Distribution Pattern and Breeding Ecology of *Idea malabarica* across Goa.

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By

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Examined by: Seal of the School

DECLARATION BY STUDENT

I hereby declare that the data presented in this Dissertation report entitled, **"DISTRIBUTION PATTERN AND BREEDING ECOLOGY OF *IDEA MALABARICA* ACROSS GOA**" is based on the results of investigations carried out by me in the Zoology at School of Biological Sciences and Biotechnology, Goa University under the Supervision of Dr. Nitin S Sawant and the same has not been submitted elsewhere for any award of a degree or diploma by me. Further, I understand that Goa University or its authorities will not be responsible for the correctness of observations/ experimental or other findings given in the dissertation. I hereby authorize the University authorities to upload this dissertation repository or anywhere else as the UGC regulations, demand and make it available to any one needed.

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Date:

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COMPLETION CERTIFICATE

This is to certify that the dissertation report entitled "**DISTRIBUTION PATTERN AND BREEDING ECOLOGY OF *IDEA MALABARICA* ACROSS GOA**" is a bonafide workcarried out by Mr. Anuraj Anant Gaonkar under my supervision in partial fulfilment of the requirements for the award of the degree of Masters in Zoology in the Discipline Zoology at the School of Biological Sciences and Biotechnology, Goa University

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CHAPTER I

INTRODUCTION

The Western Ghats forms an important bio-geographical zone in Peninsular India. It is a mountain range that runs along the western coast of India, extending from Tapti (21°N) to Kanyakumari (8° N). It is one of the most diverse hotspots of India with over 1500-1600 endemic species (Nayar, 1996).

The Western Ghats along with the west coast fall under the 'Malabar' botanical province (Clarke,1898; Joshi et al., 2004) and the 'Malabar Coast' is the stretch of land that runs from the southern tip of India in Kerala to the northern tip in Maharashtra.

Goa being a smallest State of India, harbors a total of 254 different species of Butterflies (Sharma and Borker, 2008) and (Ragnekar and Dharwadkar, 2009). With different types of macrohabitats, Goa is a Hotspot for Lepidopteran species and other flora and fauna.

Butterflies are considered to be a sign of elegance and grace. Aside from theiraesthetic values, butterflies are the second largest pollinators after honey bees. They are an ideal subject for ecological landscapes among insect. In addition, butterflies are very sensitive to even a little change in the environment hence they are considered as an 'indicator' species and indicate the health and quality of the environment. Also, they are easy to monitor and regular monitoring of their population can provide an early warning of the changes in the environment (Sreekumar and Balakrishnan 2001).

The *Idea Malabarica* (Moore, 1883)- Malabar tree nymph, is a species of butterfly belongs to the Danaid group of Family Nymphalidae. It is endemic to the Western Ghats of India and this species is known to occur at elevations ranging from 500 to 1500 meters above sea level (Kunte, 2000). It is a large butterfly (wingspan 120-150mm) and wings are predominantly white with black veins and borders. They have a unique flight in which rather than flapping wings vigorously they use slow gliding flight pattern to fly and due to this reason, they have been nicknamed as '*Paperkite'*. The flight is very weak and they are considered as one of the slowest flying butterflies. Like other milkweed butterflies, *I. malabarica* is unpalatable for their predators.

The Malabar tree nymph is listed as "Near Threatened" on the IUCN Red List of Wildlife Protection Act 1972. The species is threatened by habitat loss due to deforestation, as well as the use of pesticides and herbicides in plantations (Sondhi et al., 2020).

Goa is the eighth State in India to have its State Butterfly. Malabar Tree-Nymph has been declared as a State butterfly of Goa during the Fifth Bird Festival of Goa in December 2021. Also, some people consider the nomination of Malabar Tree Nymph as State Butterfly due to its peculiar flight resembling 'Susegad Goenkar'lifestyle.

Also, the nomination of the Malabar tree nymph as the State Butterfly of Goa was also intended to raise awareness about the importance of biodiversity conservation in the region. By highlighting the ecological and cultural significance of the butterfly, the state government hopes to encourage greater conservation efforts and promote sustainable development

practices. Despite being a charismatic species, there is limited literature available on its ecology and biology.

CHAPTER II

LITERATURE REVIEW

History of study of Indian butterflies is more than 225 years old. Indian butterflies were studied initially by Fabricus and Carmer as early as 1775. Faunistic explorations by subsequent workers like Horsfield (1828-29), Moore (1881), Marshall and de Niceville (1883), de Niceville (1886; 1890), Moore and Swinhoe (1890-1913), Bingham (1905), Bell (1909-1927), Ormiston (1924), Evans (1932) andYates (1935, 1946) has contributed much to our knowledge of these insects.

Butterflies of the Indian Region", published by Wynter- Blyth (1957) studied detailed account of the ecology and biology of Indian butterflies with good coverage of Western Ghats speciesIt is estimated that the Indian region harbors 1,641 species of butterflies representing roughly 9.50% of the total world species (Varshney, 2006). The most comprehensive study of butterflies of the peninsular India was carried out by (Kunte, 2000), where in, he reported 341 number of butterflies from Peninsular India and give detailed account of 173 species including Western Ghats. He also updated the data related to the host plants of butterflies.

Idea Malabarica- Malabar tree nymph belongs to the family Nymphalidae, subfamily Danainae, and tribe Danaini (Kunte, 2000). The species was first described by Moore in 1883 (Moore, 1883).

I. malabarica (Moore, 1883) is reported as confined to wet evergreen forests with heavy rainfall areas south of Goa to southern Western Ghats up to Kerala and is endemic to these areas (Evans 1932; Wynter-Blyth 1957; Larsen,1987; Kunte 2000; Rangnekar 2007; Kehimkar 2008; Sharma & Borkar2008).

The habitat of the *Parsonsia alboflavescens*, larval host plant of *Idea malabrica* was studied by Aishwarya and Revannavar (2018) and they stated that it is located in undisturbed swampy forest of WesternGhats of India and this plant is used for both laying the eggs and for foraging nectar by adult butterfly. The activity of adult butterfly was restricted to the above-described habitat, rarely found outside its territory. Susanth C. identified a new larval host plant *Parsonsia spiralis*of *I. malabarica* in 2005.

In 2013, Manoj Jadhav and R.M. Sharma studied and provided a distribution map of *I. Malabarica* in Western Ghats. Abin and Samson, 2018 found the presence of *Idea malabarica* in an urbanized area in Kochi city of Kerala which was an uncommon report for this species.

Borker and komarpant (2004) studied the butterflies of Bondla Wildlife Sanctuary and recorded that the activity of *Idea malabarica* was more during monsoon and post-monsoon season and was absent during the hotter months.

Latest study on *Idea malabarica* was done by Channabasava Veershetty and R. Maruthadurai (2022) in Goa and they gave a note on general biology, life cycle, habit and habitat and distribution of this butterfly in Goa.

Overall, the literature on the Malabar tree nymph is limited, with only a few studies focusing on itsbiology and ecology. Further research is needed to understand the species' life history, behaviour, and habitat requirements, which can inform conservation efforts and help protect this unique butterfly species.

CHAPTER III

OBJECTIVES

1. To study the distribution pattern of *Idea malabarica* Malabar tree nymph, across the Goa.

2. To study the breeding ecology of *Idea malabarica*.

3. To identify different nectar and larval host plants used by this butterfly.

CHAPTER IV

MATERIALS AND METHODS

Study Area

Goa has a diverse habitat that includes sandy beaches, rocky coastlines, tropical forests, wetlands and protected areas that are home to variety of flora and fauna. As wet evergreen forests with heavy rainfall areas are favorable for presence of *I. malabarica,* regions with suitable topographic and ecological ambience harbor them. Based on the criteria of accessibility and appropriate habitat for this butterfly, this study was operated within and around theprotected areas of Goa.The forest type in these areasis mainly semi- evergreen and moist deciduous.

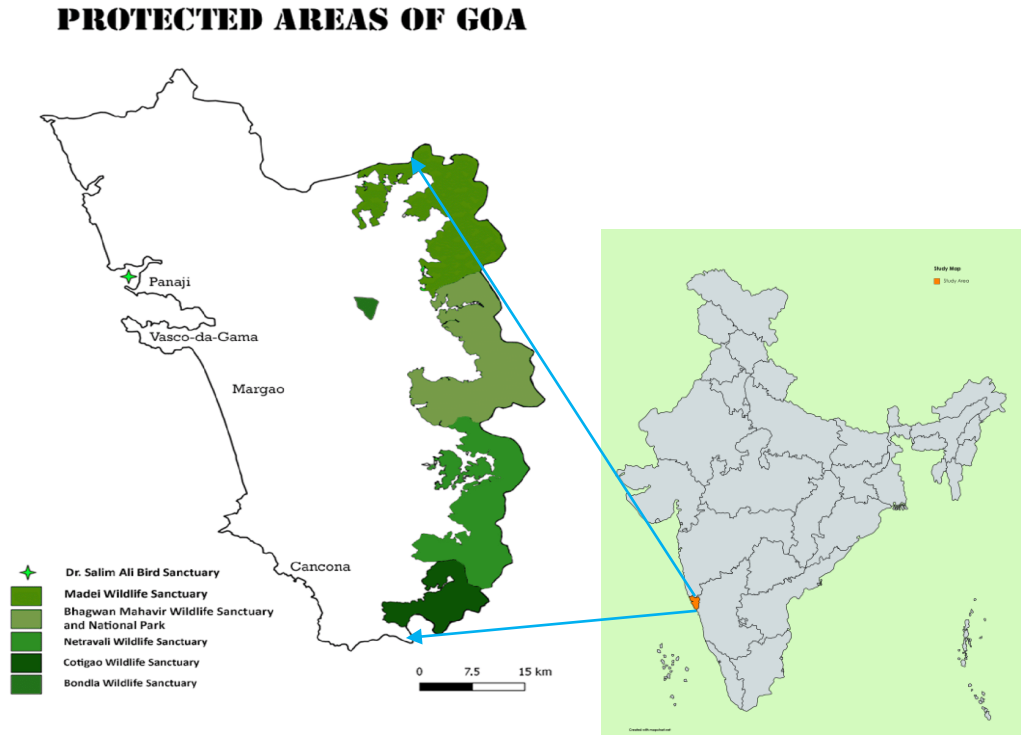

Figure. 1: Map of study area (Baidya, P., et al., 2018)

Figure 2. Selected sites used to studythe breeding ecology of *I. malabarica*

(a) Site 1; (b) Site 2

Site 1: Nirankarachi Rai: It is a sacred grove located in Nanora village of Sattari Taluka. The study site (**15°35'9.24**"N, **74°11'24.68**"E) has a dense vegetation with freshwater stream flowing across it. This sacred grove harbors Myristica swamp vegetation. Human interference is moderately less. The vegetation is dominated by tree species such as *Gymnacranthera canarica*, *Holigarna grahamii*, *Polyalthia fragrans* and *Lophopetalum wightianum* (Gaude and Janarthanam, 2005).

Site 2: Kulem: This study site (**15°19'54.36**"N, **74°15'38.74**"E) is located in Bhagwan Mahavir Wildlife Sanctuary and Mollem National Park in Dharbandora Taluka of Goa. The site has an ambience of dense vegetation with plenty waterfall; Dudhasagar being one of them. The railway track passes through the study area with no human habitation. *Leea indica, Dalbergia spp., Terminalia spp.* etc. being the dominated species of trees in this area.

\Surveying

The study was conducted for a period of 8 months from August 2022 till March 2023. For the study, pilot survey oftwo months (August- September 2022) was carried out and different sites were visited and surveyed. Through the pilot survey possible sites for butterfly's presence were identified and confirmed. Also, some sites were recognized from available literature and from previous records. Gaude and Janarthanam (2005) reported that *I. malabarica* is found mainly in the areas of swamp vegetation of Ajobachi Tali, Bibtyan, Nirankarachi Rai and Mharinginichi Rai in Sattari and Bhati, and Savari in sanguem. Of these, most of the sites were restricted to dense patch of forests.

To study the distribution pattern of *I. malabarica*, direct visual observation method was used (Kumar, M. P., et al., 2007). For the study of *I. malabarica* autecology, 2 sites; Nirankarachi Rai and Kulem (**15°19'54.36**"N, **74°15'38.74**"E) were selected randomly using a **Dice Method** and **Pollard walk** (Pollard, 1979) method was employed on these selected sites.

During the study different nectar and larval host plants were monitored and noted.*I. malabarica* was found to lay eggs on the underside of the leaves of *Parsonsia alboflavescens.* Other parameters likehumidity and temperature were recorded.

Breeding success was observed in natural habitat of butterfly as well as in laboratory conditions. The caterpillars along with leaf matter were collected and brought to laboratory and was reared in a plastic container. Mouth of the container was closed using muslin cloth to ensure easy ventilation for the larva. Young fresh leaves were supplied regularly to the

growing caterpillars as feed. Direct sunlight to the rearing container was avoided. Based on the casting of skin, the number of instars were documented. Color, shape, size and other morphological features were also observed.

The distribution map was prepared using **Google Earth Pro** app.

The photographs were taken wherever possible using **Realme Smartphone** and **Canon EOS 1200D Camera**.

CHAPTER V

OBSERVATIONS AND RESULTS

Distribution pattern of *I. Malabarica*

Idea malabarica is stated to be restricted at areasof wet evergreen forests with heavy rainfall South Goa to Southern Western Ghats up toKerala (Evans 1932; Wynter-Blyth 1957; Larsen, 1987; Kunte 2000; Rangnekar 2007; Kehimkar 2008; Sharma & Borkar 2008; Jadhav and Sharma, 2013).

Field visit was carried for the period of 7 months. From the on-going study, total 41sites belonging to seven different Talukas and two Districts (North Goa- 25 and South Goa- 16) of Goa were reported. The activities of adult *I. malabarica* wereobserved more during the month of September to November.

From the study it was observed that, in Goa, the distribution of *I. malabarica* starts from North- Eastern side of Goa and extends towards extreme South, mostly occurring in Protected Areas and their peripheries. No presence of *I. malabarica* was observed in extreme North side (pernem) and near coastal side of Goa.

Surprisingly, the presence of *Idea malabarica* was found in the center part of Goa at Keri (15.26’18.72” N, 73.58’56.82” E) in Ponda Taluka and Nanda Lake (15.14’28.87” N, 74.6’18.79” E) in Quepem taluka, kilometers away from the Western Ghats. In some places like Kudne (15°32'55.59"N, 74° 1'1.08"E) *I. malabarica* was observed actively in human dominated areas such agricultural fields and in human settlement areas.

Table 1: Taluka wise distribution pattern of *Idea Malabarica*.

Sr. No	District	Taluka	Place	Latitude	Longitude
1	North Goa	Sattari	Satrem	15°36'39.68"N	74°12'56.00"E
2			Nirankarachi Rai, Maloli	15°35'9.24"N	74°11'24.68"E
3			Chidambar Temple	15°35'47.13"N	74°11'18.05"E
4			Codal	15°35'51.51"N	74°12'2.57"E
5			Golauli	15°36'58.13"N	74° 8'28.42"E
6			Kopardem	15°35'43.67"N	74° 8'37.28"E
7			Dhave	15°33'27.68"N	74°10'24.54"E
8			Ambedem- Maloli Road	15°33'49.13"N	74°10'8.40"E
9			Querim	15°36'20.01"N	74° 4'24.28"E
10			Poriem	15°35'15.06"N	74° 1'39.16"E
11			Poriem	15°35'34.21"N	74° 1'58.31"E
12			Velgem	15°30'47.85"N	74° 8'24.47"E
13			Sonal	15°32'33.24"N	74°11'31.87"E
14			Vainguinim	15°35'8.83"N	74°13'50.08"E
15			Ustem	15°33'38.17"N	74°12'10.68"E
16			Brahma Karmali	15°34'8.40"N	74° 9'43.23"E
17			Dhamshem	15°28'15.69"N	74° 7'39.30"E
18				15°28'51.62"N	74° 7'49.17"E
19			Bimbal, Khotodem	15°28'56.72"N	74° 9'18.71"E
20			Gawane	15°28'47.64"N	74° 9'45.10"E
21			Tamdi- Surla	15°26'16.44"N	74°15'25.93"E
22				15°25'41.96"N	74°15'56.77"E
23		Bicholim	Kudne	15°32'55.59"N	74° 1'1.08"E
24			Gauthan	15°32'59.29"N	74° 1'5.56"E
25			Navelim	15°32'4.49"N	74° 0'39.31"E

26	**South Goa**	**Sanguem**	**Satpal**	**15°24'26.79"N**	**74°11'47.23"E**
27		**Dharbandora**	**Mollem**	**15°21'50.37"N**	**74°12'4.24"E**
28			**Kulem**	**15°19'54.36"N**	**74°15'38.74"E**
29				**15°19'51.84"N**	**74°15'44.88"E**
30		**Ponda**	**Bondla WLS**	**15°26'30.41"N**	**74° 5'52.78"E**
31				**15°25'57.41"N**	**74° 6'28.00"E**
32			**Keri**	**15°26'18.72"N**	**73°58'56.82"E**
33		**Quepem**	**Nanda Lake**	**15°14'28.87"N**	**74° 6'18.79"E**
34		**Sanguem**	**Mainapi Waterfall**	**15° 4'2.53"N**	**74°15'10.28"E**
35			**Savri Waterfall**	**15° 3'40.34"N**	**74°13'54.93"E**
36			**Nteravali WLS**	**15° 3'54.29"N**	**74°14'4.12"E**
37				**15° 4'44.30"N**	**74°14'28.88"E**
38		**Canacona**	**Kuske**	**15° 1'3.45"N**	**15° 1'3.45"N**
39			**Cotiigao WLS gate**	**14°59'5.99"N**	**74° 6'36.14"E**
40			**Cotigao WLS**	**14°58'35.14"N**	**74° 9'5.37"E**
41				**14°58'49.45"N**	**74° 7'31.23"E**

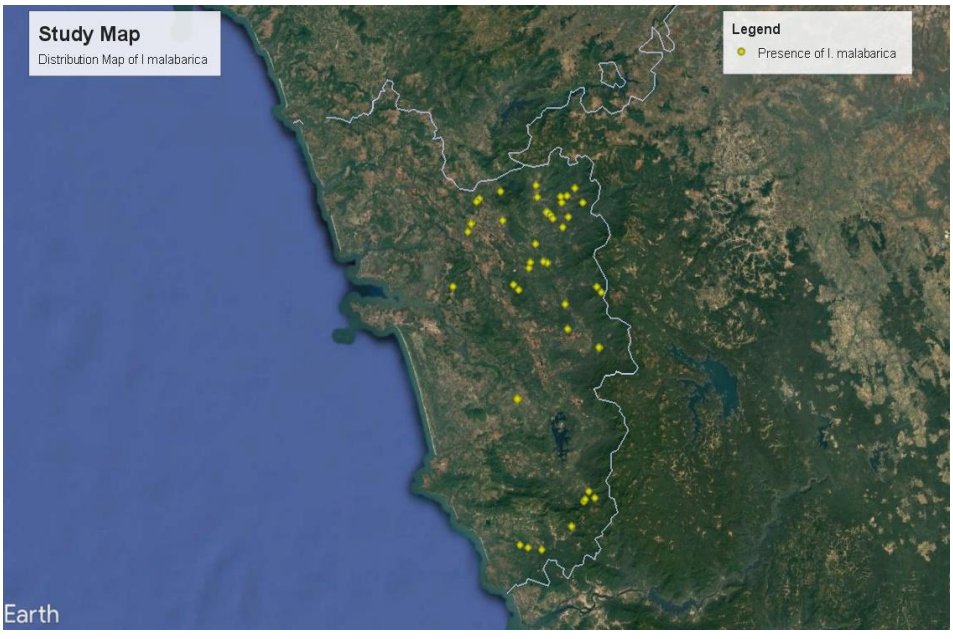

Figure 3: Map of Goa with distributional records of *Idea malabarica***.**

Breeding ecology of *I. Malabarica*

i. Adult stage

Field characters: Wingspan of adult butterfly varies between 110- 150mm. Male and female individuals are morphologically identical except for the scent scales which are present in males. Body is white in colour with a black band running dorsally from the thorax till the abdomen. They have a long antenna with a rounded white or creamish clubbed at the end. Head and Thorax are spotted and eyes are of black colour.

Wing structure and coloration is white with black venation and are semitransparent. Black venation is thicker at the edges of forewings.

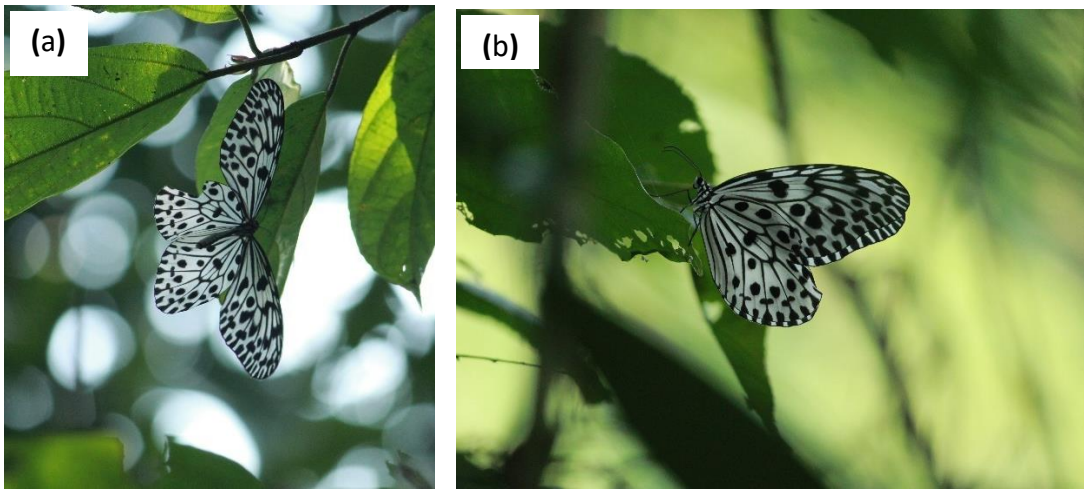

Figure 4: Adult butterfly of*I. malabarica*

(a) Open-winged (b) Close-winged

Habit: It was found flying close to the ground during patrolling at an approximate height of 2-3 meters. As it approaches near the host plant, its flight slows down. They rest their body both by keeping wings open or closed. Usually sits for basking during morning- afternoon

time by spreading wings wide open. During the courtship display, male chases the female and if the female sits, male performs courtship display by tickling the female and flapping its wings rapidly. The number of adults of *I. malabarica* was observed more on site 2 compared to that of site 1.

Figure 5: Courtship display of *I. malabarica*

Habitat: The habitat of *I. malabarica* is characterized by moist climate and undisturbed vegetation. The ongoing study imposes the presence of *Idea malabarica* in dense forests as well as in segregated patch of forest in human settlement areas. The species was dispersely found in different types of microhabitats like, forest patch, Areca-nut plantations, spice plantations, wetland and roadside.

Figure 6: Different locations where I. malabarica was documented.

(a); Bondla, **(b);** Tamdi Surla, **(c);** Maloli, **(d);** Nanda Lake

i. Egg Stage

Mating lasted for 30-40 minutes. The female lay eggs singly on the underside of the both young and matured leaves of their host plant. The eggs were oval in shape, white-yellowish in colour when laid. One closer observation, eggs were observed to have a regular bumpy surface. Egg turns translucent and black near the opening before hatching. In about 4-5 days, larva hatches out from the egg.

Maximum 4 eggs were laid on a single leaf. The larva consumes its egg shell as its first meal after hatching.

ii. Larval Stage

The caterpillar undergoes Five (I, II, III, IV and V) developmental stages in span of 14-17 days. It is black white in colour with red dots on its lateral sides. 4 pairs of filaments are present, 3 on the anterior side and one pair of filamenton anterior side.

Instar I- Stage lasted for 2-3 days. The body was light green to yellowish in colour with a prominent black head and with 4 pairs of small filaments or horn like structures, 3 on anterior side and one pair of filaments on posterior side.

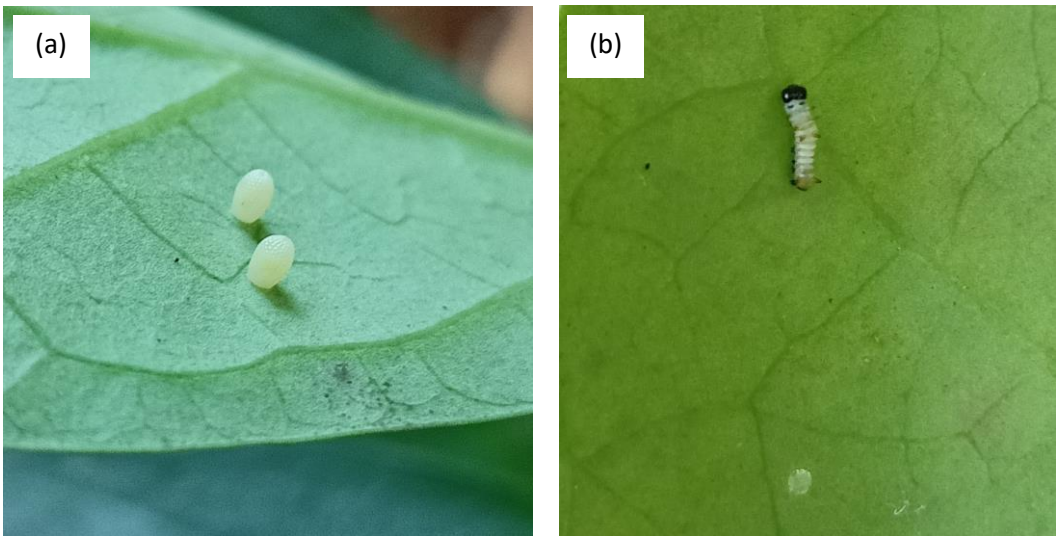

Figure 7: (a) Egg; (b) 1st instar caterpillar

Instar II- This instar develops in 2-3 days. After the shedding of skin, black and white bands are visible in this stage. Total 12 white-colored bands are present. Pair of filaments are clearly visible and these are present on 1st ,2nd ,4th and 10thblack band of caterpillar.

Instar III- This stage lasted for 2-3 days. Caterpillar feeds vigorously on fresh leaves. Size of the caterpillar increased. Segmentation was clear. Red dots on the lateral sides on black bands were clearly visible. Total 6 pairs of red dots were present starting from the 4th black colored band till 9th band.

Figure 8: 3rd instar caterpillar

Instar IV and V-Stage lasted for 3-4 days and 4-5 days respectively. There was a rapid increase in size of caterpillar. No other changes in the other characters from the previous instar.

A unique behavior of feeding in caterpillars of *I. Malabarica* was observed and noted. Unlike the caterpillar of other butterflies, caterpillars of *I. malabarica* feed on the leaves from the center of it rather than edge of the leaf. This was observed in all the stages of caterpillar.

Figure 9: Unique pattern of feeding observed in larvae of *I. malabarica*

iii. Pupa

The V instar caterpillar stops feeding, shrinks itself and turns in pupa. The chrysalis starts out very pale yellow before turning golden. Black colour marking appear on day 6-7 and are clearly visible. Pupa turnstransparent on the day before the emergence of adult. This stage lasted for 12-14 days.

The duration of life cycle from the egg to the formation of adult butterfly is spanned over 29-37 days (Egg 4-5 days; larva 13- 18 and pupa; 12- 14 days).

Nectar Plants

The adults of *Idea malabarica* butterflywas found actively during the study period. They feed on nectar of flowers of various plants during the particular period of the year. Adult butterflies of *I. malabarica* was observed foraging on total 5 different species of plants. Plant name along with flower colour and flowering season are listed in the **Table 4** below.

Table 2: List of nectar host plants used by *I. malabarica.*

Sr. No	Floral Plants	Flower Colour	Flowering Season
1	*Leea indica*	White	March- September
2	*Eupatorium perfoliate*	White	August- November
3	*Lantana camara*	Pink and Yellow	Throughout the year
4	*Calycopteris floribunda*	Greenish- yellow	Januray- May
5	*Ixora sp.*	White	March- May
6	*Parsonsia alboflavescens*	White	March- June

Larval Host Plants

During the study, adult butterfly of *I. malabarica* was seen laying eggs on a species of climber plants, *Parsonsia alboflavescens* or*Parsonsia spiralis.* Complete life cycle of butterfly was observed and recorded on mentioned plants. In the study areas of Kulem, the height of the plant was more (10-15 meters) as compared to that of Nirankarachi Rai (0.5- 3 meters).

***Parsonsia alboflavescens*:** It is a woody climber belonging to the family Apocynaceae and found semi- evergreen to evergreen forests of Southern part of India. Habitat of *P. alboflavescens* is undisturbed, cool, moist with diversified flora and fauna. Stem is grey and leaves are ovate. The older *P. alboflavescens* climb over the trunk, canopy of tall forest trees

(B & Revannavar, 2018). Flowering and fruiting period of this plant is from March- June. Other synonyms are *Parsonsia spiralis* and *Parsonsia inidora.* Caterpillars of Idea malabarica feed on leaves and pupate and adult butterflies feed on nectar and pollinate P. alboflavescens (B & Revannavar, 2018).

Figure 10: Larval host plantof *I. malabarica: Parsonsia alboflavescens*

Population Index

Table 3: Population index of *I. malabarica* in their natural habitat

Month	No. of eggs		No. of larvae		No. of pupae	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
September 2022	03	0	04	0	0	0
October 2022	07	03	03	04	01	0
November 2022	11	05	09	02	01	0
January 2023	04	05	03	04	0	0
February 2023	04	04	07	01	0	0
March 2023	02	00	03	02	0	0

Population index of eggs, larvae and pupae were assessed monthly during the study period at two different sites and is represented in Table 3. Number of frequencies of all the three stages were found higher during the month of October and November. Also, the number of all the stages recorded was more at Site 1 compared to that of Site 2. This can possibly due to difference in weather conditions at both sites.

Table 4: Pupa and adult development success of *I. malabarica* in laboratory conditions**.**

Month	Number of Larvae	Number of Pupae	Number of Adults
October	2	0	0
November	8	2	2
January	1	0	0
February	3	1	1
March	4	0	0

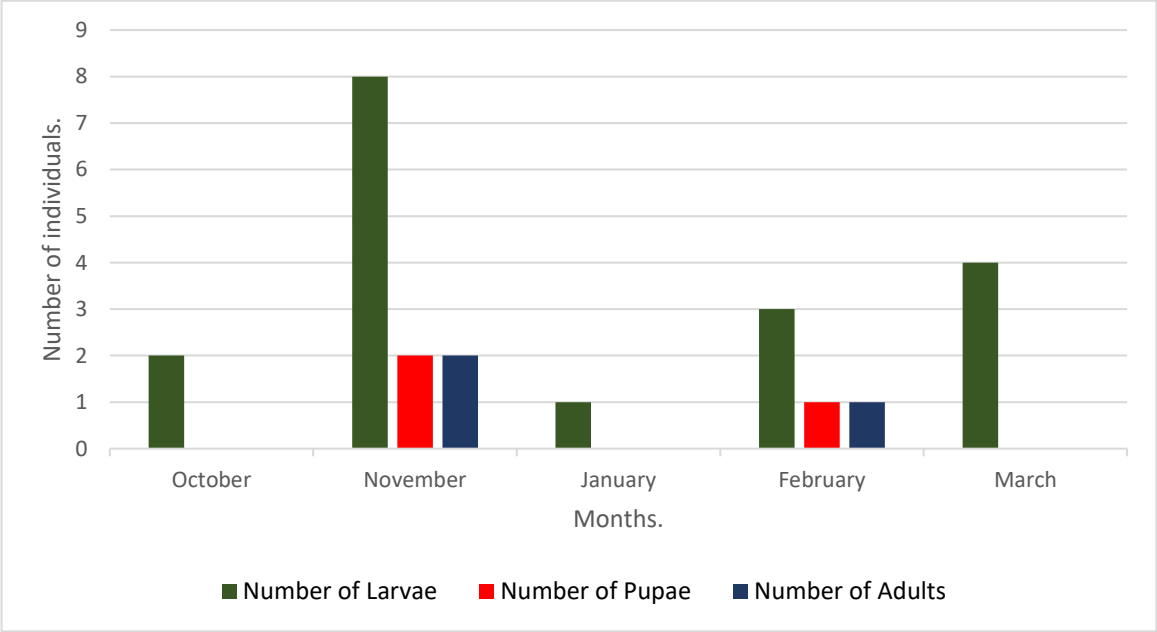

Figure 11: Graph representing the pupa and adult development success of Idea malabarica in laboratory**.**

Figure 11 represents the pupal and adult development success of I. malabarica in laboratory conditions. It was observed that form larval sage to pupal stage, success rate is very low (16.66%). All the pupae were successfully emerged into adult butterflies.

Table 5: Early stages of *I. malabarica* associated with weather conditions.

	Month					
	Sept 2022	Oct 2022	Nov 2022	Jan 2023	Feb 2023	Mar 2023
Early life stages	07	18	27	16	16	06
Relative Temperature	27.5	29.75	28.33	29.25	30.33	31.75
Relative Humidity	80.88	65.25	58.66	47.5	45	76.75

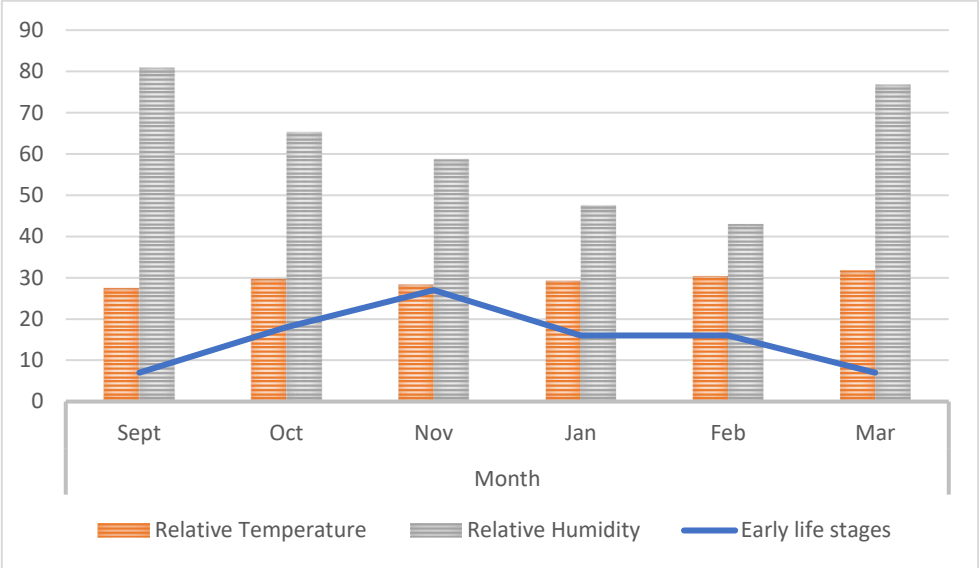

Figure 12: Graph representing the early stages of I. malabarica with weather conditions

Figure 12 shows the graphical representation of early stages of *I. malabarica* associated with the weather conditions. It was observed that the presence of early stages of I. malabarica was less during the month of September and March. The relative temperature of these months was 27.5 ℃ and 31.5℃ respectively and humidity was also high. In October- November 2022 and January- February (2023), the number of early stages found was more in number. The

temperature and humidity variation in these months were 28℃- 31.5℃ and 45%- 65% respectively.

CHAPTER VI

DISCUSSION

Formerly, in the State of Goa, the knowledge on the distribution pattern and ecology of *I. malabarica* was limited. Through this study, 41 different sites belonging to seven different Talukas and two Districts of Goa were identified and documented. It was revealed that the distribution of *I. malabarica* starts from the North-Eastern side of Goa and extends towards the extreme South, occurring mostly in protected areas (PAs) and their peripheries.

Previously, *I. malabarica* has been reported as confined to wet evergreen forests with heavy rainfall areas of Western Ghats and is endemic to these areas (Evans 1932; Wynter-Blyth 1957; Larsen,1987; Kunte 2000; Rangnekar 2007; Kehimkar 2008). Findings of this study suggest that the distribution of *I. malabarica* in Goa is not limited to the wet evergreen forests of Western Ghats only, the presence *of I. malabarica* in the central part of Goa, away from the Western Ghats, indicates that the species may have adapted to different habitats and climatic conditions or suitable habitats for the species may exist outside the mentioned areas. This finding is significant because it expands the known range of the species and indicates that the butterfly may have a wider distribution than previously thought. Also, efforts to conserve this species may need to consider the protection of habitats outside the protected areas as well.

Our study is the first study about the breeding ecology of I. malabarica across India.

Considering the status of *Idea malabarica* (Malabar tree nymph), not much literature is available on its ecology. The study of larval host plants of the *I. malabarica* is an important aspect in understanding the biology and ecology of this species. Our study includes the feeding behaviour of both early stages and adult stage of *I. malabarica* including their activity with respect to temperature and humidity. In 2018, Aishwarya and Revannavar studied about one of the host plants of *I. malabarica; Parsonsia alboflavescens* and stated that this plant is used by the butterfly for both laying eggs and foraging nectar. Similar kind of behavior was observed and documented with pictorial proofs in our study. The presence of the butterfly on this plant is also influenced by the height of the plant, as observed in the study areas of Kulem, where the height of the plant was between 10-15 meters, as compared to Nirankarachi Rai, where the height ranged from 0.5-3 meters. This observation indicates that taller *P. alboflavescens* plants could potentially support larger populations of *I. malabarica* or might been because of other factors. More study on this topic is required.

Till date, no specific research is done on types of nectar plants used by *I. malabarica* for foraging. In this study, 6 different species of nectar plants (*Eupatorium perfoliatum*, *Lantana camara*, *Calycopteris floribunda*, *Leea indica*, *Ixora sp.* and *Parsonsia alboflavescens*) were identified and additional information on their flower colour and flowering season is provided. The observation that the adults of *I. malabarica* prefer flowers of different colours and flowering seasons is consistent with the general foraging behaviour of butterflies. This preliminary data on nectar plants can serve as an important record that could aid in the development of conservation strategies of this butterfly species.

During the course of this study, all the stages of life cycle of *I. malabarica* was observed and studied thoroughly both in laboratory conditions and in their natural habitat. In laboratory conditions, though all parameter were made favorable for their growth it was observed that the success rate of larvae to pupae was very low. Further studies are required to understand the actual reason why there was low success rate.

Different morphological features of all the stages are highlighted in our study. Also, an exclusive pattern of feeding was observed and noted in the caterpillars of *I. malabarica* in which they seen feeding on leaf from its center rather than from the edges (Figure 8). This work can be of use for further studies on the ecology and biology of other butterflies.

Assessment of population revealed that the number of frequencies of all the three early stages were found higher during the month of October- November (2022) and January- February (2023). The temperature and humidity variation in these months were 28℃- 31.5℃ and 45%-65% respectively. Least number of stages were found in the month March 2023. The relative temperature in march was 31.75% humidity was 76.75.%. This indicates that weather conditions affect the breeding of *I. malabarica* and through the data obtained, we can assume that 28-31℃ is a favourable temperature for the growth of early stages of *I. malabarica*.

Due to time constraints and limited literature available, the study had limitations in terms of the breadth and depth of the research. The academic schedule also played a role in limiting the ability to conduct more extensive fieldwork. However, despite these constraints, the study still provides valuable insights into the distribution and breeding ecology of the Malabar Tree- nymph in Goa. It highlights the importance of further research in this area to better

understand the conservation needs of this species and promote effective management strategies.

Conclusion

The present study aimed to investigate the distribution pattern of the *Idea malabarica* (Malabar Tree- nymph) and its breeding ecology across Goa. The results revealed that the butterfly exhibits a patchy distribution across the state, with maximally observed in forested regions and lower in urban areas. Additionally, the study provided insights into the breeding ecology of the species, with observations of mating behavior, oviposition sites, and larval stages. However, several limitations were encountered during the course of the study, including time constraints, limited literature, academic schedule, and transportation. These limitations may have influenced the accuracy and generalizability of the findings, and further research is necessary to address these issues.

Despite the limitations, this study has important implications for the conservation of the Malabar Tree- nymph. The species is listed as 'Near Threatened' according to IUCN Red List, and as the State Butterfly of Goa, it holds significant cultural and ecological importance. The findings of this study can be used to inform conservation efforts, such as identifying areas of high conservation priority, designing habitat restoration programs, and implementing monitoring programs to track changes in population size and distribution. Moreover, the study highlights the importance of citizen science and community involvement in butterfly conservation, as the majority of the observations were made by local residents and butterfly enthusiasts.

Overall, this study contributes to our understanding of the distribution and breeding ecology of the *Idea malabarica* in Goa, and provides a foundation for future research and

conservation efforts. By addressing the limitations identified in this study and building upon these findings, we can work towards ensuring the long-term survival of this iconic and threatened species.

CHAPTER VII

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