https://doi.org/10.33307/entomon.v49i4.1337
ENTOMON 49(4): 511-518
Article No. ent. 49405

Exploring the ecological interplay: population dynamics of an ichneumon wasp (*Xanthopimpla pedator* F.) on the Raily ecorace of *Antheraea mylitta* D. in Chhatisgarh, India

B. Thirupam Reddy[1*], H.S. Gadad[2], G.R. Halagundegowda[3], Shreyansh[2], I.G. Prabhu[2], D.M. Bawaskar[4], C. Selvaraj[4], S.M. Mazumdar[4], G.V. Vishaka[4], P.C. Gedam[4], M.S Rathore[4], Vinod Singh[4], R. Gowrisankar[4], J. Komal[4], P.B. Manjunatha[4], K.V. Vikram[4], S. Ganguly[4], H. Nadaf[4], T. Selvakumar[4] and K. Sathyanarayana[5]

[1]Basic Seed Multiplication and Training, Centre, Central Silk Board, Bastar 494223, Chhattisgarh India.
[2]Central Tasar Research and Training Institute, Central Silk Board, Ranchi 835303, Jharkhand, India.
[3]Statistics Section, Central Office, Central Silk Board, Bengaluru 560068, India.
[4]Basic Tasar Silkworm Seed Organization, Central Silk Board, Bilaspur 495112, Chhattisgarh, India.
[5]Dr. Kalam Agricultural College, Bihar Agricultural University, Arrabari, Kishanganj, 855107, Bihar, India.
Email: entomophily@gmail.com; btreddy.csb@nic.in

ABSTRACT: The study provides a comprehensive examination of Ichneumon wasp damage on Raily Tasar silkworm cocoons in Chhattisgarh, offering critical insights into the prevalence and distribution of this parasitic infestation. These cocoons traditionally considered resistant to Ichneumon wasp infestations, but during the study, unexpected evident damage symptoms are exhibited during the First crop (Chaiti) harvests in June. The emergence of characteristic signs, including distinct holes at the peduncle base and pupal exit points, confirmed the presence of the Ichneumon wasp and its parasitic activity within the Raily cocoons. The investigation further revealed a notable range in the extent of Ichneumon wasp damage, with percentages ranging from 1.43 to 8.10 per cent across various forested locations in Bastar. District-wise analysis indicated that Bastar experienced the highest damage rate (23.50%), followed by Kondagoan (20.50%) and Dhantewada (17.00%). These variations underscore the localized disparities in infestation severity, emphasizing the need for targeted interventions in areas facing higher damage rates.

KEY WORDS: Bastar, tasar silkworm, insect pest, parasitoid

INTRODUCTION

Chhattisgarh State, located in central India, boasts a rich tradition of sericulture, with Tasar silk production occupying a prominent place in its cultural heritage. Second only to Jharkhand,

* Author for correspondence

Chhattisgarh has emerged as the second-largest producer of Tasar Silk, primarily due to the presence of abundant food plants for the Tasar silkworms, constituting an impressive 30 per cent of the state's total forest cover. This unique sericultural tradition is particularly significant among the tribal communities, who have cultivated the Tasar culture over generations. Raily, an endemic Tasar silkworm ecorace, is a fascinating jewel hidden in the lush tropical moist deciduous forests of Chhattisgarh and influences the socio-economic and communicational status of tasar silkworm rearers, specifically in the Bastar division (Dubey and Raut, 2022). Raily ecorace primarily feed on the leaves of *Shorea robusta* (Sal), *Terminalia tomentosa* (Asan), *T. arjuna* (Arjun), *Anogeissis latifolia* (Dhawda), among others, as they are highly adapted to their natural habitat (Sharma and Rai, 2010). This ecorace exhibits robust larvae, yielding compact and durable cocoons with rich silk content, characterized by a thick and high-denier silk thread. Raily ecorace use green coloration to blend in with the forest's Sal leaves, providing an effective camouflage mechanism for their survival. Number of Generations of tasar silkworm depends on its pupal diapause. Male and female moths exhibit distinct coloring, facilitating their mating and reproductive cycle. The follicular imprints on Raily silkworm eggs differentiate them from other ecorace Daba (Rao *et al*., 2003; Sharma and Rai, 2010; Reddy *et al*., 2010).

Tripathi and Tiwari (2021) additionally mentioned that biotic factors, including pests and diseases, contribute to the decline in the number of Raily ecorace population. Among the various pests that afflict tasar silk production, *Xanthpimpla pedator* is particularly notorious, causing substantial damage to both seed and commercial crops (Daba ecorace). The consequences of this pest infestation extend beyond the economic domain; it affects the quality, reliability, and market value of the cocoons. *X. pedator*, belonging to the family Ichneumonidae, is renowned for its parasitoid behavior, targeting Lepidopteran insects (Idris and Kee, 2002). These wasps stand out with their stout, bright-yellow bodies adorned with distinctive black spots, making them easily distinguishable within the Ichneumonidae family (Gadad *et al*., 2023). This genus predominantly thrives in tropical and subtropical regions, with a significant presence in Asia (Gómez *et al*., 2014). *X. pedator*'s life cycle involves the parasitization of *A. mylitta* silkworms during the pupal stage. The wasp uses its long ovipositor to drill through the silken cocoon and deposit a single egg in the abdominal segment. Notably, *X. pedator* is selective in its choice of hosts, preferring the early stages of cocoon formation when the cocoon is still pliable (Bhatia and Yousuf, 2013; Aruna and Devi, 2015; Marepally, 2016; Gathalkar *et al.,* 2017a; Gadad *et al.,* 2022). The cocoon toughens as the silkworm advances toward pupation, making oviposition more challenging. Despite parasitization, the silkworm completes its pupation process while the wasp egg hatches and the larva of *X. pedator* starts feeding on the silkworm pupal content. The appearance of *X. pedator* from its cocoon is marked by a unique circular opening (Fig. 1) near the peduncle (Singh *et al*., 2019). This parasitic wasp's presence significantly threatens the Raily ecorace population, causing considerable losses in cocoon yield and quality. This study seeks to quantify and understand the extent of cocoon loss attributed to *X. predator* and its implications for tasar silk production in Chhattisgarh, India.

MATERIALS AND METHODS

In the Bastar region of Chhattisgarh, a study spanned three districts and five blocks. These blocks were further divided into four sub-blocks each, notable for the Raily cocoon collection activities. In June, cocoon samples were systematically examined at sites where tribal collectors harvested the cocoons from the selected blocks. Subsequently, the collected cocoons underwent a thorough analysis to assess the incidence of Ichneumon wasp infestation, with the percentage of damage calculated.

In addition to the examination of damaged cocoon samples, deceased cocoons were collected and subjected to a destructive sampling method to identify the presence of Ichneumon wasp infestation (Fig. 1). Detailed maps were generated to visualize and analyze the distribution of cocoon damage caused by wasp infestation across various locations using ArcGIS Software. Further extent of damage was calculated by using the following formula.

$$\text{Percentage} = \frac{\text{No.of cocoons in a sample damaged by the ichneumon wasp}}{\text{Total no.of cocoons in a sample}} \times 100$$

In order to assess the relation between the estimated population distributions of Ichneumon wasp on Raily tasar silkworm cocoons in the forest ecosystem, the Poisson regression model was built by considering Ichneumon wasp number as the dependent variable and cocoons as the independent variable. The summarization of the insect count data was done by descriptive and exploratory data techniques.

RESULTS AND DISCUSSION

Population dynamics:

The descriptive statistics for the distribution of Ichneumon wasp sp under the host of Raily cocoons, the range distribution was 8 to 39, which produces sufficient variation and spread is more towards the right (Table 1). The Karl Pearson coefficient of skewness shows positive (>+1), which indicates that positively skewed population dynamics can be expected. Distribution of Ichneumon wasp, does not follow a normal distribution. The negative binomial regression model did not fit well to this data. Hence, the study considered the Poisson regression model for modeling the count data. The nature of the distribution of Ichneumon wasp counts was mapped in the form of a two dimensional histogram (Fig. 2, 3), which indicated approximately Poisson distributed data considered for the overall surveyed geographical area of the Raily ecorace.

Further, the Poisson regression model was built by considering Ichneumon wasp counts as a dependent variable and the number of Raily ecorace cocoons as the independent variable. The model was built separately for each district in order to understand the spatial ecological distribution of Ichneumon wasp sp under the Raily ecosystem. There is positive causal relationship between the number of wasp counts and Raily cocoons (B=0.0124** ; psudo R2=0.6213), (if there is an increase of one Raily ecorace cocoon in the forest ecosystem, then there will be chances of increment of Ichneumon wasp is about 0.12) which concludes that, there is the interaction between these two species in the ecosystem for all geographical areas of Raily ecorace of tasar silkworm. This model also explains the existence of predator-prey interaction between Ichneumon wasp as a parasitoid and raily ecorace as a host. The Psudo-R-square is about 0.6213, which indicates about 62.13 per cent of the variation in the dependent variable is explained by the independent variable, The K-S test values show significance (*) for all geographical ecosystems, which indicates the data is not from a normal population, which follows a non-normal distribution, which violates the assumptions of a classical linear regression model (Table 2).

Extent of Ichneumon Wasp Damage:

The damage ranged from 1.43 to 8.10 per cent across the various locations (Fig. 3). Examining individual districts within this forested area, Bastar district suffered the most from Ichneumon wasp damage, (23.50%). The Kondagoan district (20.50%); and the Dhantewada district recorded the least (17.00%) (Fig. 4). The district-wise variations in damage percentages underscore the

Table 1. Descriptive statistics for district wise distribution of Ichneumon wasp species

District	Min	Max	Mean	Std Dev	CV (%)	Kurtosis	Skewness
Bastar	9	39	25.63	12.19	47.56	1.75	1.20
Dantiwada	8	32	17.00	10.52	75.14	2.23	1.44
Kondagaon	17	26	20.5	4.04	20.73	1.30	1.09
Overall	8	39	22.00	9.00	44.00	1.99	1.60

Table 2. Maximum likelihood Estimates of Poison Regression Model

District	Parameter	B-Coefficient	Std. Error	Wald Chi-Square	P-Value	K-S test	Model Fitness (Pseudo R^2)
Bastar	Intercept	2.0695	0.2047	102.2104	0.000**	0.6523**	0.5637
	Raily Ecorace	0.0021	0.0004	27.5625	0.000**		
Dantiwada	Intercept	2.0532	0.4176	24.1736	0.000**	0.5841**	0.5249
	Raily Ecorace	0.0016	0.0006	7.1111	0.032*		
Kondagaon	Intercept	2.4834	0.506	24.0875	0.000**	0.5387**	0.4521
	Raily Ecorace	0.0012	0.0007	2.9388	0.041*		
Overall Data	Intercept	2.4987	0.1505	275.6482	0.000**	0.8549**	0.6213
	Raily Ecorace	0.0124	0.0013	90.9822	0.000**		

Note: * indicates Significance @ 5% level, ** indicates significance @ 1% level.

localized disparities in the infestation's severity (Fig. 5). Numerous studies and reports by researchers have thoroughly examined the infestation of the ichneumon wasp, *X. pedator*, in the commercial tasar silkworm race, Daba. These studies have covered its biology, the extent of damage, mating behavior, host location and various management strategies (Singh *et al.,* 2010; Marepally and Benarjee, 2016; Marepally and Benarjee, 2017; Gathalkar *et al.,* 2017b; Chandrashekharaiah *et al.,* 2018; Marepally, 2020). Whereas conventionally, Raily cocoons are thought to resist Ichneumon wasp infestations because of their robust and resilient nature of their silk shell. The Jata and Raily ecoraces are superior in shell weight and filament lengths, although their overall silk production is lower, and the silk filament is coarser with a higher denier compared to the commercial Daba race (Rao *et al.,* 2003; Reddy *et al.,* 2010; Chattopadhyaya *et al.,* 2018; Hemlal Sahu and Jayati, 2023. Before this study, there were no documented instances of Ichneumon wasp incidence on these durable cocoons. However, contrary to expectations, unmistakable symptoms of Ichneumon wasp damage were observed during the initial crop (Chaiti) harvests in June across the region.

This susceptibility highlights the adaptability and persistence of these parasitoids in identifying potential hosts (Gauld and Bolton, 1988; Tschopp *et al.,* 2013). Ichneumonids possess a unique capability to emerge from host pupae or cocoons through both mechanical and biochemical methods. Shaw *et al.* (2015), in their investigation of the emergence behavior within a variety of Ichneumonidae (Trogus subgroup), have indicated that the prevailing view holds true: the emergence from host pupae is primarily reliant on the action of the adult parasitoid's mandibles. However, they also suspected the possibility of using biochemicals during the emergence, as they have noticed staining around the edges of the emergence hole in some cases, such as *Nymphalis polychloros* (Linnaeus) parasitized by *Hoplismenus terrificus* (Wesmael) *Coenonympha pamphilus* (Linnaeus) parasitized by *Hoplismenus bispinatorius* (Thunberg), as well as in several Ichneumon species although it was not consistent. Similarly, Gadad *et al.* (2023) have documented instances of Ichneumonid infestation affecting the Daba ecorace of the tasar silkworm.

The research provides evidence that Ichneumon wasp infestation significantly impact the survival rates of Raily silkworms, consequently influencing their reproductive success. The ongoing threat posed by these parasitoids to the Raily population may lead to a decline in the population of Raily ecorace available for reproduction. This sustained pressure from Ichneumon wasp infestations has the potential to diminish the population size of the Raily ecorace over time, posing potential implications for the conservation and sustainability of this distinctive Tasar silk-producing lineage. Based on this available data helps the scientific team, policymakers, and

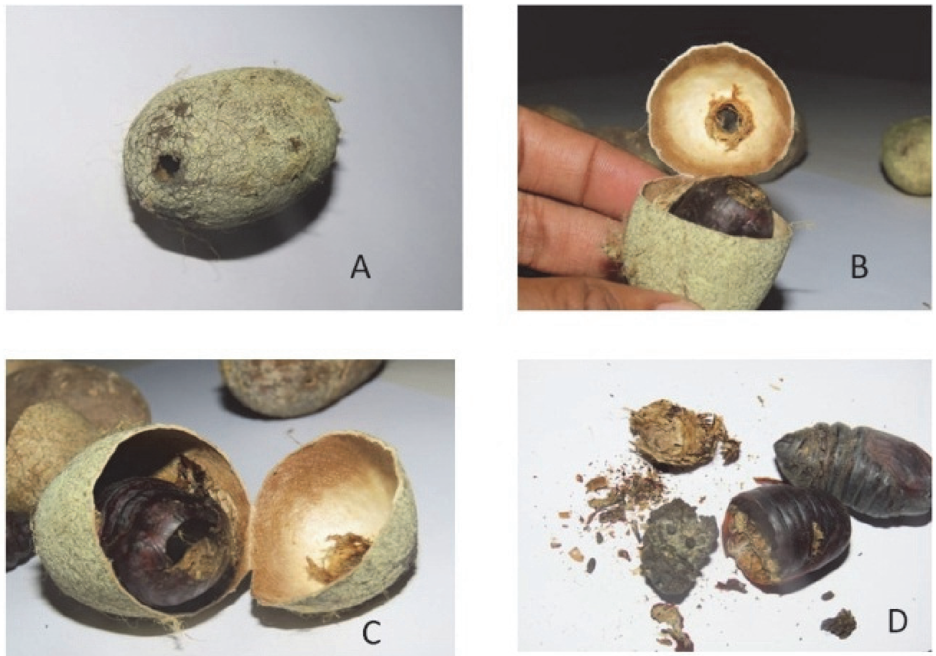

Fig. 1 A, B Ichneumon wasp emergence hole on Raily cocoon C emergence hole on pupa and D Excreta of wasp inside the pupa

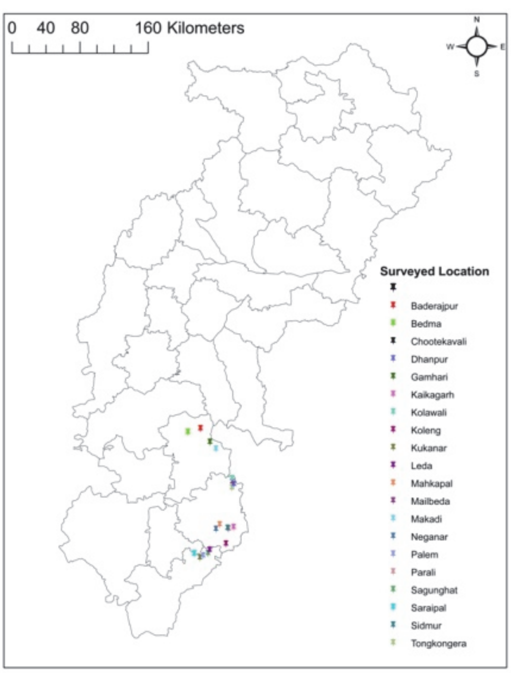

Fig. 2 Approximated poison distribution of Ichneumon wasp species

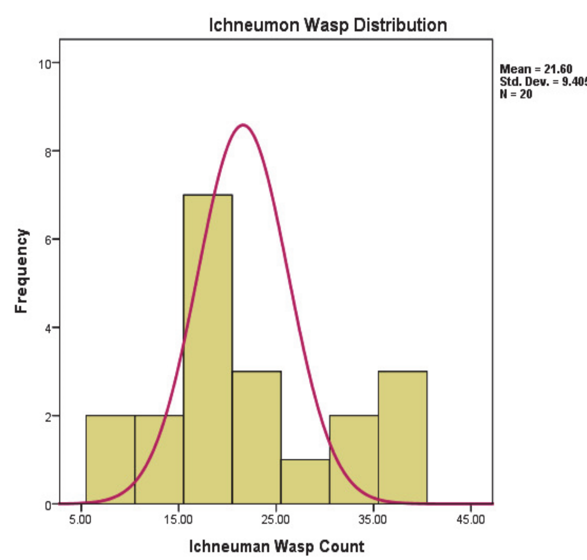

Fig. 3 Ichneumon wasp incidence recorded across the study areas

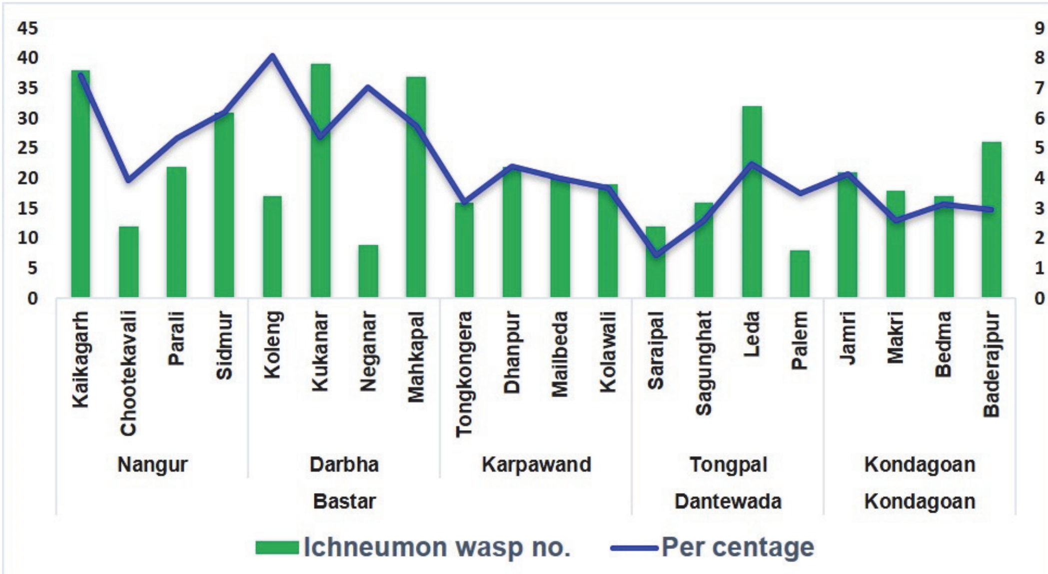

Fig. 4 Incidence and intensity of the wasp on tassar silk warm in diffrent districts of Chhattisgarh

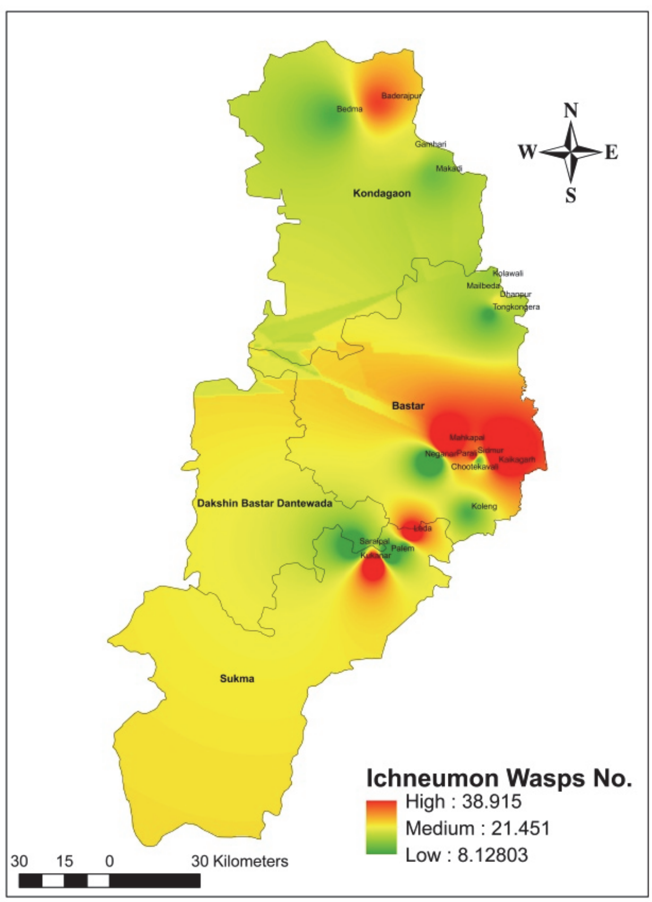

Fig. 5 Heat map showing the level of incidence of Ichneumon wasp across the study sites

tribal to make decisions for the effective conservation of Raily ecorace of tasar silkworm.

ACKNOWLEDGEMENTS

The authors are very thankful to the Basic Tasar Silkworm Seed Organization, Central Silk Board, Ministry of Textile, Government of India, Bilaspur, Chhattisgarh, India and Central Tasar Research and Training Institute, Ranchi, Jharkhand for providing the necessary facilities for conducting this study. All the authors also wish to thank the Heads/ Directors of their respective Departments/ Institutes for providing facilities for this work.

REFERENCES

Aruna A.S. and Devi A.R. (2015) Biology of a predatory bug *Eocanthecona furcellata* Wolff (Hemiptera: Pentatomidae) on Vapourer tussock moth larvae: a major pest of tasar silkworm food plants. Industrial Entomology 30: 26–30.

Bhatia N.K. and Yousuf M. (2013) Parasitic behavior of *Xanthopimpla predator* (Fab.) (Hymenoptera: Ichneumonidae) on tropical tasar silkworm, *Antheraea mylitta* Drury (Lepidoptera: Saturniidae) reared on seven forestry host plants in Uttarakhand, India. International Journal of Industrial Entomology 27: 243–264

Chandrashekharaiah M., Rathore M.S., Sinha R.B. and Sahay A. (2018) Studies on population dynamics of *Xanthopimpla pedator* (F) on tasar silkworm, *Antheraea mylitta* D in different agro-climatic zones of India. International Journal of Research and Development 5(9): 65–69.

Chattopadhyaya D., Rajiv M. and Chakravorty D. (2018) Studies on distribution of filament length and non-broken filament length for tropical tasar and muga silk cocoons vis-à-vis mulberry silk cocoons The Journal of The Textile Institute 109 (9): 1202–1207.

Dubey M.K. and Raut A. (2022) Socio-economic and Communicational Status of Tasar Silkworm Rearers in Bastar District of Chhattisgarh in India. Asian Journal of Agricultural Extension, Economics & Sociology 40(10): 1168–1174.

Gadad H., Bhagat A., Naqvi AH. and Kutala S. (2022) Host instar susceptibility and stage specific predatory potential of *Eocanthecona furcellata* on tasar silkworm *Antheraea mylitta*. Journal of Environmental Biology (l43): 702–708.

Gadad H., Prabhu D.I.G., Bhagat A., Singh J., Mittal V., Pandey J.P. and Kutala S. (2023) Mechanism of adult emergence in *Xanthopimpla predator* (Fabricius)- a major pupal parasitoid of Tasar silkworm. Journal of Environmental Biology 44: 513–518.

Gathalkar G.B., Barsagade D.D. and Sen A. (2017a) Biology and Development of *Xanthopimpla pedator* (Hymenoptera: Ichneumonidae): pupal endoparasitoid of *Antheraea mylitta* (Lepidoptera: Saturniidae). Annals of Entomological Society of America 110(6): 544–550.

Gathalkar G.B., Barsagade D.B. and Sen A. (2017b) Oviposition and feeding behaviour of *Xanthopimpla pedator* (Fabricius) (Hymenoptera: Ichneumonidae) on tropical tasar silkworm, *Antheraea mylitta* (Drury) (Lepidoptera: Saturniidae). Journal of Asia Pacific Entomology 20(3): 977–983.

Gauld I. and Bolton B. (1988) The Hymenoptera British Museum (Natural History). London: Oxford University Press. pp 332.

Gómez I.C., Sääksjärvi I.E., Broad G.R., Puhakka L.C., Castillo Peña C. and Diego D.P. (2014) The neotropical species of *Xanthopimpla* Saussure (Hymenoptera: Ichneumonidae: Pimplinae). Zootaxa 3774: 57–73.

Hemlal Sahu and Jayati Chatterjee Mitra. (2023) Assessment of variation in quality characteristics and reeling performance of tropical tasar cocoons for different ecoraces in Chhattisgarh. European Chemical Bulletin 12(5): 3040-3047

Idris A.B. and Kee S.S. (2002) Horizontal and vertical diversity of Ichneumonid wasps (Hymenoptera: Ichneumonidae) in the Sungkai Wildlife Forest Reserve in Perak, Malaysia. Journal of Asia Pacific Entomology 5: 85-89.

Marepally L. (2016) Studies on host age preference of *Xanthopimpla pedator*-A pupal parasitoid. Journal of Entomology and Zoology Studies 4: 512–514.

Marepally L. (2020) Evaluation of field and laboratory responses of male *Xanthopimpla pedator* to synthetic pheromone lures. International Journal of Pharmaceutical Sciences and Research 11(4): 1816–1822.

Marepally L. and Benarjee G. (2017) Studies on various factors affecting female sex pheromone release in *Xanthopimpla predator* - A pupal parasitoid of tasar silkworm. International Journal of Biosciences 3: 126–134.

Marepally L. and Benarjee G. (2016) Identification and Behavioral Evaluation of Sex Pheromone in *Xanthopimpla pedator* (Fabricius)-A Serious Pupal Parasitoid of Tropical Tasar Silkworm *Anthereae mylitta* Drury. Hayati Journal of Biosciences 23: 185–190.

Rao K.V.S., Mahobia G.P., Pande V.K. and Thangavelu K. (2003) Preliminary evaluation and utilization of Raily ecorace of *Antheraea paphia* L. Bulletin of Indian Academy of Sericulture 7(1): 70–76.

Reddy M.R., Sinha M.K., Kumar K.P.K., Gahlot N.S., Srivastava A.K., Kar P.K. and Prasad B.C., (2010) Influence of hybridization on the traits of silk production and filament Denier in Indian tropical tasar silk insect, *Antheraea mylitta* Drury. International Journal of Zoological Research 6: 277.

Sharma S.K. and Rai M.M., (2010) Biodiversity and conservation of tasar ecoraces. International Journal of Researches in Bioscience, Agriculture & Technology 2(7): 313–316.

Shaw M.R., Kan P. and Kan-van Limburg Stirum B. (2015) Emergence behaviour of adult *Trogus lapidator* (Fabricius) (Hymenoptera, Ichneumonidae, Ichneumoninae, Heresiarchini) from pupa of its host *Papilio machaon* L. (Lepidoptera, Papilionidae), with a comparative overview of emergence of Ichneumonidae from Lepidoptera pupae in Europe. Journal of Hymenopteran Research 47: 65–85.

Singh S., Jigyasu D.K., Roy D., Shabnam A.A. and Das R. (2019) Feeding behavior of two important predator bugs *Eocanthecona furcellata* Wolff and *Sycanus collaris* Fabricius in Muga Ecosystem. Research Journal of Agricultural Sciences 10: 185–188.

Singh U.N., Narain R., Chakravorthy D. and Tripathi P.N. (2010) Sex preference in host arasitisation of *Xanthopimpla pedator* Fabricius (Hymenoptera: Ichneumonidae), a major parasitoid of tasar silkworm. *Antheraea mylitta* Drury. Sericologia 50(3): 369–378.

Tripathi P.N. and Tiwari R.N. (2021) Sericulture in India: A Bioecological Approach. New Delhi (India). pp 14-20.

Tschopp A., Riedel M. and Kropf C. (2013) The evolution of host associations in the parasitic wasp genus Ichneumon (Hymenoptera: Ichneumonidae): convergent adaptations to host pupation sites. Evolutionary Biology 13: 74

(Received Agust 03, 2024; revised ms accepted November 13, 2024; published December 31, 2024)