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Raigad district of Maharashtra as a possible metapopulation and host plant rich area for *Attacus atlas* Lin. (Lepidoptera: Saturnidae)

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ABSTRACT

Attacus atlas Lin. (Lepidoptera: Saturnidae) is wild and largest Silkmoth. Its cocoons are used to make a durable silk called "Fagara Silk". Standard rearing technique of *A. atlas* is yet to be established. Ecology plays an important role for establishment of rearing technique. Therefore, occurrence, host plants, distribution, habitats, biotic and abiotic factors have been studied from Raigad district of Maharashtra. Although reported from almost all districts of western Maharashtra, its major occurrence was noted in Raigad district since host plant diversity including mangroove plants R*hizophora mucronata* P. *R. apiculata B.* and *Thespecia populnea Lin.* was probably rich. *T. populnea* was found along entire riverine vegetation of river Savitri. *A. atlas* was recorded feeding on leaves of 12 host plants including *Ficus carica* L. *Ricinus communis* L., *Annona squamosa* L, *Ocimum sanctum* L. *Mangifera indica* L., *Psidium guajava* L., *Eucalyptus* sp, etc. indicating Raigad district of Maharashtra as a metapopulation and host plant rich area for *A. atlas*.

Key words - *Attacus atlas*, wild silk moth, host plants, mangrove, metapopulation, Raigad.

INTRODUCTION

Attacus atlas Lin. (Saturnidae: Lepidoptera) is wild and largest silkmoth predominantly found in Indian subcontinent. The species has wide distribution in China, Taiwan, Myanmar, Shri Lanka and Java. Its cocoon produce durable silk called "Fagara silk". Durability of its silk and rearing technique is challenge in wild silk technology (Kavane and Sathe, 2011, 2015). Althrough several workers (Veenakumari *et al.,*1992, Sathe 2007, 2014; Kavane and Sathe 2011 & 2015; etc) tried, its standard rearing technique is not established yet. For establishment of standard rearing technique ecological, biological and behavioural studies have emense value. Detection of natural breeding places, habitats and host plants will certainly add great relevance in boosting wild silk technology. Mangroves, forests, herbivory between mangroves and forest and plain region, therefore, surved frequently for noting the occurrence of wild silk moths. The differences in rates of herbivory in different habitats are most often explained and are related to chemistry and age of host plants (Bradley *et al.*,1992; Butler,1989; Mulholland *et al.*, 2000).

Review of literature indicates that Ridley (1906), Beeson (1941), Chopra *et al.*, (1956), Das *et al.,* (1988), Butler (1989), Peigler (1989), Villard (1989), Murphy (1990), Bradley *et al.*, (1992), Veenakumari *et al.*, (1992), Sahu and Bindra (2007), Sathe (2007, 2014), Sathe and Kavane (2014), Kavane and Sathe (2014, 2015), etc worked on wild tasar silk moths. Availability of alternative host plants always protect survival of insect and lead population. Keeping in view all above facts, the present work was carried out.

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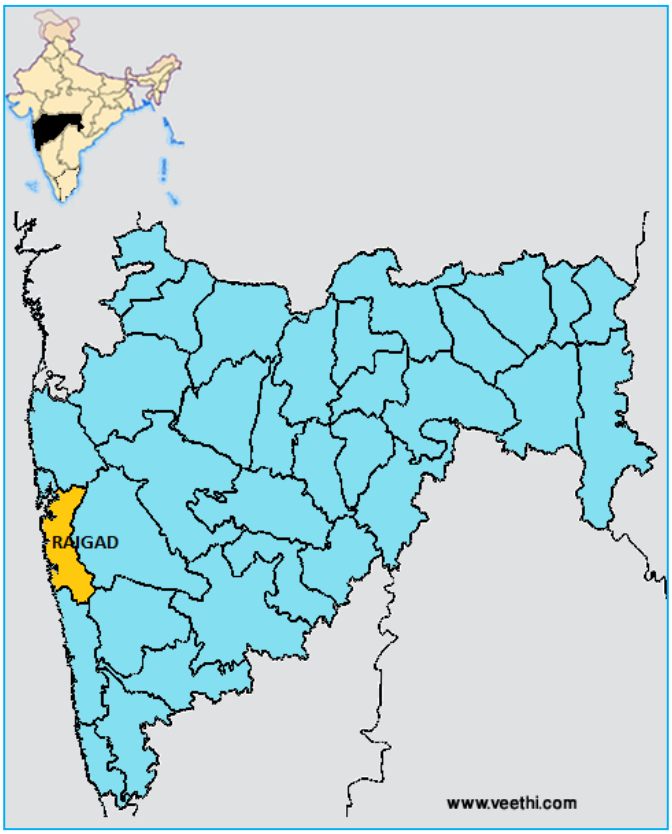
Materials and Methods

Fifteen days interval visits have been made to selected sites of field in Raigad district of Maharashtra (Fig–1). Raigad (situated between 18.5158^0 N longitude and 73.1822^0 E latitude) was selected for noting the observations on occurrence, life cycle, sex ratio and host plants of *A. atlas* throughout the years 2014-2015.

Figure-1 : Map of Maharashtra showing Raigad District



Feeding behaviour *A. atlas* larvae were noted on different host plants parts especially leaves, flowers, stem and seeds. The larvae and moths have been examined with the help of hand lens and description of life stages have been made. The species have been identified by consulting Hampson (1894, 1934, 1991), Sathe (2007), and Kavane & Sathe (2011). The larvae, pupae and adults were time being collected for identification and description, later, they have been released in the field from which they were collected. The host plants were identified with the help of appropriate literature cited in the references. A total of 12 sites namely Alibag, Revdanda, Murud, Digie, Borlai Panchaiten, Mhasla, Shrivardhan, Mangav, Raigad, Mahad and Poladpur of Raigad district of Maharashtra have been selected for the study. Only few cocoons which were collected from the field were kept at (25$^+$-1^{0}c – 80 + 2 % R.H, 12 hr photoperiod) for adult emergence. Newly emerged moths have been described and released in the appropriate fields.

Figure-2: Map of Raigad District

RESULTS

Results recorded in tables 1 and 2 and figures 1 to 8 indicated that *A. atlas* was feeding on 12 host plants from Raigad district of Maharashtra including mangrove plants such as *R. mucronata, R. apiculata* and *T. populnea.* Important host plants refer to *F. carica, O. sanctum, R. communis, A. squamosa, M. indica, P. guajava, Eucalyptus* sp. etc (Table-1).

Table -1. Host plant diversity for *A. atlas* from Raigad district, Maharashtra (2014 - 2015)

Sr No.	Host plant	No. of larvae noted	No. of moths noted
1.	*Mangifera indica* L.	8	2
2.	*Ficus carica* L.	11	3
3.	*Casurina sp.*	3	-
4.	*Ricinus communis* L.	9	2
5.	*Psidium guajava* L.	2	-
6.	*Annona squamosa* L.	7	2
7.	*Rhizophora mucronata* P.	17	4
8.	*Rhizophora apiculata* B.	10	4
9.	*Vitex* sp.	1	-
10.	*Eucalyptus* sp.	2	1
11.	*Thespecia populnea* L.	19	7
12.	*Ocimum sanctum* L.	1	-

Maximum number of larvae (19) was collected on *T. populnea* and minimum on *Vitex* sp. Raigad, Revdanda, Mahad, Murud, Mhasla and Mangav were prominent places of distribution of moths in Raigad district where catches of moths were comparative more than other places. The moths have been collected from 11 different places of Raigad indicating that Raigad district is good metapopulation and host plant rich area for *A. atlas* since it has also been reported from almost all districts of western Maharashtra but, with very small number.

Larvae of *A. atlas* (Fig – 3)

Our observations also indicated that the larvae were bulky and bluish green in colour (Fig–3) with tubular structure emerging from the body. There was clear division of body into head, thorax and abdomen. The maximum length of full grown caterpillar was 10-12 cm. The larvae feed on leaves of green flower, Guava, Casurina, Custard apple, Mango, Angir, etc. (Table -2) found during July to September. They were prominently seen from August to September in the fields of Raigad district of Maharashtra.

Figure- 3. *A. atlas* larvae

Table- 2. Abundance of *A. atlas* from Raigad district on *Rhizophosa* spp.

Sr No.	Place	No. of larvae observed/ Plant	No. of moths observed
1.	Alibag	2	1
2.	Revdanda	7	2
3.	Murud	5	1
4.	Digie	3	2
5.	Borlai Panchaiten	2	1
6.	Raigad	8	3
7.	Mahad	6	2
8.	Mhasla	5	1
9.	Shrivardhan	4	1
10.	Mangav	5	1
11.	Goregav	4	1
12.	Poladpur	3	1

Fifth instar

Head was smooth, glossy, green in colour. Dorsal and subdorsal scoli present on thoracic were with reduced stubs / warts. Spiracular scoli on thoracic segments were black and longer than on other parts of the body. Subspiracular scoli on abdominal segments I & II were small and black. Abdominal segments III to VIII were characterized by small black scoli but, situated slightly lower than on segments I and II in the subventral positions. The thoracic segments and first two abdominal segments were with a row of very short black scoli which were light blue basally. The body surface of larva was with green mottling while, the mottling on the anal segment was dark green.

Sixth instar

Head was with smooth, glossy green colour. A thin layer of white mealy matter was noted on the frons and a little on the side of epicranial suture. Ventral surface of larva was green, legs and prolegs were black and the outer surface was with sparse grey setae and crochets with dark brown colour. There was an anterior bluish-white stipe in black area of the prolegs. Spiracles were pale blue and attractive. The pink shield on anal clasper was very special and distinct. The whole larva was mottled. However, mottling became quite dense on the anal shield. The larvae were found clinging to leaf lamina especially lateral part was seen to be eaten by larvae. The larva eaten the leaf from margin towards midrib leaving typical zigzag mark and skeletonizing of the host plant.

Cocoon and pupa

The cocoon is covering to the pupa. The pupa was obtect type with narrow posteriorly and broder anteriorly. The cocoon was coarse, golden brown, with long pudenda. In a few instances two cocoons were found together in the field. Ten cocoons averaged 6.00 cm and 2.6 cm in length and width respectively and 5.29 cm in cocoon weight. The cocoon formation took place among the leaves. The last instar larva secreted a coarse silk and entrapped itself into the cocoon constructed. Cocoons were noted from October to November in the field.

Adult (Fig - 4)

Adults were with more than 18 cm wing expanse and reported from mangrove ecosystem of Achara. Adults were emerged from the cocoons within a month time, but in adverse conditions, they emerged in the next season. The development of *A. atlas* was completed within 30-40 days. The adult was characterized by rich colour of reddish-brown with distinct patterns and whitish patches. The upper wings were large and broad with the apex pronounced, while, the lower with somewhat circular in shape and smaller is size. On both the wings, a single triangular patch was present, which was a very remarkable character of the moth. Body was stout, short, furry and beautifully decorated by the circular spots presented on sides.

Figure-4. *A. atlas* adult

Fig-5: *F. carica* twig

Fig-6. *A. squamosa* twig

Fig-7: *P. guajava* twig

Fig-6. *O. sanctum* twig

Economic importance

A. atlas secreted silk to protect its pupa. The silk was secreted in broken strands. The silk produced is called Fagara silk and have some commercial use. Abandoned cocoons are often used as small coin purses in Taiwan. Besides, it has been also heavily collected for the illegal state trade of butterflies and moths. In the busy lanes of Bangkok markets mounted specimens of Atlas moth is sold for Rs. 150/- each. The larvae and pupae have nutritional value for the humans (Sathe *et al*., 2015).

DISCUSSION

Hampson (1892) reported the taxonomical diversity and distribution of the genus *Attacus* from Asia. *A. atlas* is the largest moth reported from tropical Asia (Michener, 1952). A few species are defoliators of *Eucalyptus* and *Araucauria* in Australia, New Guinea and on certain trees in North America. Sahu and Bindra (2007) reviewed some wild silk moths from North Eastern region of India. According to them 9 species of wild silk moths were prevalent in the region. Sathe (2007) reported 13 species of wild silkmoths from western Ghats of Maharashtra. Murphy (1990) was the first to mention presence of *A. atlas* in mangroove habitat. He stated that *A. atlas* occurred on *Avicennia alba* along with some other trees.

Saikia ans Handique (1998) studied the life cycle of *A. atlas* by providing the food plant *Meyna laxiflora* under which they noted 10 days, 28 days and 28 days as incubation, larval and pupal periods. They further noted that females survived for more (4-6) days than males (2-3 days). According to Jolly *et al.,* (1977) the colour of cocoon of *A. atlas* was brown.

Kavane and Sathe (2014) reported preliminary rearing technique for *A. atlas* wherein they noted that cocoons were formed within 35-43 days after oviposition. Cocoon weigh, shell length, shell width and shell thickness were 9.49, 4.4cm, 1.4 cm and 0.21mm respectively. The rearing success of *A. atlas* was 15% on Angeer *F. carica.* The mated females laid on an average 147 eggs and produced 22 offsprings with an average sex ratio (m: f) 1:0:75. Sathe and Kavane (2014) studied the biology of *A. atlas* by providing leaves of *F. carica.* They noted that the species was able to complete its life cycle from egg to adult within 62 days under laboratory conditions (27+-1^{0}c, 75-80% R.H and 12 hr photoperiod). Moth emergence was took place early in the morning and mated females laid eggs within the range of 134-160 individuals. They also described morphological features of immature stages. According to Veenakumari et al (1992) *A. atlas* from western Java and some of the species from the Philippines were with solidly orange shields on the anal prolegs. These shields on larvae of *A. atlas from* Thailand and Taiwan and *A. taprobanis* from Shri Lanka and southern India were rimmed with orange with green centers. Larvae of *A. mcmulleni* on the contrary were

intermediate, the shield appeared solidly orange at first glance, but a faint green center was visible upon closer examination. In *A. mcmulleni* the subspiracular scoli were blue proximally and blackish distally as noted in *A. taprobanis* and *A. atlas* from Taiwan and Thailand. The white waxy covering on larvae was observed in present specimen while, such white waxy covering in *A. mcmulleni* was dense or denser than in any of the other species of *Attacus.*

According to Peigler (1989) more than 100 plant species belonging to 90 genera and 48 families have been reported as host plants for various species of the genus *Attacus*. Standared rearing technique for *A. atlas.* is yet be established (Sathe,2007, Sathe and Kavane 2014, Kavane & Sathe 2014,2015). Villard (1989) recorded that greater success on the rearing of *Attacus* larvae particularly, later instars could be achieved by feeding them on a mixed diet. Present larva after providing *Phyllanthus emblica, Ocimum sanctum* as an alternative hosts along with *X. granatum* strictly preferred leaves of *X. granatum. X. granatum* was reported to be a host for *A. atlas* in Ratnagiri and Sindhudurg district.

Herbivores that habitually feed on tannin-rich plant material appear to possess some interesting adaptations to remove tannin from their digestive system. According to Butler (1989) salivary secretion of some proteins induced by ingestion of food with a high tannin content greatly diminished the toxic effects of tannins. In the present study, it was noted that *A. atlas* completely consumed the leaves of many mangrove plants probably due to specific protein content. *A. atlas* being a rare moth found in well forested areas, act as indicator of the health of the forest. However, degradation of habitats is the constant threat, which this beautiful moth is facing.

Two host mangrove species in the present study are viviparous, they can be easily, propagated and used as food for *A. atlas. X. granatum* is critically endangered host plant of *A. atlas* which is favourably taken by the larvae, it should be conserved so as to conserve *A. atlas.* Similarly, *R. mucronata* and *R. apiculata* from Raigad district are also endangered. They should also be conserved for survival and propogation of *A. atlas* in the region. *T. populnea* is abundant not only in mangroves but also along the riverine vegetation of 'Savitri' river. It can be easily propagated through seeds. Therefore, conservation of above said flora will add great relevance in wild silk technology and protection of biodiversity of Western Ghats, 18 hot spots of the world for biodiversity protection which is located in western Maharashtra.

Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

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