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Note from the Chief Editor

Dear Entomologists/ members of AAE,

Warm welcome to an overview of the current status of ENTOMON.

ENTOMON has completed 50 glorious years. The first issue was brought out in 1976 with Professor T.N. Ananthakrishnan, as the Editor in chief, Professor V.K.K. Prabhu, as the Managing Editor, and Professors G.K. Karnavar and N.R. Prabhoo as Associate Editors. Professors K.J. Joseph, M.R.G.K. Nair, N.C. Pant, D.N. Raychaudhuri and K.N. Saxena as Editors. On this occasion of the golden jubilee year of ENTOMON, let us reminisce with reverence and veneration, the illustrious academicians behind this venture - Professors T.N. Ananthakrishnan, V.K.K. Prabhu, G.K. Karnavar, N.R. Prabhoo, K.J. Joseph, M.R.G.K. Nair, K.S.S. Nair, N. Mohandas, K.S Pillai, R.V. Varma, D. Muraleedharan and many others of equal importance to all of us.

We record, with profound sadness, the demise of the former Editor, Professor V.K.K. Prabhu and the former President of AAE, Dr K.S.S. Nair.

During 2025, ENTOMON published 69 original peer reviewed articles in four issues. This year we have initiated an informative Monograph Series with the publication of - The butterflies (Lepidoptera, Rhopalocera) of Kerala: Status and distribution.

The journal as we all know, covers agricultural entomology, aquatic entomology, acarology and arachnology, entomophagy, forensic entomology, forest entomology, medical entomology, veterinary entomology, various aspects of apiculture, biodiversity, biological control, biotechnology, botanical insecticides, eco-biology, integrated pest management, morphology, nano technology, new species, reports, physiological aspects, pest outbreaks, pollinators, sericulture, systematics, toxicology and vectors.

It is encouraging that there is an upsurge in the submission of manuscripts to ENTOMON, indicating its wide recognition among the entomologists, and subscriptions from stakeholders both nationally and internationally. ENTOMON is now open access, under a Creative Commons Attribution-ShareAlike 4.0 International (CC-BY-SA) license,

providing free and immediate access globally. All published individual articles from 2013 (volume 38) are available in the journal website for free download. Published issues of the journal are available on the Internet Archive (<https://archive.org/details/entomon-vol-14-issu-no-3-4-december-1989/ENTOMON/2047/20/284/29/202022/>). Individual articles with DOI numbers including the issues are also being uploaded in the web site. We are in the process of uploading all articles from the year 1976 onwards. It is inspiring to note that the issues of ENTOMON are published as per schedule.

Another news to share is that, ENTOMON is archived in CABI's full text repository and is partnering with EBSCO. University Grants Commission, New Delhi has listed ENTOMON in the UGC Care List of approved journals. The National Academy of Agricultural Sciences, New Delhi, has given a NAAS score of 5.24 for ENTOMON, with effect from January 2024. ENTOMON is included in the Web of Science Master Journal List (Clarivate). The Journal is indexed in Scopus, Web of Science, EBSCO and CAB International. SCOPUS, Elsevier's abstract and citation database, is indexing ENTOMON with effect from 2012. The cite score of ENTOMON is 0.40, and SC Imago Journal Rank (SJR) and the Source Normalized Impact per Paper (SNIP) are 0.155 and 0.212, respectively. ENTOMON is a member of the Committee on Publication Ethics (COPE) and the journal follows the guidelines of COPE. The page charges and colour page charges have been reduced to US \$ 4/page for overseas authors from south-east Asia, and underdeveloped economies as per the UN criteria.

The subject matter specialists and peer reviewers have been very constructive on the referred manuscripts and of course with critical views wherever needed. These valuable comments and suggestions, is the backbone of quality that enabled critical evaluation of manuscripts to decide on their potential acceptance or rejection. A focus on standard practice requires that manuscripts submitted in accordance with ENTOMON format, available in the website. This saves processing time and more importantly reviewer's precious time. It would be more professional if authors, pay attention to the Instructions/guidance to the contributors and published articles. ENTOMON always welcomes scientific papers which would merit academic National and International interest.

Executive Committee members and the editors serve ENTOMON on a voluntary basis. The services of Professor K. Madhavan Nair, as the Website Manager of the AAE and ENTOMON is gratefully acknowledged. M/s SB Press, Thiruvananthapuram is in full support in bringing out ENTOMON issues on time.

ENTOMON volume 51, issue 1 (March, 2026) is presented before you.

“Excellence is a concept that embodies a commitment to continuous improvement and a relentless pursuit of perfection. ENTOMON strives for it”

*With sincere regards
March 31, 2026*

*Dr. M.S. Palaniswami
Chief Editor*

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A new species of *Euthalia* Hübner, 1819 subgenus *Limbusa* Moore, [1897] (Lepidoptera, Nymphalidae, Limenitidinae, Adoliadini) from Arunachal Pradesh, Northeast India

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ABSTRACT: A new species of *Euthalia* Hübner, 1819 (subgenus *Limbusa* Moore, [1897]) (Lepidoptera, Nymphalidae, Limenitidinae, Adoliadini) is described from Arunachal Pradesh, northeastern India. This species, *Euthalia (Limbusa) zubeengargi*, Sadasivan & Upadhaya **sp. nov.**, is assigned to the *Patala* group of *Limbusa* based on its wing pattern, venation, and male genital morphology. A detailed description of the male and its genitalia is presented, along with a revised key to the males of Subtype A2 of the *Patala* group sensu Yokochi (2011). © 2026 Association for Advancement of Entomology

KEY WORDS: New taxon, butterfly, duke, *Patala* group, morphology, Basar, Eastern Himalayas, taxonomic key

INTRODUCTION

Butterflies of the subgenus *Limbusa* Moore, [1897] of *Euthalia* Hübner, 1819 inhabit broad-leaved forests of the Oriental Region, particularly in northeastern India, southern China and Indochina, and extend northwards into the temperate Sino-Himalayan zone (Yokochi, 2010; Huang *et al.*, 2016). They are characterised by a brown ground colour variably suffused with bluish-green iridescence and a well-defined series of creamy-yellow to white discal spots on the wings (Yokochi, 2010). The group was comprehensively revised by Yokochi (2010, 2011, 2012) and currently

comprises more than 80 recognised species (Yokochi, 2010, 2011, 2012; Lang, 2012, 2025; Saito and Inayoshi, 2014; Yoshino, 2023).

Species of the subgenus *Limbusa* are classified into three principal groups—the *Patala*, *Franciae*, and *Nara* groups—based on external facies and male genital morphology (Yokochi, 2011). The *Patala* group, which contains most *Limbusa* species, is defined by a uniformly pale-brown underside lacking the glittery silver typical of the *Nara* group, males that are generally larger with forewing lengths commonly exceeding 40mm and a less acute hindwing angle, and a yellowish

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upperside suffusion that does not extend into space 7. Diagnostic wing markings include a continuous pale discal band (or its remnant) on the hindwing running from costa to dorsum, a distinct median white spot in space 6, and conspicuous submarginal spots in spaces 8 and 6 on the forewing. The male genitalia bear an elongated valva with apical serrations, showing species-level variations, whereas the females are typically larger and exhibit species-dependent sexual dimorphism with correlated pattern elements across sexes (Yokochi, 2010, 2011, 2012). Within the *Patala* group, male hindwing spotting permits recognition of Type A, characterised by a discal band (or trace) in hindwing extending from the costa to the dorsum without paralleling the termen, and Subtype A2, in which a line connecting the forewing postdiscal white spot in space 6 and the postdiscal spot in space 3, when extrapolated, reaches the termen (Yokochi, 2011).

Fieldwork in the Basar region of Arunachal Pradesh, India, yielded several individuals of an undescribed *Euthalia* species with a distinct and stable external phenotype. Morphological assessment of the captured male, supplemented by high-quality field photographs of an additional male, unequivocally indicated that this taxon is distinct from all currently recognised species. Although an extensive targeted collection was attempted for several months, no further material could be secured. Therefore, proceeded with the formal description of this species based on a single adult male, corroborated by multiple photographic records from the type locality. Although the description is presently based on a single male specimen, a formal taxonomic treatment is justified by the documented stability and diagnosability of external wing characters in *Limbusa* (Yokochi, 2010, 2011, 2012), together with the clear, non-overlapping distinctiveness of male genital morphology as a primary species-level diagnostic trait in the *Patala* group (Yokochi, 2010, 2012).

MATERIALS AND METHODS

The taxonomy of *Euthalia* Hübner, 1819, follows the treatments of Yokochi (2010, 2011, 2012), and species-level identification was performed using the diagnostic keys provided therein. Specimen imaging

was performed using a Canon EOS 70D DSLR camera fitted with a 180mm macro lens and an MP-E 65 mm f/2.8 1–5× macro lens. The male genitalia were treated overnight with KOH, dissected under a stereo-zoom microscope (HEADZ Model HD81), and preserved in glycerol. Line drawings were prepared by the senior author with the aid of a stereo-zoom microscope. The forewing length (FW) was measured as the maximum straight-line distance from the wing base to the apex, following Van Hook *et al.* (2012). The terminology for wing-pattern elements follows Evans (1932), and that for male genitalia follows Corbet and Pendlebury (1992). The holotype will be deposited in the insect collection facility of the Zoological Survey of India (ZSI) at the Western Ghat Regional Centre (WGRC), Kozhikode, Kerala.

Abbreviations

ASL	Above sea level
FW	Forewing
HW	Hindwing
TNHS	Travancore Nature History Society
UpF	Upperside of forewing
UnF	Underside of forewing
UpH	Upperside of hindwing
UnH	Underside of hindwing
ZSI	Zoological Survey of India, Kozhikode, Kerala

RESULTS AND DISCUSSION

Systematics

Family Nymphalidae Rafinesque, 1815

Subfamily Limenitidinae Behr, 1864

Tribe Adoliadini Doubleday, 1845

Genus *Euthalia* Hübner, 1819

Subgenus *Limbusa* Moore, [1897]

Euthalia (*Limbusa*) *zubeengargi*, Sadasivan & Upadhaya **sp. nov.** (Figs. 2, 3A, 5A–C)

LSIDurn:lsid:zoobank.org:act:54A0FA83-41F6-42F1-AA9B-12F7322050FD



Fig. 1 Map of north-east India showing the type locality of *Euthalia (Limbusa) zubeengargi* sp. nov. based on Google Earth

Holotype (Figs. 2A–B, 3A): 1 male. 15.vi. 2025, private homestead bordering semi-evergreen forests, Basar, Leparada District, Arunachal Pradesh, 600m ASL. Col. R. Upadhaya.

Other materials (observed but not collected): 1 male. 13.vii. 2025, Laiho community forest, Basar, Arunachal Pradesh, 750m ASL. Obs. R. Upadhaya.

Description of the Holotype (♂ TLRG 1014).

Head (Fig. 2A–B). Eyes without hairs, colored greyish-green with black eyespots in life. Labial palpi apex pointed, olive-greenish to brown on dorsum and white on ventrum. Antennae typical of the genus: club gradually swollen, upperside blackish-brown with tip orange-brown, underside ochreous-brown, turning paler towards tip, antennae 24mm, approximately two-thirds forewing length, reaching level of distal margin of forewing spot 6. Proboscis pale greenish outside, white on ventrum.

Thorax (Figs. 2A–B, 3A–C). Robust, covered with short brownish hairs on dorsum, paler brown on ventrum, covered with moderately long bluish hairs around mid, hind leg insertions, and wing bases. Legs pale greenish-brown on outer and pale bluish-white on inner aspect, claws brownish-black.

FW (Figs. 2A–B, 3A–C). 44mm. Costa evenly curved; apex weakly produced; termen slightly

undulate shallowly concave; dorsum straight. *UpF*: Ground colour deep olive-brown; basal half with irregular blackish circular markings on greenish-brown background. Discal–postdiscal band of elongate white spots in spaces 6–4 aligned as a stack; spot in 3 slightly shifted outward; spot in 2 elongate, triangular (canine-tooth shaped), extending along vein 2 toward termen, indenting submarginal greyish-white band and ending just short of termen; space 1 with heart-shaped white spot at mid-level and an additional suffused white tornal spot; two small, suffused but conspicuous white subapical spots in spaces 6, 8; discal band connected to mid-costa by elongate creamy-white spot near costa (above subcostal vein 12), parallel to and slightly longer than that in space 6. *UnF*: Ground colour greenish-brown with black dusting, basal area strongly suffused with turquoise-green; basal half with irregular blackish circular markings typical of the subgenus; discal–postdiscal band of white spots as above; inner margins broadly bordered with black (especially at suffused tornal spot in space 1), outer margins narrowly edged in black in spaces 2–6; subapical suffused white spots in spaces 6, 8; submarginal band greyish-white, ill-defined, extending from apex to tornus, inner border defined by a wavy fascia of contiguous black suffused chevron marks extending from outer border of subapical spot in 6 to distal edge of spot in 2; marginal border suffused brown.

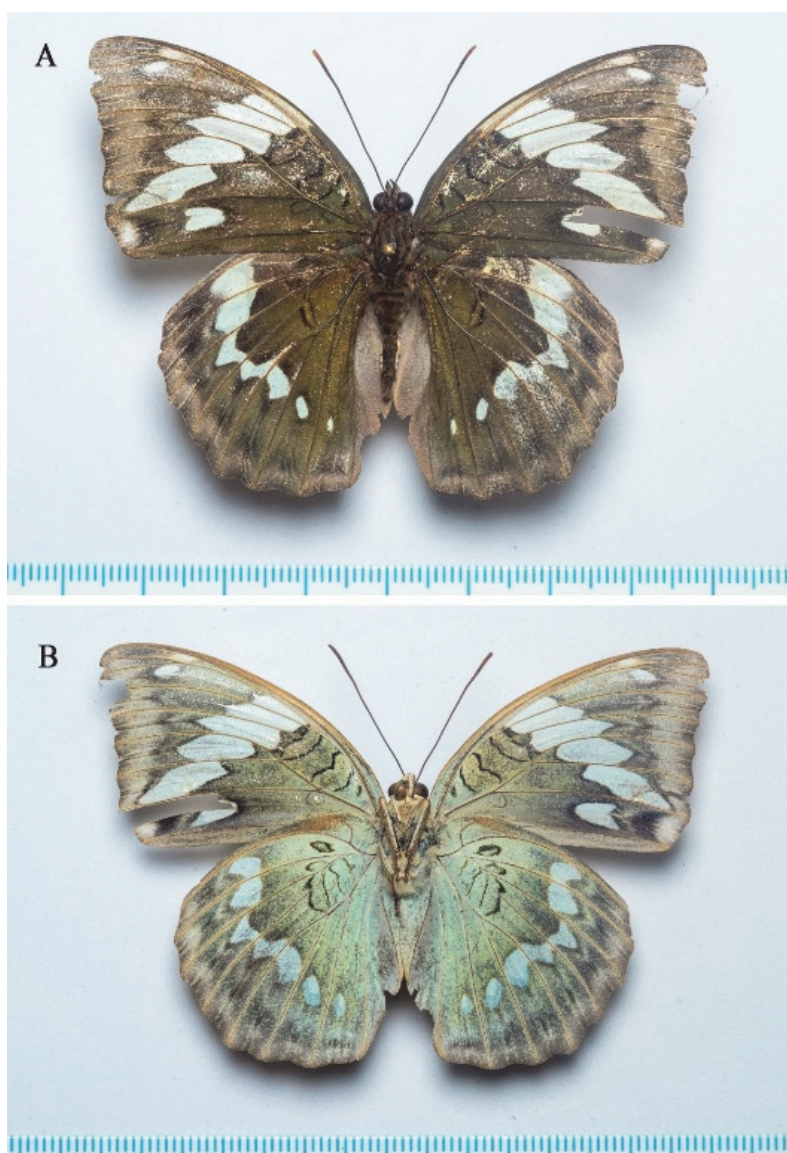


Fig. 2 *Euthalia (Limbusa) zubeengargi* **sp. nov.** Holotype male (TLRG 1014).
A: Dorsal view; B: Ventral view. © Kalesh Sadasivan

HW (Figs. 2A–B, 3A–C). Costa moderately convex; termen convex, more at v4, margin undulate, scalloped between each vein; tornus weakly angular. *UpH*: Discal band pale bluish-white, extending from spaces 3 to 7; band broader towards costa, tapering towards 3, outer margin of band undulate in spaces 3–7; a narrow greyish-brown submarginal band with its outer edge lying very close to termen. *UnH*: Ground colour pale turquoise-

green, suffused with blackish scales; discal band pale bluish-white, as in *UpH*, with spots margined in suffused black; postdiscal pale fascia, followed by another dark fascia of same size, both ill-defined and borders suffused; a submarginal narrow greyish-brown submarginal band as on the *UpH*. Wing bases clothed in long, pale brownish hairs. Cilia in scalloped edges white, near vein ends, olive greenish-brown.

Abdomen (Figs. 2A–B, 3A–C). Brown, covered in short brownish hairs on dorsum, having greenish shade in posterior segments, ventrally covered with moderately long bluish hairs.

Male genitalia (Fig. 5A–C). Valva stout, approximately three times longer than broad; dorsal margin sinuate, convex medially; apex blunt, directed posteriorly, armed apically with 4–5 large laterally curved teeth; ventral portion of valva with a prominent basal bulge merging into harpe; sacculus gently convex, ventral margin nearly straight; phallus thin, approximately half as long as male armature; tegumen with rounded dorsal margin, distal margin straight toward fenestrula; uncus stout basally, proximal half straight, distal half deflected ventrally at $\sim 40^\circ$; saccus about as long as width of vinculum.

Female. Unknown

Variation (Fig. 3) No significant variation was observed between the type male and the field-photographed specimen, except for the presence of an additional minute white dot in space 1a on the forewing upperside (UpF) of the specimen that was not collected (Fig. 3B–C).

Etymology. The species is named in honour of the celebrated Indian singer and cultural icon Mr. Zubeen Garg, in recognition of his significant contributions to contemporary music in northeast India. The epithet is a compounded Latinised form of his first and family names, treated as a masculine genitive meaning “of Zubeen Garg.” The common name suggested is Basar Duke.

Ecology (Figs. 3–4) The species inhabits semi-evergreen forests of the Basar region of Arunachal Pradesh (Fig. 1), occurring between approximately 600–700m ASL in humid, shaded understory habitats (Fig. 4). Field photographs indicate that males utilise a range of microhabitats; one individual was observed mud-puddling on a moss-covered rock beside a forest stream (Fig. 3A), while others perched on broad-leaved saplings and shrubs 1–2m above ground in filtered light along narrow trails and riparian edges (Fig. 3B). The species also visits tree sap, as indicated by a male feeding at a bark

exudate patch, a behavior typical of several *Euthalia* (Fig. 3C). Individuals were active under diffused light from late morning to early afternoon, making short and slow flights between nearby foliage. All observations were made in dense, moist understories with persistent canopy shade, suggesting a preference for cool, humid microhabitats. The species appears to be genuinely rare and highly localized, known only from two males despite repeated surveys. Larval host plants and early stages remain unknown, though likely associated with broad-leaved canopy or subcanopy trees characteristic of Eastern Himalayan evergreen forests (Fig. 4).

Morphological evidence places the new species securely within the *Patala* group sensu Yokochi (2011). Its uniformly pale-brown underside, absence of the silvery sheen typical of the *Franciae* group, and male forewing length exceeding 40mm all agree with the diagnostic range of *Patala* group taxa. The hindwing outline is comparatively rounded, lacking the sharply produced angle of the *Nara* group, and the yellowish suffusion on the upperside remains restricted, not extending into space 7. Likewise, the continuous pale discal band on the hindwing upperside, together with the distinct white median spot in space 6 and the conspicuous submarginal marks in spaces 8 and 6 on the forewings, match the characteristic pattern suite of the group. These combined characteristics confirm the placement of this species within the *Patala* group.

Examination of the forewing pattern clearly indicates that the new species conforms to Subtype A2 of Type A within the *Patala* group. In this subtype, the diagnostic configuration involves the alignment of the line connecting the postdiscal white spot in UpF space 6 with space 3, when extrapolated, directed towards the termen. Both the holotype and photographed male exhibit this feature unambiguously, with the two spots lying in a straight, outward-slanting series that neither forms an acute angle (Subtype A1) nor inclines toward the dorsum (Subtype A3). This consistent orientation is a stable character across individuals and is fully congruent with Yokochi’s (2011) definition of Subtype A2. Together with other *Patala*-group traits, such as

forewing size, pale-brown underside, hindwing discal band reaching from the costa to the dorsum, and the pattern of submarginal white spots, the alignment of the forewing spots provides strong morphological support for assigning the new species to Subtype A2.

There are four known species in the Subtype A2—*E. (L.) pratti* Leech, 1891, distributed across central and southern China, including Hubei, Hunan, Guangxi, southern Gansu, Yunnan, Sichuan, Fujian, and Zhejiang; *E. (L.) occidentalis* Hall, 1930, recorded from Sichuan, Yunnan, and southern Gansu; and *E. (L.) cooperi* (Tytler, 1926), known from Mandalay, Myanmar, and *E. (L.) monastyrskiyi* Yokochi, 2011, was reported from northern Vietnam. Within Subtype A2 of the *Patala* group, *Euthalia (L.) zubeengargi* **sp. nov.** is most readily distinguished by the configuration of the forewing discal series and the associated hindwing pattern elements. Species of this assemblage can first be separated by position of the forewing spot in space 5: whether lies basad of or aligned with the spots in spaces 6 and 4. *Euthalia pratti* and *E. occidentalis* fall into the former category and differ from that of the new species. Among species with spot 5 aligned with spots 6 and 4, *Euthalia cooperi* is easily distinguished by its strongly displaced spot in space 2, which overlaps much less than half of spot 3 and is markedly shifted toward the termen. In contrast, *E. zubeengargi* **sp. nov.** shares with *E. monastyrskiyi* the condition in which spot 2 overlaps more than half the length of spot 3 and is only slightly shifted outward. However, *E. zubeengargi* **sp. nov.** and *E. monastyrskiyi* differ significantly in several key characteristics. In *E. monastyrskiyi*, spot 2 is small and oval, not extending along vein 2 towards the termen, and the forewing lacks a spot in space 1; the hindwing postdiscal band is weak, represented only by white markings in spaces 7 and the upper half of space 6, the remaining elements appearing as dark-edged brown spots, and spaces 1 and 2 lack white spots. In contrast, *E. zubeengargi* **sp. nov.** bears an elongate, triangular spot in space 2 that extends along vein 2 almost to the termen, along with a distinctive heart-shaped white spot in space 1 and

an occasional small one in 1a; the hindwing postdiscal band is complete and clearly expressed from spaces 7 to 3, with well-developed white spots in spaces 1 and 2. This combination of forewing spot morphology and fully developed hindwing postdiscal series provides a unique suite of characters that unambiguously separates *E. zubeengargi* **sp. nov.** from all other known Subtype A2 species.

Euthalia (Limbusa) zubeengargi **sp. nov.** is distinct among Subtype A2 taxa. In *E. pratti*, *E. occidentalis*, and *E. cooperi*, the valva is long and slender and the apex is pointed with uneven serrations (Fig. D–F). In the new species the valva (Fig. 5A–C) is markedly stout, three times as long as broad; apex blunt, directed posteriorly; apical serrations set on rounded tip; ventral margin with strongly developed basal bulge meeting a broadened harpe at an acute angle (ventral expansion weak and angle more obtuse in other species). Apical serrations are regular in *E. zubeengargi* **sp. nov.** and *E. monastyrskiyi*; however, they differ in orientation, relative length, and number (Fig. 5B and 5G). The uncus is relatively long, and the distal half is sharply angulated ventrally at ~40° (only approached in *E. cooperi*; gently curved in the remaining species). The aedeagus is slender and shorter than that of the other species. This combination of characters—valval stoutness, ventral bulge development, apex form, harpe configuration, uncus angulation, and phallic structure—unambiguously diagnoses the new species.

Revised key to males of Subtype A2 of Type A of the *Patala* group in the subgenus

Limbusa Moore, [1897] of *Euthalia* Hübner, 1819, based on Yokochi (2011)

1. UpF spot in space 5 shifted basad relative to spots in space 6 and 4 2
 - UpF spot in space 5 aligned on a straight line connecting spots in space 6 and 4..... 3
2. Upperside ground colour predominantly bluish-green.....*E. (L.) pratti* Leech, 1891



Fig. 3 *Euthalia (Limbusa) zubeengargi* **sp. nov.** live insect in field. A: holotype male (TLRG 1014) mudpuddling; B: Another male (not caught) sitting on low canopy; C: Sap sucking with *Kallima inachus* (Doyère, 1840). © Roshan Upadhaya



Fig. 4 *Euthalia (Limbusa) zubeengargi* **sp. nov.** Habitat images. A: semi-evergreen forests of the Basar region of Arunachal Pradesh; B: Vantage point in low canopy. © Roshan Upadhaya

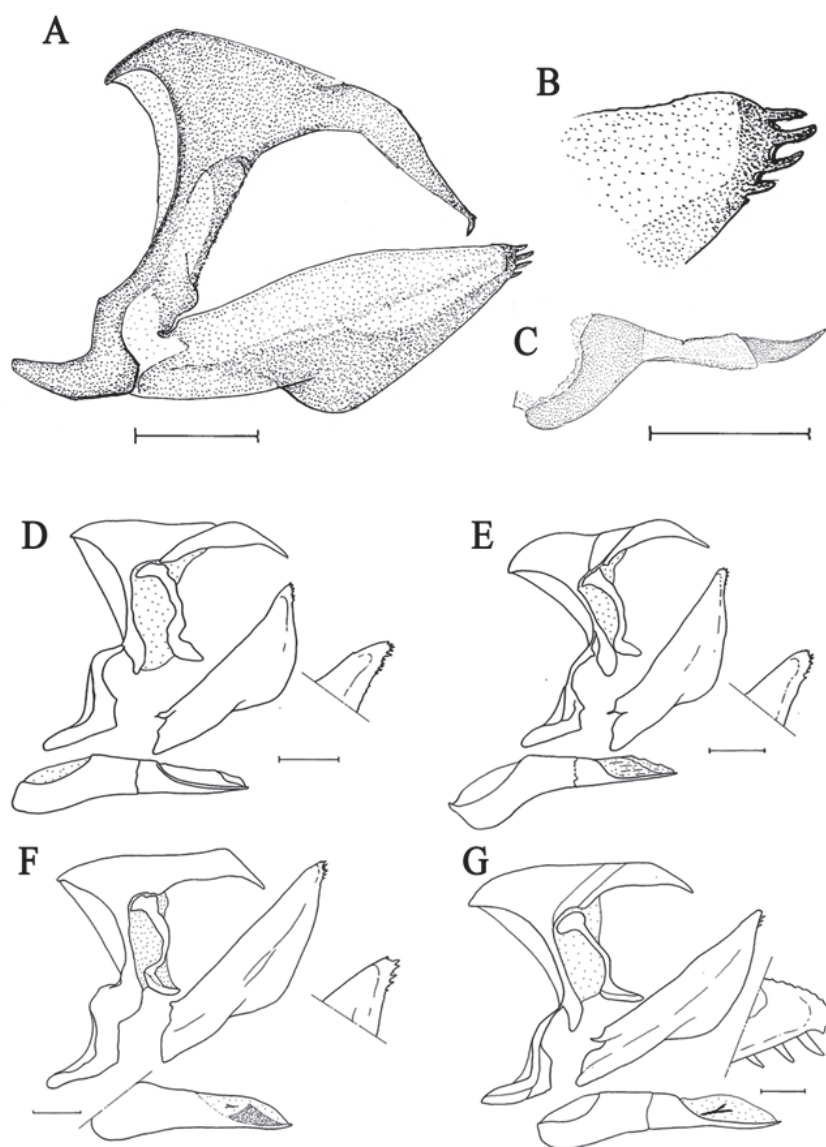


Fig. 5 Illustrations of male genitalia of Subtype A2 of Type A of the *Patala* group in the subgenus *Limbusa* Moore, [1897] of *Euthalia* Hübner, 1819. A: Right lateral view of genital armature of *Euthalia (Limbusa) zubeengargi* sp. nov.; B: Close-up of tip of valva showing the tooth; C: aedeagus; D: male genitalia of *E. (L.) pratti* Leech, 1891; E: male genitalia of *E. (L.) occidentalis* Hall, 1930; F: male genitalia of *E. (L.) cooperi* (Tytler, 1926); G: male genitalia of *E. (L.) monastyrskiyi* Yokochi, 2011. A–C male genitalia illustration based on holotype TLRG 1014; D–G illustration based on Yokochi (2011). © Kalesh Sadasivan

– Upperside ground colour predominantly brown *E. (L.) occidentalis* Hall, 1930

3. UpF spot in space 2 overlapping, much less than half the length of spot in 3, spot in 2 markedly shifted towards the termen..... *E. (L.) cooperi* (Tytler, 1926)

– UpF spot in space 2 overlapping more than half the length of spot in 3, spot in 2 only slightly displaced outward towards the termen.....4

4. UpF spot in space 2 small, oval, not extending along vein 2 towards termen, no spot in space 1a

or 1b; UpH postdiscal band from 7–3 represented by white spots in spaces 7, and half of spot in 6, remaining band represented by dark-edged brown spots from 5–3; UpH dark-edged brown spots in space 2, no spot in space 1.....
.....*E. (L.) monastyrskiyi* Yokochi, 2011

– UpF spot in space 2 elongate, triangular, extending along vein 2 towards termen and ending just short of it, a heart-shaped spot in space 1b; UpH postdiscal band well-developed, composed of white spots from spaces 7 to 3, white spots in spaces 1 and 2.....
E. (L.) zubeengargi Sadasivan & Upadhaya, **sp. nov.**

The discovery of *Euthalia (Limbusa) zubeengargi* **sp. nov.** from Basar, Arunachal Pradesh, adds a fifth Subtype A2 member to the *Limbusa patala* group and represents a significant range extension within the eastern Himalayan butterfly assemblage. Even with a lineage exceeding 80 described species, the new taxon is diagnosable based on a unique suite of facies and male genital characters. The occurrence in low–mid elevation humid forests of the region highlights its exceptional yet incompletely known butterfly diversity—further reinforced by the recent record of *E. malaccana* (Fruhstorfer, 1889) from Basar (Roshan Upadhaya and Taslima Sheikh, pers. comm.). The extremely limited number of individuals observed despite extensive survey efforts implies genuine rarity or highly cryptic habits, underscoring the need for continued sampling, documentation of early stages and host plants, and long-term monitoring of butterfly diversity in Northeast India. This discovery emphasizes that the subtropical forests of Arunachal Pradesh continue to yield previously unrecognized butterfly taxa.

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Nesting plants, nesting height selection and bee flora of *Apis dorsata* Fab. (Hymenoptera, Apidae) in selected districts of south Karnataka, India

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ABSTRACT: *Apis dorsata* is well distributed in the Indian subcontinent for rich availability of floral resources along with suitable nesting structures. Nonetheless, the nesting structures and floral resources vary from hilly regions to plains seasonally. Regular field studies were conducted on major nesting plants, nesting height selection, and major bee flora of *A. dorsata* in the plains of South Karnataka, India, during 2021-2024 at fortnight intervals. The results showed that *A. dorsata* selected 12 major plant species for nesting and among them, a few were *Ficus bengalensis*, *Terminalia arjuna*, *Delonix regia*, *F. religiosa*, *Samanea saman*, and *Eucalyptus nilgiris*. Furthermore, *A. dorsata* selected heights range between 10 and 20m above ground level for nesting in greater numbers. Similarly, *A. dorsata* workers gathered pollen and nectar from 43 major bee flora in the study regions. The major pollen flora recorded were coconut, mango, papaya, coriander, etc. Similarly, the major nectar flora identified were eucalyptus, pongamia, drumstick, tamarind, and neem. However, acacia, mustard, pigeon pea, lemon, guava, and jamun produced both pollen and nectar for *A. dorsata* colonies. The study concludes that *A. dorsata* is well adapted to the plains of South Karnataka by nesting on suitable tree plant species at an ideal height for the rich availability of floral resources. Nevertheless, nesting structures and floral resources play a crucial role in the successful establishment of *A. dorsata* colonies. © 2026 Association for Advancement of Entomology

KEY WORDS: Pollination ecology, colony distribution, tree preference, foraging resources

INTRODUCTION

The common giant honey bee, *Apis dorsata*, Fab., constructs large, single-comb open nests typically on tall trees, rocky cliffs, and on man-made structures (Reddy and Reddy, 1993; Nagaraja, 2023). These colonies significantly contribute to the pollination of crops and wild plants, in addition to providing honey and beeswax across South and Southeast Asia (Crane, 1999; Rehel *et al.*, 2024). Honeybee swarms generally decide on a new nest

site before moving to the chosen site collectively during the swarming period (Beekman and Oldroyd, 2018). The swarms of *A. dorsata* identify suitable nesting sites on the basis of their quality through repeated dances. Nagaraja (2019) recorded a greater number of *A. dorsata* colonies on buildings in urban regions and trees and rock-cliffs in rural regions. In the semi-arid zones of northwest India, *A. dorsata* build nests preferably on trees compared to buildings (Sihag, 2017). Furthermore, in South Sulawesi, Indonesia, the nest distribution

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was non-random, with specific tree species serving as primary nesting sites (Nagir *et al.*, 2016). The bee flora is equally crucial for the successful establishment of bee colonies (Aronne *et al.*, 2012). Ramyarani and Nagaraja (2024) found a strong association between thorny shrubs for the establishment of *A. florea* colonies in south Karnataka.

The plains of south Karnataka are characterized by diverse agroecosystems and a mosaic of both wild and cultivated flora, which are likely to influence colony distribution (Basavarajappa, 2010). Information on the availability of suitable nesting plants and floral resources in a region is essential for the establishment of bee colonies for honey production and pollination services (Olroyd and Wongsiri, 2006; Sihag, 2025). The present study was aimed to determine the major nesting plants and nesting height of *A. dorsata* in the plains of South Karnataka, India. Furthermore, knowledge on identifying seasonal bee flora in these regions give insights on arrival and establishment of *A. dorsata* colonies in the plains of south Karnataka.

MATERIALS AND METHODS

Study Area: The present study on the nesting ecology of the *A. dorsata* was carried out from January 2021 to December 2024 across three districts of south Karnataka such as Kolar (13° 07' 48.00" N; 78° 07' 48.00" E), Chikkaballapur (13° 33' 0" N; 77° 52' 12 E), and Bengaluru Rural (12° 15' and 13° 31' N; 77° 04' and 77° 59', E). These districts fall within the southeast dry agro-climatic zone of Karnataka, characterized by predominantly open deciduous vegetation interspersed with cultivated lands. The study area covered three districts with an area of 2.5 km² from each district. Each study area was further subdivided in to five equal sized quadrants (Ramyarani and Nagaraja, 2024).

Identification of nesting plants: Field surveys were conducted on the natural population of *A. dorsata* colonies found on various nesting plants at fortnightly intervals throughout the year. The observations were made in each quadrant from four compass points by pairs of observers and recorded

the number of colonies found on each nesting structure (Oldroyd *et al.*, 1997). Direct visual observations were performed using binoculars to detect nests found at higher heights.

Nesting height: The height of each nest above ground was measured using a laser distance meter (iBELL 40 m range, Nikon model) by fixing the instrument on tripod and switching the button to position laser beam on nesting surface at dim day light, the measurement displayed on digital screen were recorded and verified with selected nests using a theodolite (Saliu *et al.*, 2021).

Identification of floral resources: The bee flora of *A. dorsata* was identified by recording flowering plants visited by foragers throughout the day. Observations were carried out at fortnight intervals across all study sites throughout the flowering seasons. The bee flora was collected, photographed, and identified (Gamble, 1967). The bee flora was categorized into pollen flora, nectar flora, and both pollen and nectar flora (Abrol, 2012). The data obtained in the study were subjected to statistical analyses with respect to nesting heights and the preference of nesting plants between the study districts using the Chi-square test. All analyses were performed using SPSS.

RESULTS AND DISCUSSION

Nesting plants: A total of 657 *A. dorsata* colonies were documented across the three districts on 12 nesting plants (Table 1). Among them, the banyan tree was the most preferred nesting plant, hosting 43.6 per cent of colonies, followed by the Arjuna tree (13.1%) and Gulmohar (12.3%) (Plate 1). Other important nesting plants includes rain tree and peepal tree (*Ficus religiosa*) (51 colonies). In contrast, plant species such as coconut, mango, and laurel fig supported very few colonies (<9). The distribution of colonies across tree species and districts was statistically significant ($p < 0.001$), indicating strong association of *A. dorsata* with selected tree species. The observations revealed that the banyan tree in Bengaluru Rural, the arjuna tree in Kolar, and the gulmohar in Chikkaballapur districts were major nesting plants, reflecting regional variation in nesting tree preferences.

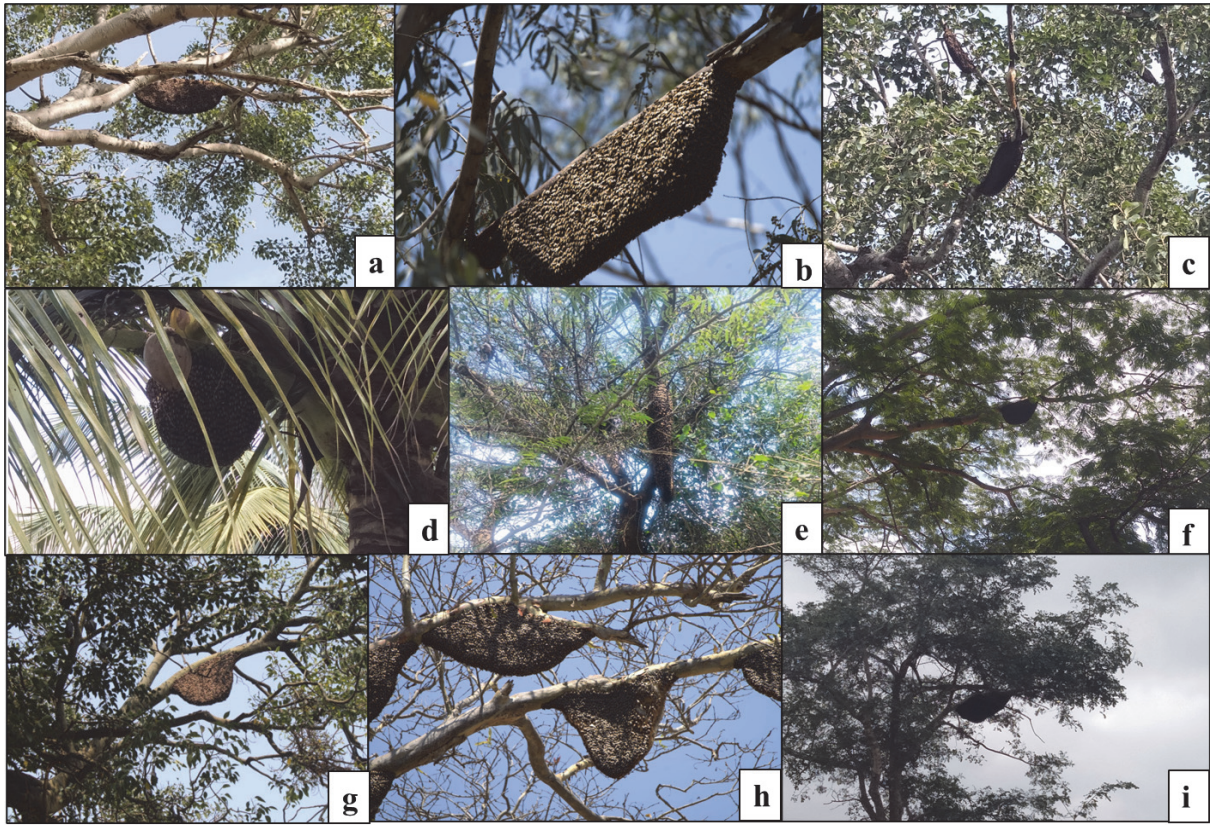


Plate 1. Nests of *Apis dorsata* on different trees: a) Peepal tree, b) Eucalyptus, c) Banyan, d) Coconut, e) Acacia, f) Earpod tree, g) Laurel fig, h) Arjun tree, i) Cutch tree

The banyan tree with its wide-spreading branches and strong structure provide a stable support for large combs, while its evergreen canopy offers shade and protection of *A. dorsata* colonies (Basavarajappa, 2010). Similar observations were made by Roy *et al.* (2011), where *A. dorsata* preferentially nest on large, mature trees with expansive canopies. Regional variation in preference, of nesting plants, reflects of suitable nesting plants availability and tree morphology (Ramyarani and Nagaraja, 2025). These findings are consistent with previous studies reporting that nesting choice is determined by ecological and landscape heterogeneity (Ramyarani and Nagaraja, 2024; Rehel *et al.*, 2024).

Nesting height: The vertical distribution of *A. dorsata* colonies at different heights revealed significant variation (Fig. 1). The observations showed that the majority of nests were located at

15-20m (45.4%) and 10-15m (34.0%), together accounting for nearly 80 per cent of all observed colonies. In contrast, a few nests were found at 0-5m (2.0%) and 20-25m (3.4%), while 5-10m supported a moderate number of nests (11.3%). A Chi-square goodness-of-fit test indicated that the distribution of colonies across height classes was highly non-uniform (< 0.001). These results demonstrate a strong preference for mid-height ranges (10-20m), suggesting that nest site selection is strongly influenced by height, possibly due to reduced predation, microclimatic stability, and foraging efficiency. Sihag (2017) reported that nearly 70 per cent of colonies in northwest India occurred between 14-17 m, while Roy *et al.* (2011) documented similar clustering in the Nilgiri Biosphere Reserve. Nesting at such heights likely reduces vulnerability to ground-level disturbances and human interference while optimizing microclimatic conditions for brood development

Table 1. Major nesting plants with number of colonies of *A. dorsata* in different districts of south Karnataka (N= 657)

Scientific name	Common name	Number of colonies found			
		Kolar	Chikkaballapur	Bengaluru rural	Total
<i>Albizia lebbeck</i>	Siris	10	07	12	29
<i>Cocos nucifera</i>	Coconut	03	00	06	09
<i>Delonix regia</i>	Gulmohar	17	44	20	81
<i>Eucalyptus nilgiris</i>	Eucalyptus	27	01	00	28
<i>Ficus bengalensis</i>	Banyan	92	67	128	287
<i>Ficus microcarpa</i>	Laurel fig	08	00	01	09
<i>Ficus religiosa</i>	Peepal tree	31	02	18	51
<i>Mangifera indica</i>	Mango	04	00	05	09
<i>Samanea saman</i>	Rain tree	08	23	11	42
<i>Tamarindus indica</i>	Tamarind	14	03	00	17
<i>Terminalia arjuna</i>	Arjuna tree	86	00	00	86
<i>Quercus subur</i>	Cork oak	09	00	00	09

(Seeley *et al.*, 1982). The selection of these elevations also enhances foraging efficiency by minimizing flight costs between nest and floral resources (Nagir *et al.*, 2016). The low occurrence of nests at <5 and >20m suggests that both extremes expose colonies to higher risks of predators and human disturbance at lower levels, and exposure to wind Wardhe and Ghonmode (2024) reported nesting preference of *A. dorsata* in urban Nagpur, where it was stated that the tall buildings were more preferred.

Bee flora: A total of 43 plant species from 21 families were identified as bee flora of *A. dorsata* in the study regions (Table 2). Among these, species from the Fabaceae (e.g., *Albizia lebbeck*, *Cajanus cajan*, *D. regia*) and Cucurbitaceae (e.g., *Cucurbita moschata*, *Lagenaria siceraria*) families were the most frequently utilized. Of the recorded plants, 17 species provided both nectar and pollen, 17 plant species provided only pollen, and 9 species supplied only nectar. This wide resource base indicates that *A. dorsata* is a generalist forager, utilizing both cultivated crops

(e.g., *Brassica nigra*, *Cicer arietinum*) and wild flora (e.g., *Tridax procumbens*, *Ageratum conyzoides*). Such floral diversity is crucial for sustaining colonies in the dry agro-climatic zone, where seasonal variability in floral abundance is high. Previous melittopalynological studies from Kolar confirmed that *A. dorsata* honey contained pollen from over 50 plant species, highlighting its wide dietary breadth (Gopal, 2021). Similarly, Rehel *et al.* (2024) demonstrated that *A. dorsata* exploited nearly one-third of available flowering plants in the Nilgiris, often overlapping with other bees. This reflects its ecological flexibility as a generalist forager (Aronne *et al.*, 2012). By diversifying floral resources, colonies buffer against seasonal gaps, ensuring continuous nectar and pollen intake. The reliance on both wild and cultivated plants underscores the role of *A. dorsata* in pollination services. Cultivated crops such as coriander, onion, sunflower, and pigeon pea, as well as wild plants like *Tridax procumbens* and *Ageratum conyzoides*, benefit significantly from its pollination, contributing to both agricultural productivity and ecosystem health (Abrol, 2012). The adaptability

Table 2. Bee flora of *Apis dorsata* in plains of south Karnataka, India

No.	Scientific name	Common name	Family	Floral Resource
1.	<i>Acacia leucophloea</i>	Whitebark Acacia	Fabaceae	Pollen + Nectar
2.	<i>Acacia polyacantha</i>	Acacia	Fabaceae	Pollen + Nectar
3.	<i>Ageratum conyzoides</i>	Billy goat weed	Asteraceae	Nectar
4.	<i>Albizia lebbek</i>	Siris	Fabaceae	Nectar
5.	<i>Allium cepa</i>	Onion	Amaryllidaceae	Pollen + Nectar
6.	<i>Azadirachta indica</i>	Neem	Meliaceae	Nectar
7.	<i>Brassica rapa</i>	Turnip	Brassicaceae	Pollen + Nectar
8.	<i>Brassica nigra</i>	Mustard	Brassicaceae	Pollen + Nectar
9.	<i>Cajanus cajan</i>	Pigeon pea	Fabaceae	Pollen + Nectar
10.	<i>Capparis grandis</i>	Tree caper	Capparaceae	Pollen
11.	<i>Carica papaya</i>	Papaya	Caricaceae	Pollen
12.	<i>Cicer arietinum</i>	Chickpea	Fabaceae	Pollen + Nectar
13.	<i>Citrus limon</i>	Lemon	Rutaceae	Pollen + Nectar
14.	<i>Cocos nucifera</i>	Coconut	Arecaceae	Pollen + Nectar
15.	<i>Coriandrum sativum</i>	Coriander	Apiaceae	Pollen
16.	<i>Cucumis melo</i>	Musk melon	Cucurbitaceae	Pollen + Nectar
17.	<i>Cucumis sativus</i>	Cucumber	Cucurbitaceae	Pollen + Nectar
18.	<i>Cucurbita moschata</i>	Pumpkin	Cucurbitaceae	Pollen + Nectar
19.	<i>Dalbergia sissoo</i>	Indian rosewood	Fabaceae	Pollen
20.	<i>Delonix regia</i>	Gulmohar	Fabaceae	Pollen
21.	<i>Eucalyptus</i> spp.	Eucalyptus	Myrtaceae	Nectar
22.	<i>Foeniculum vulgare</i>	Fennel	Apiaceae	Pollen
23.	<i>Helianthus annuus</i>	Sunflower	Asteraceae	Pollen + Pollen
24.	<i>Ixora congesta</i>	Malayan ixora	Rubiaceae	Pollen
25.	<i>Lagenaria siceraria</i>	Bottle gourd	Cucurbitaceae	Pollen + Nectar
26.	<i>Leucaena leucocephala</i>	Subabul	Fabaceae	Pollen + Nectar
27.	<i>Mangifera indica</i>	Mango	Anacardiaceae	Pollen+ Nectar
28.	<i>Mimosa pudica</i>	Touch-me-not	Fabaceae	Pollen
29.	<i>Momordica charantia</i>	Bitter gourd	Cucurbitaceae	Pollen + Nectar

30.	<i>Moringa oleifera</i>	Drumstick	Moringaceae	Nectar
31.	<i>Morus alba</i>	Mulberry tree	Moraceae	Pollen + Nectar
32.	<i>Phyllanthus emblica</i>	Amla	Euphorbiaceae	Pollen
33.	<i>Pongamia pinnata</i>	Indian beech tree	Fabaceae	Nectar
34.	<i>Prosopis juliflora</i>	Mesquite plant	Leguminosae	Nectar
35.	<i>Psidium guajava</i>	Guava	Myrtaceae	Pollen + Nectar
36.	<i>Raphanus sativus</i>	Radish	Brassicaceae	Nectar
37.	<i>Sida cordifolia</i>	Heart-leaf sida	Malvaceae	Pollen
38.	<i>Syzygium cumini</i>	Jamun	Myrtaceae	Pollen + Nectar
39.	<i>Tamarindus indica</i>	Tamarind	Fabaceae	Nectar
40.	<i>Terminalia</i> spp.	Terminalia	Combretaceae	Pollen
41.	<i>Tridax procumbens</i>	Tridax weed	Asteraceae	Pollen

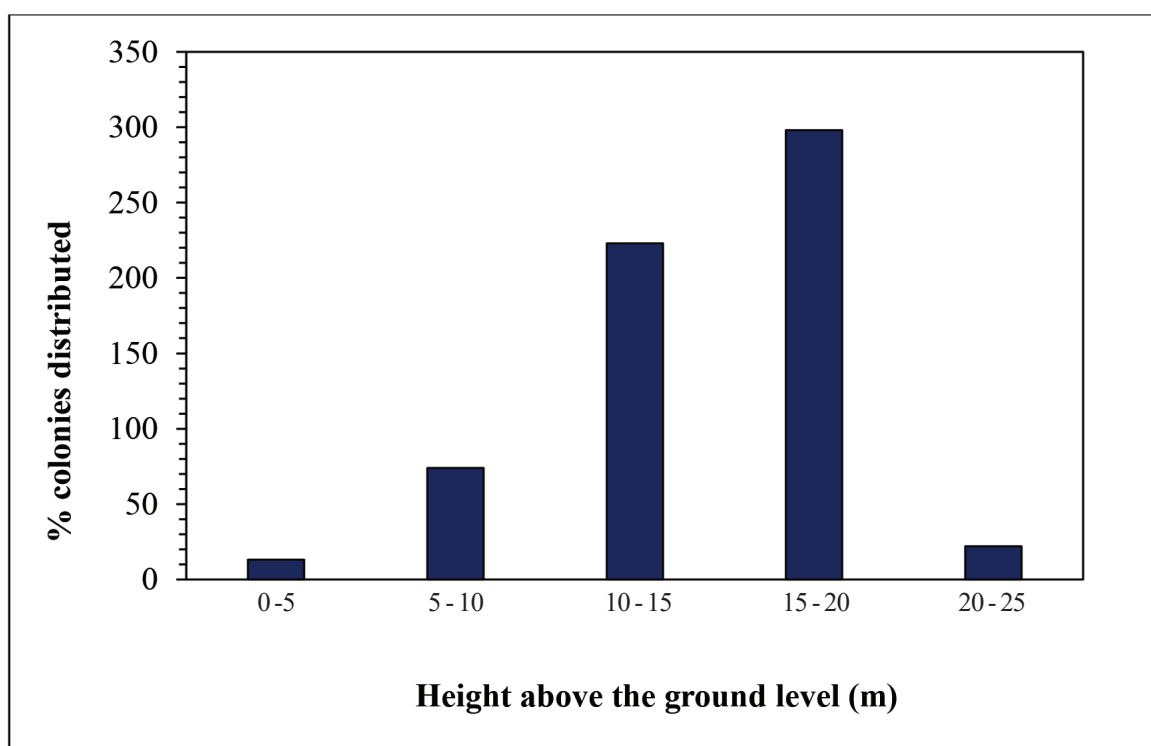


Fig. 1 Vertical Distribution of *Apis dorsata* colonies on trees at different elevation

of *A. dorsata* to forage across diverse landscapes ensures its persistence in human-dominated agroecosystems. However, the felling of nesting trees and loss of bee flora could severely affect colony sustainability (Sihag, 2025).

The study revealed that *A. dorsata* colonies in south Karnataka exhibit clear nesting preferences, with the majority located at moderate-heights (10-20 m) and predominantly on structurally suitable tree species such as *F. benghalensis* and *T. arjuna*. *A. dorsata* also utilized a wide diversity of floral resources, highlighting its role as a generalist forager and key pollinator. These findings emphasize the importance of conserving large nesting trees in these regions. Nonetheless, integration of ecological insights is essential for sustainability of *A. dorsata* populations in plains of south Karnataka, India.

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Consequences of environmental factors on the population distribution of *Acrida exaltata* (Walker), a pest in different ecosystems

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ABSTRACT: The relations between environmental factors and population of *Acrida exaltata* (Walker) in three ecosystems were studied for two years. The biplot revealed that the total population was related to the temperature. The total population at fallow land was correlated with temperature ($r = 0.4578$, $p < 0.05$ for maximum temperature and $r = 0.6644$, $p < 0.05$ for minimum temperature). Biplot of total population, nymphal population, and male population of *A. exaltata* at the forest ecosystem showed a close relation to minimum temperature. But the female population was related to precipitation and temperature. The correlation matrix revealed a positive correlation of total population with relative humidity ($r = 0.4502$, $p < 0.05$) at agriculture land. The environmental factors regulated the vegetation as well as the soil consistence of the ecosystem. The eggs of acridids were capable of surviving in adverse conditions of weather and maintained the population throughout the year in the forest and fallow land due to the availability of the supporting vegetation. © 2026 Association for Advancement of Entomology

KEY WORDS: Acridid, fallow land, forest ecosystem, agriculture land, temperature, relative humidity, precipitation, vegetation

INTRODUCTION

The acridids, commonly called short-horned grasshoppers and locusts, belong to the order Orthoptera and family Acrididae, are almost cosmopolitan in distribution and very common in India. Different environmental factors, like temperature and humidity, had an immense role in the fecundity of grasshoppers (MacCarthy, 1956). Food plants also play an important role in maintaining the population of acridids (Pickford, 1960). The fertility and survival rates were related to the mortality and different ecological factors

(Bhowmik, 1986). *Cyrtacanthacris tatarica*, a species of thicket and woodland, was a pest of crops in the plains of the Darjeeling district due to encroachments on its natural habitat (Bhowmik and Halder, 1984). *Hieroglyphus banian* is a pest of paddy in India and other tropical countries. On the other hand, some grasshoppers, regarded as minor pests of paddy, also caused damage to cotton and sorghum in Asia (Kalaisekar *et al.*, 2017). *Acrida exaltata* (Walker) was considered a pest of rice and jute in West Bengal and Bangladesh (Bhowmik, 1986). Dwivadi and Chattaraj (1985) studied the population pattern in the grassland ecosystem of

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Madhya Pradesh. Halder *et al.* (1995) have observed that the plants belonging to the family Poaceae were the most preferred food of *A. exaltata*. Nath and Halder (1998) reported that monsoon and vegetation patterns had a profound impact on the population dynamics of the acridid in the arid zone of West Bengal. Effects of different heavy metals on *A. exaltata* in the highly polluted industrial belt were also reported (Nath, 2017; Nath *et al.*, 2011). It is also a pest of sorghum in Asia (Gupta and Chandra, 2013; Kalaisekar *et al.*, 2017). Keeping these views in mind, a study was carried out on the population dynamics of this acridid in relation to different environmental factors in different ecosystems.

MATERIALS AND METHODS

Quantitative sampling of *A. exaltata* in three different ecosystems, namely, fallow land (FL), forest (FR) and agriculture land (AL) in Santiniketan (23.6776°N; 87.6852°E), West Bengal, India and its environs was carried out during a period of twenty-four months from March to February. The swiping technique of collection by an insect net was employed. Every ecosystem was divided into three quadrats, each 5m² for the collection of the grasshoppers. The distance between the two quadrats was approximately ten feet. Thus, collection was made from nine quadrats, three quadrats of each ecosystem. Fortnight collections were done for 10 minutes in each of the quadrats. Therefore, the total collection time for each ecosystem was 30 minutes. Collections were made in the morning between 8 and 9 am. The collected insects from each plot were narcotised separately and transferred to the laboratory for further study. Data were used for the principal components analysis (PCA), correlation, by applying statistics Kingdom free software (<https://www.statskingdom.com/pca-calculator.html>).

RESULTS AND DISCUSSION

Fallow land ecosystem (Figs. 1 - 8): The population pattern of *A. exaltata* studied in relation to the environmental factors, revealed in the biplot, that the total population was related to the temperature (Fig.1). The total population was

correlated with temperature ($r = 0.4578$, $p < 0.05$ for maximum temperature and $r = 0.6644$, $p < 0.05$ for minimum temperature). Whereas, the minimum temperature was correlated with the precipitation ($r = 0.4659$, $p < 0.05$). The eigenvalues from the scree plot revealed that principal components (PC-1) and PC-2 were 2.3373 and 1.4634, respectively, and the first two components explain more than 95 per cent of the variance in the data (Fig. 2).

The biplot of nymphs of *A. exaltata* at fallow land revealed that the nymph population (N1) also related to the temperature (Fig. 3), like adult population (N1 - Min temp, $r = 0.6213$, $p < 0.05$), and minimum temperature was correlated with precipitation ($r = 0.4659$, $p < 0.05$). The eigen values in the scree plot were 2.3055 and 1.4987, respectively (Fig. 4).

Male grasshopper population at fallow land was closely related to minimum temperature and rainfall (Fig. 5), and the population was directly correlated with minimum temperature ($r = 0.5135$, $p < 0.05$), and minimum temperature was correlated with rainfall ($r = 0.4659$, $p < 0.05$). The eigen values of PC- 1 and 2 were 2.253 and 1.4839, respectively, and the first two components explain more than 95 per cent of the variance in the data (Fig. 6). Female population was also correlated to minimum temperature ($r = 0.4956$, $p < 0.05$), and as presented in the biplot (Fig. 7). Eigen values for the PC-1 and PC-2 are presented in scree plot (Fig. 8).

Forest ecosystem: The biplot of total population (Fig. 9), nymphal population (Fig. 11), and male (Fig. 13) population of *A. exaltata* showed a close relation to minimum temperature. But the female population was related to precipitation and temperature (Fig. 15). There was correlation between the grasshopper total population ($r = 0.5037$, $p < 0.05$), nymphal population ($r = 0.4464$, $p < 0.05$), male population ($r = 0.4732$, $p < 0.05$) with minimum temperature and female population ($r = 0.4577$, $p < 0.05$) with precipitation. Moreover, eigen values also showed a similar trend as was observed in the fallow-land ecosystem (Figs. 10, 12, 14, 16).

Agricultural field: The biplot showed that the total population was closely related to the relative

Relation between *Acrida exaltata* population and environmental factors at Fallow land ecosystem (Figs. 1 – 8)

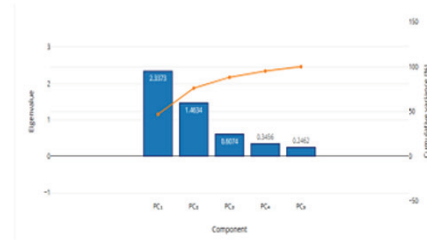
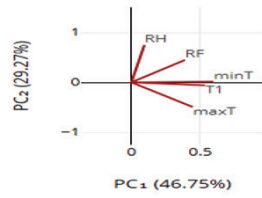


Fig. 1 Biplot - relations between total number and environmental factors; Fig. 2 Scree plot for total number and environmental factors

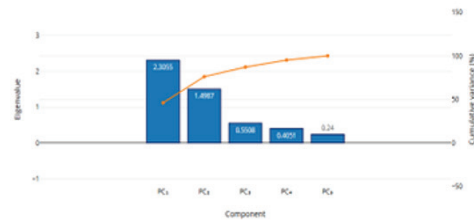
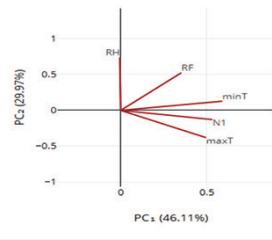


Fig. 3 Biplot - relations between nymph and environmental factors; Fig. 4. Scree plot for nymph and environmental factors

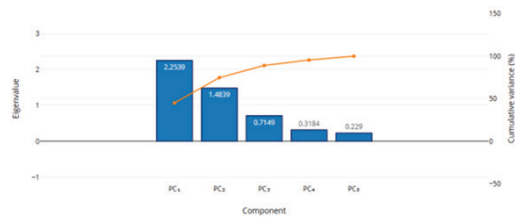
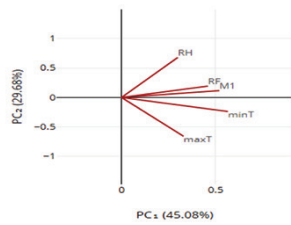


Fig. 5 Biplot - relations between male and environmental factors; Fig. 6. Scree plot for male and environmental factors

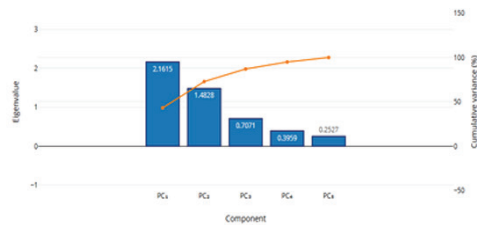
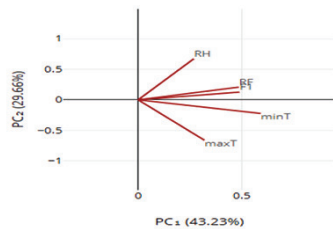


Fig. 7 Biplot - relations between female and environmental factors; Fig. 8 Scree plot for female and environmental factors

Relation between *Acrida exaltata* population and environmental factors at Forest ecosystem (Figs. 9 – 16)

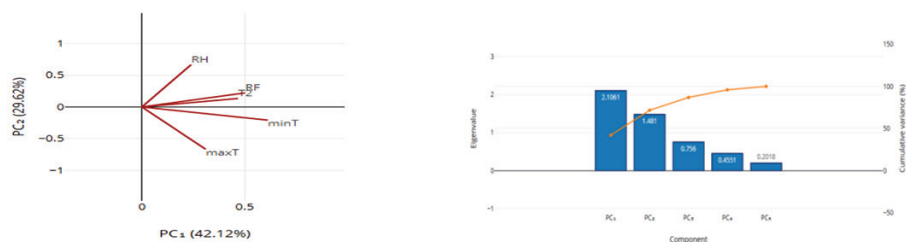


Fig. 9 Biplot - relations between total number and environmental factors; Fig. 10 Scree plot for total number and environmental factors

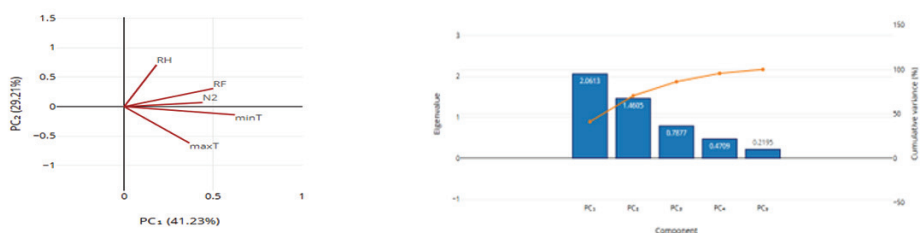


Fig. 11 Biplot - relations between nymph and environmental factors; Fig. 12 Scree plot for nymph and environmental factors

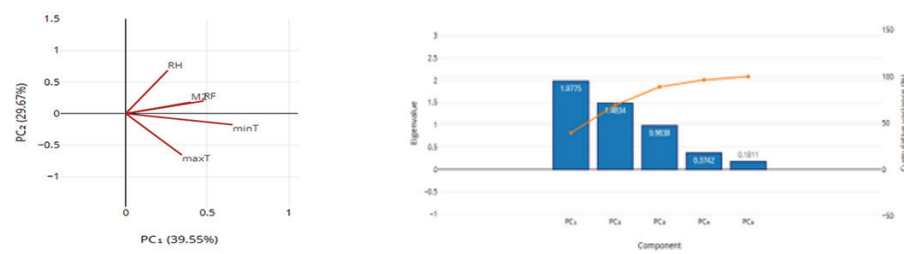


Fig. 13 Biplot - relations between male (M2) and environmental factors; Fig. 14 Scree plot for male and environmental factors

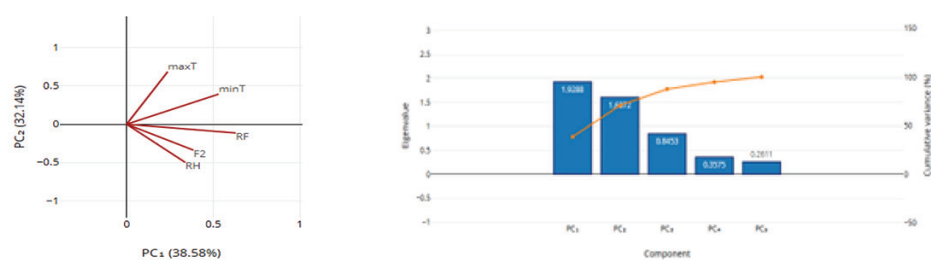


Fig. 15 Biplot - relations between female (F2) and environmental factors; Fig. 16 Scree plot for female (F2) and environmental factors

humidity and to the temperature, and precipitation (Fig. 17). The correlation matrix revealed a positive correlation of total population with relative humidity (RH) ($r = 0.4502$, $p < 0.05$). Minimum and maximum temperature also correlated ($r = 0.5563$, $p < 0.05$). Precipitation and minimum temperature had a significant correlation ($r = 0.4659$, $p < 0.05$). The eigenvalues observed from the scree plot (Fig. 18) indicate that PC-1 and PC-2 have 1.9763 and 1.654, respectively, and the first components explain more than 95 percent of the variance in the data. The nymph population also revealed almost similar pattern of relation between nymph population and environmental factors (Figs. 19, 20).

The male population of *A. exaltata* at agricultural field revealed positive correlation with precipitation ($r = 0.4993$, $p < 0.05$) and at the same time minimum temperature was positively correlated with precipitation ($r = 0.4659$, $p < 0.05$). The biplot also revealed the same phenomenon (Fig. 21). Eigen values for PC-1 and PC-2 were 2.04 and 1.5423 respectively and scree plot revealed 95 percent of cumulative variance (Fig. 22). The biplot for female population revealed a close relation with precipitation and relative humidity (Fig. 23). But correlation matrix revealed no significant relation between adult female grasshoppers and environmental factors. Eigen values for PC-1 and PC-2 are 1.9464 and 1.5554 and scree plot also revealed a high per cent of cumulative variance (Fig. 24).

Studies on *A. exaltata*, a minor pest of paddy and sorghum in Asia (Gupta and Chandra, 2013), revealed that the occurrence was related to the environmental factors. This grasshopper was available almost throughout the year in the forest and the fallow land. Whereas, available in the cultivation field, when crop cultivation was done and availability of paddy plants as food during and after the monsoon. Moreover, the soil beside the cultivation fields became soft during and after the monsoon. The study also revealed that *A. exaltata* occurred in the agriculture land ecosystem during the period from June to September, when Kharif paddy was cultivated and in November during Boro paddy cultivation. The grass-feeding insects like

grasshoppers were closely associated with the changes of weather (Jonas *et al.*, 2015). The present study revealed that the population pattern was highly correlated with the temperature, and the temperature was related to the precipitation. It appeared that the number of this insect increased gradually from April, when the temperature increased gradually, and nymphs hatched out due to the softening of the soil. After winter, the temperature rose which made the hatching easier for this insect. The minimum temperature was correlated with precipitation in all types of ecosystems.

Among the vegetation pattern of the forest, *Shorea robusta*, *Acacia auriculiformis*, *Cassia siamea*, *Anacardium occidentale*, *Eucalyptus citriodora*, *Azadirachta indica* and *Syzygium cumuni* were dominant. Among the shrubs, *Detura metel*, *Heliotropium indicum*, *Cassia occidentalis*, *Tribulus terrestris*, *Rumex dentatus*, *Polygonum plebeium*, etc. were dominant, whereas, *Chrysopogon aciculatus*, *Cynodon dactylon*, *Oplismenus compositus*, *Dactyloctenium aegyptium*, etc., were the dominant species of the herbs in the forest ecosystem. No trees were present in the fallow land, where few herbs like *Chrysopogon aciculatus*, *Cynodon dactylon*, *Poa* sp. etc. and shrubs, such as *Leucas cephalotes*, *Ocimum canum*, *Xyris indica*, *Solanum surattense*, *Argemone mexicana*, etc. were found. *A. exaltata* mainly depends upon herbs for its food. In adverse situations, a few of these herbs acts as an additional food source in the forest and fallow land ecosystems; as a result, the population of *A. exaltata* was maintained throughout the year. Due to rain, the temperature of the weather reduced, and the soil became softer than dry season. These resulted in increased vegetation in the area. Which were suitable situations for reproduction, as well as increasing the population of the grasshoppers. The growth of paddy in agriculture land was rapid in comparison to other vegetation of the surrounding areas during its cultivation time. This attracted the acridid population to the paddy field during the cultivation period. The easy availability of paddy as food and the soft soil of the surroundings of the paddy field,

Relation between *Acrida exaltata* population and environmental factors at Agricultural ecosystem (Figs. 17 – 24)

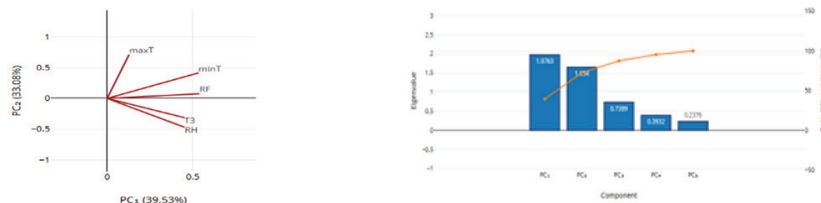


Fig. 17 Biplot - relations between total number (T3) and environmental factors; Fig. 18 Scree plot for total number (T3) and environmental factors

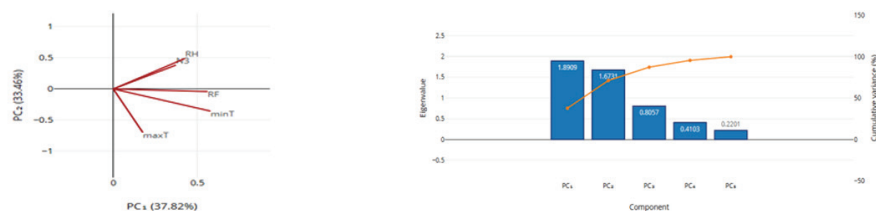


Fig. 19 Biplot - relations between nymph (N3) and environmental factors; Fig. 20 Scree plot for nymph (N3) and environmental factors

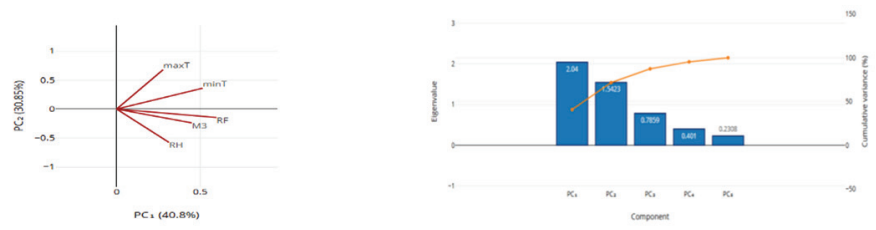


Fig. 21 Biplot - relations between male (M3) and environmental factors; Fig. 22 Scree plot for male (M3) and environmental factors

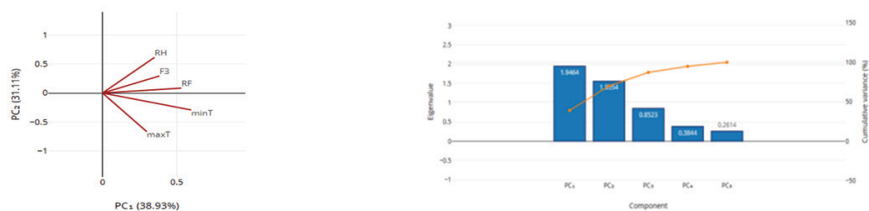


Fig. 23 Biplot - the relations between female (F3) and environmental factors; Fig. 24 Scree plot for total number (F3) of *A. exaltata* and environmental factors

which in turn would assist in the oviposition by the female with ease. As a result, this acridid was available in maximum numbers in the crop field and surrounding areas during the monsoon. Moreover, due to rapid growth and an identical pattern of vegetation, like paddy, insects also migrated in large numbers from the surrounding areas. From the beginning of the winter month and onward, the crop land became dry, and, from the end of winter to the summer months, the supporting vegetation dried up, and the soil became hard. At the same time, a change in the suitable weather temperature also took place. Probably, that might be one of the reasons for the disappearance of the species from the crop land ecosystem under stressful situations. That conformed to the results reported by Dempster (1957). It appeared from the study that changes in the environmental factors affected the vegetation pattern of the study areas. Which affected the population pattern of *A. exaltata* in the study area (Anderson, 1964; Latchininsky, 1998). The eggs of acridids were capable of surviving in adverse conditions of weather, and maintained the population throughout the year in the forest and fallow land due to the availability of the supporting vegetation. When the conditions of agriculture land were suitable, this acridid was available in noticeable numbers, and the soft soil of the cultivation field assisted in the oviposition by the female with ease. Dempster (2008) reported that tropical grasshoppers generally laid eggs when conditions were suitable for growth, while eggs underwent diapause when both temperature and moisture were extreme. Meena *et al.* (2023) also revealed the significant role of climatic factors in limiting grasshopper populations in the summer and highest in the monsoon period. It was also reported that the mean annual precipitation was the main environmental factor that affected the distribution of grasshoppers in their habitat (Li *et al.*, 2024). Development, abundance and diversity of grasshoppers influenced by the temperature of the environment (Wang and Hou, 2025). The present study also revealed that precipitation and minimum temperature were directly correlated in all the ecosystems studied, whereas precipitation, temperature, and relative humidity had direct correlation with the occurrence of the *A. exaltata* population.

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Species diversity and population dynamics of fruit flies in cucurbit ecosystem

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ABSTRACT: Investigation on the population dynamics of Tephritidae fruit flies (Diptera) was conducted by installing “Cuelure traps” in the cucurbit ecosystem, Madurai, Tamil Nadu, India. Two species of fruit flies, *Zeugodacus cucurbitae* and *Bactrocera dorsalis* were captured during the monitoring process. The population of *Z. cucurbitae* prevailed the whole season with its peak activity from 9th SMW and 40th SMW which coincided with the peak fruiting period of bitter gourd and snake gourd respectively. Relative abundance of *B. dorsalis* was more in the snake gourd (39%) than the bitter gourd (5%). The Simpson’s index and the Shannon’s index were higher in snake gourd than bitter gourd. The bitter gourd ecosystem has higher Margalef and Mehinick Index. The weather correlation showed that the population of both species and abiotic factors had no significant correlation in bitter gourd ecosystem. In snake gourd ecosystem, both the species exhibited strong inverse relationship with maximum and minimum wind speed. © 2026 Association for Advancement of Entomology

KEY WORDS: Bitter gourd, snake gourd, *Zeugodacus cucurbitae*, *Bactrocera dorsalis*, relative abundance, diversity indices

INTRODUCTION

One of the largest families of Diptera, the fruit fly family, Tephritidae has over 4500 species, of which 250 are significant economically (David and Ramani, 2011). Ruiz *et al.* (2014) described fruit flies as a major pests of fruits in the world with India being considered as the home land for fruit flies (Dhillon *et al.*, 2005). India harbors a rich diversity of fruit flies and this presents a serious risk to the export industry (Vasudha *et al.*, 2019). Attack of fruit flies cause reduction in the harvest volume and fruit quality, and also exposes them to

vulnerable secondary infections. Because of the polyphagous, florivorous and frugivorous nature of fruit flies, they are recognized as one of the top ten major threats of horticulture causing yield loss extending from 2 to 100 per cent based on the crop and season. Maggots infest and damage the pulp making the fruit unfit for consumption thus, reducing the marketability of fruits (Dhillon *et al.*, 2005).

Vegetable crops in India are occupying cultivation area of 1.03 crore hectares with a productivity of 18.94 metric tonnes (Anonymous, 2020-21). Among the vegetables grown in India, cucurbits are the

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significant summer vegetable and are grown throughout the year except winter season. Atwal and Dhaliwal (2005) reported 50 per cent damage of cucurbits in India because of fruit flies. Fruit flies are reported to attack over 70 species of cucurbits of which, bitter gourd, snake gourd and musk melon are the most favored (Doharey, 1983).

Bitter gourd (*Momordica charantia*) is an important cucurbit vegetable. In India, during 2019–2020, bitter gourd was grown on approximately 1.01 lakh hectares, producing around 12.92 lakh metric tonnes of the crop (Anonymous, 2020–21). The infestation of fruit flies in bitter gourd ranges between 41 to 89 per cent damaging fruits, tender stem and flowers (Ravindranath and Pillai, 1986). Melon fly, *Zeugodacus cucurbitae*, caused 28.56 per cent yield reduction in bitter gourd (Singh *et al.*, 2000). Snake gourd (*Trichosanthes anguina*) is an important single-season, cucurbit vegetable. In Tamil Nadu, snake gourd occupies an area of 1439 ha in cultivation, 35,411 tonnes production with 17.66 t ha⁻¹ productivity (Sowmiya *et al.*, 2020). Monitoring fruit flies is important in understanding and determining its population dynamics, assessing infestation levels at different sites and measuring the effectiveness of a particular control strategy (Enkerlin *et al.*, 1996; Eliopoulos, 2007). Parapheromone trap *i.e.*, cue-lure trap was best suited to monitor and mass trap melon fruit flies (Pawar *et al.*, 1991; Permalloo *et al.*, 1998) hence it was used for the present study.

MATERIALS AND METHODS

Field experiments on monitoring of fruit flies infestation was performed in bitter gourd and snake gourd fields during February, 2021 to April, 2021 and July, 2021 to October, 2021 respectively in Ayyur village, Alanganallur block of Madurai district, Tamil Nadu (Table 1).

Fruit flies caught in the cue-lure traps during the monitoring studies were preserved and divided into two groups according to the visible morphological distinguishing traits such as presence or absence of prominent black spot on the apical region of the wing and dark or pale colour of the body. Identification of the two fruit fly species was carried

out by Dr. K. J. David, Principal Scientist, National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru.

Table 1. Details of the locations of experimental plots

Location	Latitude	Longitude
Meenakshipuram	10°4'14.1708" N	78°4'46.4556" E
Errampatti	10°4'30.8892" N	78°5'3.4008" E
Alagapuri	10°3'47.124" N	78°4'41.5848" E
Urseri	10°4'5.0304" N	78°4'10.8132" E
Azhagapuri	10°4'37.3656" N	78°4'52.6224" E
Azhagapuri	10°4'37.3584" N	78°4'52.5648" E
Meenakshipuram	10°4'3.792" N	78°4'9.006" E
Kovilpatti	10°4'35.8428" N	78°4'55.794" E

Monitoring of melon flies in cucurbit ecosystem was done by installing the para-pheromone traps, cue-lure (4-(p-acetoxyphenyl)-2- butanone) procured from Barrix Agro Sciences Pvt. Ltd. Traps were placed @ 5 nos./acre in bitter gourd and snake gourd fields at the time of flowering. They were hung at 1 to 1.5m height in iron wired pandal. Weekly fruit fly catches in the cue-lure traps were recorded from flowering till last harvest. Weather data *viz.*, maximum and minimum temperature, max and min wind speed, precipitation (rainfall) and relative humidity, were acquired from NASA ARC POWER website during the monitoring period (Sowmiya *et al.*, 2020). Meteorological data were aggregated into weekly averages and correlated with the corresponding trap catches of fruit flies to analyze the influence of meteorological factors on population fluctuations of fruit flies.

Diversity indices *i.e.*, Simpson's index (Simpson, 1949) and Shannon-Wiener index (Shannon and Weaver, 1949) were calculated to determine the species diversity of melon flies in bitter gourd and snake gourd ecosystems.

Simpson's index (D) is the proportion of particular species in relation to total number of species. Values of this index generally range from 0.0 to 1.0 and the ecosystem with higher value was considered as diversified ecosystem.

$$D = \sum \left(\frac{n_i(n_i - 1)}{N(N - 1)} \right)$$

Shannon's index (H) was calculated by summing the proportions of different species in respect to the total number of species (p_i). Normally values of this index range from 0.0 to 5.0. Diversified ecosystems have higher index values.

$$H' = -\sum p_i \ln p_i$$

Menhinick's index (N) was calculated by dividing the number of species by the square root of the total number of individuals caught in the traps (Whittaker and Rh, 1977).

$$D_{Mn} = \frac{S}{\sqrt{N}}$$

Margalef index (D) is a species richness indicator calculated by the formula given below where, S represents the number of species and N denotes the number of individuals in the sample (Clifford, 1975).

$$D_{Mg} = \frac{(S - 1)}{\ln N}$$

Relative abundance = (No. of fruit flies of one species / No. of fruit flies of all species) X 100.

RESULTS AND DISCUSSION

The species in the parapheromone traps in bitter gourd and snake gourd fields were identified as *Zeugodacus cucurbitae* (Coquilett) and *Bactrocera dorsalis* (Hendel).

Bitter gourd ecosystem

Melon fruit fly, *Z. cucurbitae*:

During the 6th standard meteorological week (SMW), when the crop is in full flowering stage, mean fruit fly catch was 11/trap/week (T/W) (Table 2). Afterwards, trap catch was increased gradually and peak population was noted during fruiting stage i.e., 9th SMW with 26 fruit flies/trap (Ff/T). Then the fruit fly count was gradually reduced during 10th and 11th standard meteorological weeks with 23 and 21 Ff/T respectively. During the 12th SMW, trap catches reduced abruptly (12 Ff/T). In the subsequent week (13th SMW) again mean trap catch reached to 21.0. During the last harvest, in 14th SMW, trap catch of 15/week was recorded.

A correlation was drawn between the weekly fruit fly catches and weather parameters (Temperature and wind speed ranges, precipitation and moisture). Using this correlation matrix, the influence of different weather parameters on fruit fly presence was investigated. The population of *Z. cucurbitae* was found to be positively related to maximum temperature, minimum temperature and maximum wind speed. Negative correlation was detected between the trap catches of *Z. cucurbitae* and relative humidity, rainfall & minimum wind speed. In bitter gourd, population of *Z. cucurbitae* exhibited insignificant correlation with all the weather parameters. However, studies of Dhillon *et al.* (2005) reported a positive relationship between rainfall and fruit fly population. The population of *B. dorsalis* exhibited a significant positive correlation with temperature (both maximum and minimum levels) while showing a significantly negative correlation with relative humidity (Table 3).

Oriental fruit fly, *B. dorsalis*:

The flies were not captured in the traps from 6th SMW to 12th SMW. Their population appeared in the traps during 13th SMW with a mean number of 2/trap. In 14th SMW, during the final harvest of the crop, 7.0 *B. dorsalis* flies were noted per trap (Table 2). *B. dorsalis* population displayed positive correlation with maximum temperature, minimum temperature, rainfall and maximum wind speed. Weather parameters i.e., minimum wind speed and relative humidity were showing negative correlation with the abundance of this fruit fly population (Table 3, Fig. 1).

Snake gourd ecosystem

Melon fruit fly, *Z. cucurbitae*:

Observations were recorded from the 29th SMW during full flowering stage and mean fruit fly catch of 11/trap was noted (Table 4). Subsequently during 31st SMW, catches were increased to 17/trap. Later, number of fruit flies trapped decreased to 11.0 in 32nd SMW. Following this, during the fruiting stage, i.e., from 33rd to 37th SMW, catches ranged between 15 to 20/T/W. During the end of the fruiting stage, peak number of fruit flies (27/T/W) were captured

Table 2. Seasonal incidence of cucurbit fruit flies in bitter gourd ecosystem (February to April, 2021)

SMW	Crop stage	Mean catch (No. /trap/week)	
		<i>Z. cucurbitae</i>	<i>B. dorsalis</i>
6	Flowering	11.0	0.0
7	Flowering	14.0	0.0
8	Initial fruiting	21.0	0.0
9	Flowering & fruiting	26.0	0.0
10	Flowering & fruiting	23.0	0.0
11	Flowering & fruiting	21.0	0.0
12	Flowering & fruiting	12.0	0.0
13	Fruiting	21.0	2.0
14	Last harvest	15.0	7.0

* SMW – Standard meteorological week

Table 3. Correlation between fruit fly trap catches and abiotic factors in bitter gourd

Parameters		Correlation coefficient	
		<i>Z. cucurbitae</i>	<i>B. dorsalis</i>
Temperature (°C)	Maximum	+ 0.330	+ 0.577
	Minimum	+ 0.150	+ 0.540
Relative humidity (%)		-0.283	- 0.595
Rainfall (mm)		-0.269	+ 0.409
Wind speed	Maximum	+ 0.021	+ 0.309
	Minimum	+ 0.309	-0.434

in 40th SMW. Population of *Z. cucurbitae* evinced positive relation with the minimum temperature, RH and rainfall (Table 5). The studies of Boopathi *et al.* (2013) observed that the minimum temperature is an important predictor of fruit fly catches in Chilli in Mizoram. When the interaction of *Z. cucurbitae* trap catches and wind speed was probed through, a significantly negative association was noted with both maximum (0.741) and minimum levels (0.760). Peak population of *Z. cucurbitae* and *B. dorsalis* trapped were 26.0 (9th SMW) and 7.0/trap/week (14th SMW) respectively. Sowmiya *et al.* (2020) also documented maximum number of fruitfly catches in 9th and 10th standard weeks (11.30 to 12.00 fruit flies/trap) in snake gourd in Tiruchirappalli district of Tamil Nadu, India.

In snake gourd, unlike in bitter gourd, both species of fruit flies *i.e.*, *B. dorsalis* and *Z. cucurbitae* were noticed from the initiation of the observation period itself (13 weeks from 29th to 41st SMW). However, in the trapped fruit fly population, proportion of *Z. cucurbitae* was more than *B. dorsalis*. Number of *Z. cucurbitae* fruit flies captured was high from 37th to 41st SMWs and top population of 27.0/trap was recorded in 40th SMW. *B. dorsalis* population ranged between 8.0 (31st SMW) and 17.0 (39th SMW)/trap (Fig. 2). The current results align with the reports of Sowmiya *et al.* (2020) and Dale and Patel (2010) who has observed peak population of melon flies in *kharif* season in 35th standard week in snake gourd in Trichy region of Tamil Nadu, India and guava ecosystem in Sardarkrushinagar, Gujarat, India respectively. In the current investigation, a high level of fruit fly infestation was documented in snake gourd fields than in bitter gourd. Am *et al.* (2017) disclosed that the occurrence of fruit flies was high in snake gourd than in bitter gourd in Coimbatore district and this is in support of outcome of the present study.

Oriental fruit fly, *B. dorsalis*:

B. dorsalis population was noted in cue lure traps from the initiation of the observation period itself unlike bitter gourd. During initial week of observation *i.e.*, 29th SMW, 9.0 *B. dorsalis* males

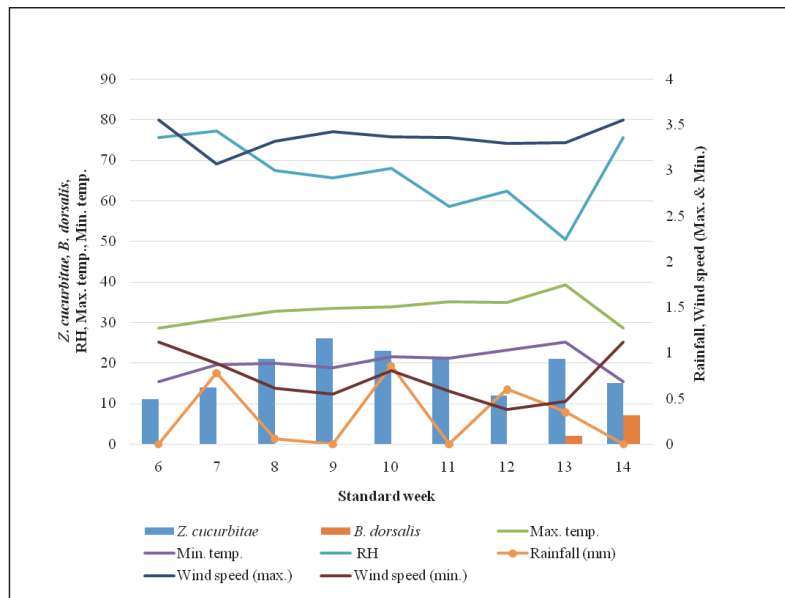


Fig. 1 Abundance of fruit flies and their correlation with weather parameters in bitter melon ecosystem

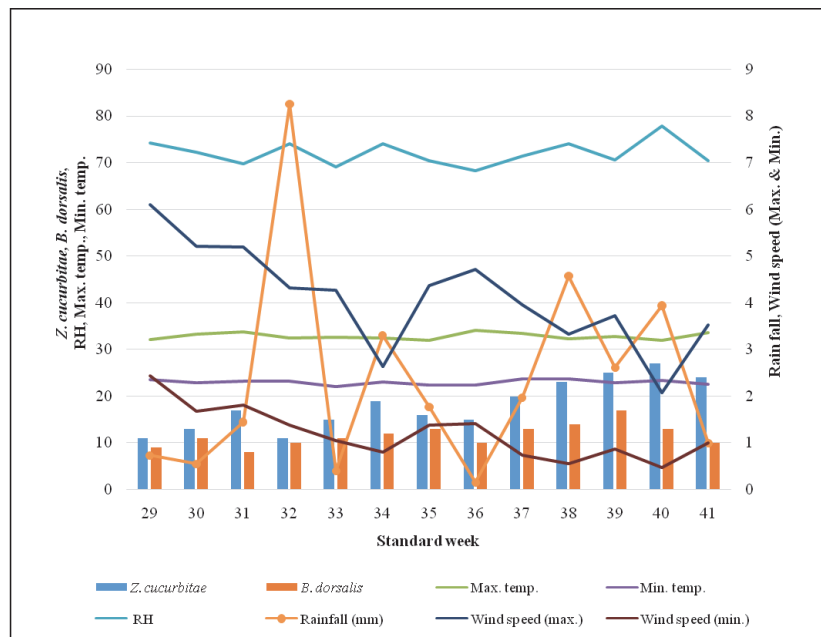


Fig. 2 Seasonal incidence of fruit flies in snake melon ecosystem

were found/trap. Henceforth, number of trapped flies ranged between 8.0 (31st SMW) to 14.0 (38th SMW). During the study period, the highest number of *B. dorsalis* fruit flies captured using cuelure traps was 17 per week, recorded during 39th SMW. Population of *B. dorsalis* and minimum temperature, relative humidity and rainfall were

positively correlated however, their interaction was inconsequential. With the maximum temperature, *B. dorsalis* population revealed an insignificant and negative correlation. Interrelationship of maximum (0.558) and minimum wind speeds (0.674) with the abundance of *B. dorsalis* fruit flies was a significantly negative relationship.

Relative abundance:

In bitter gourd, *Z. cucurbitae* was found to be more abundant than *B. dorsalis*. The same trend was noticed in snake gourd also. However, relative abundance of *B. dorsalis* was more in snake gourd (39%) than bitter gourd (5%). Population of *Z. cucurbitae* was high (95%) in bitter gourd than snake gourd (61%).

Studies of Akhtaruzzaman *et al.* (1999) and Ganie *et al.* (2013) confirmed that *Z. cucurbitae* was more abundant than other species of fruit flies in gourds. However, according to Prabhakar *et al.* (2009) *Z. tau* was found to be the dominant species compared to *Z. cucurbitae* and *B. scutellaris* in the northern Himalayan forest regions. This may be due to the variation in the geographical locations and climatic factors.

Table 4. Seasonal incidence of cucurbit fruit flies in bitter gourd ecosystem (February to April, 2021)

SMW	Crop stage	Mean catch (No. /trap/week)	
		<i>Z. cucurbitae</i>	<i>B. dorsalis</i>
29	Initial flowering	11.0	9.0
30	Flowering	13.0	11.0
31	Flowering & fruiting	17.0	8.0
32	Flowering & fruiting	11.0	10.0
33	Flowering & fruiting	15.0	11.0
34	Flowering & fruiting	19.0	12.0
35	Flowering & fruiting	16.0	13.0
36	Flowering & fruiting	15.0	10.0
37	Flowering & fruiting	20.0	13.0
38	Flowering & fruiting	23.0	14.0
39	Flowering & fruiting	25.0	17.0
40	Fruiting	27.0	13.0
41	Last harvest	24.0	10.0

* SMW – Standard meteorological week

Table 5. Correlation of seasonal incidence of fruit fly and weather factors

Parameters		Correlation coefficient	
		<i>Z. cucurbitae</i>	<i>B. dorsalis</i>
Temperature (°C)	Maximum	- 0.177	-0.344
	Minimum	0.380	0.103
Relative humidity (%)		0.362	0.165
Rainfall (mm)		0.001	0.215
Wind speed	Maximum	-0.741*	-0.558*
	Minimum	-0.760*	-0.674

Species diversity indices:

Simpson's diversity index was comparatively high (0.47) in snake gourd ecosystem than in bitter gourd (0.09) (Table 6). This had clearly revealed higher fruit fly diversity in snake gourd fields. Shannon's diversity index values in bitter gourd and snake gourd were 0.20 and 0.66 respectively. Hence, it is evident that diversity of melon flies was more in snake gourd than bitter gourd. Studies of Kishor *et al.* (2018) in Coimbatore district, Tamil Nadu also confirmed highest fruit fly diversity in snake gourd

Table 6. Diversity and richness indices of fruit flies in bitter gourd and snake gourd

Particulars	Bitter gourd		Snake gourd	
	<i>Z. ucurbitae</i>	<i>B. dorsalis</i>	<i>Z. cucurbitae</i>	<i>B. dorsalis</i>
Relative abundance (%)	95.0	5.0	61.0	39.0
Species diversity indices				
Simpson’s index	0.09		0.47	
Shannon’s index	0.20		0.66	
Species richness indices				
Menhinick index	0.15		0.10	
Margalef index	0.19		0.16	

ecosystem. Values of Margalef and Menhinick indices are more in bitter gourd indicating more species richness in bitter gourd than the snake gourd.

Species richness indices: With Menhinick values of 0.15 in bitter gourd and 0.10 in snake gourd, it is apparent that species richness of fruit flies was more in snake gourd. Margalef richness index was comparatively high (0.19) in bitter gourd fields than snake gourd (0.16).

Two species of fruit flies, *Z. cucurbitae* and *B. dorsalis*, were trapped in cue lure traps during monitoring studies of fruit flies carried out in the cucurbit ecosystem (bitter gourd and snake gourd) at Madurai district, Tamil Nadu. The population of *Z. cucurbitae* was dominant over the other fruit fly species. Simpson's index and Shannon's index, were higher in snake gourd than in bitter gourd, indicating that the fruit fly population in snake gourd was more diverse. The bitter gourd showed higher values of the Margalef and Menhinick indices, indicating that it has more species richness than the snake gourd. In the snake gourd habitat, the population of *Z. cucurbitae* and *B. dorsalis* showed a significantly negative correlation with abiotic weather factors such as max and min wind speeds. The weather correlation shown that both *Z. cucurbitae* and *B. dorsalis* had no significant correlation with weather factors in bitter gourd to strengthen the point that the fruit fly has a strong population built up over the weather fluctuations.

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An updated checklist of the butterflies of Sironcha forest division, Gadchiroli District, Maharashtra, central India

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ABSTRACT: The study was carried out to reveal the butterfly diversity in the Sironcha Forest Division, Gadchiroli district, Maharashtra. A total of 137 species were recorded. Most of the butterflies recorded belonged to the family Lycaenidae (44 species), followed by Nymphalidae (42 species), Hesperidae (23 species), Pieridae (17 species), Papilionidae (10 species), and a single representative from the Riodinidae family. Notably, 15 species recorded in the Sironcha Forest Division had not been previously documented in the Vidarbha region of Maharashtra. About 19 species of the recorded ones come under the protection category of the Indian Wild Life (Protection) Act 1972. These findings highlight the ecological significance of the Sironcha Forest Division as an important habitat supporting rich butterfly biodiversity, thereby contributing to a broader understanding of regional Lepidoptera diversity and associated conservation priorities. The study also presents an updated checklist of butterfly species for the Sironcha Forest Division, Gadchiroli.. © 2026 Association for Advancement of Entomology

KEY WORDS: Diversity, checklist, conservation, lepidoptera, papilionoidea, reserve forest, habitat, new records

INTRODUCTION

Butterflies are among the most extensively studied insect groups (Robbins and Opler, 1997) and are widely recognized as sensitive bio-indicators of ecosystem health because they respond rapidly to changes in vegetation and environmental conditions (Gardner et al., 1995; Wood and Gillman, 1998). Their ecological roles as pollinators and as integral components of food webs further underscore their importance in biodiversity assessments (Tiple *et al.*, 2006). Although global butterfly diversity is estimated at around 18,000 species (Martinez *et*

al., 2003), regional documentation remains incomplete, and diversity is often underestimated even in well-known taxa (Willmott *et al.*, 2001). In India, butterfly research has a long tradition beginning with the works of Fabricius and Cramer in the eighteenth century, followed by major contributions from Moore, Marshall, de Nicéville, Bingham, Bell, and Talbot (Moore, 1881; Marshall and de Nicéville, 1883; de Nicéville, 1886, 1890; Moore, 1890-1913; Bingham, 1905; Bell, 1909-1927; Talbot, 1939, 1947). Despite this extensive foundation, many regions-particularly the forested landscapes of central India remain poorly

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documented. Early accounts from central India were provided by Forsayeth (1884), Betham (1890, 1891), and Witt (1909), followed by the broader regional studies of Evans (1932), Talbot (1939, 1947), and Wynter-Blyth (1957), which recorded numerous species from central India. D'Abreu (1931) recorded 177 species in the former Central Provinces, covering regions such as Pachmari, Pench, Seoni, and Nagpur (now Madhya Pradesh and Vidarbha). India's diverse geography and climate support around 1,504 butterfly species (Tiple, 2011), with 351 species found in peninsular India and 336 in the Western Ghats (Sadasivan and Sengupta, 2024). D'Abreu (1931) documented 177 species, and recent studies recorded 43 species from the Tiger Reserve in Tadoba National Park (Rai *et al.*, 2006) and 68 species from the Tadoba Andhari Tiger Reserve (Sharma and Radhakrishnan, 2006). Tiple (2010) reported 111 species from Tadoba National Park. While 167 species have been documented in Vidarbha (Tiple, 2011), gaps in the data remain, with additional records contributed by Deokar and Shukla (2015); Tiple (2018, 2019), Tiple and Bhagwat (2023) and Tiple and Deokar (2024). The present study was started with a view to examine the diversity of butterflies from Sironcha forest division, Gadchiroli District, Maharashtra. Since there is no published checklist of butterfly from Sironcha forest division, prior to this, the present work could be the baseline for further research.

MATERIALS AND METHODS

The findings presented in this paper are the result of opportunistic sampling and biweekly photographic documentation conducted in and around Sironcha Forest Division, Gadchiroli. This study is carried out from May 2023 to June 2024. Surveys were conducted in reserve forest areas, buffer zones, along lake shores, riverbanks, and surrounding regions, primarily during the monsoon and post-monsoon seasons. All butterfly records were documented using high-resolution digital cameras. Photographs were captured using a Canon EOS 90D DSLR paired with a 100mm macro lens. Specimens were photographed from different angles in the field to aid in identification. Butterflies

were primarily identified in the field using photographs taken from multiple angles, with the help of field guides (Wynter-Blyth, 1957; Kunte, 2000). The species were categorized on the basis of their abundance in Sironcha Forest Division. The butterflies were categorized as VC-Very common (> 100 sightings), C- Common (51-100 sightings), FC-Frequent common (16-50 sightings), R-Rare (2-15 sightings), VR-Very rare (< 2 sightings) (Tiple, 2018). The species that come under Indian Wild Life protection Act 1972 and its amendments till 2022 are marked with an asterix*.

The Sironcha Forest Division, Gadchiroli, Maharashtra spans approximately 212,492 hectares, covering both reserved and protected forest lands. It is located between latitudes 18°41'15" N to 19°20' N and longitudes 79°55'19" E to 80°22'30" E, with an elevation ranging from 130 to 660m above sea level. The region's geology consists of formations from the Recent, Upper Gondwana, Lower Gondwana, Upper Cuddapah, and Archaean periods. The climate is predominantly hot and dry, with maximum temperatures reaching 45°C and minimum temperatures around 9.6°C in winter. The area receives an average annual rainfall of 1,923mm (Fig. 1). The forests in Sironcha are distributed across various agro-climatic zones and include sub-tropical hill forests, tropical moist and dry deciduous forests, and lush green deciduous forests (Champion and Seth, 1968), providing habitat for a wide range of plant and animal species.

RESULTS AND DISCUSSION

During the course of study 137 species of butterflies, belonging to 6 families, were recorded in Sironcha Forest Division (SDF), Gadchiroli. The family Lycaenidae had the highest representation, with 44 species, followed by Nymphalidae 42 species, Hesperidae (23 species), Pieridae (17 species), Papilionidae (10 species) and one species recorded from the family Riodinidae. Out of the 137 species recorded, 15 species documented in the SDF, had not been previously recorded in the Vidarbha region of Maharashtra. These species include *Athyma ranga* Moore, [1858], *Athyma selenophora* (Kollar, [1844]), *Pantoporia hordonia* (Stoll, [1790]), *Tanaecia lepidea* (Butler, 1868), *Curetis*

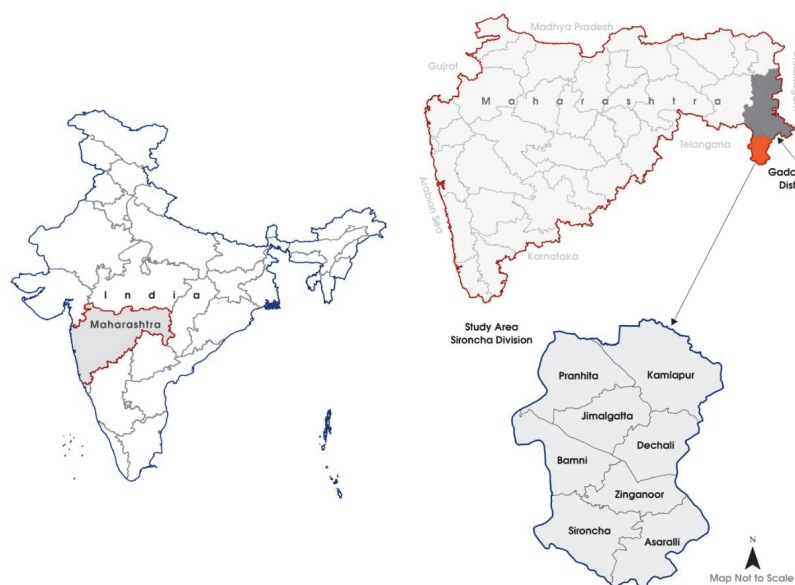


Fig 1. Location map of Sironcha Forest Division, Gadchiroli, Maharashtra, central India



Fig. 2 Newly recorded butterfly species for the Vidarbha region from the Sironcha Forest Division, Gadchiroli

Table 1. Butterfly species of Sironcha Forest Division, Gadchiroli and surroundings together with common name. * Come under Indian Wild Life (Protection) Act 1972 & amendments till 2022 (contd.) and the species recorded for the first time from Vidharbha region are marked with pound sign/ hash (#).

No.	Common Name	Scientific Name	Status	IUCN
Papilionidae (10)				
1.	Tailed Jay	<i>Graphium agamemnon</i> (Linnaeus, 1758)	VC	NE
2.	Common Jay	<i>Graphium doson</i> (C. & R. Felder, 1864)	C	NE
3.	Spot Swordtail	<i>Graphium nomius</i> (Esper, 1799)	VC	NE
4.	Common Rose	<i>Pachliopta aristolochiae</i> (Fabricius, 1775)	VC	LC
5.	Crimson Rose	<i>Pachliopta hector</i> (Linnaeus, 1758)*	C	LC
6.	Common Mime	<i>Papilio clytia</i> Linnaeus, 1758*	VR	NE
7.	Common Banded Peacock	<i>Papilio crino</i> Fabricius, 1793	R	NE
8.	Lime Butterfly	<i>Papilio demoleus</i> Linnaeus, 1758	VC	NE
9.	Blue Mormon	<i>Papilio polymnestor</i> Cramer, [1775]	FC	NE
10.	Common Mormon	<i>Papilio polytes</i> Linnaeus, 1758	VC	NE
Pieridae (17)				
11.	Pioneer	<i>Belenois aurota</i> (Fabricius, 1793)	VC	NE
12.	Common or Lemon Emigrant	<i>Catopsilia pomona</i> (Fabricius, 1775)	VC	NE
13.	Mottled Emigrant	<i>Catopsilia pyranthe</i> (Linnaeus, 1758)	VC	NE
14.	Common Gull	<i>Cepora nerissa</i> (Fabricius, 1775)	VC	NE
15.	Plain Orange Tip	<i>Colotis aurora</i> (Fabricius, 1775)	R	NE
16.	Crimson Tip	<i>Colotis danae</i> (Fabricius, 1775)	C	NE
17.	Small Orange Tip	<i>Colotis etrida</i> (Boisduval, 1836)	VC	NE
18.	Large Salmon Arab	<i>Colotis fausta</i> (Olivier, 1804)	R	LC
19.	Common Jezebel	<i>Delias eucharis</i> (Drury, 1773)	VC	NE
20.	Small Grass Yellow	<i>Eurema brigitta</i> (Stoll, [1780])	C	LC
21.	Common Grass Yellow	<i>Eurema hecabe</i> (Linnaeus, 1758)	VC	NE
22.	Spotless Grass Yellow	<i>Eurema laeta</i> (Boisduval, 1836)	VC	NE
23.	Three-Spot Grass Yellow	<i>Eurema blanda</i> (Boisduval, 1836)	R	NE
24.	White Orange Tip	<i>Ixias marianne</i> (Cramer, [1779])	VC	NE
25.	Yellow Orange Tip	<i>Ixias pyrene</i> (Linnaeus, 1764)	C	NE
26.	Psyche	<i>Leptosia nina</i> (Fabricius, 1793)	C	NE
27.	Common Wanderer	<i>Pareronia valeria</i> (Cramer, [1776])	VC	NE
Nymphalidae (42)				
28.	Tawny Coster	<i>Acraea terpsicore</i> (Linnaeus, 1758)	VC	NE
29.	Angled Costor	<i>Ariadne ariadne</i> (Linnaeus, 1763)	VC	NE

30.	Common Castor	<i>Ariadne merione</i> (Cramer, [1777])	VC	NE
31.	Blackvein Sergeant	<i>Athyma ranga</i> Moore, [1858]*#	VR	NE
32.	Staff Sergeant	<i>Athyma selenophora</i> (Kollar, [1844])#	R	
33.	Spotted Joker	<i>Byblia ilithyia</i> (Drury, [1773])	VC	NE
34.	Tawny Rajah	<i>Charaxes psaphon</i> Westwood, 1847	FC	NE
35.	Black Rajah	<i>Charaxes solon</i> (Fabricius, 1793)	FC	NE
36.	Plain Tiger	<i>Danaus chrysippus</i> (Linnaeus, 1758)	VC	LC
37.	Striped Tiger	<i>Danaus genutia</i> (Cramer, [1779])	VC	NE
38.	Common Palmfly	<i>Elymnias hypermnestra</i> (Linnaeus, 1763)	C	NE
39.	Common Indian Crow	<i>Euploea core</i> (Cramer, [1780])	VC	LC
40.	Common Baron	<i>Euthalia aconthea</i> (Cramer, [1777])	VC	NE
41.	Gaudy Baron	<i>Euthalia lubentina</i> (Cramer, [1777]) *	VR	NE
42.	Great Eggfly	<i>Hypolimnas bolina</i> (Linnaeus, 1758)	VC	NE
43.	Danaid Eggfly	<i>Hypolimnas misippus</i> (Linnaeus, 1764)*	VC	NE
44.	Peacock Pansy	<i>Junonia almana</i> (Linnaeus, 1758)	VC	LC
45.	Grey Pansy	<i>Junonia atlites</i> (Linnaeus, 1763)	VC	NE
46.	Yellow Pansy	<i>Junonia hierta</i> (Fabricius, 1798)	C	LC
47.	Chocolate Pansy	<i>Junonia iphita</i> (Cramer, [1779])	VC	NE
48.	Lemon Pansy	<i>Junonia lemonias</i> (Linnaeus, 1758)	VC	NE
49.	Blue Pansy	<i>Junonia orithya</i> (Linnaeus, 1758)	VC	NE
50.	Bamboo Treebrown	<i>Lethe europa</i> (Fabricius, 1775)	C	NE
51.	Common Evening Brown	<i>Melanitis leda</i> (Linnaeus, 1758)	VC	NE
52.	Dark Evening Brown	<i>Melanitis phedima</i> (Cramer, [1780])	R	NE
53.	Commander	<i>Moduza procris</i> (Cramer, [1777])	C	NE
54.	Dark-brand Bushbrown	<i>Mycalasis mineus</i> (Linnaeus, 1758)	C	NE
55.	Long-brand Bushbrown	<i>Mycalasis visala</i> Moore, [1858]	FC	NE
56.	Common Bushbrown	<i>Mycalasis perseus</i> (Fabricius, 1775)	VC	NE
57.	Medus Brown	<i>Orsotriaena medus</i> (Fabricius, 1775)	R	NE
58.	Common Sailer	<i>Neptis hylas</i> (Linnaeus, 1758)	VC	NE
59.	Chestnut-Streaked Sailer	<i>Neptis jumbah</i> Moore, [1858]	C	NE
60.	Common Lascar	<i>Pantoporia hordonia</i> (Stoll, [1790]) #	VR	NE
61.	Short-banded Sailer	<i>Phaedyma columella</i> (Cramer, [1780])	C	NE
62.	Common Leopard	<i>Phalanta phalantha</i> (Drury, [1773])	VC	NE
63.	Anomalous Nawab	<i>Polyura agraria</i> (Swinhoe, 1887)	VC	NE
64.	Common Nawab	<i>Polyura athamas</i> (Drury, [1773])	C	NE

65.	Baronet	<i>Symphaedra nais</i> (Forster, 1771)	VC	NE
66.	Blue Tiger	<i>Tirumala limniace</i> (Cramer, [1775])	VC	NE
67.	Grey Count	<i>Tanaecia lepidea</i> (Butler, 1868)*#	R	NE
68.	Common Three - ring	<i>Ypthima asterope</i> (Klug, 1832)	VC	LC
69.	Lesser Three - ring	<i>Ypthima inica</i> Hewitson, 1865	VC	NE
Riodinidae (1)				
70.	Two-spot Plum Judy	<i>Abisara bifasciata</i> Moore, 1877	C	NE
Lycaenidae (43)				
71.	Common Hedge Blue	<i>Acytoplepis puspa</i> (Horsfield, [1828])	VC	NE
72.	Large Oakblue	<i>Arhopala amantes</i> (Hewitson, 1862)	FC	NE
73.	Pointed Ciliate Blue	<i>Anthene lycaenina</i> (R. Felder, 1868)*	R	NE
74.	African Babul Blue	<i>Azanus jesous</i> (Guérin-Ménéville, 1849)	C	NE
75.	Angled Pierrot	<i>Caleta decidia</i> (Hewitson, 1876)	VR	NE
76.	Common Pierrot	<i>Castalius rosimon</i> (Fabricius, 1775)	VC	NE
77.	Forget-Me-Not	<i>Catochrysops strabo</i> (Fabricius, 1793)	VC	NE
78.	Lime Blue	<i>Chilades lajus</i> (Stoll, [1780])	VC	NE
79.	Small Cupid	<i>Chilades parrhasius</i> (Fabricius, 1793)	R	NE
80.	Indian Sunbeam	<i>Curetis thetis</i> (Drury, [1773])#	R	NE
81.	Angled Sunbeam	<i>Curetis acuta</i> Moore, 1877	VR	NE
82.	Gram Blue	<i>Euchrysops cnejus</i> (Fabricius, 1798)*	VC	NE
83.	Indian Cupid	<i>Everes lacturnus</i> (Godart, [1824])	R	NE
84.	Eastern Grass Jewel	<i>Freyeria putli</i> (Kollar, [1844])	VC	NE
85.	Common Onyx	<i>Horaga onyx</i> (Moore, [1858])*#	VR	NE
86.	Orchid Tit	<i>Hypolycaena othona</i> Hewitson, [1865] *#	R	NE
87.	Common Cerulean	<i>Jamides celeno</i> (Cramer, [1775])	VC	NE
88.	Pea Blue	<i>Lampides boeticus</i> (Linnaeus, 1767)*	VC	NE
89.	Zebra Blue	<i>Leptotes plinius</i> (Fabricius, 1793)	VC	NE
90.	Plains Cupid	<i>Luthrodes pandava</i> (Horsfield, [1829])	VC	NE
91.	Dingy Lineblue	<i>Petrelaea dana</i> (de Nicéville, [1884])	R	NE
92.	Tailless Lineblue	<i>Prosotas dubiosa</i> (Semper, [1879])	C	NE
93.	Common Lineblue	<i>Prosotas nora</i> (C. Felder, 1860)	C	NE
94.	Pale Grass Blue	<i>Psuedozizeeria maha</i> (Kollar, [1844])	C	NE
95.	Slate Flash	<i>Rapala manea</i> (Hewitson, 1863)	VR	NE
96.	Common Red Flash	<i>Rapala iarbus</i> (Fabricius, 1787)	C	NE
97.	Copper Flash	<i>Rapala pheretima</i> (Hewitson, [1863])#	VR	NE

98.	Indigo Flash	<i>Rapala varuna</i> (Horsfield, [1829])*#	R	NE
99.	Monkey Puzzle	<i>Rathinda amor</i> (Fabricius, 1775)	VR	NE
100.	Apefly	<i>Spalgis epius</i> (Westwood, [1851])#	VR	NE
101.	Common Shot Silverline	<i>Spindasis ictis</i> (Hewitson, 1865)	C	NE
102.	Scarce Shot Silverline	<i>Cigaritis elima</i> (Moore, 1877)*	R	NE
103.	Plumbeous Silverline	<i>Spindasis schistacea</i> (Moore, 1881)	R	NE
104.	Common Silverline	<i>Spindasis vulcanus</i> (Fabricius, 1775)	VC	NE
105.	Red Pierrot	<i>Talica niseus</i> (Guérin- Menéville, 1843)	C	NE
106.	Black-spotted Pierrot	<i>Tarucus balkanicus</i> (Freyer, 1844)	FC	NE
107.	Spotted Pierrot	<i>Tarucus callinara</i> Butler, 1886 *	C	NE
108.	Striped Pierrot	<i>Tarucus nara</i> (Kollar, 1848)	VC	NE
109.	Plains Blue Royal	<i>Tajuria jehana</i> Moore, 1883#	VR	NE
110.	Common Guava Blue	<i>Virachola isocrates</i> (Fabricius, 1793)	C	NE
111.	Redspot	<i>Zesius chrysomallus</i> Hübner, [1819]*#	VR	NE
112.	Dark Grass Blue	<i>Zizeeria karsandra</i> (Moore, 1865)	VC	NE
113.	Lesser Grass Blue	<i>Zizina otis</i> (Fabricius, 1787)	VC	NE
114.	Tiny Grass Blue	<i>Zizula hylax</i> (Fabricius, 1775)	VC	NE
Hesperiidae (23)				
115.	Brown Awl	<i>Badamia exclamationis</i> (Fabricius, 1775)	VC	NE
116.	Paintbrush Swift	<i>Baoris farri</i> (Moore, 1878)*	C	NE
117.	Rice Swift	<i>Borbo cinnara</i> (Wallace, 1866)	VC	NE
118.	Blank Swift	<i>Caltoris kumara</i> (Moore, 1878)	FC	NE
119.	Golden Angle	<i>Caprona ransonnetii</i> (Felder, 1868)	R	NE
120.	Tricolour Pied Flat	<i>Coladenia indrani</i> (Moore, [1866])	R	NE
121.	Giant Redeye	<i>Gangara thyrsis</i> (Fabricius, 1775)#	R	NE
122.	Common Banded Awl	<i>Hasora chromus</i> (Cramer, [1780])	VC	NE
123.	Plain Banded Awl	<i>Hasora vitta</i> (Butler, 1870)*	R	NE
124.	Moore's Ace	<i>Halpe porus</i> (Mabille, [1877])	R	NE
125.	Tree Flitter	<i>Hyarotis adrastus</i> (Stoll, [1780])*#	VR	NE
126.	Chestnut Bob	<i>Iambrix salsala</i> (Moore, [1866])	FC	NE
127.	Common Redeye	<i>Matapa aria</i> (Moore, [1866])	C	NE
128.	Restricted Demon	<i>Notocrypta curvifascia</i> (C. & R. Felder, 1862)	R	NE
129.	Small Branded Swift	<i>Pelopidas mathias</i> (Fabricius, 1798)	VC	NE
130.	Obscure Branded Swift	<i>Pelopidas agna</i> (Moore, [1866])	C	NE
131.	Fulvous Pied Flat	<i>Pseudocoladenia dan</i> (Fabricius, 1787)	C	NE

132.	Indian Skipper	<i>Spialia galba</i> (Fabricius, 1793)	VC	NE
133.	Indian Palm Bob	<i>Suastus gremius</i> (Fabricius, 1798)	C	NE
134.	Common Snow Flat	<i>Tagiades japetus</i> (Stoll, [1781])*#	VR	NE
135.	Dark Palm Dart	<i>Telicota bambusae</i> (Moore, 1878)	VC	NE
136.	Pale Palm Dart	<i>Telicota colon</i> (Fabricius, 1775)	C	NE
137.	Grass Demon	<i>Udaspes folus</i> (Cramer, [1775])	C	NE

thetis (Drury, [1773]), *Rapala varuna* (Horsfield, [1829]), *Rapala pheretima* (Hewitson, [1863]), *Horaga onyx* (Moore, [1858]), *Hypolycaena othona* Hewitson, [1865], *Spalgis epius* (Westwood, [1851]), *Tajuria jehana* Moore, 1883, *Zesius chrysomallus* Hübner, [1819], *Gangara thyrasis* (Fabricius, 1775), *Hyarotis adrastus* (Stoll, [1780]), *Tagiades japetus* (Stoll, [1781]) (Fig. 3). Among the 137 butterfly species observed in the Sironcha Forest Division, their distribution varied in terms of abundance. Approximately 44 per cent of the species, accounting for around 60 species, were classified as very common. Another 23 per cent (31 species), were categorized as common. About 6 per cent (8 species) were found to be frequently common. Additionally, 16 per cent (23 species) were considered rare, while the remaining 11 per cent, representing 15 species, were identified as very rare. A detailed list of these species along with their abundance status furnished (Table 1).

Among the 137 butterflies recorded from Sironcha Forest Division, 19 species come under the protected category of the Indian Wild Life (Protection) Act, 1972 and amendments till 2022 (contd.). Among them *Papilio clytia* Linnaeus, 1758 and *Hypolycaena othona* Hewitson, [1865] come under Schedule I of the Act. The species recorded which come under Schedule II were *Pachliopta hector* (Linnaeus, 1758), *Hypolimnas misippus* (Linnaeus, 1764), *Athyma ranga* Moore, [1858], *Anthene lycaenina* (R. Felder, 1868), *Cigaritis elima* (Moore, 1877), *Tanaecia lepidea* (Butler, 1868), *Euchrysops cnejus* (Fabricius, 1798), *Horaga onyx* (Moore, [1858]), *Zesius chrysomallus* Hübner, [1819], *Lampides boeticus* (Linnaeus, 1767), *Rapala varuna* (Horsfield, [1829]), *Tarucus callinara* Butler, 1886, *Tagiades japetus* (Stoll, [1781]). The species recorded which

came under schedule IV were *Baoris farri* (Moore, 1878), *Euthalia lubentina* (Cramer, [1777]), *Hasora vitta* (Butler, 1870) and *Hyarotis adrastus* (Stoll, [1780]).

Out of the 137 butterfly species recorded in the SFD, nine are listed in the IUCN Red List of Threatened Species. The species classified as Least Concern include *Pachliopta aristolochiae*, *P. hector*, *Colotis fausta*, *Eurema brigitta*, *Danaus chrysippus*, *Euploea core*, *Junonia almana*, *J. hierta*, and *Ypthima asterope*. The remaining 127 species have not yet been evaluated (NE) by the International Union for Conservation of Nature. Among the 137 butterfly species recorded, several species were observed throughout the year, including *Papilio demoleus* (Papilionidae), *Catopsilia pomona*, *C. pyranthe*, *Eurema brigitta*, *E. hecabe*, *Cepora nerissa* (Pieridae), and *Melanitis leda*, *Junonia lemonias*, *J. almana*, *Hypolimnas bolina*, *H. misippus*, *Tirumala limniace*, *Danaus chrysippus*, and *Euploea core* (Nymphalidae). Species from Lycaenidae, such as *Castalius rosimon*, *Talicauda nara*, *Lampides boeticus*, *Zizeeria karsandra*, and *Zizina otis*, as well as *Borbo cinnara* (Hesperiidae), were also present throughout the year. In contrast, the other 113 species were mainly active from June to early summer (April–May).

The abundance of butterflies increased during the monsoon (June–July), peaking in early winter (August–November), and then declined in late winter (December–January) until summer, reflecting seasonal patterns reported by Tiple *et al.* (2007) in similar Central Indian climates. These studies also noted that human-impacted areas lacked unique species, while less-disturbed zones supported greater species diversity. The Sironcha

Forest Division, where this study was conducted, is heavily impacted by human activities like habitat destruction, including cutting of grasses, shrubs, and trees, which may explain the lower presence of unique species in disturbed areas. Kunte (2001) observed similar peaks in butterfly abundance in Pune, with two distinct peaks one in the late monsoon and another in winter. Padhye *et al.* (2006) also highlighted seasonal differences, with species richness peaking in summer and early winter, consistent with Wynter-Blyth's (1957) observations. This study revealed that while species richness was lower in undisturbed and wild sites, these locations were more likely to harbor unique species. Conversely, disturbed and human-impacted sites showed greater species richness but less uniqueness. These findings support those of Padhye *et al.* (2006), Kunte (2001), Tiple *et al.* (2007), Tiple and Bhagwat (2023) and Tiple and Deokar (2024), who noted that impacted zones tend to have higher species richness.

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New distributional records of thrips (Insecta, Thysanoptera) from West Bengal, India

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ABSTRACT: Several extensive field surveys conducted in West Bengal, India from 2022-2024, to explore the species diversity of order Thysanoptera, revealed a total of 10 species of thrips identify to be new for the state. These species come under three subfamilies of two families, Thripidae (six species) and Phlaeothripidae (four species). The subfamily Panchaethripinae is represented by *Helionothrips aino* (Ishida); subfamily Thripinae by *Arorathrips mexicanus* (D.L. Crawford), *Ctenothrips transeolineae* Chen, *Megalurothrips usitatus* (Bagnall), *Taeniothrips orchidi* Ananthakrishnan, and *Thrips florum* Schumtz; and subfamily Phlaeothripinae by *Androthrips flavipes* Schmutz, *Gynaikothrips cecidii* Ananthakrishnan, *Liophloeothrips ablusus* Ananthakrishnan, and *Mesandrothrips flavitibia* Ananthakrishnan & Jagadish. Species diagnoses and their distribution data are also provided. The study highlights the rich yet understudied diversity of thrips in West Bengal and underscores the need for continued faunistic exploration. © 2026 Association for Advancement of Entomology

KEY WORDS: New records, Phlaeothripidae, Thripidae, species diagnosis

INTRODUCTION

Members of the insect order Thysanoptera are typically ranging from 1 to 15 mm in size. Thrips are unique due to presence of only left mandible; tarsal claws reduced to bladder-like arolium; and four slender wings, each with a long fringe of peripheral cilia (Ananthakrishnan, 1969; Mound and Marullo, 1996). Approximately, 6500 species are reported globally in nine families and six subfamilies within the two suborders (Terebrantia and Tubulifera) of the order Thysanoptera (ThripsWiki,

2025). Members of this group exhibit an extremely wide range of habitats from phytophagous to spore-feeders, and fungivorous. Around 150 species of this group are considered pests and the group includes the sole vectors of plant viruses of the genus *Orthotospovirus* (Riley *et al.*, 2011; Mound *et al.*, 2022). Few species are also act as pollinators and predators on aphids and mites (Corlett, 2004).

India is known by 836 species in 273 genera, which represents the ~12.9 percent of species reported globally (Tyagi *et al.*, 2025). Of these, 315 species

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are endemic to the India and major endemism is reported in the state of Tamil Nadu, Kerala and Karnataka. However, the fauna of Thysanoptera in West Bengal state of India is highly diverse due to the wide range of climates and vegetation ranging from the Himalayan foothills to the Gangetic plains and coastal mangroves. Currently, 156 species were reported from the West Bengal, of which 24 are endemic (Tyagi *et al.*, 2025). This state ranks fifth in India in terms of thrips biodiversity along with reporting of serious pests and vectors of *Orthotospovirus*. Despite the large number of species reported in this state, several knowledge gaps remain because many areas are still poorly explored. The objective herein is to report 10 new records including three pest species of thrips collected from surveys undertaken from 2022 to 2024, in West Bengal to analyse the diversity, distribution and ecological significance of thrips in this state with a focus on endemic species, pest species and vector of *Orthotospovirus* in order to provide baseline data for biodiversity assessment, pest management and conservation planning.

All these new distributional records belong to the two families, Thripidae (six species) and Phlaeothripidae (four species). The species are: *Heliothrips aino* (Ishida) under subfamily Panchaethripinae; *Arorathrips mexicanus* (D.L. Crawford), *Ctenothrips transeolineae* Chen, *Megalurothrips usitatus* (Bagnall), *Taeniothrips orchidi* Ananthakrishnan, *Thrips florum* Schumtzt under subfamily Thripinae; *Androthrips flavipes* Schmutz, *Gynaikothrips cecidii* Ananthakrishnan, *Liophloeothrips ablusus* Ananthakrishnan, *Mesandrothrips flavitibia* Ananthakrishnan & Jagadish under subfamily Phlaeothripinae.

MATERIALS AND METHODS

Specimens were collected by the bush beating method on different plant families on a white tray and preserved in (70%) alcohol (Tyagi *et al.*, 2017). The vials were labelled with their host plant, date of collection, and GPS coordinates. The collected specimens were first initially sorted out using a stereoscopic binocular microscope (Leica EZ4) and further processed for the permanent slide mounting protocol. All the specimens were mounted on to

the glass slides using natural canada balsam for morphological analysis. Photographs were captured using the Leica software application suite (LAS EZ) and a Leica compound microscope (DM-1000). Published morphological keys were used for the identification of specimens (Mound and Ng, 2009; Mirab-Balou *et al.*, 2013). Each slide was properly labelled with a registration number, locality, and deposited in the National Zoological Collections (NZC) at the Zoological Survey of India in Kolkata.

RESULTS AND DISCUSSION

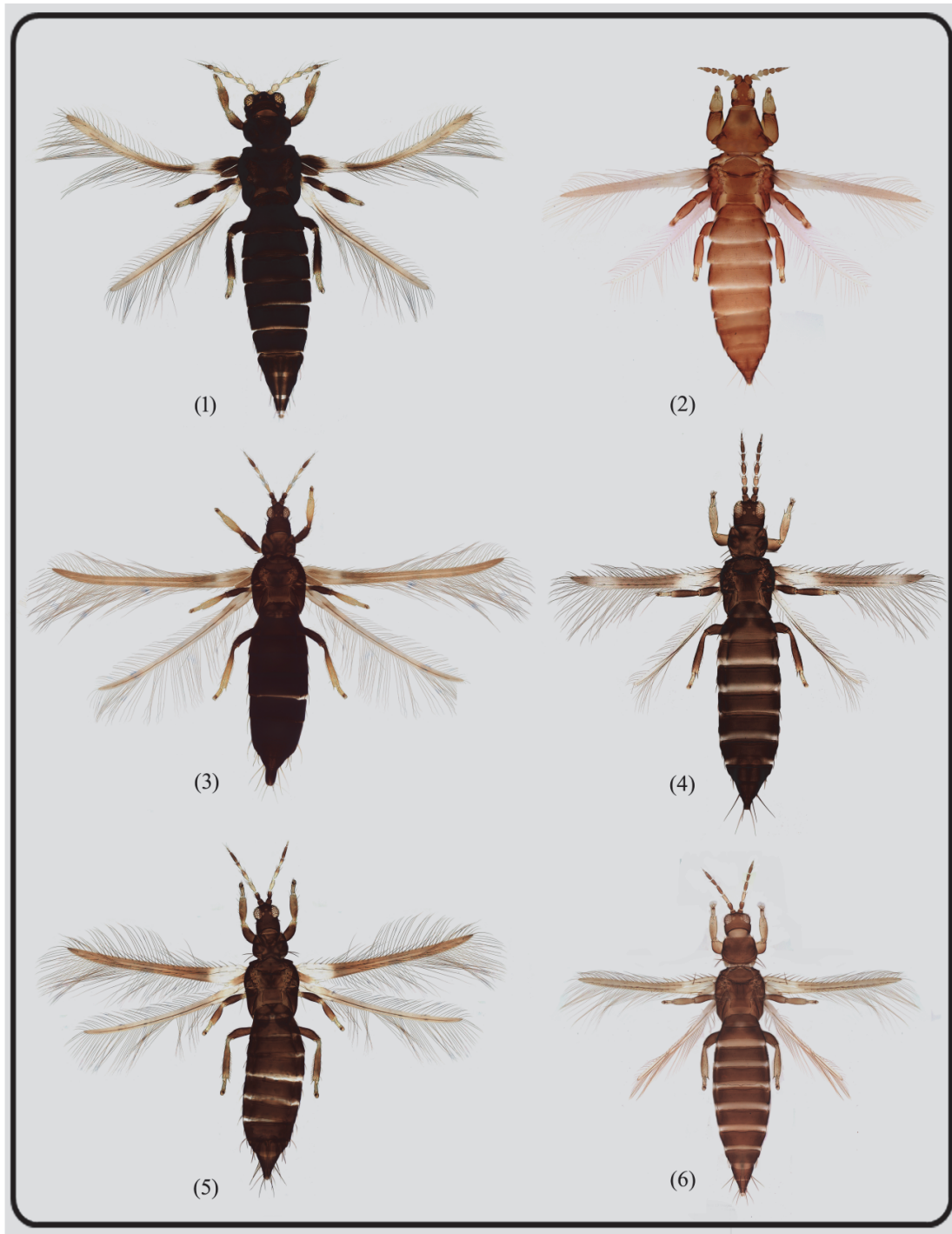
1. *Helionothrips aino* (Ishida, 1931): The genus *Helionothrips* Bagnall is known by twenty-nine species from Old World tropics and generally associated with leaves of different plant families. Among these, only nine species are recorded from India. *Helionothrips aino* was originally described from Japan but also widespread from southern China to Timor Leste. This species is primarily associated with the leaves of *Colocasia esculenta*. *H. aino* is differentiated from other members by constricted apex of the antennal segment IV which is shorter in comparison to segment III. Other body characters, sculpture and chaetotaxy are similar to *H. ananthakrishnani* Wilson.

Material examined: 3 females, India, West Bengal, Beliatare Barjora Road, 61m, 2.x.2023, coll. D. Mondal (Reg. No. 27170/H17, 27176/H17 and 27177/H17).

Distribution: India: Himachal Pradesh, West Bengal (new record).

Elsewhere: Japan, Taiwan.

2. *Arorathrips mexicanus* (D.L.Crawford, 1909): The grass-associated genus *Arorathrips* Bhatti comprises sixteen species, all from the New World, except *A. mexicanus* is a widely distributed species across tropical and subtropical regions. Members of this genus are grouped into three subgroups: *mexicanus* group, *crassus* group, and *vestis* group (Nakahara & Footitt, 2012). *A. mexicanus* lied under the *mexicanus* group and differentiated from other group members by the presence of long fore tibial outer apical process,



Figs. 1-6: (1) *Helionothrips aino*, female; (2) *Arorathrips mexicanus*, female; (3) *Ctenothrips transeolineae*, female; (4) *Megalurothrips usitatus*, female; (5) *Taeniothrips orchidi*, female; (6) *Thrips florum*, female



Figs. 7-10: (7) *Androthrips flavipes*, female; (8) *Gynaikothrips cecidii*, female; (9) *Liophloeothrips ablusus*, female; (10) *Mesandrothrips flavitibia*, female

metanotal campaniform sensilla situated medially or sometimes slightly posteriorly, five pairs of dorsal setae on tergites III-VII, and presence of dermal tuberculate scallops in a row on anterior part of abdominal tergites, on sternites, and on mesonotum.

Material examined: One female, India, West Bengal, Rabindra Sarobar, 16.iv.2024, coll. A. Datta and Party (Reg. No. 27551/H17).

Distribution: India: Karnataka, Kerala, Tamil Nadu, West Bengal (new record).

Elsewhere: Mexico, USA, Argentina.

3. *Ctenothrips transeolineae* Chen, 1979:

Holarctic genus *Ctenothrips* Franklin comprises five species, mainly associated with the families Liliaceae, Orchidaceae, and Asparagaceae. India is known by only one species, *C. transeolineae*

which was originally described from Taiwan. This species can be differentiated from other species of this group by the position of ocellar setae III arising posterior to the ocellar triangle, uniserial arrangement of postocular setae, the presence of transverse striations on the pronotum, and a pair of thorn-like setae on tergite IX in males.

Material examined: One female, India, West Bengal, Ichha forest, 1247m, 24.v.2024, coll. A. Datta and Party (Reg. No. 27828/H17); One female, India, West Bengal, Pashupati phatak, 1780m, 11.vii.2024, coll. A. Ghosh (Reg. No. 27899/H17).

Distribution: India: Himachal Pradesh, West Bengal (new record).

Elsewhere: Taiwan.

4. *Megalurothrips usitatus* (Bagnall, 1913): This genus *Megalurothrips* Bagnall comprises fourteen species distributed across the Old World tropics and is predominantly associated with flowers of the Fabaceae. Among these, five species are recorded from India, including *M. peculiaris* (Bagnall) and *M. usitatus*, both originally described from the India. Several members of this genus are serious pests of cultivated legumes. *M. usitatus* is the most common and widespread species of the genus in the Oriental region and is a recognised pest causing yield losses in several legume crops in Asia, including mung bean, groundnut, and soybean. Members of this group can be identified by males as females show similar resemblance to each other. Prothorax of males yellow, abdominal sternites without spine-like setae, posterior margin of abdominal tergite IX without a pair of seta like projections.

Material examined: One female, India, West Bengal, Beliatare barjora road, 61m, 2.x.2023, coll. D. Mondal (Reg. No. 27206/H17); One female: India, West Bengal, Ranigunj siuri road, 32m, 29.ix.2023, coll. D. Mondal (Reg. No. 27207/H17).

Distribution: India: Assam, Delhi, Karnataka, Manipur, Nagaland, Tamil Nadu, Uttar Pradesh, West Bengal (new record).

Elsewhere: Sri Lanka, Australia, Thailand.

5. *Taeniothrips orchidi* Ananthakrishnan, 1968: The Holarctic genus *Taeniothrips* Amyot & Serville is known by 32 extant species and associated with flowers and young leaves of different plant families. Only four species, *T. bharokariensis* Kumar & Tyagi, *T. major* Bagnall, *T. orchidi* and *T. tigris* Bhatti are described from India. Mound *et al.*, (2012) indicated that three species *T. orchidi*, *T. picipes* (Zetterstedt), *T. oreophilus* Priesner were difficult to separate from each other based on females, but based on males there are possibly slight differences in the genitalia and chaetotaxy of the ninth tergite. *T. orchidi* was originally described by Ananthakrishnan from India. Moreover, we did not found a single male of *T. orchidi* during the survey of West Bengal. Based on female specimens, we have considered these specimens under *T. orchidi*.

Material examined: 2 females, India, West Bengal, Ichha forest, 1247m, 24.v.2024, coll. A. Datta and Party (Reg. No. 27833/H17 and 27855/H17).

Distribution: India: Sikkim, Uttar Pradesh, West Bengal (new record).

Elsewhere: This species is endemic to India.

6. *Thrips florum* Schumtze, 1913: The genus *Thrips* Linnaeus is the second largest genus in the order Thysanoptera and currently comprises about 285 species worldwide, of which 54 are recorded from India. *Thrips florum* was originally described from Sri Lanka and is now widespread across Asia and eastern Australia. This species is closely related to *T. hawaiiensis* (Morgan), but can be distinguished by the length of the subapical veinal seta on the forewing clavus, which is longer than the apical seta, and the absence of sculpture lines on the mesonotum around the anterior pair of campaniform sensilla.

Material examined: 2 females, India, West Bengal, Baghmundi forest office, 240m, 24.ix.2024, coll. A. Ghosh (Reg. No. 28160/H17 and 28161/H17).

Distribution: India: Andaman Island, Delhi, Karnataka, Punjab, West Bengal (new record).

Elsewhere: Australia, Indonesia, Java, Nigeria, Sri Lanka, The Bahamas, USA.

7. *Androthrips flavipes* Schmutz, 1913: The Asian genus *Androthrips* Karny comprises twelve species, usually invading galls induced by other thrips species. India is known by five species including originally described three species, *A. coimbatorensis* Ramakrishna, *A. flavitibia* Moulton, and *A. ramachandrai* Karny. *A. flavipes* is a predatory thrips and is frequently associated with thrips galls on various plants in India, Southeast Asia, and other regions. This species is a beneficial inquiline that preys on gall-forming thrips species and is considered an effective natural enemy. *A. flavipes* can be differentiated from others by the presence of bicoloured legs, and well developed postocular, posteroangular, and epimeral setae.

Material examined: 2 females, India, West Bengal, Bankura, 39m, 4.x.2023, coll. D. Mondal (Reg. No. 27179/H17, 27180/H17).

Distribution: India: Assam, Kerala, Manipur, Meghalaya, Tamil Nadu, Tripura, Uttarakhand, West Bengal (new record).

Elsewhere: Sri Lanka.

8. *Gynaikothrips cecidii* Ananthakrishnan, 1968: The Asian genus *Gynaikothrips* Zimmermann comprises thirty-eight species, of which twelve are recorded from India, including eleven that were originally described from the country. Members of this genus are gall-inducing on leaves, particularly on *Ficus* species. Species of the genus *Gynaikothrips* lied in the *Liothrips* lineage group due to presence of one sense on antennal segment III and three sense ones on IV. *G. cecidii* was originally described from India and can be distinguished from other species by yellow antennal segments III–VIII, brown femora and tibiae, parallel-sided head which is never constricted at the base; broadly rounded mouthcone; incomplete mesopraesternum represented by two triangular

sclerites, long pronotal anteroangular setae, vestigial anteromarginals, and subequal posteroangular and epimeral setae.

Material examined: 3 females, India, West Bengal, Beliatare barjora road, 61m, 2.x.2023, coll. D. Mondal (Reg. No. 27170/H17, 27176/H17 and 27177/H17).

Distribution: India: Assam, Madhya Pradesh, Manipur, Tamil Nadu, West Bengal (new record).

Elsewhere: This species is endemic to India.

9. *Liophloeothrips ablusus* Ananthakrishnan, 1971: The leaf-feeding genus *Liophloeothrips* Priesner comprises 19 species, 13 from India and six species from Europe. Species of the genus are usually gall inducing on different plant families (Tyagi & Kumar 2011). Species of the genus *Liophloeothrips* lied in the *Liothrips* lineage group due to presence of one sense on antennal segment III and three sense ones on IV. *L. ablusus* can be differentiated from others by brown body, and complete mesopraesternum, constricted in middle.

Material examined: 3 females, India, West Bengal, Radhamadhavpur, 51m, 29.ix.2023, coll. D. Mondal (Reg. No. 27184/H17, 27185/H17, 27186/H17); 10 females, India, West Bengal, Beliatare barjora road, 61m, 2.x.2023, coll. D. Mondal (Reg. No. 27168/H17, 27169/H17, 27173/H17, 27174/H17, 27175/H17, 27183/H17, 27188/H17, 27189/H17, 27194/H17, 27205/H17); 2 females, India, West Bengal, Simlapat road, 61m, 4.x.2023, coll. D. Mondal (Reg. No. 27171/H17, 27178/H17).

Distribution: India: Kerala, West Bengal (new record).

Elsewhere: This species is endemic to India.

10. *Mesandrothrips flavitibia* (Ananthakrishnan & Jagadish, 1969): The genus *Mesandrothrips* Priesner comprises nine species that are widespread in tropical regions of Asia, of which, seven are recorded from India. This species was originally described by Ananthakrishnan & Jagadish in 1969 in the genus *Xylaplothrips* Priesner. Mound & Tree (2019) re-diagnoses species under the genus

Xylaplothrips based on the three sense cones of antennal segment III and four on IV placed in the genus *Mesandrothrips*. *M. flavitibia* can be differentiated from others by body colour, absence of anteromarginals, and S1setae on tergite IX expanded apically.

Material examined: 3 females, India, West Bengal, Uparbandha, 74m, 2.x.2023, coll. D. Mondal (Reg. No. 27190/H17, 27191/H17 and 27193/H17).

Distribution: India: Chandigarh, Delhi, Madhya Pradesh, Tamil Nadu, Uttar Pradesh, West Bengal (new record).

Elsewhere: This species is endemic to India.

The present study significantly contributes to the understanding of the order Thysanoptera faunal diversity in West Bengal, India. Prior to this work, 124 species had been reported from the state (Sanyal *et al.*, 2012). After 12 years of knowledge gap, few systematic field surveys were conducted from 2022-2024. This led to the identification and documentation of ten additional species, enriching the known thrips fauna of the region. These findings highlight the rich but underexplored diversity of thrips in West Bengal.

The newly recorded 10 species belong to two families: Thripidae (six species) and Phlaeothripidae (four species), representing a diverse range of ecological niches and host plant associations. Moreover, *Helionothrips aino* and *Ctenothrips transeolineae*, were previously known only from Himachal Pradesh, India or neighboring countries such as Taiwan, suggesting that their wider distribution has been under-documented due to limited sampling efforts. Similarly, *Thrips florum*, with a broad distribution across Asia and beyond, underscores the biogeographical connectivity of the West Bengal region. Moreover, the identification of endemic species like *Gynaikothrips cecidii*, *Liophlaeothrips ablusus*, and *Mesandrothrips flavitibia* from West Bengal enhances the conservation value of the local agricultural ecosystems. These species, restricted to India, might be sensitive indicators of environmental

changes and habitat specificity.

The findings emphasize the importance of continued, targeted fieldwork across diverse habitats to uncover hidden insect diversity. Thrips are not only agricultural pests but also vectors of plant viruses such as *Orthotospoviruses* (Rotenberg *et al.*, 2015), understanding their distribution is critical for pest management strategies and for monitoring potential threats to biodiversity and agriculture. Overall, this study contributes to filling the knowledge gaps in the taxonomy and distribution of Indian thrips, particularly from the state of West Bengal. It also provides a valuable baseline for future ecological, agricultural, and conservation research involving thrips.

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Population dynamics of major insect pests in bottle gourd

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ABSTRACT: The experiment on population dynamics of insect pests in bottle gourd under semi-arid conditions was carried out, revealed that peak infestation of fruit fly *Zeugodacus cucurbitae* (Coquillett) (49.36%) reached during the 6th November 2023, and after that it declined gradually. The infestation of aphid *Aphis gossypii* (Glover), white fly *Bemisia tabaci* (Genn.), red pumpkin beetle *Aulacophora foveicollis* (Lucas), hadda beetle *Epilachnini demurli* (Mulsent), mirid bug *Nesidiocoris cruentatus* (Ballard) and leaf miner *Liriomyza trifoli* (Burgess) started in the first week of September (36th SMW). The infestation of *A. gossypii* (120.1 aphids three leaves/plant), *B. tabaci* (12.3 whiteflies per three leaves/plant), *A. foveicollis* (4.7 adults/plant), *E. demurli* (5.9 adults/plant), *N. cruentatus* (14.2 mirid bugs three leaves/plant) and *L. trifoli* (53 % leaf infestation) reached its peak level in 44th, 40th, 41st, 43rd, 40th, and 43rd SMW respectively, after that it declined gradually. The correlation *Z. cucurbitae* infestation with abiotic factors revealed a significant negative correlation with minimum RH ($r = -0.552$), and maximum RH ($r = -0.484$). There existed a significant negative correlation between yield loss and minimum RH ($r = -0.689$).

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KEY WORDS: Aphid, whitefly, fruit fly, leaf miner, red pumpkin beetle, mirid bug

INTRODUCTION

Bottle gourd [*Lagenaria siceraria* (Molina) Standley] also known as Calabash, is one of the most important cucurbitaceous vegetable crops grown in both rainy and summer seasons (Srivastava *et al.*, 2002). Like other cucurbits, bottle gourd is vulnerable to a variety of insect and non-insect pests, the primary pests affecting it include the fruit fly, red pumpkin beetle, leaf miner, aphids, whitefly, and mites (Tiwari *et al.*, 2012). These pests can cause damage from the early growth stages of the crop until the harvest in India. The impact of various insect pests on cucurbits has caused yield losses of

30 to 100 percent, varying by host type and seasonal factors in various locations around the globe (Dhillon *et al.*, 2005; Haldhar *et al.*, 2015a, b). The population dynamics of the insect pests help in the study of pest behaviour, its population trend with natural enemies, and other abiotic factors and thus, play an important role in pest management. It will help to decide on the timely application of insecticides as it reveals the insect pest's activity and insect-free periods during crop growth. Hence, this study are crucial for understanding pest behaviour, population trends influenced by natural enemies and abiotic factors, and their role in effective pest management.

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MATERIALS AND METHODS

This study was carried out at the Instructional Farm of the College of Agriculture, Agriculture University, Jodhpur, Rajasthan. The bottle gourd sown in lines in August 2023. The bottle gourd variety Pusa Naveen was replicated three times in a plot measuring $3 \times 3\text{m}^2$ keeping row-to-row and plant-to-plant distance of 3m and 0.75m, respectively. All agronomic practices were followed as per the recommendation of the package of practices of Zone-1a (Arid Western Plains).

Insect pest incidence was systematically monitored at weekly intervals using standardized protocols to quantify damage and pest pressure across bottle gourd crops. Fruit fly infestation was assessed from the onset of fruit formation until final harvest, with fruit health evaluated every three days based on marketable size. Infestation levels were determined by calculating the percentage of infested fruits relative to the total picked fruits, while yield losses were quantified by comparing the weight of infested fruits to the total harvested yield. For sucking pests, i.e., aphid, whitefly and mirid bug, observations were recorded by counting on three compound leaves i.e., one each from the top, middle, and bottom canopy of the plants. For defoliators, number of adult beetles was counted per plant. Leaf miner infestation was evaluated by calculating the proportion of infested leaves to total observed leaves per plant. To study the influence of various abiotic factors (minimum and maximum temperature, maximum and minimum relative humidity, and rainfall) on the incidence of population dynamics of insect pests in bottle gourd, the correlation coefficient was worked out. Multiple linear forms of the regression model were used to assess the effect of the abiotic factors on incidence of insect pests of bottle gourd by using the SPSS software.

RESULTS AND DISCUSSION

The major insect pests observed throughout the cropping season were only studied for population dynamics in response to weather conditions. The major pests studied were *Zeugodacus cucurbitae* (Coquillett), defoliators, *Aulacophora foveicollis*

(Lucas), *Epilachna demurili* Mulsant, sucking pests (*Aphis gossypii* (Glover), *Bemisia tabaci* (Genn.) and *Nesidiocoris cruentatus* (Ballard)), leaf miner, *Liriomyza trifolii* (Burgess).

Fruit fly, *Z. cucurbitae*: Infestation began in the third week of October, reaching a peak in the first week of November (49.36%). Subsequently, it declined (20.36%) but remained above 20 per cent throughout the season (Table 1). Yield losses due to infestation followed a similar trend, reaching a peak (41.55%) in the first week of November. These results are in agreement with Raghuvanshi *et al.* (2012) who reported mean fruit damage of 40 per cent.

The correlation *Z. cucurbitae* infestation and abiotic factors revealed a significant negative correlation with minimum RH ($r = -0.552$), and maximum RH ($r = -0.484$). There existed a significant negative correlation between yield loss and minimum relative humidity ($r = -0.689$) (Table 2). Bhowmik *et al.* (2014) found a negative correlation with per cent Morning and Evening relative humidity ($r = -0.809$ and $r = -0.717$). Parkash *et al.* (2023) found a non-significant positive correlation of fruit fly infestation with minimum and maximum temperature. The present results are in agreement with Ravikumar and Viraktmath (2006) who reported a non-significant negative correlation, however, Banerji *et al.* (2005) could not observe relationship between rainfall and fruit fly population in bitter gourd.

Sucking pests: The incidence of *A. gossypii*, *B. tabaci* and *N. cruentatus* was presented in Table 3. Aphid infestation began in the first week of September, peaking at 120.1 aphids per three leaves during the first week of November (44th SMW), the results are in agreement with Parkash *et al.* (2023), who observed the initial infestation in the 34th SMW and peak infestation in 39th SMW. Whitefly population was at peak during the 40th SMW (12.3 per three leaves). The results corroborate reports of Gangurde *et al.* (2021) in bitter gourd and Parkash *et al.* (2023), who reported peak infestations in September. Population of *N. cruentatus* was reaching a maximum of 14.2 bugs in three leaves per plant in the 40th SMW

Table 1. Weather parameters and bottle gourd fruit infestation and yield loss due to *Zeugodacus cucurbitae* on during 2023

Observation date	% Fruit infestation	Yield loss
16 th October	16.96	15.76
19 th October	19.36	17.31
22 nd October	23.31	19.07
25 th October	27.02	25.31
28 th October	33.30	30.21
31 st October	40.06	31.83
3 rd November	46.81	32.29
6 th November	49.36	41.55
9 th November	47.53	39.18
12 th November	42.06	39.79
15 th November	37.12	38.26
18 th November	36.19	36.80
21 st November	34.15	35.05
24 th November	27.17	34.27
27 th November	26.99	28.55
30 th November	24.05	22.53
3 rd December	20.36	21.72

before declining towards season's end. The present results are consistent with Halder *et al.* (2017) and Sharath *et al.* (2021), who noted similar trends in mirid bug populations on snake gourd during the rabi season and the lowest counts during severe winter conditions.

The correlation analysis of pest populations with weather parameters revealed significant trends for *A. gossypii*, *B. tabaci* and *N. cruentatus*. Aphid population showed significant negative correlation with maximum ($r = -0.701$) and minimum RH ($r = -0.643$), aligning with previous studies by Konar *et al.* (2013) who indicated negative correlation of aphid incidence in okra with humidity. Whitefly population showed a significant negative correlation with minimum temperature ($r = -0.761$) and both maximum and minimum relative humidity ($r = -0.621$ and $r = -0.764$). Khaliq *et al.* (2023) also reported that maximum temperature had a positive

relationship with whitefly population in mung bean while the minimum temperature and morning relative humidity revealed a negative one, and evening relative humidity and rainfall showed a highly significant but negative correlation. Bairwa and Singh (2017) also reported a non-significant negative correlation between rainfall and whitefly population infesting green gram. Mirid bug, *N. cruentatus* population exhibited negative non-significant correlation with abiotic factors. These findings diverge from Sharath *et al.* (2021), who reported significant correlations with various weather parameters.

Defoliators: The study on pest dynamics of defoliators in bottle gourd highlighted notable population trends of *A. foveicollis* and *E. demurili*. *A. foveicollis* population varied from 1.4 to 4.7 adults per plant, peaking at 4.7 adults per plant during the 41st SMW (Table 3). This is consistent with earlier findings by Rathod and Borad (2010), who observed maximum infestations on pumpkin from August to September, and Parkash *et al.* (2023), who recorded the highest population in the 38th SMW on bottle gourd. Meanwhile, the *E. demurili* population increased gradually from the 36th SMW, reaching a peak of 5.9 adults per plant in the 43rd SMW before declining to 3.3 adults per plant, indicating fluctuating pest dynamics throughout the growing season.

The correlation analysis of *A. foveicollis* and *E. demurili* populations with abiotic factors revealed significant negative relationships. For *A. foveicollis*, a significant negative correlation was observed with minimum temperature ($r = -0.496$) and minimum

Table 2. Correlation between the incidence of fruit fly, *Z. cucurbitae* and abiotic factors

Parameters	Infestation %	Yield loss
Max temperature	0.267 ^{NS}	-0.005 ^{NS}
Min temperature	0.136 ^{NS}	-0.233 ^{NS}
Max RH	-0.484*	-0.413 ^{NS}
Min RH	-0.552*	-0.689*
Rainfall	-0.384 ^{NS}	-0.437 ^{NS}

* Correlation is significant at $p \leq 0.05$ level

Table 3. Effect of weather parameter on incidence of major insect pest complex of bottle gourd during 2023

SMW	Observation	Mean population					
		Aphid	Whitefly	Red beetle	Mirid bug	Hadda beetle	Leaf miner
33	13 Aug – 19Aug	0.0	0.0	0.0	0.0	0.0	0.0
34	20 Aug – 26Aug	0.0	0.0	0.0	0.0	0.0	0.0
35	27 Aug – 02Sep	0.0	0.0	0.0	0.0	0.0	0.0
36	03 Sep – 09 Sep	3.0	2.5	1.4	4.1	0.3	14.9
37	10 Sep – 16 Sep	15.0	3.5	3.3	6.7	0.9	21.7
38	17 Sep – 23 Sep	20.3	3.6	3.3	10.1	1.6	27.4
39	24 Sep – 30 Sep	40.2	4.8	3.5	12.0	1.8	33.2
40	01 Oct – 07 Oct	60.1	12.3	3.9	14.2	2.6	35.6
41	08 Oct – 14 Oct	90.0	6.2	4.7	12.9	4.5	37.8
42	15 Oct – 21 Oct	100.0	7.1	4.3	11.7	5.3	50.0
43	22 Oct – 28 Oct	105.1	7.8	4.1	10.1	5.9	53.0
44	29 Oct – 4 Nov	120.1	9.6	4.1	9.3	4.8	49.6
45	5 Nov– 11 Nov	95.0	12.2	4.3	8.5	4.5	46.1
46	12 Nov – 18Nov	85.0	11.6	4.0	8.0	4.0	42.1
47	19 Nov – 25Nov	55.0	10.3	3.8	6.2	3.6	40.0
48	26 Nov – 2 Dec	23.9	8.3	3.4	5.1	3.3	33.2

*SMW- Standard Metrological Week; Aphid/ 3 leaves/plant; Whitefly/ 3 leaves/plant; Red pumpkin beetle/ plant; Mirid bug/ 3 leaves/ plant; Hadda beetle/ plant; Leaf miner/ 3 leaves/ /plant

Table 4. Correlation of major insect pests of bottle gourd with prevailing weather parameters

Parameters	Aphid	Whitefly	Pumpkin beetle	Mirid bug	Hadda beetle	Leaf miner
Min temperature	-0.467 ^{NS}	-0.761*	-0.496*	-0.140 ^{NS}	-0.625*	-0.584*
Max temperature	-0.090 ^{NS}	-0.369 ^{NS}	-0.161 ^{NS}	0.216 ^{NS}	-0.292 ^{NS}	-0.209 ^{NS}
Max RH	-0.701*	-0.621*	-0.413 ^{NS}	-0.276 ^{NS}	-0.595*	-0.573*
Min RH	-0.643*	-0.764*	-0.503*	-0.230 ^{NS}	-0.612*	-0.626*
Rainfall	-0.333 ^{NS}	-0.280 ^{NS}	-0.008 ^{NS}	-0.051 ^{NS}	-0.334 ^{NS}	-0.203 ^{NS}

* Correlation is significant at $p \leq 0.05$ level

relative humidity ($r = -0.503$). Dubale *et al.* (2018) also indicated similar negative correlations of red pumpkin beetle population on ridge gourd with maximum temperature and other weather factors. Bhowmik and Saha (2017) confirmed that minimum temperature was negatively correlated with red pumpkin beetle population. In contrast, the *E. demurili* showed a negative significant correlation

with minimum temperature ($r = -0.625$), as well as maximum ($r = -0.595$) and minimum relative humidity ($r = -0.612$). These results partially align with Sharma and Tayde (2017) and Naveen *et al.* (2023), who also identified significant negative correlations with humidity and rainfall in brinjal.

Leaf miner: *L. trifolii* infestation in bottle gourd

Table 5. Multiple linear regression between abiotic factors and insect pests of bottle gourd

Insects		Regression equations	R ² value
Fruit fly	Fruit infestation %	$Y = 48.10 + (-0.536) X_4$	0.305
	yield loss %	$Y = 46.41 + (-0.534) X_4 - 11.227 X_5$	0.655
Red pumpkin beetle		$Y = 5.45 + (-0.064) X_4$	0.252
Hadda beetle		$Y = -2.56 + 0.519 X_1 + 0.557 X_2$	0.567
Aphid		$Y = 219.32 + (-2.417) X_3$	0.491
White fly		$Y = 16.01 + 0.257 X_4$	0.584
Mirid bug		No regression	
Leafminer		$Y = 63.686 + (-0.877) X_4$	0.391

Y = Dependent variable X_1 = Max. Temp. (°C), X_2 = Min. Temp. (°C), X_3 = Maximum RH (%), X_4 = minimum RH (%), X_5 = Rainfall(mm)

initiated in the 36th SMW and gradually increased, reaching its peak in the 43rd SMW with 53 per cent leaf infestation. These findings are consistent with the observations of Sharath *et al.* (2021) in snake gourd and Kachave *et al.* (2020) in tomato. Correlation analysis revealed a significant negative correlation between *L. trifolii* infestation and minimum temperature ($r = -0.584$), minimum relative humidity ($r = -0.626$), and maximum relative humidity ($r = -0.573$). The present findings corroborate with Sharath *et al.* (2021) who reported a significant negative correlation between minimum temperature and morning relative humidity, and a non-significant negative correlation with maximum temperature in snake gourd.

The study on the population dynamics of major insect pests infesting bottle gourd under semi-arid conditions of Jodhpur revealed distinct seasonal patterns influenced by prevailing abiotic factors. The fruit fly *Z. cucurbitae* caused the highest fruit damage, peaking in early November, while other key pests such as aphids, whiteflies, red pumpkin beetles, hadda beetles, mirid bugs, and leaf miners exhibited peak activity between the 40th and 44th standard meteorological weeks. Correlation analysis indicated that maximum and minimum relative humidity generally showed significant negative relationships with pest populations, whereas temperature variations influenced pest incidences differently depending on species. These findings emphasize that understanding pest population trends

in relation to weather parameters can facilitate timely pest management decisions, minimize crop losses, and support sustainable production of bottle gourd in arid and semi-arid regions of Rajasthan.

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Additional records to the Pteromalidae (Hymenoptera, Chalcidoidea) fauna of Odisha with first report of seven species from India

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ABSTRACT: The survey conducted to find out the diversity of pteromalids (Hymenoptera, Pteromalidae) in Odisha and documented 22 species for the first time in the state, representing 18 genera and 03 subfamilies. Notably, seven of these species were recorded for the first time in India. In addition, a comprehensive checklist of the Pteromalidae of Odisha has been prepared, comprising 47 species across 26 genera and 03 subfamilies © 2026 Association for Advancement of Entomology

KEY WORDS: New records, checklist, diversity

INTRODUCTION

The family Pteromalidae is one among the largest families of parasitic Hymenoptera, belonging to the superfamily Chalcidoidea, whose species are distributed in all zoogeographical regions worldwide (Mitroiu *et al.*, 2011). They are primary or secondary parasitoids of various insect orders such as Coleoptera, Diptera, Lepidoptera, Hymenoptera, and Hemiptera at their different developmental stages (Bouèek and Rasplus, 1991; Desjardins *et al.*, 2007). The family Pteromalidae is one of the known groups within the Chalcidoidea with its economic importance (Shaaban *et al.*, 2005). The family is represented by 34 subfamilies, about 648 genera, and approximately 4275 species worldwide (Gibson *et al.*, 2021). Recently, Burk *et al.* (2022) revisited the genera of Pteromalidae based on their classical morphology and many genera were shifted

to elevated subfamilies, consequently, some of subfamilies were omitted from the family Pteromalidae and upgraded to new family status. The Indian Pteromalidae fauna is now represented with 242 species, 96 genera under 6 subfamilies. The state of Odisha is only explored by Sureshan 2009 and Noyes 2019, while the state of Odisha is one of state of diverse flora and climatic condition, and this condition favours the insect diversity and the parasitic fauna. Therefore, the present study was undertaken to investigate the Pteromalidae faunal diversity of Odisha, India.

MATERIALS AND METHODS

The study was conducted to explore the diversity of Pteromalidae fauna in Odisha. A field survey of 14 districts - Puri, Cuttack, Khorda, Ganjam, Jajpur, Jagatsinghpur, Nayagarh, Bhadrak, Balasore, Mayurbhanj, Angul, Dhenkanal, and Kendrapara

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noticeably shorter than the sum of length of the head and mesosoma, petiole quadrate, longer than broad, reticulate, dorsally with medial carina.

Material examined: 1 ♀; India: Odisha: Tarajanga: Dhenkanal; 20.96972222N; 85.62944444E; 27.ii.2022; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23539.

Distribution: India (Odisha*); Elsewhere: Czech Republic, Europe, Germany, Hungary, , Iran, Ireland, Italy, Netherlands, China, Romania, Russia, Sweden, Turkey, United Kingdom.

3. *Halticoptera flavicornis* Spinola, 1808

1811. *Halticoptera flavicornis* Spinola. Essaid'une nouvelle classification générale des Diplolépaires. *Annals Mus. Hist. nat. Paris*. 17: 148.

Diagnosis: Female: Body length 2.05mm. Dark metallic bluish green body; testaceous antennae with black pedicel and scape; coxae concolorous with thorax, brown femora, and testaceous remaining legs. Forewing having either no hairs at all or very few hairs on the basal cell apex. The pronotal collar has a rounded anterior end and is reticulate, with a very thin, glossy strip at most running along its hind margin. Propodeum nearly glossy; gastral petiole with median carina firmly reticulates.

Material examined: 1 ♀ 5 ♂; India: Odisha: Buduli forest: Ganjam; 19°58'31.1"N; 84°33'16.9"E; 29.ix.2021; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23208.

Distribution: India (Odisha*); Elsewhere: Belgium, Croatia, Czech Republic, Czechoslovakia, France, Germany, Hungary, Iran, Netherlands, Romania, Slovakia, Sweden, United Kingdom.

4. *Halticoptera shimlica* Narendran and Girish Kumar, 2010

2010. Narendran, and Girish Kumar, 7 (1): 2-4.

Diagnosis: Female- body length 1.62mm . Eyes cupreous, head and mesosoma dark green with golden reflection; POL almost equal to OOL (1.13x); antennae (11263) with scape and pedicel

dark green, basal part of scape testaceous, anelli and funicular segments brown; gaster brownish with strong golden green reflection on T1 in dorsal view and slightly lateral sides of all tergites; legs with coxae concolorous with mesosoma, femora brown, trochanter, tibiae, and tarsal segments yellowish, with the exception of the tips of the tarsal brown.

Material examined: 2 ♀; India: Odisha: NALCO: Angul; 20.842087N; 85.150425E; 04.xi.2022; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23308.

Distribution: India (Himachal Pradesh, Odisha*)

Genus: *Merismus* Walker

1. *Merismus megapterus* Walker, 1833

Diagnosis: Female. Body length 2.38mm. Clypeus having two sharp, asymmetrical teeth. Antennae 11263, scape not reaching median ocellus, clava slightly capitate with a row of micropilosity along its length. Notauli complete, frenal groove complete without longitudinal striations. FW hairy, speculum broad and open below. Apex of propodeum broad, median carina present crossed with transverse carinules, plicae present. Gaster petiolated, petiole longer than wide, strongly reticulate.

Material examined: 1 ♀; India: Odisha: Basudevpur: Balasore; 21.459476N; 86.872663E; 19.xii.2022; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23559.

Distribution: India (Odisha*); Elsewhere: Ireland, Italy, Kazakhstan, Belgium, Bulgaria, Europe, France, Germany, Hungary, Mongolia, Netherlands, China, Poland, Romania, Russia, Serbia, Canada, Croatia, Czech Republic, Czechoslovakia, Spain, Sweden, United Kingdom.

Genus: *Stictomischus* Thomson

1. *Stictomischus obscurus* (Walker, 1833)

1833: *Miscogaster obscura* Walker, 459

1833: *Miscogaster obscuripennis* Walker, 460.

1833: *Miscogaster chrysochlora* Walker, 461.

1841: *Chrysolampus splendens* Forster, 37.

1841: *Chrysolampus subquadratus* Forster, 37.

1848: *Lamprotatus Mallius* Walker, 111, 166.

1955: *Stictomischus obscurus* (Walker) Delucchi, 79, 89-90.

Diagnosis: Female. Body length 2.102mm; Body metallic green; eyes cupreous; POL=OOL; antenna 11263, brown in colour; scape not touching median ocellus; notauli deep and complete; mesosoma length 1.69x head length; notauli complete; FW hyaline, stigma moderately capitate; Legs calcareous with brown tarsal segments; gaster minutely petiolate.

Material examined: 1♀; India: Odisha: Chikiti: Ganjam; 19° 11' 28" N; 84° 37' 16" E; 09.ix.2021; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23337.

Distribution: India (Odisha*); Elsewhere: Austria, Belgium, Czech Republic, Czechoslovakia, Europe, France, Germany, Hungary, Ireland (north and south), Kazakhstan, Montenegro, Netherlands, Poland, Romania, Serbia, Slovakia, Sweden, Switzerland, Tselinograd Obl., United Kingdom, USSR.

2. *Stictomischus longiventris* (Thomson)

1976: *Stictomischus longiventris* Thomson, 1876a: 237.

1955: *Stictomischus longiventris* Thomson; Delucchi, 1955: 77, 79.

Diagnosis: Female. Body length 2.53mm. Head 2.3x as wide as long. Antennae formula 11263, clava with micro pilosity only on apex of third segment. Notauli deep and complete, scutellar frenum finely reticulated. Propodeum having complete median carina and plicae. Gaster petiolated, petiole distinctly longer than broad. FW with a narrow bare line just outside the basal vein, stigma of FW capitate.

Material examined: 1♀; India: Odisha: Bhatasahi: Nayagarh; 20.122108N; 85.071202E; 07.i.2023; Coll. By: Aishwarya Ray. Accession number: FRI/

NFIC/23512.

Distribution: India (Odisha*); Elsewhere: Austria, Europe, Germany, Sweden.

Genus: *Syntmopus* Walker

1. *Syntmopus rajamalaiensis* Sureshan & Narendran, 1999

1999: *Syntmopus rajamalaiensis* Sureshan & Narendran.

Diagnosis: Female body length 2.61mm. Head and mesosoma dark green with golden reflection, petiole dark bluish green; Eyes cupreous, anelli silvery white. Antennae yellowish brown except scape and pedicel testaceous; FW hyaline, veins paler, discal pubescence normal, marginal fringe moderate. Propodeum with median effaced at middle. Legs with all coxae concolrous with mesosoma, trochanter, femora, tibiae very light brown, tarsal segments yellowish except tips of tarsal segments brown.

Material examined: 1♀; India: Odisha: Kuhudi: Khorda; 19°52'27.7"N; 85°20'41.6"E; 29.ix.2021; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23200.

Distribution: India (Odisha*, Kerala)

Subfamily: Pachyneurinae

Genus: *Acroclisoides* Girault and Dodd, 1915

1. *Acroclisoides indicus* Ferriere, 1931

1931: *Acroclisoides indicus* Ferriere, 1931: 279. M. India: Dehra Dun (BMNH).

2002: *Acroclisoides indicus* Ferriere (Sureshan and Narendran, 2002). 123-131.

Diagnosis: Female. Body length 1.46 mm. Head and mesosoma black except frontal basal half of head green with golden reflection; Antennae 11263, scape, pedicel and anelli yellowish or testaceous, flagellum brown; eyes cupreous, ocelli silvery white; FW hyaline, veins paler, basal cell with few hairs, costal cell with few scattered hairs; speculum short and closed below. Legs with fore and hind coxa

Table 1. Check list of Pteromalidae species recorded from Odisha, India#

No	Subfamily/species	Record
Subfamily: Miscogasterinae		
1	<i>Halticoptera andriscui</i> Mitroiu	New Record, India#
2	<i>H. crius</i> Walker	New Record, India#
3	<i>H. flavicornis</i> Spinola	New Record, India#
4	<i>H. shimlica</i> Narendran & Girish Kumar	New Record
5	<i>Merismus megapterus</i> Walker	New Record, India#
6	<i>Stictomischus obscurus</i> (Walker)	New Record, India#
7	<i>St. longiventris</i> (Thomson)	New Record, India#
8	<i>Sphegigaster brunneicornis</i> (Ferriere)	Sureshan, 2009
9	<i>Sp. stepicola</i> Boucek	Sureshan, 2009
10	<i>Syntmopus rajamalaiensis</i> Sureshan & Narendran	New Record
Subfamily: Pachyneurinae		
1	<i>Acroclisoides indicus</i> Ferriere	New Record
2	<i>A. maculatus</i> Sureshan and Narendran	New Record
3	<i>Metastenus indicus</i> Sureshan & Narendran	Sureshan, 2009
4	<i>Pachyneuron aphidis</i> (Bouche)	New Record
5	<i>P. groenlandicum</i> (Holmgren)	Noyes (2019)
6	<i>Toxeumorpha minuta</i> Sureshan & Narendran	Sureshan, 2009
Subfamily: Pteromalinae		
1	<i>Anisopteromalus quinarius</i> Gokhman & Baur	New Record, India#
2	<i>A. calandrae</i> (Howard)	Sureshan, 2009
3	<i>Callitula anguloclypea</i> Sureshan	New Record
4	<i>Ca. peethapada</i> Narendran & Mohana	Sureshan, 2009
5	<i>Ca. rugosa</i> (Waterston)	Sureshan, 2009
6	<i>Ca. travancorensis</i> Sureshan	Sureshan, 2009
7	<i>Cholorocytus indicus</i> Sureshan	New Record
8	<i>Cryptoprymna elongate</i> Sureshan & Narendran	New Record
9	<i>Dinarmus acutus</i> (Thomson)	Sureshan, 2009
10	<i>D. basalis</i> (Rondani)	New Record
11	<i>D. maculatus</i> (Masi)	Sureshan, 2009
12	<i>D. colemani</i> (Crawford)	Sureshan, 2009

13	<i>Halticopterella rampurensis</i> Sureshan	New Record
14	<i>Manineura pentatomivora</i> (Mani)	New Record
15	<i>Merisomorpha minuta</i> Sureshan	New Record
16	<i>Mokrzeckia menzeli</i> Subba Rao	New Record
17	<i>Norbanus acuminatus</i> Dutt & Ferriere	Sureshan, 2009
18	<i>N. indorum</i> (Masi)	Noyes (2019).
19	<i>Oniticellobia longigastra</i> Sureshan & Narendran	Sureshan, 2009
20	<i>Oxysychus nupserhae</i> (Dutt & Ferriere)	Sureshan, 2009
21	<i>Panstenon oxylus</i> (Walker)	Sureshan, 2009
22	<i>Propicroscythus mirificus</i> (Girault)	Sureshan, 2009
23	<i>Pr. oryzae</i> (Subba Rao)	Sureshan, 2009
24	<i>Pteromalus puparum</i> (Linnaeus)	Sureshan, 2009
25	<i>P. semotus</i> (Walker)	Sureshan, 2009
26	<i>Trichomalopsis apanteloctena</i> (Crawford)	Sureshan, 2009
27	<i>T. nigra</i> Sureshan & Narendran	Sureshan, 2009
28	<i>T. ovigastra</i> Sureshan & Narendran	Sureshan, 2009
29	<i>T. travencorensis</i> Sureshan & Narendran	New Record
30	<i>T. thekkadiensis</i> Sureshan & Narendran	Sureshan, 2009
31	<i>T. kannurensis</i> Sureshan & Narendran	New Record

concolorous with mesosoma, mid coxa, trochanter, tibiae testaceous or yellowish, tarsal segments whitish, tips of tarsal segments brown. Gaster deep blue to brownish with slightly golden reflection in some tergites and T1 brownish.

Material examined: 1 ♀; India: Odisha: Athagarh: Cuttack; 20°31'16.8"N; 85°38'01.4"E; 13.ii.2022; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23364.

Distribution: India (Odisha*, Uttar Pradesh, Uttarakhand, Kerala, Tamil Nadu); Elsewhere: Sri Lanka, Myanmar, China.

Remarks: Parasitic on bug eggs on Citrus plant.

2. *Acroclisoides maculatus* Sureshan and Narendran, 2002

Acroclisoides maculatus Sureshan & Narendran, 2002a: 128. Holotype F: India, Kerala.

Diagnosis: Female. Body length. 1.98mm. Head and mesosoma metallic green with reflection of golden color, lower face green with reflection of golden colour; occipital carina present; eyes cupreous; ocelli whitish. Antennae (11263) with scape, pedicel and anelli testaceous, flagellum brown and clava brown; Mandibles yellowish with teeth testaceous margins. Noauli deep and complete. Forewing hyaline with brown infuscated spot beneath STV; veins and pubescence brown, Gaster petiolated, T1 very large, funnel shaped.

Material examined: 1 ♀; India: Odisha: Mahavinayak: Jajpur; 20° 42' 12"N; 86° 05' 07"E; 11.iii.2021; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23306.

Distribution: India (Odisha*, Kerala, Karnataka, Tamil Nadu)

Genus: *Pachyneuron* Walker

1. *Pachyneuron aphidis* (Bouche, 1834)

1834: *Diplolepis aphidis* Bouche. *Natur. Ins. Berlin*. 5: 170. M, F.

1939: *Pachyneuron lali* Mani. *Ind. J. Ent.* 1: 81. M. India (Karnal) IARI.

1939: *Pachyneuron ferrieri* Mani. *Ind. J. Ent.* 1: 83. India: Chaubattia (IARI).

1974: *Pachyneuron triarticulata* Mani & Saraswat. *Mem. School. Ent. Agra* No. 3: 98. F. India (Dalhousie) (USNM). Examined.

Diagnosis: Female. Body length 1.487mm. Body black or deep blue; gaster with a greenish or bluish tinge; Mandibles yellowish, teeth testaceous; Antennal formula 11353; scape, pedicel brownish black and flagellum dark brown; Eyes cupreous; ocelli silvery white. FW hyaline, veins paler, discal pubescence reduced basally and moderate beyond MV. Legs with coxae, trochanter, femora and basal part of tibiae concolorous with mesosoma, knees yellowish; tibiae distally and tarsal segments yellowish except tips of tarsal segments brown.

Material examined: 2♀; India: Odisha: Ghatagaon: Keonjhar; 21.407985N; 85.898484E; 22.vii.2022; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23193.

Distribution: India (Odisha*, Delhi, Haryana, Karnataka, Punjab, Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh); Elsewhere: Iran, Iraq, Israel, Kirgizia, Korea, Korea, South Libya, Mexico, Netherlands, New Zealand, Pakistan, China, Argentina, Armenia, Italy, Japan, Kazakhstan, Australia, Belgium, Brazil, Bulgaria, Canada, Chile, Colombia, Croatia, Cuba, Czech Republic, Egypt, Europe, France, Germany, Peru, Poland, Romania, Russia, Serbia, Spain, Sweden, Switzerland, Syria, Taiwan, Greece, Hawaii, Hungary, Turkey, Ukraine, United Kingdom, United States of America, Yemen, Yugoslavia.

Subfamily- Pteromalinae

Genus: *Anisopteromalus* Ruschka

1. *Anisopteromalus quinarius* Gokhman and Baur

Diagnosis: Female. Length of body size is 2.21mm. Olive-green colour of the head, uniform black belly, greenish-black mesosoma, and dark reddish-brown eyes and ocelli. Third anelli quadrate, light brown pedicel and scape, antenna 11353. Hyaline FW with dark brown veins. The head is noticeably reticulate and fairly setose; the femora is brownish yellow with brighter apices; the fore tibia is white apically and pale yellow in the basal half; the legs have coxae concolorous with the mesosoma; the Gaster is sessile.

Material examined: 1♀; India: Odisha: Neulpur: Jajpur; 20.71111111N; 86.14138889E; 11.vii.2022; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23534.

Distribution: India (Odisha*); Elsewhere: Russia, USA.

Genus: *Callitula* Spinola

1. *Callitula anguloclypea* Sureshan, 2002

Diagnosis: Female. Body length 1.98mm. Head and mesosoma black; gaster brown and a yellowish spot at base dorsally; Antennal formula 11353, scape, pedicel and anelli testaceous, flagellum brown, apex of clava pointed; Eyes cupreous, ocelli silver white; FW hyaline, veins paler; Legs testaceous except coxae concolorous with mesosoma and tips of tarsal segments brown.

Material examined: 1♀; India: Odisha: Kapilash road: Dhenkanal; 20°39'53.4"N; 85°38'12.7"E; 25.ix.2021; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23388.

Distribution: India (Odisha*, Kerala, Tamil Nadu); Elsewhere: Sri Lanka

Genus: *Chlorocytus* Graham

1. *Chlorocytus indicus* Sureshan, 2000

2000: *Chlorocytus indicus* Sureshan, 2000: 98. Holotype F: India.

Diagnosis: Female. Body length 2.00mm. Body metallic blue with reflection of golden colour; Antenna 11263; Antenna having scape & pedicel testaceous. Remainder brown. Head distinctly punctuate. Notauli incomplete; Pronotal collar sharply carinate; Mesoscutum width 1.7x length; Propodeum with fine and complete median carina. Forewing with basal vein setae. SV is 0.5x PMV. Gaster sessile and longer than sum of length of head and mesosoma combined.

Material examined: 2♀; India: Odisha: Sribantapur: Cuttack; 20.415927N; 85.842296E; 17.xii.2022; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23403.

Distribution: India (Odisha*, Kerala, Arunachal Pradesh, Jammu, Karnataka, Tamil Nadu)

Genus: *Cryptoprymna* Forester

1. *Cryptoprymna elongata* Sureshan & Narendran, 2000

2000: *Cryptoprymna elongata* Sureshan & Narendran, 2000: 403. Holotype F: India, Kerala.

Diagnosis: Female. Body length 2.609mm. Body black; Antenna 11263, testaceous. Head finely reticulate, clypeus's anterior margin slight emarginate. Antenna with scape touching median ocellus. Clava slightly longer than the three segments that came before it. F1-F3 are slight larger than other funicular segments. Notauli incomplete; Mesoscutum finely reticulate; Gaster petiolate.

Material examined: 12♀, 5♂; India: Odisha: North Odisha University campus, Baripada: Mayurbhanj; 21.929373N; 86.760524E; 18.vii.2022; Syrphid fly pupa; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23536.

Distribution: India (Odisha*, Karnataka, Kerala)

Remarks: Pupa of Syrphid fly (*Episyrphus* sp.)

Genus: *Dinarmus* Thomson

1. *Dinarmus basalis* (Rondani, 1877)

1877: *Entedon basalis* Rondani. *Bull. Soc. Ent. Ital.* 9: 174.

1974: *Dinarmus basalis* (Rondani), in Boucek. *Redia.* 55: 241-285.

Diagnosis: Female. Body length 2.26mm. Head and mesosoma dark blue or green with reflection of golden colour and with abundant white pubescence, gaster brownish or blackish with golden or brassy reflection. Antennae 11353, scape pedicel and anelli yellowish or testaceous, rest of antennae brown. F1 distinctly longer than pedicel. FW hyaline, veins brown, discal pubescence proximally reduced greatly and moderate distally, large, open speculum underneath, basal vein absent, basal cell open. Legs with coxae concolrous with mesosoma, all trochanter, femora and basal part of tibiae testaceous, distal part of tibiae, tarsal segments yellowish except tips of tarsal segments brown.

Material examined: 10♀ 4♂; India: Odisha: Talabania: Puri; 19° 48' 46" N; 85° 51' 02" E; 07.ix.2021; Stored Yellow pea: *Calosobruchus chinensis*; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23190.

Distribution: India (Odisha*, Andhra Pradesh, Bihar, Kerala, Madhya Pradesh, Delhi, Haryana, Karnataka, Rajasthan); Elsewhere: Bangladesh; France; Iran; Israel; Italy; Kazakhstan; South Africa; Sri Lanka; Sudan; Thailand; Ukraine; United States of America.

Remarks: Parasitic on *Callosobruchus chinensis* and other bruchid beetles pest of stored chick pea & *Pisum sativum*.

Genus: *Halticopterella* Girault and Dodd

1. *Halticopterella rampurensis* Sureshan, 2001

Diagnosis: Female. Body length 3.65mm. Thorax and head are dark in colour. Brown tint on the propodeum. Testaceous antenna, slightly darker in the club. Gaster brown with a faint dorsal metallic blue reflection on T1. All legs are pale brown, with the exception of the darker tarsi tip. Brown telula,

hyaline forewing membrane, pale brown veins.

Material examined: 2♂; India: Odisha: Biruhan: Balasore; 21.44879N; 86.858465E; 20.xii.2022; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23540.

Distribution: India (Odisha*, Kerala)

Genus: *Manineura* Boucek

1. *Manineura pentatomivora* (Mani, 1939)

1939: *Acroclisoides pentatomivorus* Mani, 1939

Diagnosis: Female. Body length 1.58mm. Clypeus's anterior margin slightly emarginated. Antennal formula 11263 with scape reaching above vertex. FW with MV thickened, shorter than STV and PMV, stigma of FW moderately capitate, speculum broad and open below. Notauli deep and

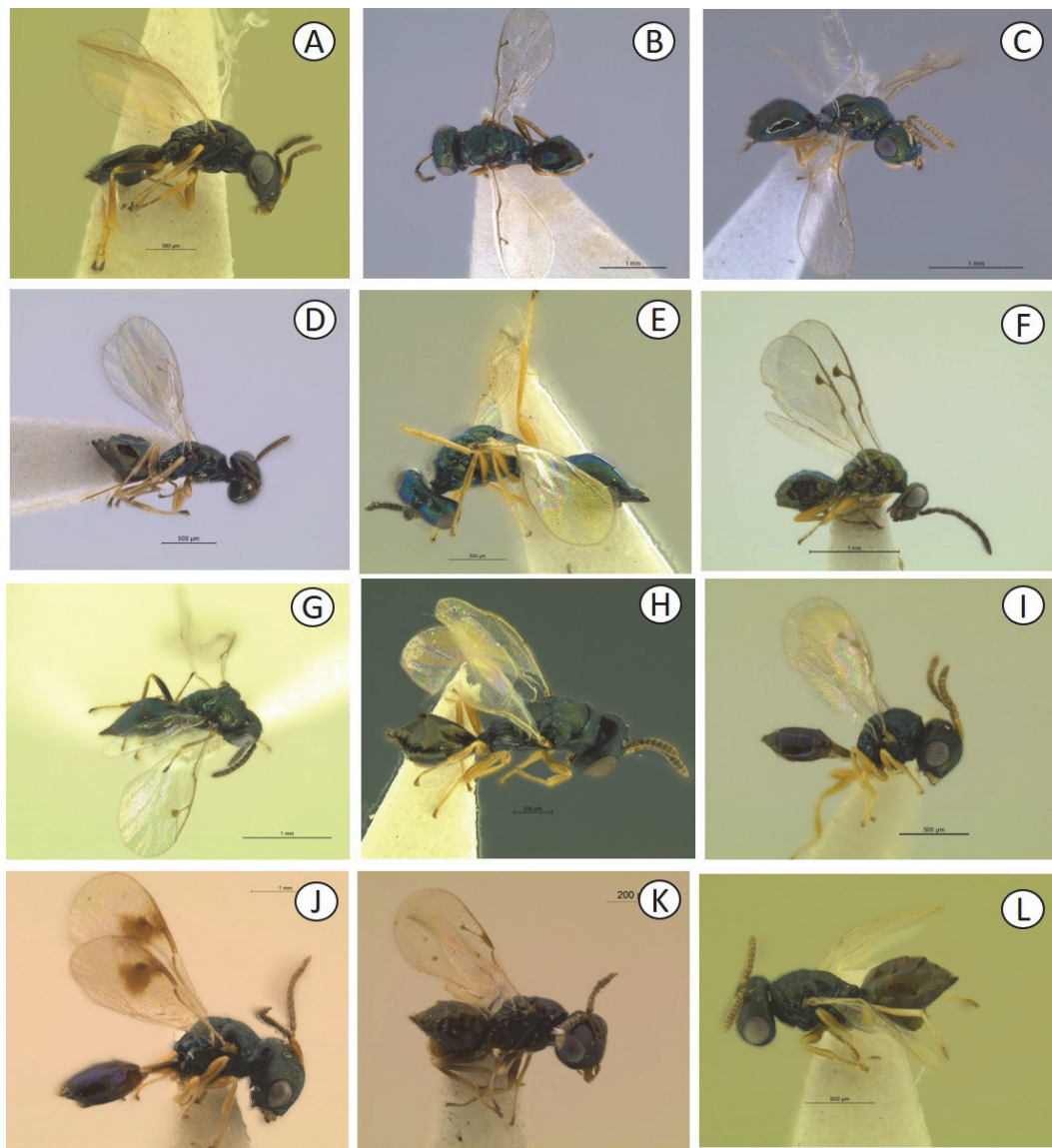


Fig. 1 (A-L): Pteromalidae species recorded from Odisha. A) *Halticoptera andriscui*, B) *Halticoptera crius*, C) *Halticoptera flavicornis*, D) *Halticoptera shimlica*, E) *Merismus megapterus*, F) *Stictomischus obscurus*, G) *Stictomischus longiventris*, H) *Syntomopus rajamalaiensis*, I) *Acroclisoides indicus*, J) *Acroclisoides maculatus*, K) *Pachyneuron aphidis*, L) *Anisopteromalus quinarius*

complete. Gaster subsessile, petiole as long as or slightly longer than broad.

Material examined: 1 ♀; India: Odisha: Panikoili: Jajpur; 20.9146N; 86.232E; 20.xi.2020; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23556.

Distribution: India (Odisha*, Assam, west Bengal)

Genus: *Mokrzeckia* Mokrzecki

1. *Mokrzeckia menzeli* Subba Rao, 1981

1981: *Mokrzeckia menzeli* Subba Rao. *Proc. Ind. Acad. Sci. (Allim. Sci.)*.90: 479. M. F. India (Dehra Dun) (BMNH).

Diagnosis: Female. Body length 2.42mm. Head and mesosoma is bright metallic bluish green.

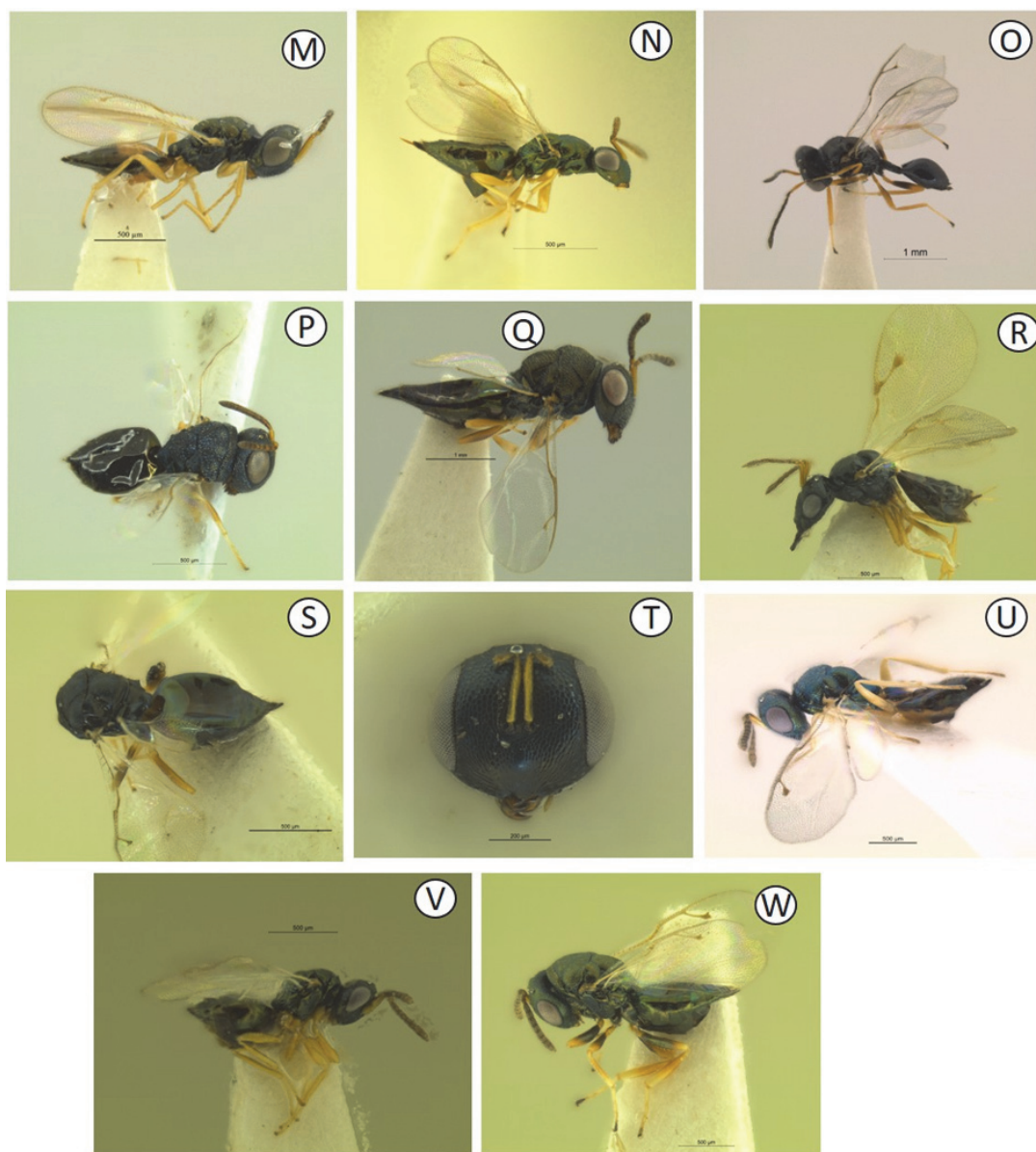


Fig. 2 (M-W): Pteromalidae species recorded from Odisha. M) *Callitula anguloclypea*, N) *Chlorocytus indicus*, O) *Cryptoprymna elongata*, P) *Dinarmus basalis*, Q) *Halticopterella rampurensis*, R) *Manineura pentatomivora*, S-T) *Merismomorpha minuta*, U) *Mokrzeckia menzeli*, V) *Trichomalopsis travencorensis*, W) *Trichomalus kannurensis*

Antenna brown. Gaster is yellowish brown with metallic tinge on sides. Head moderately reticulate. Clypeus with anterior margin deeply incised. Antennae 11263, inserted in the middle of the face. POL shorter than OOL. Pronotal collar carinate. Forewing without irregular cilia below SMV. Gaster depressed and lanceolate.

Material examined: 5 ♀, 1 ♂; India: Odisha: Mahanga: Cuttack; 20.52944444N; 86.20166667E; 09.vii.2022; Bracon Pupa; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23311.

Distribution: India (Odisha*, Karnataka, Kerala, Uttar Pradesh, Uttarakhand)

Remarks: Parasitic on Bracon pupa.

Genus: *Merismomorpha* Girault

1. *Merismomorpha minuta* Sureshan, 2000

2000c: *Mersimomorpha minuta* Sureshan, *Rec. Zool. Surv. India*, 98 (3):105. (ZSIK).

Diagnosis: Female. Body length 1.63mm. Head and mesosoma bluish black with gaster metallic bluish black except T1 and ventral part dark brown; POL longer than OOL; lower margin of clypeus angulates, antennal formula 11353, propodeum without median carina; FW with MV longer than MV; petiole short, embraced by a long extension of first gastral sternite; pedicel as long as F1, inserted somewhat above middle of face; gaster small, oval, little longer than head plus mesosoma combined.

Material examined: 1 ♂; India: Odisha: Cuttack; 20.446912N; 85.91365E; 14.xi.2022; Coll. By: Aishwarya Ray. Accession number: FRI/23444.

Distribution: India (Odisha*, Kerala)

Genus: *Trichomalopsis* Crawford

1. *Trichomalopsis travancorensis* Sureshan & Narendran, 2001

2001: *Trichomalopsis travancorensis* Sureshan & Narendran.

Diagnosis: Female. Body length 1.80mm. Dark green head and mesosoma with a bronzy reflection; brown gaster with a bluish reflection dorsally; POL 1.373 x OOL. A brown antennal formula 11263 with a testaceous basal scape; a strongly margined pronotum; a prominent scutellum with a frenal area; a weak propodeum with a midline carina; a fairly convex nucha; a basal cell and naked basal vein in the apex Gaster is oval, elongate, 1.79 times longer than wide, longer than mesosoma, and sessile with a strongly transverse petiole. MV is longer than STV (1.89x).

Material examined: 1 ♀; India: Odisha: Gopalpur: Ganjam; 19°17'25.2"N; 84°52'11.6"E; 29.ix.2021; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23532.

Distribution: India (Odisha*, Kerala)

Genus: *Trichomalus* Thomson

1. *Trichomalus kannurensis* Sureshan & Narendran, 1995

1994b. *Trichomalus kannurensis* Sureshan & Narendran,

Diagnosis: Length 1.92mm. Dark green body with a hint of bronzy colour. Antennae 11263 with scape reaching level of vertex; propodeum with median carina not reaching beyond costula; anterior border of clypeus almost straight; POL 1.23x OOL; Gaster longer than head plus mesosoma combined; FW length 2.58x width. Brown with a hint of greenish-gray.

Material examined: 1 ♀; India: Odisha: Udala: Mayurbhanj; 21.579356N; 86.572343E; 18.vii.2022; Coll. By: Aishwarya Ray. Accession number: FRI/NFIC/23533.

Distribution: India (Odisha*, Kerala)

Burks *et al.* (2022) revisited the genera of Pteromalidae based on morphological characteristics, leading to the elevation of several subfamilies to family rank and the reassignment of certain genera to other subfamilies. Prior to this reclassification, twenty-eight species were reported

from Odisha by Sureshan (2009) and Noyes (2019). Following the revision, the fauna of Odisha was updated and the subfamilies Herbertinae and Spalanginae were excluded from Family Pteromalidae due to their elevation to family status. Consequently, three species *Herbertia indica* Howard, *Spalangia nigroaenea* Curtis, and *Spalangia simplex* Perkins previously recorded under Pteromalidae from Odisha were removed from the checklist. Additionally, the subfamily Panstenoninae was dissolved, with its genera transferred to sub-family Pteromalinae. In the present study, twenty-two new species records have been added for Odisha, including seven species viz. *Halticoptera andriscui* Mitroiu, *Halticoptera crius* Walker, *Halticoptera flavicornis* Spinola, *Merismus megapterus* Walker, *Stictomischus obscurus* (Walker), *Stictomischus longiventris* (Thomson), and *Anisopteromalus quinarius* Gokhman & Baur reported for the first time from India. Accordingly, an updated checklist of Pteromalidae fauna from Odisha has been prepared, comprising 47 species belonging to 26 genera under three subfamilies.

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Seasonal occurrence of teak skeletonizer *Eutectona machaeralis* (Walker) (Lepidoptera, Crambidae) on *Tectona grandis* L. (Lamiaceae) in Saharanpur, Uttar Pradesh, India

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ABSTRACT: A field survey of teak trees grown along roadsides and in farmer's fields conducted in Saharanpur, Uttar Pradesh, during 2023-2024, revealed a considerable infestation of teak skeletonizer, *Eutectona machaeralis* (Walker). The incidence of *E. machaeralis* was recorded in the fifth week of May, ie., 42 standard meteorological week (SMW). The population of *E. machaeralis* started to increase gradually from the first week (27th SMW) of July in both the years and reached its peak level in the fifth and first weeks (31st and 32nd SMW) of July and August, which started to decline from the second week (33rd SMW) of August and reached its lowest level in the fourth week (48th SMW) of November. The population was nil in the month of December during 2023 and 2024. The higher population was recorded during the year 2023 as compared to 2024. © 2026 Association for Advancement of Entomology

KEY WORDS: Incidence, peak level, May - December, larval population, damage per leaf

INTRODUCTION

Teak, (*Tectona grandis* Linn) commonly known as Sagun and Sagwan is an economically important plant of the family Lamiaceae. It is a large deciduous tree that demands proper light and is very sensitive to drought, coppices, frost, and pollards (Troup, 1921a). Teak is one of India's most valuable commercial timber trees. The high oil content and toxic substances make it highly durable. It is commonly used in ship, bridge, and wharf construction, as well as carpentry and military applications. Besides these utilities, teak is very susceptible to damage by insects in teak plantations and nurseries (Dhobe *et al.*, 2014). Teak naturally

grows in India below 24° N latitude in Kerala, Andhra Pradesh, Karnataka, Orissa, Madhya Pradesh, Maharashtra, Gujrat, Rajasthan, Uttar Pradesh, and Manipur (Troup, 1921b). Teak is one of the most durable timbers in the world; it is practically impervious to fungus and white ant attack and resistant to decay (Palanisamy *et al.*, 2009). In India, teak trees are infested with approximately 187 different insect species (Hutacharim and Tubtim, 1995). The worst leaf-feeders are the teak skeletonizer *Eutectona machaeralis* Walker (Pyralidae) and the teak defoliator *Hyblaea puer*a Cramer (Hyblaeidae), both of which are abundant and cause significant damage to the teak trees (Tripathy, 2022). The teak

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skeletonizer is named for its ability to transform the entire leaf into a skeleton, preserving the veins. Teak skeletonizer is a significant pest on teak plantations, nurseries, and forests, feeding on leaf green matter, leaving veins intact, and feeding on leaves of all qualities until natural leaves fall (Roychoudhury and Mishra, 2021). The present study aims to describe the seasonal occurrence of teak skeletonizer in Saharanpur U.P., India. No such study is carried out in this region before.

MATERIALS AND METHODS

The present study was conducted from May to December 2023–2024 in district Saharanpur, Uttar Pradesh, India. Saharanpur is a city in the state of Uttar Pradesh in northern India which is located at 29°58'1.4844"N; 77° 33' 3.6612" E. Field surveys were conducted on teak plants (approximately 5 years old) planted along the road sides on Janta Road as well as in farm lands. The leaves of the teak plants were severely infested with larvae of the teak skeletonizer, *Eutectona machaeralis* causing skeletonization. To record the seasonal incidence ten infected teak plants were selected and weekly observations were made on the larval population. Data on the seasonal population trends of larvae, percentage of infestation, mode of feeding, and damage per leaf were observed for two years by qualitative and visual scoring. The mean values and standard errors of the collected data were calculated and compiled using Microsoft Excel. Photographs of the egg (Fig. 1), larvae (Fig. 2), pupae (Fig. 3), adults (Figs. 4, 5), and damage (Fig. 6) on the host plants were taken with the help of a digital camera. The daily meteorological data, like temperatures (°C), rainfall, and relative humidity (RH), were taken from HRI and the Training Centre, Saharanpur.

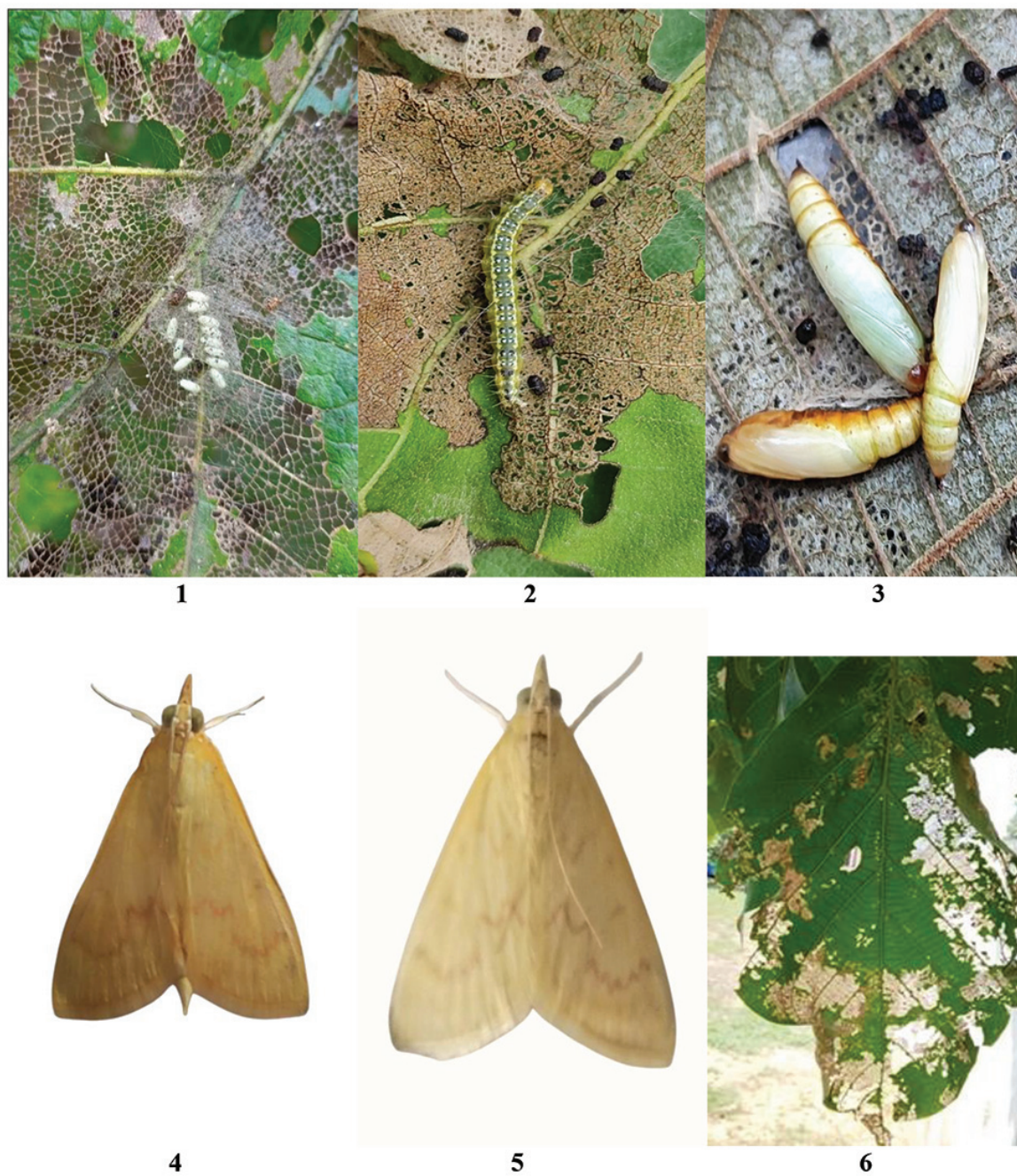
RESULTS AND DISCUSSION

The seasonal occurrence of the teak skeletonizer, *E. machaeralis*, in *T. grandis*, noted from the last week of May until the last week of December in both 2023 and 2024. Initial larval population was observed at 1.3 ± 0.67 and 1.0 ± 0.40 larvae per twig with 2.5 and 1.9 per cent damage/leaf/plant in both

years. The population increased gradually from the first week (27th SMW) of July and was observed to be 3.4 ± 0.51 larvae/twig/plant with 4.10 per cent leaf damage/plant in 2023 and 2.4 ± 0.41 larvae/twig causing 3.9 per cent damage/leaf/plant in 2024. The population of *E. machaeralis* reached up to 11.9 ± 0.73 larvae/twig/plant with 12.30 per cent leaf damage per plant during the year 2023 and 10.9 ± 0.56 larvae/twig/plant with 10.21 per cent leaf damage per plant during the year 2024 in the 4th week (30th SMW) of July. The population reached 12.9 ± 0.52 larvae/twig/plant with 14.45 per cent leaf damage/plant in the 5th week (30th SMW) of July during 2023 and 10.9 ± 0.51 larvae/twig/plant with 12.35 per cent leaf damage/plant during the 5th week (30th SMW) of July during 2024. The highest population was 13.2 ± 0.62 larvae/twig/plant with 15.47 per cent leaf damage/plant in the 1st week (32nd SMW) of August during the year 2023 and 12.2 ± 0.52 larvae/twig/plant with 14.91 per cent leaf damage/plant in the 1st week (32nd SMW) of August during the year 2024. In the 2nd week (33rd SMW) of August, the larval population was recorded at 11.5 ± 0.53 larvae/twig/plant with 15.985 per cent leaf damage/plant during the year 2023, whereas it was observed to be 10.5 ± 0.51 larvae/twig/plant with 13.78 per cent leaf damage/plant in 2024. The population started to decline from the 3rd week (34th SMW) of August in both years and reached 7.9 ± 0.51 larvae/twig/plant with 10.10 per cent leaf damage/plant in the 1st week (36th SMW) of September during the year 2023 and 5.9 ± 0.55 larvae/twig/plant with 9.35 per cent leaf damage/plant in the 1st week (36th SMW) of September in 2024. The population increased slightly in the 2nd and 3rd weeks (37th and 38th SMW) of September. The larval count was observed at 9.3 ± 0.62 and 9.7 ± 0.52 larvae/twig/plant with 11.10 and 11.12 per cent leaf damage/plant, respectively, during the years 2023 and 2024. Again, from the 4th week (39th SMW) of September, the population started to decrease continuously till the 4th week (48th SMW) of November during 2023 and 2024. The lowest larval population was observed at 2.1 ± 0.42 larvae/twig/plant with 3.76% leaf damage/plant in the 4th week (48th SMW) of November, 2023, and 1.8 ± 0.47 larvae/twig/plant with 2.98 per cent leaf damage/plant in the 4th week (48th SMW) of

Table1. Seasonal occurrence of teak skeletonizer *E. machaeralis*

Months and week		2023						2024				
		SMW	Larvae/ plant	Leaf damage %	Mean temp. (°C)	Rain fall (mm)	R H (%)	Larvae per plant	Leaf damage %	Mean temp. (°C)	Rain fall (mm)	R H (%)
May	V	22	1.3±0.67	2.5	34.91	93.28	14.12	1.0±0.40	1.9	35.23	92.21	13.13
June	I	23	1.4±0.69	2.7	34.21	94.70	31.23	1.1±0.39	2.1	36.71	90.10	10.21
	II	24	1.6±0.69	3.30				1.3±0.49	2.9			
	III	25	1.7±0.48	3.45				1.3±0.49	3.1			
	IV	26	1.1±0.66	3.52				1.1±0.38	3.4			
July	I	27	3.4±0.51	4.10	30.15	415.45	55.56	2.4±0.41	3.9	30.29	305.62	58.32
	II	28	6.5 ±0.52	6.25				4.5 ±0.53	5.29			
	III	29	8.5±0.51	7.90				6.5±0.55	6.9			
	IV	30	11.9±0.73	12.30				10.9±0.56	10.21			
	V	31	12.9±0.52	14.45				10.9±0.51	12.35			
August	I	32	13.2±0.62	15.47	29.41	354.25	76.90	12.2±0.52	14.91	28.32	310.25	74.32
	II	33	11.5±0.53	15.98				10.5±0.51	13.78			
	III	34	9.5±0.62	11.80				7.5±0.42	10.76			
	IV	35	8.7±0.53	11.71				6.7±0.56	10.31			
September	I	36	7.9±0.51	10.10	28.50	208.39	63.25	5.9±0.55	9.35	29.41	208.39	72.28
	II	37	9.3±0.62	11.10				8.3±0.65	10.25			
	III	38	9.7±0.52	11.12				8.7±0.54	10.35			
	IV	39	8.5±0.48	9.65				7.5±0.51	7.55			
October	I	40	6.3±0.59	8.58	26.49	20.51	61.81	4.9±0.55	6.52	27.67	16.49	60.83
	II	41	5.7±0.62	7.36				4.3±0.45	5.39			
	III	42	5.8±0.49	6.29				4.5±0.49	6.10			
	IV	43	4.9±0.61	5.39				3.9±0.63	4.32			
	V	44	3.9±0.54	5.81				2.9±0.56	3.41			
November	I	45	2.8±0.67	4.81	22.96	4.25	47.84	2.1±0.57	3.98	23.98	14.56	51.61
	II	46	2.5±0.52	4.62				2.1±0.56	3.78			
	III	47	2.3±0.42	4.17				1.9±0.45	3.10			
	IV	48	2.1±0.42	3.76				1.8±0.47	2.98			
December	I	49	0.00	0.00	15.70	25.58	40.51	0.00	0.00	15.32	12.45	30.15
	II	50	0.00	0.00				0.00	0.00			
	III	51	0.00	0.00				0.00	0.00			
	IV	52	0.00	0.00				0.00	0.00			
	Mean			7.77±4.10					6.69±3.82			



Figs. *Eutectona machaeralis* Walk. - (1) Eggs, (2) Larva, (3) Pupa, (4) Male adult, (5) Female adult, (6) skeletonized leaf of *Tectona grandis*

November, 2024. The population of the pest nil in all the weeks of December 2023 and 2024 (Table 1).

Several authors have studied the seasonal incidence and population dynamics of *E. machaeralis* from various parts of India. As no prior data are available for Saharanpur, existing results from other states are used as a reference. Patil and Thontadarya (1983) noticed the larval activity of *E. machaeralis* throughout the year and also noticed the negligible population from January to March. Similarly, Khan *et al.* (1988) noted peak incidence of *E. machaeralis* during September in Madhya Pradesh. Longanathan *et al.* (2001) observed the activity of *E. machaeralis* throughout the year with two peaks. The above finding are more or less similar to the present findings. Chauhan *et al.* (2013) observed the activity of *E. machaeralis* in the fifth week of May in 2006 and 2007, which reached its peak in the fourth week of July in 2006 and the first week of August in 2007 and declined up to the first week of November. Kabade *et al.* (2015) reported the activity of the teak skeletonizer from April to December in Gujarat. Elsewhere, Wu *et al.* (1979) also reported the similar observations, which were almost similar to our findings. The weather parameters like, monsoon rainfall, cooler nights, and high relative humidity favors larval buildup, while dry and cool winter suppresses activity.

Mode of infestation and damage to the host plant: The infestation begins at the leaf margin; caterpillars gradually skeletonize the leaves to the midrib, and two caterpillars do not feed in the same feeding zone. Only the larval stages of *E. machaeralis* are responsible for the unique skeletonization of leaves. The larvae of *E. machaeralis* consume the green leaf tissue found between the veins, leading to the distinctive symptom of skeletonization (Fig. 6). Partially damaged leaves are not immediately shed, and even completely skeletonized leaves remain on the affected tree for an extended period, giving it a dry, scorched appearance.

Teak skeletonizer *E. machaeralis* is a serious pest of teak plants in Saharanpur, leading to major leaf damage to the teak plants. The highest leaf damage

per plant was observed from 12.30 to 15.98 per cent leaf damage/plant from the fourth week of July to the first week of August during the year 2023 and from 10.21 to 13.78 per cent leaf damage from the fourth week of July to the first week of August during the year 2024. The pest population showed a positive correlation with relative humidity and rainfall, and a negative correlation with maximum temperature.

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Alteration in secondary metabolites in *Lasioptera* sp. (Diptera, Cecidomyiidae) induced galled and ungalled leaves of *Glycosmis pentaphylla* (Retz.) DC.

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ABSTRACT: *Glycosmis pentaphylla* (Retz.) DC. (Rutaceae) is an ethnobotanically important medicinal plant. On this host, cylindrical- green epiphyllous galls are induced on the leaves by *Lasioptera* sp. (Diptera, Cecidomyiidae). In the present study, the changes in concentration of major secondary metabolites during the development of insect-induced plant galls in *G. pentaphylla* analysed and the results show that gall tissues contained significantly higher concentrations of tannins, phenols, and alkaloids, but lower concentrations of flavonoids, compared with ungalled leaves. These gall-associated alterations in secondary metabolite profiles may represent host defense responses initiated by gall induction and reflect the complex biochemical interactions between the gall inducer *Lasioptera* sp. and the host plant.

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KEY WORDS: Gall inducer, phenol, flavonoids, tannin, alkaloids

INTRODUCTION

Insect-induced galls represent a highly specialized form of plant-insect interaction in which gall-inducing insects manipulate host plant tissues to form novel structures that provide nutrition and protection for the developing inducer (Raman *et al.*, 2005). Gall formation is associated with localized physiological stress in host plants and involves extensive cellular hypertrophy and hyperplasia, leading to the differentiation of specialized tissue zones such as nutritive and mechanical zones (Mishra *et al.*, 2020). Gall inducing insects are known to modulate host defense signaling pathways through the production or manipulation of phytohormones such as salicylic acid, jasmonic acid and, ethylene, thereby influencing the synthesis and

accumulation of secondary metabolites (Bennet and Wallsgrove, 1994; Erb *et al.*, 2012). The production of plant secondary metabolites in galled tissues is strongly dependent on the specific insect-plant interaction (Dicke, 1999). Among these metabolites, phenolic compounds and alkaloids are particularly important due to their defensive roles against herbivores, phytophagous insects and pathogens (Cornell and Hawkins, 2003; Lattanzio, 2013). Phenolic compounds, including phenols, flavonoids and tannins constitute one of the largest and widely distributed groups of plant secondary metabolites and are frequently reported to accumulate in higher concentrations in gall tissues, especially in the outer mechanical layers (Abrahamson *et al.*, 1991; Bronner, 1992; Cuevas- Reyes *et al.*, 2004; Mishra *et al.*, 2020). In contrast, inner nutritive tissues often

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contain reduced levels of phenolics, which may facilitate larval feeding by minimizing chemical deterrence (Ferreira *et al.*, 2017; Tataroglu *et al.*, 2023). Alkaloids and terpenoids have also been reported to function as chemical defenses in galls, acting as feeding deterrents and contributing to protection against natural enemies (Amorim *et al.*, 2017; Kuster *et al.*, 2019).

Glycosmis pentaphylla (Retz.) DC. (Rutaceae) is an ethnobotanically important shrub or small tree widely distributed across south and southeast Asia and Australia. The species is well known for its medicinal properties (Babu and Nair, 2019; Babu and Radhamany, 2021). Leaves of *G. pentaphylla* attacked by *Lasioptera* sp. (Diptera, Cecidomyiidae) inducing galls. The present study investigates the variation in phenols, flavonoids, tannins, and alkaloids between galled and ungalled leaves of *G. pentaphylla*, with the aim of elucidating the biochemical consequences of gall.

MATERIALS AND METHODS

Cecidomyiid induced galls along with the leaves and ungalled leaves (Fig 1), were collected from the 3rd to 6th phytomer below the shoot apex to ensure comparable leaf and gall developmental stages (Motta *et al.*, 2005) from Janakikkad (11.64253° N; 75.78353° E) during 2021-2022. The galls (excluding all leafy part) were washed thoroughly, dissected for removing insects and its remnants like exuviae, shade dried and powdered in a mixer and used for the solvent extraction. For the sample preparation, the dried samples of the galls and ungalled leaves (both 15g) were extracted separately with methanol (99%) using a Soxhlet apparatus (15 cycles) and the extracts were evaporated to dryness to obtain the crude extracts of the galls and the ungalled leaves.

Quantitative analysis of total phenol, flavonoids, tannin, and alkaloids in galls and ungalled leaves was done by standard methods.

The total phenolic content was determined using slightly modified version of Folin and Ciocalteu reagent method described by Makkar (2003). The sample and standard reading were made using

spectrophotometer at 725nm against the reagent blank. The stock standard solution was made by dissolved 10mg of gallic acid in methanol and made up to 10ml in a standard flask. Then 0.05ml of phenol extract of sample and control sample was pipetted into a series of test tubes, the contents in the all test tubes were made up to 1ml with distilled water and performed the analyses in triplicates. Another test tube marked as 'B' with 1ml of distilled water serve as blank. Then 0.5ml of Folin-Ciocalteu reagent (1 N) was added to each test tubes including the blank, and allowed to stand for 5 min at 30-32°C. After that, 2.5ml of sodium carbonate (5%) was added to all test tubes, incubated for 40 min in dark at room temperature. Measured the absorbance of the blue colour developed against the reagent blank at 725nm using spectrophotometer. The data was used to estimate the total phenol content using a standard calibration curve obtained from various diluted concentrations of gallic acid.

The flavonoids estimation was carried out by slightly modified version of aluminium chloride (Zhishen *et al.*, 1999). This method is based on the formation of the flavonoids aluminium complex, which has an absorptivity maximum at 510nm. The stock standard solution was made by dissolved 20mg of Rutin in methanol and made up to 20ml in a standard flask. Then added 0.5ml of extract of the sample and control into series of test tubes. Performed the analyses in triplicates. Made up all contents of all test tubes to 1ml with distilled water. Another test tube marked as 'B' with 1 ml of distilled water serve as blank. Then 0.15ml of 5% Sodium nitrite was added to all test tubes and incubated for 5 min at 30-32°C. After that 0.15ml of 10 % Aluminium chloride was added to all the test tubes and incubated for 6 min at room temperature. Then 2ml of 4% Sodium hydroxide was added to all the test tubes and made up to 5ml using distilled water. Allowed to stand for 15 min at 30-32°C and measured the absorbance of pink colour developed against the reagent blank at 510nm using spectrophotometer. The standard graph was plotted by concentration of Rutin on X - axis and respective absorbance on Y- axis. Calculated the amount of flavonoids in the samples and expressed as mg

Rutin equivalents/g sample.

Total tannin was estimated by standard methods of Bray and Thorpe (1954). The stock standard solution was made by dissolved 10mg of Tannic acid in methanol and made up to 10ml in a standard flask. One ml of the sample was mixed with 5ml of freshly prepared vanillin hydrochloride reagent and incubated at room temperature for 20 minutes. Absorbance was read at 510nm against reagent blank.

The total alkaloids were done by slightly modified version of Harborne (1973). The sample each at 0.25g was taken in 5ml beaker, added 10ml of acetic acid (10%) in ethanol and allowed to stand for 4 h. Then it was filtered and the extract was concentrated on a water bath to one quarter of the original volume. Concentrated ammonium hydroxide was added drop wise to the extract until the precipitation was complete. The whole solution was allowed to settle overnight and the precipitate was centrifuged for 15 min at 3000 rpm and 30-32°C. Collected and washed with dilute ammonium hydroxide and then filtered. The residue was dried and weighed.

RESULTS AND DISCUSSION

The present study demonstrates significant alterations in secondary metabolite profiles between galled and ungalled leaves of *G. pentaphylla*. Galled tissues exhibited significantly higher concentrations of total phenolics, tannins and alkaloids, whereas total flavonoid content was significantly reduced compared to ungalled leaves.

The total phenolic content in galls and ungalled leaves was quantified using a standard curve of Gallic acid ($y = 0.008x + 0.012$, $R^2 = 0.998$). Gall tissues exhibited a significantly higher phenolic content (9.45 ± 1.30 mg/g GA) than ungalled leaves (6.12 ± 1.25 mg/g GA). A paired-samples t-test confirmed that the difference was not statistically significant, $p > 0.05$. The elevated phenolic concentration in gall tissues is consistent with previous studies establishing increased accumulation of phenolic compounds in insect-induced galls (Abrahamson *et al.*, 1991; Hartley, 1998; Connor

et al., 2012; Hall *et al.*, 2017). In cecidomyiid-induced galls, phenolic compounds are often concentrated in mechanically protective tissues, where they may deter herbivores and natural enemies (Mishra and Patni, 2008; Mishra *et al.*, 2020). The increased phenolic levels observed in *G. pentaphylla* therefore suggests defensive response mediated by the gall inducer.

Total flavonoid content was estimated using a rutin standard curve ($y = 0.0015x + 0.079$, $R^2 = 0.996$). Gall tissues contained significantly lower flavonoid levels (9.15 ± 1.67 mg/g R) compared to ungalled leaves (17.13 ± 2.40 mg/g R). The difference was statistically significant ($p < 0.05$). The reduction in flavonoid concentration within gall tissues contrasts with the general trend of increased phenolic accumulation in galls. Flavonoids can exert toxic or inhibitory effects on insect development, particularly during early larval stages (Guimarães *et al.*, 2021). Suppression of flavonoid synthesis within gall tissues may therefore represent a strategic manipulation by the gall inducer to create a favourable nutritive environment. Similar patterns have been reported in gall-inducing systems where inner gall tissues are characterized by reduced defensive compounds, facilitating larval feeding (Abrahamson *et al.*, 1991; Hartley and Lawton, 1992), while Motta *et al.* (2005) did not detect any flavonoids or flavones in galls.

Tannin content was quantified using a tannic acid standard curve ($y = 0.007x + 0.0018$, $R^2 = 0.98$). Galled tissues showed a significantly higher tannin concentration (22.73 ± 0.46 mg/g T) compared to the ungalled leaves (6.06 ± 1.09 mg/g T). Statistical analysis indicated a highly significant difference between the two tissue types ($p < 0.05$). High tannin accumulation in galls has been widely documented and is often associated with defensive functions (Abrahamson *et al.*, 1991; Connor *et al.*, 2012). Tannins are known to reduce tissue palatability and inhibit digestion in herbivores, thereby protecting gall tissues from external feeders and natural enemies (Hartley, 1998). In cecidomyiid-induced galls, tannins are frequently localized in outer cortical and sclerenchymatous tissues (Mishra and Patni, 2008; Mishra *et al.*, 2020). This significantly



Fig. 1 *Glycosmis pentaphylla* (Retz.) DC. leaves - **A**: ungallo, **B**: induced galls by the *Lasioptera* sp.

higher tannin concentration observed in *G. pentaphylla* galls supports the hypothesis that tannin accumulation contributes to gall defense while maintaining a relatively less defended inner nutritive zone.

Alkaloid concentration was substantially higher in galled tissues ($120 \pm 0.001 \text{ mg g}^{-1}$) compared to ungallo leaves ($30 \pm 0.015 \text{ mg g}^{-1}$). This difference was statistically significant ($p < 0.05$). Alkaloids are well-known defensive compounds their accumulation in galls has been previously reported to enhance chemical defense for gall inducers (Mani, 1964). Feeding activity of young gall-inducing insects has been shown to influence host biochemical pathways, leading to elevated alkaloid concentrations (Kuster *et al.*, 2020). In *G. pentaphylla*, alkaloids are naturally abundant in leaves (Babu and Radhamany, 2021).

In conclusion, the results indicate that gall induction in *G. pentaphylla* leads to selective increase in concentration of phenolics, tannins, and alkaloids, accompanied by a reduction in flavonoids. Such patterns support the nutritional and defensive compartmentalization hypotheses, wherein gall inducers manipulate host metabolism to create a

protective outer gall structure while maintaining a chemically suitable environment for larval development (Abrahamson *et al.*, 1991; Hartley and Lawton, 1992; Isaias *et al.*, 2014; Ferreira *et al.*, 2017). These findings highlight the complex biochemical reprogramming associated with insect-induced gall formation and its implications for plant defense and insect survival.

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Community analysis of nematodes associated with *Philodendron burle-marxii* with a new record of *Meloidogyne incognita* in Thiruvananthapuram, Kerala, India

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ABSTRACT: Survey conducted on *Philodendron burle-marxii*, an ornamental plant, in 13 panchayats of Thiruvananthapuram district, Kerala, revealed the occurrence of plant parasitic nematodes like *Meloidogyne incognita*, *Rotylenchulus reniformis* and *Helicotylenchus dihystra*; and predatory nematodes such as *Iotonchus indicus* and *Mylonchulus minor*. Rhabditids and other free-living nematodes were also encountered. The highest population of *M. incognita* was recorded from Vallakadavu area of Thiruvananthapuram Corporation (199 J₂ 200 cm³ soil⁻¹) followed by Veniyoor area of Venganoor panchayat. The highest population of *R. reniformis* was recorded from Pallichal area of Kalliyoor panchayat (99 nematodes 200 cm³ soil⁻¹). The highest population of *I. indicus* was from Ponmudi area of Peringamala panchayat (3.5 nematodes 200 cm³ soil⁻¹) and that of *M. minor* was from Peppara area of Vithura panchayat (6 nematodes 200 cm³ soil⁻¹). The bacterial feeding nematodes belonging to order Rhabditida was recorded from all the areas sampled. *M. incognita* recorded the highest prominence value to a tune of 1827.0 and 2959.0 for both Nemom and Vamanapuram respectively. This is the first report of *M. incognita* infecting *P. burle-marxii* in India evidenced by the morphology of female and second stage juveniles. The infected plants exhibited stunting, chlorosis of the lower leaves, abnormal leaf glossiness, and crinkling, curling, and a reduction in leaf size ranging from 30 to 80 per cent.

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KEY WORDS: Phytoparasites, first report, stunting, chlorosis, predatory nematodes, Rhabditida

INTRODUCTION

The genus *Philodendron*, belonging to the family Araceae, comprises numerous species valued in horticulture for their attractive foliage and adaptability to indoor environments. Among them, *Philodendron burle-marxii*, commonly known as 'Burle Marx,' has gained popularity for its visual

appeal and ease of maintenance. Native to the tropical rainforests of Brazil, *P. burle-marxii* thrive under conditions of high humidity, consistent warmth, and indirect light. These ecological conditions make it particularly well-suited for indoor cultivation. It prefers well-drained, organic-rich soil and benefits from regular misting to simulate its native habitat. The species is characterized by deep

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green leaves with prominent venation and a distinctive wavy or rippled margin, contributing to its ornamental value.

Root-knot nematodes (*Meloidogyne* spp.) are considered the most economically destructive plant-parasitic nematodes because of their global distribution and exceptionally wide host range, which includes more than 3,000 plant species (Abad *et al.*, 2003). With over 100 described species, *Meloidogyne* spp., infest nearly all agricultural crops as well as a wide range of weed hosts (Hussey and Janssen, 2002; Elling, 2013). Root-knot nematodes are known to suppress plant growth in *Philodendron* cv. Red Princess, even when gall formation is minimal and egg masses are small and often inconspicuous (Lehman and Stokes, 1979). *P. burle-marxii* is generally hardy and exhibits resistance to most common pests and diseases. However, sucking pests such as mealybugs and spider mites have occasionally been observed feeding on the plant. However, there is hardly any report of nematodes attacking this plant. Preliminary observations on the potted plants of *P. burle-marxii* in many locations across Thiruvananthapuram district, Kerala revealed symptoms including stunted growth, rosetting and narrowing of leaves. Affected plants exhibited severely galled roots indicative of nematode activity. Nematodes are important phytopathogens reported to cause an economic loss of \$173 billion to agriculture sector worldwide (Elling, 2013). There are reports of nematodes attacking other members of family Araceae. Kumar (1991) reported the incidence of root knot nematode *Meloidogyne* sp., on *Colocasia* sp., from all twenty-five panchayats selected for the study. A survey was undertaken to ascertain the occurrence of nematodes infecting *Philodendron burle-marxii* in and around Thiruvananthapuram district of Kerala.

MATERIALS AND METHODS

A survey was under taken to ascertain the nematodes associated with *P. burle marxii* in 13 panchayats of Thiruvananthapuram district and Thiruvananthapuram Corporation (Table 1), following purposive sampling technique. Fifty-two soil samples were collected from the following

panchyats viz., Parassala, Chenkal, Amaravila, Athiyannur, Venganoor, Vizhinjam, Kalliyoor, Vithura, Nanniyode, Peringamala, Attingal, Kizhuvilam, and Chemaruthi. Soils were collected from the rhizosphere of *P. burle-marxii* at a depth of 15-30cm with a soil auger. Soil samples were drawn both from potted plants and those raised in the gardens in the ground and also from wild growing plants. These samples were thoroughly mixed, bulked and nematodes were extracted from 200 cm³ composite sample by Cobb's sieving and decanting technique and fine-tuned by modified Baermann's funnel technique.

Community analysis of nematodes was computed from 12 localities of Nemom and Vamanapuram blocks of Thiruvananthapuram district (Table 2). Absolute frequency (AF%), Relative frequency (RF%), Absolute Density (AD%), Relative density (RD%), and Prominence value (PV) were used to describe the nematode community structure (Norton, 1978). (1) AF % = Number of samples containing a species /total number of samples examined $\times 100$, (2) RF % = Frequency of the species /sum of frequencies of all species $\times 100$, (3) AD % = No. of individuals of a species in a sample / volume of sample $\times 100$, (4) RD % = No. of individuals of in a sample /total of all individuals in a soil $\times 100$, (5) Prominence value = Density $\times$ Frequency.

Females of root knot nematodes were extracted from the galled roots under a stereomicroscope Zeiss Stemi 508. Female nematode was kept in a drop of 45 per cent lactic acid and the posterior region having the perineal pattern was cut carefully and cleaned. Perineal pattern was cutout based on the procedure provided by (Hartman and Sasser, 1985). Morphological characters of the nematodes were recorded; microphotographs of the specimen mounted on permanent slides were taken using a light microscope mounted with a digital camera.

RESULTS AND DISCUSSION

The survey showed that *M. incognita* was the major plant parasitic nematode infecting *P. burle-marxii* grown in most of the localities (Table 1). The highest population of *M. incognita* was found

Table 1. Distribution of nematodes in the rhizosphere of *Philodendron burle-marxii* in and around Thiruvananthapuram district

Location	Block	Panchayat	samples	<i>M. incognita</i>	<i>R. reniformis</i>	<i>H. dihystra</i>	<i>I. indicus</i>	<i>M. minor</i>	Rhabditida	free living
Karikkakom	TVPM	Corporation	3	177.7	49.3	54.3	3.0	0.0	215.0	124.3
Vallakadavu			2	199.0	73.0	35.0	2.5	4.0	207.0	129.0
Kulathoor	Parassala	Parassala	2	140.0	50.5	10.0	0.0	2.0	217.5	123.0
Arayur		Chenkal	3	54.0	55.0	31.0	2.7	3.3	235.3	136.7
Kannakuzhy	Perumkadavila	Amaravila	2	63.5	20.0	77.0	2.0	4.0	158.0	132.0
Avanakuzhy	Athiyannur	Athiyannur	2	145.0	52.0	0.0	2.0	2.0	250.0	153.0
Veniyoor		Venganoor	2	189.5	67.0	22.0	0.0	4.0	213.0	135.5
Vizhinjam		Vizhinjam	1	23.0	45.0	34.0	3.0	2.0	178.0	230.0
Pappanchani	Nemom	Kalliyoor	3	116.0	75.0	59.0	2.7	4.7	231.0	170.7
Vellayani			4	57.25	0.00	8.0	3.0	4.5	183.0	129.8
Shasthamkovil			2	34.5	45.0	20.0	2.5	0.0	158.0	85.0
Balaramapuram			2	52.0	50.0	30.5	2.5	4.0	206.0	120.0
Pallichal			2	58.0	91.0	53.0	0.0	2.0	219.5	134.5
Peppara		Vithura	2	47.5	76.0	50.5	2.0	6.0	228.5	108.5
Vattapankade	Vamanapuram	Nanniyode	2	107.5	77.5	66.0	2.5	4.0	204.5	146.0
Anakulam			2	135.5	62.0	0.0	2.0	4.5	216.5	120.5
Alammoodu			2	112.0	63.5	50.0	0.0	4.0	116.5	122.0
Thennoor		Peringamala	2	147.5	0.00	22.0	2.5	1.0	31.0	88.0
Njaraneeli			3	44.0	56.3	73.3	3.0	0.0	49.0	
Ponmudi			3	45.3	67.3	62.7	3.5	4.3	206.7	137.7
kadakom	Chiryankeezhu	Attingal	2	86.5	46.0	28.5	0.0	2.0	75.5	104.5
Anchuthengu		Kizhuvilam	2	34.5	51.5	48.5	2.0	0.0	204.5	103.0
Narikkallumukku	Varkala	Chemaruthi	2	95.5	61.5	0.00	2.5	2.0	200.0	150.0

from Vallakadavu area of Thiruvananthapuram Corporation (199 J₂ 200 cm³ soil⁻¹.) followed by Veniyoor area of Venganoor panchayat. The next important phytoparasitic nematode was *Rotylenchulus reniformis* followed by *Helicotylenchus dihystra*. The population of *R. reniformis* was maximum in Pallichal area of Kalliyoor panchayat (99 nematodes 200 cm³ soil⁻¹). *Itonchus indicus* and *Mylonchulus minor* were the major predatory nematodes recorded from the rhizosphere of *P. burle-marxii*. The population of *I. indicus* was highest in Ponmudi area of Peringamala panchayat (3.5 nematodes 200 cm³ soil⁻¹). Whereas *M. minor* was recorded maximum

in Peppara area of Vithura panchayat (6 nematodes 200 cm³ soil⁻¹) followed by Pappanchani of Kalliyoor panchayat (4.7 nematodes 200 cm³ soil⁻¹). The bacterial feeding nematodes belonging to order Rhabditida was recorded from all the areas sampled. Other free-living nematodes belonging to different orders were also recorded from the rhizosphere of *P. burle-marxii*. Mc Sorley (1980) reported that *M. javanica* and *M. incognita* were the major nematodes infecting *Colocasia esculenta* and *Xanthosoma* spp. *Meloidogyne* sp., was the major nematode infecting yams cultivated in Kalliyoor panchayat (11.02) of Thiruvananthapuram district followed by Kulakada panchayat of Kollam

Table 2. Community analysis of nematodes (200 cm³ soil) associated with rhizosphere of *Philodendron burle-marxii* in Thiruvananthapuram district

Nematode Species	AF	RF	AD	RD	PV
Block/ Nemom -15					
<i>Meloidogyne incognita</i>	100	14.7	182.7	12.5	1827.0
<i>Rotylenchulus reniformis</i>	93.3	13.7	168.5	11.5	1627.6
<i>Helicotylenchus dihystra</i>	100	14.7	110.5	7.5	1105.0
<i>Iotonchus indicus</i>	93.3	13.7	6.4	0.4	19.5
<i>Mylonchulus minor</i>	93.3	13.7	10.6	0.7	102.4
Rhabditida	100	14.7	613.0	41.8	6130.0
Other free-living nematodes	100	14.7	374.3	25.5	3743.0
Block/ Vamanapuram - 14					
<i>Meloidogyne incognita</i>	100	14.9	295.9	22.2	2959.0
<i>Rotylenchulus reniformis</i>	92.9	13.8	163.3	12.3	1567.7
<i>Helicotylenchus dihystra</i>	92.9	13.8	137.0	10.3	1315.2
<i>Iotonchus indicus</i>	92.9	13.8	6.8	0.5	65.3
<i>Mylonchulus minor</i>	92.9	13.8	8.9	0.7	85.4
Rhabditida	100	14.9	412.1	31.0	4121.0
Other free-living nematodes	100	14.9	307.1	23.1	3071.0

district. Whereas in *Colocasia* sp., root knot nematode was abundant in Mangalapuram of Thiruvananthapuram district (12.14) and Mayyanad of Kollam district (12.09). Other nematodes reported from these tuber crops were *R. reniformis*, *Helicotylenchus* sp., *Radopholous similis* and *Hoplolaimus* sp., (Kumar, 1991). *Meloidogyne* sp was reported to be important nematode infecting *Colocasia* sp., in India (Srivastava *et al.*, 1969). Nadakal and Thomas (1964) reported root knot nematode infecting *Colocasia* sp., from Kerala. *M. incognita*, *Paratylenchus minutus*, *Pratylenchus coffeae*, and *H. dihystra* were the phytonematodes reported to be associated with anthuriums and other tropical ornamentals (Bala and Hosein, 1996). Gu *et al.* (2022) reported the association of *Meloidogyne* sp., with caladium tubers. Esser (1973) extracted *Meloidogyne* spp. from 52.8 per cent of soil samples and 27.9 per cent of caladium tuber samples. Kokalis – Burelle *et al.* (2017) reported that 56 of the 75 varieties tested were found to be susceptible to *Meloidogyne* spp.

Perusal of the data on community analysis of nematodes from 12 localities of Nemom and Vamanapuram blocks (Table 2) revealed that nematodes belonging to order Rhabditida were the most prominent nematode fauna in both blocks surveyed (6130.0 and 4121.0 for Nemom and Vamanapuram respectively). They also recorded the highest absolute frequency and density. Among the phytonematodes *M. incognita* was the most frequent nematode with a relative frequency of 14.7 and 14.9 for both the blocks surveyed. *M. incognita* recorded the highest prominence value to a tune of 1827.0 and 2959.0 for both Nemom and Vamanapuram respectively. *R. reniformis* was the next prominent nematode in both the blocks (1627.6 and 1567.7 for Nemom and Vamanapuram respectively). However, they have frequency value of 93.3 and 92.9 respectively compared to *H. dihystra* which was more frequently occurring with a relative frequency of 14.7 per cent in the Nemom block. In Vamanapuram block both *R. reniformis* and *H. dihystra* recorded the same



Fig. 1 *Meloidogyne incognita* infected *Philodendron burle-marxii*: a. Healthy & Infected plant; b. Plant with galls on roots

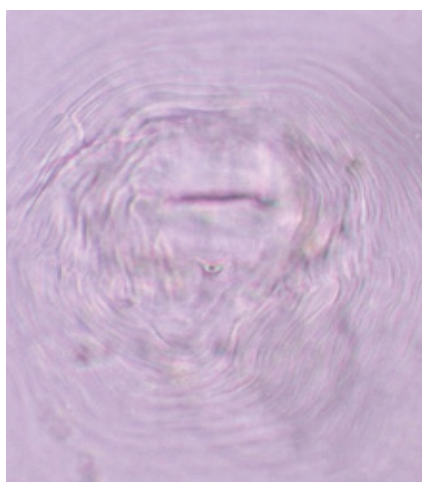


Fig. 2 Perineal pattern of *Meloidogyne incognita* female

relative frequency (13.8). The high population of rhabditids indicates the soil is rich in organic matter and suitable for cultivation of ornamentals. However, the high population of root knot nematode is a concern since these ornamental plants are being propagated by rooted cuttings. There are more chances for fast spread of the nematodes to new areas and related ornamental crops. Hence, treatment of rooted cutting with nematicides or biocontrol agents is a necessity. Sigariova and Karplyk (2015) reported that *M. incognita*, *Rotylenchus robustus*, *Pratylenchus penetrans*, *Tylenchorynchus claytoni*, *Helicotylenchus dihystra* and *Paratylenchus nanus* was associated with the rhizosphere of *Dahlia variabilis* grown in Kyiv, Ukraine. Community analysis of nematodes extracted from the soil around the roots of ornamental plants showed that *H. dihystra* was the most frequent (AF 51.90 per cent) and prominent plant parasitic nematode (PV

401.99) cultivated in Jorhat, Assam (Deuri, *et al.* 2015). Our studies also showed similar results in which *H. dihystra* exhibited high Absolute frequency of occurrence in the Nemom block. In contrary, *M. incognita* was the most prominent nematode in both the blocks.

Based on the characters of the perineal pattern the nematode has been identified as *M. incognita* (Kofoid and White, 1919) (Chitwood, 1949). The nematode was identified by the morphological features of ten adult females including and ten second stage juveniles (J_2). Measurements of females: body length (L) = 565.32- 773.31 μ m; body width = 387.87-661.32 μ m; a = 1.17- 1.46 μ m; stylet length = 12.52-16.82 μ m; neck length = 148.47- 210.61 μ m; LMB = 29.46- 41.89 μ m; WMB = 25.53- 43.03 μ m. The perineal pattern of female nematodes (Netscher and Taylor, 1974) have a high, dorsal, and trapezoidal arch, characterized by thickened transverse striations akin to the original description of the *M. incognita*., LVS = 19.79-26.89 μ m; AVS = 16.93-21.32 μ m; ATT = 13.89-20.94 μ m; IPD = 22.83-29.68 μ m (Fig. 4). Second stage juveniles (J_2): body length (L) = 395.42-415.42 μ m; stylet length = 12.92-16.76 μ m; H-MB = 46.78-57.92 μ m; ABW = 8.97-11.98 μ m; tail length = 46.98-54.95 μ m; c = 6.92-12.00 μ m; c' = 4.15-5.62 μ m.

M. incognita infected plants exhibited pronounced stunting, chlorosis of the lower leaves, abnormal leaf glossiness, and significant morphological alterations including crinkling, curling, and a reduction in leaf size ranging from 30 to 80 per cent (Figs. 1, 2). Additional symptoms included leaf rosetting and stem twisting. These aboveground manifestations were visibly distinguishable from a considerable distance. Below ground, the primary symptom was root galling (Fig. 3), with root tip galls being particularly prominent. Symptom severity was notably higher in potted plants compared to those cultivated in open soil. The infected plants displayed a prostrate growth habit, deviating markedly from the symmetrical architecture typical of healthy plants, thereby significantly diminishing their aesthetic value. This is the first report of *M. incognita* infecting *P. burle-marxii* from India. Nematode infestation severely affects both

the quantity and quality of ornamental crop production by reducing flower size, total flower number, and the productive life span of plants. Among the nematodes associated with ornamental crops, root-knot nematodes (*Meloidogyne* species) are the most destructive and economically significant, causing extensive root galling and growth suppression. Other important nematode groups include foliar nematodes (*Aphelenchoides* spp.), stem and bulb nematodes (*Ditylenchus* spp.), and root-lesion nematodes (*Pratylenchus* spp.), which also contribute to yield and quality losses (Khan *et al.*, 2024)

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Analysis on the chemical spectra of *Acraea terpsicore* Linnaeus, 1758 and *Parantica aglea* (Stoll, [1782]) (Lepidoptera, Nymphalidae) wing scales

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ABSTRACT: The wing scale chemical spectra of two nymphalid species, *Parantica aglea* and *Acraea terpsicore* was investigated using Fourier Transform Infrared Spectroscopy (FTIR) to determine characteristic functional groups. Comparative analysis of the functional groups revealed the presence of several major groups, including alcohols, phenols, aldehydes, alkanes, alkenes, alkyl halides, alkynes, methylene, acids, nitro compounds, primary, secondary, and tertiary amines, esters, ethers, polysulfides, aryl disulfides, cyanide and thiocyanate ions, carbonate ions, organic sulphates, organic nitrates, nitrate ions, aromatic ethers, aromatic phosphates, phosphate ions, ammonium ions, silicate ions, transition metal carbonyls, and organic siloxanes or silicones. Common functional groups between the two species include alcohols and phenols, alkanes, alkenes, alkyl halides, methylene, acids, esters, ethers, aryl disulfides, cyanide and thiocyanate ions, carbonate ions, organic nitrates, nitrate ions, phosphate ions, and silicate ions. However, certain elements are specific to particular regions, such as alkynes. This study represents the first FTIR analysis conducted on the wing scales of *P. aglea* and *A. terpsicore* providing valuable insights into their chemical compositions. © 2026 Association for Advancement of Entomology

KEY WORDS: Functional groups, chemical compositions, FTIR, specific to regions

INTRODUCTION

Butterflies, with their captivating wing coloration, encompass various pigmentary, structural, and androconial scales, crucial for functions such as camouflage and mate attraction (Das *et al.*, 2017). The vibrant coloration observed on butterfly wings arises from the combination of microstructures and particular pigments present within them and the pigments exhibit vivid colours as a result of their selective absorption and reflection of light at specific wavelengths, with the residual energy being dissipated as heat (Shamim *et al.*, 2014; Sharmila *et al.*, 2020).

In our study, a comparative spectroscopic analysis of wing scales of two Nymphalid species of butterflies namely *Acraea terpsicore* Linnaeus, 1758 and *Parantica aglea* (Stoll, [1782]) was conducted using Fourier-Transform Infrared Spectroscopy (FTIR) to elucidate the functional groups. *P. aglea* belongs to subfamily Danainae and has wings with a mesmerizing combination of black and white stripes whereas *A. terpsicore* that belongs to subfamily Heliconiinae is a medium sized butterfly with wings displaying a rich tawny-orange colour with intricate black markings. FTIR spectroscopy enables the identification of molecular structures by analyzing the vibrational frequencies

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of functional groups. Optical studies on *P. aglea* and *A. terpsicore* has been conducted by Thaj and Prasad, (2025) using Ultraviolet–Visible Near-Infrared Spectroscopy. Limited studies have been conducted on arthropods such as honeybees and dragonflies using FTIR analysis (Machovic *et al.*, 2017), and only a few reports exist on FTIR analysis in butterflies (Tian *et al.*, 2015; Krishna *et al.*, 2020).

MATERIALS AND METHODS

Specimens of *P. aglea* and *A. terpsicore* were collected from Kariavattom Campus, University of Kerala, Thiruvananthapuram (8°32', 8° 34'N; 76° 52', 76° 54'E). The species was identified following Kunte *et al.* (2026). The study is made partially following the methodology of Archana *et al.* (2022). Functional groups of dorsal black and white regions of *P. aglea* forewing and dorsal orange and spot region of *A. terpsicore* hindwing was selected for the study (Fig. 1). The selected regions were cut using clean scissors and the regions of about 0.5cm sample size was isolated and studied by placing on FTIR spectroscopy (Smart Orbit™ Thermoscientific Nicolet iS50). The method employed is Attenuated total reflection (ATR) method where the sample can be placed directly without any special preparation and the spectrum was obtained between 400-4000cm⁻¹ in the mid IR region. The wavenumbers of FTIR peaks obtained is compared using frequency chart and it is graphically represented by origin 2023b software (<https://www.originlab.com/>).

RESULTS AND DISCUSSION

Analysis of the functional groups in *P. aglea* and *A. terpsicore* of dorsal side revealed comparable spectral features with peaks occurring at similar positions irrespective of the region studied; however, minor variations are observed in the peak intensities (Fig. 2). On analysing the FTIR peaks of *P. aglea* black region, the black coloured region shows peaks at wavenumbers 3725.89, 3269.48, 2918.26, 2849.70, 2161.84, 2018.64, 1625.73, 1540.77, 1456.75, 1374.95, 1307.76, 1238.44, 1156.81, 1065.89, 509.74, 491.18 and 465.52cm⁻¹. The corresponding functional groups are alcohol with

weak stretch, H- bonded OH stretch, acid (O-H) stretch, amide (N-H) stretch, methylene (C-H) asymmetric stretch, alkane (C-H) stretch, methylene (C-H) symmetric stretch, methoxy, methyl ether weak stretch, aldehyde (=C-H) stretch, cyanide ion and thiocyanate ions, alkynes, aryl substituted C=C stretch, primary amine and secondary amine (NH bend), organic nitrates, organic chain azo(-N=N-), alkene (C=C) stretch, aromatic ring, aliphatic nitro compounds, aromatic stretch, nitro stretch, carbonate ion, alkanes, organic sulfates, nitro stretch, carboxylic acid salt, alkyl halide (C-F) stretch, amine (C-N) stretch, aromatic ethers, aromatic phosphates, alkyl halide (C-F) stretch, ether (C-O) stretch, acid (C-O) stretch, ester (C-O) stretch, secondary amine (CN stretch), tertiary amine (CN stretch), cyanate ion, aliphatic fluoro compounds, phosphate ion, silicate ion, alcohol (C-O) stretch, aliphatic iodo compounds, alkyl halide (C-Br) stretch, polysulfides and aryl disulfides.

The peaks of *P. aglea* white region are observed at wavenumbers 3726.37, 3266.45, 2917.36, 2849.15, 2076.51, 1624.29, 1540.94, 1462.01, 1371.06, 1157.50, 1072.19, 1027.69, 953.48, 898.72, 763.61, 575.53 and 467.62cm⁻¹. Functional groups observed on white region are alcohol (O-H) stretch, ammonium ion, acid (O-H) stretch, amide (N-H) stretch, methylene C-H asymmetric stretch, alkane (C-H) stretch, methoxy, cyanide ion, thiocyanate ion, alkenyl C=C stretch, secondary amine (NH) bend, open chain imino(-C=N-), open chain azo (-N=N-), organic nitrates, alkene (C=C) stretch, aliphatic nitro compounds, methylene C-H bend, carbonate ion, phenol or tertiary alcohol (OH) bend, organic sulfates, nitrate ion, alkane, alkyl halide (C-F) stretch, secondary amine and tertiary amine (CN stretch), cyanate and sulfonates, ether and ester (C-O) stretch, cyclohexane ring vibrations, skeletal C-C vibrations, aliphatic phosphates, organic siloxane, silicate ion, alkene(C-H) bending, aliphatic chloro compounds, alkyl halide (C-Cl) stretch, aliphatic iodo compounds (C-I), alkyl halides (C-Br) stretch and aryl disulfides.

Analysis on the *A. terpsicore* hindwing orange region specifies peaks at 3726.70, 3271.68, 2918.06,

Table 1. Wavenumbers and their corresponding functional groups of *P. aglea* and *A. terpsicore*

Hydrocarbons and functional groups	Spectral peak values (cm ⁻¹)			
	<i>P. aglea</i>		<i>A. terpsicore</i>	
	Black region	White region	Orange region	Spot region
Alcohols and Phenols	3725.89, 3269.48	3726.37, 3266.45, 1371.06, 1072.19	3726.70, 3271.68	3725.78
Aldehydes	2849.70	Not detected	Not detected	2849.01
Alkanes	2918.26, 1456.75	2917.36, 1462.01, 1371.06	2918.06, 1458.75,	2917.34, 1457.15, 1376.82
Alkenes	1625.73	1624.29, 953.48, 898.72, 763.61	1624.94	1625.56
Alkyl halides	1307.76, 1156.81, 1065.89 (C-F), 509.74 (C-Br)	1371.06, 1072.19, 1027.69 (C-F), 763.61(C-Cl), 575.53(C-Br)	1375.94, 1235.13, 1023.73(C-F), 526.41(C-Br)	1376.82, 1235.31, 1023.77(C-F), 526.71(C-Br)
Alkynes	2161.84	Not detected	Not detected	Not detected
Methylene	2918.26, 2849.70, 1456.75	2917.36, 2849.15, 1462.01	2918.06, 2849.37, 1458.75	2917.34, 2849.01, 1457.15
Acid	3269.48, 2918.26, 2849.70, 1238.44	3266.45, 2917.36, 2849.15	2849.37, 1235.13	3268.96, 2917.34, 2849.01, 1235.31
Carboxylic acid	1307.76	Not detected	1375.94	1376.82
Nitro compounds	1540.77	1540.94, 1371.06	1375.94, 1540.88	Not detected
Primary, secondary and tertiary amines	1625.73, 1156.81	1624.29, 1157.50, 1072.19	Not detected	1023.77
Ester	1238.44, 1156.81, 1065.89	1157.50, 1072.19, 1027.69	1235.13, 1023.73	1235.31, 1023.77
Ether	1238.44, 1156.81, 1065.89	1157.50, 1072.19, 1027.69	1235.13, 1023.73	1023.77
Polysulfides	491.18	Not detected	465.83	Not detected
Aryl disulfides	465.52	467.62	495.04	464.87
Cyanide and thiocyanate ion	2161.84	2076.51, 1157.50	2049.82	2039.91
Carbonate ion	1456.75	1462.01	1458.75	1457.15
Organic sulfates	1374.95	1371.06	Not detected	Not detected
Organic nitrates	1625.73	1624.29	1624.94,	1625.56
Nitrate ion	1374.95	1371.06	1375.94	1376.82
Aromatic ethers	1238.44	Not detected	Not detected	Not detected
Aromatic phosphates	1238.44	Not detected	1235.13	Not detected
Phosphate ion	1065.89	1072.19, 1027.69,	1023.73	1023.77
Ammonium ion	Not Detected	3266.45	3271.68	3268.96
Silicate ion	1065.89	1072.19, 1027.69, 953.48	1023.73	1023.77
Transition metal carbonyls	Not detected	Not detected	2049.82, 1980.80	1980.99
Organic siloxane or silicone	Not detected	1027.69	1023.73	1023.77

2849.37, 2049.82, 1980.80, 1624.94, 1514.45, 1458.75, 1375.94, 1235.13, 1023.73, 526.41, 495.04, and 465.83 cm⁻¹ (Table 1). The corresponding functional groups are alcohol (O-H) weak stretch, ammonium ions weak stretch, methylene (C-H) asymmetric stretch, alkane (C-H) stretch, methylene (C-H) symmetric stretch, methoxy, methyl ether O-CH₃, (C-H) stretch, cyanide ion, thiocyanate ion, transition metal carbonyls, alkenyl (C=C) stretch, open chain azo (-N=N-) stretch, open chain imino (-C=N-) stretch, organic nitrates, alkene (C=C) stretch, aromatic (C=C) stretch, methyl (C-H) asymmetric bend, methylene (C-H) bend, carbonate ion, alkane (-C-H) bending, carboxylate, aliphatic nitro compounds, nitrate ion, alkyl halide (C-F) stretch, aromatic phosphates, amine (C-N) stretch, ether (C-O) stretch, acid (C-O) stretch, ester (C-O) stretch, cyclohexane ring vibrations, aliphatic fluoro compounds (C-F) stretch, aliphatic phosphates (P-O-C) stretch, organic siloxane, aliphatic iodo compounds (C-I) stretch, aryl disulfides and polysulfides with broad peaks.

On *A. terpsicore* spot region the respective peaks formed are at wavenumbers 3725.78, 3268.96, 2917.34, 2849.01, 2039.91, 1980.99, 1625.56, 1540.88, 1457.15, 1376.82, 1235.31, 1023.77, 526.71 and 464.87 cm⁻¹ (Table 1). Here the functional groups observed are alcohol (O-H) stretch, H-bonded O-H stretch, ammonium ion, acid (O-H) stretch, amide (N-H) stretch, methylene (C-H) asymmetric stretch, alkane (C-H) stretch, methylene (C-H) symmetric weak and broad stretch, methoxy, methyl ether O-CH₃ weak stretch, aldehyde (=C-H) stretch, cyanide ion, thiocyanate ion, transition metal carbonyls weak stretch, open chain azo (-N=N-) stretch, organic nitrates weak and broad stretch, alkene (C=C) stretch, weak and broad peaks showing aliphatic and aromatic nitro compounds, aromatic (C=C) stretch, carbonate ion, alkane (-C-H) bending, aromatic (C=C) stretch in which the peaks are weak and symmetric, alkyl halide (C-F) stretch, acid (C-O) stretch, ester (C-O) stretch in which the peaks are broad and weak, cyclohexane ring vibrations, primary amine (C-N) stretch, aliphatic phosphates (P-O-C) stretch, organic siloxane, phosphate ion, ether (C-O) stretch, alkyl halides (C-Br) stretch and aryl disulfides (S-S stretch) that

shows broad and weak peaks.

A comparative region-wise analysis of functional group distribution in *P. aglea* and *A. terpsicore* (Table 1) reveals the presence of alcohol groups across multiple wing regions in both species. In *P. aglea*, alcohol-related peaks were recorded at 3725.89 and 3269.48 cm⁻¹ in the black region, and at 3726.37, 3266.45, 1371.06, and 1072.19 cm⁻¹ in the white region. Similarly, *A. terpsicore* exhibited alcohol peaks at 3726.70 and 3271.68 cm⁻¹ in the orange region and at 3725.78 cm⁻¹ in the spot region, indicating that alcohol groups are common to all regions examined.

Aldehyde groups were detected at 2849.70 cm⁻¹ exclusively in the black region of *P. aglea* and were absent in its white region. Likewise, aldehydes were not observed in the orange region of *A. terpsicore* but were present in the spot region of the hindwing at 2849.01 cm⁻¹, suggesting a region-specific distribution.

Alkanes functional groups were identified in both black and white regions of *P. aglea*, with peaks at 2918.26 and 1456.75 cm⁻¹ in the black region and at 2917.36, 1462.01, and 1371.06 cm⁻¹ in the white region. Correspondingly, *A. terpsicore* showed alkane peaks at 2918.06 and 1458.75 cm⁻¹ in the orange region and at 2917.34, 1457.15 and 1376.82 cm⁻¹ in the spot region.

Alkene groups were present in both species across the studied regions. In *P. aglea*, alkenes were identified at 1625.73 cm⁻¹ in the black region and at 1624.29, 953.48, 898.72 and 763.61 cm⁻¹ in the white region. In *A. terpsicore*, alkene peaks were observed at 1624.94 cm⁻¹ in the orange region and at 1625.56 cm⁻¹ in the spot region.

Alkyl halides were detected in all examined regions of both species. In *P. aglea*, characteristic peaks appeared at 1307.76, 1156.81, 1065.89 and 509.74 cm⁻¹ in the black region and at 1371.06, 1072.19, 1027.69, 763.61 and 575.53 cm⁻¹ in the white region. In *A. terpsicore*, alkyl halide peaks were observed at 1375.94, 1023.73, and 526.41 cm⁻¹ in the orange region and at 1376.82, 1235.31, 1023.77 and 526.71 cm⁻¹ in the spot region.

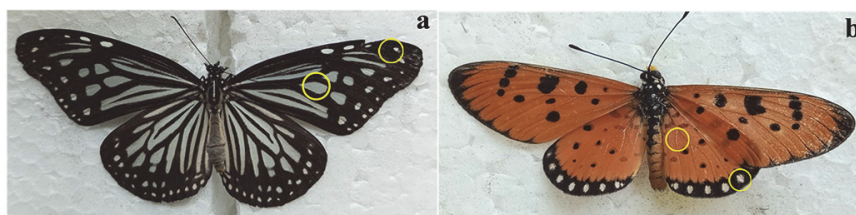


Fig. 1 (a) *Parantica aglea*; (b) *Acraea terpsicore* (Yellow circles represent the region of study)

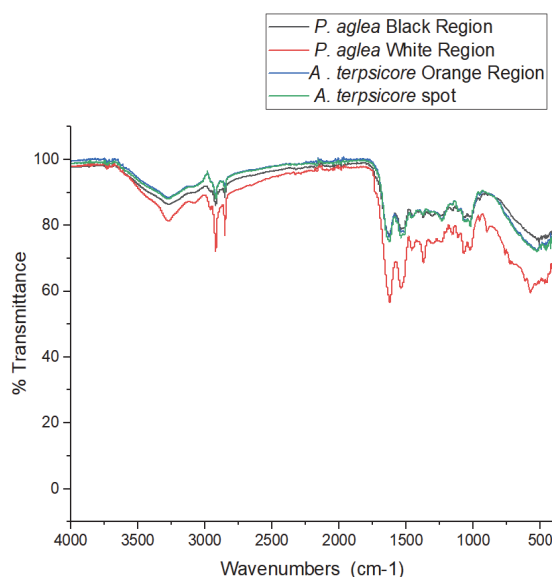


Fig. 2 FTIR spectra of *P. aglea* and *A. terpsicore*

Alkyne functional groups were detected only in the black region of *P. aglea* at 2161.84cm^{-1} . Methylene groups were consistently observed in all regions of both species, with characteristic peaks around 2918.26 , 2849.70 , and 1456.75 , 2917.36 , 2849.15 , 1462.01 , 2918.06 , 2849.37 , 1458.75 , 2917.34 , 2849.01 and 1457.15cm^{-1} . Acid functional groups were also identified across regions, showing peaks at 3269.48 , 2918.26 , 2849.70 , 1238.44 , 3266.45 , 2917.36 , 2849.15 , 2849.37 , 1235.13 , 3268.96 , 2917.34 , 2849.01 and 1235.31cm^{-1} . Carboxylic acid groups were present in all regions except the white region of *P. aglea*, with notable peaks at 1307.76 , 1375.94 and 1376.82cm^{-1} .

Nitro compounds were absent only in the spot region of *A. terpsicore*, while all other regions

exhibited nitro-related peaks ranging from 1540.77 , 1540.94 , 1371.06 , 1375.94 and 1540.88cm^{-1} . Ester and ether groups were identified in all studied regions, with ester peaks occurring between 1238.44 , 1156.81 , 1065.89 , 1157.50 , 1072.19 , 1027.69 , 1235.13 , 1023.73 , 1235.31 and 1023.77cm^{-1} , while ether groups were observed within a spectral range of 1238.44 , 1156.81 , 1065.89 , 1157.50 , 1072.19 , 1027.69 , 1235.13 , 1023.73 and 1023.77cm^{-1} . Polysulfides were not detected in the white region of *P. aglea* nor the spot region of *A. terpsicore*, but were present in other regions with peaks at 491.18 and 465.83cm^{-1} . Aryl disulfides were observed consistently across all regions, showing peaks at 465.52 , 467.62 , 495.04 and 464.87cm^{-1} .

Other region-wise functional groups and their corresponding spectral peaks are summarized (Table 1). From the study, some elements appear common to all the regions studied such as alcohols, alkanes, alkenes, alkyl halides, methylene, acid, ester, ether, aryl disulfides, cyanide and thiocyanate ion, carbonate ion, organic nitrates, nitrate ion, phosphate ion and silicate ion (Table 1). Similar observations were reported in the FTIR analysis of *Leptosia nina* wing scales by Thaj and Prasad (2024). In addition, X-ray dot mapping of *A. terpsicore* indicated that carbon and oxygen are the predominant elements (Thaj and Prasad, 2024).

The functional groups can play many roles in the physiology of insects. Alkanes acts as water barrier and has hydrophobic property (Drijfhout *et al.*, 2009). The presence of alkynes is an important diagnostic tool because only a few organic compounds show absorption in this region (Archana *et al.*, 2022). Carboxylic acid plays an important role as anti-desiccation agent and water proofing

agent (Chung and Carroll, 2015). When analysing the presence of alkyl halide, it is observed as one of the major elements present in all regions studied. As per previous reports alkyl halides are compounds that carbon group banded with halogen and they act as sex pheromones, kairomones and anti-aphrodisiac agent (Gibbs and Pomonis, 1995; Chung and Carroll, 2015).

These components are involved in communication and signalling, nest- mate recognition, task-specific cues, dominance and fertility cues, chemical mimicry, mate selection and kin recognition (Archana *et al.*, 2022). Differentiating cryptic species poses a frequent challenge in taxonomy and even species that are morphologically identical can be distinguished by their hydrocarbon profiles (Schlick-Steiner *et al.*, 2006). Additionally, butterfly wings have attracted extensive scientific attention due to their striking coloration, hydrophobicity, natural fluorescence, self-cleaning properties, mechanical flexibility, and low weight (Kaspar *et al.*, 2019; Krishna *et al.*, 2020; Devi *et al.*, 2021). Also, Cuticular hydrocarbons contribute to thermoregulation, mate recognition, and predator avoidance (Archana *et al.*, 2022).

Chitin is a key structural component of the insect cuticle and plays an essential role in the formation of butterfly wing scales and their colour patterns (Nakazato and Otaki, 2023). Structurally, chitin consists of a linear chain of $\beta(1-4)$ -linked N-acetylglucosamine (GlcNAc) units with the repeating formula $[\text{CHON}]^{\text{TM}}$ (Muthukrishnan *et al.*, 2012). In the FTIR spectra, the amides, O–H/ N–H stretching along with C–O–C stretching vibrations shows the presence of chitin backbone.

There were no significant differences detected in the chemical composition of the differently coloured wing regions of the two nymphalid species examined in the present study. Similar observations were previously reported by Archana *et al.* (2022), who suggested that colour variation in butterfly wings does not arise mainly from differences in cuticular hydrocarbons, but is instead largely governed by variations in microstructural features such as scales, ridges, and grooves. This interpretation aligns with the concept that the visual appearance of butterfly

wings emerges from the collective arrangement of numerous microscopic scales of specific colours, producing species-specific patterns comparable to pointillist art (Nijhout, 1991).

In nymphalid butterflies, wing scales are typically flattened, sac-like structures consisting of a lower lamina connected to an upper lamina bearing ridges and crossribs through trabeculae (Ghiradella, 1998; 2010). The thin-film optical properties of the lower lamina play a dominant role in defining scale colour, with reflectance spectra closely tuned to the underlying pigmentation and overall wing coloration is further modulated by the stacked arrangement of neighbouring scales (Stavenga *et al.*, 2014).

Pigment distribution plays a crucial role in butterfly wing coloration that possess functional groups. Melanin is consistently associated with black scales across butterfly taxa, white scales are often assumed to lack pigments, pierid butterflies possess leucopterin in these scales, which primarily absorbs ultraviolet radiation. The yellow, orange, and red scales of pierids, on the other hand, contain xanthopterin and/or erythropterin pigments that selectively absorb violet and blue wavelengths (Kayser, 1985; Wijnen *et al.*, 2007).

Scale coloration arises from the combined influence of wavelength-selective pigment absorption and structural light reflection, resulting in reflectance spectra that are largely complementary to pigment absorbance profiles, the absorbance characteristics of ommochrome pigments in nymphalid wings have been experimentally demonstrated through methanol extraction studies in *Precis coenia* (Nijhout, 1997).

In addition, butterflies are widely recognised as sensitive ecological indicators (Ghazanfar *et al.*, 2016), due to their highly delicate and responsive wings (Han *et al.*, 2014), even subtle chemical changes in the scales can reflect environmental stress and ecosystem health.

Recent ecological investigations have shown that minor chemical variations in insect cuticles can serve as indicators of environmental pressures such as pollution and climate variability. Studies on *Danaus*

plexippus have revealed complex patterns of metal incorporation in wings, demonstrating the potential of elemental and chemical analyses for assessing environmental contamination, metal toxicity, micronutrient dynamics, and insect movement patterns (Reich *et al.*, 2023). Furthermore, phenotypic changes in butterfly wing coloration have been linked to adaptive ecological and evolutionary responses to climate change (MacLean *et al.*, 2016). In this context, comparative FTIR analysis of butterfly wing scales emerges as a powerful and sensitive tool for monitoring ecological disturbances and evaluating ecosystem health.

Beyond ecological relevance, insights into natural chemical functional groups have inspired numerous biomimetic innovations. For instance, the specialised surface chemistry underlying the adhesive properties of gecko feet has led to the development of switchable dry–wet self-peeling adhesives (Zhang *et al.*, 2021). Understanding the chemical foundations of such biological architectures is therefore essential for translating natural designs into functional engineering materials. Consequently, the present study not only contributes to the limited knowledge of butterfly wing-scale chemistry but also provides a valuable framework for integrating spectrochemical analysis with ecological monitoring and biomimetic material development.

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Documenting moths (Lepidoptera, Heterocera) in Bengaluru urban district, Karnataka, India

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ABSTRACT: During the observation in three areas of Bengaluru Urban District, moths belonging to 42 genera, of which 39 were identified until the species level, belonging to seven families. Thirteen species of moths were identified from 18 samples in the study area I, and 17 species in II and 12 in study area III. This checklist would serve as a first milestone for further surveys on the diversity of moths of the Bengaluru region. © 2026 Association for Advancement of Entomology

KEY WORDS: Macromoths, checklist, genera, species

INTRODUCTION

Urban moth communities consisted of multi-dimensional generalist species with larger distribution ranges, more variable colour patterns, longer reproductive seasons, broader diets, and were more likely to overwinter as eggs, more thermophilic, and occupied more habitat types compared with moth communities in surrounding areas (Markus *et al.*, 2020). Documentation of moth diversity from different parts of urban India has been reported (Chandra, 2007; Gadhikar *et al.*, 2015; Shubhalaxmi, 2018; Komal *et al.*, 2021; Nagaraja *et al.*, 2021; Nayak and Ghosh, 2020; Nayak and Sasmal, 2020; Paul, 2021; Singh *et al.*, 2021). Literature on documenting moth diversity in Peninsular India is minimal (Sondhi *et al.*, 2021). So far, 52 species of moths have been recorded in Bengaluru (Firos and Haneesh, 2020), part of

Peninsular India. In this paper, moths in the three areas of Bengaluru Urban District (12°58'24.43" N; 77°35'23.03" E), Karnataka, embodied. This region has a tropical savanna climate (Köppen climate classification Aw) with distinct wet and dry seasons. There is no record of a moth survey having been conducted in any of these areas.

MATERIALS AND METHODS

The three study areas are located in the suburban part of Bengaluru, Karnataka. First study site is St. Joseph's College (now St. Joseph's University) (12.9629°N; 77.5964°E) is situated in the centre of the city between Lalbagh Botanical Garden and Cubbon Park (the campus has various trees and a huge lawn), the second one is Chikkalasandra, Uttarahalli Hobli (13.0804°N; 77.6528°E) and the third is Vidyapeeta (12.9296°N; 77.5585°E). The

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survey was conducted, covering the majority of the areas. Important wild trees of Bengaluru include: *Alstonia scholaris*, *Artocarpus heterophyllus*, *Azadirachta indica*, *Bombax cecilia*, *Butea monosperma*, *Ficus bengalensis*, *F. religiosa*, *F. mysorensis*, *Gmelina arborea*, *Kigelia pinnata*, *Lagerstroemia speciosa*, *Mangifera indica*, *Madhuca longifolia*, *Melia composite*, *Michelia champaca*, *Neolamarkia kadamba*, *Pogonia pinnata*, *Pterocarpus marsupium*, *Syzgium cumini*, *Saraca indica*, *Swietenia* sp., *Terminalia arjuna*, *T. bellerica*, *Tabebuia spectabilis*, etc. Some of the exotic trees include: *Delonix regia*, *Enterolobium saman*, *Parkia biglandulosa*, *Peltophorum pterocarpum*, *Spathodea campanulata*, *Tabebuia spectabilis*, etc. Additionally, some flowering shrubs and medicinal plants include *Withania somnifera*, *Hibiscus* sp., and *Lawsonia inermis* (Hegde, 2012).

The samples were collected and preserved under cold conditions. The samples were then pinned onto a spreading board and placed in a hot air oven at 60°C for 1 hour. The dried moth samples were later pinned on a pinning board using an entomological pins. Moths collected during the present study were identified using the 'Moths of India' website (Sondhi et al., 2023) and the resources listed therein.

RESULTS AND DISCUSSION

Forty-two genera of which thirty-nine were identified to the species level, belonging to seven families during the observation undertaken in the three study areas of Bengaluru Urban District, Karnataka, India (Table 1, Fig. 1). The species recorded under seven families are—

Crambidae (8 species): *Chabula acamasalis*, *Herpetogramma rudis* group (Grass Webworm moth), *Maruca vitrata* (Lima bean pod borer/ Mung bean moth), *Nausinoe geometralis* (Asian hydrilla moth), *Poliobotys ablactalis* (Pearl grey moth), *Spoladea recurvalis* (Beet webworm moth/ Hawaiian beetle webworm), *Conogethes punctiferalis* (Yellow peach moth), *Cirrhochrista brizalis* (Yellow margin moth).

Under Erebidae (22 species): *Ericeia pertendens*, *Eudocima phalonia* (Common fruit piercing moth), *Erebus macrops* (Common owl moth), *Simplicia* sp., *Achaea janata* (Castor semi looper moth), *Brunia antica* (Lichens moth), *Brunia cf. antica*, *Cyana peregrina* (Two spotted cyana moth), *Cyana* sp., *Dysgonia torrida* (Jigsaw moth), *Ercheia cyllaria* (Squirrel moth), *Eudocima homaena* (Fruit piecing moth), *Oeonistis cf. entella*, *Pandesma* sp., *Plecoptera* spp., *Siccia taprobanis*, *Amata passalis* (Crimson banded Handmaiden), *Lymantria marginata* (Mango Tussock), *Nepita conferta* (Footman moth), *Olepa ricini* agg. (Yellow underwing tiger), *Orvasca subnotata*, and *Syntomoides imaon* (Imaon Handmaiden).

Geometridae (7 species): *Chiasmia emersia* (Little chiasmia/ Pente tasil moth), *Idaea* sp., *Petelia* sp., *Chiasmia nora* (Banded geometrid), *Traminda mundissima*, *Anisephyra ocularia* (Four ringed yellow ruler moth), *Idaea costiguttata* (Three-line bogey moth).

Noctuidae (3 species): *Pandesma* sp., *Spodoptera litura* (Oriental leaf worm), *Chrysodeixis eriosoma* (Green garden looper).

Pyrilidae (2 species): *Endotricha mesenterialis*, *Pyrilis manihotalis* (Tropical meal moth).

Sphingidae (5 species): *Angonyx krishna* (Southern dark green hawkmoth), *Agrius convolvuli* (Convolvulus hawkmoth), *Daphnis nerii* (Oleander hawkmoth), *Hippotion celerio* (Celerio hawkmoth), *Cephonodes cf. picus* (Green Bumble-bee hawkmoth).

Eupterotidae (1 species): *Eupterote undata*

The study area I (St. Joseph's College campus) showed most species belonging to Crambidae (33%), followed by Erebidae (22%), Geometridae (17%), Noctuidae and Pyralidae (11% each) and Sphingidae (6%).

In the study area II (Chikkalasandra), the species recorded were belonging to the family Erebidae

Table 1. Moth species recorded in the three study areas

No	Study area I	Study area II	Study area III
1	<i>Angonyx krishna</i> Eitschberger & Haxaire, 2006	<i>Aemene taprobanis</i> Walker, 1854	<i>Achaea janata</i> (Linnaeus, 1758)
2	<i>Chabula acamasalis</i> (Walker, 1859)	<i>Agrius convolvuli</i> (Linnaeus, 1758)	<i>Anisephyra ocularia</i> (Fabricius, 1775)
3	<i>Chiasmia emersaria</i> (Walker, 1861)	<i>Amata passalis</i> (Fabricius, 1781)	<i>Brunia antica</i> (Walker 1854)
4	<i>Endotricha mesenterialis</i> (Walker, 1859)	<i>Chiasmia nora</i> (Walker, 1861)	<i>Brunia cf. antica</i> (Walker, 1854)
5	<i>Erebus macrops</i> (Linnaeus, 1768)	<i>Daphnis nerii</i> (Linnaeus, 1758)	<i>Cephonodes cf. picus</i> (Cramer, 1777)
6	<i>Ericeia pertendens</i> (Walker, 1858)	^a <i>Dysgonia torrida</i> (Guenée, 1852)	^a <i>Dysgonia torrida</i> (Guenée, 1852)
7	<i>Eudocima phalonia</i> (Male) (Linnaeus, 1763)	<i>Eupterote undata</i> Blanchard, [1844]	<i>Cirrhochrista brizoalis</i> (Walker, 1859)
8	<i>Herpetogramma rudis</i> sp. Group (Warren, 1892)	<i>Hippotion celerio</i> (Linnaeus, 1758)	<i>Conogethes punctiferalis</i> (Guenée, 1854)
9	<i>Idaea</i> sp.	<i>Lymantria marginata</i> Walker, 1855	<i>Cyana peregrina</i> (Walker, 1854)
10	^b <i>Maruca vitrata</i> (F, 1787)	^b <i>Maruca vitrata</i>	^b <i>Maruca vitrata</i>
11	<i>Nausinoe geometralis</i> (Guenée, 1854)	<i>Nepita conferta</i> (Walker, 1854)	<i>Chrysodeixis eriosoma</i> (Doubleday, 1843)
12	<i>Pandesma</i> sp.	<i>Olepa ricini</i> agg. (Fabricius, 1775)	<i>Ercheia cyllaria</i> (Cramer, 1779)
13	<i>Petelia</i> sp.	<i>Orvasca subnotata</i> Walker, 1865	<i>Eudocima homaena</i> (Hübner, 1816)
14	^c <i>Spodoptera litura</i> (F, 1775)	^c <i>Spodoptera litura</i>	<i>Plecoptera</i> spp.
15	^d <i>Spoladea recurvalis</i> (Fabricius, 1775)	^d <i>Spoladea recurvalis</i> (Fabricius, 1775)	<i>Idaea costiguttata</i> (Warren, 1896)
16	<i>Simplicia</i> sp.	<i>Syntomoides imaon</i> (Cramer, 1780)	<i>Cyana</i> sp.
17	<i>Poliobotys ablactalis</i> (Walker, 1859)	<i>Traminda mundissima</i> (Walker, 1861)	<i>Oeonistis cf. entella</i> Cramer, [1779]
18	<i>Pyrallis manihotalis</i> Guenee, 1854		<i>Pandesma</i> sp.

Note: Same alphabets in superscript indicate common occurrence of moth species in more than one study area

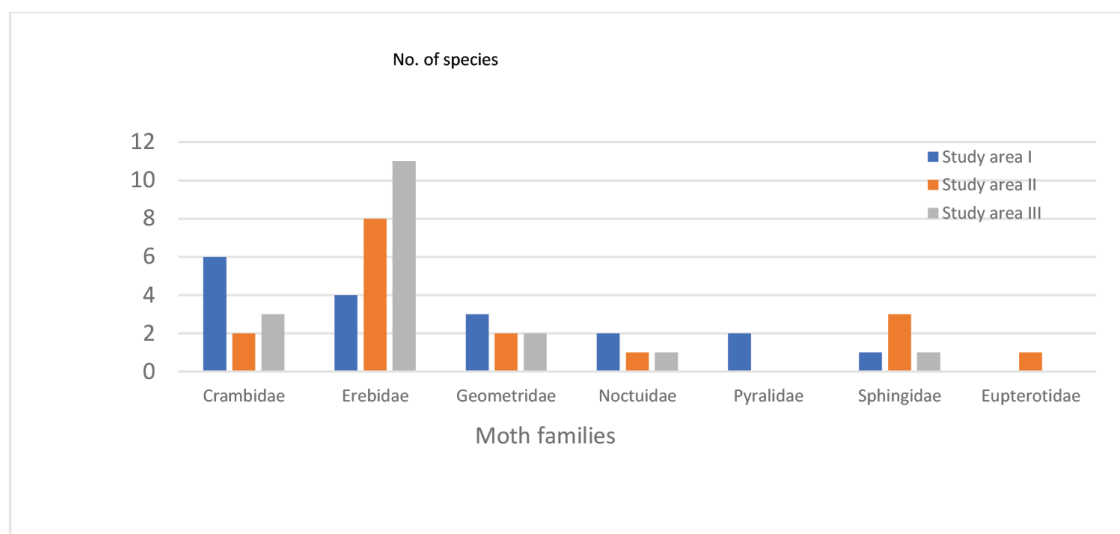


Fig.1 Family-wise representation of moths among the study areas

(47%), Sphingidae (17%), Crambidae and Geometridae (12% each), and Eupterotidae and Noctuidae (6% each).

The study area III (Vidyapeeta) exhibited the highest number of species belonging to the family Erebidae (61%), followed by Crambidae (17%), Geometridae (11%), Sphingidae (6%) and Noctuidae (5%).

Members of the family Crambidae (grass moths) are the highest in number, mainly due to the presence of grass lawns on the campus, a well-known breeding ground for these insects. Nayak and Ghosh (2020) reported diversity of moths in Banaras Hindu University (Varanasi, India) campus and Ahire and Khobragade (2021) Ahmednagar College campus, Ahmednagar (Maharashtra). Nayak and Sasmal (2020) recorded monsoon moths of Midnapore town, West Bengal. Moths as pests in agri-horticultural ecosystems have been widely reported (Sharma *et al.*, 2008; Sharma and Ramamurthy, 2009; Muddasar *et al.*, 2017; Kotikal *et al.*, 2022). The moth species associated with agri-horticultural ecosystems recorded during the study are likely due

to landscaping, and peri-urban farms. They are *Conogethes punctiferalis*, *Spodoptera litura*, *Chrysodeixis eriosoma*, *Achaea Janata*, *Olepa ricini*, *Amata passalis*, *Eudocima phalonia*, *Spoladea recurvalis*, *Nausinoe geometralis*, *Maruca vitrata*, and *Herpetogramma rudis* sp. group. Three families, Crambidae, Erebidae, and Geometridae, represented more than 75% of the moth species documented during the present observations. The dominance of Crambidae could be attributed to the presence of grassy habitats in the study areas. The dominance of these families in other parts of India has also been recorded in Amravati (Gadhikar *et al.*, 2015); Midnapore (Nayak and Sasmal, 2020); Varanasi (Nayak and Ghosh, 2020), Chennai (Nagaraja *et al.*, 2021); Wardha (Chandrakar *et al.*, 2022). Numerous factors contribute to the decline of moths, such as rapid urbanisation, habitat loss, artificial light, intensive agriculture, pesticide pollution, and lack of conservation policies (Dennis *et al.*, 2019). This paper presents the findings from three areas of Urban Bengaluru, focusing on macro-moths. It is

the first time report of moths from the selected areas in Bengaluru.

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First report of *Malcus indicus* Štys, 1967 (Lygaeoidea, Malcidae, Malcinae) as a pest of clove bean, *Ipomoea muricata* (L.) Jacq. (1798) with a note on the host plants of the genus *Malcus*

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ABSTRACT: *Malcus indicus* has been reported as a pest of clove bean, *Ipomoea muricata* (L.) Jacq. (1798) for the first time from India, Kerala. Nymphs and adults were observed to suck sap from the matured leaves. Feeding points on leaves were seen as minute pale spots. Severely infested leaves were observed to have low photosynthetic area. Damage was observed in summer months but persisted during the onset of monsoon initially. However, heavy rains lowered the population of insect.

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KEY WORDS: Damage, photosynthetic area, nymphs, adults, alternate hosts

The monotypic genus *Malcus* Stål found primarily in oriental region belongs to the subfamily Malcinae under the family Malcidae. There were some disagreements on the taxonomic placement of the genus. Stål placed the genus in then polyphyletic family Lygaeidae and later raised to a subfamily status. Finally it has been escalated to a familial status. The family Malcidae consists three extant genera (in two subfamilies namely Malcinae and Chauliopininae (Štys, 1967). One extinct genus's fossil record was also reported (Camier *et al.*, 2019).

The family Malcidae claims notable economic relevance after the genus *Chauliops* in

Chauliopininae, being important legume pests. Except for a few stray records, there are little insights into the host plants of genus *Malcus*. *Malcus japonicus* Ishihara & Hasegawa, feed on the leaves of *Morus bombycis* Koidz, is known as mulberry bug in Japan as reported by Hasegawa though the genus is doubtlessly not specific to *Morus* (Sweet, 2000). Mohanasundaram (1972) reported the nymphs and adults of *Malcus scutellatus* Distant (= *M. flavidipes* Stål) were found breeding on cucurbits in a fruit farm in south India (Coimbatore district in Tamil Nadu). Kerzhner (2001) stated some Malcinae consume legumes. There was an indication of *Ipomoea indica* as a host plant of a

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a) Adult and nymphs of *Malcus indicus*



b) *Ipomoea muricata*



c) *Commelina bengalensis*



d) *Synedrella nodiflora*



e) *Acalypha*

Fig. 1 Adult and nymphs of *Malcus indicus*; Host plants with damage by *Malcus indicus*

Malcus sp. (Bay, 2022). *M. flavidipes asper*, *M. flavidipes flavidipes*, *M. tuberculatus*, and *M. nigrofasciatus* were collected by sweeping herbages from an island in China. *M. flavidipes flavidipes* was reported on banana leaves from Cambodia (Štys, 1967). Zheng (1999) reported the members of the families like Araceae, Convulvulaceae, Fabaceae, Moraceae, Sterculiaceae, and Urticaceae as the host plants of *Malcus* spp. Roca-Cusachs and Goula (2017) discussed about the host plants of the genus, like *Bahuinia variegata*, *Cassia didymotrya* or *Sophora japonica* of the family Fabaceae, *Raphis excelsa* of Araceae and *Ficus* spp., *Maclura* spp. or *Morus* spp. of Moraceae.

Ipomoea muricata (L.) Jacq. is a herbaceous climber native to central America whose swollen pedicels are consumed as delicious vegetable mostly in Kerala, India where it is referred as clove bean or 'nithyavazhuthana'. The fruits are medicinal and rich in protein, fibres, vitamin C, Potassium, Calcium, Iron, etc. (Parisa *et al.*, 2019; Palanisamy *et al.*, 2019).

Malcus indicus Štys, 1967 (Lygaeoidea, Malcidae, Malcinae) is an endemic species of south India, described by Štys, 1967 from Trichinopoly, Tamil Nadu. No host plant information available for this species so far. Nymphs and adults of *M. indicus* (Fig. 1a) observed feeding on the mature green leaves of clove beans (Fig. 1b) in Kerala in Changanassery and Puthupally of Kottayam district and Mazhuvannoor of Ernakulam district during February to April, 2024. Nymphs and adults were collected from the infested areas and identity was confirmed by dissecting male genitalia. Infestation noticed in seedlings and bearing plants of desi varieties of clove bean.

Nymphs and adults were observed to suck sap from the matured leaves. Feeding points on leaves were seen as minute pale spots. Severely infested leaves were observed to have low photosynthetic area. Damage was observed in summer months but persisted during the onset of Monsoon initially. However, heavy rains lowered the population of insect.

Three weeds, namely, *Commelina bengalensis* L., *Synedrella nodiflora* (L.) Gaertn. and *Acalypha* sp. were recorded as alternate hosts (Fig. 1c-e) of *M. indicus* during the study. Severe incidence was noticed on the leaves of *C. bengalensis* and *Acalypha* sp.

This is the first report of *M. indicus* as a pest of clove bean, *I. muricata*.

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Redescription of the female and first description of the male of *Runcinia ghorpadei* Tikader, 1980 (Araneae, Thomisidae) from India

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ABSTRACT: *Runcinia* spider is distinguished by a cephalothorax that is slightly wider than it is long, with a cephalic region featuring prominent ocular tubercles covered in hairs and spines. Its legs are long and robust, with the first and second pairs significantly longer than the others. The abdomen is elongated, adorned with spines, tapering at the rear, and marked by prominent longitudinal muscular corrugations along the lateral sides. *Runcinia ghorpadei* Tikader, 1980 (only female specimen) described by the original author was poor in the light of modern taxonomy or specimen was immature, hence this redescription of the female along with the description of the male. © 2026 Association for Advancement of Entomology

KEY WORDS: Taxonomy, sexual dimorphism, crab spider, genitalia.

The spider genus *Runcinia* Simon, 1875, is characterized by a cephalothorax that is slightly wider than it is long, with a cephalic region bearing prominent ocular tubercles covered in hairs and spines. The legs are long and sturdy, with the first and second pairs being notably longer than the others. The abdomen is elongated, adorned with spines, tapering at the rear, and features distinct longitudinal muscular corrugations along the lateral sides. Type species is *Thomisus lateralis* C.L. Koch, 1837 [now *Runcinia grammica* (C.L. Koch, 1837) as Roberts (1995) synonymised]. They are distributed all over the world excepting Nearctic region.

Runcinia Simon is known by 27 species till today throughout the World (World Spider Catalogue,

2025) while 7 species recorded so far from India (World Spider Catalogue, 2025). *Runcinia ghorpadei* Tikader, 1980 (only female specimen) was described by B. K. Tikader that was not enough in the light of modern taxonomy or specimen was immature. Moreover, there was no record of male specimen and description too. Therefore, the female species is redescribed, and a hitherto unknown male morph is also described here.

Specimens were obtained through hand collection as well as by beating vegetation and using sweep nets. Additional samples were recovered by hand from the nests of crab spider. Genital structures were cleared in lactic acid and examined in temporary mounts embedded in glycerol. Photographic documentation was carried out using

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an MC170 HD camera mounted on a Leica EZ4 HD stereo zoom binocular microscope, and a DFC 500 camera attached to a Leica M205A stereomicroscope. Line illustrations were produced with the aid of a Leica MZ16 stereo zoom binocular microscope fitted with a camera lucida. All examined material is deposited in the National Zoological Collections of the Zoological Survey of India, Western Ghat Regional Centre, Calicut (ZSIK).

Abbreviations used in text and figures:

AER = anterior eye row; ALE = anterior lateral eyes; AME = anterior median eyes; CD = copulatory duct; CO = copulatory opening; E = embolus; FD = fertilisation duct; MOA = median ocular area; OL = opisthosoma length; OW = opisthosoma width; PER = posterior eye row; PL = prosoma length; PLE = posterior lateral eyes; PME = posterior median eyes; PW = prosoma width; RTA = retrolateral tibial apophysis; S = spermatheca; SD = sperm duct; TL = total length; VTA = ventral tibial apophysis.

Family: Thomisidae

Runcinia ghorpadei Tikader 1980

Tikader, B. K. (1980). Thomisidae (Crab-spiders). Fauna India (Araneae) 1: 64

Diagnosis: The carapace has a chalk-white patch in the middle, while the clypeus bears a row of three forward-pointing spines, with the middle spine directed downward. A prominent, strong spine originates just behind each posterior lateral eye. The legs are long and robust, with the first and second pairs being significantly longer than the others. Tibiae I and II possess seven and 3 pairs of ventral spines, respectively, while the metatarsi of legs I and II bear 14 and four pairs of ventral spines, respectively. The posterior legs are devoid of spines. The epigynum is approximately triangular, resembling a ring with an open region at the top. The copulatory ducts are ampulla-shaped and coiled, the spermathecae are pear-shaped, and the fertilization ducts are long and coiled, initially directed upward and then downward.

Description: Female

General (Fig. A): Cephalothorax and abdomen red

to deep brown, legs pale. Total length 8.00mm. Carapace 3.25mm. long, 1.50mm. wide; abdomen 5.00mm. long, 1.70mm. wide. **Cephalothorax** (Fig. A): Slightly longer than wide, the carapace is spined and features broad longitudinal deep brown patches along the sides, with conspicuous whitish bands along the lateral margins. Medially, it displays a chalk-white patch, truncated at the front with four tiny protuberances. The ocular area is raised and laterally divergent. The eyes are black, arranged in two rows, with the anterior row more strongly recurved than the posterior row. The ocular quadrangle is longer than wide, narrowing at the front, and each posterolateral eye is accompanied by a prominent spine.

The clypeus bears a row of three forward-directed spines, with the middle spine angled downward, and a strong, conspicuous spine emerges just behind each posterior lateral eye. The legs are long and robust, with the first and second pairs significantly longer than the others. Tibiae I and II have seven and three pairs of ventral spines, respectively, while the metatarsi of legs I and II are armed with 14 and four pairs of ventral spines, respectively. The posterior legs lack spines entirely.

Legs: I 3.40 (1.20, 0.56, 0.90, 0.44, 0.30); II 3.12 (0.77, 0.55, 0.81, 0.55, 0.44); III 2.27 (0.44, 0.51, 0.63, 0.51, 0.18); IV 2.10 (0.44, 0.30, 0.77, 0.38, 0.21). Leg formula 1234.

Abdomen (Fig. A): Long, cylindrical, spined, narrow behind, highly overlapping the posterior region of cephalothorax, dorsum with a long median broad, chalk white pigmented irregular lines from the base to the end, two longitudinal black depressions medially. Sides with conspicuous U-like muscular corrugations and prominent muscular ridges, each provided with a row of spines. Venter red brown to deep brown.

Epigyne-Internal genitalia (Fig. B-D): Epigynum more or less triangular ring like excepting a free region upside; copulatory ducts (CD) ampulla like and coiled; spermathecae (SP) pear shaped; fertilization ducts (FD) long, coiled, first upwardly then downwardly directed.

Material examined: Kerala; 1, ♀, Kakkayem, 22.

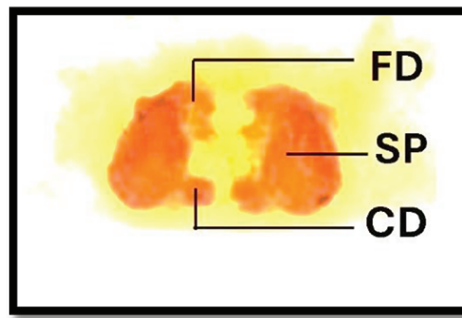


Fig. A - General habitus: *Runcinia ghorpadei* (Female); **Fig. B** - Internal genitalia (Photograph)



Fig. C - Epigynum (hand drawing)

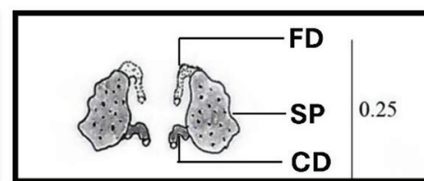


Fig. D - Internal genitalia (hand drawing)



Fig. E - General habitus: *Runcinia ghorpadei* (male)



Fig. F - Male genitalia, ped-palp (Photograph)



Fig. G - Male genitalia, ped-palp (Photograph)



Fig. H - Male genitalia, ped-palp (Photograph)

xii. 2015, coll. J. Palot & party (Reg. No. ZSI/WGRC/IR.INV /5232).

Description: (New male morph)

General (Fig. E): Cephalothorax and abdomen red to deep brown, legs pale. Total length 2.8mm. Carapace 1.15mm. long, 1.00mm. wide; abdomen 1.65mm. long, 1.15mm. wide. **Cephalothorax** (Fig. E): Minutely longer than wide, the carapace is spined and features broad longitudinal light brown with fawn white patches along the sides, with sharp whitish bands along the lateral margins. Medially, it displays a chalk-white patch, truncated at the front with four tiny protuberances. The ocular area is raised and laterally divergent. The eyes are black, arranged in 2 rows, anterior more strongly recurved than the posterior. The ocular quadrangle is longer than wide, narrowing at the front, and each posterolateral eye is accompanied by a prominent spine.

The clypeus bears a row of three forward-directed spines, with the middle spine angled downward, and a strong, conspicuous spine emerges just behind each posterior lateral eye.

Two rows of eyes; anterior one on frontal lobe, posterior one on dorsal side; lateral eyes placed on carina; both rows slightly recurved; lateral eyes larger than median; Median ocular quadrangle wider posteriorly than anteriorly. The legs are long and robust, with the first and second pairs significantly longer than the others. Tibiae I and II have seven and three pairs of ventral spines, respectively, while the metatarsi of legs I and II are armed with 14 and four pairs of ventral spines, respectively. The posterior legs lack spines entirely.

Legs: I 2.37 (1.00, 0.35, 0.68, 0.24, 0.10); II 2.22 (0.47, 0.35, 0.61, 0.45, 0.34); III 1.47 (0.24, 0.31, 0.43, 0.31, 0.18); IV 1.10 (0.24, 0.10, 0.47, 0.18, 0.11). Leg formula 1234.

Abdomen (Fig. E): Long, cylindrical, spined, narrow posterior, minutely overlapping the posterior of cephalothorax, dorsum with a long median broad, chalk white pigmented irregular lines from the base to the end, two longitudinal black depressions

medially. Sides with prominent U-like muscular corrugations and muscular ridges, each provided with a row of spines. Venter red brown to deep brown.

Pedi-palp (Fig. F-H): Palp with two tibial apophyses; ventral one hooklike in appearance; retro-lateral apophysis longer and thinner, extending almost half the length of tegulum.

Material examined: Himachal Pradesh:1, ♂, Sundernagar, 12. viii.2016, coll. Chhavi and Party (Reg. No. ZSI/WGRC/IR.INV/5246).

Distribution: India: Karnataka, Himachal Pradesh and Kerala.

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Seasonal incidence of *Haritalodes derogata* (Fabricius) (Lepidoptera, Crambidae) on *Urena lobata* in Saharanpur, Uttar Pradesh, India

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ABSTRACT: A field study was conducted to determine the seasonal incidence of *Haritalodes derogata* on *Urena lobata* weed in Saharanpur, Uttar Pradesh, during the year 2023-2024. The study revealed that *H. derogata* is a serious pest of *U. lobata* and its activity began in the first week of June and continued until December of 2023 and 2024. The larval population was minimum in June, with the lowest leaf damage. In contrast, the maximum population was observed in September and October, with the highest damage per leaf and per plant during the year 2023 and 2024. The pest remained active from June to December during both years. © 2026 Association for Advancement of Entomology

KEY WORDS: Leaf roller, Caesar weed, population, first report

The leaf roller, *Haritalodes derogata* (Fabricius) (Lepidoptera, Crambidae) is a polyphagous pest which feeds on Okra, cotton, cashew, jujube, ujubecrops and others herbaceous plants and trees in ornamental plantings in many countries around the world (Dhindsa *et al.*, 1980; Anioke, 1989; Byun *et al.*, 2008; Yamanaka, 2008; Mariselvi and Manimegalai, 2016; Roychoudhury *et al.*, 2017; Karpun *et al.*, 2022; CAB International, 2022). Its young larvae roll growing leaves into funnel shapes and feed on the leaf margins from within, causing defoliation (Kandaswamy, 2025). In the present investigation, *H. derogata* feeding on *Urena lobata* is reported from Saharanpur, Uttar Pradesh. The pest is available in this region from June to October and leads to considerable damage to the *U. lobata* plants during the peak time of infestation. *Urena lobata*, often known as Caesar weed or

Congo jute, is a flowering plant from the family Malvaceae. It is endemic to tropical and subtropical locations across the world, including Asia, Africa, South and Central America, and the Pacific Islands. In many places, it is considered a weed, yet it is also important in many traditional medicinal systems (Babu *et al.*, 2016). In Saharanpur, *U. lobata* is widely distributed and occurs in a variety of habitats, including disturbed forests, pastures, waste areas, swamps, roadsides, riverbanks, and agricultural lands. This study aims to describe the seasonal occurrence of *H. derogata* in *U. lobata* plants.

A field survey was conducted in Saharanpur (29.97° N; 77.55° E), Uttar Pradesh, India, from June to December in 2023 and 2024 on agricultural farms, roadside areas, and abandoned lands where *U. lobata*, was abundant. During the field survey,

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the plants were observed to be infested with larvae of *H. derogata*. Ten plants from the *U. lobata* plantation were randomly selected and permanently marked to monitor larval infestation on a weekly basis. The infestation was assessed by examining the presence of rolled leaves and calculating the percentage of damage for each leaf and each plant. The number of larvae and the extent of damage on each plant were evaluated weekly by inspecting the rolled and damaged leaves. The meteorological data, such as temperature, humidity, and rainfall, were taken from the Horticulture Research Institute, Saharanpur, Uttar Pradesh to record the influence of these abiotic factors on population dynamics of *H. derogata*.

The results showed that the larval population of *H. derogata* first appeared in the first week of June and remained active until December in the years 2023 and 2024. In the month of June, the larval population was recorded at 14.31 ± 1.45 larvae/plant, 14.3 ± 1.45 rolled leaves/plant, and 20.3 ± 1.54 per cent leaf damage/plant during the year 2023 and 10.2 ± 1.19 larvae/plant, 10.0 ± 1.39 rolled leaves/plant, and 16.4 ± 1.45 per cent leaf damage/plant in 2024. The larval population increased in July (recording 21.21 ± 1.51 larvae/plant, 25.6 ± 1.65 rolled leaves/plant, and 40.5 ± 1.56 % leaf damage/plant during the year 2023, whereas in 2024 July, it was 17.38 ± 1.29 larvae/plant, 19.92 ± 1.29 rolled leaves per plant and 38.69 ± 1.35 % leaf damage per plant were recorded). The population increased significantly in the month of August (45.82 ± 1.67 larvae/plant with 75.3 ± 1.56 rolled leaves/plant and 60.2 ± 1.72 % leaf damage/plant in 2023 and 40.65 ± 1.75 larvae/plant, 61.51 ± 1.48 rolled leaves/plant, and 54.96 ± 1.29 % leaf damage/plant in 2024). The larval population, number of rolled leaves, and percentage of leaf damage were observed to gradually increase in both years with rising temperature, rainfall, and humidity, indicating a positive effect on the population growth of *H. derogata*. The larval population increased drastically in the month of September (105.59 ± 1.39 larvae/plant, 120.2 ± 1.67 rolled leaves/plant, and 90.3 ± 1.13 % leaf damage/plant in 2023 and 90.54 ± 1.54 larvae/plant, 112.21 ± 1.35 rolled leaves/plant, and 86.22 ± 1.35 % leaf damage/plant during

the year 2024). The highest population of *H. derogata* was observed in October, with a peak during the first week (165.52 ± 1.56 larvae/plant, 225.4 ± 1.54 rolled leaves/plant, and 95.3 ± 1.48 % leaf damage/plant during the year 2023 and 160.72 ± 1.32 larvae/plant, 217.57 ± 1.43 rolled leaves/plant, and 95.43 ± 1.43 % leaf damage per plant in 2024). The population of *H. derogata* declined gradually in the month of November (110.32 ± 1.61 larvae/plant, 110.3 ± 1.65 rolled leaves/plant, and 65.4 ± 1.51 % leaf damage/plant in 2023 and 102.78 ± 1.31 larvae/plant, 103.39 ± 1.54 rolled leaves/plant, and 60.92 ± 1.56 % leaf damage/plant in 2024) and drastically in the month of December (20.5 ± 1.63 larvae/plant, 29.9 ± 1.67 rolled leaves/plant, and 25.3 ± 1.38 % leaf damage/plant during the year 2023 and 16.71 ± 1.35 larvae/plant, 24.55 ± 1.19 rolled leaves/plant, and 19.5 ± 1.25 % leaf damage/plant during the year 2024). The variations in population fluctuation, infestation levels, and damage to the host plant *U. lobata* during the years 2023 and 2024 could be attributed to differences in weather parameters (Table 1).

So far, various researchers have conducted the study on the seasonal occurrence of *S. derogata* on various host plants, but no one has described it in *U. lobata*. In the study, the maximum activity of the pest was observed from September to October, while Bhatnagar *et al.* (1993) reported peak activity from the last week of August to the last week of September in cotton. Ghosh *et al.* (1999) recorded the higher population of *H. derogata* from July to August in okra. Hiramatsu *et al.* (2001), observed *H. derogata* activity from the last week of June to the first week of November, with peak incidence during August, September and October, continuing up to November. According to Naresh *et al.* (2003), the peak incidence of *H. derogata* was observed in the second week of August, whereas Roychoudhury *et al.* (2009) and Badiyala (2011), reported from July to September and the first and third weeks of August in Palampur. Behera (2018) recorded the infestation in the fourth week of August and peak population in the second week of November in non-Bt cotton. Karpun *et al.* (2022), reported the presence of *H. derogata* from late July to early August, resulting in significant damage

Table1. Seasonal incidence of *Haritalodes derogata* in *Urena lobata*

Year/Month	Larvae/ plant	Rolled leaf/ plant	Leaf damage/ plant (%)	Mean temp. (°C)	Rainfall (in mm)	R.H. (%)
June 2023	14.31±1.45	14.3±1.45	20.3±1.54	34.21	94.70	31.23
July	21.21±1.51	25.6±1.65	40.5±1.56	30.15	415.45	55.56
August	45.82±1.67	75.3±1.56	60.2±1.72	29.41	354.25	76.90
September	105.59±1.39	120.2±1.67	90.3±1.13	28.50	208.39	63.25
October	165.52±1.56	225.4±1.54	95.3±1.48	26.49	20.51	61.81
November	110.32±1.61	110.3±1.65	65.4±1.51	22.96	4.25	47.84
December	20.50±1.63	29.9±1.67	25.3±1.38	15.70	25.58	40.51
June 2024	10.20±1.19	10.0±1.39	16.4±1.45	36.71	90.10	10.21
July	17.38±1.29	19.92±1.29	38.69±1.35	30.29	305.62	58.32
August	40.65±1.75	61.51±1.48	54.96±1.29	28.32	310.25	74.32
September	90.54±1.54	112.21±1.35	86.22±1.35	29.41	208.39	72.28
October	160.72±1.32	217.57±1.43	95.43±1.43	27.67	16.49	60.83
November	102.78±1.31	103.39±1.54	60.92±1.56	23.98	14.56	51.61
December	16.71±1.35	24.55±1.19	19.5±1.25	15.32	12.45	30.15

to *Hibiscus* species. Dalsaniya *et al.* (2024), observed the peak incidence in October. In the present study, the activity of *H. derogata* was higher in September, reached a peak in October, and started to decline in November. The lowest larval population was observed in the month of December.

Symptoms of infestation and damage: The presence of rolled leaf on *U. lobata* is a key indicator of *H. derogata* larval infestation that can be easily identified. The larvae roll the leaf into a conical trumpet and tie it with silk thread before feeding on the leaf portion inside. Early instar larvae are gregarious and feed inside a leaf trumpet, but later instar larvae disperse to other leaves and each larva builds its own leaf trumpet for feeding.

The study finds that *H. derogata* is a regular pest of *U. lobata* being reported for the first time in Saharanpur. The population trends of *H. derogata* in *U. lobata* are almost parallel to those observed in crops like okra and *Hibiscus*. Peak infestation in late monsoon months aligns with optimal temperature and humidity for larval development.

Understanding the pest's ecological role in wild hosts like *U. lobata* can also provide insights into off-season survival and population build-up, which may affect nearby cultivated crops like okra and cotton.

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New record of *Holotrichia serrata* (Fabricius) (Coleoptera, Scarabaeidae, Melolonthinae) infestation on cassava

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ABSTRACT: *Holotrichia serrata* (Fabricius) (Coleoptera, Scarabaeidae, Melolonthinae), a polyphagous pest was noted for the first time infesting cassava in Kerala. Extensive feeding on the foliage was observed. The number of beetles per plant ranged from 25 to 85 during the infestation and defoliation ranged from 45 to 70 per cent. Stunted growth and yellowing of the plants were observed. After four months, grub population was observed in the root zone, which ranged from 4-12 numbers per plant. The occurrence of another species, *Anomala dussumieri* Blanchard (Coleoptera, Scarabaeidae, Rutelinae), was also noticed along with *H. serrata* in the infested field. But *A. dussumieri* strictly avoided cassava leaves for feeding and copulation in the field and in the lab. © 2026 Association for Advancement of Entomology

KEY WORDS: white grub beetles, infestation, massive occurrence

The white grubs (Coleoptera, Scarabaeidae) are polyphagous and pestiferous both in the grub and adult stages, attacking various fruit and forest trees, vegetables, cereals, millets, pulses, oilseeds, sugarcane, tobacco and lawns (Chandel *et al.*, 2021). White grubs belong to four major subfamilies, Melolonthinae, Sericinae, Rutelinae and partly Dynastinae of Scarabaeidae. In Melolonthinae, *Holotrichia* Hope, 1837, is the largest genus with several species and the most ubiquitous are *H. serrata* (F.) and *H. consanguinea* (Blanchard), infesting economically important crops in India (Sreedevi *et al.*, 2021). *Holotrichia serrata* was reported to be predominant pest in sugarcane in the western Uttar Pradesh (Sreedevi *et al.*, 2014, 2017).

In India, cassava (*Manihot esculenta* Crantz) is one of the most important tuber crops, cultivated extensively by small and marginal farmers due to their large scale and varied uses (Prakash *et al.*, 2020).

Cassava is infested by a complex of arthropod pests across the tropical regions of the world, including thrips, mites, whiteflies, mealybugs, scales, horn worms, cutworms, stem borers, white grubs and storage pests (Bellotti and Schoonhoven, 1978; Lal and Pillai, 1981; Palaniswami, 1999; Bellotti *et al.*, 2012; Palaniswami and Peter, 2008; Qing *et al.*, 2015; EPPO, 2024). A massive infestation of scarab beetle, *Holotrichia serrata* (F.) on cassava was observed in Michaelgiri, Marayoor panchayath, Idukki district, Kerala (10.23846°N; 77.16357°E)

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during the 2nd week of April 2023. The number of beetles per plant during the night hours (7.30 pm to 8.00 pm) was counted from 25 randomly selected cassava plants with the aid of torch light. The defoliation was also calculated from the infested pockets in the neighboring three cassava fields. For the damage assessment, ten plants were randomly selected from the infested pockets in each of the fields, and the number of leaves infested to the total number of leaves of the plant were counted. Symptoms of grub damage and grub population were noted during the subsequent field visit during second week of September, 2023. For confirming and assessing the grub damage in the root zone of cassava, five plants showing the visible symptoms of yellowing and stunting were selected from the adult infested pockets. The root zone of the plant was carefully searched with slight digging up to a depth of one foot and a diameter of three feet from the plant base with a small spade and recorded the number of grubs present.

At the sunset, around thousands of the beetles landed on the foliage of cassava plants and found feeding only on the cassava leaves. The beetles preferred younger leaves; feeding starts from the margin and defoliate completely leaving the midrib (Fig. 1). Severe defoliation of the cassava crop was observed next day (Fig. 2). Excretory pellets of beetles were seen more or less uniformly on the soil surface, like black broadcast seeds (Fig. 3). About 95% of the beetles were in copula (Fig. 4) within 15–30 minutes after alighting on cassava plants (between 6.45 pm to 7.30 pm). During copulation initially the male holds the female feeding on cassava leaves (Fig. 5); later, after the insertion of the aedeagus into the female genital chamber, the male hangs freely downward in an upside-down position (Fig. 6). The number of beetles per plant during the aggregation period ranged from 25 to 85. The defoliation by the adult beetles in the cassava fields was ranging from 45 to 70 per cent.

The beetles were identified as *Holotrichia serrata* (Fabricius) with the available keys (Frey, 1971). Along with the *H. serrata* beetles, shiny green-colored beetles were also collected from the cassava field, which were identified as *Anomala*

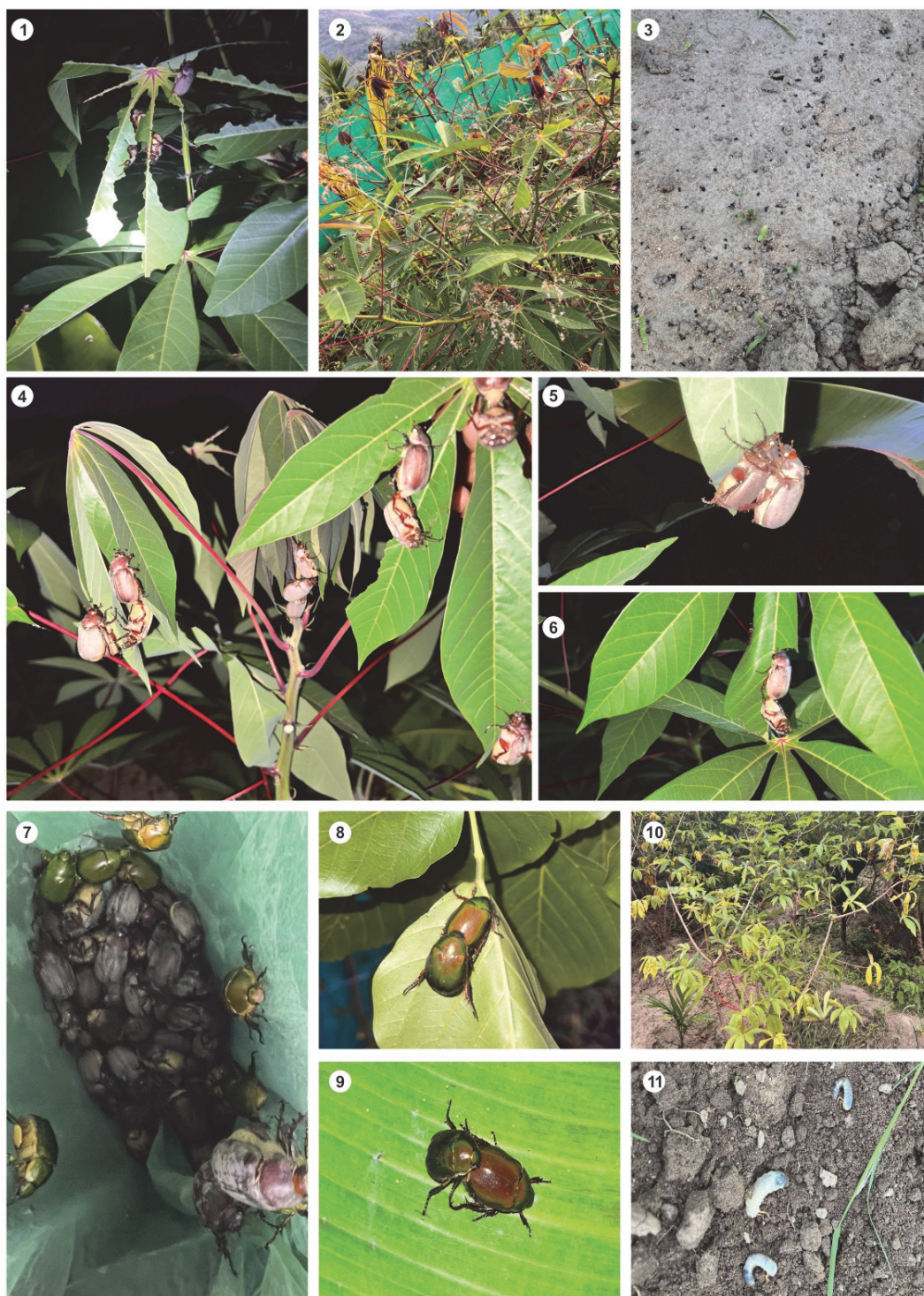
dussumieri Blanchard (Fig. 7). Around 5 per cent of the total beetle population was found to be *A. dussumieri*. These beetles observed to avoid cassava leaves for feeding and copulation in the field and in the lab. Landing and copulation of *A. dussumieri* was observed on *Erythrina* (Fig. 8), banana (Fig. 9) and on some weed plants in the field. Symptoms of root grub damage like yellowing and stunted growth (Fig. 10) of cassava plants were observed in the field during second week of September, 2023. A number of white C- shaped grubs (Fig. 11) were observed in the root zone portion, and root damage was noticed. Grub population in the root zone ranged from 4–12 per plant in the infested area.

The adult beetles of scarabs cause damage to the foliage by feeding on the leaves of neem, guava, jackfruit, ber, babul, khair, khezri, arjun, laurel tree, jamun, West Indian elm, rosewood, flame of the forest, apple, walnut, mango, drumstick, cherry, strawberry, mulberry, maize, French bean, etc. (Veeresh, 1978; Yadava and Sharma, 1995; Bajad *et al.*, 2017; Sreedevi *et al.*, 2019, 2021; Kumar and Pandey, 2022; Gautam *et al.*, 2023).

This is a new host record for *H. serrata*. More than twelve scarabaeid species were reported as pests of cassava, where the immature stages feeding on roots, *Leucopholis rorida* and *Phyllophaga* spp. were predominant (Bellotti and Schoonhoven, 1978; Lal and Pillai, 1981; Bellotti *et al.*, 2000; Palaniswami and Peter, 2008; Palaniswami, 1999; Qing *et al.*, 2015; EPPO, 2024). This is the first report of the *H. serrata* adult infestation on cassava crop.

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Figs. 1 - 11. Massive occurrence and infestation of *Holotrichia serrata* on cassava. 1. Feeding of *Holotrichia serrata* adults, 2. Defoliation symptom, 3. Excretory pellets in the soil, 4. Aggregation and copulation of *H. serrata* in cassava leaves, 5. Copulation – initial stage, 6. later stage 7. *Anomala dussumieri* in the collection chamber, 8. Copulation of *A. dussumieri* in *Erythrina*, 9. Copulation of *A. dussumieri* in banana leaves in the cassava field, 10. Stunted growth and yellowing of the grubs infested plant, 11. Grubs in the root zone

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Management of mango weevil *Sternuchus* spp. (Coleoptera, Curculionidae) in Nagaland, India

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ABSTRACT: A field experiment was carried out in the farm of AICRP on Fruits, SAS:NU to evaluate the best treatments against mango weevil (*Sternuchus* spp.). The experiment was laid out in Randomized block designed using 7 different treatments. Among the different treatments, thiamethoxam (25% WG) gave the overall least mean number of incidence (1.17), with overall lowest mean per cent infestation (7.78). The treatment, thiamethoxam recorded highest overall yield (5.67 t ha⁻¹) with maximum CB ratio (1:10.60).
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KEY WORDS: Nut weevil, incidence, infestation, yield, cost benefit ratio, thiamethoxam

Mango cultivation started more than 6000 years back and India accounts for nearly 80 per cent of the world's production and exports substantial quantities (Dhamo K. Butani, 2021). The production of mango, as per second advance estimate, during 2024-25 is expected to be 228.37 Lakh Metric Tons (LMT) in comparison to 223.98 LMT during 2023-24. (MoA & FW, 2025). Mango trees are vulnerable to attacks by numerous insect pests, with over 175 species (Nayar *et al.*, 1976). Among the pests, 87 species feed on the fruit, 127 on the foliage, 36 on the inflorescences, 33 inhabit the buds, and 25 target the branches and trunk (Pena *et al.*, 1998). Among the most serious pests is the mango weevil (*Sternuchus* spp.), particularly *S. mangiferae*. A major concern is that infestation by the mango weevil often goes unnoticed, as affected fruits may

appear healthy externally while being internally damaged. Therefore, the present study was undertaken to evaluate and identify the most effective treatment for the management of mango weevil under local agro-climatic conditions.

The field trial was conducted on standing (3-4 years old) plants i.e.. Amrapali variety in the year 2024 and 2025. Randomized block design was followed, where 7 different treatments (Table 1) were applied to observe the effectiveness in management of mango weevil. The efficacy of different treatments was evaluated after the harvest, where 15 numbers of mango fruits were selected, cut open and examined for signs/symptoms of weevil infestation. The per cent infestation was calculated using the formula -

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Table 1. Effect of different treatments against of mango weevil (*Sternochetus* spp.) infestation during 2024 and 2025

Treatments	Mango weevil (<i>Sternochetus</i> spp.) infestation from 15 no. of fruits per plant						Yield (t/ha)			Pooled BC Ratio
	Mean (no.) 2024	Mean (no.) 2025	Pooled mean (no.)	Mean 2024 (%)	Mean 2025 (%)	Pooled mean (%)	2024	2025	Pooled	
T ₁ -Smoking the mango tree after fruit setting (Every 3 days after fruit set)	5.00	4.33	4.67	33.33	28.89	31.11	4.79	4.27	4.53	8.22
T ₂ -Spraying of Neem oil (5 ml/ litre of water after fruit set (second spray after 2-week etc)	4.67	3.33	4.00	31.11	22.22	26.67	4.66	4.67	4.67	8.79
T ₃ -Spraying of Neem oil +Smoking the mango tree after fruit setting (5 ml/ litre of water after fruit set (second spray after 2-week etc) + Every 3 days from after fruit set)	3.67	2.67	3.17	24.44	17.78	21.11	5.20	4.93	5.07	8.38
T ₄ -Proper sanitation and collection of fallen fruits (At weekly interval)	5.33	3.67	4.50	35.56	24.44	30.00	4.66	4.53	4.60	8.34
T ₅ -Raking the soil and spraying of <i>Beauveria bassiana</i> in soil and tree trunk (Once During flowering and once at marble size stage of fruit)	4.67	3.67	4.17	31.11	24.44	27.78	4.53	4.53	4.53	7.47
T ₆ -Standard Check: Thiamethoxam (0.5 gm/ litre of water at marble size)	1.67	0.67	1.17	11.11	4.44	7.78	5.60	5.73	5.67	10.60
T ₇ -Control	10.00	7.33	8.67	66.67	48.89	57.78	3.18	3.07	3.12	6.53
Sem±	0.69	0.41	0.40	4.59	2.72	2.64	0.40	0.16	0.22	-
CD at 5%	2.12	1.26	1.22	14.14	8.39	8.15	1.23	0.50	0.69	-

$$\% \text{ infestation} = \frac{\text{Number of infested mangoes}}{\text{Total number of mangoes}} \times 100$$

The cost economic of the different treatments was analysed using the prevailing market prices.

$$\text{Benefit Cost ratio} = \frac{\text{Net profit (Rs.)}}{\text{Total Cost (Rs.)}}$$

The pooled data of the years 2024 and 2025, (Table 1) reveals that the overall least mean 1.17 number of infestations was observed in T_6 i.e., Thiamethoxam 25 % WG followed by 3.17 mean number of infestation T_3 i.e., treatment with Neem oil + smoking the mango trees after fruit setting. Highest overall pooled mean number infestation 8.67 was observed in T_7 i.e., Control. The lowest overall pooled per cent infestation was observed in T_6 i.e., Thiamethoxam 25 % WG followed by T_3 i.e., treatment with Neem oil + smoking the mango trees after fruit setting with 7.78 and 21.11 respectively. The highest overall pooled mean percentage was observed in T_7 i.e., Control, followed by T_1 i.e. smoking of mango trees after fruit setting with 57.78 and 31.11 respectively. The highest overall yield was observed in T_6 i.e., Thiamethoxam 25 % WG with a yield of 5.67 (t/ha.) and the lowest yield was observed in T_7 i.e. control, with a yield of 3.12 (t/ha.). The highest pooled cost benefit ratio was observed in T_6 i.e., Thiamethoxam 25 % WG with a CB ratio of 1:10.60 (Table 1)

Statistical analysis using the Critical Difference (CD) at 5% level confirmed that the differences between the control and each treatment were significant,

Sudeep *et al.* (2022) has reported similar kind of findings stating that thiamethoxam was the best treatment among the different treatments used. The insecticides of plant and animal origin were found to be comparatively less effective, leaving synthetic insecticides such as thiamethoxam as an effective option in case of severe infestation (Verghese *et al.*, 2003).

Cultural measures such as gathering and destroying the fallen fruits helps prevent adult weevils from emerging and attacking new fruit. Which provide an environmentally friendly option that minimizes reliance on pesticides, thereby reducing the chances of resistance development and chemical residues in fruits. The findings underscore the pest's potential to cause severe economic losses in mango production. However, the study also demonstrates that integrated management strategies- particularly the adoption of cultural practices, the use of biocontrol agents, and the application of insecticides such as Thiamethoxam- can effectively reduce weevil infestation. These combined measures offer a promising approach to safeguard mango yields and improve the livelihoods of the farming community.

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New record of *Thysia wallichii* Hope, 1831 (Coleoptera, Cerambycidae) from Arunachal Pradesh, India

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ABSTRACT: The study reports the first confirmed occurrence of *Thysia wallichii* Hope, 1831 (Coleoptera, Cerambycidae, Lamiinae) from Sangram circle, Kurung Kumey district, Arunachal Pradesh, India. This new locality record extends the known geographical distribution of the species within the state and contributes valuable information to the expanding documentation of cerambycid diversity in the region.

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KEY WORDS: Long horned beetle, occurrence, Sangram, Eastern Himalaya, biodiversity hotspot

Arunachal Pradesh, one of the eight northeastern states of India, is globally recognized as a component of the Eastern Himalaya biodiversity hotspot (Myers *et al.*, 2000). Its diverse altitudinal gradients and varied forest types from tropical to alpine support a remarkably rich assemblage of flora and fauna, including numerous endemic and threatened species (Mao and Hegde, 2002; Choudhury, 2013). Kurung Kumey is relatively underexplored district. In the present study, the occurrence of *Thysia wallichii* Hope, 1831 is reported from Sangram circle, Kurung Kumey district (Fig. 1), one of the 27 districts of Arunachal Pradesh. This species is a member of the family Cerambycidae, a highly diverse group within the order Coleoptera, encompassing more than 36,000 recognized species distributed globally under 5,000

genera (Lawrence, 1982; Švácha and Lawrence, 2014).

During a faunistic survey conducted in Sangram circle Kurung Kumey (formerly known as Lower Subansiri district), Arunachal Pradesh, a male adult specimen of *T. wallichii* was collected from outside old wooden logs by Temjenmongla and team in March 2025 from Leel village, Sangram circle. Identification was carried out following the keys and diagnostic characters described by Stebbing (1914), Beeson (1941) and Sengupta and Sengupta (1981). The specimen is housed in the National Zoological Collection of the Arunachal Pradesh Regional Centre, Zoological Survey of India, Itanagar. The map of the collection locality was generated using the open-source QGIS software

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(version 3.22.0). Location coordinates for the distribution site (Fig. 1) was obtained with the aid of a GPS (Garmin Oregon 550).

Systematic Account

Tribe: Ceroplesini Thomson, 1860; Genus: *Thysia* Thomson, 1860.

Thysia wallichii Hope, 1831 (Figs. 2, 3)

Lamia wallichii Hope, 1831. The Zoological Miscellany 1: 27.

Thysia wallichii Thomson, 1861. Essai d'une classification de la famille des Cérambycides, et matériaux pour servir à une monographie de cette famille 404pp.

Material examined: 01 ♂, Reg. No. ZSI/APRC/IV-7290, 25.iii.2025, India, Arunachal Pradesh, Kurung

Kumey Dist., Sangram, Leel village, 27.84232°N, 93.4577°E; 915m asl., Coll. Temjenmongla & party.

Diagnostic features: Antennae with 10 segments, greenish and ornamented with tufts of long silky black pubescence; total body length 25 mm; elytra exhibiting a dull metallic bluish to bronzy-green to purplish coloration covered with minute, dense, scale-like pubescence that produces a variable iridescence under light; head length 7 mm, prognathous, brownish with green and purple lustre with finely faceted eyes. Prothorax greenish with a pair of small somewhat blunt median spines along its lateral margins. The scutellum is broad and slightly narrowed posteriorly, brownish with a purple lustre. Elytra elongate and parallel sided, each bearing a pair of rounded spots covered with long black erect hairs and a transverse velvety-black band on the posterior half. The legs are glossy

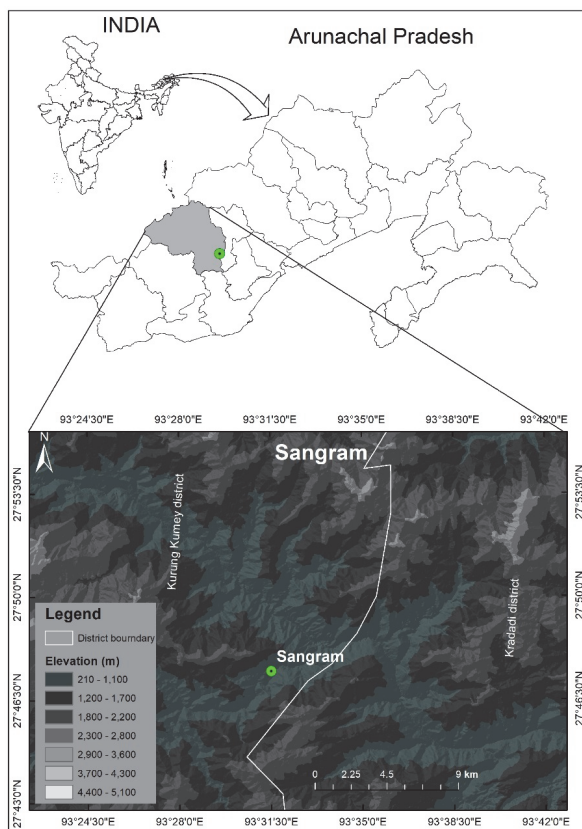


Fig. 1 Map of Sangram circle in Kurung Kumey district, Arunachal Pradesh



Fig. 2 Dorsal view of *T. wallichii* (Live specimen);



Fig. 3 Ventral view of *T. wallichii* (Preserved specimen)

indigo-green and comparatively short (Stebbing, 1914; Beeson, 1941; Sengupta and Sengupta, 1981).

Distribution: India: Arunachal Pradesh, Assam, Meghalaya, Mizoram, Nagaland, and Sikkim (Sengupta and Sengupta, 1981, Mitra *et al.*, 2017b) as well as West Bengal (Mitra, 2015), Bihar, Uttarakhand and Uttar Pradesh (Saha *et al.*, 2013).

Elsewhere: Borneo, China (Guangdong, Guangxi, Guizhou, Sichuan, Yunnan), Iran, Laos, Malaysia, Myanmar, Nepal, Thailand and Vietnam (Özdikmen *et al.*, 2009, Kariyanna *et al.*, 2017, Mitra *et al.*, 2016).

The record of *T. wallichii* from Sangram circle, Kurung Kumey district, represents the first confirmed occurrence of this species from the area, extending its known distribution within Arunachal Pradesh. *Thysia wallichii* Hope, 1831 was first reported by Sengupta & Sengupta (1981) from the Kameng division of Arunachal Pradesh (now bifurcated into West and East Kameng districts) under the name *Diastocera wallichii* Hope, 1831, based on a specimen collected by K.C.J in 1961. The species has now been recorded by the present authors from Kurung Kumey district, which was originally part of the Subansiri Frontier Division, later renamed Lower Subansiri district. On 1st April 2001, Kurung Kumey was created as a separate district by bifurcating Lower Subansiri. This district lies adjacent to the Kameng districts. The present finding represents a new locality record within Arunachal Pradesh but does not necessarily indicate an extension of the species distributional range. Being a relatively uncommon longhorn beetle (Kariyanna *et al.*, 2017; Mitra *et al.*, 2017a; Kiewhuo *et al.*, 2024), its presence in this remote locality highlights the largely unexplored entomofaunal richness of Arunachal Pradesh. It is the sole representative of the monotypic genus *Thysia*, although it is occasionally recorded under the synonym *Diastocera wallichii* (Thomson, 1857).

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New distributional record of *Argiope versicolor* (Doleschall, 1859) (Araneae, Araneidae) from Kerala, India

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ABSTRACT: The orb-weaving spider *Argiope versicolor* (Doleschall, 1859), previously recorded from south and southeast Asia, is reported for the first time from Kerala, India. Specimens were collected from Kottayam district using hand collection methods and confirmed through morphological and molecular analyses. This record extends the known distribution of the species and contributes to the documentation of Kerala's spider fauna. Detailed observations on morphology, habitat, web structure, and stabilimentum pattern are provided. The mitochondrial sequence obtained in this study has been deposited in GenBank (Accession No. PQ721811.1). © 2026 Association for Advancement of Entomology

KEY WORDS: Orb-weaver, morphology, habitat, web structure, stabilimentum, molecular analyses, GenBank

Spiders of the family Araneidae are key predators in terrestrial ecosystems, contributing significantly to insect population control. The genus *Argiope* Audouin, 1826 is well known for its striking coloration, distinctive web architecture, and sexual dimorphism. *Argiope versicolor* (Doleschall, 1859) (Araneae, Araneidae), commonly referred to as the multi-colored St. Andrew's cross spider, has been documented across southeast Asia but remains understudied in the Indian subcontinent. Recent studies (Tyagi *et al.*, 2019) reported its occurrence from Assam, India. However, to date, no records exist from peninsular India. Here, we report the first confirmed record of *A. versicolor* from Kerala, expanding the known distribution of the species.

Specimens were collected during field surveys in Kottayam district, Kerala using hand collection and

individuals were preserved in 70% ethanol. Morphological features were examined using a Leica S8 APO MSV266 stereomicroscope, and photographs were taken using a Leica digital camera Flexacam C1 with image stacking via Automontage software.

Genomic DNA was extracted from leg tissue using NucleoSpin® Tissue Kit (Macherey-Nagel, Germany). PCR amplification and sequencing were conducted at the Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram. The resulting mitochondrial DNA sequence was deposited in GenBank under the accession number PQ721811.1. Sequence quality was verified using Sequence Scanner Software v1.0, and alignments were performed using Geneious Pro v5.1. The distribution map was created using Data wrapper.

* Author for correspondence

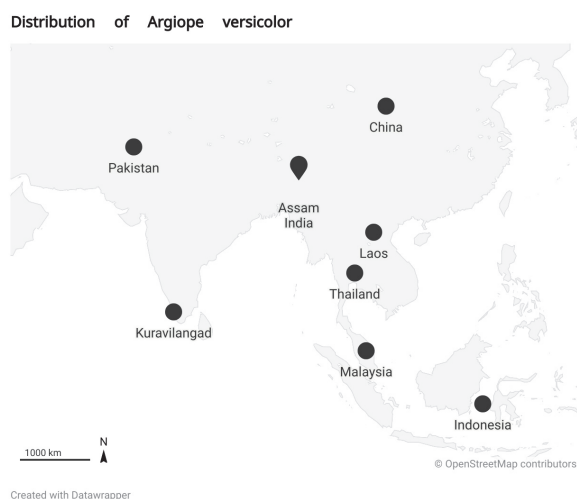


Fig. 1 Distribution of *Argiope versicolor* in the world.
<https://datawrapper.dwcdn.net/fYYIJ/5/>

Argiope versicolor (Doleschall, 1859) (Figs. 1 - 5)

Morphology

Diagnosis:

Female identifiable by elongate pentagonal abdomen with yellow background and black symmetrical dorsal markings including a central folium-like patch; ventrally with a distinct black anchor-shaped marking. Epigyne with slender V-shaped anterior elevation, narrow median septum, and nearly rectangular basal plate; differs from *Argiope pulchella* by more delicate anterior elevation and scapus base configuration. Male palpal organ resembles *A. pulchella*, but embolus base lacks distinct tubercle; embolus does not extend beyond conductor tip; median apophysis slender with fine denticles dorsally (Yin *et al.*, 1997).

Description (♀):

Total length: 11 mm, carapace 4 mm long, abdomen 7 mm long. Carapace yellowish-brown, slightly convex, with distinct black marginal markings. Covered with fine setae. Cephalic region moderately elevated. Eyes: Eight in two rows. Median ocular quadrangle slightly wider than long.

Lateral eyes close together. Eye arrangement as typical for Araneidae. Chelicerae: Short and strong; dark brown with lighter basal segment. Promargin with three teeth; retromargin with two smaller teeth. Sternum: Heart-shaped, yellowish with dark marginal spots; setose. Legs: Long and slender. Legs I and II longer than III and IV. Bright yellow with prominent black annulations at tibial, metatarsal and tarsal joints. Dense short setae along segments; few long spines especially on femora and tibiae. Leg formula: I > IV > II > III. Spination: femora with 1-2 dorsal spines, tibiae with multiple pairs of ventral spines.

I: 17.00 (4.60 + 6.40 + 4.80 + 1.20); II: 15.90 (3.90 + 5.90 + 4.80 + 1.30); III: 10.90 (3.80 + 2.70 + 3.10 + 1.30); IV: 19.00 (6.20 + 5.60 + 5.80 + 1.40).

Abdomen elongate and pentagonal, tapering posteriorly. Dorsal surface brightly colored: yellow background with black symmetrical markings; central folium-like dark patch evident. Dorsum with three horizontal bands. Lateral margins slightly serrated. Ventrally, abdomen yellowish with a prominent black anchor-shaped marking extending anteroposteriorly; epigastric region reddish.

Epigynal plate broad, wider than long, with a distinct, tongue-shaped median septum. Copulatory openings crescent-shaped, located laterally at the base of the septum. Lateral lobes well-developed, smoothly curved. In cleared view, spermathecae are subglobular, placed anterolaterally; copulatory ducts short and slightly curved. Plate moderately sclerotized, especially around openings and septum. The structure is superficially similar to that of *Argiope pulchella*, but distinguishable by the more delicate anterior elevation and the configuration of the scapus base (Yin *et al.* 1997). Spinnerets: Three pairs; pale brown; posterior lateral spinnerets slightly elongate.

Colour in life: Bright yellow and black contrasting body with striking leg banding; ventral side more vivid, aiding in predator deterrence.

Distribution: Known from southeast Asia including India (Tyagi, 2019), China (Chen and Gao, 1990; Yin, 1997), Pakistan (Younas, 2024), Laos

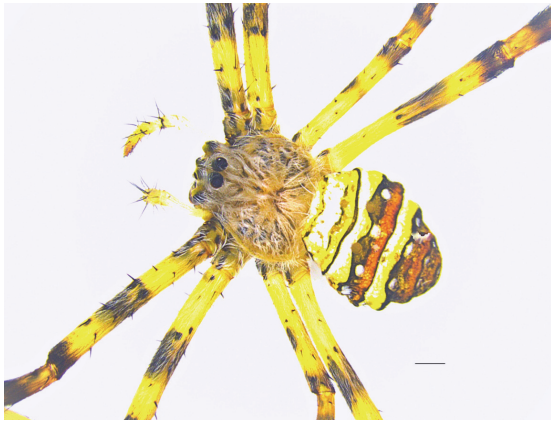


Fig. 2 Dorsal view. Scale bar =1 mm



Fig. 3 Ventral view. Scale bar =1 mm

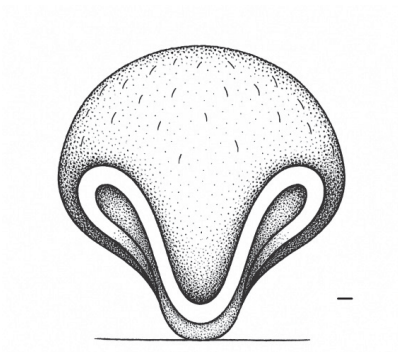


Fig. 4 Epigyne - Ventral view

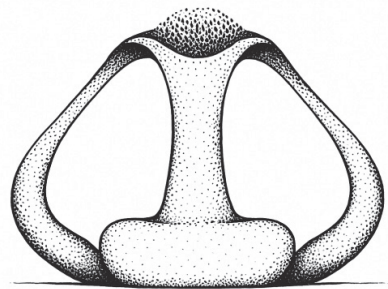


Fig. 5 Epigyne - Dorsal view

(Jäger, 2009), Malaysia (Pocock, 1897; Workman, 1896), Thailand and Indonesia (Dolleschall, 1859). New record from Kuravilangad, Kottayam District, Kerala.

Specimen examined: 1 ♀, INDIA: Kerala: Kuravilangad, Kottayam, 52m, 9°45' 20.53" N; 76°33' 46.33" E., 02.ii.2024

Web architecture and stabilimentum: The webs feature prominent stabilimenta. Juveniles build discoid patterns; adults construct cruciform types. The structure varies with spider size, light intensity, and feeding status, supporting both prey attraction and predator deterrence functions.

Habitat and distribution: The species was observed in open, semi-disturbed habitats including gardens and paddy field margins. It constructs vertical orb-webs between shrubs and tall grasses. The coloration and patterning aid in camouflage and predator deterrence.

Molecular confirmation: The mitochondrial gene sequence obtained from the specimen (GenBank Accession No. PQ721811.1) matched closely with other known sequences of *Argiope versicolor*, confirming species identity. Phylogenetic analysis placed the specimen within a clade consisting of other *A. versicolor* entries from southeast Asia, supporting its identification and expanding the

biogeographical range of this species.

TGGGAGGTTTATGGGAGATGATCAATTATATAAT
GTGATTGTAACAGCACATGCTTTTGTAATAA
TTTTTTTTTATAGTAATGCCTATTTTAATT
GGGGGATTTGGAAATTGATTAGTGCCTCTTATA
TTA GGAGCCCCAGATATAGCATTTCCAC
GAATAAATAATTAAGATTTTGACTATTACCTCCT
TCGTTATTTCTTTTAATT GTCTCTTCAATA
GTAGAAATAGGGGTAGGAGCAGGGTGAAC
TGTGTACCCTCCTTTAGCTGGATTAGAA
GGCCATGCTGGAAGATCTGTTGATTTT
GCAATTTTTCTCTTCATTTGGCAGGTGCTT
CTTCTATTATGGGGGCAATTAATTTTATTCTA
CAATTATTAATATACGATTTTATGGAATGACT
ATAGAAAAGGTTCCCTTTATTTGTTTGATCAGTC
TTAATTACTGCTGTTCTTTTACTTCTTTTCGT
TACCGGTTTTAGCAGGAGCTATTACT
ATATTATTAAGTACCGGAATTTAATACTTCTTT
TTTTGACCCTTCTGGGGGAGGAGATCCCAT
TTTATTTTCAGCATTT

The presence of *Argiope versicolor* in Kerala expands the species' known distribution into peninsular India. Further surveys across the Western Ghats may yield more insights into its range and ecological interactions.

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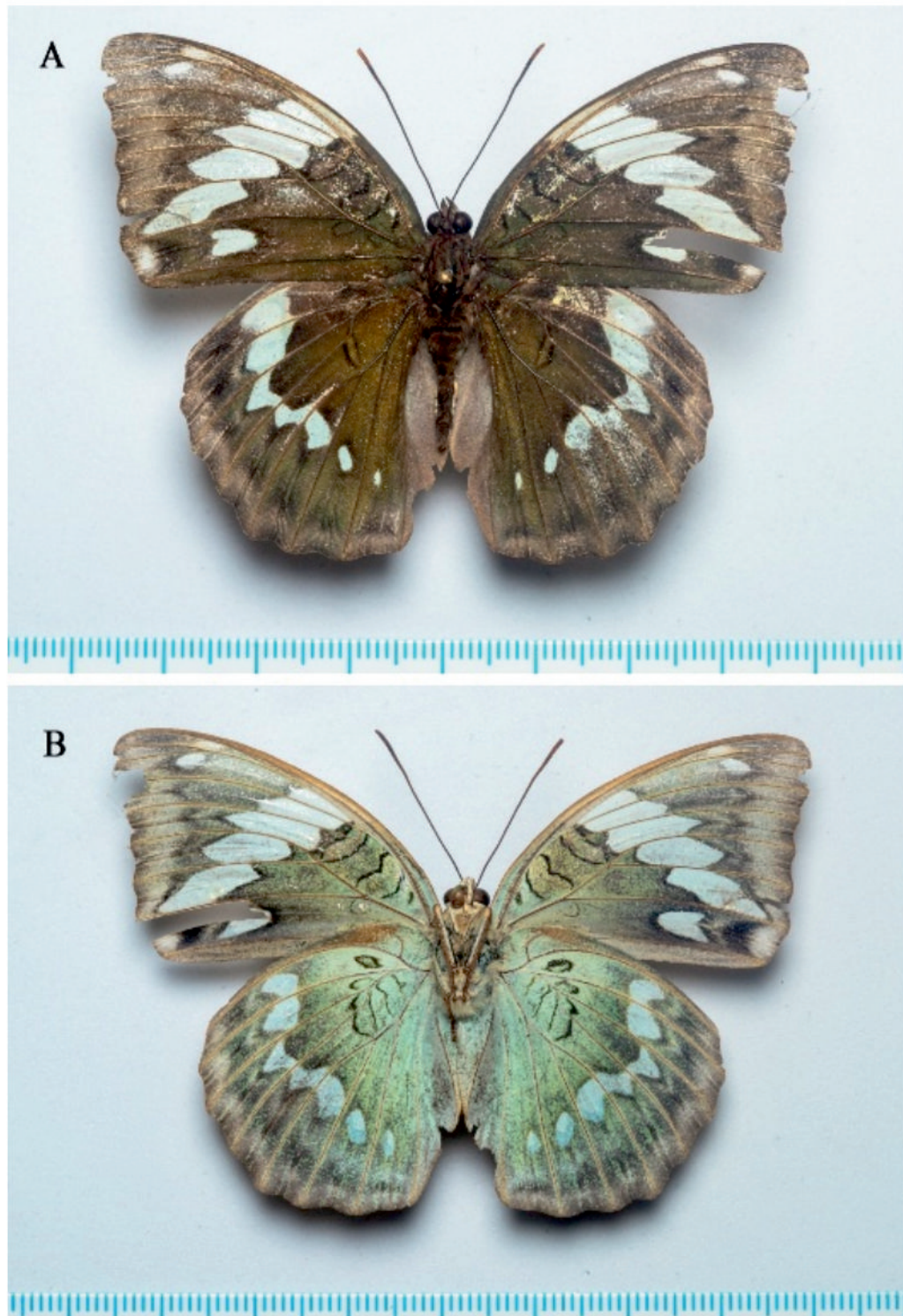
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Euthalia (Limbusa) zubeengargi sp. nov. Holotype male (TLRG 1014). A: Dorsal view; B: Ventral view. © Kalesh Sadasivan



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