ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 7, Issue 2, pp: (495-502), Month: April - June 2019, Available at: www.researchpublish.com

Influence of climatic regions on species richness, distribution and abundance of wild Silk moths in Maharashtra, India

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Abstract: **Recently, wild silk has got great importance in many fields including medical. Wild sericulture has dependence on wild species, host plants and climatic conditions. Therefore, present study was intended to know the climatic drivers and role of host plant species richness on wild silk moth species richness and abundance. Geographical distribution of wild silkmoths was also studied based on the climatic regions. Silk moths were collected by using light traps from 10 sites located in six districts of Maharashtra with gradually changing climatic condition. Host plants were also recorded during the collection. Data obtained was analysed with statistical packages to deduce conclusions and comparison. 7 species belonging to 5 genera of family Saturniidae were recorded in the study. Three species belonging to genus *Antheraea* and one species from each of other genera *Actias*, *Samia*, *Attacus* and *Loepa* were recorded from the study area. Six species of host plants were found common at sites with dominant *Terminalia* genus. Species richness and abundance was found higher at the sites of Kolhapur District than other districts. Regression analysis predicted the richness of wild silk moths was depends on host plant richness. Cluster analysis also indicated relatedness between the population structures of sites in the Kolhapur district with higher species richness. Three climatic regions of Maharashtra have variation in species richness, distribution and the abundance of wild silk moths merely due to larval host plant species richness.**

Keywords: **Wild Silk moths, richness, Distribution, Saturniidae, climatic regions, Maharashtra.**

I. INTRODUCTION

Wild Silk moths are members of family Saturniidae which is largest family of super family Bombycoidae. Family Saturniidae contains about 1861 species distributed into 162 genera and 9 subfamilies [1]. Out of 1200-1500 species of Saturniidae all over the world, about 50 species were predicted to be present in Indian sub-continent [2]. 40 species of Wild Silk moths are known to found in different states of India. 19 species of sericigenous lepidopterans were reported from North Eastern part of India [3]. The geographical distribution of 17 species of wild Silk moth belonging to 10 genera was studied throughout India [4]. Twenty four species from North East India and 14 species from Nagaland were also recorded by some authors [5,6]. 6 species of silk producing insects were recorded from Johrat, Assam [7]. Total of 15 species distributed to nine genera were recorded from Khasi Hill, Meghalaya [8,9]. Recently, 29 species were recorded with two new subspecies and one new record (*Antheraea platessa platessa*) from North Eastern India [10].

Increasing applications of wild silk in many fields such as in medicine, created demand of high quality silk [11]. India can achieve the topmost position in the wild silk production by exploring and exploiting its all wild silk moth varieties. Sericulture being eco-friendly cottage industry is growing to larger scale in recent years. Its basic needs are type of silkworm species, their food plants, and climatic conditions. These factors directly affect the yield and quality of silk produce. To avail better variety of silkworm, sericulturists are dependent on grainage producers or rearing of wild Silk moth for getting disease free layings (DFLs). There are also many tribles solely depends on forest for obtaining the wild silk cocoons for silk. The wild sericulture is based on the availability of the wild Silk moth species and their preferred food plants in the area. In the contemporary view to increase and extend potential of wild sericulture; species richness and distribution records of wild Silk moths and their food plants are badly needed.

Wild sericulture industry has great deal with climatic factors for healthy rearing and the higher silk production. The abundance is greatly affected by the seasonal climatic variations and larval food plants abundance. Recently it has been reported that the abundance of wild Silk moths was maximum during monsoon season in Northeast India [9]. Lara-Pérez *et al*. [12] recorded positive relation of temperature with the species richness and the abundance in tropical semi-deciduous forest of Mexico. However, population structure of wild silkmoth community in the tropical-wet, dry and dry-wet and semi arid climate is not yet explored. A study on butterfly population has reported positive role of climatic factors (temperature and rainfall), flowering and nectaring plants in structuring population [13]. Similarly, the positive relation of larval host plant in the abundance of butterflies was clearly known [14]. However, role of larval host plant richness in structuring species richness of lepidopteran species is unknown. Hence, we expect dependence of wild silkmoth population merely on host plant richness.

State of Maharashtra has varied environmental conditions. These definitely affect the distribution, richness and abundance of the wild Silk moths. Earlier literature shows only diversity records of the wild Silk moths from Maharashtra [15–19]. Therefore, the wild sericulture has not yet grown to expectation besides its potential. For the growth of sericulture industries herein, it is very essential to study species abundance, richness and distribution of wild Silk moths with respect to climatic conditions and to underline the relatedness of the population in different regions of the Maharashtra. This will definitely be useful for extension of wild sericulture. It will also be used to design restoration of larval host plants and therefore conservation of wild silk moths.

II. MATERIAL AND METHODS

Collection of wild Silk moths was done at 10 sites located in six districts of Maharashtra located within and around the Western Ghats *viz.* Ratnagiri, Kolhapur, Sangli, Satara, Solapur and Osmanabad (Table I). These districts are located in different geographical ranges and represent variation in climatic conditions [20]. These districts also represent the great temperature variations. These districts were classified into three climatic regions. Ratnagiri region (Ratnagiri district only) represent high annual rainfall with low altitude and hilly; Kolhapur region (Kolhapur, Sangli and Satara districts) has more annual rainfall with high altitude and hilly topography whereas Solapur region (Solapur and Osmanabad districts) recognised with low annual rainfall with medium altitude and plateau geography.

TABLE I: Region wise collection sites, geographical locations and climatic factors of study area

Regions	Collection Site	Geographic locations	Altitude (M)	Annual Rain Fall (cm)*
Ratnagiri	Rajapur	16°34’43.48”N, 73°26’37.75”E	68	352.79
Kolhapur	Radhanagari	16°26’00.67”N, 73°53’01.08”E	967	145.56
	Amba	17°00’04.11”N, 73°46’55.22”E	270	145.56
	Jotiba	16°50’33.38”N, 74°10’38.75”E	937	145.56
	Palus	17°07’08.00”N, 74°26’08.65”E	599	57.81
	Koyananagar	17°23’31.01”N, 75°41’49.38”E	655	91.24
	Mayani	17°26’30.21”N, 74°33’26.12”E	690	91.24
Solapur	Madha	18°01’41.14”N, 75°30’27.26”E	498	57.49
	Surdi	18°04’28.29”N, 75°41’49.83”E	495	57.49
	Sarola	20°01’28.93”N, 75°10’18.63”E	602	78.50

Silk moths were collected by using simple light trap (designed by using mercury lamp light focused on the white cloth). Light trap was operated in the night for about six hours (usually from 24:00 – 06:00 hours). The geographical positions were recorded at the collection site with Geographical Positioning System (Model - Garmin *etrex10*). District wise monthly rainfall data was made available from ‘Customized Rainfall Information System (CRIS)’ maintained by India Meteorological Department [21]. Collected specimens were immediately captured and transferred to the large plastic containers for transport to laboratory.

Collected specimens were sacrificed with ethyl acetate, pinned with entomological pins (38mm x 0.40mm; 38mm x 0.55mm) and stretched to dry in oven at 60°C for 4 hours. Photographs of specimens were taken by digital camera (Canon

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 7, Issue 2, pp: (495-502), Month: April - June 2019, Available at: www.researchpublish.com

600D) and identified to species level by using available literature. Identification was confirmed by observing male genitalia from one of the specimen [4,22–24]. Labelled specimens were stored in the insect storage boxes.

Data analyses were performed by using a statistical package PAST ver. 3.20 [25] and Microsoft Excel 2007. The PAST was used for the calculation of diversity indices such as Simpson, Shannon, Margalef's, Fisher's alpha, Evenness and equitability. The individual rarefaction curve was also computed for analysis of species richness in the regions and its comparison. Species richness and diversity based clustering of all collection sites from three regions was performed by using 'Unweighed Pair-Group Average (UPGMA)' algorithm with Euclidean similarity index. Jaccard's similarity index (*J*) was also computed in PAST for the design of Venn diagram for visualization of similarity among the regions varying in diversity.

III. RESULTS

Present study reports seven species of wild Silk moths distributed in five genera of family Saturniidae. Genus *Antherea* was found to be dominant among five in the study with three species viz. *Antherea mylitta, A. pernyi, A. helferi*. Other genera *Attacus, Actias, Samia* and *Loepa* were represented by only one species each includes *Attacus atlas, Actias selen, Samia ricini* and *Loepa katinka* respectively. 7 species were found in Kolhapur district followed by 4 species in Ratnagiri and Satara further followed by 2 species in Sangli and Solapur while one in Osmanabad (Fig. 1). Six species of plants were also recorded in the study area included *Terminalia arjuna, T. cattappa, T. chebula, T. tomentosa, Moringa oleifera* and *Zizypus mauritiana.* Host plant, *T. arjuna, T. cattappa, T. chebula, T. tomentosa* were found dominant at the Rajapur, Radhanagari and Amba while dominance of *T. arjuna* and *T. catappa* was at the Jotiba and *Z. mauritiana and T. tomentosa* at the Palus. *M. oleifera* and *Z. mauritiana* were distributed at all sites.

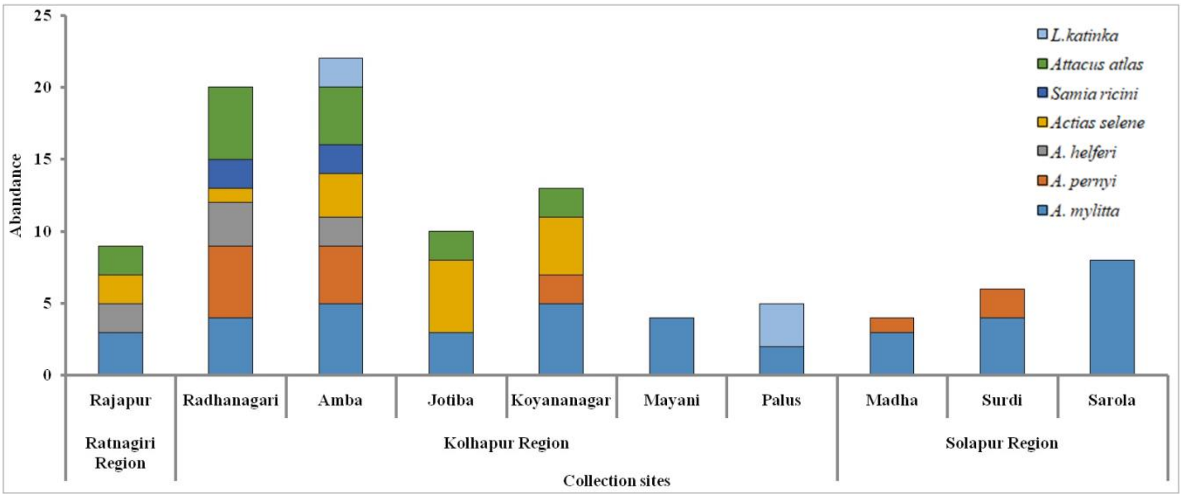

Figure 1. Region wise abundance of wild silk moths from study area.

Diversity and species richness of wild Silk moths was studied from ten sites located in six districts of Maharashtra. Species diversity indices have shown that Amba and Radhanagari sites were more diverse in the wild Silk moths. Sarola and Mayani have no diversity represented by only one species. Species richness was also recorded higher at sites located in Kolhapur district. The individual rarefaction curve (Fig. 2) has shown difference in both richness and abundance of the moths among the three climatic regions. Richness and abundance was higher at Kolhapur than the other regions. Alpha diversity index also shows that the Amba and Radhanagari site of Kolhapur region have high biodiversity (Table II). Species composition of wild Silk moths was also analysed to delineate relation with other factors such as rainfall and the host plant richness. Logistic regression analysis shown that the wild Silk moth species composition is correlated with composition of larval host plant species (r^2 = 0.728, p=0.001) (Fig. 3a). Silkmoth species richness has not shown significant relation with the rainfall (r^2 = 0.169, p=0.245) (Fig. 3b).

Distribution of *A. mylitta* was recorded from all collection site located in the six districts. However, *A. pernyi* was found distributed in three districts namely Kolhapur, Satara, and Solapur whereas *A. selene* was found in Ratnagiri, Kolhapur and Satara districts. *A. helferi* found in Ratnagiri and Kolhapur. *Loepa katinka* recorded from Kolhapur and Sangli districts. *Attacus atlas* was recorded from three districts and *Samia ricini* was found in only Kolhapur. *Loepa katinka* was found in Kolhapur and Sangli districts. *Attacus atlas* was reported from three districts and *Samia ricini* was found in only Kolhapur. Jaccard's similarity index was also higher in for Kolhapur-Ratnagiri (J = 0.57) than the other combinations (Ratnagiri-Solapur, J = 0.2 and Kolhapur-Solapur, J = 0.28) (Fig. 4). Clustering of the species richness was done using the data of the climatic factors rainfall, altitude and the host plant. Cluster dendrogram (fig. 5) showed the robust grouping of silkmoth composition according to the climatic regions. However, some sites also fall out of cluster due to non-specification in availability of the data on climatic condition for a region.

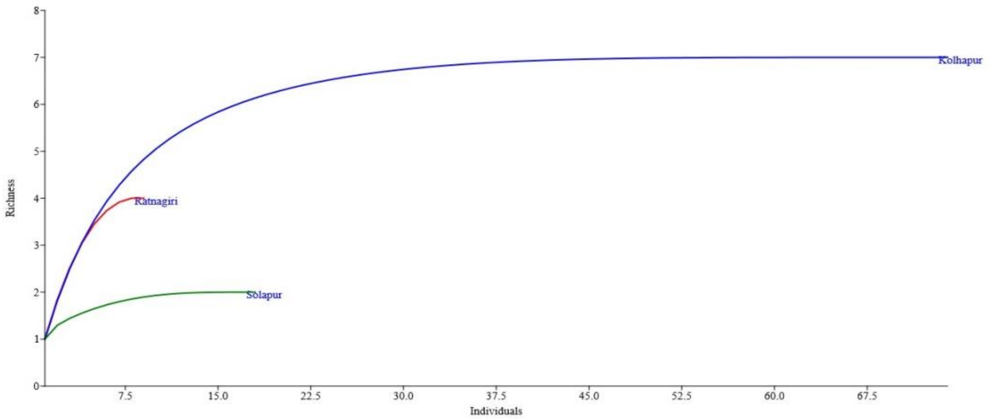

Figure 2. Individual rarefaction curves of wild silkmoths species from six districts of Maharashtra.

TABLE II: Wild Silk moth diversity indices from six districts of Maharashtra

	Ratnagiri	Kolhapur						Solapur		
	RJA	RDH	AMB	JTB	PLS	KYN	MYN	MDH	SRD	SRL
Taxa_S	4	6	7	3	2	4	1	2	2	1
Individuals	9	20	22	10	5	13	4	4	6	8
Simpson_1-D	0.74	0.8	0.84	0.62	0.48	0.71	0	0.38	0.44	0
Shannon_H	1.37	1.68	1.88	1.03	0.67	1.31	0	0.56	0.64	0
Evenness_e^H/S	0.98	0.89	0.94	0.93	0.98	0.92	1	0.88	0.94	1
Margalef	1.37	1.67	1.94	0.87	0.62	1.17	0	0.72	0.56	0
Equitability_J	0.99	0.94	0.97	0.94	0.97	0.94	NC	0.81	0.92	NC
Fisher_alpha	2.76	2.91	3.54	1.45	1.24	1.97	0.43	1.59	1.05	0.3

Rajapur- RJA, Radhanagari- RDH, Amba-AMB, Jotiba – JTB, Palus –PLS, Koyananagar –KYN, Mayani –MYN, Madha – MDH, Surdi –SRD, Sarola – SRL; NC – Not calculable due single species.

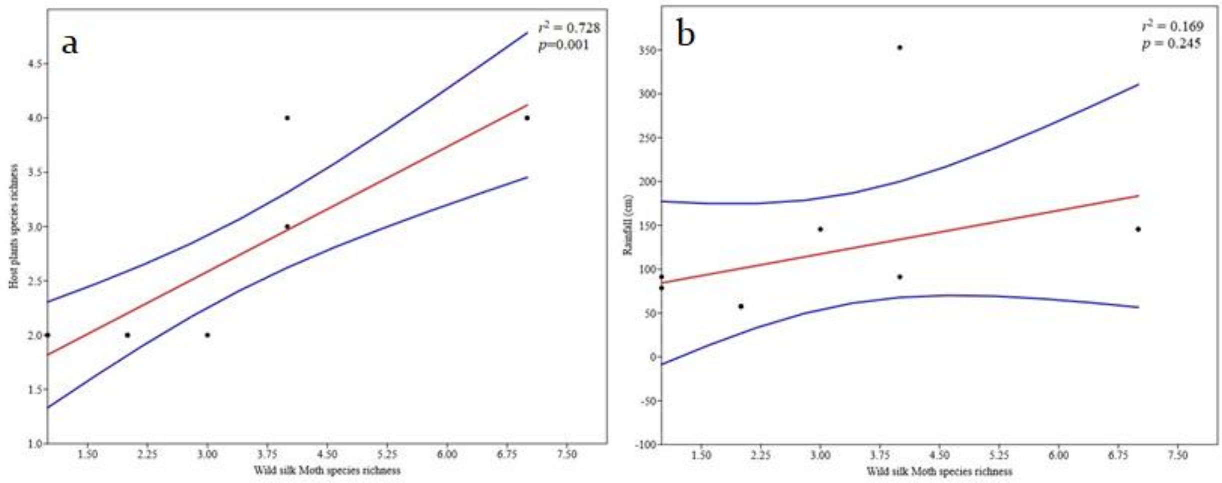

Figure 3. Regression plots showing relationship of species richness with a) host plant species composition, b) annual rainfall.

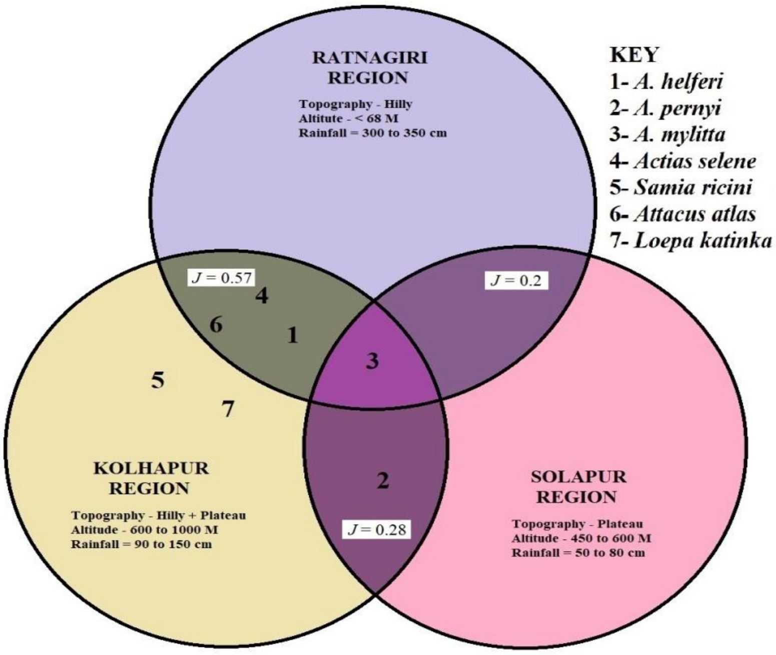

Figure 4. Venn diagram shows distribution of wild silk moths in three climatic regions.

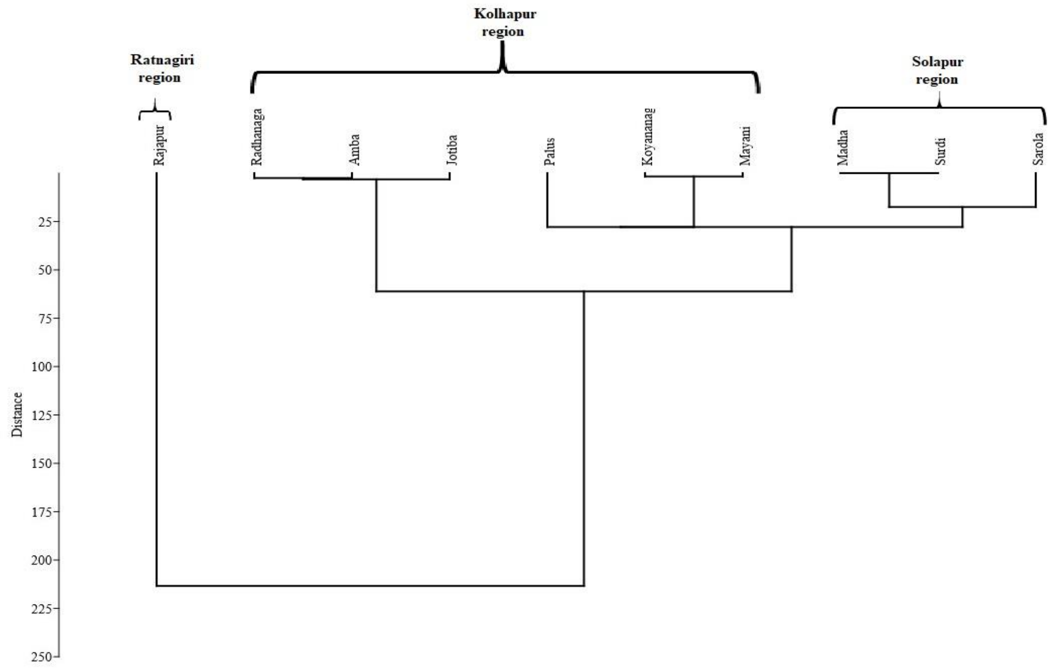

Figure 5. Clustering shows distribution and relatedness of wild Silk moth populations among the regions.

IV. DISCUSSION

Biodiversity of wild silkmoth was studied partially by some authors from Maharashtra and reported only four species from Amba region [17–19, 26]. Here we report 7 species with their species richness in six districts located in and around the Western Ghats, one of the biodiversity "Hottest Spots". State of Maharashtra has very diverse topography with hilly and plateau regions [27]. It is well known fact that topography affects the climatic conditions of the region and the species richness as well [28–30]. Wild silk moth population in such a varied climatic condition from six districts of Maharashtra was revealed variation in species richness and diversity. Present study also observed higher silkmoth abundance in rainy season only, similar to previous observations from the Northeast India [9]. Species richness was found higher at the high altitude and high rainfall zone. Previous reports were also supported the certain level of elevational influence on species richness [30]. A study on the richness and abundance of wild silkmoths from tropical semi-deciduous forest revealed its dependence on the temperature and evapotranspiration [12]. Here, in the tropical wet climate of Western Ghats and the tropical semi-arid climate to its eastern side have different population structure. Although, there was statistically unpredictable relation found between environmental factors and wild silk moth species richness reported during the study, it appears to be dependant indirectly. Such unpredictable relation seems due to the higher fluctuation in the climatic conditions of the region.

Higher richness of wild silkmoth was found in Kolhapur district was significantly correlated with the host plant richness. Radhanagari and Amba sites have significantly more species richness and different species composition than the other site. It clearly revealed that the wild silkmoth species richness has influenced by the host plant richness. Theodore-Munyuli [13] observed butterfly abundance and species richness was dependent on species richness of nectaring plants in the area. However, lepidopteran species (butterflies and moths) equally have a need of larval host plants [14]. Therefore, larval host plant species richness was more involved in the regulation of lepidopteran species richness. Hence, the variation in wild silk moth species richness among the different site is mainly depends on host plant richness and abundance [31–33]. However, plant richness and distribution is mainly governed by the rainfall [34]. Conversely, these Silk moths are polyphagous, feeds on different host plants from different families as well [4,15,16,35–37]. Recent reports were also correlated the insect diversity to the to the host plant diversity than the abiotic factors [38,39]. Therefore, richness of the species seems to depend directly on the host plant richness. The species richness is less affected by different environmental factors including rain, temperature, humidity and altitude as well.

Studies also revealed that species richness and population structure has variation among three different climatic regions. Collection sites were located in the Solapur region showed low species richness related to low rainfall and low host plant richness. However, the regions with higher Silk moth richness come in high rainfall, moderate average temperature and hilly regions. The host plant diversity was also recorded higher in these regions. Therefore, the host plant richness has played important role in distribution and richness of wild Silk moths. These environmental conditions affects directly to the health of crop or indirectly by influencing various diseases in the worms [40–42]. Therefore, extreme environmental conditions prevailing in the Ratnagiri and Solapur region seems to affect abundance and species richness. The environmental factors vary at the different geographical locations and therefore the species richness and abundance. Therefore, present study of species richness and distribution of the wild Silk moths will be helpful in selection of species for wild sericulture and extension of it in the new area. It is also beneficial to conserve wild silkmoth species through plantation of larval host plants in the respective area. The restoration, cultivation and plantation of host plant species in the area can reprieve the decrease in the species diversity.

V. CONCLUSION

Present study recorded seven species of wild Silk moths belonging to five different genera. These were distributed in different sites located in six districts divided into three climatic regions has variations in their wild silkmoth species richness. Kolhapur region had high silk moth species richness and abundance merely correlated with host plant richness, high rainfall and elevation. Distribution, abundance and species richness was highly influenced by host plant richness and thereby climatic factors. Study elucidated the dependence of the wild silkmoth species richness on the larval host plant species. Study will be helpful in the designing the extension of host plant cultivation and wild sericulture. It is also useful to delineate the conservation strategies for the wild silkmoths.

ACKNOWLEDGEMENT

Authors are thankful to authorities of Shivaji University, Kolhapur for providing facilities to perform present work.

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