# Parasites–predators: their occurrence and invasive impact on the tropical tasar silkworm *Antheraea mylitta* (Drury) in the zone of central India

**Ganesh B. Gathalkar*,† and Deepak D. Barsagade†**

Department of Zoology, MJF Educational Campus, RTM Nagpur University, Nagpur 440 033, India

**Tasar silk is produced by the wild silkworm *Antheraea mylitta* (Drury) (Lepidoptera: Saturniidae). Owing to its inherent wild nature, the silkworm is exposed to a complex of parasites, predators and diseases that reduce the total silk production. Occurrence and invasion by three parasites and nine predators of *A. mylitta* are studied here. Moreover, on the basis of their attack and symptoms of parasitism and/or predation, percentage of crop loss (mortality) of *A. mylitta* is calculated. The parasites including *Xanthopimpla pedator* (Fabricius) (Hymenoptera: Ichneumonidae) were observed as a major pupal endoparasitoid of *A. mylitta*, which affects about 7–12% of tasar cocoon. In addition, the beetle *Dermestes ater* (De Geer) (Coleoptera: Dermestidae) also affects the pupa/cocoon of *A. mylitta*, while the Tachnid fly, *Blepharipa* sp., recognized as a larval-pupal parasite of the silkworm, cause about 1–2% and 2–3% of tasar crop loss respectively. Consequently, among the predators, *Canthecona furcellata* (Wolff) (Pentatomidae: Hemiptera), was observed as a major predator of *A. mylitta* that causes about 6–11% of tasar larval mortality. However, 2–3% and 3–4% of crop mortality occurs due to predation by *Hierodula bipapilla* (Serville) (Mantidae: Dictyoptera) and *Vespa orientalis* (Linnaeus) (Vespidae: Hymenoptera) respectively. The predatory ants *Oecophylla smaragdina* (Fabricius) (Formicidae: Hymenoptera) and *Myrmicaria brunnea* (Saunders) (Formicidae: Hymenoptera) also contribute to crop reduction by 4–5% and 3–5% respectively. Similarly, non-insect predators such as birds, lizards, squirrels, rats, etc. also affect the silkworm, which further reduces tasar silk production. Therefore, a survey was undertaken in the tasar rearing fields of Vidarbha, Maharashtra, India and the occurrence of the parasites and predators was studied.**

**Keywords:** *Antheraea mylitta*, mortality, parasites, predators, tasar silk.

THE sericigenous insect, *Antheraea mylitta* Drury (Lepidoptera: Saturniidae) produces a variety of 'wild tasar silk', commonly known as 'Kosa silk'[1]. It primarily feeds on *Terminalia tomentosa* (Roxb. Wight. & Arn.), *T. arjuna* (Roxb. Wight. & Arn.) besides several other secondary food plants such as *Ziziphus jujuba* (Mill). and *Ziziphus mauritiana* (Lam.) (Ber), etc. It is distributed in tropical deciduous forests of West Bengal, Jharkhand, Bihar, Odisha, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and Maharashtra in India. There are 44 eco-races of *A. mylitta* distributed throughout India and one of the eco-races, 'Bhandara' is reared in central India (21°8′58.6140″N, 79°4′50.7468″E) with varied phenotypic, physiological and behavioural characters[2–4]. At present, tropical tasar silkworm, *A. mylitta*, has attained a unique status as an important cash crop for the tribes living in villages of central India.

However, in the wild, the larvae are exposed to diverse meteorological conditions such as temperature, humidity and rainfall. These variations make the larvae vulnerable to microbial diseases such as bacterial (*Flacherie*), viral (*Grasserie*), fungal (Microsporidiosis) and protozoan (Pebrine)[5–7]. Similarly, parasites and predators also affect the silkworm, *A. mylitta*, resulting in heavy loss of silk production[8–12]. The protection of silkworm from various pests is a chronic problem in sericulture[10]. Due to the attack of a number of insects as well as non-insect pests, the tropical tasar silkworm *A. mylitta*, is being affected[8–10,13]. Thus, the prospects of tasar culture in India depends on the condition of pest population[14,15]. These major and minor threats of silk industry cause heavy loss to the total silk production of India resulting in loss for Indian economy.

Therefore, a survey was undertaken in the Vidarbha region of Maharashtra, India to study the occurrence of parasites and predators of tropical tasar silkworm *A. mylitta*. The damage caused by both the parasites and predators was studied and mortality of tasar silkworm *A. mylitta* in central zone of India was calculated.

## Materials and methods

### *Insect resources*

The tasar silkworm *A. mylitta* (Figure 1 *a–l*) is the principal non-mulberry silk producing insect in the tropical

*For correspondence. (e-mail: ggathalkar@gmail.com)
†Authors contributed equally to this work.

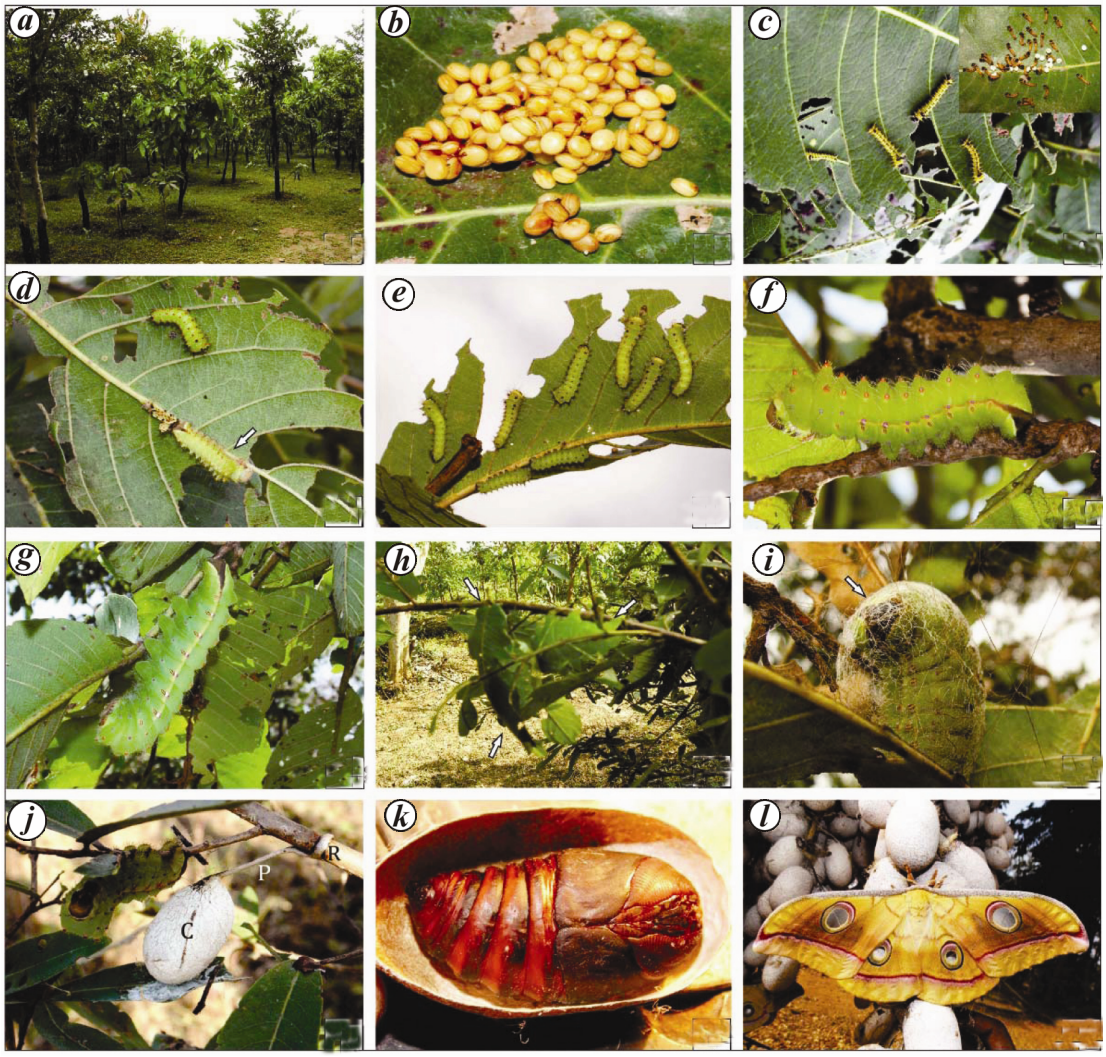


**Figure 1.** Rearing of tropical tasar silkworm *A. mylitta* (D) showing: ***a***, Host plant (*T. tomentosa* and *T. arjuna*) of *A. mylitta*; ***b***, Eggs of *A. mylitta*; ***c***, First instar larvae (in inset) just hatched first instar larvae; ***d***, Second instar larvae, arrow showing newly molted larva; ***e***, Third instar; ***f***, Fourth instar larva; ***g***, Fifth instar; ***h***, Hammock formation by the spinning larva; ***i***, Spinning larva; ***j***, Matured cocoon; ***k***, Pupa inside the cocoon and ***l***, Female moth. Abbr.: C, Cocoon, P, Peduncle and R, Ring.

forest of Bhandara, Chandrapur, Gadchiroli and Gondia districts of Vidarbha region in Maharashtra. There are three crops, viz. Crop I, Crop II and Crop III in the months of June–August, August–October and October–January respectively. The collected samples of parasites and predators were preserved in 70% alcohol while some specimens with the host *A. mylitta* (larvae–adult) were brought to the laboratory and reared for further studies.

### *Study sites and field observations*

A survey was conducted in the natural forest and the tasar-rearing sites of Bhandara (lat. 21.059972, long. 79.686987; coordinates 21°3′35.8992″N, 79°41′ 13.1532″E) along with its neighbouring districts, viz. Chandrapur, Gadchiroli and Gondia in Vidarbha region. Observations were made regularly during each crop from 2010 to 2013. Visual observations were made on host–parasite and host–predator interactions and photographed.

The meteorological parameters, viz. temperature, relative humidity and rainfall were recorded to highlight the environmental conditions prevalent in the study sites during the period of study. The average temperature ranged between 35.5 ± 0.3°C and 38.4 ± 0.2°C during the first crop (June–August); 31.8 ± 0.2°C and 33.4 ± 0.3°C during the second crop (August–November) and 17.4 ± 0.4°C and 21.2 ± 0.3°C during the third crop (November–February) while the relative humidity was 87.2 ± 0.2%, 90.8 ± 0.6% and 77.2 ± 0.6% during the first, second and third crops respectively. Similarly, the mean rainfall was 361.6 ± 0.9 mm, 195.8 ± 0.6 mm and 39 ± 0.5 mm during the first, second and to third periods of crop production respectively.

### *Identification of pests of A. mylitta*

Identification of parasites and predators were carried out on the basis of morphological characteristics of collected specimens in the Department of Zoology, RTM Nagpur University, Nagpur, and also confirmed with the help of Network Project on Insect Biosystematics (NPIB) and the Indian Agricultural Research Institute (IARI), New Delhi.

### *Statistical analysis*

All the stages of *A. mylitta* including feeding and post-feeding (first instar to spinning) were observed. On the basis of attack, symptoms of parasitism and/or predation and larval as well as pupal death, percentage of larval mortality during and/or after the attack by parasites/predators was calculated. The attack by *Xanthopimpla pedator* was calculated on the basis of damaged cocoons, out of the total cocoons harvested after each grainage. The data for the larval attack was analysed in randomized block design, where 12 DFLs (disease-free egg laying, 1 DFL = 200 eggs approx.) of *A. mylitta* were reared in each of the three crops per year. The variables (stage-wise and year-wise mortality/crop damage) of the study was calculated by ANOVA – two-way analysis used SPSS 19 software package (SAS, Carey, NC, USA). The null ($H_0$) and alternate ($H_a$) hypotheses were analysed to assume mortality at ($P < 0.05$) significance level, to compare the mortality percentage at each stage of *A. mylitta* by the parasites and predators, for the 3 years of experimental study.

## Results

### *Occurrences of pests on A. mylitta*

On the basis of feeding behaviour and damage caused by parasites and/or predators to *A. mylitta*, the larval and pupal parasites include the Tachinid flies *Blepharipa* sp., the yellow fly, *Xanthopimpla pedator*, and the dermestid beetle, *Dermestes ater*. Predators such as *Canthecona furcellata*, *Hierodula bipapilla*, *Vespa orientalis*, *Oecophylla smaragdina* and *Myrmicaria brunnea* were observed. In addition, predation by birds, lizard, squirrel, and rat was also recorded. The occurrence of these parasites and predators fluctuates considerably during each crop, depending on the habitat and climatic conditions, for e.g. rainy, winter and summer seasons (Table 1).

### *Xanthopimpla pedator*

An Ichneumonid, *Xanthopimpla pedator* is a major pupal endoparasitoid of tasar silkworm commonly known as 'Yellow fly' (Figure 1 *a*–*c*). The adult female yellow fly searches out a suitable tasar prepupa/pupa as a host after palpating its antenna on the host cocoon. It pierces the cocoon with its 1 cm long ovipositor and lays a single egg on the developing pre-pupa/pupa of *A. mylitta*. Usually, the parasitoid prefers matured and healthy pupa (Figure 2 *b*) as a suitable host and it rarely prefers cocoons that have not yet developed into a pupa. Also, sunny days are preferred for egg laying and maximum infestation was noted during 12.30 pm to 5.00 pm, while its hovering activity completely disappeared at about 6.00 pm. It completes its life cycle in about 20–22 days by devouring the body content of the host pupa. Pupation takes place inside the host pupa and the adult emerges by rupturing the anterior end of dead pupa and peduncle end of the cocoon by cutting with help of its strong mandibles.

### *Tachinid fly (Uzi fly)*

The Uzi fly, *Blepharipa* sp. is a larval endoparasite of tasar silkworm. *Sarcophaga* sp. is also predominant in tasar-rearing fields. The gravid Tachnid female lays eggs on silkworm larvae from third instar onwards. The newly hatched maggot penetrates into the body of tasar silkworm and feeds on haemolymph. It undergoes three instars inside the host, and the mature maggots come out by making a hole on the host shell and pupate outside (Figure 1 *d*–*f*).

### *Dermestid beetle*

The attack of dermestid beetle, *Dermestes ater* recognized as pierced cocoons, was studied on the stored tasar cocoons of *A. mylitta* (Figure 1 *g*–*i*), in the field or in grainage house or storage rooms. Both the grubs and adults feed on the pupa resulting in damaged and seedless cocoons. The female beetles lay eggs in the floss of cocoons. Due to its attack, the pupae are damaged subsequently affecting their quality.

### *Canthecona furcellata*

The carnivorous stink bug *C. furcellata* (Hemiptera: Pentatomidae) is a harmful predator on *A. mylitta*. Both the nymphs and adults attack the early stages of tasar silkworm (usually first to third instar), with the rate of predation being high during moulting. The rostrum or proboscis is pierced into the larval integument and haemolymph is sucked from the host larva (Figure 2 *a*, *b*). Sometimes, the bugs suck the haemolymph from the spinning larva through the moist and thin network of silk thread of cocoon (Figure 2 *c*).

**Table 1.** Occurrence and attack of parasites and predators on tropical tasar silkworm *A. mylitta* (D) and physical parameters of the tasar-rearing field during 2010–11, 2011–12 and 2012–13

| Year | 2010–2011: (Crop-I, II and III)<br>2011–2012: (Crop-I, II and III)<br>2012–2013: (Crop-I, II and III) | Stages of Silkworm<br>Total duration range (day) of life stages of *A. mylitta* in all crops<br>Larval stages 30–35 (D) | | | | | 5–7 (D) | 7–8 (D) | 10–15 (D) | 10–12 (D) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parasites/ predators | Season | I instar | II instar | III instar | IV instar | V instar | Spinning | Cocoon (Pupa) | Emergence | Adult | Damage (%) |
| Parasite | | | | | | | | | | | |
| *X. predator* | July–February | – | – | – | – | – | – | +++ | – | – | 7–12 |
| *Blepharipa* sp. | October–November | – | – | + | ++ | +++ | – | – | – | – | 2–3 |
| *D. ater* | June–January | – | – | – | – | – | + | – | | | 1–2 |
| Predators | | | | | | | | | | | |
| *C. furcellata* | June–December | +++ | +++ | +++ | + | + | + | – | – | – | 6–11 |
| *H. bipapilla* | July–October | | + | +++ | +++ | + | – | – | – | + | 3–4 |
| *V. orientalis* | June–January | ++ | +++ | +++ | + | – | – | – | – | – | 3–4 |
| *O. smaragdina* | June–January | +++ | +++ | +++ | ++ | + | – | – | – | – | 4–5 |
| *M. brunnea* | June–January | +++ | +++ | +++ | ++ | + | – | – | – | – | 3–5 |
| Lizard | Throughout year | + | + | + | + | + | + | + | – | – | – |
| Bird | Throughout year | + | + | + | + | + | + | – | – | – | – |
| Squirrel | Throughout year | – | – | – | + | + | + | +++ | + | + | – |
| Rat | Throughout year | – | – | – | – | – | – | ++ | – | + | – |

+++, More attack; ++, Moderate attack; +, Less attack; –No attack; D, No. of days.

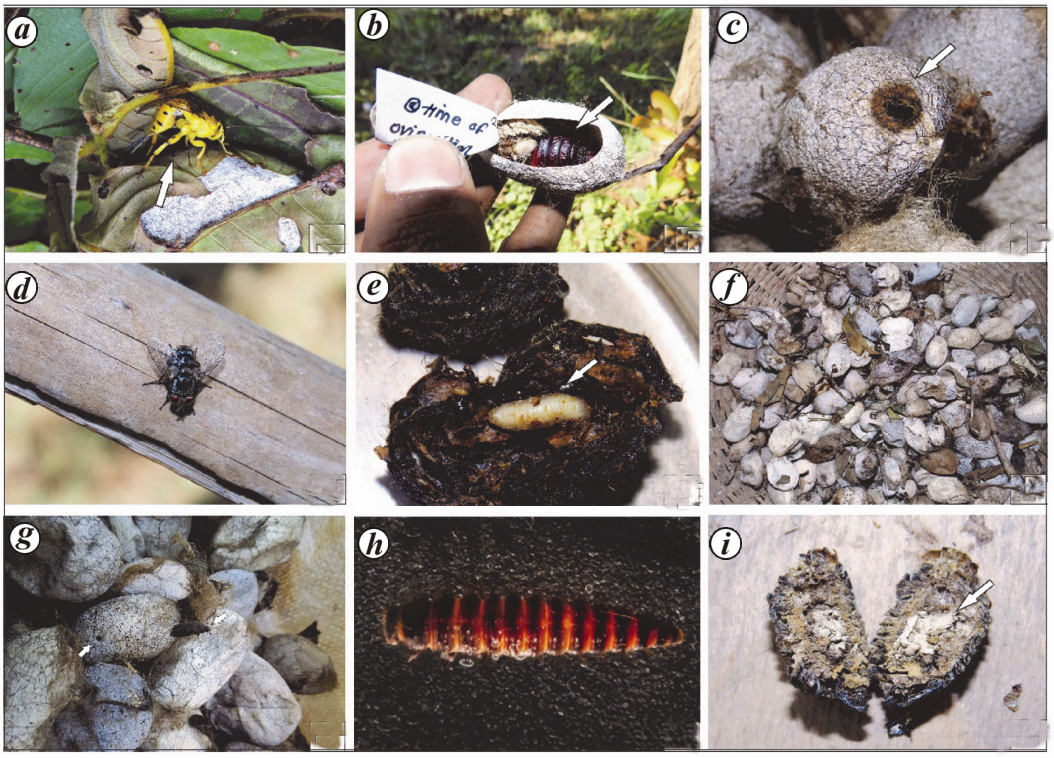


**Figure 2.** Parasites of *A. mylitta* (D) showing: ***a–c***, Parasitism by yellow fly, *X. predator* – ***a***, Pupal infestation; ***b***, Mature pupa of *A. mylitta* during oviposition; ***c***, Damaged cocoon; ***d–f***, Parasitism by Tachinid fly – ***d***, *Blepharipa* sp., ***e***, Maggot; ***f***, Damaged cocoon; ***g–i***, Parasitism by dermestid beetle – ***g***, *D. ater*; ***h***, Larva of *D. ater*; ***i***, Damaged pupa.

## *Hierodula bipapilla*

The praying mantis, *H. bipapilla* is also a serious predator of *A. mylitta*. It is recognized by its foreleg which is modified into a raptorial type and elongated thorax. It has a small triangular head on a slender body with well-developed wings. The forelegs are specially adopted for catching their prey (Figure 2 *d–e*). *H. bipapilla* is active in all the seasons and causes damage during all three crops. Both the nymphs and adults preferably feed on

early instar larvae of *A. mylitta*. The female deposits its eggs in a definite pattern which are glued together into an egg mass, called 'ootheca' on the host plants. The emerging nymphs and adults are predacious at all times and the adult attacks third and fourth instar larvae and sometimes it also attacks adult moths (Figure 2 *f*).

### *Vespa orientalis*

The common wasp, *V. orientalis* is a serious predator of *A. mylitta*, preferably attacking the early larval instars of silkworm (Figure 3 *f*). The mouth parts of the wasp are of biting and chewing type and it has strong mandibles to catch the prey, generally first to third instar larvae of *A. mylitta*. After catching the host larvae, it cuts the larvae and starts feeding on them. The wasp, *V. orientalis* is predacious in each crop throughout the year. It is a medium sized reddish or brown coloured wasp with yellow bands on a slender, elongated spindle shaped abdomen. They construct nests on the ground, with the help of mud, plant traces along with saliva and sometimes in the crevices of tree trunks, including tasar host plants (e.g. *T. tomentosa* and *T. arjuna*). These are social insects with the queen, worker and drone. The queen looks after the young ones which feed on small larvae including early instars of *A. mylitta*, brought by worker wasps.

### *Oecophylla smaragdina*

The aggressive, omnivorous weaver ant, *O. smaragdina* makes large nests on the host plants of *A. mylitta*, i.e. *Terminalia* species. It is a very common forager attacking the larval stages of tasar silkworm from first to third instars (Figure 4 *a–c*) and sometimes it attacks fourth and fifth instar larvae as well. The life cycle of *O. smaragdina* passes through egg, larva, pupa and adult and the nest contains workers, queen and drones. The workers are very aggressive and attack the early instars, especially from first to third instar *A. mylitta*. The workers cut the larvae into pieces by their strong mandibles and the pieces are carried to their nest. During feeding, the workers release an irritating secretion through the mandibular glands. The sting apparatus is absent and, therefore, it does not sting, but it releases formic acid from the last abdominal segment causing irritation to the larval skin. They attack in groups and within a minute, they kill early larval stages of *A. mylitta*.

### *Myrmicaria brunnea*

*M. brunnea* belonging to the sub-family Myrmicinae has a distinctive curved abdomen and two spines on the metathorax. Workers are chestnut brown in colour with shining mandibles. The worker ants attack the host tasar larvae in groups (Figure 4 *d–f*). Initially, the host larvae are captured by few workers and subsequently pricked. After that, the other workers nearby attack the larva on all sides. Predatory workers are highly aggressive and cut the prey into small pieces which are later on transported to their ground nest or sometimes the whole prey also transported to the nest (Figure 4 *f*).

### *Monomorium sp.*

These are small ants, reddish-brown in colour belonging to the order – Hymenoptera, family – Formicidae. The workers attack the first to third instar larvae of *A. mylitta* and in addition, they also enter the cocoon by making small holes and feed on the pupa (Figure 4 *g–i*).

### *Birds*

Birds are very common in tasar fields and often cause larval mortality. The birds, viz. crow, *Rufous treepie* (*Dendrocitta vagabunda*) and common hawk cuckoo (*Cuculus varius*) (Figure 5 *a*, *b*) feed on the larvae of *A. mylitta*. These birds prefer to attack third to fourth stage larva, while, sometimes they also attack on fifth instar.

### *Garden lizard*

Garden lizard (*Callotes versicollar*) is a diurnal reptilian, also observed in the fields of tasar silkworm on tasar host plants (i.e. *Terminalia*) and it feeds on the early stage larvae of *A. mylitta.*

### *Mammalian predators*

Some of the mammalian predators such as squirrels and rats create serious problems in tasar sericulture. The attack by squirrels is also serious during field rearing; they attack mature hanging cocoons on tasar host trees and cause damage to the cocoons by cutting the cocoon shell (Figure 5 *c*). Rat (*Rattus rattus*) attacks are very common in grainage house where the cocoons are damaged (Figure 5 *d*).

### *Infestation and mortality percentage of tropical tasar silkworm*

Occurrence and infestation of parasites and predators of tropical tasar silkworm were studied in the natural tasar-rearing fields. The mean mortality percentage (including larval, pupal and adult) of *A. mylitta* by the parasites and predators were calculated on the basis of observations taken from 2010 to 2013. Pupal mortality in *A. mylitta* by *X. pedator* was about 7%, 9% and 12% during the 1st, 2nd and 3rd crops respectively. The larval mortality by

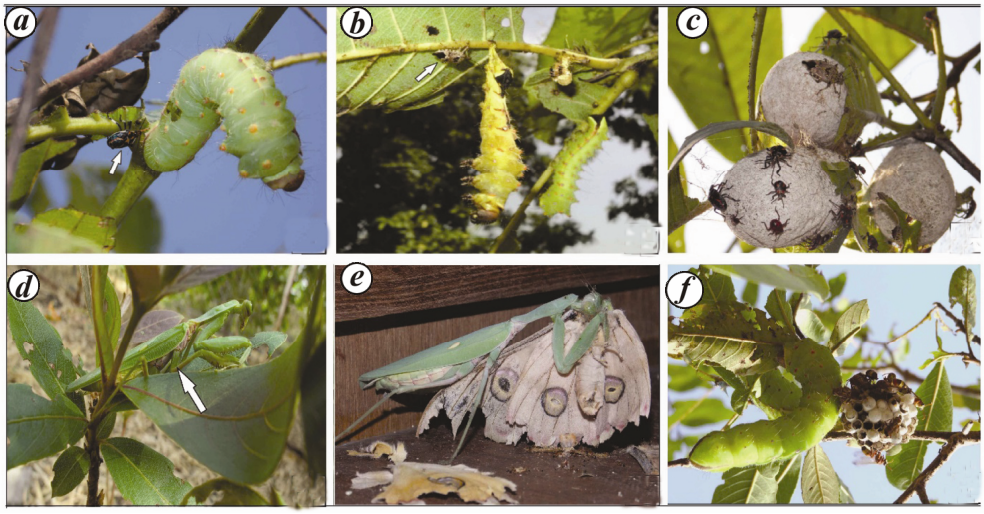


**Figure 3.** Predator of *A. mylitta* (D) showing: ***a–c***, Predation by stink bug, *C. furcellata* – ***a***, Attack of stink bug; ***b***, Damaged larva of *A. mylitta* by attack of stink bug; ***c***, Attack of stink bug on cocoon of *A. mylitta*; ***d–e***, Predation by praying mantis, *H. bipapilla* – ***d***, *H. bipapilla*; ***e***, Attack of *H. bipapilla* on adult of *A. mylitta*; ***f***, Larva of *A. mylitta* with predatory wasp *V. orientalis*.

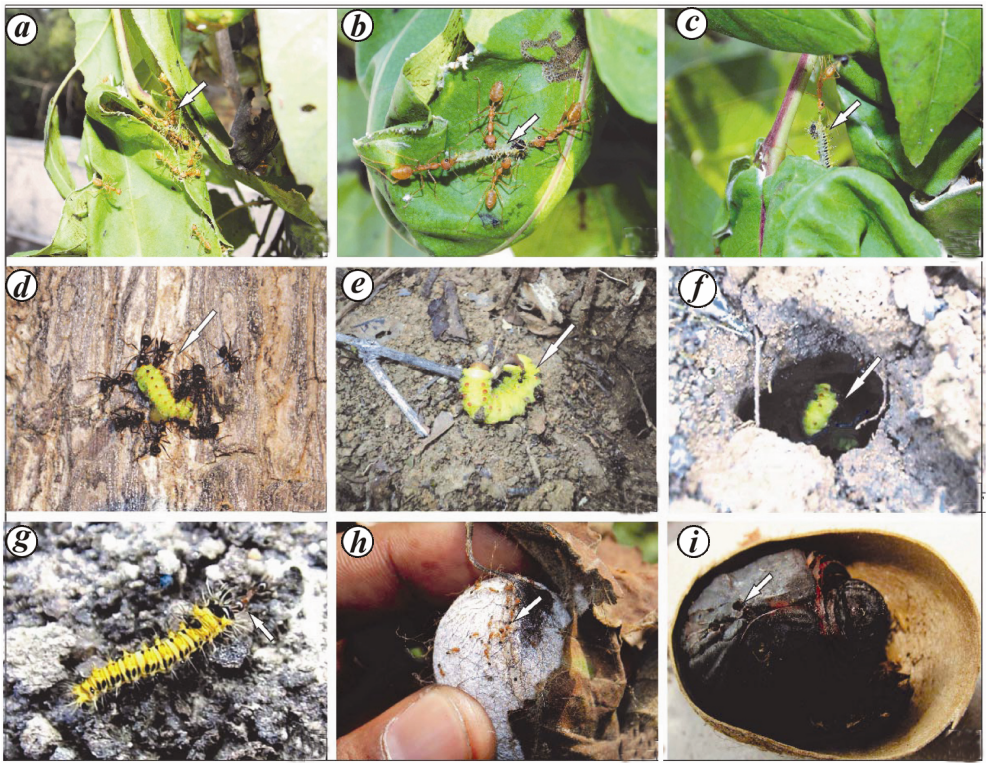


**Figure 4.** Ant predators of *A. mylitta* (D) showing: ***a–c***, Predation on early larval instar of *A. mylitta* by Weaver ant, *O. smaragdina*; ***d–f***, Predation by *M. brunnea* showing – ***d***, Group attack on single tasar larva; ***e***, Larval attack of *M. brunnea* on ground level (beneath the tasar host plant); ***f***, Tasar larva with predators inside the ground nest of *M. brunnea*; ***g–i***, Predation by *Monomorium* sp. – ***g***, Larval attack, ***h***, Pupal attack through cocoon shell; ***i***, Damaged or seedless cocoon of *A. mylitta*.

Uzi fly was about 2–3%, whereas attack by the dermestid beetle on the pupae resulted in 1–2% mortality. Among the predators, *C. furcellata* reveals high infestation during second crop, i.e. 11%, whereas it was 9% and 6% in the first and third crops respectively. Likewise, the mortality by *H. bipapilla* fluctuated from 2% to 3% during each crop. An active appearance of *V. orientalis* throughout the year resulted in 3–4% of total crop damage. Among the ants,

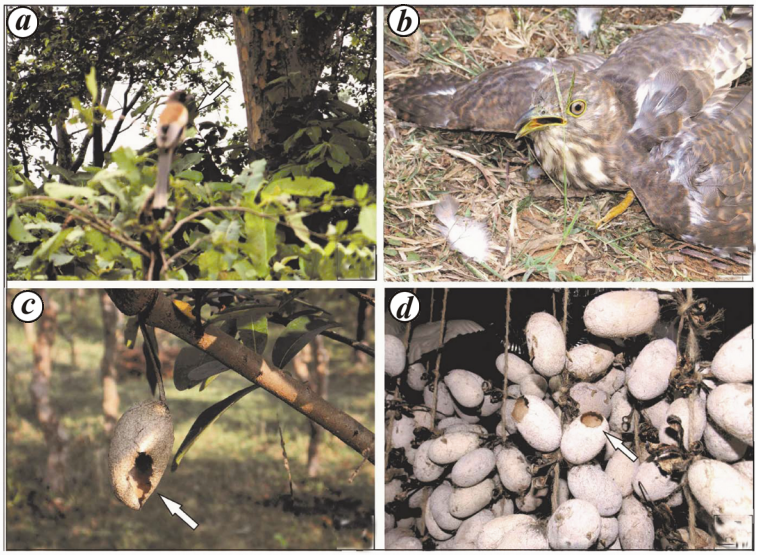


**Figure 5.** Predator of *A. mylitta* (D) showing its presence and/or attack on the stages *A. mylitta* in the tasar field; ***a***, Rufous treepie (*Dendrocitta vagabunda*); ***b***, Common hawk cuckoo (*Cuculus varius*); ***c***, Tasar cocoon damaged by squirrel; ***d***, Tasar cocoon damaged by rat attack.

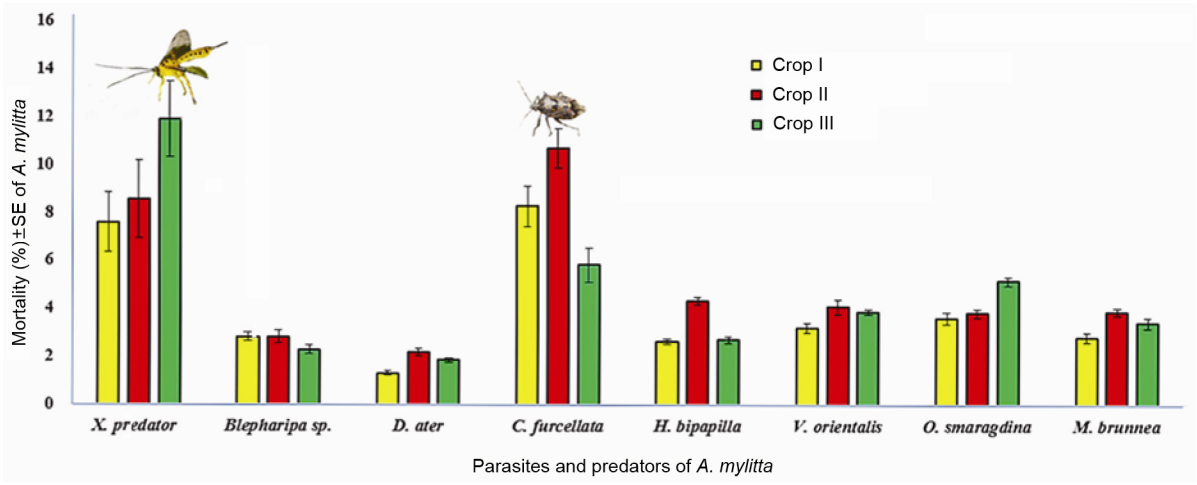


**Figure 6.** Graph showing mortality percentage of *A. mylitta* (D) by infestation of parasites and predators in the field condition during Crop I, Crop II and Crop III.

*O. smaragdina* caused about 4–5% mortality, whereas mortality due to *M. brunnea* was noted to be 3–5% of total crop damage (Figure 6). Among the non-insects, pests, birds, lizards, rats and squirrels were found predating on *A. mylitta*. Average mortality of three crops/year suggested that the early instar stages are more vulnerable to predation while the fourth and fifth stages showed less predation by the above predators. Mean values of mortality by parasites and predators differed significantly with respect to its cropwise mean mortality ($df = 7, 2$; $F = 196.89, 20.97$, $P < 0.5$). Its interaction with crops is significant ($df = 14$, $F = 6.19$, $P < 0.05$) (Table S1; see Supplementary material online). Among different rearing seasons, the maximum population of parasites and predators were recorded in the order of crop I < crop II > crop III. The mortality percentage of *A. mylitta* due to its major parasite, i.e. *X. pedator*, gradually increases from crop I to crop III and in case of its major predator, i.e. *C. furcellata*, it was moderate to high during crop I, high during crop II and low during crop III (Figure 6). The rearing performance of *A. mylitta* was good in crop III followed by crop I and least in crop II, as measured by cocoon yield.

## Discussion

The parasite–predator complex of the silkworm *A. mylitta* results in loss of wild tasar silk production, ultimately affecting the livelihood security and economic status of

the stake holders who are mainly the tribal folk[8–11,16,17]. Major threat includes the Ichneumonid, *X. pedator* (a pupal parasitoid) and *C. furcellata* a major larval predator of *A. mylitta*. Being solitary in nature, *X. pedator* lays a single egg in the pupal body cavity by inserting its well developed ovipositor[18] and completes its life cycle in about 20–22 days by devouring entire pupal mass. Pupation takes place inside the host pupa and the adult emerges out by leaving only the dead shell full of excreta. Due to the parasitism by *X. pedator*, the tasar cocoon gets damaged and is seedless, affecting the population in the next generation. It was also observed that one maggot of *X. pedator* develops inside a single host pupa of *A. mylitta* and similar observations have been made by earlier workers[1,9,11,19,20].

The Uzi fly, *Blepharipa* sp. was also observed as a larval endoparasite of *A. mylitta* and it can result in heavy damage if left unchecked[21]. The tasar Uzi fly is known to lay eggs directly on the host larvae, *A. mylitta* and *A. proyeli*[22]. The mature maggots of Uzi fly come out of the cocoon by making a hole and pupate outside[10,11]. Furthermore, the parasite developmental period was significantly extended in larvae parasitized with 5 and 10 developing maggots per larva (mpl) as also observed in *B. zebina*[23].

The dermestid beetle, *D. ater* also damages the stored cocoons and pupae of *A. mylitta* during harvesting. The availability of both bivoltine and trivoltine races may be the primary reason for rapid multiplication of the beetle pest population[8,15]. Nine species of dermestid beetles have been reported to cause damage to tasar silkworm[24].

The stink bug, *C. furcellata* has been reported as a predator of tropical tasar silkworm *A. mylitta* and also temperate tasar silkworms, *A. proylei* and *A. roylei*[8,25–27] and causes heavy larval mortality. The present study revealed the serious loss in silk production due to attack by both the nymphs and adults of *C. furcellata*, on the early (first to third instar) larval stages of tasar silkworm. However, the predation by *C. furcellata* was also serious during the moulting as well as spinning stages of *A. mylitta*[28]. After the bug attack, the larva becomes paralysed, hangs downwards and finally death occurs. In contrast, attack during spinning results in incomplete and poor quality cocoons[28] and a single bug kills about 130 to 220 tasar larvae in its life span[29]. *C. furcellata* is a major predator of several pests of agricultural crops in southeastern Asia[30–34], also highlighting its potential as a biological control agent against Lepidopteran pests[35,36].

The praying mantis, *H. bipapilla*, recognized by its raptorial forelegs, lays eggs in gummy egg masses[10,37]. In the present study, it was observed that both the nymphs and adults attacked and fed on early instar larvae of *A. mylitta*, while sometimes the fifth instar was also affected.

The common wasp, *V. orientalis* was also observed as a serious larval predator of *A. mylitta*. These wasps paralysed the early instar silkworm larvae after stinging and fed on them. The paralysed larvae are picked up by the wasps and transported to their nests, as observed in earlier studies[10,38].

Ants are the most abundant terrestrial carnivorous insects and cause a considerable loss to the sericulture industry[39]. Ants attack silkworms during resting and/or moulting on trees while the pupae, adult and eggs are primarily affected at grainage. The workers of *O. smaragdina* directly attack the early larval stages of *A. mylitta* in groups. Generally, they prefer first and third instar larvae and cut them into pieces and carry to their nests as observed in earlier studies[8,40]. *Myrmicaria* species are known to be highly predacious to many lepidopteran larvae and several other species of insects[41]. The feeding incidence of *M. brunnea* on the larvae of *A. mylitta* also contributes to loss of tasar silk production (G. B. Gathalkar and Barsagade, unpublished). The predation of *M. brunnea* was also observed on Muga silkworm, *A. assama* in earlier studies[27,39].

Birds, rats, lizards and squirrels were observed to be very common predators of tasar silkworm, as reported in earlier studies[10]. Nevertheless, birds with their continuous presence and active food searching in rearing fields, predate on large numbers of tasar silkworm larvae. Mammalian predators also attack the harvested seed cocoons, where they cut the cocoon shell and feed on the pupae of *A. mylitta* and similar observation were also made in the field of Muga sericulture[42].

Losses in wild tasar silk production are mainly due to the invasion by its parasite–predator complex. The occurrences of these pests in the tasar-rearing fields also depend on the variability in abiotic factors such as temperature, relative humidity and rainfall. Therefore, the rearing of tasar silkworms is affected by these pest population causing loss to tasar silk production. To increase wild silk production, attack by the parasites and predators needs to be addressed along with exploration of the remedial measures against the pest population.


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