal, Pebrine, Pests, rainfall, and loss due to shifting , were (36), (50), (6), (Nil), (41), (28) and (30) respectively (total loss of 50.25%), while that in indoor rearing were (44), (47), (8), (nil), (3), (nil) and (55) respectively (total loss 39.5%); in the crop II, mortality were (32), (51), (5), (nil), (25), (21) and (35) respectively, (total loss of 44.25%) loss), while in indoor rearing loss of worms were (35), (43), (nil), (nil), (8), (nil), (42) respectively (total loss of 32%); in the crop III, loss of worms in outdoor rearing were (36), (47), (2), (nil), (25), (19) and (26) respectively (total loss of 38. 75%), while that in the indoor rearing were (20), (35), (10), (nil), (7), (nil) and (37) respectively (Percent loss 27.25%).

During the third year, in crop I, loss in outdoor rearing due to bacterial viral, Fungal, Pebrine, Pests, rainfall, and loss due to shifting , were (38), (43), (9), (Nil), (37), (20) and (23) respectively (total loss of 42.5%), while that in indoor rearing were (28), (38), (12), (nil), (3), (nil) and (37) respectively (total loss 29.5%); in the crop II, mortality were (35), (42), (5), (6), (31), (10) and (30) respectively, (total loss of 38.25%) loss), while in indoor rearing loss of worms were (35), (43), (nil), (nil), (8), (nil), (42) respectively (total loss of 38.25%); in the crop III, loss of worms in outdoor rearing were (34), (51), (6), (nil), (18), (17) and (25) respectively (total loss of 32. 25%), while that in the indoor rearing were (30), (30), (5), (nil), (2), (nil) and (31) respectively (Percent loss 24.25%).

The statistical data on disease incidence in the present investigation in the three crops / year for three consecutive years indicates that loss due to bacterial and viral disease in outdoor rearing is much higher than that in indoor rearing, while a marginal increase in fungal diseases is observed in indoor rearing conditions than that of outdoor rearing. The effect of sporadic incidence of pebrine was more or less same in both the rearing conditions. Owing to loss of worms in outdoor conditions due to rainfall and pests (which was not seen in indoor conditions) there was depletion in total percent loss in outdoor conditions. However, The Effective Rate of Rearing (by number) has shown occasional increase in some of the crops in the three years of indoor rearing.

Table 1
The common Pests and predators which damage the Tasar silkworm, *Antheraea mylitta* D (Daba TV)

Common Name (Scientific Name)	Period of Occurrence	Morphological Characters	Nature of the damage
A. Parasites 1. Uzi fly (*Blepharipa zebina*)	Sep-Dec	Adult flies are grayish in colour. Size 12-14mm, Number of eggs laid by a female fly is 250-300.	The flies lay eggs on the body of larvae; the eggs hatch and the young maggots bore through the skin into the body of the larvae leaving a black scar on it and derive its food from internal tissues of the larvae.
2. Ichneumon fly (*Xanthopim*)	July-Aug. Oct-Dec.	Adult fly is bright yellow in colour with a number of black bands and there is a black spot on each sternum located dorso ventrally. Length of the adult about 2cm with 1cm long ovipositor in female	The female pierces its ovipositor in to the body of the larva through newly formed cocoon shell and lay eggs. The young ones after hatching consume the tissues and pupate inside, metamorphoses into adult fly and comes out by piercing the cocoon shell.
B. Pest and Predators a. Stink bug *(Canthecona furcellata)*	June-Jan	It is pentatomid bug. Adult bug is brownish in colour. Body is brownish in colour. Body is triangular. Adult is about 15 mm in length.	Both young and adult suck the blood of the larvae leading to its death.
b. Praying mantis (*Hirodula bipapilla)*	Throughout the year	Adult is green in colour and is about 5-8 cm in length. It has powerful raptorial forelegs in which tibia works in opposition to the femur works in opposition to the femur like the blades of a scissors and both are partially spined.	Both nymph and adult eat the larvae.
c. Reduvid bug (*Sycanus collaris*)	Aug-Oct	Adult bug is black and is about 2.5cm long. Head is long conical and mouth parts are modified into along prominent proboscis which lies in a cross striated groove between front coxae during rest.	Both nymph and adult suck the haemolymph of the larvae.
d. Common wasp (*Vespa oriantalis*)	July-Nov	Abdomen has yellow and dark brown bands. It has poisonous string and clubbed antennae. The wings are longitudinally folded during rest	Feed on the larvae.

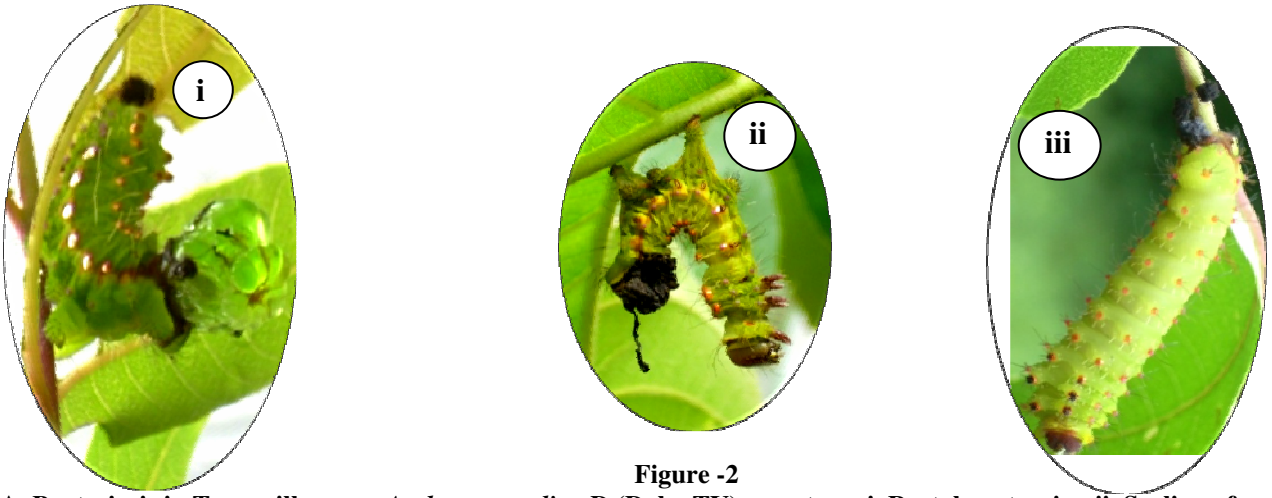

Figure -2
A. Bacteriosis in Tasar silkworm, *Antheraea mylitta* D (Daba TV) symptoms i. Rectal protrusion ii. Sealing of anal lips iii. Chain type excreta

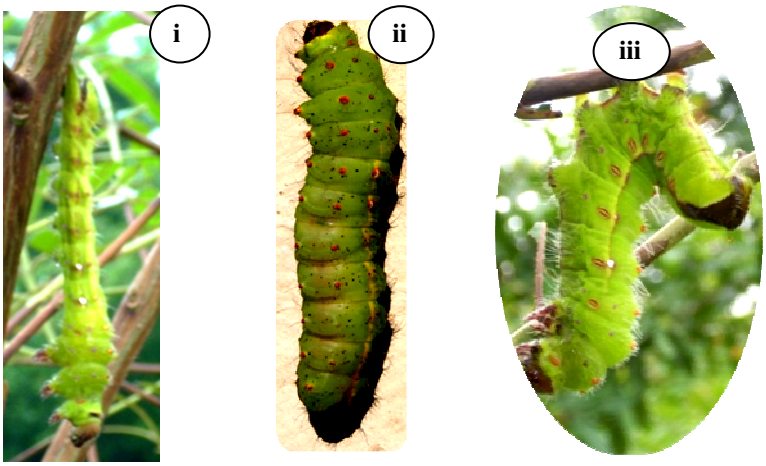

Figure-2B
i. Virosis ii. Microsporiodisis and iii. Mycosis infecting Tasar silkworm, *Antheraea mylitta* D (Daba TV)

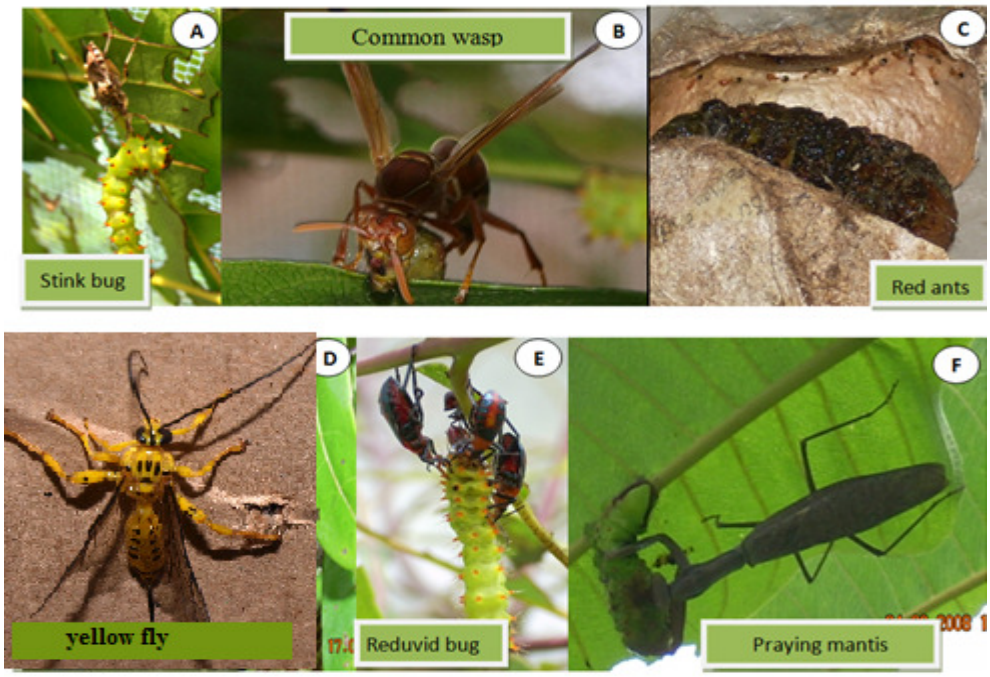

Figure-3
Tasar silkworm, *Antheraea mylitta* Drury (Daba TV) pests and predators A. Stink Bug, B. Common wasp, C. Red ants, D. Yellow fly E. Reduvid Bug, F. Praying mantis

Table-2
Mortality by parasites, pests and rain fall of tasar silkworm, Antheraea mylitta Drury,(Daba TV) during three crops of 2008

Crop	Type of loss Rearing	Bacterial	Viral	Fungal	Pebrine	Pests	Rain fall	Loss due to shifting	Total loss	% Loss
1	Outdoor	18	23	3	-	17	12	15	88	44.0
	Indoor	15	19	6	-	2	-	18	60	30.0
2	Outdoor	28	42	5	6	18	10	30	139	46.3
	Indoor	13	34	6	5	-	-	35	93	31.0
3	Outdoor	34	51	16	-	24	27	35	187	46.75
	Indoor	20	42	5	-	2	-	41	110	27.5

Table-3
Mortality by parasites, pests and rain fall of tasar silkworm, Antheraea mylitta Drury, (Daba TV) during three crops of 2009

Crop	Type of loss Rearing	Bacterial	Viral	Fungal	Pebrine	Pests	Rain fall	Loss due to shifting	Total loss	% Loss
1	Outdoor	36	50	6	-	41	28	30	201	50.25
	Indoor	44	47	8	-	3	-	55	158	39.5
2	Outdoor	32	51	5	-	25	21	35	169	42.25
	Indoor	35	43	-	-	8	-	42	128	32.0
3	Outdoor	36	47	2	-	25	19	26	155	38.75
	Indoor	20	35	10	-	7	-	37	109	27.25

Table-4
Mortality by parasites, pests and rain fall of tasar silkworm, Antheraea mylitta Drury, (Daba TV) during three crops of 2010

Crop	Rearing	Bacterial	Viral	Fungal	Pebrine	Pests	Rain fall	Loss due to shifting	Total loss	% Loss
1	Outdoor	38	43	9	-	37	20	23	170	42.5
	Indoor	28	38	12	-	3	-	37	118	29.5
2	Outdoor	35	42	5	6	31	10	30	153	38.25
	Indoor	26	34	6	5	2	-	40	117	29.25
3	Outdoor	34	41	6	-	18	17	25	141	32.25
	Indoor	30	30	5	-	2	-	31	98	24.5

Mahobia and Yadav[26] in order to identify specific reasons for low productivity of *Antheraea mylitta*, Tasar silkworm rearing, conducted a survey on Daba ecorace at Bastar Plateau of Chattisgarh during 2003-04, based on the data indicated that the 15.01% of bacterial incidence followed by 12.08% of virosis, 10.58% of Pebrine and the other accounted for 7.07% at larval, moth and cocoon levels. Due to these effects 28.27% of ERR in 1st crop decreased. 11.46% recorded as 17.11% of ERR in 2nd crop suggested that application of integrated packages which includes usage of nylon net for Chawki rearing, leaf surface microbes, Resham Jyothi enhanced the cocoon yield by 25-40%.

In the present studies, the loss of worms due to *pests* is minimal to nil in the indoor rearing, owing to the measures taken for prevention of pests and predators while it is alarmingly greater in the outdoor rearing condition, which is constantly exposed to the natural enemies. In the present studies, a number of pests like stink bug, common wasp, reduvid bug and praying mantis were amongst the common pests of tasar silkworm larvae. The outdoor cocoons were generally attacked by red ants, which suggests for effective disinfectant measures.

The *Xanthopimpla* predator commonly known as yellow fly or ichneumon fly is one of the major endoparasite of tasar silkworm, currently, 10-20% tasar seed cocoons produced in the country are being affected by yellow fly. Its control measures include trapping them manually and killing the adults in the rearing field as well as seed cocoon preservation halls by gum sticks[27].

In view of frequent crop losses in tropical areas due to aggravated silkworm diseases coupled with unfavourable weather conditions, notwithstanding the disinfection measures adopted, the present study gives a promising future for indoor rearing of the wild silkworm, now being semi-domesticated, towards the fulfillment of many sericologists, who are still making concerted efforts towards complete domestication of this wild silkworm. An important observation from this study is a decreased incidence of bacterial and viral diseases and no loss of worms due to rainfall and pests in indoor rearing method. It is also corroborated by the view that a genotype with disease resistance always has much more chance to survive[28].

The disease incidence in the present investigation for three consecutive years indicates that loss due to bacterial and viral disease is much higher in outdoor conditions. Owing to loss of worms in outdoor conditions due to rainfall and pests (which was not seen in indoor conditions) there was depletion in total percent loss in outdoor conditions. However, The Effective Rate of Rearing (by number) has shown occasional increase in some of the crops in the three years of indoor rearing. *The most significant finding of the present studies is that, loss due to pests is minimal to nil and due to rainfall is altogether absent in the indoor rearing method.* The percent *loss of worms due to shifting* in the field of outdoor rearing is also found to be lesser than that of indoor rearing conditions.

Moreover, the indoor rearing method adopted in the present study which has shown significant reduction of crop loss due to diseases, pests and predators, also opens avenue for further improvement in the technique by way of optimizing temperature and relative humidity and significantly increase the crop yield.

Conclusion

It can be concluded that the total indoor rearing of Tasar silkworm, *Antheraea mylitta* D, has resulted in low mortality that could be caused by pests and predators and improved indoor rearing method can be adopted to enhance crop yield and stabilize tasar silk production.

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