

**INTEGRATING TAXONOMY, PHYLOGENY, HOST PLANT
ASSOCIATIONS AND GUT MICROBIAL DIVERSITY IN LYNX
SPIDERS (ARANEAE: OXYOPIDAE) OF KERALA**

Thesis submitted in partial fulfilment of the requirement for the degree of

DOCTOR OF PHILOSOPHY IN ZOOLOGY

Under the Faculty of Science

University of Calicut



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JULY 2026



DECLARATION

I, **Amulya Baji K.**, hereby declare that the work embodied in this thesis, **'INTEGRATING TAXONOMY, PHYLOGENY, HOST PLANT ASSOCIATIONS AND GUT MICROBIAL DIVERSITY IN LYNX SPIDERS (ARANEAE: OXYOPIDAE) OF KERALA'** submitted to the University of Calicut in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Zoology is a bona fide record of the research work carried out by me under the supervision of Dr. (Prof) Honey Sebastian, Vimala College (Autonomous), Thrissur, affiliated to University of Calicut and co-guidance of Dr. Sudhikumar A. V., Associate Professor, Department of Zoology, Christ College (Autonomous), Irinjalakuda, affiliated to University of Calicut. No part of the thesis has formed the basis for the award of any degree, diploma or similar titles of any university. The contents of the thesis have undergone a plagiarism check using iThenticate software at the C.H.M.K. Library, University of Calicut, and the similarity index was found to be within the permissible limit. I also declare that this thesis is free from AI-generated content.

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This is to certify that **Ms. Amulya Baji K.** has completed the research work for the entire period prescribed under the PhD ordinance of the University of Calicut. This thesis, **'INTEGRATING TAXONOMY, PHYLOGENY, HOST PLANT ASSOCIATIONS AND GUT MICROBIAL DIVERSITY IN LYNX SPIDERS (ARANEAE: OXYOPIDAE) OF KERALA'**, embodies the results of her investigations conducted during the period in which she worked as a research scholar. I recommended the thesis to be submitted for evaluation for the Doctor of Philosophy in Zoology degree award from the University of Calicut.



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Amulya Baji K.

***"The greatest artist and web designer ever is
indeed a spider!"***

- Munia Khan, English Poet

***Dedicated to my Parents &
Husband***

Acronyms and Abbreviations

AL	Abdomen Length
AW	Abdomen Width
CL	Carapace Length
CW	Carapace Width
TL	Total Length
AME	Anterior Median Eye
ALE	Anterior Lateral Eye
PME	Posterior Median Eye
PLE	Posterior Lateral Eye
MTA	Median Tegular Apophysis
RTA	Retrolateral Tibial Apophysis
VTa	Ventral Tibial Apophysis
AER	Anterior Eye Row
PER	Posterior Eye Row
WSC	World Spider Catalogue

Study area

AFM	Aaralam Farm
AWS	Adyanpara Waterfalls
AWA	Athirapilly Waterfalls
ATM	Ayiram Tengu Mangroove forest
BDM	Banasurasagar Dam
BFR	Bekkal Fort
CGN	Cabbage Garden Nileswaram

CUG	Calicut University Garden
CFR	Carborandam Factory
CPR	Cashew Plantation in Periyar
CRN	Chalakkudi River Region
CBE	Chavakkad Beach Side
CPP	Chengara Pine-apple Plantation
DMF	Dharmadam Mangrove Forest
DEM	Dhoni Ecotourism
EKK	Illikkalkallu
FKR	Fort Kochi Regions
HTP	Harrison Tea Plantation
HPK	Hill Palace Kochi
IDM	Idukki Dam
IKU	Iringol Kavu
IPF	Irinjalakuda Paddy Field
JKD	Janakikkad
JTK	Jathavan Kotta
KME	Kadalundy Mangrove Ecosystem
KEM	Kalashamala Ecotourism
KPA	Kanthan Para
KDM	Karapuzha Dam (Ambala Vayal)
KRN	Kava Region
KFP	Konni Forest Premises
KFN	Kothamangalam Forest Region
KFR	Kottoor Forest Region

KPE	Krishnapuram Palace
KMF	Kuttiyadi Mangrove Forest
MBG	M S Swaminathan Botanical Garden
MPR	Maggattuparambhu Region
MDG	Malampuzha Dam Garden
MDM	Mangalam Dam
MPK	Mannampurathu Kavu
MEP	Munnar Eco-point
MGB	Munnar Government Botanical Garden
NRF	Nedumgayam Rain Forest
NKS	Neeliyar Kottam Sacred Grove
NDM	Neyyar Dam
NTM	Nilamboor Teak Museum
PRP	Pala Rubber plantation
PID	Pathiamanal Island
PDM	Pazhassi Dam
PMG	Pazhassi Museum Garden
PDG	Peechi Dam Garden
PEA	Periya 35
PHS	Ponnmudi Hills
PDD	Poomala Dam
PPF	Pullu Paddy Field
PUP	Pulpalli
RHS	Ranipuram Hill Station
RPP	Rubber Plantation in Periyar

SPK	Sarovaram Biopark
SAF	St Angelo Fort
TBP	Thenmala Butterfly Park
TES	Thenmala Ecotourism
TFS	Thirunelly Forest
TFT	Tholpetty Forest
TBP	Thumboormuzhi Butterfly Park
TPK	Tobacco Plantation Kanhangad
VRS	Valapattanam Riverside
VBS	Vallapad Beech Side
VDM	Vazhani Dam

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Objectives

The study is focused on the following objectives:

1. Collection and taxonomic description of lynx spiders of Kerala.
2. DNA barcoding and phylogenetic analysis of lynx spiders in Kerala with other counterparts across the tropics and subtropics.
3. Study the host plant preference in lynx spiders of Kerala.
4. Comparison of the gut microbial diversity of *Oxyopes birmanicus* from 4 selected ecosystems.

Structure of thesis

Chapter I — Introduction

This chapter introduces Kerala, agroecosystems, Araneae and its general morphological features, collection, preservation and examination of spiders, family Oxyopidae, ecological importance, molecular phylogeny V/s classical taxonomy, habitat, spider host plant preference and gut microbial diversity in spiders.

Chapter II — Review of literature

It is the collection of already done works to ensure the significance of the current study. This chapter is elaborated in five sub-headings, including classical taxonomy works on Oxyopidae, molecular taxonomy to trace phylogeny among oxyopids, molecular phylogenetic works in India, spider–host plant associations, and lynx’s gut microbial diversity - an investigation.

Chapter III — Materials and Methods

This chapter deals with the study area, materials, and methodology applied to the present study.

Chapter IV — Results

This chapter includes the observations and findings of the present study.

Chapter V — Discussion

This chapter compares the present study with previous works.

Summary and conclusion

This chapter summaries the thesis.

Recommendations

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Appendices

സംഗ്രഹം

ലിൻക്സ് സ്പൈഡറുകൾ (ഓക്സിയോപിഡെ) കേരളത്തിലെ വിവിധ ആവാസവ്യവസ്ഥകളിൽ വ്യാപകമായി കാണപ്പെടുന്നു. വലകൾ നിർമ്മിക്കാത്ത ഈ ചിലന്തികൾ വേഗത്തിലും ദൃശ്യശേഷിയിലും പ്രാവീണ്യം നേടിയിരിക്കുന്ന വേട്ടക്കാരാണ്. പൂക്കളിലും ഇലകളിലും കാണപ്പെടുന്ന ഇരകളെ ആകസ്മികമായി പിടികൂടുന്നതിനായി ഇവർ വേഗത്തെയും കൃത്യതയെയും ഉപയോഗിക്കുന്നു. പ്രത്യേകതയുള്ള മുൾക്കാലുകളും ഷഡ്ഭുജാകൃതിയിലുള്ള കണ്ണുകളും അവരുടെ വേട്ടയാടൽ കാര്യക്ഷമത മെച്ചപ്പെടുത്തുന്നു. കേരളത്തിലെ ലിൻക്സ് സ്പൈഡറുകളുടെ വൈവിധ്യത്തെ ഈ പഠനം പരിശോധിക്കുന്നു. ഓക്സിയോപിഡിസിന്റെ രൂപപരമായ സാമ്യം കണക്കിലെടുത്ത്, പരമ്പരാഗത രീതികൾക്കു പകരം ക്ലാസിക്ക്, മോളികുലാർ ടാക്സണോമി സംയോജിപ്പിച്ച ഒരു വിശ്വസനീയമായ മാർഗം ഉപയോഗിച്ചു. കേരളത്തിൽനിന്നും ഓക്സിയോപേസ്, ഹമാറ്റാലിവ, ഹമാഭുവാസ്, പ്രൂഷിയ എന്നീ നാല് ജനുസുകളിലായി മൊത്തം 31 ഓക്സിയോപിഡ് സ്പീഷിസുകൾ തിരിച്ചറിയപ്പെട്ടു. ഈ ഗവേഷണത്തിൽ ഓക്സിയോപേസ് വിഭാഗത്തിൽ പെടുന്ന ഓ. ട്രൈഗ്രിസ്, ഓ. പീതം, ഓ. സോളിയ, ഓ. രാമുൽസ്, ഓ. ഔറിസ്, ഓ. ഹിപ്പോകാമ്പസ്, ഓ. സിർക്കും, ഓ. അക്വിലെ, ഓ. കാസറഗോഡൻസിസ്, ഓ. തുമ്പൂർമുഴിയൻസിസ്, ഓ. പാറ്റേറ എന്നിവ ഉൾപ്പെടുന്ന 11 പുതിയ സ്പീഷിസുകളെ കണ്ടെത്തി. കൂടാതെ, ഓ. സ്ക്രിയാഗറ്റസ്, ഓ. ഷക്കിലെ എന്നീ സ്പീഷിസുകളെ ഇന്ത്യയിൽ നിന്നും ആദ്യമായി രേഖപ്പെടുത്തി. ഹമാറ്റാലിവ ജനുസിൽ നിന്നും ശേഖരിച്ച ഹ. ട്രയാങ്കുലസ്, ഹ. ക്വാഡ്രാറ്റ, ഹ. സാഗിറ്റ, ഹ. ക്രിസ്റ്റ, ഹ. റോംബിയ എന്നിവ പുതിയ സ്പീഷിസുകൾ

ആണ്. 31 സ്പീഷിസുകളുടെ ഡിഎൻഎ ബാർകോഡിംഗ് ചെയ്തതിൽ 19 സ്പീസിസ് ന്റെ കൺസെൻസസ് സീക്വൻസ് ലഭിച്ചു. ഓക്സിഡോപി ഡിസിൻറെ പരിസ്ഥിതി പൊരുത്തപ്പെടലുകളും വേട്ട രീതികളും ഇവരെ വംശാവലി, പരിസ്ഥിതി പഠനങ്ങൾക്ക് അനുയോജ്യമാക്കി മാറ്റുന്നു. ഓക്സിഡോപി ഡിസിൻറെ വംശാവലി ബന്ധം ഡിഎൻഎ ബാർകോഡുകൾ ഉപയോഗിച്ച് ഫൈലോജനെറ്റിക് ട്രീകൾ നിർമ്മിച്ച് നിർണ്ണയിച്ചു. കൂടുതൽ വിശ്വസനീയമായ ടാക്സോണമിക് പ്ലേസ്മെന്റുകൾ അറിയുന്നതിനായി മൈറ്റോകോണ്ട്രിയൽ സൈറ്റോക്രോം സി ഓക്സിഡേസ് ഉപയൂണിറ്റ് 1 (CO1) മാർക്കറിൽ നിന്നുള്ള ഡിഎൻഎ ബാർകോഡുകൾ ഉപയോഗിച്ച് നെയ്ഗ്ബോർ ജോയിൻ, മാക്സിമം പാർസിമോണി, ബേസിൻ ഇൻഫെറെൻസ്, മാക്സിമം ലിക്ലൈഡ് എന്നിങ്ങനെ നാലു ഫൈലോജനെറ്റിക് ട്രീകൾ നിർമ്മിച്ചു. വിളകൾക്കു ഹാനികരമായ കീടങ്ങളെ തടയുന്നതിൽ ഓക്സിഡോപിയെ സ്പീഷിസുകളുടെ കാര്യക്ഷമത പ്രകൃതിദത്ത കീടനിയന്ത്രണത്തിൽ ഉപയോഗിക്കാവുന്നതാണ്. ഈ സാഹചര്യത്തിൽ, കേരളത്തിലെ വിവിധ ആവാസവ്യവസ്ഥകളിലുടനീളമുള്ള ലിൻക്സ് ചിലന്തികളുടെ ആതിഥേയ സസ്യ മുൻഗണനകൾ പരിശോധിച്ച പഠനം, 30 കുടുംബങ്ങളിൽ നിന്നുള്ള 88 ആതിഥേയ സസ്യങ്ങളെ തിരിച്ചറിഞ്ഞു. പോയേസി കുടുംബത്തിൽ ഏറ്റവും കൂടുതൽ സ്പീഷിസ് സമ്പന്നതയും വർദ്ധനയും കാണപ്പെടുമ്പോൾ ബാൽസാമിനേസി കുടുംബത്തിൽ ഏറ്റവും കുറഞ്ഞതാണു രേഖപ്പെടുത്തിയത്. ലിൻക്സ് ചിലന്തികളിൽ വിദേശ, തദ്ദേശീയ ഇനങ്ങളെ അപേക്ഷിച്ച് അധിനിവേശ സസ്യങ്ങൾക്ക് മുൻഗണന നൽകുന്നത് നിരീക്ഷിക്കപ്പെട്ടു. ചിലന്തികളിലെ കൂടൽ സൂക്ഷ്മാണുക്കളെ കൈകാര്യം ചെയ്യുന്നത് സ്വാഭാവിക ജൈവ നിയന്ത്രണ

രീതികൾക്കായി ലിൻക്സ് ചിലന്തികളുടെ എണ്ണം വർദ്ധിപ്പിക്കും, ഇത് കീട നിയന്ത്രണത്തിനായി രാസ കീടനാശിനികളെ ആശ്രയിക്കുന്നത് കുറയ്ക്കും. ആവാസവ്യവസ്ഥയെ ആശ്രയിച്ച് ചിലന്തികളുടെ കൂടലിലെ സൂക്ഷ്മജീവികളുടെ ഘടന വ്യത്യാസപ്പെടുന്നു. നഗരപ്രദേശം, വനം, അണക്കെട്ടിന്റെ വശം, നെൽവയൽ എന്നിവയുൾപ്പെടെ നാല് വ്യത്യസ്ത ആവാസവ്യവസ്ഥകളിൽ നിന്നുള്ള *ഓ. ബിർമാനിക്കസി*ന്റെ കൂടൽ സൂക്ഷ്മജീവി വൈവിധ്യത്തെ ഈ പഠനം താരതമ്യം ചെയ്യുകയും 107 ബാക്ടീരിയൽ സ്പീഷീസുകൾ, 162 ജനുസ്സുകൾ, 88 കുടുംബങ്ങൾ, 56 ഓർഡറുകൾ, 18 ഫൈലയിൽ പെട്ട 27 ക്ലാസുകൾ എന്നിവ തിരിച്ചറിയുകയും ചെയ്തു. അണക്കെട്ടിന്റെ വശത്തുനിന്നും ശേഖരിച്ച *ഓ. ബിർമാനിക്കസി*നാണ് കൂടൽ സൂക്ഷ്മജീവികളുടെ വൈവിധ്യം കൂടുതലുള്ളത്, നഗരപ്രദേശത്തെ സ്പെസിമെനിൽ ഏറ്റവും കുറവ് വൈവിധ്യം കണ്ടെത്തി. ലിൻക്സ് ചിലന്തികളിലെ നാല് തലത്തിലുള്ള അന്വേഷണങ്ങളുടെ സംയോജനമാണ് ഈ പഠനത്തിൽ ഉൾപ്പെടുന്നത്, ഇത് കേരളത്തിൽ നിന്നുള്ള ഒരു നൂതന സമീപനമാണ്, കൂടാതെ സംസ്ഥാനത്തിന്റെ ആവാസവ്യവസ്ഥയിൽ കീട നിയന്ത്രണത്തിൽ സാധ്യതയുള്ള ഉപയോഗങ്ങളുമുണ്ട്.

മുഖ്യപദങ്ങൾ: ലിൻക്സ് പൈഡറുകളുടെ വൈവിധ്യം, ഡിഎൻഎ ബാർകോഡിംഗ്, വംശപരമ്പരാഗത വികാസം, ആതിഥ്യ സസ്യങ്ങൾ, അടുത്ത തലമുറ സീക്വൻസിംഗ്.

ABSTRACT

Lynx spiders (Oxyopidae) are widespread across various ecosystems in Kerala. This family, which does not create webs, comprises fast and visually adept hunters that use speed and precision to ambush their prey, typically found on flowers and leaves. Their distinctive spiny legs and hexagonally arranged eyes enhance their hunting prowess. This study investigates the diversity of Lynx spiders in Kerala. Given the highly cryptic nature of Oxyopids, a more dependable method that integrates classical and molecular taxonomy has been employed instead of traditional techniques. A total of thirty-one Oxyopid species across four genera (*Oxyopes*, *Hamataliwa*, *Hamadruas*, and *Peucetia*) have been identified in Kerala. Notably, this research introduces eleven new *Oxyopes* species: *O. tigris*, *O. peetham*, *O. solea*, *O. ramulus*, *O. auris*, *O. hippocampus*, *O. circum*, *O. aquilae*, *O. kasaragodensis*, *O. thumboormuzhiensis*, and *O. patera*. In addition, *O. striagatus* and *O. shakilae* are recorded for the first time in India. New species identified within the *Hamataliwa* genus include *H. triangulus*, *H. quadrata*, *H. sagitta*, *H. crista*, and *H. rhombiae*. DNA barcoding of the 31 species gives consensus sequences of 19 species only. The adaptability and hunting tactics of Oxyopids make them excellent subjects for evolutionary and ecological studies. The evolutionary relationship of Oxyopids was determined by constructing phylogenetic trees using DNA barcodes derived from the mitochondrial Cytochrome C Oxidase subunit I (COI) marker. Four phylogenetic trees Neighbour Joining, Maximum Parsimony, Bayesian, and Maximum Likelihood - were created to establish more dependable taxonomic placements. As dominant predators of crop pests, Oxyopidae species have promising roles in natural pest control. In this context, the study examined the host plant preferences of Lynx spiders across different ecosystems in Kerala, identified 88 host

plants from 30 families. The Poaceae family showcased the highest species richness and abundance, while Balsaminaceae exhibited the lowest. An observable preference for invasive plants over exotic and native varieties among lynx spiders was noted. Manipulating gut microbes in spiders could enhance Lynx spider populations for natural biocontrol methods, potentially decreasing the reliance on chemical pesticides for pest management. The gut microbial composition in spiders varies based on the ecosystems. The present study compares the gut microbial diversity of *O. birmanicus* from four different ecosystems, including an urban area, forest, dam side and paddy field and identifies 107 bacterial species, 162 genera, 88 families, 56 orders, and 27 classes belonging to 18 phyla. *O. birmanicus* from the dam side has higher gut microbial diversity, and the species from the urban area have the lowest. This study involves integrating four aspects in the Lynx spiders, a novel approach from Kerala, and has prospective uses in pest management in the state's ecosystems.

Key words: Lynx spider diversity, DNA barcoding, phylogeny, host plants, next-generation sequencing.



CHAPTER 1

INTRODUCTION

Chapter 1: Introduction

1.1. Introduction

Human beings have always had conflicts with their surroundings since they shifted from nomadic to permanent settlements. Until then, he was a manservant of nature. As they began encroaching on the ecosystem to meet his needs, his avidity to grab escalated. This progressive escalation of basic requirements into excessive acquisitive behaviour altered his mind, and he considered himself a dominant creature globally. In fact, from that point, our biodiversity became its enemy. It took centuries for man to understand that he was grievously exploiting nature and its diversity. At the first Earth summit, the lion's share of world nations announced trigger points for dismantling Earth's ecosystems, eliminating genes, species, and biological traits at an alarming rate, the result of human activities (Cardinale et al., 2012). Biodiversity loss is a common phenomenon that results from permanent ecological changes from microhabitats to the global biosphere. It is a slow process. In contrast, human-induced species extinctions are drastic and enduring. So far, he does not have exact data on the actual count of existing biodiversity, nor is he aware of how many are extinct, especially among invertebrates. Costello et al. (2013) argued that almost 5 ± 3 million species are present on Earth, with only 1.5 million species named so far. Humans have no idea how many species are in their surroundings, and numerous species are going extinct without proper identification, yet they play a significant role in the ecosystem. Conservation of species and biodiversity is possible only with bona fide expertise on organisms'

characteristics, behaviour, and habitats. Here, taxonomy is significant as a basis for biodiversity conservation.

Invertebrates are among the living groups once largely ignored, but they have gradually gained recognition in Indian taxonomy. Over the past few decades, more works on invertebrates have been published. The phylum Arthropoda receives significant taxonomic recognition. Its members are segmented-bodied, joint-legged, and have a chitinous cuticle. The class Insecta is the most celebrated group within the phylum Arthropoda. The class Arachnida has been gaining importance in taxonomy and ecology in recent decades. Spiders come under this class. They are eight-legged chelicerate invertebrates. The other groups include scorpions, whip scorpions, tailless whip scorpions, pseudoscorpions, mites, ticks, harvestmen, and horseshoe crabs.

1.2. Fascinating Spiders

Spiders are widely distributed except in Antarctica, yet, compared with other animal taxa, they have only recently become the subject of ecological research (Turnbull, 1973; Witt & Rovner, 2014; Wise, 1984; Shear, 1986; Nentwig, 1987). Modern research has established that spiders consume about 800 million tons of prey annually (Nyffeler & Birkhofer, 2017). Spiders usually prefer lepidopterans, hymenopterans, and coleopterans as prey; hence, they are considered among the dominant predators in agroecosystems (Nyffeler et al., 1987). The spiders belong to the order Araneae. Some distinguishing characteristics of spiders include the presence of silk glands in the abdomen, modification of the adult male palp into a secondary sexual organ, and venom glands in the carapace. They make foraging webs using the silk glands, the modified palp used for mating, and the venom gland for prey capture.

When we investigate the morphological features of spiders, we see that the spider's body is divided into cephalothorax (front) and abdomen (back). The cephalothorax is covered with a hard carapace at the top and sternum at the bottom. The anterior segment contains the leg, pedipalps, endites and labium. Spiders have eight eyes, and the region in the carapace is known as the ocular region. Based on their position, the eyes are denoted as anterior, posterior, median, or lateral. The arrangement of these eyes is different in different spider families. So that this feature can be used in taxonomic identification. The fovea is the depression in the carapace where the muscles are attached, also known as the thoracic groove or pit. Muscle or endoskeleton attachment is known as sigila, a circular depression on the sternum. Endite, or maxillae, is the pair of coxae of the pedipalp. Exactly beneath the endites, the labium is a transverse sclerite, an extension of the sternum with a soft membrane and serrated margin. A hardened structure with a fang at its tip is called a chelicera. The chelicera contains cheliceral teeth on its marginal (near the mouth) and rear marginal (away from the mouth) side. The arrangement of retro marginal and marginal teeth and their presence and absence are some taxonomic features used for identification. Venom glands open in the tip fang. Fang also has a microsetae near its base named rastellum. There are four pairs of legs, each with seven segments. The segments near the body to the tip are the coxa, trochanter, femur, patella, tibia, metatarsus, and tarsus. The pedipalp looks like a leg that lacks the metatarsus, with or without palpal claws. Trichobothrium, a singular hair-like setae perpendicular to the body cuticle arising from a pit, functions as a sensory seta to detect the air current.

The spider abdomen is a large and soft part compared to the cephalothorax, covered with a sclerotised plate called the scutum, which is absent in some spiders. The region was where the genitalia, book lungs, spigots, cribellum and spinnerets are

present. Genitalia and the book lungs are present in the anterior ventral side of the abdomen. The former is for reproduction, and the latter is for respiration. Abdominal sigillae are the muscle and endoskeleton attachments that appear as a cuticular depression. In earlier times, spiders had four pairs of spinnerets. Later, they became three. Spiders produce distinct types of silk by using diverse kinds of spigots. In cribellate spiders, the anterior median spinneret becomes fused and functional, called the cribellum. Cribellate spiders also have specialised hairs on the fourth legs called calamistrum. Calamistrum helps to comb the cribellate silk. In ecribellate spiders, there is a non-functional structure called a colulus.

In spider taxonomy, the genitalia of both males and females have greater importance in species differentiation. The female genitalia are known as the epigyne, a hardened structure connected to the ovaries inside the body. Epigyne is situated in the anterior portion below the pedicel. Below the epigyne, an epigastric furrow is present. Inside the epigyne is a paired structure called the spermatheca, which stores the sperm after mating. The structure of the epigyne varies from simple to complex. The male pedipalp is a complex structure, and its complexity varies from species to species. The coiled structure in the pedipalp is called the embolus, which redirects sperm into the spermatheca during mating.

Spider web patterns vary as different in the families. There are six types of webs. A circular web with radii and spirals, as in Araneidae, is called an orb web. *Fecenia* spiders form pseudo-orb webs. Linyphiidae and Cyantholipidae webs are shaped like thin two-dimensional sheets, sometimes with vertical lines. Cobweb is a three-dimensional structure, as in Nesticidae and Theridiidae. A tubular silk-lined burrow

with or without a trapdoor is a primitive foraging web. Members of the family Lycosidae form brush sheet webs that retreat inside the ground (Eberhard, 2020).

Order Araneae includes all the spider families. However, it is further classified into two suborders: *Mesothelae* and *Opisthothelae*. The family Liphistiidae, which provides for primitive spiders, is the only spider family under *Mesothelae*. Liphistiids have tergite plates on the abdomen and spinnerets arranged in the middle part of the abdomen. This group lacks venom glands. Trapdoor spiders belong to this category. They are ambushers and well-camouflaged ones. The suborder *Opisthothelae* is further classified into two infra-orders. One is *Mygalomorphae*, which includes tarantulas (Theraphosidae). They are the most significant and heaviest spiders, with profusely haired, backwardly oriented fangs with the parallel movement of chelicerae, and can live up to 25 years. The second infra-order is *Araneomorphae*, which contains most spiders. Their fangs face each other, and chelicerae move in the transverse direction and have only a single pair of book lungs. The spiny-legged, hexagonally eyed, ecribellate spider family Oxyopidae belongs to this infra-order Araneomorphae and is widely distributed in tropical zones (Churchill, 1998).

1.3. The Lynx spider ‘Oxyopidae’

The family name Oxyopidae is based on the sharp spiny legs; ‘Oxy’ means sharp and ‘pes’ means legs (Thorell, 1869). Members of this family are otherwise known as Lynx spiders. They jump on their prey just like a wild cat (Lynx), hence called Lynx spiders. Every member has six more or less equally sized eyes in a hexagon pattern, with another two eyes below. Hexagonally arranged eyes with profusely spined legs, often blocky, and a powerfully built cephalothorax squared off at the front are this

group's primary morphological identification features up to the genus level. A detailed analysis of the epigyne and pedipalp is needed for the species-level identification of spiders. Most of the epigynes are simple structures, but the pedipalps are complex. Most lynx spiders inhabit the agroecosystem and open vegetation like grasslands. They are highly active in the daytime. These groups are diurnal hunters and show a characteristic posture to catch the prey. The taxonomic and ecological works on Oxyopidae are significantly less compared to other spider groups because it is exceedingly difficult to observe them in the field (Nyffeler & Sunderland, 2003).

Nine genera of Oxyopidae members were identified across the world, including *Oxyopes*, *Peucetia*, *Hamataliwa*, *Hamadruas*, *Tapponia*, *Hostus*, *Pseudohostus*, *Tapinillus* and *Schaenicoscelis*. The above group identified the first four genera of spiders from India, specifically in Kerala. According to the World Spider Catalogue (2026), 438 species of Oxyopidae members were identified worldwide. Regarding the Indian scenario, fifty-eight *Oxyopes*, nine *Hamataliwa*, two *Hamadruas*, and twenty-one *Peucetia* members are identified (WSC, 2026).

Oxyopes

The genus *Oxyopes* was first identified and described by Latreille in 1804. It is a ubiquitous group in all our agroecosystems. They show many colour variations and a wide range of host plant preferences. The members of *Oxyopes* grabbed more attention in India when Pocock described four species of *Oxyopes* (Pocock, 1901).

Peucetia

The first description of the genus *Peucetia* was given by Thorell in 1869. They are green Lynx spiders. They are more significant in their size compared to all other oxyopid members. The members of this group are less studied in India. They are incredibly famous for their greater efficiency in predation.

Hamataliwa

Keyserling, in 1887a, identified and described the genus *Hamataliwa*. They are negligible compared to the other four members. The primary identification features for this group are that the first three legs are directed forwardly, and the fourth is directed backwards. They are usually deep brown or muddy coloured. They typically prefer lower shrubs.

Hamadruas

Deeleman-Reinhold (2009) identified and described the members of *Hamadruas*. Only two members from India were identified, including *Hamdruas sikkimensis* and *Hamadruas insulana*. They are second in size behind the *Peucetia*. Usually, they are dark-coloured.

Habitat

Compared to other taxa, spiders are habitual inhabitants of terrestrial ecosystems. Spiders have various habitat preferences, from forests and grasslands to deserts and urban areas. Their habitat selection is based on the availability of shelter, sustenance, web-building conditions and predatory circumstances. They could live in

vegetation, under rocks, tree barks, inside cracks and crevices. Some are orb-weaving spiders that live in webs and catch their prey. Certain wolf spiders are ground dwellers. Evidence is also available that they are adaptable to dry and humid surroundings.

Members of the Oxyopidae are found in various warm, sunny ecosystems, including tropical and subtropical regions, gardens, agroecosystems, and urban areas. They are rarely seen in dense forests. Lynx spiders are fast-moving ambush predators that capture small insects as their prey. Hence, they are non-web builders. Habitat selection is closely related to their hunting methods, food resources and predator avoidance. They are also adaptable and able to survive in human-modified environments. Lynx spiders could wait for static in the host plant until prey came, then jump on it with exceptional speed. Dense vegetation provides a perfect hiding ground for Lynx spiders.

1.4. Ecological importance of Lynx spiders

When it comes to the ecological role of lynx spiders, they are dominant predators. The members of this group maintain a mutualistic relationship with plant communities. The lynx prefers Hymenopterans, Coleopterans, and Lepidopterans for their diet, which are major predators of plant communities. Hence, the plant protects the lynx from predation and provides shelter. A study on oxyopids found that they are effective biocontrol agents in pest management (Whitehouse & Grimshaw, 2007). However, their wide application in integrated pest management needs a detailed study. Also, their net worth in the agroecosystem is highly contentious given their predation on pollinating agents.

1.5. Collection, preservation, and examination

Several methods are used to collect spiders. Hand collection is the simplest method. Place the collection container near the spider and tap it carefully. This method is more applicable to web-living spiders. Use the inverted umbrella method if the spider lives in foliage and shrubs. Usually, light-coloured ones are used. Hold the umbrella in one hand and shake the shrub with the other so that the spider falls under the umbrella. During application, wear gloves for protection and a headlamp for better visibility. Sweep nets are preferable for collecting spiders inhabiting grass and ground-level herbaceous plants. For spiders living in forest grounds, collect the mud with litter, spread it on a light-coloured plastic sheet on the floor, and isolate the spiders on the sheet. Collect tiny spiders in the litter using a small paintbrush moistened with alcohol. Collect very tiny spiders using an aspirator consisting of two plastic tubes telescoped together, separated by gauze, and attached to a pipe fastener. Blow it into a collection bottle. Nocturnal spiders are collected at night. When a torch is used at night, their webs are easily visible against the night background. Oxyopid members are usually collected by hand-picking and sweep nets.

Spiders are preserved in small vessels containing 70-80% ethanol. Store them in glass or plastic containers with a tight-fitting lid to prevent leakage. For additional protection, dip the specimen into the alcohol in a glass vial, cap it with cotton, and immerse it in the large vessel filled with alcohol. Label the specimen with the date, locality of collection, name of the collector, and name and sex of the specimen. Use alcohol-proof archival ink to label the specimen for long-term preservation.

Examining spiders is challenging because many species share morphological similarities. Identification up to the genus level is possible by observing morphological features. This observation can be done with the naked eye or with a simple microscope. To identify the specimen up to the species level, examine the epigyne and pedipalp structures. Use an advanced stereo-zoom microscope for this.

1.6. Classical vs. Molecular Taxonomy

Taxonomy is a branch of science that groups organisms based on similarities and differences. This branch involves describing, classifying and naming living organisms worldwide based on their morphological, behavioural, genetic, and biological features. The taxonomic classification based on considering species as a basic unit is known as classical taxonomy. It is the most common and traditional way of animal classification. Many taxonomic studies on spiders are based on morphology, especially in India. Most spider identifications, especially in Oxyopidae, have been done through morphological evaluations. Even so, members of the same Lynx spider species show fewer morphological variations, with only minor differences in genital structures. This leads to misidentification of similar species and improper classification. Hence, the morphological classification of Oxyopids requires a novel tool to maintain precise discrimination. This concern underscores the need for genetic taxonomic classification. Molecular taxonomy not only provides species identification but also underpins the phylogenetic history of organisms.

Understanding the phylogenetic relationships among arachnid orders remains challenging, but fossils have helped tie up some branches of the arachnid tree of life. The confirmation of the spider as an ancestral creature and its land origin, long before

vertebrates diverged from their ancestral life, was supported by fossil evidence. A record of the enigmatic, spurious spider *Paleoctenzia* from Scotland *shows that much* of spider evolution occurred during the Devonian period (Agnarsson et al., 2013). An in-depth study of magnificent spider fossils from Carboniferous coal beds found that typical spiders were already in existence. At the same time, there is no clear evidence to confirm that the spider is derived from other organisms, extinct arachnids, or arthropods. There is little evidence that it may be derived from slug-like *Peripatus* (Selden et al., 2009).

The phylogeny of spiders has been the subject of long-standing discussion, yet no universally accepted fundamental pathways have been identified. Phylogeny is the evolutionary history of living organisms. This history is depicted by using fossil evidence and taxonomic classifications. The body of the fossilised spiders in the coal deposits of the Carboniferous period is covered with rigid plates, tergites, and sternites. Earlier spiders were effective hunters (Dunlop & Horrocks, 1996). At first, they used silk to coat the egg with their excretory materials. Ancient female spiders produced eggs in masses, covered with silk, and guarded them against enemies. Palaeozoic spiders show a slight change from their precursors. All modern spiders, derived from the old Mesothelae, were placed in a single group called *Opisthothelae*. At the end of the Palaeozoic era, two main groups of spiders emerged: Mygalomorphae (Tarantulas) and Araneomorphae (true spiders).

Various measures are used to obtain the phylogeny of organisms. Molecular phylogeny is an advanced technique that uses DNA barcoding. It studies the evolutionary relatedness of a group of organisms using DNA and protein sequences. A phylogenetic tree is a graphical or diagrammatic representation of the evolutionary

history of organisms. In molecular phylogeny, the phylogenetic tree is constructed based on differences and close similarities among organisms. It is similar to the case of spiders. Zuckerkandl & Pauling (1962) introduced molecular phylogenetics. According to them, the number of amino acid exchanges between two species is proportional to the divergence time of the species. Molecular taxonomy strengthens traditional evolutionary findings and helps resolve some complex problems regarding branching orders within many evolutionary lineages. Large-scale sequencing projects provide enormous amounts of molecular data to reconstruct detailed phylogenetic trees. It helps build relationships among species, populations, and communities. In molecular phylogeny, maximum parsimony and likelihood methods are used to make a phylogenetic tree.

1.7. Lynx Spider Plant Habits

Spider-plant interactions are an important topic of ecological research. Spiders are highly influenced by plant architecture. Most interactions between spiders and plants are mutualistic or neutral. The host plant provides shelter and accessibility to prey. In turn, spiders protect the host plant from potential plant pests. Orb weavers build webs on host plants that trap flying prey, whereas active predators like jumping and wolf spiders vigorously chase prey on the plant surface. Indirectly, the spiders control insect pests' populations, including aphids, caterpillars, and flies. Spiders are not active pollinators, but they play an indirect role in pollination. Sometimes they capture pollinators such as bees, flies, and butterflies. While catching or releasing the prey from the web, some pollen is released to the flower, leading to cross-pollination. The plants possess defensive mechanisms to avoid spider inhabitation through physical and chemical barriers. Some plants have spiny or hairy structures that serve as physical

barriers, preventing orb weavers from making them their hosts because web-making is difficult. Specific plants produce chemicals that deter spiders or insect pests, keeping them away from those plants. Despite that, there are exceptions, too. For some non-web builders, these defensive mechanisms are a helpful tool for predation and camouflage. Members of the family Lycosidae prefer to live in litter, but they use plant surfaces to catch their prey. Salticids use plants as habitats and for hunting and breeding.

As the lynx's spiders never make a web to capture prey, their predatory success depends on the host plants. The dense foliage, often tall vegetation, reticulate venation, glandular trichomes and spider position in the host are the main limiting factors in lynx's host plant selection and prey capture. Lynx is common in shrubs, grasses, flowers, and crops. Host plants not only provide a preying ground but also protect the spider from predators through camouflage. Host plants function as a protective shield from extreme weather conditions. Lynx has a wide range of habitat preferences, including open forests, grasslands, agroecosystems, gardens, and other human-made ecosystems. Kerala is famous for its rich vegetation and habitat diversity. Lynx's multifarious diet includes various insects, primarily agricultural pests. Plants that attract a variety of small insects, such as flowers with nectar or those infested with aphids, are particularly attractive to lynx spiders.

As active predators of insect pests, investigations on the biocontrol aspect of lynx spiders have not been conducted properly. In Kerala, a richly biodiverse, agriculture-based state, knowledge of lynx spiders' biocontrol efficiency offers excellent opportunities for integrated pest management in the future. Prior to this, a perusal of lynx spider plant preferences is particularly important in India, especially in Kerala.

1.8. Exploring Gut Microbial Diversity in Lynx

Gut microbiota refers to the diversity of microorganisms inhabiting an organism's digestive tract, including bacteria, fungi, archaea, and viruses. Investigations into gut microbial diversity in insect fauna are gaining increasing importance in modern research due to their role in insect physiology and ecology, as well as their potential applications in integrated pest management and biotechnology. In herbivorous insects, gut microbes help break down cellulose and lignin using enzymes they produce. Antimicrobial compounds produced by gut microbiomes prevent pathogens from colonising, thus maintaining gut health and influencing feeding, mating behaviour and communication. The microbial composition of the spider gut may change as insects progress through their life cycles. Microbial communities can influence the growth rate and reproductive success of insects.

Spider gut microbiota remains underexplored compared to that of other arthropods. Spiders are primarily carnivores. Their gut microbes produce enzymes that liquefy proteins, carbohydrates, and other compounds the spider itself cannot digest. The microbiomes can supplement essential nutrients that the spider's diet cannot provide. They detoxify toxins, break down secondary metabolites in prey, and modulate the host's immune system. The microbial community in the spider's gut could control the host's response to environmental cues. Bacteria and fungi are more significant than archaea and viruses in gut microbial communities. The composition of gut microbes is not enduring in nature. It varies with external factors such as ecosystem type, dietary diversity, and evolutionary relationships.

Compared to other spider families, the lynx spider family, Oxyopidae, is particularly important for investigating gut microbial diversity due to its predominantly

predatory nature and its role in pest management. Detailed knowledge of the lynx's gut microbiome provides beneficial insights into their behaviour, physiology, and ecology. Understanding the gut microbiome enables researchers to enhance spider digestion and improve spiders' role as biocontrol agents against pests. Knowledge of pathogen-resistant microbes helps develop strategies to prevent the decline of the spider population and maintain a healthy spider community. To address the above applications, it is essential to have a basic understanding of the microbial diversity of the lynx spider gut, which has not been studied before in Kerala. Along with investigations into the habitat preferences of lynx spiders in Kerala, understanding gut microbial diversity is indispensable for future spider applications that benefit pest management.

The Oxyopidae members identified from India are either from a state or a type locality. This points to a call for a detailed and explicit study of the Oxyopid members all over India (Singh, 2021). According to Harmon et al. (2010), in spider identification and classification, it is best to use classical and molecular methods, with careful examination of protocols, to resolve or identify taxonomic problems. The present study involves a combination of classical and molecular taxonomic tools to identify the members of Oxyopidae in Kerala and try to elucidate the phylogenetic history of Oxyopidae. In addition, a detailed study of Lynx spiders' host plant preferences in Kerala was conducted. A preliminary gut microbial analysis of the dominant lynx spider, *Oxyopes birmanicus*, was conducted across four ecosystems.



CHAPTER 2

REVIEW OF LITERATURE

Chapter 2: Review of Literature

Spiders have inhabited Earth for 400 million years, dating back to the Devonian period. They are diverse, predatory arthropods (Luddecke et al., 2022). A new extinct arachnid order, Uraraneida, was identified from the fossils of spiders of the Devonian period. It points to the view that spiders are twice as old as mammals (Selden et al., 2008; Dunlop & Penny, 2012). The spiders akin to their present-day species were abundant as early as the Tertiary period, roughly 70 million years ago (Foelix, 1996). Spiders have become a successful group due to their varied ways of using silk (Hilliard, 1994; Carwardine, 1995). Spiders can make distinct kinds of silk. However, the primary ecological function of silk is to build prey-catching webs. The ability to disperse by ballooning through the atmosphere makes them colonise various habitats (Nyffeler & Birkhofer, 2017). According to the World Spider Catalogue 2026, almost 53305 spiders have been identified to date, belonging to 4471 genera and 138 families. The ecological role of spiders as insectivores has been widely recognised only in recent decades; most biologists are unfamiliar with the specific feeding habits of this remarkably diverse order (Nyffeler et al., 1994). According to Caleb & Sankaran (2026), 1977 spider species from 514 genera and 63 families were identified in India. Spider classification up to the family level is a dynamic area of research worldwide, including in India. In 1869, in his review of the European genera of spiders, Thorell discovered a new family of spiny-legged, hexagonally eyed spiders, the Oxyopidae. This family belongs to the Lycosoidea superfamily of Araneomorph spiders.

2.1. Classical taxonomy works on Oxyopidae

The family Oxyopidae holds ten genera. The genus *Oxyopes* was first described by Latreille in 1804, using *Aranea heterophthalma*, the senior synonym of *Sphasus* Walckenaer, 1805. Genus *Oxyopes* is the most abundant and widely distributed in this family. According to the World Spider Catalogue 2026, 284 *Oxyopes* species have been identified worldwide. To date, sixteen species of *Oxyopes* have been transferred into *Hamataliwa* Keyserling, 1887, and *Hamadruas* Deeleman-Reinhold, 2009, both genera belonging to the family Oxyopidae. These species include *O. banksi* Mello-Leitão, 1928; *O. barroanus* Chamberlin & Ivie, 1936; *O. bikakaeus* Barrion & Litsinger, 1995; *O. brunneus* F. O. Pickard-Cambridge, 1902; *O. cambridge* Mello-Leitão, 1928; *O. clypeatus* F. O. Pickard-Cambridge, 1902; *O. globosus* F. O. Pickard-Cambridge, 1902; *O. helius* Chamberlin, 1929; *O. labialis* Song, 1991; *O. ovatus* Biswas et al., 1996; *O. pupulus* Thorell, 1890; *O. reticulatus* Biswas et al., 1996; *O. sikkimensis* Tikader, 1970; *O. subhadrae* Tikader, 1970; *O. triangularis* Kraus, 1955; and *O. tricuspidatus* F. O. Pickard-Cambridge, 1902. *O. arcuatus* Walckenaer, 1837, was transferred to the genus *Spintharus* within the Theridiidae family as *S. arcuatus* by Brady in 1964.

Thirty species of Oxyopidae were synonymised. *O. aequior* was synonymised with *O. sertatus* by Koch in 1878. *O. atticus*, *O. eymiri*, and *O. maracandensis* were later identified as *O. globifer* Simon, 1876 (Levy, 1999). *O. cinereus*, *O. classicus*, *O. scalaris*, *O. compactus*, *O. pictipes*, *O. rufipes*, and *O. tanneri* were synonymised as *O. scalaris* Hentz, 1845 by Brady in 1964. *O. javanus nicobaricus* is now known as *O. javanus* Thorell, 1887 (Nentwig et al., 2019). Recently, Caleb & Wijesinghe synonymised *O. nilgiricus*, *O. pankaji*, and *O. ratnae* under *O. hindostanicus* Pocock, 1901 in 2022.

Forty-nine Oxyopids were identified from India. Most of the taxonomic identification, description, and redescription of *Oxyopes* are provided by Gajbe (1999) in his work titled 'Fauna of India and Adjacent Countries'. He discovered *O. ashae*, *O. bharatae*, *O. biharensis*, *O. gujaratensis*, *O. jabalpurensis*, *O. kamalae*, *O. ketani*, *O. kusumae*, *O. naliniae*, *O. pawani*, and *O. rukminiae*. He provides an account of the general and taxonomically significant morphological features of 35 *Oxyopes* species. His study area covers West Bengal, northeast and north India, and some parts of southern India. *O. birmanicus*, *O. shweta*, and *O. javanus* are the most common inhabitants of Indian gardens, especially in Kerala and the Northeast regions. A first report and detailed redescription of these members were provided by Tikader & Biswas in 1981 in their publication 'Spider Fauna of Calcutta and Vicinity'. They identified two new species, *O. pandae* and *O. assamensis*, from Uttar Pradesh, India. *O. armatipalpis* Strand, 1912, *O. boriensis* Bodkhe & Vankhede, 2012, *O. dinendrai* Sen & Sureshan, 2021, *O. fabae* Dhali et al., 2015, *O. gorumaraensis* Sen et al., 2011, *O. haryanaensis* Goyal & Malik, 2020, *O. hotingchiehi* Schenkel, 1963, *O. kohaensis* Bodkhe & Vankhede, 2012, *O. kumarae* Biswas & Roy, 2005, *O. linearis* Sen et al., 2015, *O. longinquus* Thorell, 1891, *O. minutus* Biswas et al., 1996, *O. praedicta* Pickard-Cambridge, 1885, *O. rajai* Saha & Raychaudhuri, 2003, *O. saradae* Biswas & Roy, 2005, *O. sataricus* Kulkarni & Deshpande, 2012, *O. scapeus* Sen & Sureshan, 2021, *O. thumboormuzhiensis* Amulya et al., 2022, and *O. travancoricola* Strand, 1912 are commonly seen in Indian ecosystems.

Although the genus *Oxyopes* is more abundant, *Peucetia* receives greater recognition in ecological, dietary, and behavioural studies. This broad recognition is due to its abundance, size and colour. Thorell reviewed the European genera of spiders and contributed a new genus, *Peucetia*, widely distributed in tropical regions (Santos

& Brescovit, 2003). They are medium-sized and green-coloured, and their chelicerae are toothless (Van & Dippenaar, 1994). Forty-seven species of *Peucetia* are known worldwide. Santos & Brescovit (2003) noted that members of the *Peucetia* are primarily distributed in tropical areas, and only the African species were given detailed revisions. They synonymised *P. amazonica* Mello-Leitão, 1929, *P. argentina* Mello-Leitão, 1941, *P. duplovittata* Mello-Leitão, 1941, *P. heterochroma* Mello-Leitão, 1929, *P. maculipedes* Piza, 1938, *P. roseonigra* Mello-Leitão, 1943, *P. similis* Keyserling, 1877, *P. trivittata* Mello-Leitão, 1940 into *P. rubrolineata* Keyserling, 1877. Also synonymised *P. bibranchiata* F. O. Pickard-Cambridge, 1902, *P. poeyi* Lucas, 1857, *P. rubricapilla* Petrunkevitch, 1925, with *P. viridans* Hentz, 1832. *P. cauca* Lourenco, 1990 changed to *P. longipalpis* F. O. Pickard-Cambridge, 1902. Van & Dippenaar (1994) revised the Afrotropical species of *Peucetia*. This revision synonymised *P. fasciiventris* Simon, 1890; *P. foliifera* Butler, 1879; and *P. rubrosignata* Strand, 1906 into *P. striata* Karsch, 1878. A similar degree of affinity was observed by Benoit in 1977; he synonymised *P. fasciiventris kunenensis* Lawrence, 1928, and *P. fasciiventris longistriga* Strand, 1913, with *P. striata*. *P. langi* Lessert, 1927 and *P. longipes* Pocock, 1900, are presently called *P. casseli* Simon, 1900, due to their high-level similarity with the latter species (Van & Dippenaar, 1994; Blick & Gloor, 2017). Currently, *P. lampei* Strand, 1906 and *P. viridissima* Franganillo, 1926, are known as *P. viridis* Blackwall, 1858 (Van & Dippenaar, 1994; Barrientos, 1991).

As per the revision done by Santos & Brescovit in 2003 on “Neotropical species of the genus *Peucetia*”, the taxonomy of *Peucetia* is so complex that it is infeasible to identify some specimens from specific regions around the globe. This complexity became a barrier to natural history studies. Even so, the taxonomic understanding of *Peucetia* is more advanced than that of any other oxyopid. They found a close affinity

between *P. meridionalis* Mello-Leitao, 1929, *P. rubrigastra* Mello-Leitao, 1929, *P. tranquilini* Mello-Leitao, 1922, *P. villosa* Mello-Leitao, 1929, *P. viridisternis* Mello-Leitao, 1945, and *P. flava* Keyserling, 1877. Hence, all of them are synonymised with a single species, *P. flava*.

Eighteen species of *Peucetia* were identified in India. *P. ananthakrishnani* is a new species identified in Tamil Nadu by Murugesan et al. in 2006. This species resembles *P. pawani* Gajbe, 1999, but differs in its genital characteristics. Gajbe (1992, 1999, 2008), in his work titled 'Fauna of India and adjacent countries', described nine new species of *Peucetia* from various parts of India. It includes *P. yogeshi*, *P. viveki*, *P. rajani*, *P. punjabensis*, *P. pawani*, *P. ketani*, *P. jabalpurensis*, *P. biharensis*, and *P. ashae*. He also gave a detailed redescription of *P. akwadaensis* Patel, 1978; *P. choprai* Tikader, 1965; *P. gauntietia* Gajbe, 2008; *P. harishankarensis* Biswas, 1975; and *P. latikae* Tikader, 1970. Saha & Raychaudhuri (2007) conducted a study on the lynx spiders of Betla Forest, Jharkhand, and identified a new species of *Pecucetia*, *P. betlaensis*. Blackwall (1864) describes the new species, *P. elegans*, from East India. *P. graminea* was first identified by Pocock in 1900. It is included in his work 'The Fauna of British India'. Biswas & Roy (2005) described the species *P. rangathanani* for the first time, *P. phantasma*, a tree-dwelling *Peucetia* described by Ahmed et al. (2015). In the Zoological Survey of India, Tikader & Biswas (1981) collected and redescribed *P. viridana* Stoliczka, 1869 from Calcutta.

The genus *Hamataliwa* is a small member of the family Oxyopidae and has a perplexing history. They were once placed in the Agalenoidae family and later transferred to the Oxyopidae family (Keyserling, 1887b). Pickard-Cambridge (1894) described seven species of Oxyopidae and grouped them in the genus *Oxyopeidon*. *Oxyopeidon* differs from *Hamataliwa* only in eye arrangement; however, this character

was considered invalid because eye arrangement is not a credible tool for distinguishing taxa, as proposed by Brady in 1964. He synonymised *Oxyopeidon* with *Hamataliwa* and redefined *Hamataliwa*, giving greater emphasis to the structure of the male and female genitalia, especially the form of the embolus. He transferred many *Oxyopes* to *Hamataliwa*. According to the World Spider Catalogue (2026), 87 *Hamataliwa* species have not yet been identified.

Brady (1970) studied *Hamataliwa* species from Mexico and Central America. He identified five new species of *Hamataliwa*, including *H. ursa*, *H. hista*, *H. crocata*, *H. cheta*, and *H. bufo*; synonymised *H. absoluta* Chamberlin, 1924 and *H. absoluta obliqua* Chamberlin, 1924 with *H. grisea* Keyserling, 1887, the type species of the genus *Hamataliwa*; noted *H. molesta* as *H. difficilis* Pickard-Cambridge, 1894; and treated *H. cambridgei* Mello-Leitão, 1928, transferred from *Oxyopes* as *H. banksi* Mello-Leitão, 1928. *H. cubana* Chamberlin, 1925, was synonymised with *H. rana* Simon, 1898 (Bryant, 1940).

Deeleman-Reinhold (2009) did distinguishable work in the field of *Hamataliwa* taxonomy. As part of a canopy fogging project in northern Borneo, she described five new species of *Hamataliwa*. She synonymised an *Oxyopes* species (*H. bikakaeus* Barrion & Litsinger, 1995) as *H. incompta* Thorell, 1895. She discovered *H. catenula*, *H. cornuta*, *H. floreni*, *H. ignifuga*, *H. peterjaegeri*, *H. pricompta* and *H. vanbruggeni*. Also redescribed *H. obtusa*, *H. latifrons*, *H. incompta*, *H. helia*, *H. fronto* and *H. cornuta*. A detailed study of *Oxyopes* species in Brazil conducted by Mello-Leitao (1929) led to the discovery of 11 species of *Hamataliwa*. They include *H. argyrescens*, *H. bicolor*, *H. bituberculatum*, *H. caudata*, *H. dubia*, *H. micropunctataum*, *H. marmorata*, *H. nigrescens*, *H. nigriventre*, *H. perdita*, and *H. quadrimaculatum*. In

1943, he discovered two new species, *H. albibarbis* and *H. buelowae*. *H. penicillata* was identified in 1945.

Taxonomic work on *Hamataliwa* from India is scarce. Only a few works are available. Dhali et al. (2017) conducted taxonomic work on spiders inhabiting the litter and ground of the Dooars, West Bengal, reserve forests. They identified a new species of *Hamataliwa*, *H. hellia*, and redescribed *H. incompta*. Amulya et al. (2022a, 2022b) identified two *Hamataliwa* species from Kerala, including *H. crista* and *H. rhombiae*, and also identified *H. sagitta* in 2024. Sen & Sureshan (2022) located *Hamataliwa indica* in the Western Ghat of India and redescribed *H. ovata* and *H. reticulata*. Tang & Li (2012) reported the first record of *H. subhadrae*, which Tikader (1970) had identified as *O. subhadrae*. Asalatha & Prasadani (2020) reported the first occurrence of *H. pentagona* Tang & Li, 2012, previously known only from China.

In 1929, a new genus, *Hamadruas*, was introduced within the family Oxyopidae by Deeleman-Reinhold (2009), based on the type *O. hieroglyphicus* Thorell, 1887. Currently, its presence is limited to Asia. Nine species of *Hamadruas* have not yet been described. India has only two representatives of this genus. Earlier, all the members of *Hamadruas* were included in the genus *Oxyopes*, along with *Tapponia*; later, Deeleman-Reinhold (2009) transferred them into a new genus. *H. austera* Thorell, 1895, *H. heterosticta* Pocock, 1897, *H. hieroglyphica* Thorell, 1887, *H. insulana* Thorell, 1891, *H. pupulus* Thorell, 1890, *H. severa* Thorell, 1895, *H. signifera* Doleschall, 1859, *H. sikkimensis* Tikader, 1970, and *H. superba* Thorell, 1887 are the members of this genus. *H. insulana* is reported only from the Nicobar Islands of India. *H. sikkimensis* enjoys a wide distribution all over India.

Genus *Hostus* Simon, 1898; *Pseudohostus* Rainbow, 1915; and *Tapponia* Simon, 1885 belong to the family Oxyopidae and have only one representative each,

none of which is present in India. The genus *Shuqiangius* Wang, Marusik & Yao, 2025 has two representatives. The remaining genus, *Schaenicoscelis* Simon, 1898, had seven members, except for one identified from Guyana, and all were identified only from Brazil. One more genus, *Tapinillus* Taczanowski, 1872, has three members collected from Brazil and some regions of North America.

Research on spiders is being done in India. A group of Indian researchers has been focusing on spider taxonomy over the past few years. However, it is unfortunate to note that the taxonomic aspects of Oxyopidae have not been well studied in India in recent decades, apart from a few new species discoveries and new reports from some parts of India, especially from Kerala.

2.2. Molecular taxonomy to trace phylogeny among Oxyopids

Spider taxonomy has now entered a new phase with the advent of modern genetic technologies. In this taxonomic method, a short genetic marker in the organism's DNA is used for identification up to the species level. It is considered an additional taxonomy tool to overcome the taxonomic impediments (Gaikwad et al., 2017). Though several markers are available, Mitochondrial Cytochrome Oxidase (COX1) is considered the most suitable marker for DNA barcoding (Herbert et al., 2003). DNA barcoding not only supports species identification but also reveals the phylogenetic history of the respective organism. From molecular phylogenetic analysis, evolutionary biologists can understand two aspects. The first one is the species that share the same cohesive lineages based on their morphological similarities, which represent cryptic lineage complexes (Riddle et al., 2000; Zink et al., 2001). And secondly, commonly, the taxa co-distributed in the same geographical area may show

indistinguishable phylogenetic structuring (Avice & Ball, 1990). DNA barcoding and molecular phylogeny are widely used worldwide. In the Indian scenario, these techniques are novel or rarely used in spiders, especially in Oxyopids.

Mondejar & Nuneza (2018) conducted a study on pholcids to understand the effectiveness of DNA barcoding for species identification. The study analysed 61 CO1 sequences from 12 pholcids and achieved 95.08% diagnostic effectiveness in neighbour-joining (NJ) clusters. In barcode analysis, they observed a barcode gap, with the distance between neighbouring species ranging from 0.16 to 19.69%. Hence, they concluded that DNA barcoding is an efficient tool for better understanding species diversity among pholcids.

According to Blagoev et al. (2016), DNA barcoding could overcome the difficulties in identifying cryptic species by delineating species and accelerating specimen identification. 7394 DNA barcode sequences were created from 170 morphologically identified Nearctic wolf spider species, and a DNA barcode reference library for Nearctic lycosids was composed, confirming that DNA barcodes are best for species identification. A Barcode of Life campaign conducted in Germany collected and analysed 3,300 Araneae and 200 Opiliones. The barcoding of the above specimens shows a median distance of 9% in spiders and 13% in harvestmen. In most cases, intraspecific distances were below 2.5% and 8%, respectively, with intraspecific medians of 0.3% and 0.2%, respectively. They could not distinguish almost 20 species from the family Lycosidae through DNA barcoding (Astrin et al., 2016).

Nadolny et al. (2016) used DNA barcoding to determine the boundaries of the closely related spider species *P. lugubris* and *P. alacris*. Similar work was done by Blagoev & Dondale (2014), who identified a new species, *Alopecosa koponeni*, which closely resembles *A. pictilis* Emerton, 1885, but is smaller and differs in colour pattern

and epigyne structure. Their barcode result shows an interspecific distance of 0.93, highlighting recent separation or shallow genetic divergence.

Hazzi & Hormiga (2023) conducted a molecular phylogenetic study of tropical wandering spiders (Ctenidae) using five nuclear (Histone H3, 28S, 18S, Actin, and ITS-2) and four mitochondrial (NADH, COI, 12S, and 16S) markers and estimated divergence times using fossils as calibration points and biogeographic events. They found that *Ancylometes* Bertkau, 1880, is a genus in the family Ctenidae, recognised as the sister group of Oxyopidae.

A revision of the spider genus *Oxyopes* Latreille, 1804 in Taiwan was done by Lo et al. (2021). They identified species boundaries by considering morphological and molecular characters in seven oxyopids from Taiwan. Partial COI sequences were used for molecular phylogeny and species delimitation investigations. Maximum Likelihood Bayesian phylogenies and DNA barcoding gap analysis strengthened the accuracy of morphologically identified species. The Automatic Barcode Gap Discovery (ABGD), PID (Liberal), and Generalised Mixed Yule Coalescent (GMYC) tools used in species delimitation analyses proved inappropriate for species assignment. The examination found that interspecific genetic divergence between *O. sertatus* and *O. taiwanensis* was relatively low ($1.28 \pm 0.43\%$), whereas it was relatively high in *O. striagatus*.

Wheeler et al. (2017) conducted a molecular phylogenetic analysis of 932 spiders from 115 families using six markers from the mitochondrial (12S, 16S, COI) and nuclear (histone H3, 18S, 28S) genomes. They used multiple methods, including constrained analysis based on a backbone tree from transcriptomic data. They obtained a monophyletic oval-calamistrum clade that includes Oxyopidae. They also noted that their data regarding the monophyly of Oxyopidae is ambiguous.

The complete mitochondrial genome of *O. sertatus* was analysed by Pan et al. (2019), and a circular molecule of 14,442 bp in length was identified. The mitochondrial genome contains 13 protein-coding genes, two ribosomal RNAs, 22 transfer RNAs, and a control region. Li et al. (2022) conducted a comparative mitogenomic analysis of the retrolateral tibial apophysis (RTA) clade, Araneae's most extensive spider lineage, to better understand diversity and evolution. They also considered the oval calamistrum clade, where the Oxyopidae are sister to the Lycosidae plus Pisauridae, and addressed the monophyly of Oxyopidae and Gnaphosidae. In their analysis, they used six molecular markers and found that *Senoculus* (Araneae: Senoculidae) was closely related to some Oxyopidae species, confirming the diphyletic nature of Oxyopidae.

The estimation of divergence time using fossil calibrations was done using the BEST tool. *Zamilia aculeopectens* Wunderlich, 2015 (Oecobiidae) is the fossil used for calibration of divergence time. The node speaks for Oecobiidae, *O. succini* Petrunkevitch, 1958 (Oxyopidae) for Oxyopidae + Pisauridae (Gorneau et al., 2023). Su et al. (2007) conducted a molecular phylogenetic study on Salticidae. The study found that Thomisidae and Oxyopidae are potential sister groups of Salticidae. They are polymorphic in the construction of prey-catching webs.

Afzal et al. (2020) distinguished five spider species, including Oxyopidae, using COI gene sequences. They compared these with 40 previously published GenBank sequences based on the maximum similarity index. COI gene sequences from all five spider species were deposited in GenBank. Zhang & Maddison (2013) investigated the phylogenetic relationships of jumping spiders using molecular phylogeny obtained from Bayesian, likelihood, and parsimony methods. They also derived divergence times and biogeographic patterns.

Yang et al. (2019) found a close phylogenetic relationship between *O. hupingensis* and *O. sertatus* by comparing the COI sequences of the two. Ashfaq et al. (2019) did a morphological study of 1,795 individuals from 27 families in Pakistan. The specimens were subjected to Neighbour-joining trees, Bayesian inference, barcode gap analysis, and Barcode Index Numbers (BINs) analysis using the COI sequences and 400 bp recovered. From the above analysis, it could be identified that the maximum conspecific divergences ranged from 0-5.3%, and congeneric distances varied from 2.8-23.2%, except in the case of a pair, *O. azhari* - *O. oryzae*, where the maximum intraspecific distance was always less than the nearest-neighbour (NN) distance. It made them conclude that intraspecific divergence values are not significantly correlated with geographic distance.

Mehmood et al. (2021) conducted a DNA barcoding analysis to verify spider composition in the agroecosystems of Punjab using COI sequences from 90 specimens. Neighbour-joining trees separated the species into various clusters. They confirmed an Oxyopid composition of 13.51% from these specimens, including *O. tiengianensis* Barrion & Litsinger, 1995; *O. aspirasi* Barrion & Litsinger, 1995; *O. javanus* Thorell, 1887; *O. oryzae* Mushtaq & Qadar, 1999; and *O. hindostanicus* Pocock, 1901.

2.3. Molecular Phylogenetic Works in India

Chatterjee et al. (2017) provided barcode data of *Menemerus nigli* Wesolowska & Freudenschuss, 2012, which was reported for the first time from Eastern India. They confirmed the species as the original western Pakistani species based on sequence similarity in the BOLD database. Kulkarni et al. (2017) did a parsimony analysis and Bayesian inference and placed *Meotipa sahyadri* n. sp. and *Meotipa picturata* within

the Theridiidae family as a sister group to *Chrysso*. Both species have monophyletic origins. Lasker et al. (2022) conducted a molecular analysis to determine the exact faunal diversity of Kotumsar cave in the Eastern Ghats. They collected environmental DNA samples and conducted DNA barcoding. They identified *Heteropoda leprosa* in the environmental samples. Gaikwad et al. (2017) generated DNA barcodes for 60 spider species in India, including Oxyopidae, for the first time. The first large-scale attempt at DNA barcoding of spiders from India, by Tyagi et al. (2019), included 101 morphospecies from 72 genera across 21 families, including Oxyopidae, and demonstrated that DNA barcoding is a valuable tool for specimen identification and species discovery in Indian spiders. They detected shallow genetic distances in *Cyrtophora cicatrosa*, *Hersilia savignyi*, *Argiope versicolor*, *Phintella vittata*, and *Oxyopes birmanicus*.

Jalajakshi & Usha (2019) conducted a DNA barcoding of *Argiope aemula*, *Nesticodes rufipes*, *O. lineatype*, *Leucauge decorata*, *Nephila kuhli*, and *Nephila philipis* using CO1. After sequencing, the DNA sequence is subjected to a BLAST search for sequence similarity. It was found that all species in the study belonged to different families that shared a common ancestor. *O. lineatype* emerged as an out-group from other members. *Argiope aemula* and *Laevis decorata*, which share a common ancestor, show homology. *Oxyopes* sp., as reported by Kumari et al. (2025), showed a close relationship between the Indian population and that of China. According to Yuan et al. (2020), molecular species delimitation based on ABGD, PID, and GMYC was incongruent in species assignment and showed that the interspecific genetic divergence between *O. sertatus* and *O. taiwanensis* was relatively low ($1.28 \pm 0.43\%$). The intraspecific genetic divergence of *O. striagatus* was relatively high ($1.69 \pm 0.35\%$).

2.4. Spider – Host plant associations

Habitat structure and prey availability are always the limiting factors in spider biology. Both biotic and abiotic factors of the ecosystem transmute the spider's attributes. Spiders' habitat selection is based on their innate characteristics. Plant height, plant cover, foliage density, inflorescence, prey availability, environmental conditions, and protection from predators are the decisive factors in spider habitat selection. Arango et al. (2000) examined the population structure, seasonality, and habitat use of the green lynx spider, *P. viridans*. Spiders can recognise and evaluate the physical state of the microhabitat. Alterations in these microhabitats can destabilise this spider–plant association (Rypstra et al., 1999). The plant parameters and the number of male and female flowers determine the number of *P. viridans* on *Ciliato glanduliferus*, and spotted those adult spiders that were positively associated with plant cover. Many inflorescences and male flowers may attract more pollinators and serve as cues for spider prey availability. This validates the idea that plant architecture alters spider habitat preferences (Jimenez & Corcuer, 2008). Crab spiders exhibit a predilection for *Senna rugosa*, *Styrax ferrugineus* and *Banisteriopsis campestris* as their natural territory.

There was a prior notion that plants and spiders have negative associations; however, modern research provides verifiable evidence of a high likelihood of mutualistic relationships between plants and spiders (Morais & Romero, 2008). The host plant provides shelter to the spider, whereas the spider consumes the host's pests and bestows protection on the host. *Oxyopes gracilipes* White, 1849, is a common inhabitant of *Carpobrotus edulis* (L.). *O. Javanus* dwells in rice plants (*Oryza sativa*) in agroecosystems (Tahir & Butt, 2009). The polyphagous predator *O. globifer* is

inclined towards *Salsola nodulosa* plants because the primary food of the worker ant, which occurs in the above plant, is found there (Oglu, 2006). *O. salticus* is the most abundant inhabitant in cotton plants and controls diverse arthropod pests in cotton; hence, cotton plants are protected (Nyffeler et al., 1987). Spider communities in an ecosystem change as plant communities change (Lowrie, 1948). Present-day ecosystems are highly prone to the invasion of nuisance plants, which alter spider distribution, especially among Oxyopidae. Even though Oxyopids are dominant predators in agroecosystems, gardens and forests, members of this family have received scant attention in India. Members of the Lynx genus have the greatest potential as biocontrol agents. Unfortunately, there is little data on the ecological behaviour of lynx spiders, aside from taxonomic works. Understanding the host plant preferences of Oxyopid members is necessary, as it is fundamental for future use of lynx in an economic context. Detailed knowledge of spiders' relative position in the host plant is obligatory to maximise the target-specific application of lynx biocontrol potential. The Oxyopid members usually prefer hairy or spiny plants with rosette architecture. However, there are exceptions as well. Changes in the rosette architecture, inflorescence, plant size, and leaves will alter the lynx's habitat selection.

De Sousa et al. (2019) found that the lynx spider *Peucetia flava* is more attracted to the Brazilian Cerrado, the plant *Mimosa setosa* var. *paludosa*, from the Fabaceae family and concluded that both show facultative mutualism, where the spider gets its prey from the host plant, and in return, they protect the plant from damage caused by the herbivore. A survey in three localities of southeastern Brazil to determine plant choice in lynx spiders, *Peucetia rubrolineata* and *P. flava*, revealed that these species associated with 55 plant species. *Peucetia* prefer plants with glandular trichomes (Vasconcellos et al., 2007). *P. flava* acts as a protector for their host plant *Solanum*

thomasiifolium by feeding the leaf miners (Jacobucci et al., 2009). According to Guzmán-Vásquez & García (2024), *Peucetia viridans* is associated with *Croton ciliatoglandulifer* Ortega, *Lantana camara* Linnaeus, *Solanum mitlense* and *Wigandia urens*, plants from the Valles Centrales region of Oaxaca. Due to the abundance of prey sources in these plants, they also inhabit *Cnidoscolus multilobus* (Gutierrez et al., 2012). Villanueva-Bonilla et al. (2019) revealed that Oxyopidae members coexist and exhibit niche partitioning. *Peucetia rubrolineata* and *P. flava* co-exist in the host plant *Trichogoniopsis adenantha* of the Asteraceae family. *P. rubrolineata* opts for the shaded areas of *T. adenantha*, whereas *P. flava* favours the open areas of the host plant. Miliczky & Horton (2007) observed that *Oxyopes scalaris* is a common inhabitant of native plants in apple and pear orchards. Butt & Xaaceph (2015), in their surveys on paddy fields of Punjab, noted that *O. javanus* is the dominant spider in the rice plants and feeds on plant hoppers. There is a close association between the plant *Cnidoscolus multilobus* and *Peucetia viridans* (Arango et al., 2012). *Peucetia viridans* colonise in *Croton ciliatoglandulifer*, and their distribution depends on the plant height, cover, and inflorescences of the host plant (Corcuera et al., 2010). Morais-Filho & Romero (2008) conducted a study on the microhabitat use of *Peucetia flava* on the glandular plant *Rhyncanthera dichotoma* of the Melastomataceae family and recorded the vertical distribution of spiders of different ages in the plant canopy; distribution depended on prey and leaf availability. The host plant associations of Oxyopidae members in *Vitis vinifera*, *Bursaria spinosa*, and *Leptospermum continentale* were studied by Retallack et al. (2019). Arango and his colleagues conducted a 2000 study of the plant association of *Peucetia viridans* on *Cnidoscolus aconitifolius* and concluded that spider distribution was higher on isolated plants and lower in plants in a patch. Singh & Sekhar (2020) reported high genetic diversity among Oxyopid species in fruit crops in Punjab.

Oxyopids are common inhabitants of tomato, kidney bean, maize, and shallot (Memah et al., 2014)

Kerala is a state in the Western Ghats. This geographic zone has rich flora and fauna—conservation is as important as protecting related species. Lynx spiders are widely distributed all over Kerala and act as natural pest control agents. Future use of lynx spiders as biocontrol agents in pest management requires detailed knowledge of their associations with host plants. Such studies have not yet been conducted in Kerala. The present study aims to identify the host plant preferences of Oxyopids in Kerala and to determine spiders' relative positions on host plants.

2.5. Lynx's Gut Microbial Diversity - An investigation

A healthy gut microbiota is responsible for the host's overall health (Jandhyala et al., 2015). Sekirov et al. (2010), in their study on the influence of gut microbiota on disease and health, state that an organism's gut microbial makeup is host-specific and changes in response to endogenic and exogenic factors. Gibiino et al. (2017) investigate the anatomy and physiology of gut microbiota over a lifetime and propose that advances in modelling and analysing gut microbial diversity will help customise existing and future therapeutics and prophylactic modalities. An organism's diet can have short- and long-term effects on its gut microbial community; thus, microbial composition can be manipulated through diet. A mutual give-and-take occurs between the gut microbiota, diet, and health (Flint et al., 2012).

Gut microbial diversity in arthropods has always been an interesting subject for researchers since the invention of the NGS technique (Eichler & Schaub, 2002; Hu et al., 2019), which was successfully implemented in termites, ticks and scorpions (Nakao

et al., 2013; Brune & Dietrich, 2015; Bolanos et al., 2016). In insect hosts, gut microbiota influences parasite and pathogenic resistance, nutrient supply, cell renewal, and diet (Koch & Schmid, 2011). Gut microbes produce molecules that enable interspecies communication (Leroy et al., 2011). This makes sense when considering the gut microbiota as a biological organ in insect systems (Backhed et al., 2005). Spiders are members of the phylum Arthropoda, which are widely distributed around the globe (Nyffeler & Sunderland, 2003). Microbial diversity in spider guts depends directly on their environment and diet and is transmitted vertically through the prey they consume (Sheffer et al., 2019). Yuan et al. (2020) examined 31 Chinese spiders and proved horizontal transmission of *Wolbachia* between prey and predator. Despite spiders' crucial role as generalist predators of crop pests in sustainable agro-ecosystems, research on the microbial communities of these creatures remains relatively limited (Liu et al., 2023). Some spiders act as biological control agents against cotton and apple orchard pests and can also serve as ecological indicators (Churchill, 1997; Maelfait & Hendrickx, 1998; Marc et al., 1999). Recent studies on spider microbial communities focused on endosymbionts like *Rickettsia*, *Wolbachia* and *Spiroplasma* (Duron et al., 2008; Sanada et al., 2013; White et al., 2020), which positively influence reproductive health, reproductive success and evolution in a host (Mao et al., 2020; Perlmutter & Bordenstein, 2020). Spiders of different families have distinct predatory strategies, leading to differences in microbial diversity (Zhang et al., 2017). Paula et al. (2015) and Bili et al. (2016) classified gut microbes into 1) resident core microbes, which never change their composition, and 2) Prey-associated microbes, which vary based on the prey composition. Irregularity in the feeding behaviour of spiders disrupts their gut microbial community, hindering the establishment of a stable gut microbial environment (Vanthournout & Hendrickx, 2015). Kennedy et al. (2020)

identified an explicit association between prey and gut microbiome in the spider species *Badumna longinqua*, and Hu et al. (2019) found that Tenericutes, Actinobacteria, Firmicutes and Bacteroidetes are dominant in the spider gut. Busck et al. (2020) found that spiders in the same web have similar gut microbial diversity, whereas spiders in different webs have different gut microbial diversity. pH, oxygen levels, environmental conditions, developmental stage, and the host's immune system are some abiotic and biotic factors that can modify the microbial architecture of the spider gut (Domingo et al., 1998). Dunaj et al. (2020) studied the heritability of the gut microbiota in *Ariamnes waikula* (Araneae, Theridiidae) from a Hawaiian island and found that it has been conserved for 20 million years. Compared to other arthropods, spiders are liquid feeders and therefore have additional oral digestion. This peculiarity differentiates the microbial composition of spiders from that of other arthropods (Macias et al., 2018). The gut microbiota is under pressure from continued exposure to environmental pollutants, pesticides, and antibiotics. This degrades microbial health in the spider gut, which in turn delays development, reduces body mass, and increases mortality in the host. These kinds of studies are very rare in spiders (Li et al., 2019; Zheng et al., 2021). Wang et al. (2023) proved cadmium contamination and delayed growth in *Pardosa pseudoannulata*. Tyagi et al. (2020) compared intersubfamily diversity in gut microbiomes in twelve wild spider species, including Araneinae (8), Argiopinae (2) and Gasteracanthinae (2) of the family Araneidae. It also demonstrated the gut microbiome's involvement in carbohydrate, lipid, amino acid, fatty acid, and energy metabolism. Zhang et al. (2017) conducted a detailed study of the entire bacterial community of the spider *Marpiss magister* using Illumina sequencing of 16S rRNA amplicons. They found not only the endosymbionts but also other bacterial taxa. A comparative study by Gao et al. (2021) examined male and female *Pardosa astrigera*

to determine whether sex is a determinant of microbial diversity. They find that female spiders have lower microbial diversity than males.

Lynx spiders are potent predators in agroecosystems, pouncing on their prey like a wild cat and vigorously feeding on crop pests. Hence, they have a greater future as a tool in integrated management. Understanding and preserving gut microbial diversity in lynx is essential for their conservation and health management. Studies in lynx spiders' gut microbial diversity open avenues for understanding their physiology, ecology, and evolution. Unfortunately, only a limited number of studies have been conducted so far. Kumar et al. (2020) studied gut microbial diversity in seven spiders: four from the Thomisidae and three from the Oxyopidae. They identified 16 bacterial phyla in both. In this, Proteobacteria are dominant in Thomisidae and Firmicutes are dominant in Oxyopidae. *Paraclostridium* was only observed in *Peucetia viridans*. They also found that the microbiota metabolises fatty acids and sugar and makes vitamins. Vinolia & Agnes (2023) used 16S rRNA gene sequencing to reveal the gut microbial diversity in *Peucetia viridana*. 40 bacterial classes, 156 families and genera were identified. The families Oxyopidae and Lycosidae belong to the same superfamily Lycosoidea. Wu et al. (2021) used shotgun metagenomic sequencing to compare two Lycosidae species, *Pardosa agraria* and *P. laura*, from farmland and woodland habitats. They could find that both the spiders show the same richness and abundance. The gut microbiota may differ by gender in different species. A comparative study of *Pardosa astrigera* in both sexes was conducted by Li et al. (2024) using 16S rRNA gene sequencing and found that the Chao1 and Shannon indices were higher in females, whereas the Simpson index was higher in males. They concluded that a significant gender difference occurs in gut microbial diversity. A similar study in *Pardosa astrigera* found that males had lower bacterial diversity than females (Gao et al., 2022).

The family Oxyopidae shows significant richness and diversity in gut microbial communities. They are an interesting model for studying gut microbial composition due to their special feeding habits. Unfortunately, there are very few such studies from India. The identification and comparison of gut microbes in spiders, especially lynx spiders, is the first of its kind in Kerala and has future applications in an agrarian economy.

Molecular and phylogenetic works on Oxyopids are highly skewed in India. Only a countable number of studies have been done in this field. The need for genus revisions within the family Oxyopidae has long been a demand of the peer-review community. However, the high level of morphological similarity and parallelism in genital structure makes classical taxonomic identification challenging. A combination of classical and molecular taxonomy is considered a more reliable way of identifying Oxyopid members. The Lynx spiders are widely distributed across Kerala; however, knowledge of their ecology is limited. A proper understanding of the lynx's host plant preference is fundamental to understanding its role in pest management. Spider gut microbiomes also play a major role in shaping spiders' diets. A comprehensive gut microbial analysis of the lynx spider is the first of its kind from Kerala.



CHAPTER 3

MATERIALS AND METHODS

Chapter 3: MATERIALS AND METHODS

Research is an expedition towards knowledge, which needs a systematic collection of data and its respective analysis. This is possible by preplanning and methodological collection. The present study combines field and laboratory work. The fieldwork involves collecting spider specimens from selected sites in 14 districts of Kerala. The research room involves DNA barcoding, phylogenetic analysis, diversity indices and next-generation sequencing.

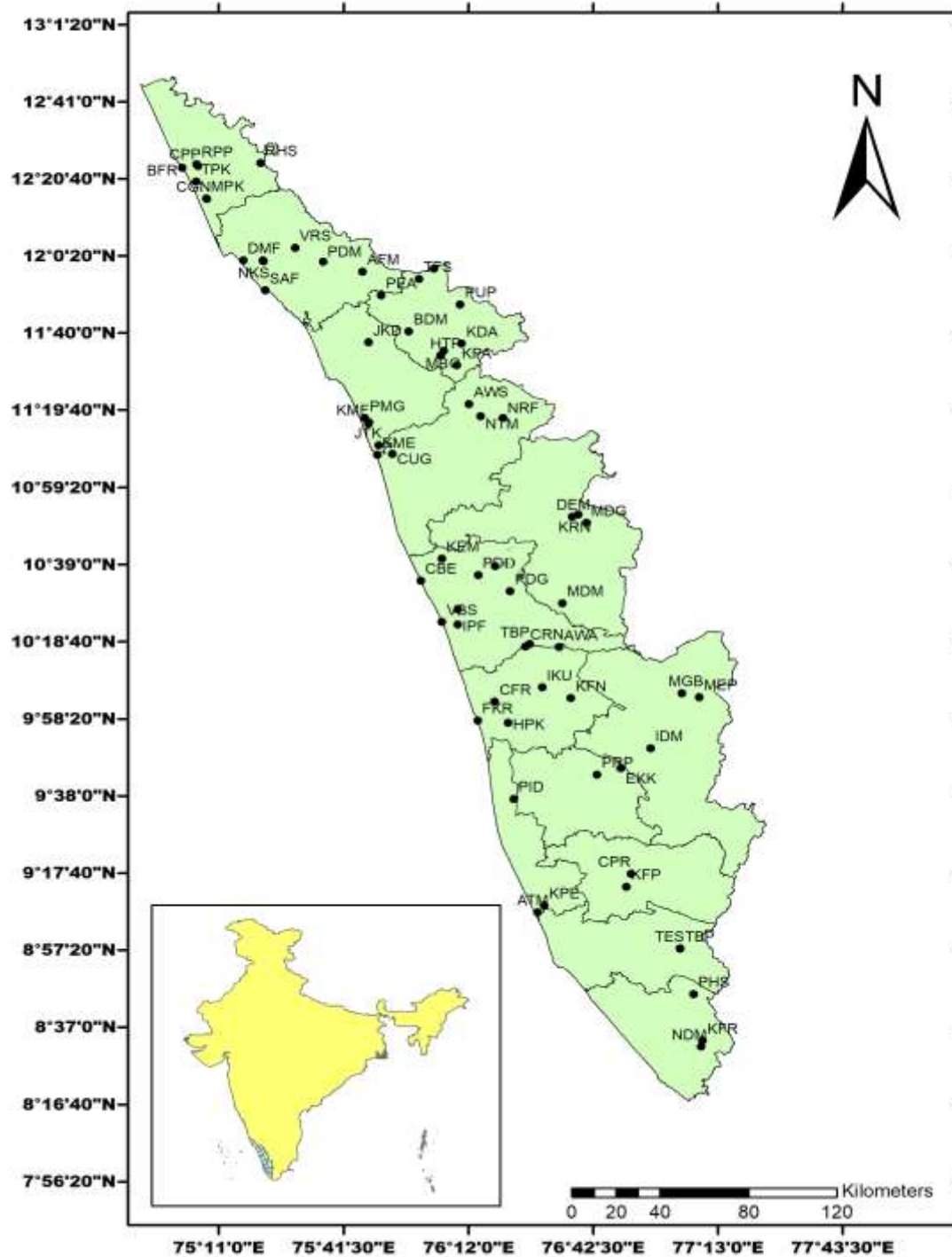
3.1. Study Area

The study area involves 14 districts of Kerala (10° 51' 1.8576" N, 76° 16' 15.8880" E). The state is one of the southern states of India, situated on the tropical Malabar coast. It is a narrow strip of land. From a geographical view, Kerala has three divisions: 1) Highlands, 2) Midlands, and 3) Lowlands. A part of the Western Ghats extending from north Kasaragod to south Thiruvananthapuram belongs to the highlands. 43% of the state's total landmass is highland regions—the highlands are home to montane subtropical and temperate sholas.

Oxyopidae specimens were collected from three peaks of the Western Ghats, Ponmudi hills, Illikalkallu and Ranipuram hills. Ponmudi Hills are 22 km west of Vithura in Thiruvananthapuram.

Plate1

COLLECTION SITES IN KERALA MAP



district, with an altitude of 916 m above sea level. This landscape is a combination of valleys and hills. Kallar River passes through these hills.

The hill vegetation includes ground-level grasses and infrequent shrubs. Ranipuram Hills are situated at the northern tip of Kerala in the Kasaragod district. The hill is 750m above sea level. This area's vegetation combines grassland, monsoon forest and evergreen shola. Elaveezhapoonchira, located in Kottayam, has an elevation of 962m. Hillocks of Mankunnu, Kodayathoomala and Thonippara surround it. Because of its high elevation, it has a skewed vegetation community, with low-lying grasses and some members of the Poaceae family. These three peaks are highly prone to wind.

Gardens are among the preferred habitats of lynx spiders. They are man-made ecosystems which contain both flowering and non-flowering plants. Garden ecosystems are relatively rare in Kerala. Lynx specimens were collected from various gardens in eleven districts of Kerala. Neyyar Dam Garden is an extension of the Neyyar Wildlife Sanctuary in the Thiruvananthapuram district. They are known for rare medicinal herbs and plants. Another one is the Thenmala Butterfly Park Garden, which was part of the Thenmala ecotourism project in the Kollam district. It is the first of its kind in India. Swallowtails, Clerodendrum, Mussaenda, Lantana and Cassia are the common plants here.

In Kayamkulam (Alappuzha district), the Kerala State Department of Archaeology owns the royal residence, Krishnapuram Palace, with a well-maintained garden. This garden has a lawn, flowering shrubs and some trees. Munnar Government Botanical Garden and Munnar Garden are positioned in the Idukki district. Munnar Garden only contains exotic flowering plants, whereas Munnar Government Botanical Garden combines exotic and native plants. The Kerala Archaeology Department

maintains the Hill Palace garden. This garden is in Thrippunithura of Ernakulam district. *Araucaria columnaris* is the common plant there, with other shrubs. Dr M. MS Swaminathan Botanical Garden in Wayanad expands over 20 acres. This garden is mainly devoted to conserving rare and endemic plant communities. The majority of its area is covered by mature trees. Peechi Dam Garden in the Thrissur district is a well-maintained garden with various flowering flora. This garden is situated near the Peechi drinking water project. Thumbboormuzhi Butterfly Park in the Thrissur region is a man-made garden on the banks of the Chalakkudy River, in the lap of the Western Ghats. Most of the plants are flowering ones to attract the butterflies. In Malappuram, the Nilambur Teak Museum has a well-kept garden. It is a combination of medicinal plants, flowering plants and large trees. The Kerala Forest Research Institute administers this garden and museum. Calicut University Garden is situated within the university campus and features a variety of flowering plants. Malampuzha Dam Garden is located in the Palakkad district. It is an established garden within the Malampuzha rock-cut dam. Pazhasi Museum is located in the Kozhikode district and is surrounded by a garden ecosystem with flowering flora. Bekkal Fort and St. Angelo Fort in the Kasaragod district have well-maintained gardens and surrounding grass vegetation.

Dams are large barriers that restrict the water flow from one side to another. Kerala has eighty-one dams. Most of the dams are located within protected areas with extensive vegetation. Some dams in Kerala are considered study areas for the current study. Neyyar Dam was built on the Neyyar River in Thiruvananthapuram district. It is a part of the Neyyar Wildlife Sanctuary at the foot of the Western Ghats. Karappuzha Dam is one of the biggest earth dams in India, located in the Wayanad district of Kerala. It was constructed on the Karappuzha River. This dam is renowned for its adjoining dense vegetation. Banasurasagar is the foundation of the Banasurasagar irrigation and

drinking water project. This dam was set up on the Kabini River. It is Asia's second-largest earth dam with comparatively less vegetation than other dams. This dam is at the foot of the Banasura Hills in Wayanad district. Vazhani Dam was erected on the Wadakkanchery River in Thrissur district. In addition, the dam has a 4-acre garden. Intense vegetation surrounded this dam. Poomala Dam is under the administration of the Kerala Minor Irrigation Department. This dam is made up of mud and stone and is only 15km from the Thrissur district. This dam is comparatively smaller. Mangalam Dam is located in Palakkad district. It was constructed across the Cherukunnappuzha River, which is a tributary of the Mangalam River. A dense canopy with various floral and faunal species surrounds the dam. Rubber, Coffee, and Pepper plantations are present near this dam. Pazhassi Dam, also known as Kulur Barrage, does not surround dense vegetation as in the other mentioned dams.

Ecotourism maintains ecosystems that link conservation, communities and sustainable travel. It enables travel to landing places with rich flora and fauna without disturbing the inhabitants. Three eco-tourism destinations were selected as areas of study. Thennmala Ecotourism is located in the Kollam district. People depend on this ecosystem for their livelihood through the collection of honey and timber. It is one of the UNESCO World Heritage sites in the foothills of the Western Ghats. Some parts of this ecotourism are within the Shenduruney Wildlife Sanctuary. Another one is Kalashamla ecotourism in Thrissur district. This ecosystem contains open vegetation with a majority of grasses, small shrubs and a limited number of trees. It is situated on a hill called Kalashamala, also known as Narimada Hills. One more is the Dhoni ecotourism area in Palakkad district. It is a combination of dense forests and waterfalls. This ecosystem has rich wildlife. This ecosystem is under the surveillance of the Kerala Forest Department. Pathiramanal Island is in the Alappuzha district and is surrounded

by Vembanad Lake. This island is a combination of forest and waterlogged areas. This ecosystem is rich in species. Janakikkad Ecotourism is in the Kozhikode district, and its ecosystem is similar to that of Dhoni. Specimens were collected from there also. Kottoor Ecotourism Region is part of Agastyamala Biological Park. This place is famous for elephant rehabilitation and tribal settlement. It is a homogeneous ecosystem. Paddy fields are mostly distributed in the Alappuzha and Palakkad districts of Kerala. Paddy fields are waterlogged areas used to cultivate rice. Specimens collected from Pullu and Irinjalakuda paddy fields. Both are in Thrissur district and span more than 5 acres. These paddy fields are cultivated twice a year. Plantations are homogeneous groups of plants. Usually found in tropical and semi-tropical zones. Kerala is famous for its tea, coffee, cashew and rubber plantations. As the main crops differ, the lower vegetation changes accordingly. Pathanamthitta is well known for its pineapple cultivation along with Kottayam and Ernakulam. Chengara hills in Pathanamthitta have expanded pineapple cultivation over acres. It is one of the study areas for the present study. Rubber plantations are estates where rubber trees are grown on a large scale in elevated zones. Rubber plantations in Pala, Kottayam, and Periyar, Kasaragod, are such study areas. Harison tea plantation is located in the Wayanad district, spanning acres and being completely homogeneous. Kasaragod district is famous for its cashew and tobacco cultivation. Specimens collected from the cashew plantation in Kanhangad and the tobacco cultivation in Periyar. Specimen gathered from the cabbage garden in Nileschwaram, which is also homogeneous like plantations without ground grasses.

Mangroves are situated in the coastal intertidal zones. Plant types include salt-tolerant trees and shrubs. In Kerala, 18 mangrove species are present. It expands to 7.55 sq. km. Mangroves and their surrounding vegetation were selected as the study area. Specimens were collected from the Ayiram Tengu mangrove forest of

Thiruvananthapuram, the Kuttiyadi and Kadalundy mangroves of Kozhikode, and the Dharmadom mangroves of Kannur. Sacred groves are conserved ecosystems associated with places of worship. Kerala has sacred groves that extend from north to south. These ecosystems are mostly seen in northern Kerala. These are the regions that have less human interference and abundant diversity. The study involved specimens from Mannampurathukavu in Kasaragod, Neeliyarkottam in Kannur, and Jathavankotta in Kozhikode district. Kerala has 44 rivers that span from Kasaragod to Thiruvananthapuram. Riversides surround open vegetation. They are wet as well. Specimens from the bank of the Valapattanam river of Kannur, the Chalakkudy river of Thrissur, the riverside of the Athirapilly waterfalls, and the Adyanpara waterfalls of Malappuram in the Kanjirapuzha river were subjected to study.

The Western Ghats extend into Kerala; hence, the state is abundant in forest ecosystems. Most of the forests are rainforests. All the districts except Alappuzha have forest ecosystems. Forest ecosystems, including the Kothamangalam Forest Division of Eranamkulam, Tholpetty, Thirunelly, Kanthanpara, and Periya; 35 forest regions of Wayanad district; the Nedumgayam rain forest of Malappuram district; and the Kava region of Palakkad, were taken as the field of study. Aralam Farm is an extension of Aralam Wildlife Sanctuary. It expanded to acres where tribes cultivated various crops for their livelihood. This region was also part of the study area. Sarovaram Park is located in Kozhikode district and is a forest-like man-made ecosystem with abundant trees and surrounding undergrowth. Specimens were gathered from there. Abandoned areas with ample vegetation are favourable habitats for members of the family Oxyopidae. Hence, the Fort Kochi region, the Carregionm factory premises in Eranamkulam, the roadside vegetation on the Pulpalli and the Sulthan Bathery sides of Wayanad, and the Mangattuparambu region of Kannur district are included in the study

area. Specimens were collected from Valppadu and Chavakkadu beachside vegetation in the Thrissur district.

A map (Plate 1) of all locations where specimens were collected is plotted on a Kerala map using ArcGIS 10.8. using the coordinates of each collection site.

3.2. Study Time

The study was conducted from January 2021 to February 2026. First, 6 months were dedicated to the literature review and to defining the study area and the collection period. Collection time is determined as early morning from 6.00 AM to 10 AM and evening from 4.30 PM to 6.30 PM. The sample collection was done from January 2021 to 2024. Specimens were collected throughout the year. A minimum of three visits were made in all the study areas, including pre-monsoon (February-May), monsoon (June-September), and post-monsoon (October-January).

3.3. Collection Techniques

Specimen collection is an important part of research, especially for taxonomic research. For taxonomic studies, specimens without damage are necessary to record measurements and detailed characterisation of a particular species. The collection involves both adults and subadults. Only adult specimens were subjected to the study. Oxyopids are known for their high nimbleness. They could leap from one place to

Plate 2

Fig. 1 Collection Methods



Bottle method

Fig. 2



Sweeping Net

another with the greatest accuracy. This makes the collection of this species a little bit difficult. Hand-picking and sweep netting are the common methods of Oxyopid collection.

3.3.1. Hand-picking

Hand-picking (**Plate 2, Fig 1**) is a basic method for spider collection. Primarily, this is a visual search. This method applies to organisms ranging from medium-sized to large. Organisms that don't pose any health threat by biting are suitable for this collection method. It is more practical for spider collection. The specimen could be picked using a collection bottle. For Oxyopids, hand-picking should be done quickly due to their rapid movement

3.3.2. Sweep Net

Sweep nets (**Plate 2, Fig 2**) are insect-collecting equipment. It is commonly used for collecting arthropods. This method is suitable for a random collection of arthropods which can't be easily seen in the vegetation. Oxyopids usually hide behind the leaves of bushy vegetation; hence, they are not easily visible. So, sweep netting is the most convenient method of collection for this species. During collection, the sweep net moves back and forth through the grasses and is held to prevent the escape of trapped spiders. Then transfer the samples to their respective vials.

3.4. Sample preservation

The samples collected from the respective fields were directly transferred into separate vials. Both adults and sub-adults were collected from the field and transferred to 70% ethyl alcohol. Specimen collected as a pair (male and female) stored in a single

vial. Subadults help identify specimens to the genus level. For species-level identification, adult specimens are needed. The field samples were brought to the laboratory. The specimens for the molecular study (DNA barcoding) were transferred into pure ethyl alcohol to avoid DNA decay. Samples for the detailed taxonomic study were preserved in 70% isopropyl alcohol to facilitate microscopic identification. Pure ethanol makes the specimen brittle. Proper labelling was done. Labels on each specimen contain the place and date of collection, species name, collector name, gender name and number, based on which the specimen is kept in the laboratory. For labelling, a permanent marker pen is used. The specimen, which needs to be retained for future reference, was transferred to 90% alcohol in vials after a taxonomic study. Then these vials containing specimens in ethanol were put into a large vessel containing 90% alcohol. These specimens were further deposited in the museum of the Centre for Animal Taxonomy and Ecology, Department of Zoology, Christ College (Autonomous), Irinjalakuda.

3.5. Identification

Specimen identification is the most important and difficult part of taxonomic study. Even minute details of the specimen need to be considered for the species-level identification. Only adult spider specimens were used for species identification. Hexagonal eyes and spiny legs are the first identification features of Oxyopids at the family level. For genus-level identification, the size and shape of the carapace and abdomen and the length of the legs were noted. The structure and shape of genitalia or copulatory organs are the major features for species-level identification. In female spiders, their copulatory organs are placed on the ventral side of the abdomen just above the epigastric furrow. The dorsal side of the copulatory organ is called the epigyne, and

the ventral side is the vulva. Female genitalia include two spermathecae, two copulatory ducts, one from each spermatheca and a fertilisation duct at the end of each copulatory duct. Some additional features could be seen in other spider families. In male spiders, the genitalia are called pedipalps. It is the first pair of appendages located in the anterior part of the cephalothorax. The pedipalp contains cymbium, cymbial apophysis, embolus, conductor, medium tegular apophysis, tegulum, subtegulum, and tibial apophysis. The above are the notable features of species identification. The prolateral, retrolateral, and ventral sides of the pedipalps were studied. Most of the external features of spiders could easily be visible under a simple microscope. Since the genital structures are highly microscopic for their study, an advanced microscope is needed. Hence, for the genitalia study, digital images were taken using a Leica DMC45000 digital camera attached to a stereo zoom microscope (Leica M205C), and editing was done by the software package Leica Application Suite (LAS), version 4.3.0, LAS montage facility available in the Centre for Animal Taxonomy and Ecology (CATE) Laboratory in Christ College (Autonomous), Irinjalakuda, Thrissur. The dorsal view of the adult, dorsal and ventral views of the female genitalia and the prolateral, retrolateral and ventral views of the pedipalp were photographed. Note down the colour and body pattern of the cephalothorax and abdomen. The number of promarginal and retromarginal cheliceral teeth, length of each palp part (coxa, femur, trochanter, tibia, tarsus), length of each leg part including coxa, femur, trochanter, tarsus, metatarsus, promarginal and retromarginal, dorsal and ventral spines, length and width of carapace, abdomen, the diameter of anterior, posterior, anterior median and posterior median pairs of eyes and their inter distance and length of the chelicera and clypeus were measured. All these measurements were included in the description. The plates for each species were created in Adobe Photoshop 2021, version 22.0. Each plate includes the

images of adult habitus dorsal view, vulva ventral view, epigyne dorsal view, pedipalp prolateral, retrolateral and ventral views. The collected species were stored in the CATE lab under unique identification numbers.

3.6. DNA barcoding and phylogenetic analysis of collected species

The specimens meant for DNA barcoding were stored in pure ethanol until the DNA extraction. Genomic DNA was isolated from three legs and the coxa of the spiders using the QIAquick Gel Extraction Kit. For purification, the legs are cut into pieces ($\leq 25\text{mg}$) to enable more efficient lysis and placed in a 1.5 ml microcentrifuge tube. Add 180 μl Buffer ATL and 20 μl Proteinase K. Mix thoroughly by vortexing for up to 15s, then incubate at 56°C until the tissue is completely lysed. Vortex occasionally during incubation. Add 200 μL Buffer AL to the sample, vortex to mix, and incubate at 56°C for 10 min. Then add 200 μl ethanol (96–100%) and mix again thoroughly by vortexing. Pipet the mixture, including any precipitate, into the DNeasy Mini spin column placed in a 2 ml collection tube. Centrifuge at $\geq 6000 \times g$ (8000 rpm) for 1 min. Discard the flow-through and the collection tube. Place the DNeasy Mini spin column in a new 2 ml collection tube, add 500 μl Buffer AW1, and centrifuge for 1 min at $\geq 6000 \times g$. Discard the flow-through and the collection tube. Place the DNeasy Mini spin column in a new 2 ml collection tube (provided), add 500 μl Buffer AW2, and centrifuge for 3 min at $20,000 \times g$ (14,000 rpm) to dry the DNeasy membrane. Discard the flow-through and the collection tube. Place the DNeasy Mini spin column in a clean 1.5 ml tube and pipette 200 μl Buffer AE directly onto the DNeasy membrane. Incubate at room temperature for 1 min and then centrifuge for 1 min at $\geq 6000 \times g$ to elute. For maximum DNA yield, repeat the elution step (last step).

Agarose gel electrophoresis for DNA quality check

The quality of the isolated DNA was assessed by agarose gel electrophoresis. 1 µl of 6X gel-loading buffer (0.25% bromophenol blue, 30% sucrose in TE buffer pH-8.0) was added to 5 µl of DNA. The samples were loaded into a 0.8% agarose gel prepared in 0.5X TBE (Tris-Borate-EDTA) buffer containing 0.5 µg/ml ethidium bromide. Electrophoresis was performed in 0.5X TBE buffer at 75 V until the bromophenol dye front reached the bottom of the gel. The gels were visualised on a UV transilluminator (Genei), and the images were captured under UV light using a Gel documentation system (Bio-Rad).

PCR amplification

The partial Cytochrome C Oxidase subunit I gene (COI) was amplified using the primer pairs LCO 1490 (GGCGGCGCGTCTTAAACATG) and HCO 2198 (TCCCCCATTTGAGCAAGATT) (Folmer et al., 1994). PCR amplification was performed using a thermal cycler (Bio-Rad, USA). The reactions were carried out in 20 µl reaction mixtures (Emerald Amp GTPCR Master Mix) as per the manufacturer's instructions, using 10 picomoles of each forward and reverse primer. 20 µl containing 10 µl Takara - EmeraldAmp GT PCR Master Mix, 2 µl forward primer (10pmol/ µl), 2 µl reverse primer (10pmol/ µl), 2µl template DNA, and the volume was made up to 20 µl with nuclease-free water (4µl). Thermal cycling is initiated with an initial denaturation at 98 °C for 2 min, followed by 30 cycles of denaturation at 98 °C for 10 sec, annealing at 49.5 °C for 30 sec, and elongation at 72 °C for 45 sec, then a final hold at 72 °C for 5 min and a hold at 4 °C. The PCR products were analysed by electrophoresis on a 2% agarose gel.

ExoSAP-IT (GE Healthcare) consists of two hydrolytic enzymes, Exonuclease I and Shrimp Alkaline Phosphatase (SAP), in a specially formulated buffer for the removal of unwanted primers and dNTPs from a PCR product mixture with no interference in downstream applications. Five microlitres of PCR product is mixed with 0.5 μ l of ExoSAP-IT and incubated at 37 °C for 15 minutes, followed by enzyme inactivation at 85 °C for 5 minutes.

Sequencing using BigDye Terminator v3.1

The sequencing reaction was performed in a PCR thermal cycler (GeneAmp PCR System 9700, Applied Biosystems) using the BigDye Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems, USA) according to the manufacturer's protocol. This kit is used for Sanger sequencing. Sequencing was performed at OmicsGen LifeSciences Pvt. Ltd., Cochin.

Post-Sequencing PCR Clean-up

Mix D/W, 125 mM EDTA, 3 M sodium acetate (pH 4.6), and ethanol were prepared and properly mixed. 50 μ L of the mix was added to each well of the sequencing plate containing the sequencing PCR product. Vortex by Mixmate vortex and incubated at room temperature for 30 minutes. Spun at 3700 rpm for 30 minutes. Decanted the supernatant and added 50 μ L of 70% ethanol to each well. Spun at 3700 rpm for 20 minutes. Decanted the supernatant and repeated the 70% ethanol wash. Decanted the supernatant and air-dried the pellet. The cleaned-up air-dried product was sequenced in the ABI 3500 DNA analyser (Applied Biosystems).

Sequence analysis

The forward and reverse sequences obtained after Sanger sequencing were trimmed and edited using Sequencher 5.4.1, then aligned with ClustalW in BioEdit v.7.0.5.3 (Hall, 1999). The consensus sequence obtained was deposited in NCBI – GENBANK (Sayers et al., 2024) to obtain the Accession number.

The DNA sequence database was further used to construct a phylogenetic tree to examine the interrelationships among lynx spiders in Kerala and those worldwide. DNA barcodes of already deposited sequences mined from NCBI-GENBANK based on maximum homology by using the Basic Local Alignment Search Tool (BLAST) and BOLD (Ratnasingham et al., 2024).

Outgroup selection

For the phylogenetic analysis, presumed closer members from the sister families of Oxyopidae were considered. Based on phylogenetic trees and previous literature, the family Ctenidae can be considered a sister family to the Lynx spiders (Polotow, 2015). *Parabatinga brevipes*, belonging to the family Ctenidae and superfamily Lycosoidea, was stipulated as an outgroup for the study. COI molecular DNA barcode collected from GenBank.

Phylogenetic analysis

The sequenced and mined data are arranged in Notepad and saved in FASTA format. The mean intergeneric distance between the Oxyopid genus was calculated using Microsoft Excel based on the interspecies distance obtained by the Kimura 2 Parameter model (Kimura, 1980) using MEGA 11 (Tamura et al., 2021). The Best

Nucleotide Substitution model was identified using JModelTest (Santorum et al., 2014).

A bottom-up (agglomerative) method called Neighbour-Joining is a frequently used method for phylogenetic tree construction. The branch lengths as well as the topology of a parsimonious tree can quickly be obtained by using this method. The Neighbor-Joining tree was constructed in MEGA11 using the aligned sequence generated by Clustal W and the Kimura 2-parameter model with 10,000 bootstraps (Saitou & Nei, 1987; Felsenstein, 1985).

Maximum Parsimony (MP) is another method in which the phylogenetic tree that minimises the total number of character-state changes is preferred. Under the maximum-parsimony criterion, the optimal tree will minimise the amount of homoplasy (i.e., convergent evolution, parallel evolution, and evolutionary reversals) (Felsenstein, 1985; Nei & Kumar, 2000). Maximum parsimony tree constructed using MEGA 11 with 10,000 bootstraps.

Another method for constructing trees is Bayesian phylogenetic inference based on Bayes' theorem, which provides a way to revise existing knowledge (the prior) when new data become available (the likelihood). The phylogenetic tree was constructed using MrBayes software (Huelsenbeck & Ronquist, 2001; Ronquist & Huelsenbeck, 2003; Ronquist et al., 2012). The Fasta file was converted to the Nexus (.nex) format using Mesquite software (Doe, 2012; Maddison & Maddison, 2023; Za, 2014). Mr Bayes only read Nexus files and ran the programme up to 100,000 bootstraps to obtain the best tree.

Maximum Likelihood phylogenetic analysis is grounded in probability theory, allowing one to find the tree that maximises the likelihood of the observed data given a

model of molecular evolution. Maximum Likelihood is an explicit model of molecular evolution, such as substitution models, that provides a better account of differences in evolutionary rates across sites and among lineages. Maximum Likelihood tree constructed by using RAxML software (Stamatakis, 2014). RAxML only reads PHYLIP files. Fasta file (.fasta) converted into Phylip format (.phy) using Mesquite. The programme runs up to 100,000 bootstraps.

The phylogenetic tree constructed using the above method was saved into a Tree file (.tre). The tree file was opened in the FigTree app for further modifications (Rambaut, 2018). After modifications, the tree files were saved as JPEGs (.jpg) and subjected to further interpretation.

3.7. Study the host plant preference in lynx spiders of Kerala

At each collection site, spider species identification will be performed visually for known species. For unknown species, spiders were collected by handpicking and sweep netting and examined using a stereo-zoom microscope for species-level identification. Host plant identification for known plant species and field identification was completed. Unknown species identification was carried out by taking photographs, collecting plant parts and sending them to plant experts for species-level identification. Also, rely on online websites under the Kerala Forest Research Institute (KFRI) (<https://www.kfri.res.in/herbarium.asp>). Host plants are categorised as native, exotic, or invasive to assess their tendency towards these plant types. The plant parts (stem, leaf, flower) on which the Oxyopids could be found are noted. The data is tabulated. To determine species richness and abundance, the number of species and the number of specimens collected from each host plant during the field visit were recorded and tabulated.

Statistical analysis was performed using R software version 4.4.2. To visualise the number of species and specimens collected from each host plant family, Dot plots were generated using the software above. To check the sampling sufficiency and species richness estimation, a species accumulation curve was plotted. The alpha diversity indices, including Chao1, Evenness, Shannon, and Simpson, are also calculated.

Pie diagrams were plotted to visualise the percentage distribution of species and specimens in three host plant types (invasive, native, and exotic). Also calculated alpha diversity indices, including Chao1, Evenness, Shannon, and Simpson.

3.8. Analysis of the gut microbial diversity of *Oxyopes birmanicus* from 4 selected ecosystems

A total of 20 specimens, 5 of *O. birmanicus* (OBRM), were collected alive by hand-picking from 4 different ecosystems: the Irinjalakuda paddy field, the Kothamangalam forest region, the Mangalam dam, and the urban area of Kunnankulam. Only adult specimens were used for sequencing. Live specimens were brought to the lab, killed by immersion in 90% alcohol for 2 min, then rinsed with PBS and washed three times with Milli-Q water to remove surface impurities.

For sample preparation, cut the dissected gut of OBRM from four different ecosystems into small pieces of ≤ 25 mg each and place them in separate 1.5 ml microcentrifuge tubes. In each tube, 180 μ l ATL buffer (a tissue lysing buffer) and 20 μ l Proteinase K (to digest protein) were added, mixed by vortexing, and incubated at 56°C until completely lysed (1–3 h), with occasional vortexing during incubation. Added 200 μ l AL buffer (for cell membrane lysis). Mixed thoroughly by vortexing for

15 seconds. Incubated at 70°C for 10 min. Briefly centrifuged the tube to remove drops from the lid. Added 200µl ethanol (96– 100%). Vortexed for 15 seconds. Centrifuged the tubes shortly to remove drops from the lid.

DNA was isolated by transferring the mixture into the QIAamp Mini kit and following the standard protocol. The DNA extracts from 4 samples from each ecosystem were subjected to further analysis. Sequence quality was checked using agarose gel electrophoresis. Bacterial 16S rRNA V3–V4 regions were amplified using specific primers (Tyagi et al., 2020). All PCR reactions were conducted in 50µL reactions with 25µL of Phusion® High-Fidelity PCR Master Mix (New England Biolabs), 0.4µM of forward and reverse primers, and about 20ng template DNA. Thermal cycling was initiated with an initial denaturation at 98°C for 1 min, followed by 30 cycles of denaturation at 98°C for 10 s, annealing at 60°C for 30 s, and elongation at 72°C for 60 s. Finally, within 72°C for 5 min. Electrophoresis was performed to quantify and qualify PCR products. PCR products are detected by electrophoresis on a 2% agarose gel. Samples with one bright main strip between 400-450bp were chosen for further experiments. PCR products were purified through bead-based purification. As the beads were immobilised, the bead-bound DNA were retained during washing. An elution buffer is added, and the magnetic field is removed. The DNA becomes purified, making it ready for quantitation and analysis. Sequencing libraries were created by using the NEB Next® Ultra™ DNA Library Prep Kit for Illumina (NEB, USA). Library quality was assessed using the Qubit® 4.0 fluorometer (Thermo Scientific) and the Agilent Bioanalyzer 2100 system. At last, the library was sequenced on an Illumina MiSeq platform, generating 250 bp paired-end reads. The sequence data generated were deposited in the GenBank portal under the Bio project accession number (PRJNA1236495).

Bioinformatics analysis

The Fasta files of four samples were imported into QIIME2, and then the "Dada2" (Divisive Amplicon Denoising Algorithm, version 2) method was used, which significantly advances quality control measures by 'denoising' the sequences to better discriminate between true sequence diversity and sequencing errors. The plugin qiime demux summarise was used to visualise the distribution of sequence qualities at each position in the sequence data.

The relative taxonomic abundance and count data in all seven ranks (kingdom, phylum, class, order, family, genus, species) were made. The taxonomy Krona plots show the distribution of different taxonomic levels in each sample (Howe et al., 2011). α -diversity estimates the number of species in the microbial community as well as the abundance and diversity of species in environmental communities through statistical indices, including Chao1, Observed features, Shannon, and Simpson indices.



CHAPTER 4

RESULT

OBJECTIVE 1

4.1. Collection and taxonomic description of lynx spiders of Kerala

4.1.1. Taxonomy of Collected Spiders

A total of 31 species belonging to four genera were collected from various locations in Kerala. All of them are adults, identified to the species level. The collection includes new species and new reports from India, the Western Ghats, and Kerala.

4.1.2. Genus *Oxyopes* Latreille, 1804

A total of 23 *Oxyopes* species were collected from various locations in Kerala. Among these, 11 are new species and 2 new reports from India. Only female representatives could be collected for 12 species, and 5 have males. Both sexes are collected for 6 species.

Diagnosis

The hexagonally arranged eyes (2-2-2-2) and spiny legs confirm that they belong to the family Oxyopidae. Strongly procurved and sub-equidistant posterior row of eyes, and Legs IV longer than III, are the identifying characters for the genus *Oxyopes* (Gajbe, 2008).

4.1.2.1. *Oxyopes aquilae* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 3, Figs. 1A-C]

Materials examined: 1 Paratype female adult ♀ (**Fig. 1A**), 1 paratype female adult ♀, collected at Neyyar Dam, 08°31'45.28"N, 77°08'54.06"E, 22/09/2022, 24/10/23; 3 paratype female adult ♀, 3 paratype female subadult ♀, Karapuzha Dam (Ambalavayal), 11°37'10.36"N, 76°10'17.17"E, 02/09/221, 09/01/22, 07/05/23; 2 paratype female adult ♀, Periya 35, 11°49'54.10"N, 75°50'36.02"E, 12/01/22,

10/05/24; 3 paratype female subadult ♀, Thirunelly Forest, 11°54'28.90"N, 75°59'49.84"E, 04/09/21.

Etymology: The noun “Aquilae” is derived from the Latin word for “eagle”. The void space inside the copulatory duct forms an eagle shape. Hence the name *O. aquilae*.

Diagnosis: *O. aquilae* is like *O. sertatus* L. Koch, 1878. However, it can be distinguished from the latter by the following characters: 1) Spermatheca rounded in *O. sertatus*, which is oval-shaped in *O. aquilae*; 2) Copulatory duct highly curved in the middle in *O. sertatus*, which is less curved in *O. aquilae*; 3) In dorsal view, the copulatory duct question mark-shaped in *O. sertatus*, which is “C” shaped with a thick posterior edge in *O. aquilae*.

Description: Holotype, Female (Fig. 1A) (CATE212601), Measurements: TL 7.23 (including pedicel); CL 1.36, CW 2.54; AL 4.98, AW 1.81. The carapace is yellowish-brown and pear-shaped, without any characteristic marks. The posterior edge of the carapace has greenish patches. Fovea longitudinal and reddish. Eyes are arranged in four rows on the dorsal side with AER strongly recurved and PER procurved. Clypeus high with two dark black stripes from the AME margin to the front of each chelicera. Ocular area length 0.72, width 1.12. Eye diameters and inter-distances: AME 0.11, ALE 0.25, PME 0.23, PLE 0.21, eye sizes ALE>PME>PLE>AME; AME-AME 0.17, AME-ALE 0.11, PME-PME 0.30, PME-PLE 0.33, ALE-PLE 0.24, ALE-ALE 0.27, PLE-PLE 1.12. Clypeus height is 0.61; Chelicera is 0.87, and it is downward with two pro marginal teeth and two retro marginal teeth. Broad fang at the base and narrowed towards the tip, and less pointed. Endite and labium longer than wide. The sternum is longer than wide, and the hair is scattered, long and short. The abdomen is fusiform and yellowish, with an olive-coloured cardiac mark at the centre with an orange border. The

cardiac mark is covered with a white band on both sides, extending anteriorly from the abdomen, fusing towards the spinnerets. The lateral sides of the abdomen have narrowed alternating black and white bands. A dark longitudinal band extend from the epigastric furrow to the spinnerets in ventral view. Legs are covered with many conspicuous short spines and two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 2.49 (0.45+ 0.93 + 0.25+ 0.86), I 14.58 (4.23 + 0.99+ 4.36 + 3.44 + 1.56), II 14.24 (4.03 + 1.31+ 3.71 + 3.48 + 1.71), III 10.43 (3.14+ 0.93 + 2.53+ 2.99+ 0.84), IV 13.29 (3.71 + 1.14 + 3.62 + 3.54+ 1.28). Leg formula: I>II>IV>III.

Genitalia: (Fig. 1B-C) The vulva is highly sclerotised and resembles an inverted Mughal arch. Copulatory ducts on each side are question mark-shaped with a pointed anterior tip. Spermatheca is oval-shaped, situated at the tip of the anterior copulatory duct. In the dorsal view, the copulatory duct is “C” shaped with a thickened posterior edge. The fertilisation duct is a narrow tube that opens on the copulatory duct's lateral side.

Male: Unknown.

Distribution: India.

Plate 3

Fig 1

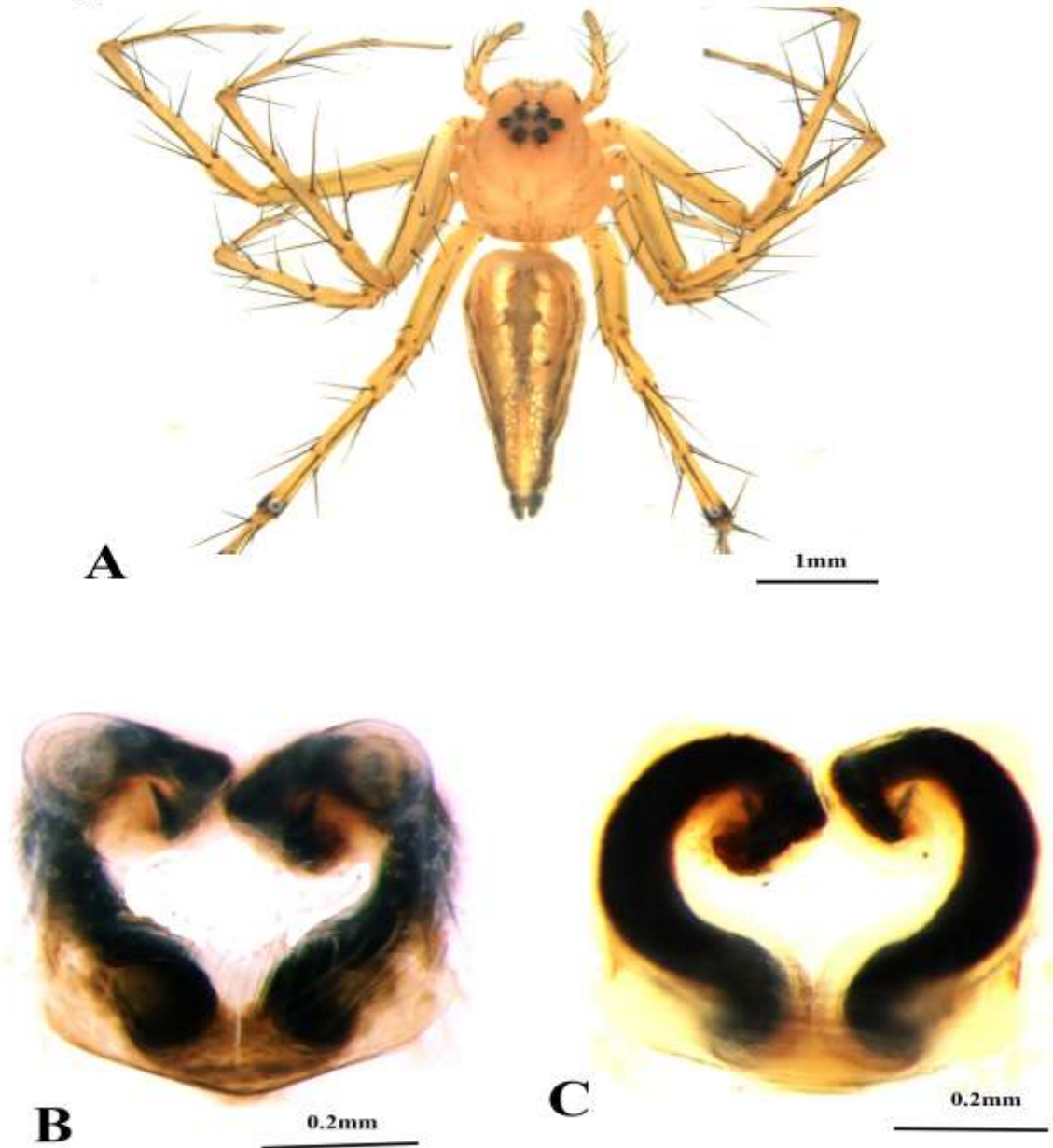


Fig. 1: *Oxyopes aquilae* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.2. *Oxyopes auris* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 4, Figs. 2A-C]

Materials examined: 1 Paratype female adult ♀ (**Fig. 2A**), 2 paratype female subadults ♀, collected at Iringol Kavu, 10°06'30.95"N, 76°30'01.77"E, 19/07/2022, 25/01/23; 1 paratype female adult ♀, Kothamangalam Forest Region, 10°03'38.29"N, 76°36'59.93"E, 24/01/23.

Etymology: The noun “Auris” is derived from the Latin word for ear. Each side of the epigyne ear pod is shaped. Hence, the name *O. auris*.

Diagnosis: *O. auris* is like *O. scapeus* Sen & Sureshan, 2021. However, it can be distinguished from the latter by the following characters: 1) The epigyne has a downward-projecting long median scape in *O. scapeus*, whereas the scape is absent in *O. auris*. 2) Spermatheca is round in *O. scapeus* and elongated oval in *O. auris*. 3) The fertilisation duct is very thin and short in *O. scapeus*, whereas it is comparatively thick and long in *O. auris*.

Description: Holotype, Female (Fig. 2A) (CATE212602), Measurements: TL 6.90 (including pedicel); CL 1.27, CW 2.29; AL 4.88, AW 1.42. The carapace is yellowish and pear-shaped, with orange-coloured bands extending from the PME to the end of the carapace. Two parallel orange bands extend from the anterior of the clypeus to the posterior end of the carapace. Eyes are arranged in four rows on the dorsal side with AER strongly recurved and PER procurved. Clypeus high with two dark black stripes from the AME margin to the front of each chelicera. Ocular area length 0.62, width 0.90. Eye diameters and inter-distances: AME 0.12, ALE 0.28, PME 0.26, PLE 0.25; eye sizes: ALE > PME > PLE > AME; AME-AME 0.12, AME-ALE 0.07, PME-PME

0.22, PME-PLE 0.29, ALE-PLE 0.19, ALE-ALE 0.17, PLE-PLE 0.90. Clypeus height is 0.48; Chelicera is 0.61, and it is downward, with two pro-marginal teeth and one retro-marginal tooth. Broad fang at the base and narrowed towards the tip, and less pointed. Endite and labium longer than wide. The sternum is longer than wide, and the hair is scattered, long and short. Abdomen fusiform, yellowish, with two white bands originating from the anterior end of the abdomen and fused together towards the spinnerets. Red patches surround the inside and outside of the white band. The lateral edge of the abdomen is blackish-coloured. Dark longitudinal bands extend from the epigastric furrow to the spinnerets in ventral view. Legs are covered with many conspicuous short spines and two tarsal claws. Pedipalps bear apical claw. Measurements of pedipalps and legs: pedipalp 1.6 (0.53+ 0.32 + 0.20 + 0.55), I 12.33 (4.38 + 0.98+ 1.02 + 4.68 + 1.27), II 11.41 (3.20 + 0.93+ 3.18 + 3.55 + 0.55), III 9.99 (2.37+ 1.12 + 2.24 + 3.53+ 0.73), IV 11.00 (2.92 + 0.93 + 3.58 + 2.08+ 1.49). Leg formula: I>II>IV>III.

Genitalia: (Fig. 2B-C) Vulva highly sclerotised. Each side of the vulva forms an ear pod structure. Spermathecae elongated, oval-shaped. The copulatory duct is thin and short, extending from the posterior end of the spermatheca. The fertilisation duct is tiny and opens to the lateral side of the copulatory duct. A thin flap of tissue connects the posterior tip of the copulatory duct.

Male: Unknown.

Distribution: India.

Plate 4

Fig 2

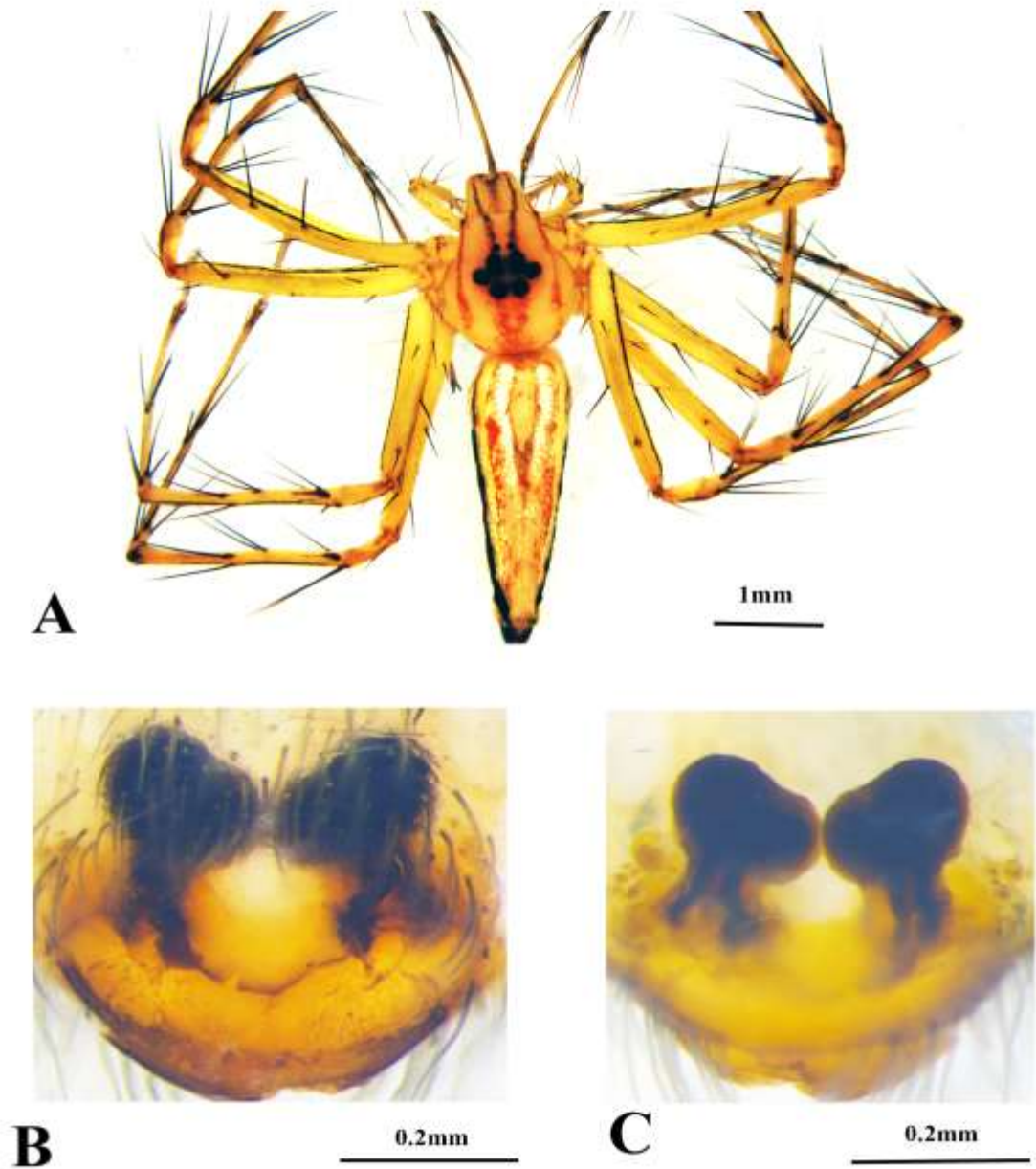


Fig. 2: *Oxyopes auris* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype female: A) Habitus, dorsal view; B) Vulva, ventral view; C) Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.3. *Oxyopes bharatae* Gajbe, 1999 [Plate 5, Figs. 3A-D]

Materials examined: 1 Paratype male adult ♂ (Fig. 3A), 4 paratype male adult ♂, collected at the locality, Fort Kochi region, 09°57'56.81"N, 76°14'31.62"E 18/07/2022, 26/01/23; 1 paratype male adult ♂, Vazhani dam, 10°38'28.37"N, 76°18'30.12"E, 05/06/21; 2 paratype male adult ♂, Poomala dam, 10°36'8.98"N, 76°14'21.74"E, 11/10/22.

Description: Male (Fig. 3A) (CATE212603), Measurements: TL 6.40 (including pedicel); CL 2.04, CW 2.52, AL 3.85, AW 1.51; ocular diameter: AME 0.14, ALE 0.23, PME 0.22, PLE 0.21, eye sizes ALE>PME >PLE>AME; ocular distance: AME-AME 0.15, AME-ALE 0.09, PME-PME 0.27, PME-PLE 0.28, ALE-PLE 0.21, ALE-ALE 0.27, PLE-PLE 1.04; Clypeus height 0.32. Length of chelicera 0.78. Leg measurements: I 13.77 (3.66, 0.83, 2.80, 4.50, 1.98), II 12.55 (3.59, 0.89, 2.72, 3.83, 1.52), III 11.05 (2.91, 1.06, 2.50, 3.08, 1.50), IV 12.16 (3.62, 1.05, 2.77, 3.57, 1.15); leg formula I>II>IV>III. Cephalothorax is pale yellow with a medium-dark band extending from the posterior median eye to the end of the cephalothorax. Two dark lateral bands start at the tip of the clypeus and extend to the cephalothorax. Fovea blackish. Abdomen fusiform, pale yellow in colour with orange patches and a “Y” shaped white marking. The lateral side of the abdomen contained white patches on a black background. Abdomen in ventral view, two narrow, dark longitudinal lines extend from the epigastric furrow to the spinnerets. Legs pale yellow in colour with a black line extending from the dorsal femur to the tarsus. Chelicera is downwards and has one marginal and one retro marginal tooth. Sternum yellowish with short hair.

Pedi palp: (Fig. 3B-D) Tegulum protruded outside the cymbium. In the prolateral view, the embolus and the medium tegular apophysis form a “C”-shape. In the ventral view, the embolus starts on the posterior ventral side and ends on the anterior retrolateral side at the 2 o'clock position. The median tegular apophysis is square-shaped. Tibia with VTA and RTA. VTA is more prominent, with a nearly pentagonal shape, and RTA is digitiform; both are closely arranged. A transparent, wavy structure extends from the anterior retrolateral side, descends, and ends on the median prolateral side.

Distribution: India.

Plate 5

Fig 3

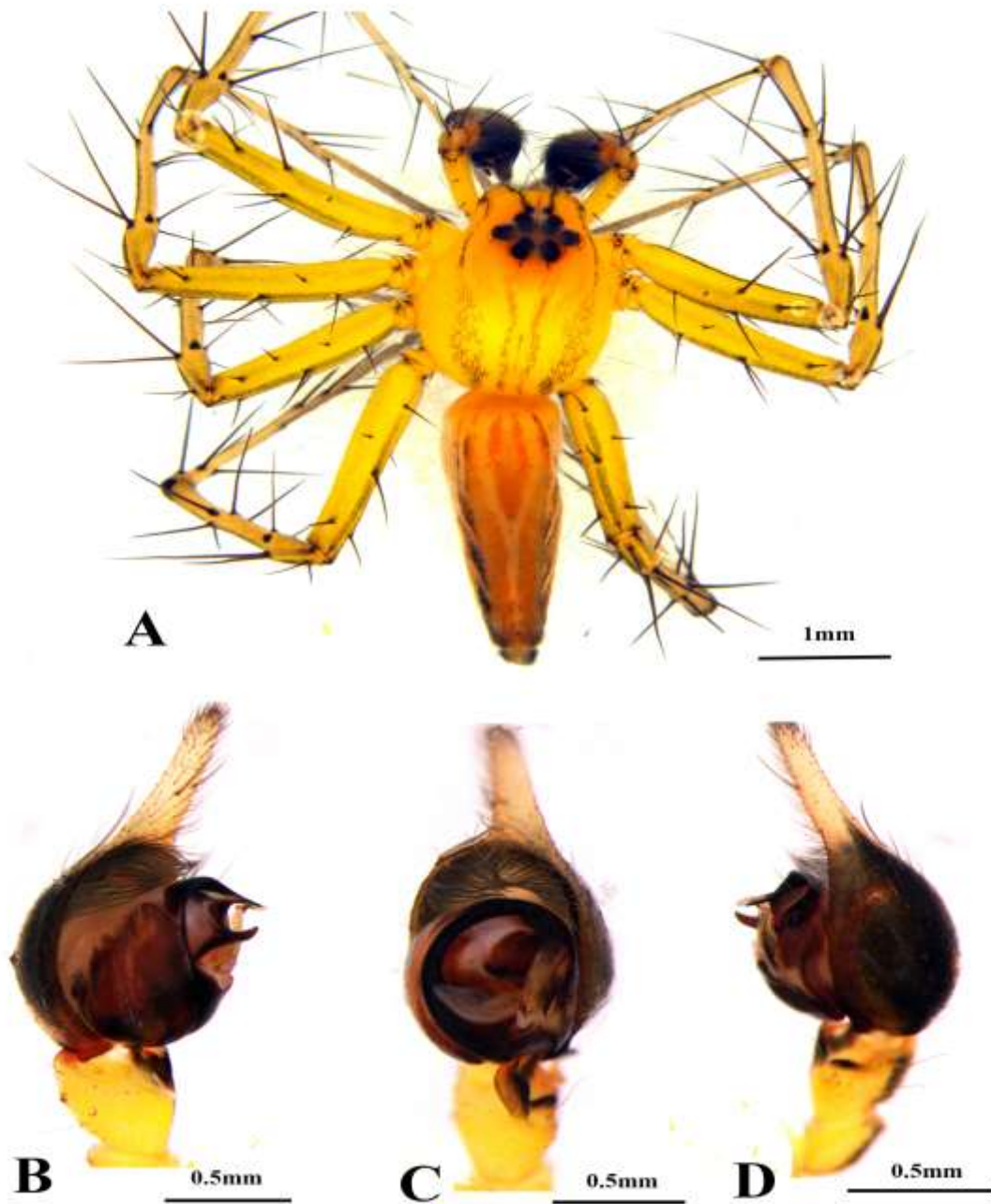


Fig. 3: *Oxyopes bharatae* Gajbe, 1999, male. **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.2.4. *Oxyopes birmanicus* Thorell, 1887 [Plate 6, Figs. 4A-C]

Materials Examined: 1 Paratype female adult ♀ (**Fig. 4A**), 2 paratype female adult ♀ collected at Aaralam farm, 11°56'12.81"N, 76°20'25.19"E, 09/04/23; 3 paratype female adult ♀, Maggattuparambhu region, 11°58'55.47"N, 76° 0'19.15" E, 11/12/22; 1 paratype female adult ♀, Kuttiyadi Mangroove Forest, 11°16'28.43"N, 75°47'39.59"E, 12/07/21; 3 paratype female adult ♀, Nilamboor Teak Museum, 11°18'0.29"N, 76°15'1.63"E, 02/07/21.

Description: Female (Fig. 4A) (CATE212604), Measurements: TL 6.86 (including pedicel); CL 3.19, CW 2.90; AL 6.36, AW 2.36. The carapace is light orange in colour and pear-shaped, with a pair of long, narrow orange lines extending from the PME to the posterior margin. A pair of distinctive, narrow, medium orange lines on the submargin. A pair of narrow, short orange lines between marginal and submarginal lines starts from PLE to above the middle of the carapace. Fovea longitudinal and black. In dorsal view, the eyes are arranged in four rows, with the AER strongly recurved and the PER procurved. Clypeus is high with two black stripes from the AME margin to the front of each chelicera. Eye diameters and inter-distances: AME 0.47, ALE 0.55, PME 0.53, PLE 0.49, eye sizes ALE > PME > PLE > AME; AME-AME 0.77; AME-ALE 0.55; PME-PME 1.03; PME-PLE 1.11; Eye row width measurement: I 0.22, II 0.33, III 0.77, IV 0.24. Clypeus height 3.17; Chelicerae downward with two pro-marginal teeth and one retro-marginal tooth. Endite and labium longer than wide. Sternum with scattered long and short hairs. The abdomen is cone-shaped and has a silvery snakeskin appearance. A creamy arrow-shaped marking is on the centre margin of the abdomen, and its head is facing towards the carapace. Bifurcated yellow lines above the arrowhead. A pair of yellow bands on the submarginal side of the abdomen throughout.

Three pairs of narrow white lines are lateral. In ventral view, a broad, dark longitudinal band extends from the epigastric furrow to the spinnerets. Spinnerets are horizontally arranged. The legs are covered with many conspicuous long spines with black stripes, one on each dorsal and lateral side of the femur. Three tarsal claws. Palps bear apical claws. Measurements of palps and legs: Palp 2.42 (0.78, 0.53, 0.27, 0.847), leg I 12.99 (2.57, 1.13, 4.07, 2.64, 1.58), leg II 10.35 (2.25, 1.28, 2.13, 3.28, 1.41), leg III 8.77 (2.45, 1.25, 2.48, 2.12, 0.47), leg IV 9.2 (2.10, 1.26, 2.88, 2.06, 0.88). Leg formula: I>II>IV>III.

Genitalia: (Fig. 4B-C) Epigyne is less sclerotised, and the copulatory duct is ‘C’-shaped. The fertilisation duct is a narrow, transparent flap below the copulatory duct. Spermatheca is rounded and transparent. The copulatory duct narrows towards the anterior end and opens to the spermatheca.

Distribution: India, China, Indonesia (Sumatra).

Plate 6

Fig 4

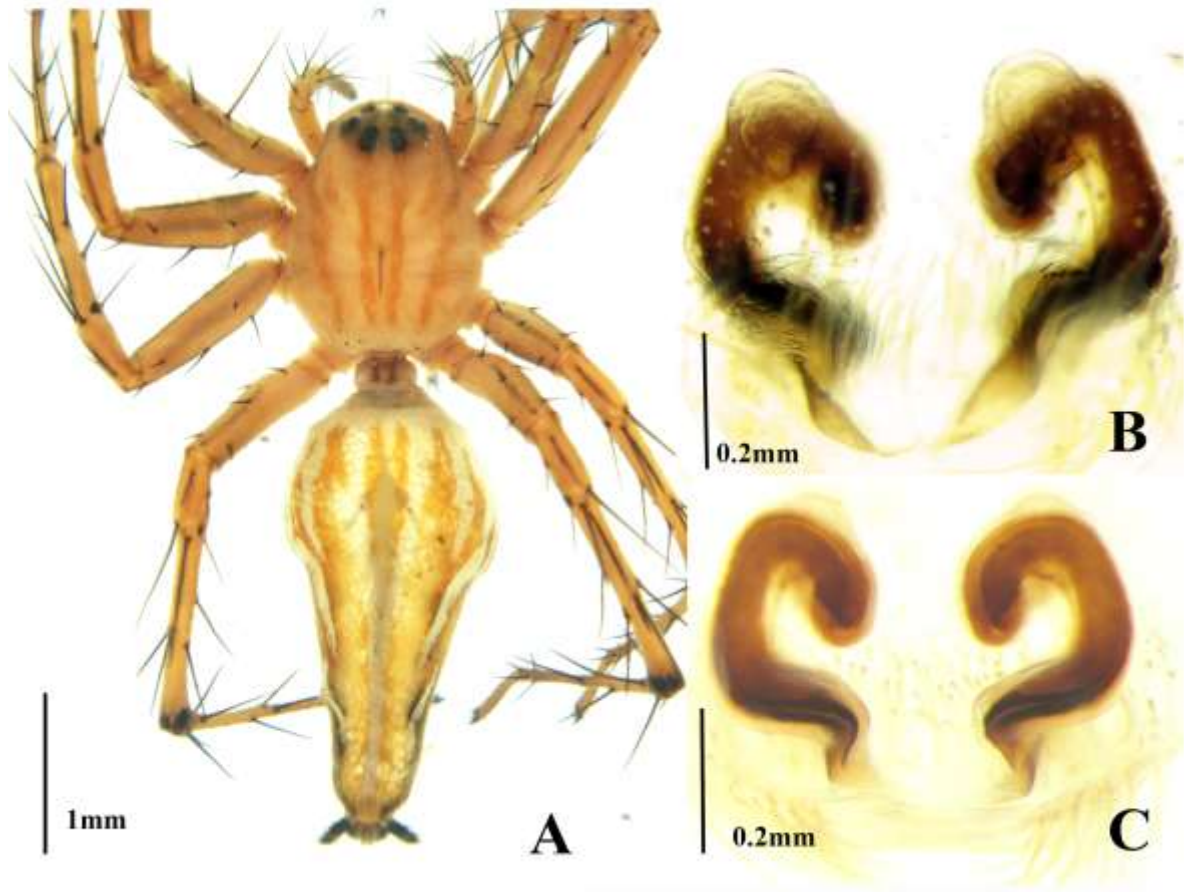


Fig. 4: *Oxyopes birmanicus* Thorell, 1887, female: A) Habitus, dorsal view; B) Vulva, ventral view; C) Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.5. *Oxyopes circum* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 7, Figs. 5A-C]

Materials examined: 1 Paratype female adult ♀ (**Fig. 5A**), 2 paratype female adult ♀, collected at Periya 35, 11°49'54.10"N, 75°50'36.02"E, 12/01/22, 10/05/24; 1 paratype female adult ♀, 1 paratype female subadult ♀, Tholpetty Forest, 11°57'8.31"N, 76°3'34.29"E, 03/09/21; 1 paratype female adult ♀, Pulpalli, 11°40'22.17"N, 76°15'30.30"E, 13/01/22.

Etymology: The noun “Circum” is derived from the Latin word for “round”. The spermathecae of perfect are round shaped in this species, hence the name *O. circum*.

Diagnosis: *O. circum* is like *O. javanus* Thorell, 1887. However, it can be distinguished from the latter by the following characters: 1) The copulatory duct is “C” shaped in *O. javanus*, which is “V” shaped in *O. circum*; 2) The posterior end of the copulatory duct of each side is connected by a horseshoe-shaped flap of tissue in *O. javanus*, which is absent in *O. circum*; 3) The spermatheca bulged out of the anterior end of the copulatory duct in *O. javanus*, which is inside the copulatory duct in *O. circum* as a perfect round.

Description: Holotype, Female (Fig. 5A) (CATE212605), Measurements: TL 8.96 (including pedicel); CL 2.80, CW 2.94; AL 4.99, AW 2.1.81. The carapace is yellowish and pear-shaped, with light, green-coloured bands extending from the PME to the edge of the carapace. The lateral sides of the carapace from the clypeus end to the posterior edge are covered with light green patches. Eyes are arranged in four rows on the dorsal side with AER strongly recurved and PER procurved. Clypeus high with two dark black stripes from the AME margin to the front of each chelicera. Ocular area length 0.66, width 0.87. Eye diameters and inter-distances: AME 0.08, ALE 0.27, PME 0.25, PLE

0.17; eye sizes: ALE > PME > PLE > AME; AME-AME 0.19, AME-ALE 0.12, PME-PME 0.30, PME-PL 0.27, ALE-PL 0.22, ALE-ALE 0.28, PLE-PL 0.87. Clypeus height is 0.71; Chelicera is 1.05, and it is downward with two pro marginal teeth and one retro marginal tooth. Broad fang at the base and narrowed towards the tip and less pointed. Endite and labium longer than wide. The sternum is longer than wide, and the long and short hairs are scattered. The abdomen is fusiform and brownish, with an olive-coloured cardiac mark that originates from the abdomen's anterior end and narrows towards the spinnerets. Pale yellow bands surround the anterior lateral sides of this cardiac mark. The lateral sides of the abdomen have alternating black and white bands from anterior to posterior. A dark longitudinal band extend from the epigastric furrow to the spinnerets in ventral view. Legs are covered with many conspicuous short spines and two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 3.19 (0.67+ 0.54 + 1.01 + 0.97), I 16.03 (3.78 + 1.30+ 4.70 + 4.60 + 1.65), II 14.68 (3.93 + 1.25+ 3.99 + 4.11 + 1.40), III 12.11 (3.34+ 1.14 + 3.05+ 3.41+ 1.17), IV 13.86 (4.19 + 1.23 + 3.58 + 3.31+ 1.55). Leg formula: I>II>IV>III.

Genitalia: (Fig. 5B-C) Highly sclerotised vulva. Copulatory ducts on each side are “<” shaped. The spermatheca is round and situated within the copulatory duct. In the posterior, the copulatory duct is slightly twisted and further projected with a pointed tip. In dorsal view, the copulatory duct is question-mark-shaped. The fertilisation duct is a narrow tube that opens from the middle lateral region into the lumen of the copulatory duct.

Male: Unknown.

Distribution: India.

Plate 7

Fig 5

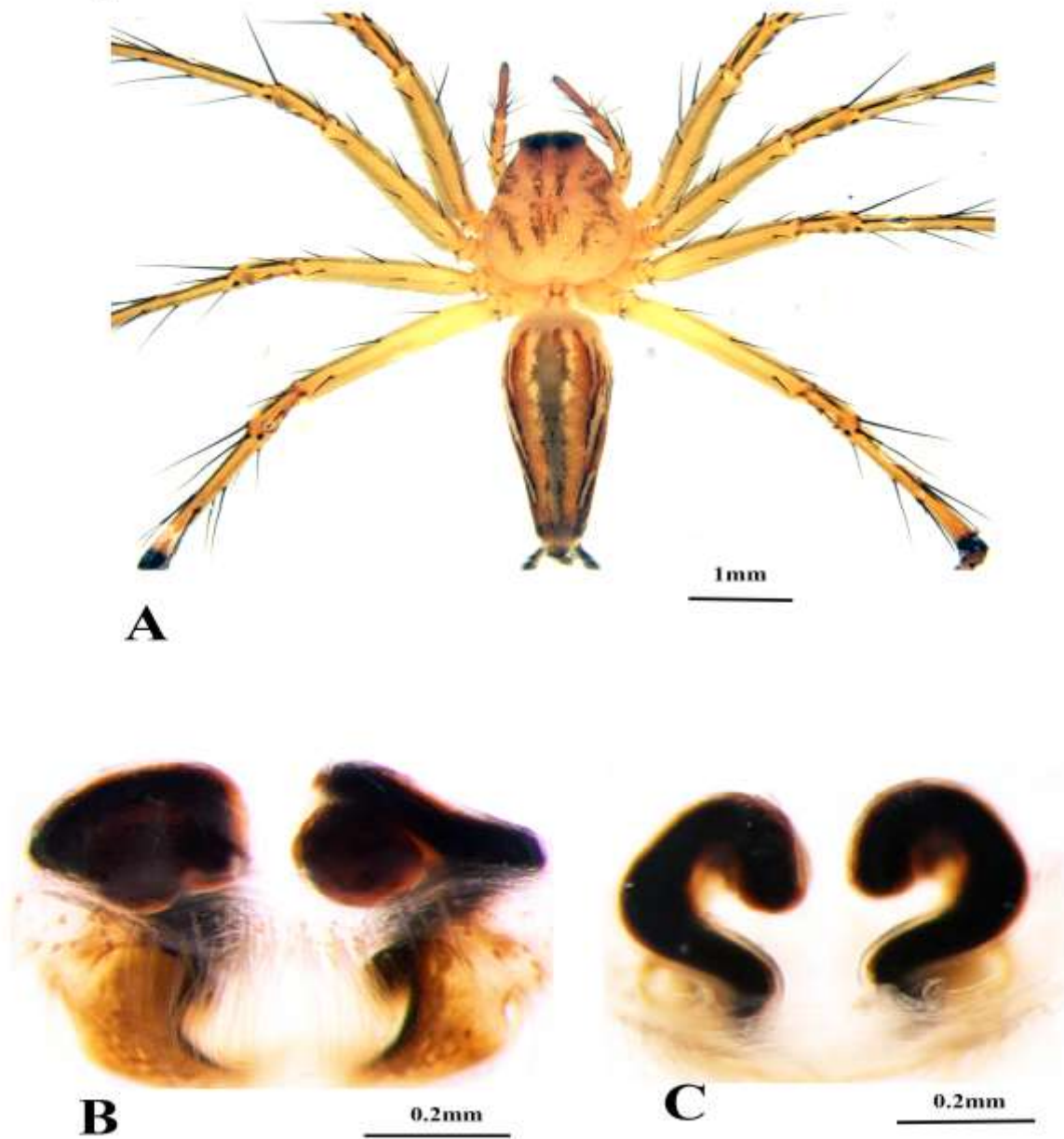


Fig. 5: *Oxyopes circum* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.6. *Oxyopes fabae* Dhali, Saha & Raychaudhuri, 2015 [Plate 8, Figs. 6A-C]

Materials examined: 1 Paratype female adult ♀ (**Fig. 6A**), 3 paratype female subadult ♀ collected at Munnar government botanical garden, 10°04'58.99"N, 77°04'15.35"E, 23/11/23, 24/03/24; 1 paratype female adult ♀, Munnar eco-point, 10°03'57.96"N, 77°08'27.11"E, 24/11/23; 1 paratype female adult ♀, Idukki dam, 09°50'28.67"N, 76°56'35.79"E, 24/03/24.

Description: Female (Fig. 6A) (CATE212606), Measurements: TL 8.8 (including pedicel); CL 2.24, CW 2.48; AL 5.96, AW 3.20. The carapace is light brown and pear-shaped, with two black bands extending from PME to the posterior end of the carapace. Two black bands extend from the anterior clypeus end to the posterior edge of the carapace. Two short bands originate from the PLE and end below the lateral PME. Fovea longitudinal and blackish. In dorsal view, the eyes are arranged in four rows, with the AER recurved and the PER procurved. Clypeus is high with two black stripes from the AME margin to the front of each chelicera. Ocular area length 0.58, width 1.10. Eye diameters and inter-distances: AME 0.09, ALE 0.22, PME 0.20, PLE 0.19, eye sizes ALE>PME >PLE>AME; AME-AME 0.13, AME-ALE 0.12, PME-PME 0.24, PME-PLE 0.28, ALE-PLE 0.25, ALE-ALE 0.24, PLE-PLE 1.10. Clypeus height is 0.52; Chelicera is 0.63, and it is downward, with one pro-marginal tooth and one retro-marginal tooth. Fang with a broad base and a narrow, less pointed tip. Endite and labium longer than wide. Sternum with long and short hair. Abdomen fusiform-shaped, with a broad white region anteriorly that narrowed towards the spinnerets. The lateral side of the abdomen has alternating broad black and narrow white bands. In ventral view, one dark band extends from the epigastric furrow to the spinnerets in a non-

parallel fashion. The legs are covered with many conspicuous long spines with black stripes, one on each dorsal side from the femur to the metatarsus. Two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 3.32 (1.23+ 0.54 + 0.83+ 0.72), I 11.6 (2.64 + 1.11+ 3.42 + 2.80 + 1.63), II 10.83 (2.31 + 1.10 + 3.34 + 2.67 + 1.41), III 8.71 (2.36 + 0.90 + 2.07 + 2.44 + 0.94), IV 9.23 (2.78 + 0.97 + 2.63 + 2.04 + 0.81). Leg formula: I>II>IV>III.

Genitalia: (Fig. 6B-C) Vulva is highly sclerotised, with an anteriorly directed scape that is nearly square-shaped, with smooth edges and laterally concave sides. The epigyne is butterfly-shaped. The spermatheca is thick and semicircular, with curved ends. The curved ends face outside. The tubular copulatory duct coiled over the spermatheca and extended downwards. The fertilisation duct is short and thick, opening onto the lateral side of the copulatory duct.

Distribution: India.

Plate 8

Fig 6

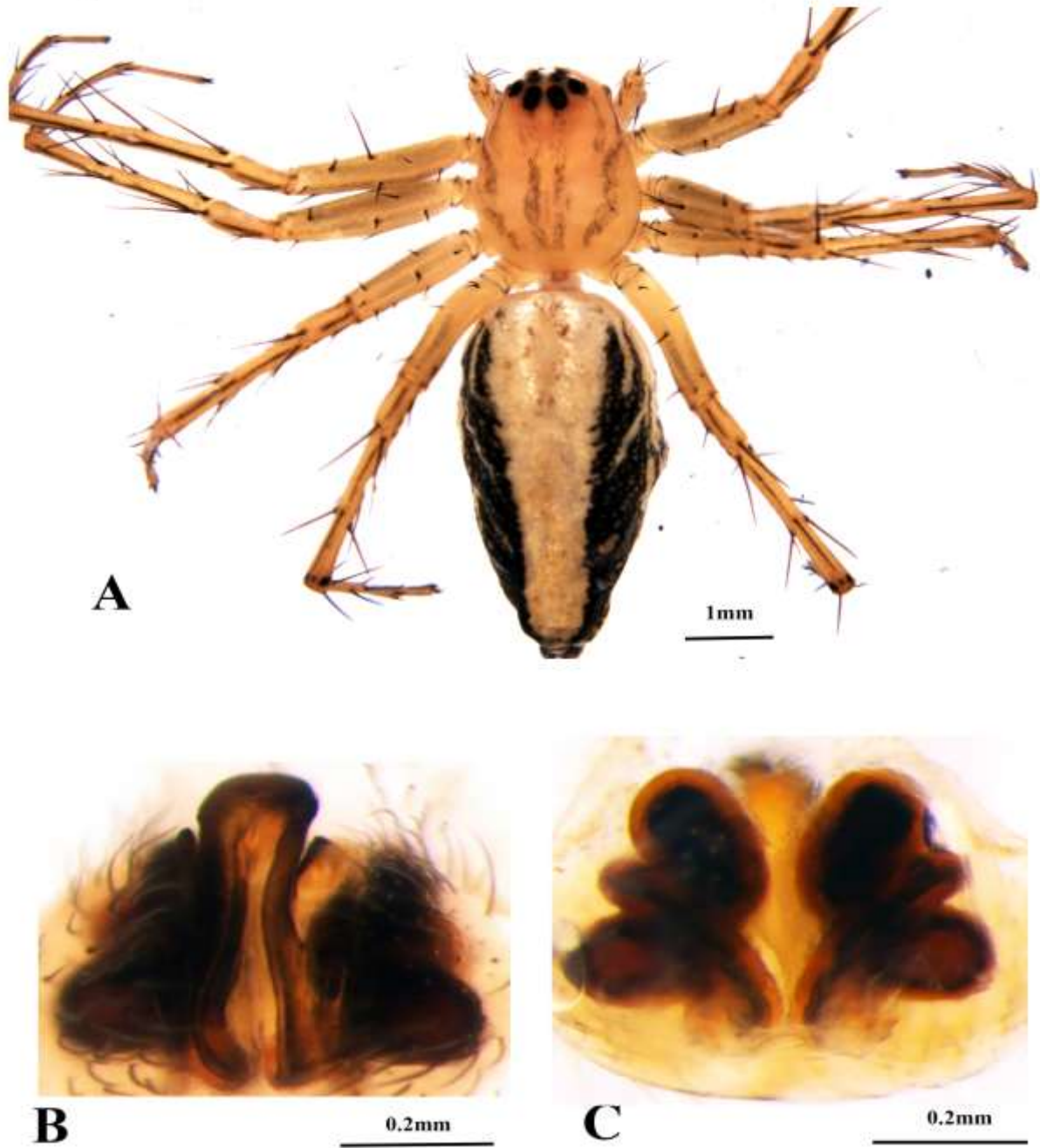


Fig. 6: *Oxyopes fabae* Dhali, Saha & Raychaudhuri, 2015, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.7. *Oxyopes hindostanicus* Pocock, 1901 [Plate 9, Figs. 7A-C; Plate 10, Figs. 8A-D]

Materials Examined: 1 Holotype female adult ♀ (**Fig. 7A**) 1 paratype male ♂ (**Fig. 8A**), collected at the locality, Hill Palace Kochi, 09°57'09.37"N, 76°21'44.90"E, 19/07/2022, 25/01/23; 4 paratype female adult ♀, Dhoni ecotourism, 10°51'34.76"N, 76°37'22.24"E, 02/10/22, 12/02/23; 3 paratype female adult ♀, Mangalam dam, 10°28'44.19"N, 76°35'0.60"E, 13/06/21, 01/10/22; 1 paratype female adult ♀, 3 paratype male ♂, Malampuzha dam garden, 10°49'52.90"N, 76°40'54.05"E 01/10/22, 11/02/23.

Description: Female (Fig. 7A) (CATE212607), Measurements: TL 7.04 (including pedicel); CL 3.10, CW 2.67; AL 3.94, AW 2.15. Carapace light brown, pear-shaped with a pair of brown lines extending from PME to the posterior end. A pair of distinctive, larger dark patches on the lateral sides. Fovea longitudinal and reddish. In dorsal view, the eyes are arranged in four rows, with the AER strongly recurved and the PER procurved. Clypeus is high with two black stripes from the AME margin to the front of each chelicera. Eye diameters and inter-distances: AME 0.16, ALE 0.29, PME 0.20, PLE 0.19; eye sizes: ALE > PME > PLE > AME; AME-AME 1.18; AME-ALE 1.19; PME-PME 0.34; PME-PLE 0.28. Eye row width measurement: I 0.19, II 0.29, III 0.73, IV 0.26. Clypeus height 0.47; Chelicerae downward with two pro-marginal teeth and one retro-marginal tooth. Endite and labium longer than wide. Sternum with scattered long and short hair and several pairs of black flecks on the marginal sides. The abdomen is fusiform with distinct cardiac marks and a whitish, longitudinal, and central band. The lateral region is blackish brown with three pairs of narrow white lines. In ventral view, a broad, dark longitudinal band extends from the epigastric furrow to

the spinnerets. Legs are covered with many conspicuous long spines with black stripes, one on each femur's dorsal, ventral and lateral sides. The proximal margin of the coxae is black. Two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: palp 3.25 (1.16, 0.26, 0.53, 1.30), leg I 10.66 (3.16, 3.89, 3.02, 1.20), leg II 10.35 (2.56, 1.20, 2.52, 2.72, 1.35), leg III 8.178 (2.25, 1.26, 2.40, 0.94), leg IV 10.19 (2.25, 1.26, 2.38, 3.28, 1.02). Leg formula: I > II > IV > III.

Genitalia: (Fig. 7B-C) Epigyne sclerotised. The spermathecae are oblong and arranged on the anterior lateral side of the copulatory duct. The copulatory duct is thick and roughly curved in ventral view. Both the anterior and posterior ends of the copulatory duct are narrowed. The anterior region of the copulatory duct slides down towards the posterior region, then extends anteriorly again, and ends in the copulatory duct. The fertilisation duct bulges at its posterior end, and the copulatory duct opens into it. The epigastric furrow is less sclerotised. The posterior ends of the copulatory ducts are connected by a narrow band of distally concave tissue.

Description: Male (Fig. 8A) (CATE212608), Measurements: TL 5.16 (including pedicel); carapace length 1.85, width 1.25; abdomen length 3.09, width 0.93. The carapace is brown, pear-shaped, with a single light orange central line from PME extending to the posterior end of the carapace and discontinuous orange patches along the lateral sides. Fovea longitudinal black coloured. Clypeus high, with two black stripes from AME to the front of each chelicera. A narrow black line along the lateral end of the carapace extends from the tip of the clypeus to the AME. Eye diameters and inter-distances: AME 0.11, ALE 0.20, PME 0.14, PLE 0.16; eye sizes: ALE > PLE > PME > AME; AME-AME 0.24; AME-ALE 0.10; PME-PME 0.22; PME-PL 0.25; Eye row width measurement: I 0.17, II 0.21, III 0.71, IV 0.24. Clypeus height 0.27.

Chelicerae 0.45, downward, with one pro-marginal tooth and one retro-marginal tooth. Endite and labium longer than wide. The sternum is yellowish with tiny hairs. The abdomen is fusiform, greenish yellow with a longitudinal orange band that starts at the posterior end and bifurcates in the anterior region; the area within the bifurcation is filled with yellow. A black band just above the spinneret. In ventral view, a broad, dark longitudinal band extends from the epigastric furrow to the spinnerets. Legs clothed with many conspicuous long spines, distinct black stripes on lateral sides of femur I–III. Three tarsal claws. Measurements of legs: leg I 12.38 (3.67, 0.79, 3.28, 3.50, 1.14), leg II 10.06 (3.52, 1.40, 2.57, 1.55, 1.02), leg III 6.66 (3.62, 0.59, 1.05, 0.77, 0.63), leg IV 9.04 (3.50, 0.63, 2.33, 1.81, 0.77). Leg formula: I>II>IV>III.

Pedipalp: (Fig. 8B-D) Highly sclerotised, proximal cymbal apophysis short, a dark, small projection on the distal prolateral side of the cymbium. The medium tegular apophysis is transparent, with a mirror image of a capital ‘L’-shape, and its anterior tip is dark-coloured. The sperm duct is flattened and “C” shaped towards the retrolateral side of the cymbium. The ventral tibial retrolateral apophysis appears highly twisted. Embolus at 1 o’clock in position. The conductor did not overlap the embolus. The tip of the medium tegular apophysis and the embolus are arranged in parallel. Presence of proximal and distal retrolateral patellar apophysis.

Distribution: Pakistan, Maldives, India, Sri Lanka, Bangladesh

Plate 9

Fig 7

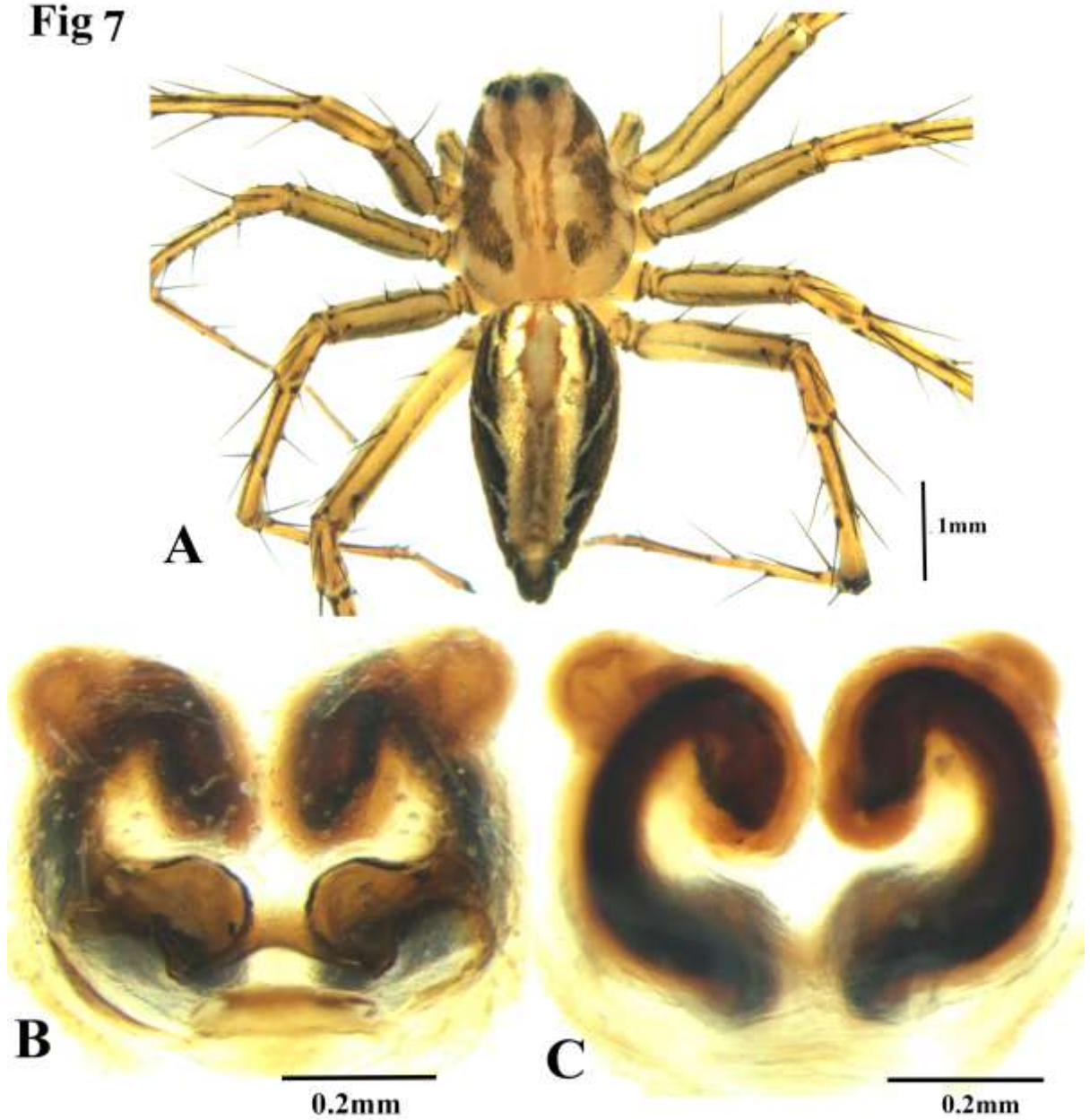


Fig. 7: *Oxyopes hindostanicus* Pocock, 1901, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

Plate 10

Fig 8



Fig. 8: *Oxyopes hindostanicus* Pocock, 1901, male. **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.2.8. *Oxyopes hippocampus* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 11, Figs. 9A-C]

Materials examined: 1 Paratype female adult ♀ (**Fig. 9A**), 1 paratype female adult ♀, collected at Thumboormuzhi butterfly park, 1017'55.83"N, 76°27'0.92"E, 09/06/21; 1 paratype female adult ♀, 3 paratype female subadult ♀, Athirapilly Waterfalls, 10°17'6.26"N, 76°34'12.28"E, 13/10/22, 07/02/23; 1 paratype female adult ♀, Kalashamala Ecotourism 10°40'27.51"N, 76° 5'27.12" E, 08/02/23.

Etymology: The noun “Hippocampus” is derived from the Latin word for “Seahorse”. The copulatory duct on each side of the epigyne is seahorse-shaped, hence the name *O. hippocampus*.

Diagnosis: *O. hippocampus* is like *O. thumboormuzhiensis* Amulya, Sebastian & Sudhikumar 2021. However, it can be distinguished from the latter by the following characters: 1) The epigyne has an anteriorly projecting short median scape between the copulatory ducts in *O. hippocampus*, whereas the scape is absent in *O. thumboormuzhiensis*. 2) The copulatory duct “C” shaped in epigyne dorsal view *O. hippocampus* which is question mark shaped in *O. thumboormuzhiensis* 3) The copulatory duct of each side connected by a thin flap of tissue in *O. thumboormuzhiensis* which is absent in *O. hippocampus*.

Description: Holotype, Female (Fig. 9A) (CATE212609), Measurements: TL 7.45 (including pedicel); CL 2.25, CW 2.28; AL 4.40, AW 2.04. The carapace is brownish and pear-shaped, with red-coloured bands extending from the PME to the end of the carapace. Two non-parallel lateral orange bands extend from the anterior of the clypeus to the posterior end of the carapace. Fovea longitudinal and reddish. Eyes are arranged in four rows on the dorsal side with AER strongly recurved and PER procurved.

Clypeus high with two dark black stripes from the AME margin to the front of each chelicera. Ocular area length 0.69, width 1.12. Eye diameters and inter-distances: AME 0.07, ALE 0.25, PME 0.23, PLE 0.18; eye sizes: $ALE > PME > PLE > AME$; AME-AME 0.15, AME-ALE 0.08, PME-PME 0.29, PME-PLE 0.28, ALE-PLE 0.29, ALE-ALE 0.26, PLE-PLE 1.12. Clypeus height is 0.21; Chelicera is 1.45, and it is downward with one pro marginal tooth and one retro marginal tooth. Broad fang at the base and narrowed towards the tip, and less pointed. Endite and labium longer than wide. The sternum is longer than wide, and the hair is scattered, long and short. Abdomen fusiform, silver-white with two white bands; originates from the anterior end of the abdomen, is fused into a single band, and ends in spinnerets. The white bands form an oval space in the anterior abdomen, which is filled with a creamy white patch surrounded by an orange patch. The lateral sides of the abdomen have alternating black and white bands. Two Dark longitudinal lines extend from the epigastric furrow to the spinnerets in ventral view. Legs are covered with many conspicuous short spines and two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 1.74 (0.39+ 0.48 + 0.44 + 0.43), I 11.02 (2.55 + 0.97+ 3.44 + 2.84 + 1.22), II 9.23 (2.53 + 1.00+ 3.22 + 1.89 + 0.59), III 8.07 (2.59+ 0.89 + 2.09+ 1.62+ 0.88), IV 9.46 (2.46 + 1.03 + 1.58 + 2.64+ 1.75). Leg formula: $I > II > IV > III$.

Genitalia: (Fig. 9B-C) Vulva highly sclerotised. Copulatory ducts on each side are seahorse shaped. A short scape is present between the copulatory ducts, which are directed towards the anterior of the Vulva. The copulatory duct is pointed at its anterior end. The spermathecae are elongated and round, located at the tip of the copulatory duct. The copulatory duct “C” is shaped and thick in its posterior end in dorsal view. Copulatory ducts are not connected in the posterior. The fertilisation duct is tiny and opens to the lateral side of the copulatory duct.

Male: Unknown. Distribution: India.

Plate 11

Fig 9

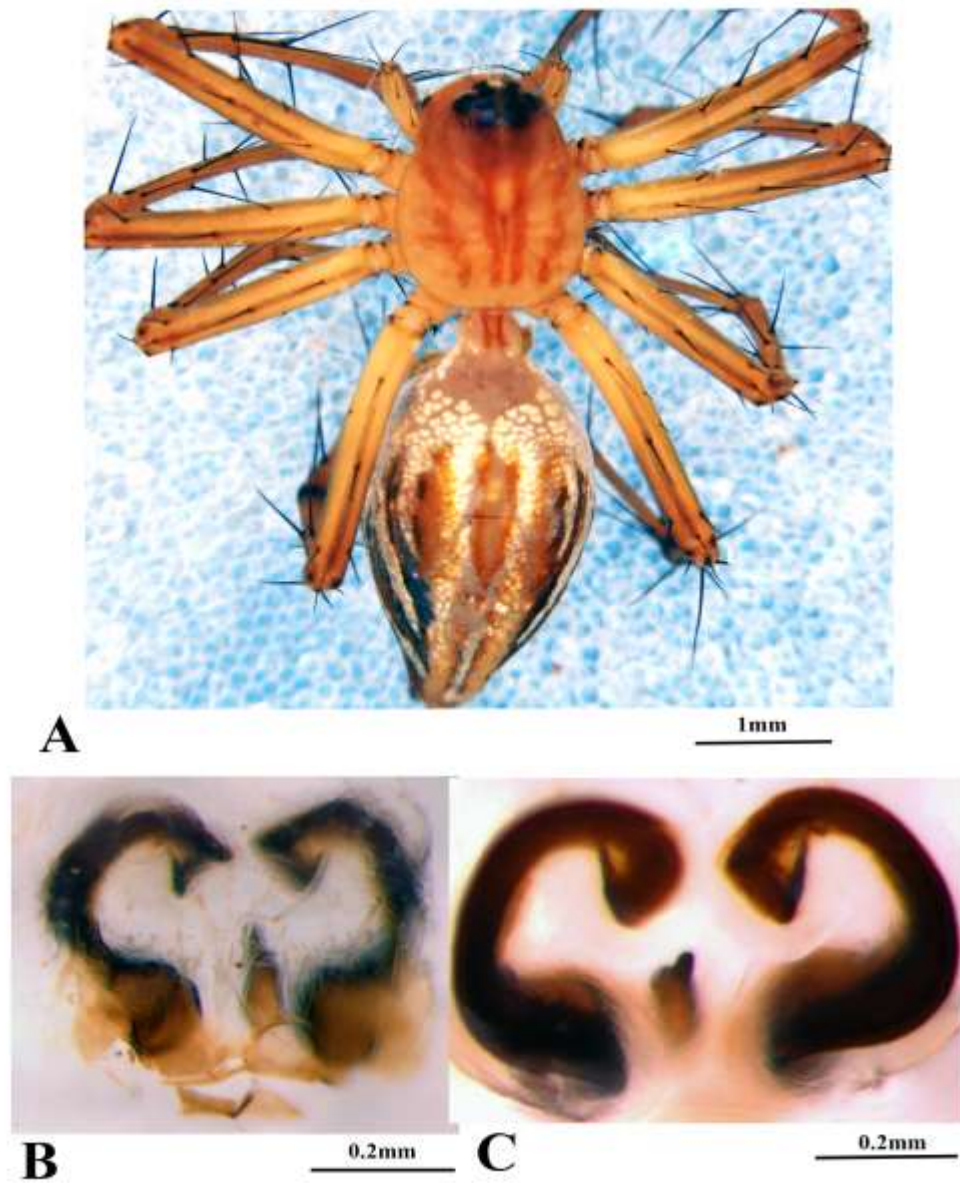


Fig. 9: *Oxyopes hippocampus* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.9. *Oxyopes javanus* Thorell, 1887 [Plate 12, Figs. 10A-C]

Materials examined: 1 Paratype female adult ♀ (**Fig. 10A**) collected at Hill Palace Kochi, 09°57'09.37"N, 76°21'44.90"E, 19/07/2022; 2 paratype female adult ♀, Pathiamanal Island 09°37'07.11" N, 76°23'04.95"E, 28/02/24; 1 paratype female adult ♀, Adyanpara waterfalls, 11°21'16.47"N, 76°12'10.82"E, 04/11/22; 2 paratype female adult ♀, Thumbboormuzhi butterfly park, 10°17'55.83"N, 76°27'0.92"E, 09/06/21.

Description: Female (Fig. 10A) (CATE212610), Measurements: TL 7.12 (including pedicel); CL 2.62, CW 2.58; AL 3.92, AW 1.66. The carapace is pear-shaped and brownish-coloured, with dark brown patches on the lateral side extending from the PLE eye to the posterior end. A pair of dark brown patches extends from PME to the posterior end. Fovea longitudinal and reddish. Eyes are arranged dorsally in four rows, with AER recurved and PER procurved. Clypeus is high with two black stripes from the AME to the front of each chelicera. Ocular area length 0.66, width 0.92. Eye diameters and inter-distances: AME 0.10, ALE 0.22, PME 0.18, PLE 0.14, eye sizes ALE>PME>PLE>AME; AME-AME 0.12, AME-ALE 0.10, PME-PME 0.20, PME-PLE 0.36, ALE-PLE 0.34, ALE-ALE 0.56, PLE-PLE 0.92. Clypeus height: 0.43; Chelicera downward, with one promarginal and one retromarginal tooth. Fang with a broad base and a narrow, less pointed tip. Endite and labium longer than wide. The sternum is longer than wide, nearly heart-shaped, with a few short hairs. Abdomen fusiform-shaped, light brown, with two white bands extending from the anterior tip of the abdomen, their non-parallel ends towards the spinnerets. The lateral side of the abdomen contains alternating dark and light bands. In ventral view, a dark black patch extends from the epigastric furrow to the spinnerets in a nonparallel fashion. The legs are covered with many conspicuous spines with black stripes, one on each dorsal side

from the femur to the metatarsus. Two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 2.31(0.28+ 0.54 + 0.73+ 0.76), I 12.87 (3.08 + 1.18+ 3.35 + 3.83 + 1.43), II 8.54 (2.44 + 1.22 + 3.61 + 0.82 + 0.45), III 7.31 (2.43+ 0.19 + 2.69 + 1.20 + 0.80), IV 8.55 (3.25 + 0.95 + 1.36 + 1.78 + 1.21). Leg formula: I>II>IV>III.

Genitalia: (Fig. 10B-C) Epigyne highly sclerotised. Copulatory duct “C” shaped. The spermatheca is rounded and located anterior to the copulatory duct. A horseshoe-shaped tissue flap connects the copulatory duct at its posterior end. Spermatheca is not visible in the ventral view. The fertilisation duct opens on the lateral sides of the copulatory duct.

Distribution: India, Nepal, Bangladesh, Thailand, Indonesia (Java), Philippines, China.

Plate 12

Fig 10

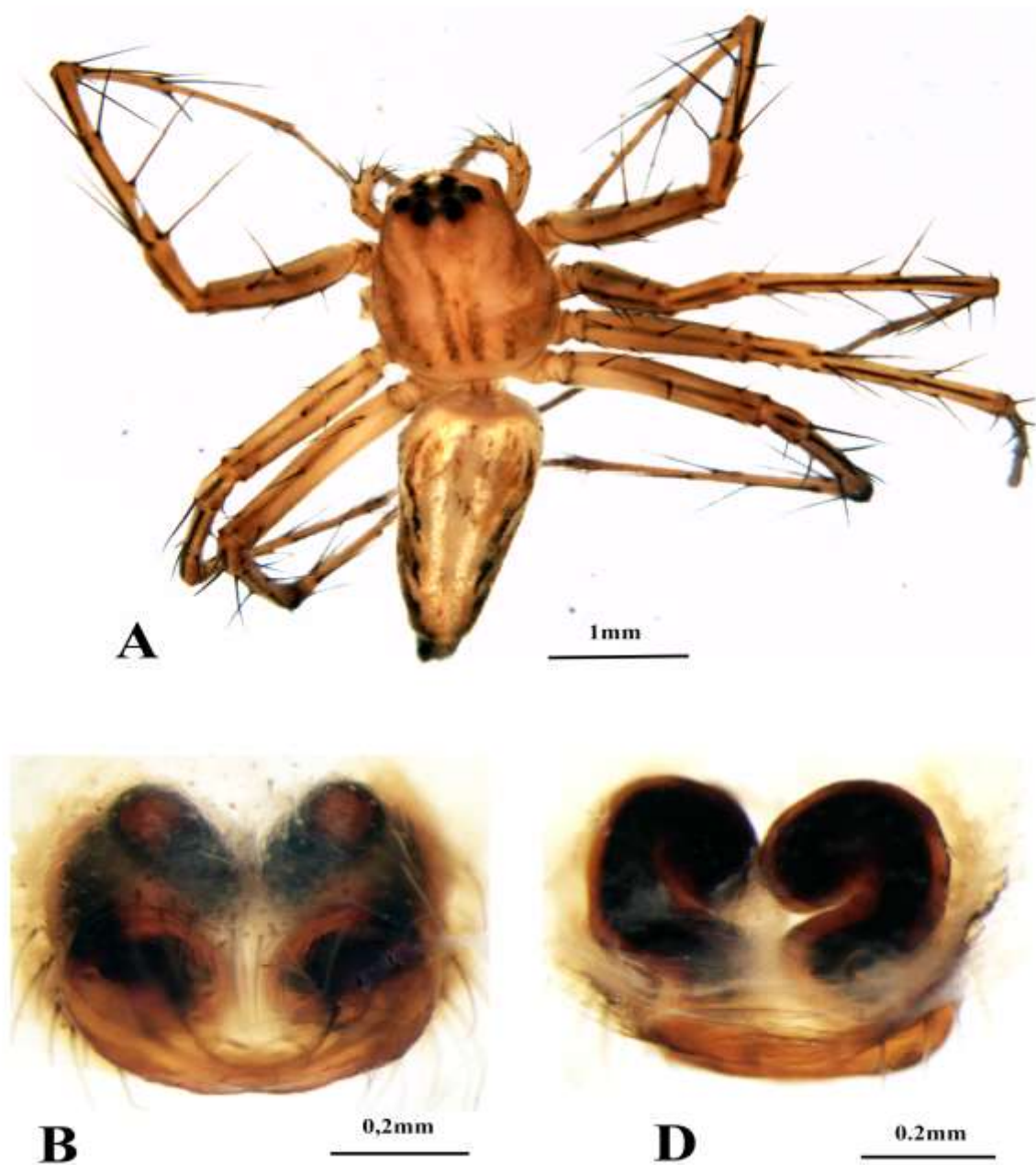


Fig. 10: *Oxyopes javanus* Thorell, 1887, female: A) Habitus, dorsal view; B) Vulva, ventral view; C) Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.10. *Oxyopes kasaragodensis* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 13, Figs. 11A-C; Plate 14, Figs. 12A-D]

Materials examined: 1 Holotype female adult ♀ (**Fig. 11A**) 1 paratype male ♂ (**Fig. 12A**), collected at the locality, Bekkal fort, 12°23'35.81"N, 75°53'26.31"E, 05/08/21, 13/12/22; 2 paratype female adult ♀, 1 paratype male subadult ♂, Cashew plantation in Periye, 12°23'58.13"N, 76°35'0.60"E, 05/01/22, 02/05/23; 1 paratype male adult ♂, Ranipuram hill Station, 12°24'52.42"N, 76°37'22.24"E. 06/01/22.

Etymology: The specimen was collected from Kasaragod district in Kerala, India. The specific epithet is derived from this district name. Hence the name *O. kasaragodensis*.

Diagnosis: *O. kasaragodensis* is relatively like *O. hindostanicus* Pocock, 1901. Even so, the first differs from the second in the following respects. 1) The pedipalp with proximal and distal retrolateral patellar apophysis in *O. hindostanicus*, which is absent in *O. kasaragodensis* 2) The proximal end of the MTA in the retrolateral side has a broad and sclerotised tip in *O. hindostanicus* which is thin and pointed in *O. kasaragodensis* 3) Presence of sclerotised structures above the prolateral end of the MTA in *O. hindostanicus* which is transparent in *O. kasaragodensis*.

Description: Holotype, Female: (Fig. 11A) (CATE212611), Measurements: TL 7.39; CL 2.22; CW 2.68; AL 4.44; AW 2.30. The carapace is pear-shaped and reddish-brown, with two copper-red central longitudinal bands extending from PME to the posterior edge of the carapace. The lateral sides, with copper-red bands, extend from the anterior clypeal end to the posterior edge of the clypeus. Fovea longitudinal and reddish. In dorsal view, the eyes are arranged in four rows, with the AER recurved and the PER procurved. Clypeus is high with two black stripes from the AME margin to the

front of each chelicera. Ocular area length 0.78, width 1.20. Eye diameters and inter-distances: AME 0.13, ALE 0.21, PME 0.19, PLE 0.16; eye sizes: ALE > PME > PLE > AME; AME-AME 0.16, AME-ALE 0.24, PME-PME 0.34, PME-PLE 0.29, ALE-PLE 0.28, ALE-ALE 0.29, PLE-PLE 1.20. Clypeus height is 0.58; Chelicera is 0.76, and it is downward, with one pro-marginal tooth and two retro-marginal teeth. Fang with a broad base and a narrow, pointed tip. Endite and labium longer than wide. Sternum with short hair. Abdomen fusiform-shaped, yellowish-brown with a copper-red, oval-shaped cardiac mark at the centre. There are centrally forwarded light and dark bands on the lateral side of the abdomen. In ventral view, a dark band extends from the epigastric furrow to the spinnerets, non-parallel. The legs are covered with many conspicuous long spines with black stripes, one on each dorsal side from the femur to the metatarsus. Two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 2.30 (0.66+ 0.40 + 0.54+ 0.70), I 13.04 (3.26 + 1.33 + 3.29 + 4.50 + 0.66), II 11.85 (2.78 + 0.74 + 3.21 + 3.39 + 1.73), III 8.45 (2.53 + 0.37 + 1.03 + 3.24 + 1.28), IV 9.68 (2.07 + 1.25 + 0.51 + 4.33 + 1.52). Leg formula: I>II>IV>III.

Genitalia: (Fig. 11B-C) The vulva is less sclerotised, with two petal-like sclerotised structures at its posterior end. In epigyne, the spermatheca is round-shaped and situated anterior to the copulatory duct. The copulatory duct thickened and was "C" shaped. The fertilisation duct is a narrow tube that runs along the lateral sides of the copulatory duct and opens onto its posterior side.

Description: Paratype, Male (Fig. 12A) (CATE212612), Measurements: TL 4.83 (including pedicel); CL 0.69, CW 1.90; AL 3.41, AW 1.11. The carapace is golden yellow with dense orange dots on its posterior side. Two black lines originate from the

lateral end of the clypeus and end on the lateral side of PME. In dorsal view, the eyes are arranged in four rows, with the AER recurved and the PER procurved. Clypeus is high with two black stripes from the AME margin to the front of each chelicera. Ocular area length 0.56, width 0.84. Eye diameters and inter-distances: AME 0.11, ALE 0.19, PME 0.16, PLE 0.18, eye sizes ALE>PME >PLE>AME; AME-AME 0.12, AME-ALE 0.07, PME-PME 0.20, PME-PLE 0.22, ALE-PLE 0.24, ALE-ALE 0.19, PLE-PLE 0.84. Clypeus height is 0.40; Chelicera is 0.86, and it is downward with one pro marginal tooth and one retro marginal tooth. Fang with a broad base and a narrow, less pointed tip. Endite and labium longer than wide. Sternum without short hair. Abdomen fusiform, grey-coloured without any characteristic marks. Two black spots are present in the lateral middle of the abdomen and the posterior end of the abdomen, which is coloured. In ventral view, two dark lines extend from the epigastric furrow to the spinnerets, nonparallel. Legs are covered with many conspicuous long spines. Two tarsal claws. Measurements legs: I 15.35 (4.37 + 0.99 + 4.97 + 3.42 + 1.60), II 13.71 (4.05 + 0.79 + 4.17 + 3.28 + 1.42), III 12.39 (3.15 + 0.62 + 3.34 + 4.11 + 1.17), IV 13.39 (3.48 + 0.99 + 3.86 + 0.77 + 0.67). Leg formula: I>II>IV>III.

Pedipalp: (Fig. 12B-D) Cymbium with two short dorsal spines. The tegulum inside the cymbium. Tibia without hair. The embolus originates from the posterior tegulum, narrowed and curved on the prolateral side, extends to the anterior tegulum, and terminates in a pointed tip at the 1 o'clock position. The conductor is short, has a broad base and a less pointed tip, and is parallel to the embolus. The sperm duct on the retrolateral side is flattened and less sclerotised. MTA is transparent, with an “L”-shaped anterior-to-prolateral cymbal position. The horizontal end of the “L”- shaped MTA is broader, and its edge is twisted, forming a transparent structure above it on the prolateral side. Tibia with one RTA and VTA. VTA is a sclerotised projection turned

towards the retrolateral side. RTA below the VTA is a broad, semicircular sclerotised structure.

Distribution: India.

Plate 13

Fig 11

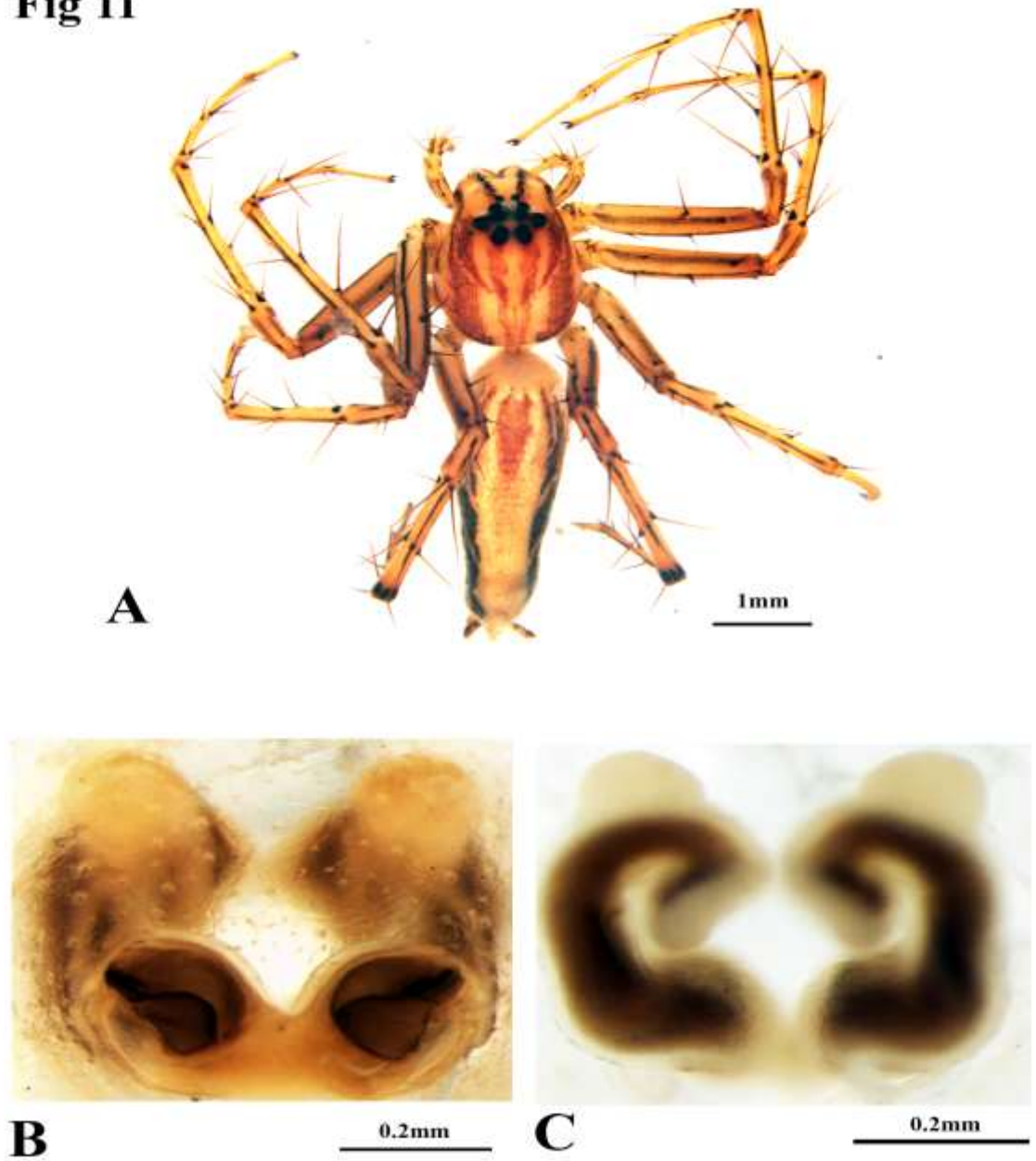


Fig. 11: *Oxyopes kasaragodensis* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, female : A) Habitus, dorsal view; B) Vulva, ventral view; C) Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

Plate 14

Fig 12

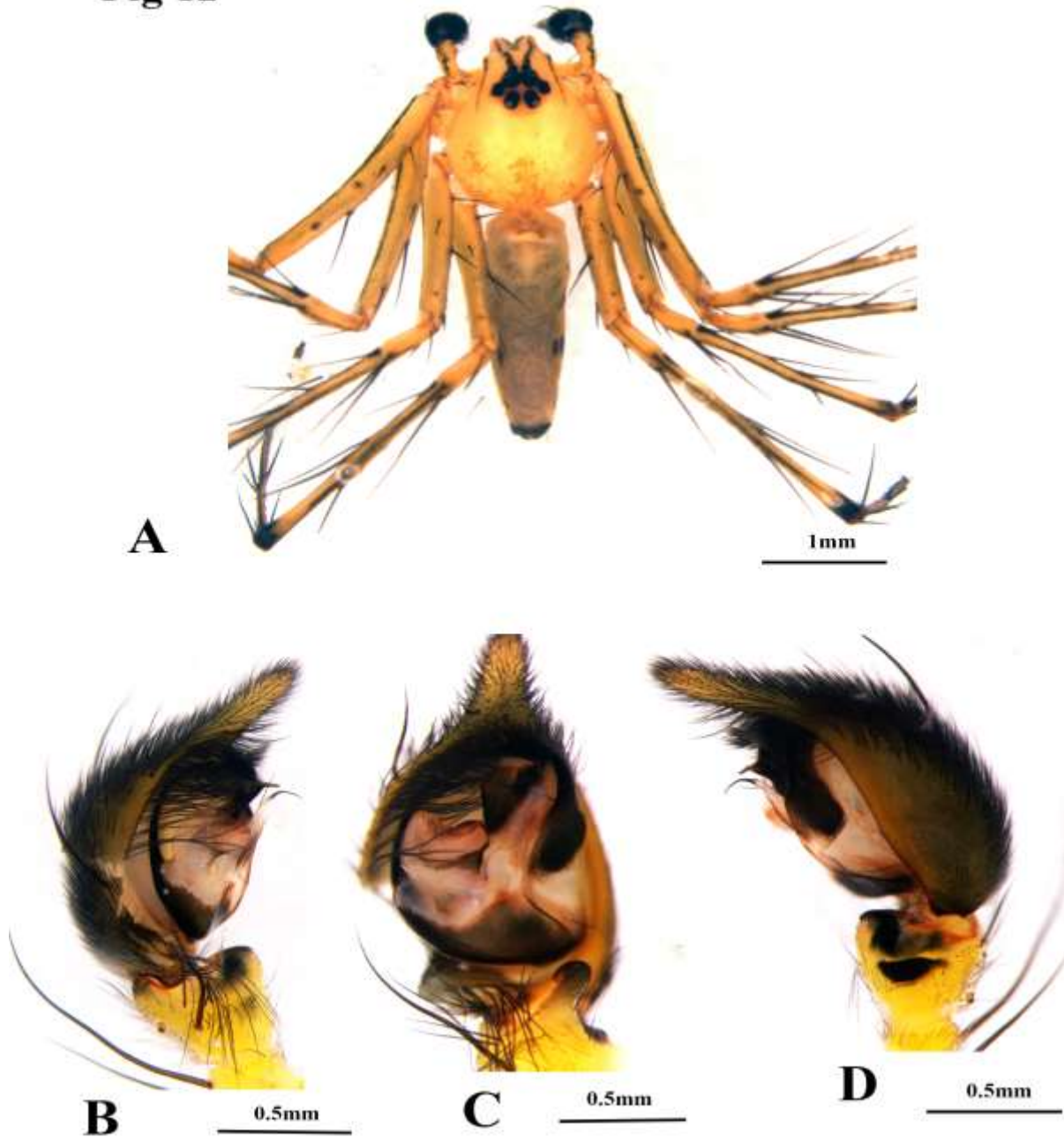


Fig. 12: *Oxyopes kasaragodensis* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, male. **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.2.11. *Oxyopes longinquus* Thorell, 1891 [Plate 15, Figs. 13A-C]

Materials examined: 1 Paratype female adult ♀ (**Fig. 13A**), 2 paratype female adult ♀, collected at Kottur forest region, 08°33'20.75"N, 77°09'16.71"E, 26/10/23, 27/04/24; 1 paratype female adult ♀, 2 paratype female subadult ♀, Ayiramtengu mangrove forest, 09°07'12.04"N, 76°28'53.85"E, 29/09/2022, 30/04/24; 1 paratype female adult ♀, Krishnapuram palace, 09°09'00.57"N, 76°30'32.69"E, 22/01/23; 2 paratype female subadult ♀, Pala rubber plantation, 09°43'29.95"N, 76°43'27.00"E, 31/05/24; 1 paratype female adult ♀, Fort Kochi regions 09°57'56.81"N, 76°14'31.62"E, 18/07/2022; 1 paratype female adult ♀, Kalashamala ecotourism, 10°40'27.51"N, 76° 5'27.12"E, 08/02/23.

Description: Female (Fig. 13A) (CATE212613), Measurements: TL 6.66 (including pedicel); CL 1.84, CW 2.67; AL 4.82, AW 1.72. The carapace is light brown and pyriform, with many light black lines starting from the lateral sides and merging towards the carapace's central parallel lines. The fovea is blackish and longitudinal. Eyes are arranged in four rows on the dorsal side with AER strongly recurved and PER procurved. Clypeus high with two dark black stripes from the AME margin to the front of each chelicera. Ocular area length 0.57, width 1.05. Eye diameters and inter-distances: AME 0.07, ALE 0.21, PME 0.17, PLE 0.18, eye sizes ALE>PME >PLE>AME; AME-AME 0.17, AME-ALE 0.08, PME-PME 0.31, PME-PLE 1.22, ALE-PLE 0.21, ALE-ALE 0.38, PLE-PLE 0.05. Clypeus height 0.38; Chelicera downward with two pro-marginal teeth and one retro-marginal tooth. Broad fang at the base, narrowing towards the tip, and pointed. Endite and labium longer than wide. The sternum is longer than wide, and the hair is scattered long and short. Abdomen fusiform, silvery white. centre of the abdomen with a grey-coloured inverted triangular mark.

The lateral middle side of the abdomen to the end contains an alternating pattern of light and dark bands. In ventral view, two dark longitudinal bands extend from the epigastric furrow to the spinnerets. Legs are covered with many conspicuous short spines and two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 2.65 (0.47+ 0.43 + 0.94 + 0.81), I 12.07 (2.99 + 1.53 + 3.58 + 3.41 + 0.56), II 11.93 (2.87 + 1.35+ 3.47 + 3.25 + 0.99), III 8.5 (2.78 + 1.26 + 2.53 + 1.53+ 0.40), IV 9.65 (2.40 + 0.97 + 3.24 + 1.94 + 1.10). Leg formula: I>II>IV>III.

Genitalia: (Fig. 13B-C) Vulva less sclerotised. Spermathecae are round and arranged on the anterior end of the copulatory duct. The copulatory duct is thick, and its anterior end is curved, forming a rounded shape and ending in the spermatheca. The anterior copulatory ducts are oriented backwards. The copulatory duct's posterior ends are connected with a thread-like tissue flap, forming an inverted “V” at the centre. In the ventral view, the copulatory duct is “S” shaped. The fertilisation duct originates anterior to the copulatory duct and opens on the posterolateral side of the copulatory duct.

Distribution: India (Nicobar Is.), Myanmar, China (Hainan).

Plate 15

Fig 13

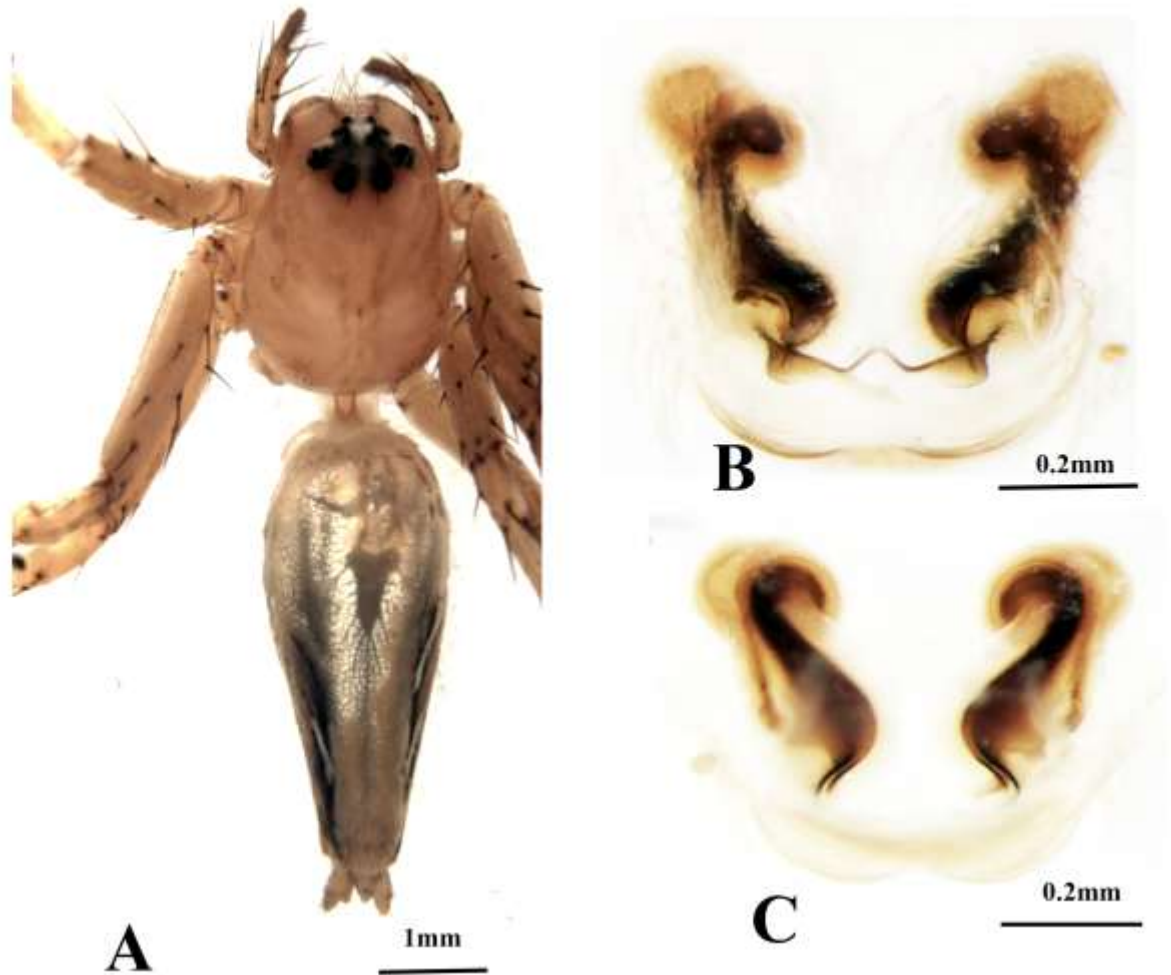


Fig. 13: *Oxyopes longinquus* Thorell, 1891, female **A)** Habitus, dorsal view **B)** Vulva, ventral view **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.12. *Oxyopes macilientus* L. Koch, 1878 [Plate 16, Figs. 14A-D]

Materials examined: Paratype male adult ♂ (Fig. 14A), 2 paratype male adult ♂, collected at the locality, Bekkal fort, 12°23'35.81"N, 75°53'26.31"E, 05/08/21, 09/04/23; 3 paratype male adult ♂, Valapattanam riverside, 12°02'28.97"N, 76°15'1.63"E, 04/08/21, 12/12/22; 1 paratype male adult ♂, 2 paratype male subadult ♂, Pazhassi museum garden, 11°17'33.54"N, 75°46'40.14"E, 13/07/21, 13/02/23; 1 paratype male adult ♂, Sarovaram biopark, 11°16'7.33"N, 75°47'34.13"E, 11/07/21; 3 paratype male adult ♂, Mangalam dam, 10°28'44.19"N, 76°35'0.60"E, 11/02/23; 1 paratype male subadult ♂, Pullu paddy field, 10°27'8.57"N, 76°9'20.09"E, 04/02/23.

Description: Male (Fig. 14A) (CATE212614). Measurements: TL 6.28 (including pedicel); CL 2.01, CW 2.29; AL 3.81, AW 1.50. The carapace is light brown and pear-shaped, with a yellowish central band extending from PME to the posterior end of the carapace and a pair of pale-yellow bands extending from PLE to the posterior edge of the carapace. Fovea longitudinal and blackish. In dorsal view, the eyes are arranged in four rows, with the AER strongly recurved and the PER procurved. Clypeus high with black stripes from the AME margin to the front of each chelicera. Ocular area length 0.46, width 0.85; Eye diameters and inter-distances: AME 0.07, ALE 0.19, PME 0.18, PLE 0.15; eye sizes: ALE > PME > PLE > AME; AME-AME 0.38, AME-ALE 0.22, PME-PME 0.23, PME-PLE 0.17, ALE-PLE 0.34, ALE-ALE 0.23, PLE-PLE 0.85. Clypeus height 0.60; Chelicera downward with one pro-marginal tooth and one retro-marginal tooth. The fang is broad at the base and narrows towards the tip but is less pointed. Sternum yellow without hair. Abdomen fusiform-shaped, light brown with an orange central band that broadens anteriorly and narrows towards the spinnerets. The lateral side of the abdomen has black discontinuous patches. In ventral view, the

abdomen is light coloured. Legs are covered with conspicuous long spines. Two tarsal claws. Measurements of legs: I 10.05 (1.90+ 0.86 + 3.17 + 2.69+ 1.43), II 10.02 (2.05 + 0.08 + 2.81+ 3.05 + 1.29) III 9.28 (1.83 + 0.90+ 2.81 + 2.77 + 1.38), IV 9.46 (2.09 + 1.05+ 1.45 +3.58+ 1.29). Leg formula: I>II>IV>III.

Pedipalp: (Fig. 14B-D) The tegulum inside the cymbium. The conductor and the embolus are closely spaced, with their tips parallel. The MTA is whitish and wavy, with broad anterior and posterior portions and a narrow middle, extending from the middle of the prolateral side of the tegulum, strongly curved, and ending at the anterior of the retrolateral side of the tegulum. The embolus at the 1 o'clock position. The sperm duct is a convex, flattened structure arranged on the retrolateral side. RTA two, ventral RTA longitudinal and dorsal RTA oblique. The retrolateral side of the abdomen has an extension at the base.

Distribution: Japan, China, Australia.

Plate 16

Fig 14

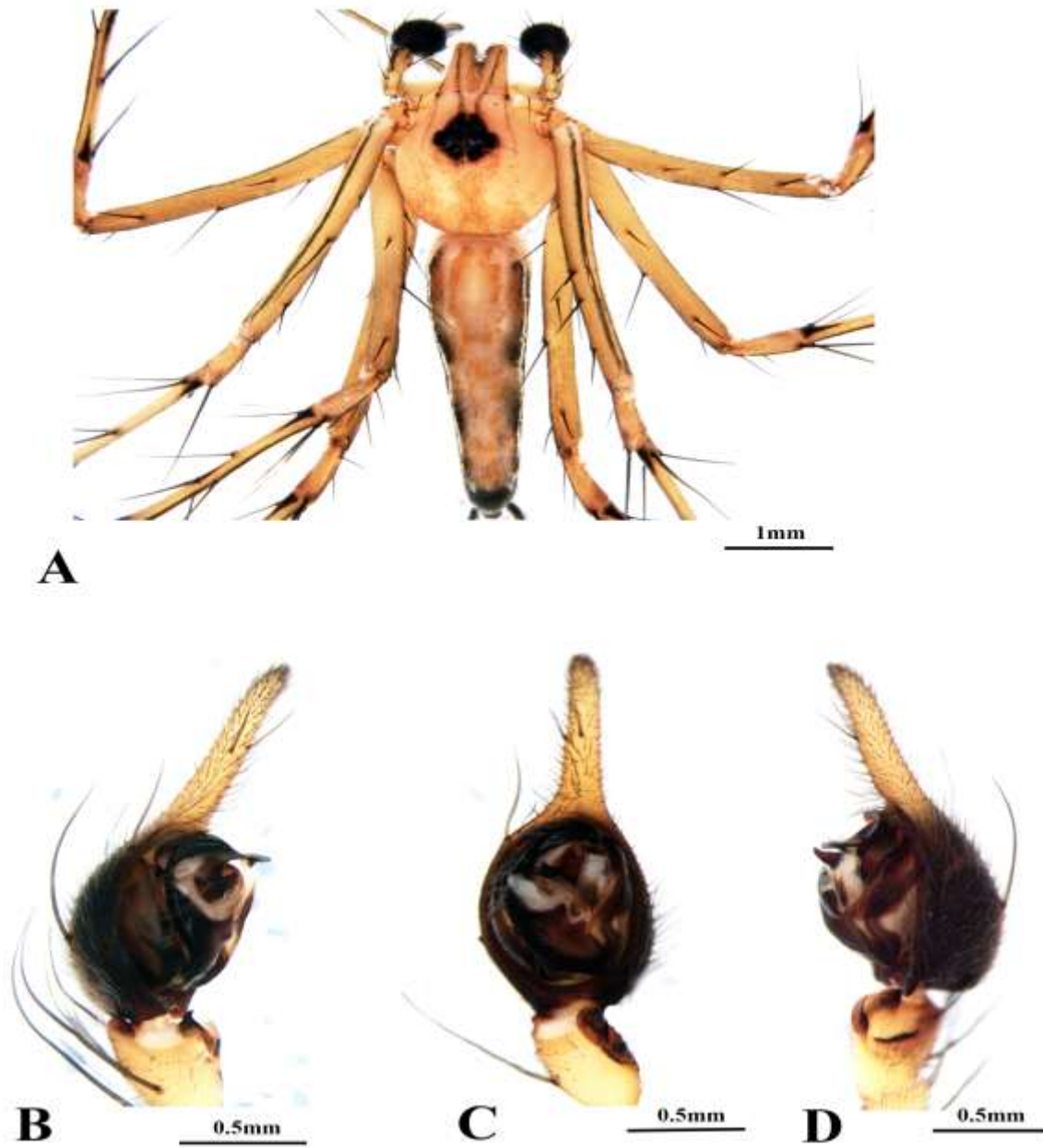


Fig. 14: *Oxyopes macilentus* L Koch, 1878. Male. **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.2.13. *Oxyopes mirabilis* Zhang, Yang & Zhu, 2005 [Plate 17, Figs. 1A-D]

Materials examined: Paratype male adult ♂ (Fig. 15A), 3 paratype male adult ♂, collected at the locality, Nedumgayam rain forest, 11°17'32.82"N, 76°20'25.19"E, 02/07/21, 02/03/23; 4 paratype male adult ♂, Pulpalli, 11°40'22.17"N, 76°15'30.30"E, 05/09/21, 11/05/24; 1 paratype male adult ♂, Nilamboor teak museum, 11°18'0.29"N, 76°15'1.63"E, 02/03/23; 1 paratype male adult ♂, Maggattuparambhu region, 11°58'55.47"N, 76°0'19.15"E, 07/04/23.

Description: Male (Fig. 15A) (CATE212615), Measurements: TL 3.59 (including pedicel); CL 1.33, CW 1.59; AL 1.38, AW 0.93. The carapace is golden yellow and pear-shaped, without any characteristic marks. Fovea longitudinal and blackish. In dorsal view, the eyes are arranged in four rows, with the AER strongly recurved and the PER procurved. Clypeus high with black stripes from the AME margin to the front of each chelicera. Ocular area length 0.54, width 0.82; Eye diameters and interdistances: AME 0.07, ALE 0.16, PME 0.14, PLE 0.12; eye sizes: ALE > PME > PLE > AME; AME-AME 0.12, AME-ALE 0.17, PME-PME 0.20, PME-PLE 0.19, ALE-PLE 0.20, ALE-ALE 0.35, PLE-PLE 0.82. Clypeus height 0.36, Chelicera downward with two pro-marginal and two retro-marginal teeth. The fang is broad at the base and narrows towards the tip but is less pointed. Sternum yellow with short hair. Abdomen fusiform-shaped, reddish-yellow coloured, densely covered with black patches except the anterior of the abdomen. In ventral view, the abdomen is reddish-yellow. Legs are covered with a few spines. Two tarsal claws. Measurements of legs: I 10.44 (2.31 + 0.70 + 3.54 + 2.70 + 1.19), II 8.10 (2.25 + 0.64 + 1.80 + 2.50 + 0.91), III

6.79 (1.70+ 0.57 + 1.81 + 2.33 + 0.38), IV 7.36 (2.20 + 0.54 + 1.41 + 2.47 + 0.74). Leg formula: I>II>IV>III.

Pedipalp: (Fig. 15 B-D) Tegulum inside the cymbium. The presence of VTA is arrow-headed and projected towards the cymbium. RTA is minor and adjacent to the VTA. An embolus is a narrow tube that ends anteriorly on the cymbium at the 1 o'clock position. The conductor and the embolus are close, and their tip are overlapped. MTA is transparent and ribbon-shaped, expanding below the embolus and moving toward the posterior end of the prolateral side. The sperm duct convex tubular structure in the retrolateral region of the pedipalp. A “V” shaped apophysis projected towards the prolateral side of the cymbium.

Distribution: India, China.

Plate 17

Fig 15

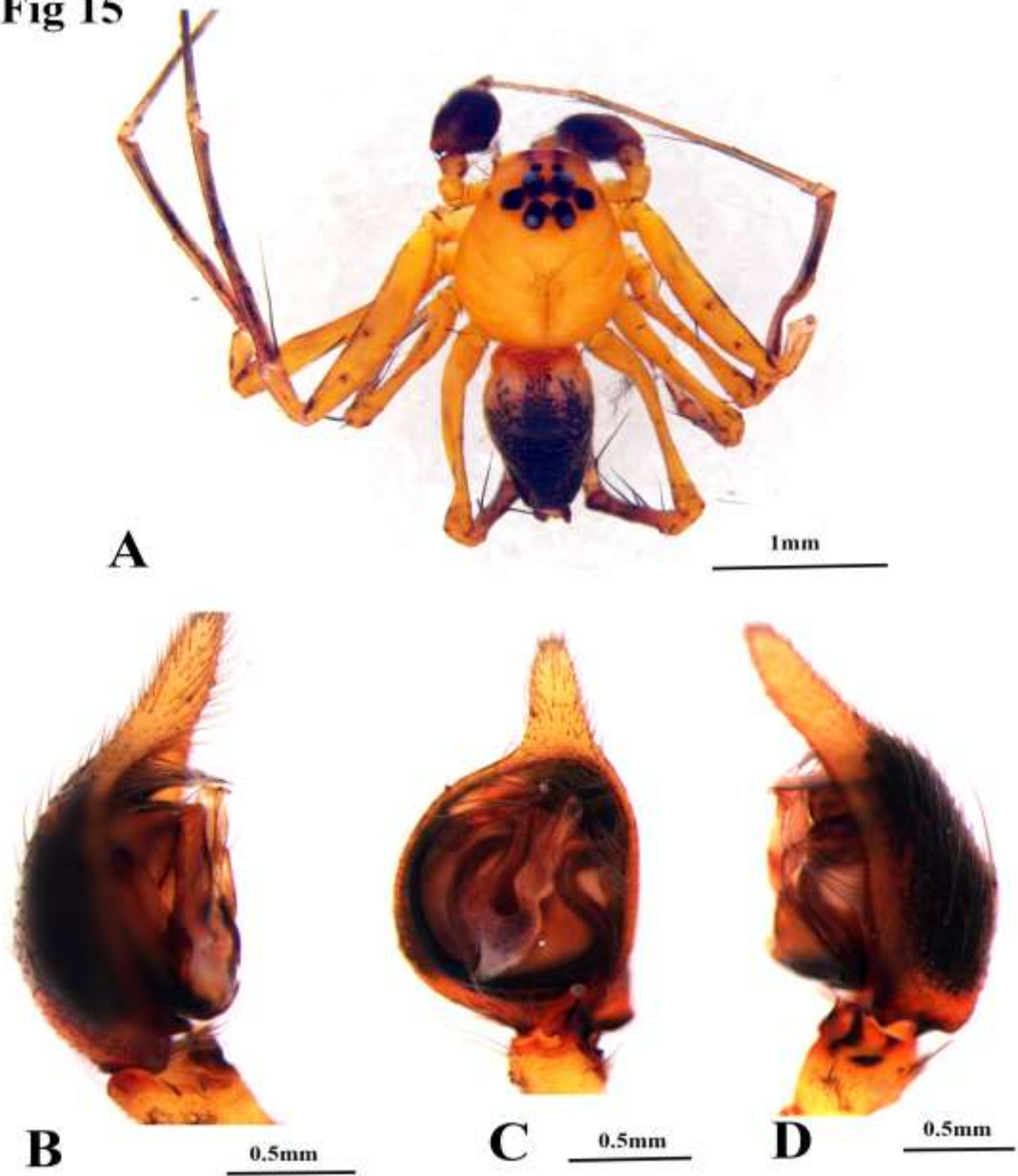


Fig. 15: *Oxyopes mirabilis* Zhang, Yang & Zhu, 2005, male. **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.2.14. *Oxyopes patera* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 18, Figs. 16A-C]

Materials examined: 1 Holotype female adult ♀ (**Fig. 16A**), 4 paratype female subadults ♀, collected at Kothamangalam forest region, 10°03'38.29"N, 76°36'59.93"E, 20/07/2022, 24/01/23, 25/02/24.

Etymology: The noun “Patera” is derived from the Latin word for “bowl.” The copulatory duct and spermatheca are inside a bowl-like tissue flap (scape), hence the species name *O. patera*.

Diagnosis: *O. patera* is similar to *O. scapeus* Sen & Sureshan, 2021. However, it can be distinguished from the latter by the following characters: 1) The scape is elongated, tube-like in *O. scapeus*, whereas it is short and bowl-like in *O. patera*. 2) The copulatory duct is short in *O. scapeus*, whereas it is long and extends downwards in *O. patera*. 3) The spermatheca is globular-shaped in *O. scapeus*, which is oval-shaped in *O. patera*.

Description: Holotype, Female (Fig. 16A) (CATE212616), Measurements: TL 7.92 (including pedicel); CL 3.08, CW 2.07; AL 4.04, AW 1.55. The carapace is reddish-brown and pear-shaped, with dark red-coloured bands extending from the PME to the edge of the carapace. The entire lateral surface of the carapace has densely radiating dark red patches. Eyes are arranged in four rows on the dorsal side with AER strongly recurved and PER procurved. Clypeus high with two dark black stripes from the AME margin to the front of each chelicera. Ocular area length 0.64, width 1.04. Eye diameters and inter-distances: AME 0.10, ALE 0.19, PME 0.17, PLE 0.18; eye sizes: ALE > PME > PLE > AME; AME-AME 0.15, AME-ALE 0.09, PME-PME 0.26, PME-PLE 0.24, ALE-PLE 0.23, ALE-ALE 0.24, PLE-PLE 1.04. Clypeus height is 0.41; Chelicera is

1.61, and it is downward, with two pro-marginal teeth and one retro-marginal tooth. Broad fang at the base, narrowing towards the tip, and pointed. Endite and labium longer than wide. The sternum is longer than wide, and the hair is scattered, long and short. Abdomen fusiform, dark brown with two pinkish bands originating from the anterior end and fusing in the middle of the abdomen. The inside of this fused region is filled with a dark brown patch, and a light brown patch surrounds the outside. The lateral sides of the abdomen have alternating black and white bands. A dark longitudinal band extend from the epigastric furrow to the spinnerets in ventral view. Legs are covered with many conspicuous short spines and two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 2.22 (0.19+ 0.34 + 0.64 + 1.05), I 11.86 (3.97+ 2.02+ 3.42 + 1.07 + 1.38), II 10.67 (2.46 + 1.01+ 3.22 + 2.64 + 1.34), III 9.82 (2.67+ 1.87 + 1.77+ 2.34+ 1.17), IV 10.48 (3.46 + 1.89 + 2.44 + 1.04+ 1.65). Leg formula: I>II>IV>III.

Genitalia: (Fig. 16B-C) The vulva is less sclerotised and “W”- shaped, with two oval structures within. Copulatory ducts on each side are ribbon-shaped and short. In dorsal view, the spermatheca is oval-shaped. The copulatory duct originates behind the spermatheca. The fertilisation duct opens behind the copulatory duct. The copulatory duct and spermatheca are situated inside a bowl-like tissue flap (scape).

Distribution: India

Plate 18

Fig 16

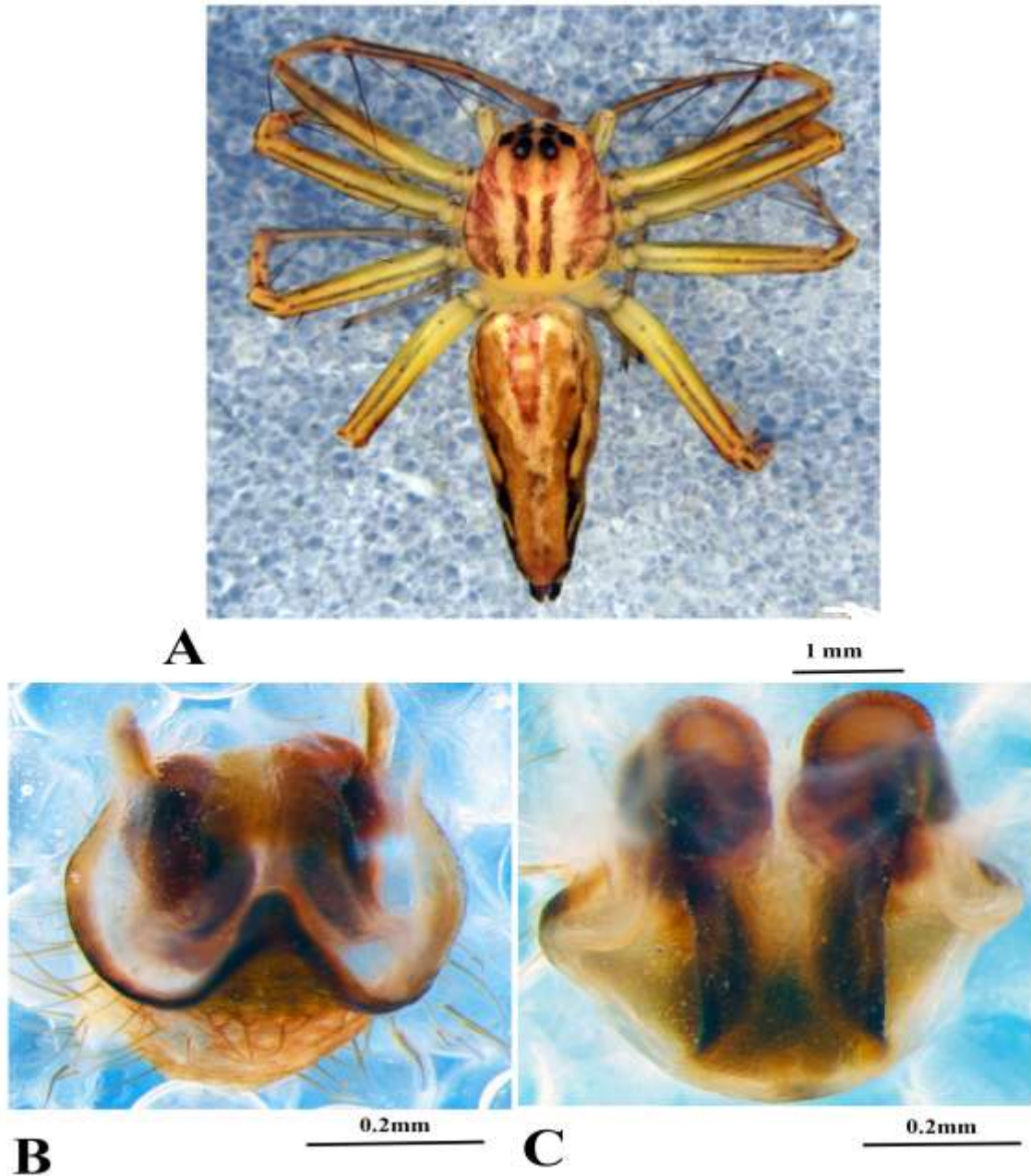


Fig. 16: *Oxyopes patera* sp. nov. Amulya, Sebastian & Sudhikumar 2026, Holotype, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.15. *Oxyopes peetham* sp. nov., Amulya, Sebastian & Sudhikumar, 2021 [Plate 19, Figs. 17A-C; Plate 20, Figs. 18A-D]

Materials examined: 1 Holotype female adult ♀ (**Fig. 17A**) 1 paratype male ♂ (**Fig. 18A**), collected at the locality, Calicut university garden, 11° 8'1.92"N, 75°53'26.31"E, 01/07/21; 1 paratype female adult ♀, 1 paratype male subadult ♂, Mangalam dam, 10°28'44.19"N, 76°35'0.60"E, 11/02/23; 1 paratype male adult ♂, Chalakkudi river region, 10°17'18.89"N, 76°25'56.16"E, 13/10/22; 1 paratype male adult ♂, Nedumgayam rain forest, 11°17'32.82"N, 76°20'25.19"E, 02/03/23.

Etymology: The specific name is a Sanskrit adjective referring to the yellow-coloured body in both sexes.

Diagnosis. *Oxyopes peetham* sp. n. is somewhat similar to *O. bharatae* Gajbe, 1999 in epigyne morphology. It could be distinguished from the latter species by the following characters: i) Copulatory duct eroteme shaped "?" in ventral view, which is coiled into one turn towards the dorsal side and ends in the spermatheca (this turn is absent in *O. bharatae*). ii) Male pedipalp having a prominent ventral tibial apophysis and a pitcher-shaped median tegular apophysis. Median tegular apophysis is triangular and less prominent in *O. bharatae*. iii) Embolus is short and distinctly separated from the conductor. The embolus is longer and covered with the conductor in *O. bharatae* (Gajbe, 1999; Gajbe, 2008; Malik et al., 2016).

Description: Holotype, Female (Fig. 17A) (CATE212617), Measurements: TL 7.45 (including pedicel); CL 2.02, CW 1.73, AL 4.54, AW (at the middle) 1.56; ocular area length 0.397, width 0.280; ocular diameter: AME 0.075, ALE 0.149, PME 0.115, PLE 0.0.147; ocular inter distance: AME-AME 0.147, AME-ALE 0.076, PME-PME 0.193,

PME-PLE 0.277, ALE-PLE 0.248, ALE-ALE 0.109, PLE-PLE 0.748. Clypeus height 0.45. Length of chelicera 0.87. Palp 2.32 (0.85, 0.15, 1.00, 0.32). Leg measurements: I 12.17 (3.29, 0.77, 3.44, 3.31, 1.36), II 11.11 (3.34, 0.72, 2.94, 3.09, 1.02), III 8.79 (2.61, 0.63, 2.20, 2.50, 0.85), IV 10.43 (3.19, 0.63, 2.42, 3.23, 0.96). Leg formula I>II>IV>III. Cephalothorax, abdomen, and legs are yellowish-brown in colour, with black lines on both dorsal and ventral sides and spines. The cephalothorax is broader and raised posteriorly than anteriorly, with a narrowly curved anterior tip, and has a carapace with a single median and two lateral white bands. Pale red markings on the distal side of the carapace. Chelicerae downward, with two pro-marginal teeth, the first larger than the second, and four retro-marginal teeth arranged as a distorted quadrangle. The fang is broad at the base and narrows towards the tip, but is less pointed. Endite and labium longer than wide. The sternum is semi-pointed, dome-shaped, with disproportionately arranged setae, and is yellowish in colour. Abdomen fusiform. The anterior dorsal region is convex and has a distinguishable creamy white marking in the centre. Dark broad bands on the lateral and tip of the abdomen. In ventral view, a broad, dark longitudinal band extends from the epigastric furrow to the spinnerets. Two tarsal claws.

Genitalia: (Fig. 17B-C) Epigyne is less sclerotised, with a central depression. Copulatory ducts are thick and eroteme-shaped "?" with the anterior end coiled into one turn towards the dorsal side and end with the rounded spermathecae. Fertilisation ducts are slender, elongated downwards, and pointed with a transparent flap at the tip, clearly visible as a separate tube from the copulatory duct.

Description: Paratype, Male (Fig. 18A) (CATE212618), Measurements: TL 5.25 (including pedicel); CL 1.58, CW 1.68, AL 2.90, AW 0.82; ocular diameter: AME

0.080, ALE 0.162, PME 0.122, PLE 0.158; ocular distance: AME-AME 0.107, AME-ALE 0.069, PME-PME 0.191, PME-PLE 0.188, ALEPLE 0.156, ALE-ALE 0.156, PLE-PLE 0.290; Clypeus height 0.38. Length of chelicera 0.85. Leg measurements: I 14.07 (3.58, 0.78, 3.97, 4.02, 1.72), II 11.41 (3.24, 0.61, 3.39, 3.08, 1.09), III 10.12 (2.09, 0.59, 2.90, 3.52, 1.02), IV 10.64 (3.34, 0.57, 1.98, 3.63, 1.12); leg formula I>II>IV>III. Cephalothorax and abdomen pale yellow in colour without any characteristic markings. The abdomen narrowed, and in ventral view, two narrow, dark longitudinal lines extended from the epigastric furrow to the spinnerets. Legs pale yellow in colour. Chelicerae go downward and have one pro-marginal and one retro-marginal tooth. The sternum is an oil lantern chimney-shaped structure without any setae.

Pedipalp: (Fig. 18B-D) Tibia with distinct retrolateral depression between the two adjacent apophyses; ventral retrolateral tibial apophysis large pointed, retrolateral apophysis smaller and ridge shaped; cymbium with elongated anterior apophysis; conductor black not coiled with embolus; embolus slender, originating at 5.30 o'clock position and encompassing prolateral side of the genital bulb to 1 o'clock position; median tegular apophysis white pitcher shaped, distal tegular apophysis sclerotized.

Distribution: India.

Plate 19

Fig 17

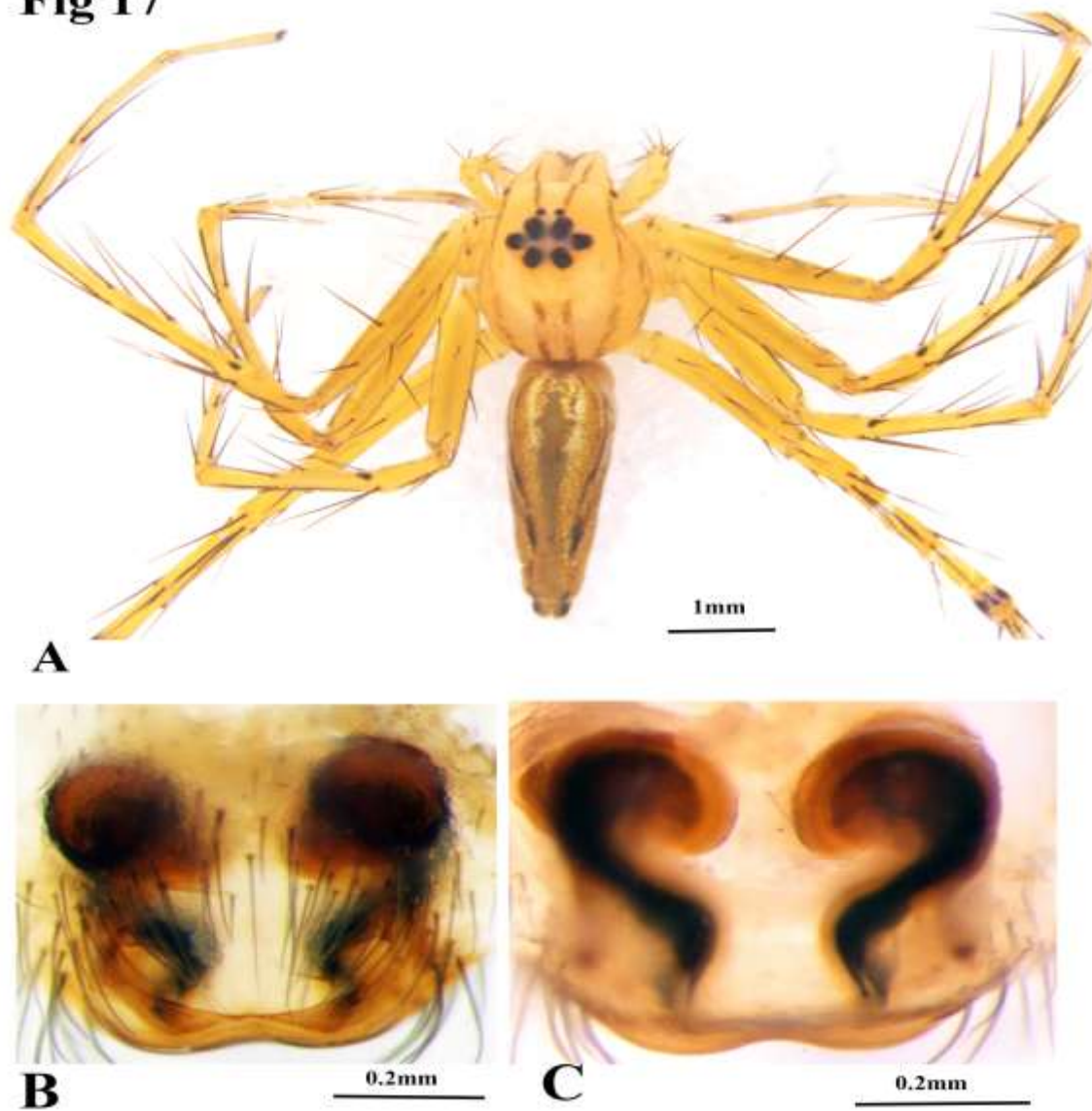


Fig. 17: *Oxyopes peetham* sp. nov. Amulya, Sebastian & Sudhikumar 2021, Holotype, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

Plate 20

Fig 18

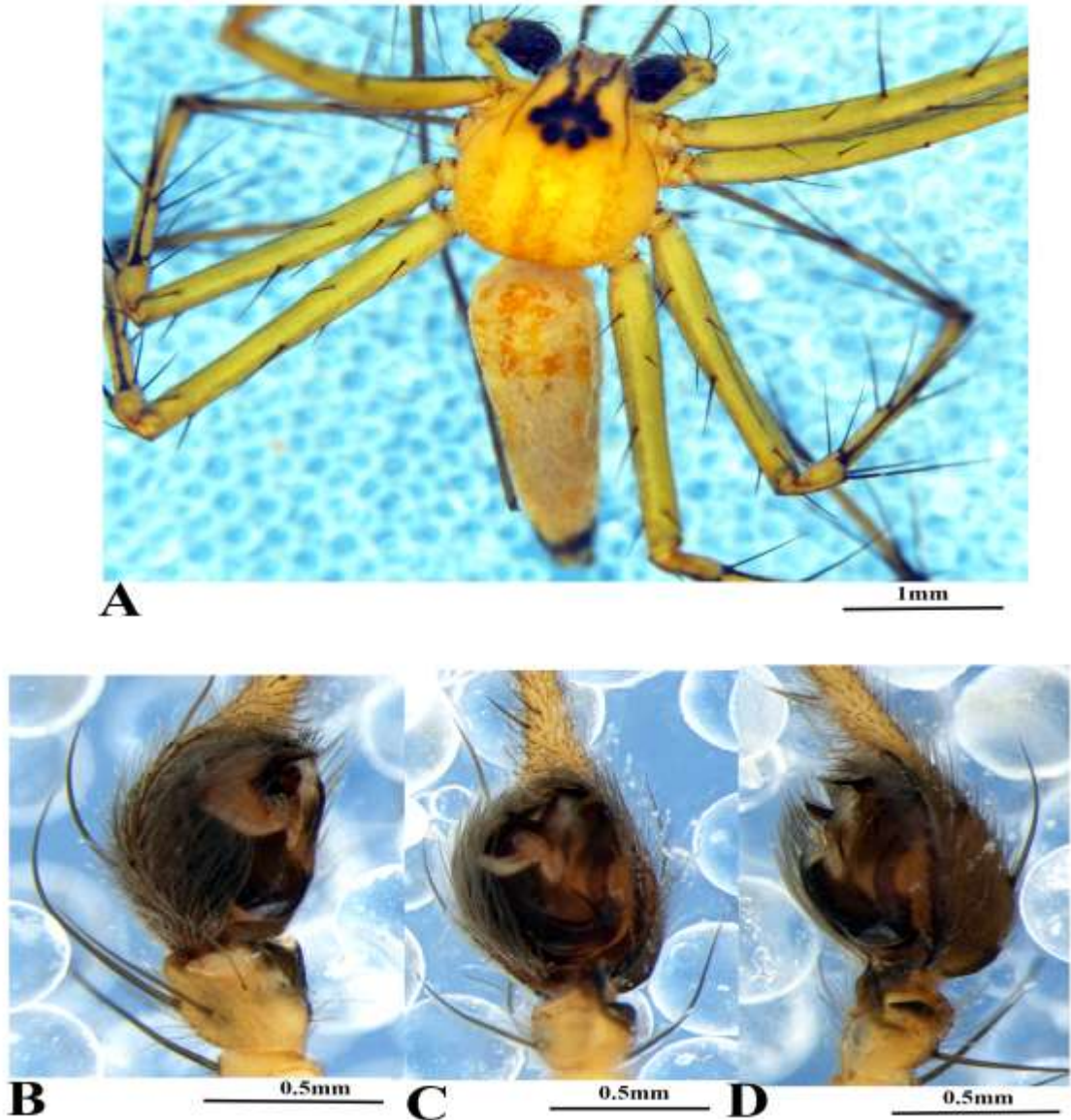


Fig. Fig 18: *Oxyopes peetham* sp. nov. Amulya, Sebastian & Sudhikumar 2021, Paratype male. **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.2.16. *Oxyopes ramulus* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 21, Figs. 19A-D]

Materials examined: 1 Paratype male adult ♂ (**Fig. 19A**), 2 paratype male adult ♂, collected at the locality, Aaralam farm, 11°56'12.81"N, 76°20'25.19"E, 13/12/22, 09/04/23; 2 paratype male adult ♂, Valapattanam riverside, 12°02'28.97"N, 76°15'1.63"E, 08/04/23; 1 paratype male adult ♂, Neeliyar Kottam sacred grove, 11°59'5.94"N, 76°25'56.16"E, 11/12/22.

Etymology: The sclerotised structure above the prolateral MTA looks like “Twig” in this species. “Ramulus” is the Latin word for twig. Hence the specific epithet *O. ramulus*.

Diagnosis: *O. ramulus* is like *O. hindostanicus* Pocock, 1901. However, it can be distinguished from the latter by the following characters: 1) Presence of distal and proximal patellar apophysis in *O. hindostanicus*, whereas these structures are absent in *O. ramulus*. 2) Sclerotised structure above the MTA triangular shaped in *O. hindostanicus*, which is twig shaped in *O. ramulus* 3) The anterior retrolateral tip of the MTA broad and sclerotised in *O. hindostanicus* which is narrow and pointed in *O. ramulus*.

Description: Holotype, Male (Fig. 19A) (CATE212619), Measurements: TL 5.52 (including pedicel); CL 1.95, CW 2.39; AL 3.17, AW 1.27. The carapace is pear-shaped and yellowish without any characteristic marks. Two narrow black lines extend from the anterior end of the clypeus and end on the lateral side of the PME. The fovea is longitudinal and blackish. In dorsal view, the eyes are arranged in four rows, with the AER recurved and the PER procurved. Clypeus is high with two black stripes from the

AME margin to the front of each chelicera. Ocular area length 0.65, width 0.95. Eye diameters and inter-distances: AME 0.08, ALE 0.22, PME 0.17, PLE 0.16; eye sizes: $ALE > PME > PLE > AME$; AME-AME 0.14, AME-ALE 0.08, PME-PME 0.25, PME-
PLE 0.22, ALE-PLE 0.23, ALE-ALE 0.22, PLE-PLE 0.95. Clypeus height is 0.52; Chelicera is 0.73, and it is downward with two pro marginal teeth and one retro marginal tooth. Fang with a broad base and a narrow, less pointed tip. Endite and labium longer than wide. Sternum with short hair. Abdomen fusiform in shape, golden yellow at the centre. Alternative light and dark bands radiate towards the centre on the lateral sides. In ventral view, two dark lines extend from the epigastric furrow to the spinnerets in a nonparallel fashion. with many Legs covered with conspicuous short spines. Two tarsal claws. Measurements legs: I 12.48 (3.08 + 0.84 + 3.00 + 3.68 + 1.88), II 10.86 (3.12 + 0.70 + 2.36 + 3.00 + 1.68), III 9.61 (3.22 + 0.72 + 2.17 + 2.36 + 1.14), IV 9.52 (2.15 + 0.66 + 1.49 + 3.86 + 1.36). Leg formula: $I > II > IV > III$.

Pedipalp: (Fig. 19B-D) Cymbium with three dorsal spines. The tegular region inside the cymbium. Tibia with two long hairs. The embolus narrows, originates from the posterior cymbi, extends and curves toward the prolateral side, forward to the anterior middle, and ends at a 1 o'clock position with a pointed tip. The conductor is on the retrolateral side, short, and broad-based, with a pointed tip parallel to the embolus tip. MTA transparent, “L” shaped in an anterior-to-prolateral cymbial direction. The prolateral MTA looks like “Twig”. A triangular opaque apophysis on the prolateral side smoothly points towards the MTA. The sperm duct is situated on the retrolateral side, flattened, and convex in the middle. VTA is a small projection towards the cymbium. RTA absent.

Female: Unknown. **Distribution:** India.

Plate 21

Fig 19

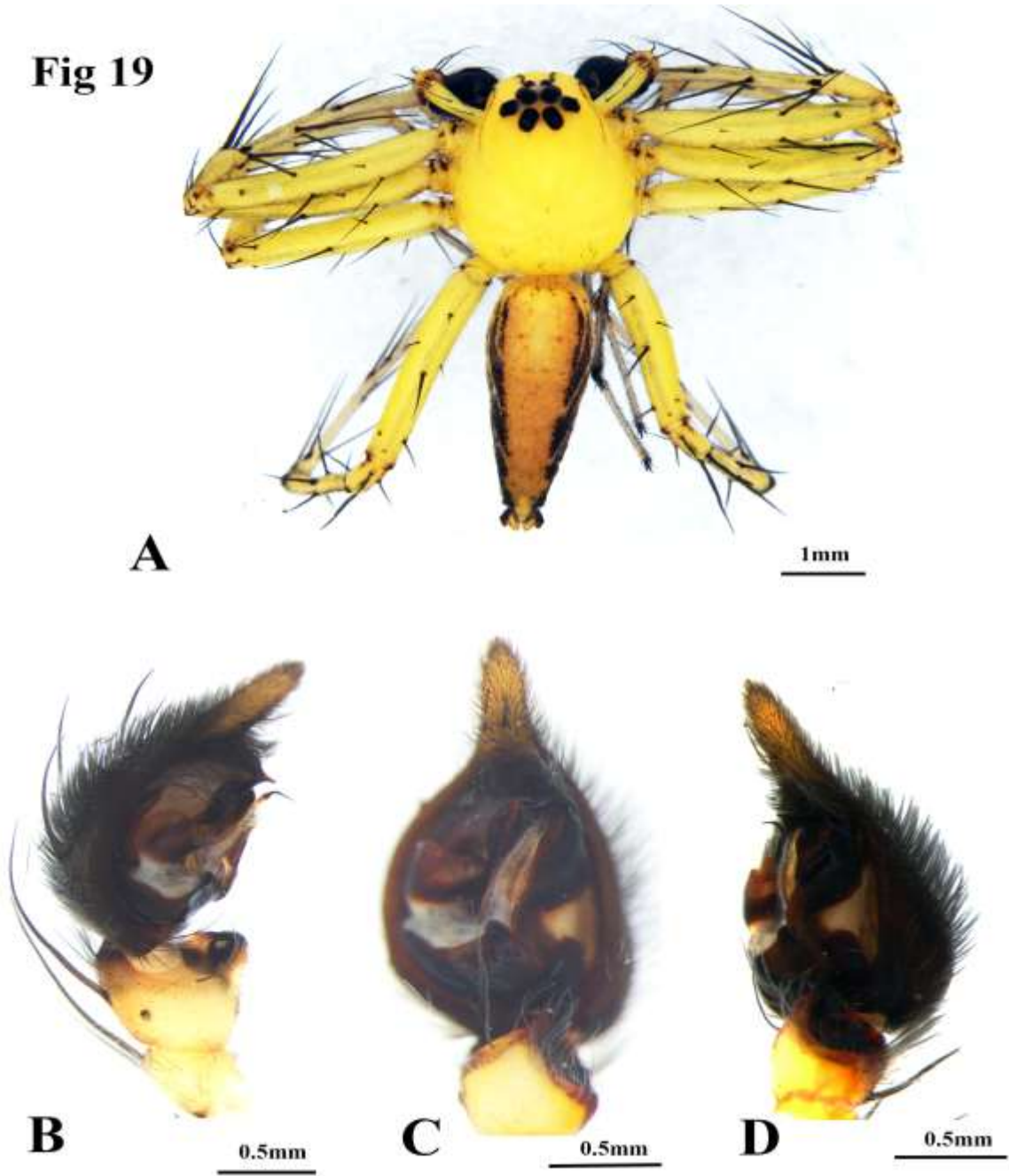


Fig. 19: *Oxyopes ramulus* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, male. **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.2.17. *Oxyopes sertatus* L. Koch, 1878 [Plate 22, Figs. 20A-C]

Materials examined: 1 Paratype female adult ♀ (Fig. 20A), 4 paratype female subadult ♀ collected at Pathiamanal Island, 09°37'07.11"N, 76°23'04.95"E 28/06/2022, 21/01/23; 2 paratype female adult ♀, Peechi dam garden, 10°31'53.38"N, 76°22'13.11"E 04/02/23; 2 paratype female adult ♀, Kalashamala ecotourism, 10°40'27.51"N, 76°5'27.12"E 08/02/23.

Description: Female (Fig. 20A) (CATE212620), Measurements: TL 7.88 (including pedicel); CL 1.89, CW 2.54; AL 5.14, AW 2.43. The carapace is reddish-brown and pear-shaped, with black lines extending from PME to the posterior end and a pair of distinctive black bands extending from PLE to the posterior end. The fovea is reddish and longitudinal. Eyes are arranged dorsally in four rows, with AER strongly recurved and PER procurved. Clypeus high with two dark black stripes from the AME margin to the front of each chelicera. Ocular area length 0.70, width 1.12. Eye diameters and inter-distances: AME 0.13, ALE 0.24, PME 0.19, PLE 0.18, eye sizes ALE>PME>PLE>AME; AME-AME 0.15, AME-ALE 0.10, PME-PME 0.27, PME-PLE 0.32, ALE-PLE 0.24, ALE-ALE 0.24, PLE-PLE 0.10. Clypeus height: 0.39; Chelicera downward with one pro-marginal tooth and one retro-marginal tooth. Broad fang at the base and narrowed towards the tip, but less pointed. Endite and labium longer than wide. Sternum with scattered short hair. Abdomen fusiform, light yellow, with a longitudinal white central band bifurcating anteriorly and the innermost of the bifurcations pale yellow. The lateral region is coloured with narrow white lines. In ventral view, a broad, dark longitudinal band extends from the epigastric furrow to the spinnerets. The legs are covered with many conspicuous long spines with black stripes, one on each ventral side of the femur to the metatarsus. Two tarsal claws. Pedipalps

bear an apical claw. Measurements of pedipalps and legs: pedipalp 1.88 (0.37+ 0.40 + 0.76 + 0.35), I 9.98 (2.12 + 0.81 + 2.84 + 2.71 + 1.50), II 9.90(2.66 + 0.79 + 2.48 + 2.80 + 1.17), III 7.42 (2.46 + 0.46 + 1.24 + 2.50+ 0.77), IV 8.37 (3.00 + 0.81 + 2.54 + 1.28 + 0.74). Leg formula: I>II>IV>III.

Genitalia: (Fig. 20B-C) Vulva highly sclerotised. Spermathecae ampulla-shaped, arranged anterior to the copulatory duct. The copulatory duct is thick and question-mark-shaped. In ventral view, the anterior end of the copulatory duct becomes triangular and opens into the spermatheca. The fertilisation duct opens on the sides of the copulatory duct. A thin flap of tissue connects the copulatory ducts on both sides.

Distribution: India, Nepal, China, Taiwan, Korea, Japan.

Plate 22

Fig 20

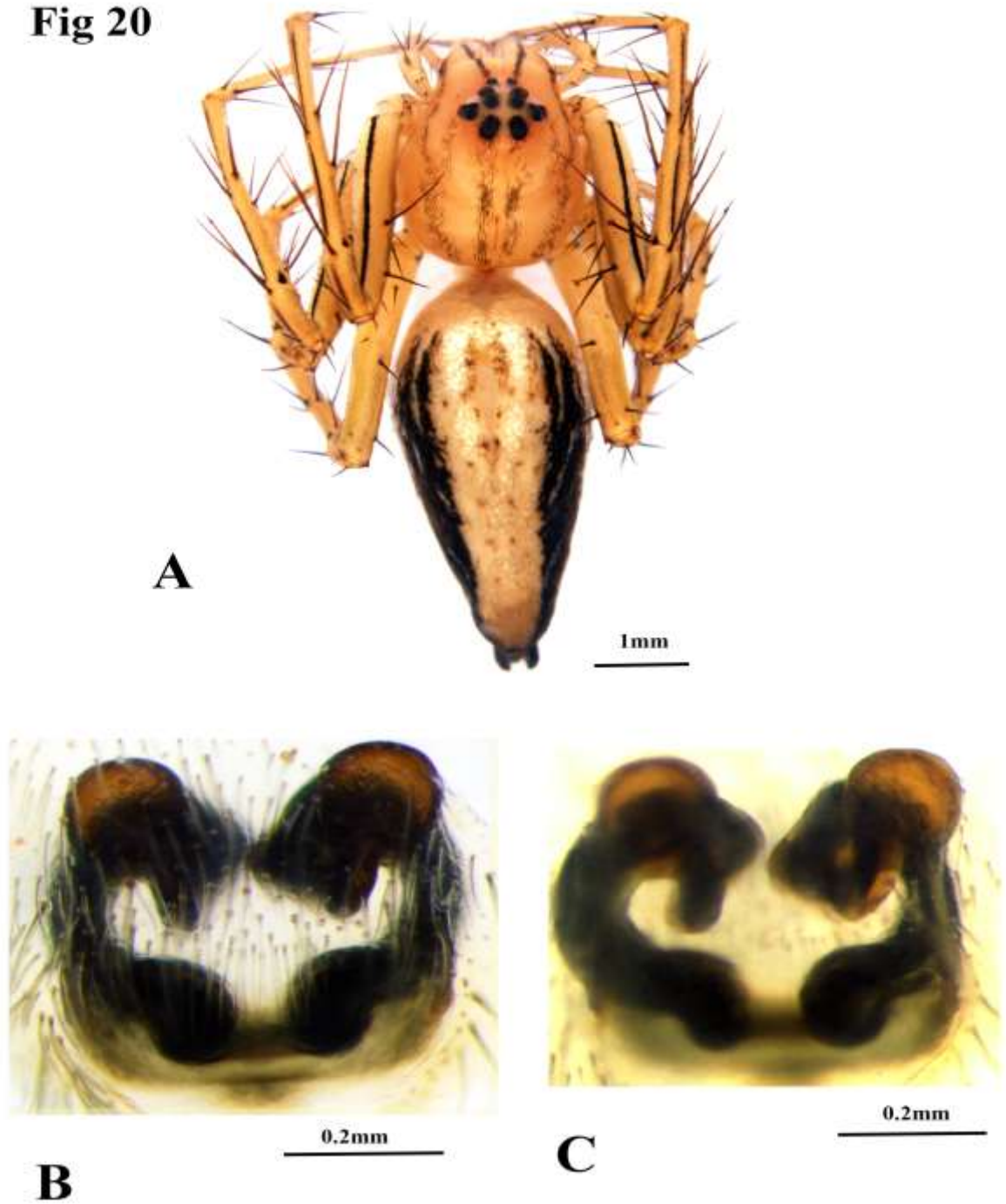


Fig. 20: *Oxyopes sertatus* L. Koch, 1878, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.18. *Oxyopes shakilae* Mukhtar, 2013 [Plate 23, Figs. 21A-C]

Materials examined: 1 Paratype female adult ♀ (**Fig. 21A**), 4 paratype female adult ♀, collected at the Ponnemudi hills, 08°45'35.79"N, 77°07'00.75"E, 25/10/23, 26/04/24; 3 paratype female adult ♀, 1 paratype female subadult ♀, Thenmala butterfly park, 08°57'39.21"N, 77°03'46.84"E, 28/09/2022, 29/04/24; 2 paratype female adult ♀, Pathiamanal Island, 09°37'07.11"N, 76°23'04.95"E, 28/06/2022, 21/01/23; 4 paratype female subadult ♀, Munnar eco-point, 10°03'57.96"N, 77°08'27.11"E, 26/07/2022, 24/11/23; 1 paratype female adult ♀, Banasurasagar dam, 11°40'16.61"N, 75°57'40.77"E, 09/01/22; 2 paratype female adult ♀, Thirunelly forest, 11°54'28.90"N, 75°59'49.84"E, 04/09/21, 10/05/24; 3 paratype female subadult ♀, Janakikkad, 11°37'32.77"N, 75°47'36.74"E, 11/07/2021, 10/11/22.

Description: Female (Fig. 21A) (CATE212621), Measurements: TL 7.46 (including pedicel); CL 2.40, CW 2.82; AL 4.40, AW 2.69. The carapace is reddish-white and pear-shaped, with dark, reddish-brown narrow bands extending from the PME to the edge of the carapace. The entire lateral sides of the carapace, with wide reddish-brown bands, extend from the tip of the clypeus to the posterior edges of the carapace. Fovea longitudinal and reddish. Eyes are arranged in four rows on the dorsal side with AER strongly recurved and PER procurved. Clypeus high with two thin, dark black stripes from the AME margin to the front of each chelicera. Ocular area length 0.71, width 1.12. Eye diameters and inter-distances: AME 0.11, ALE 0.22, PME 0.20, PLE 0.19, eye sizes ALE>PME>PLE>AME; AME-AME 0.25, AME-ALE 0.23, PME-PME 0.26, PME-PLE 0.27, ALE-PLE 0.23, ALE-ALE 0.40, PLE-PLE 1.11. Clypeus height is 0.37; Chelicera is 0.58, and it is downward, with one pro-marginal tooth and one retro-marginal tooth. Broad fang at the base, narrowing towards the tip, and pointed. Endite

and labium longer than wide. The sternum is longer than wide, and the hair is scattered long and short. Abdomen fusiform, whitish with one light brown central band origin from the anterior tip and ending just above the spinnerets. The lateral sides of the abdomen have alternative broad black and thin white bands. A dark longitudinal band extend from the epigastric furrow to the spinnerets in ventral view. Legs are covered with many conspicuous short spines and two tarsal claws. Pedipalps bear apical claw. Measurements of pedipalps and legs: pedipalp 2.24 (0.94+ 0.28 + 0.72 + 0.55), I 12.5 (3.79+ 1.13+ 2.10+ 3.68 + 1.80), II 10.71 (3.81 + 0.55+ 1.37 + 3.39 + 1.59), III 8.08 (2.50+ 0.87 + 1.09+ 2.62+ 1.00), IV 10.69 (4.35 + 1.04 + 2.14 + 1.80+ 1.36). Leg formula: I>II>IV>III.

Genitalia: (Fig. 21B-C) Vulva is highly sclerotised and “V”- shaped anteriorly, touching the anterior end of the copulatory duct. Copulatory ducts on each side are “C”- shaped and thick throughout their length. In dorsal view, the spermatheca is oval and positioned at the tip of the copulatory duct. The fertilisation duct, narrow and curved, opens on the posterior lateral side of the copulatory duct towards the centre.

Distribution: India, Pakistan.

Plate 23

Fig 21

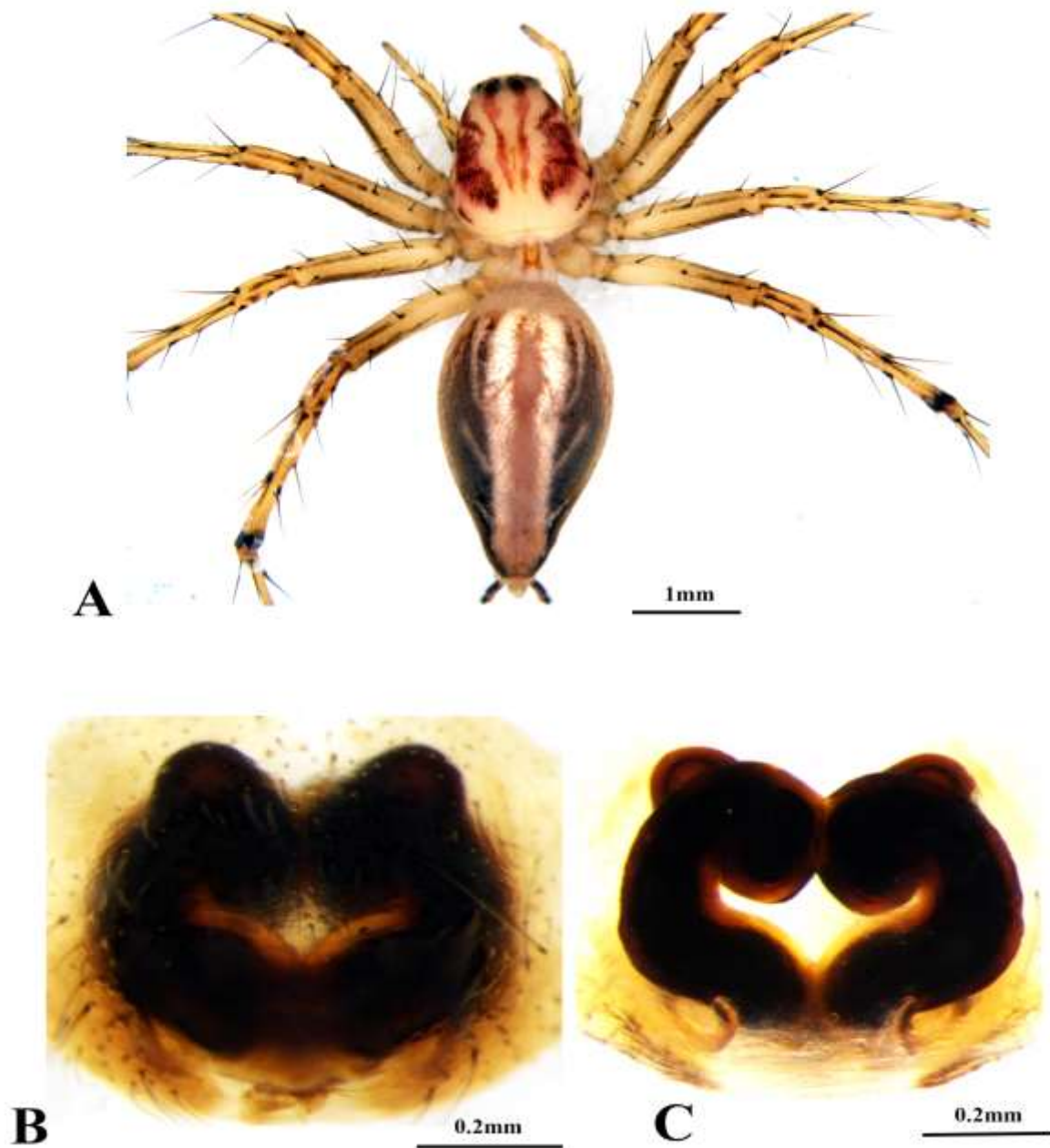


Fig. 21: *Oxyopes shakilae* Mukhtar, 2013, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.19. *Oxyopes shweta* Tikader, 1970 [Plate 24, Figs. 22A-C; Plate 25, Figs. 23A-D]

Materials examined: 1 Holotype female adult ♀ (**Fig. 22A**) 1 paratype male ♂ (**Fig. 23A**), collected at the locality, Irinjalakuda paddy field, 10°23'4.53"N, 76°9'25.18"E 06/06/21; 5 paratype female adult ♀, Calicut university garden, 11° 8'1.92"N, 75°53'26.31"E, 05/11/22, 03/03/23; 4 paratype female adult ♀, Mangalam dam, 10°28'44.19"N, 76°35'0.60"E, 13/06/21, 01/10/22; 3 paratype female adult ♀, 3 paratype male ♂, Bekkal fort, 12°23' 35.81"N, 75°53'26.31" E, 13/12/22, 09/04/23.

Description: Female (Fig. 22A) (CATE2126322), Measurements: TL 7.34 (including pedicel); CL 1.67, CW 2.10; AL 5.17, AW 1.47. The carapace is pear-shaped, white with reddish-brown lateral sides extending from the PME to the posterior end. Fovea longitudinal and reddish. In dorsal view, the eyes are arranged in four rows, with the AER recurved and the PER procurved. Clypeus is high with two black stripes from the AME margin to the front of each chelicera. Ocular area length 0.56, width 0.74. Eye diameters and inter-distances: AME 0.09, ALE 0.19, PME 0.15, PLE 0.16, eye sizes ALE>PME >PLE>AME; AME-AME 0.12, AME-ALE 0.13, PME-PME 0.20, PME-PLE 0.18, ALE-PLE 0.19, ALE-ALE 0.52, PLE-PLE 0.73. Clypeus height: 0.48; Chelicera downward with one pro-marginal tooth and one retro-marginal tooth. Fang with a broad base and a narrow, less pointed tip. Endite and labium longer than wide. Sternum with a few short hairs. Abdomen fusiform in shape with a whitish centre and brown border. Two short red parallel lines are present in the anterior abdomen. In ventral view, two dark lines extend from the epigastric furrow to the spinnerets in a nonparallel fashion. Legs are covered with many conspicuous long spines with black stripes, one on each dorsal side of the femur to the metatarsus. Two tarsal claws.

Pedipalps bear apical claw. Measurements of pedipalps and legs: pedipalp 2.04 (0.23+0.44+0.73+0.64), I 13.68 (2.75+1.04+4.74+3.41+1.74), II 13.12 (3.14+1.16+4.38+3.25+1.19), III 10.04 (2.40+0.01+3.38+2.92+1.33), IV 12.64 (3.38+1.97+3.28+3.08+0.93). Leg formula: I>II>IV>III.

Genitalia: (Fig. 22B-C) Epigyne is highly sclerotised, oval-shaped with an anterior margin V-shaped, copulatory duct kidney-shaped, and thickened in the mesial. Spermathecae are oval-shaped and arranged anterior to the copulatory duct. The fertilisation duct is a narrow tube whose ends face the copulatory ducts on the lateral sides. A quarter-circle-shaped flap extending from the lower side of the copulatory duct towards the inner side of the vulva is joined at its forward tip.

Description: Male (Fig. 23A) (CATE212623). Measurements: TL 3.01 (including pedicel); CL 0.96, CW 2.05; AL 4.47, AW 0.82. The carapace is light brown with yellow patches on the posterior side and two black lines from anterior to posterior. The lateral edge of the clypeus is bordered by narrow black lines. The fovea is longitudinal and reddish. In dorsal view, the eyes are arranged in four rows, with the AER recurved and the PER procurved. Clypeus is high with two black stripes from the AME margin to the front of each chelicera. Ocular area length 0.45, width 0.67. Eye diameters and inter-distances: AME 0.08, ALE 0.18, PME 0.16, PLE 0.15, eye sizes ALE>PME>PLE>AME; AME-AME 0.11, AME-ALE 0.12, PME-PME 0.18, PME-PLE 0.19, ALE-PLE 0.20, ALE-ALE 0.43, PLE-PLE 0.58. Clypeus height: 0.68; Chelicera downward with one pro-marginal tooth and one retro-marginal tooth. Fang with a broad base and a narrow, less pointed tip. Endite and labium longer than wide. Sternum without short hair. Abdomen fusiform in shape with a whitish centre and a black border. In ventral view, two dark lines extend from the epigastric furrow to the spinnerets,

nonparallel. Legs are covered with many conspicuous long spines. Two tarsal claws. Measurements legs: I 12.64 (1.92 + 2.01 + 3.41 + 3.76 + 1.54), II 12.07 (3.01 + 1.74 + 3.38 + 3.05 + 0.89), III 10.04 (2.34 + 0.20 + 3.28 + 2.82 + 1.39), IV 11.96 (3.58 + 0.97 + 3.18 + 3.40 + 0.83). Leg formula: I>II>IV>III.

Pedipalp: (Fig. 23B-D) Cymbium with two dorsal spines. The tegular region inside the cymbium. The tips of the conductor and the embolus are close together. Tibia with three long hairs. A whitish, transparent, amorphous, medium-sized tegular apophysis extending from the middle prolateral side of the tegulum in a ribbon-like fashion, slightly curved posteriorly, extending vertically, and ending below the conductor. Embolus at the 2 o'clock position. The sperm duct in the retrolateral region starts linearly from the anterior cymbium and forms a semicircular shape in the posterior. A prominent flap with a forward tip presents on the left side of the embolus, and the tip is parallel to the embolus. Tibia with one RTA and VTA. Both are placed closely and form a circular shape in the retrolateral view.

Distribution: Pakistan, India, China.

Plate 24

Fig 22

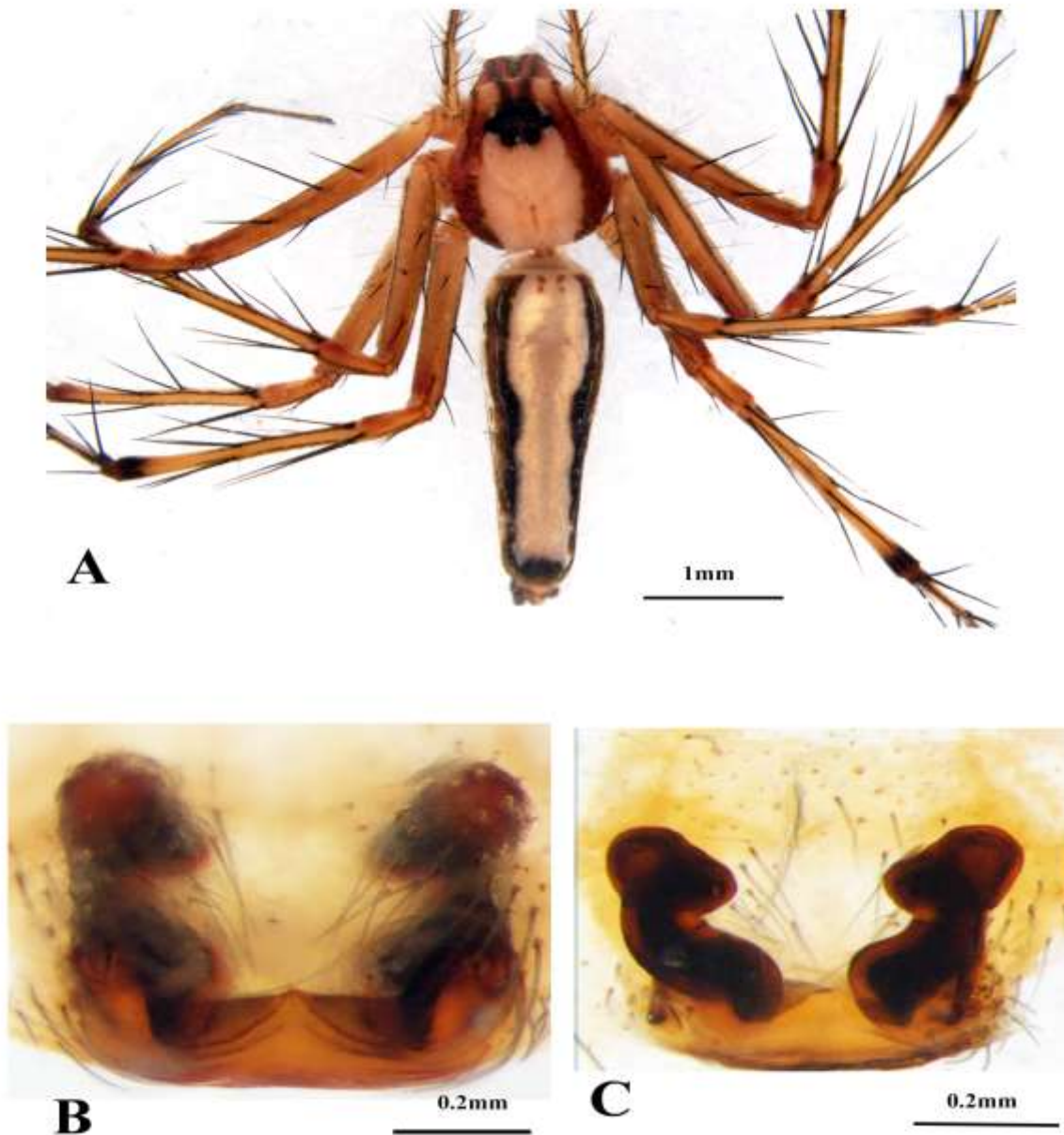


Fig. 22: *Oxyopes shweta* Tikader, 1970, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

Plate 25

Fig 23

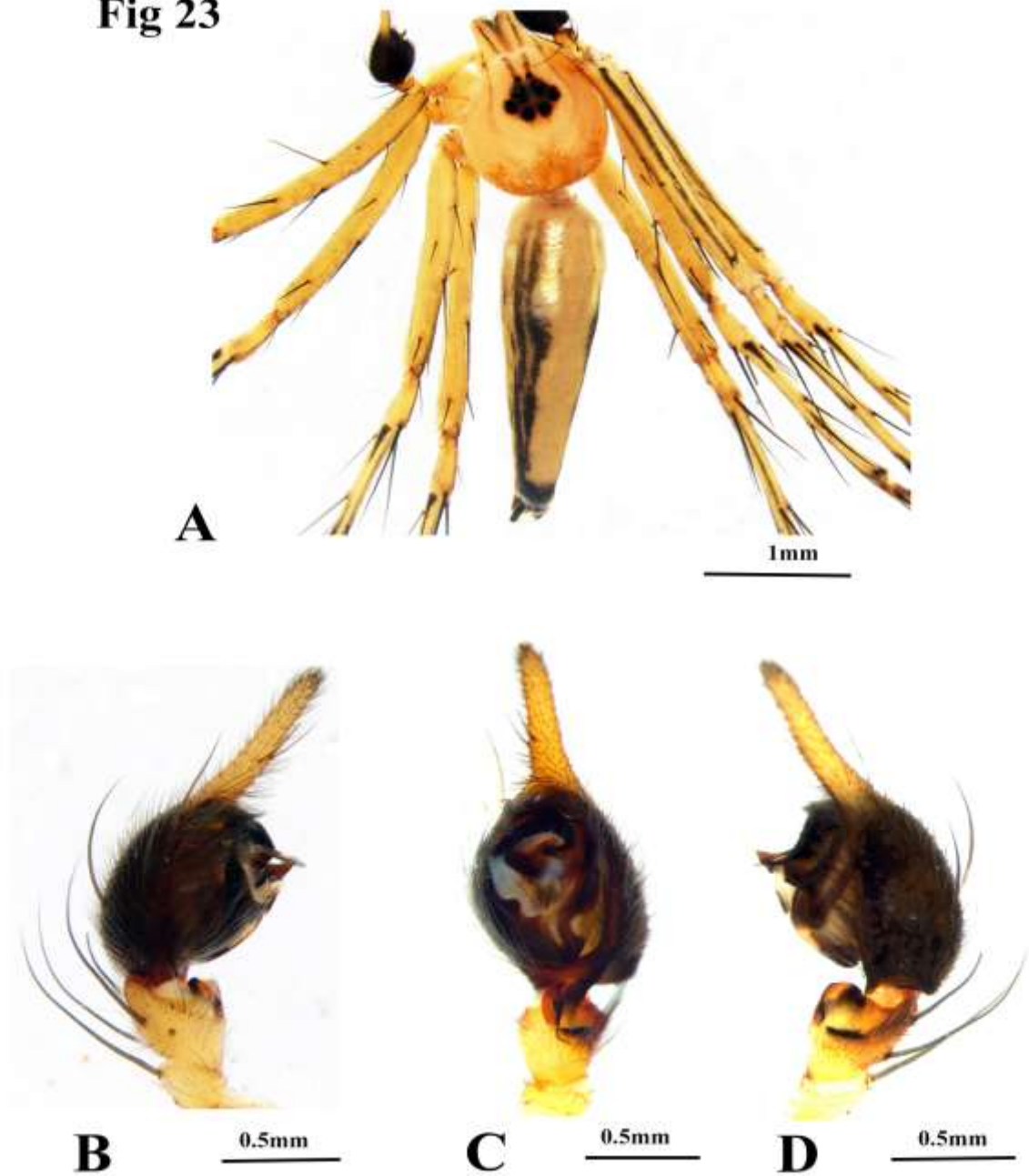


Fig. 23: *Oxyopes shweta* Tikader, 1970, male: **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

**4.1.2.20. *Oxyopes solea* sp. nov., Amulya, Sebastian & Sudhikumar,
2026 [Plate 26, Figs. 24A-C; Plate 27, Figs. 25A-D]**

Materials examined: 1 Holotype female adult ♀ (**Fig. 24A**) 1 paratype male ♂ (**Fig. 25A**), collected at the locality, Karapuzha dam, 11°37'10.36"N, 76°10'17.17"E, 02/09/21, 09/01/22; 1 paratype female adult ♀, 2 paratype male subadult ♂, M S Swaminathan botanical garden, 11°35'13.55"N, 76° 6'2.35"E, 10/01/22; 1 paratype male adult ♂, Periya 35, 11°49'54.10"N, 75°50'36.02"E, 10/05/24.

Etymology: The noun “Solea” is derived from the Latin word for “horseshoe”. The vulva forms a horseshoe shape. Hence the name *O. solea*.

Diagnosis: *O. solea* is relatively like *O. attenuatus* L. Koch, 1878. Even so, the first differs from the second in the following respects. 1) Inverted “U” shaped scapus short in *O. attenuates*, whereas scapus elongated in *O. solea*. 2) The copulatory duct is thin and anteriorly ends above the scapus, whereas it is short, and anteriorly ends in the middle of the scapus. 3) The spermatheca is globular-shaped in *O. attenuatus*, whereas it is axe-head-shaped in *O. solea*.

Description: Holotype, Female (Fig. 24A) (CATE212624). Measurements: TL 10.46 (including pedicel); CL 2.42, CW 2.60; AL 7.23, AW 1.34. The carapace is yellowish and pear-shaped, with two reddish bands extending from the PME and fused at the centre. Two lateral blackish bands extend from the clypeus edge to the posterior edge of the carapace. Fovea longitudinal and reddish. In dorsal view, the eyes are arranged in four rows, with the AER recurved and the PER procurved. Clypeus is high with two black stripes from the AME margin to the front of each chelicera. Ocular area length 0.76, width 0.99. Eye diameters and inter-distances: AME 0.09, ALE 0.29, PME 0.24,

PLE 0.20, eye sizes ALE>PME>PLE>AME; AME-AME 0.16, AME-ALE 0.11, PME-PME 0.28, PME-PLE 0.21, ALE-PLE 0.18, ALE-ALE 0.20, PLE-PLE 0.98. Clypeus height is 0.84; Chelicera is 0.68, and it is downward, with two pro-marginal teeth and two retro-marginal teeth. Fang with a broad base and a narrow, less pointed tip. Endite and labium longer than wide. Sternum with a few short and long hairs. Abdomen fusiform-shaped, with a dark reddish centre extending from the anterior abdomen to the spinnerets and surrounded by golden yellow. The lateral side has a black-and-white band extending from the anterior to the spinnerets. In ventral view, two dark lines extend from the epigastric furrow to the spinnerets, nonparallel. The legs are covered with many conspicuous long spines with black stripes, one on each dorsal side from the femur to the metatarsus. Three tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 2.61 (0.43+ 0.58 + 0.84+ 0.76), I 15.15 (5.52 + 1.33 + 3.75 + 3.55 + 1.00), II 14.16 (4.11 + 1.32 + 3.69 + 3.42 + 1.62), III 13.02 (3.03 + 1.08 + 3.19 + 4.59 + 1.31), IV 14.07 (3.63 + 1.25 + 3.18 + 4.48 + 1.53). Leg formula: I>II>IV>III.

Genitalia: (Fig. 24B-C) Vulva is highly sclerotised, with an anteriorly projecting inverted “U” shaped flattened scape. The spermatheca is an Axe-head shaped structure with smooth or curved edges in the epigyne. The copulatory duct thickened and coiled over the spermatheca, then elongated downward with a slightly flattened posterior tip. The fertilisation duct is short and thick, opening in the middle lateral region of the copulatory duct.

Description: Paratype, Male (Fig. 25A) (CATE212625), Measurements: TL 5.88 (including pedicel); CL 2.34, CW 2.49; AL 3.00, AW 1.17. The carapace is brownish, with centrally radiating light-black lines that merge at the centre. The fovea is

longitudinal and reddish. In dorsal view, eyes are arranged in four rows with AER recurved and PER procurved. Clypeus is high with two black stripes from the AME margin to the front of each chelicera. Ocular area length 0.78, width 0.97. Eye diameters and inter-distances: AME 0.09, ALE 0.24, PME 0.23, PLE 0.21, eye sizes ALE>PME>PLE>AME; AME-AME 0.11, AME-ALE 0.06, PME-PME 0.25, PME-PLE 0.26, ALE-PLE 0.20, ALE-ALE 0.19, PLE-PLE 0.97. Clypeus height is 0.32; Chelicera is 0.55, and it is downward, with one pro-marginal tooth and two retro-marginal teeth. Fang with a broad base and a narrow, less pointed tip. Endite and labium longer than wide. Sternum without short hair. The abdomen is light black-coloured, fusiform-shaped, with a greyish centre surrounded by a narrow dark black border that starts anteriorly and fuses in the middle; it is further laterally bordered by a greyish band that fuses towards the spinnerets. The lateral side of the abdomen is black. In ventral view, two dark lines extend from the epigastric furrow to the spinnerets, nonparallel. Legs are covered with many conspicuous long and short spines. Two tarsal claws. Measurements legs: I 12.66 (3.57 + 1.03 + 2.45 + 3.75 + 1.86), II 12.02 (2.99 + 0.82 + 1.77 + 4.64 + 1.80), III 9.54 (2.93 + 0.63 + 1.05 + 3.82 + 1.11), IV 11.36 (3.05 + 0.92 + 2.12 + 3.78 + 1.49). Leg formula: I>II>IV>III.

Pedipalp: (Fig. 25B-D) Cymbium with dorsal spines. Tibia has one long and one short hair. The tegulum inside the cymbium. The sperm duct in the retrolateral region is flattened and convex in the middle. from the anterior cymbidium and forms a semicircular shape posteriorly. Conductor with a broad base and a pointed tip. The embolus originates in the prolateral middle, curved towards the anterior cymbium, and ends in a 1 o'clock position with a pointed tip. The tip is located just below the conductor. MTA transparent and “L” shaped. An apophysis is nearly square-shaped, with a convex lateral side on the prolateral side. Above this, there is a transparent

region. VTA is convexly curved and projected towards the retrolateral side. The RTA semicircle is shaped below the VTA projection.

Distribution: India.

Plate 26

Fig 24

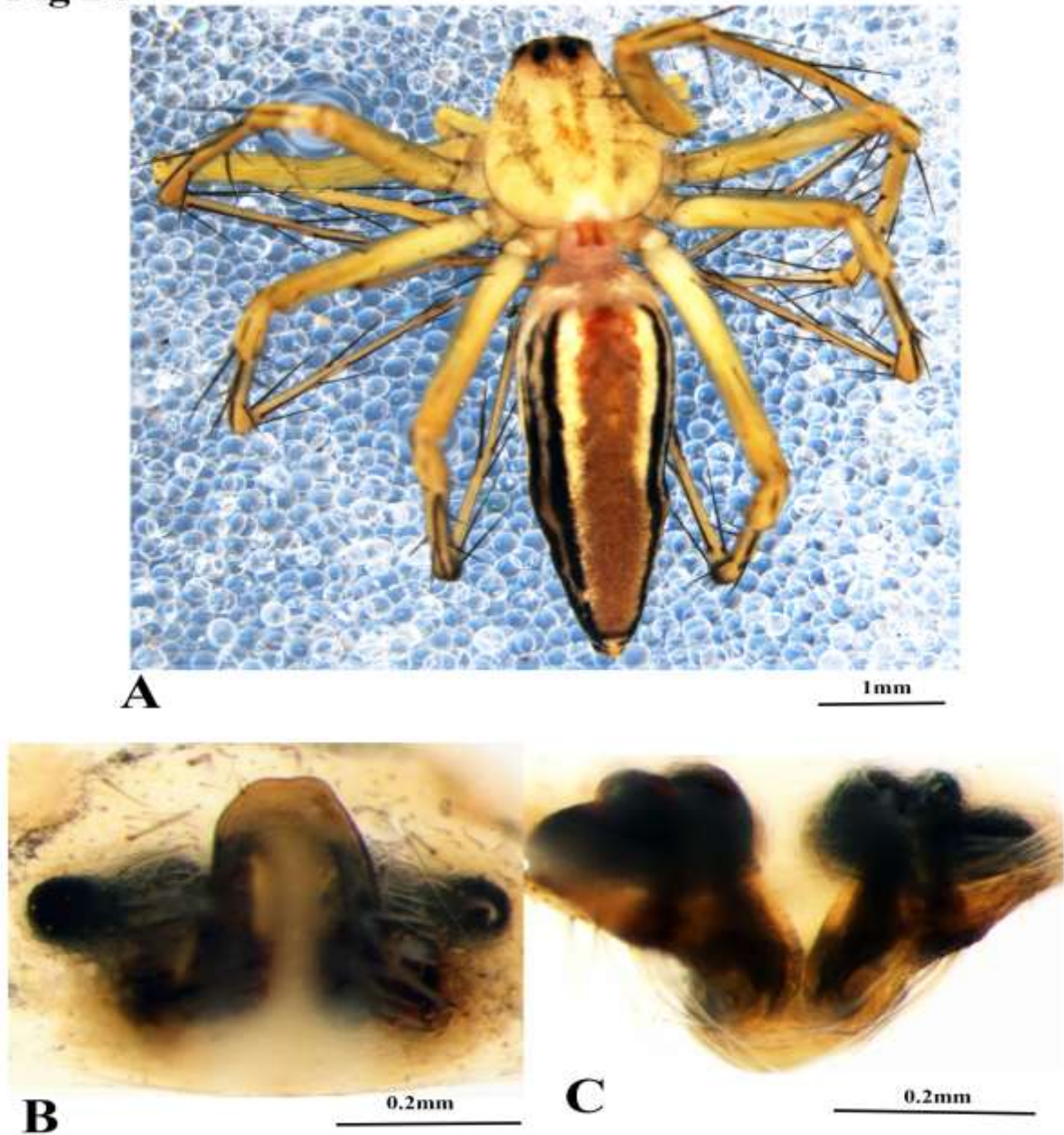


Fig. 24: *Oxyopes solea* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

Plate 27

Fig 25

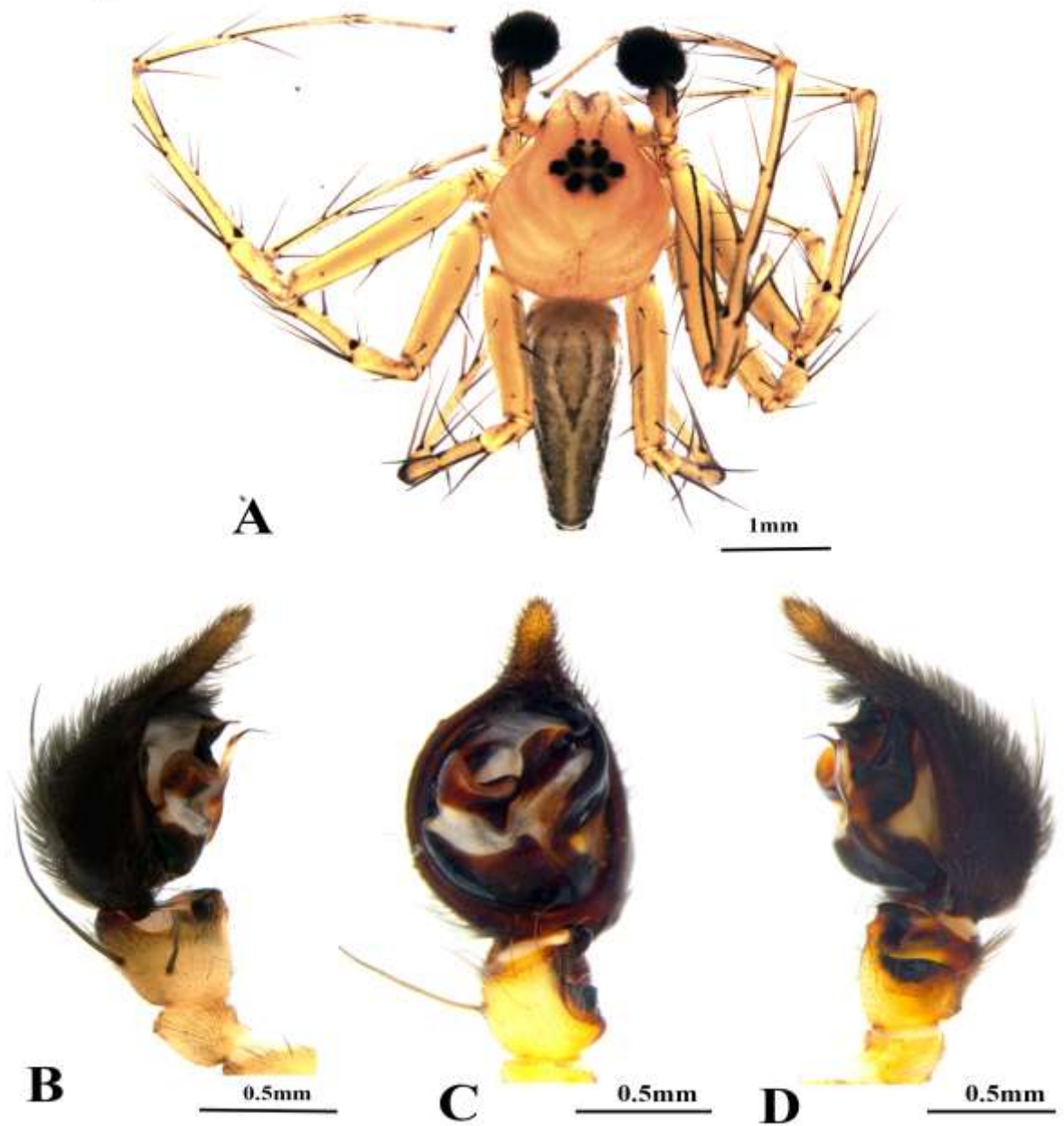


Fig. 25: *Oxyopes solea* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Paratype, male: **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.2.21. *Oxyopes striagatus* Song, 1991 [Plate 28, Figs. 26A-C]

Materials examined: 1 Paratype female adult ♀ (**Fig. 26A**), 2 paratype female subadult ♀ collected at Chengara pineapple plantation, 09°17'21.87"N, 76°51'43.08"E, 23/07/2022; 2 paratype female adults ♀, Konni forest premises, 09°13'55.65"N, 76°50'37.55"E, 24/07/2022, 23/03/24.

Diagnosis: *O. striagatus*, somewhat like *O. macilentus* L. Koch, 1878. However, the first distinguished from the latter species by the following characters: 1) The ventral side of the epigyne has a protrusion with a distal columnar edge (Tapering in *O. macilentus*) 2) The fertilisation duct is long and slender in *O. striagatus* (short in *O. macilentus*).

Description: Female (Fig. 26A) (CATE212626), Measurements: TL 10.74 (including pedicel); CL 2.96, width 2.74; Abdomen length 6.90, width 2.48. The carapace is light brown, pear-shaped, with greenish lateral patches extending from the PME to the posterior end. Fovea is 'V'-shaped and blackish. In front of the carapace, eyes are arranged in four rows with AER strongly recurved and PER procurved. The Clypeus is high, with two black stripes from the AME margin, extending towards the tip of each chelicera. Ocular area length 0.57, width 1.19. Eye diameters and inter-distances: AME 0.07, ALE 0.23, PME 0.21, PLE 0.19; eye sizes: ALE > PME > PLE > AME; AME-AME 0.14, AME-ALE 0.15, PME-PME 0.28, PME-PLE 0.33, ALE-PLE 0.27, ALE-ALE 0.34, PLE-PLE 1.19. Clypeus height is 0.41; Chelicera is 0.87, and it is downward with one pro marginal tooth and one retro marginal tooth. Fang with a broad base and narrow pointed tip. Endite and labium longer than wide. The sternum is yellowish with long and short hair. The abdomen is spindle-shaped with a dark red centre and a yellowish border extending from the anterior abdomen to the

posterior end. The lateral side of the abdomen is blackish. A dark, thickened patch extends from the epigastric furrow to the spinnerets in the ventral view. Legs covered with conspicuous long spines. Two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 2.83 (0.76+0.56+0.82+0.69), I 13.38 (2.59 + 1.27+ 4.03 + 3.99+ 1.50), II 11.08 (2.90 + 1.30 + 3.53 + 2.92 + 1.15), III 9.88 (2.12 + 1.20 + 2.80 + 2.62 + 1.14), IV 10.84 (2.68 + 1.08 + 2.15+ 3.42+ 1.51). Leg formula: I>II>IV>III.

Genitalia: (Fig. 26B-C) Vulva with a highly sclerotised protrusion, with a distal columnar edge that starts at the base and ends midway along the copulatory duct; copulatory duct curved, large, bean-shaped, and thickened. Round-shaped spermathecae are arranged anterior to the copulatory duct. A fertilisation duct is a long, thin tube that ends with a hook-like tip.

Distribution: China, India, Taiwan.

Plate 28

Fig 26

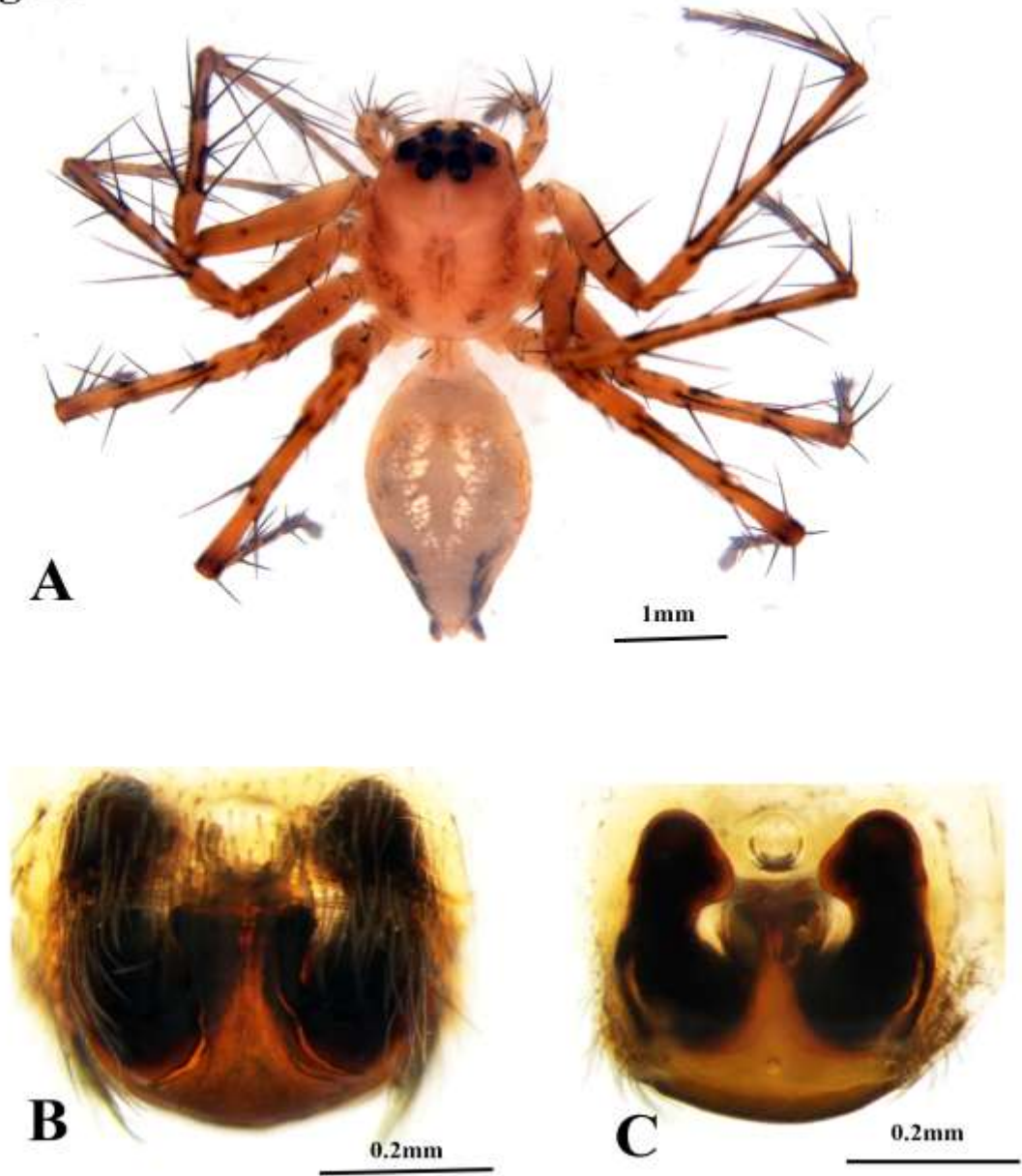


Fig. 26: *Oxyopes striagatus* Song, 1991, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.2.22. *Oxyopes thumboormuzhiensis* sp. nov., Amulya, Sebastian & Sudhikumar, 2022 [Plate 29, Figs. 27A-C; Plate 30, Figs. 28A-D]

Materials examined: 1 Holotype female adult ♀ (**Fig. 27A**) 1 paratype male ♂ (**Fig. 28A**), collected at the locality, Thumboormuzhi butterfly park, 10°17'55.83"N, 76°27'0.92"E 09/06/21, 12/10/22; 2 paratype female adult ♀, M S Swaminathan botanical garden, 11°35'13.55"N, 76° 6'2.35" E, 10/01/22; 1 paratype female adult ♀, Hill Palace Kochi .09°57'09.37"N, 76°21'44.90"E, 24/02/24; 1 paratype female subadult ♀, Iringol kavu, 10°06'30.95"N, 76°30'01.77"E, 19/07/2022; 1 paratype male subadult ♂, Kalashamala ecotourism 10°40'27.51"N, 76°5'27.12"E 14/10/22. 1 paratype male adult ♂, Thenmala butterfly park, 08°57'39.21"N, 77°03'46.84"E 28/09/2022.

Etymology: The specific epithet refers to Thumboormuzhi Butterfly Park, in which *O. thumboormuzhiensis* sp. nov. was collected.

Diagnosis: *O. thumboormuzhiensis*, somewhat similar to *O. sertatus* L. Koch, 1878. However, it can be distinguished from the latter by the following combination of characters: 1) the anterior end of the copulatory duct is triangle-shaped in ventral view in *O. thumboormuzhiensis* whereas it is smoothly curved in *O. sertatus*; 2) the shape of the spermatheca is rounded in *O. thumboormuzhiensis* whereas it is elliptical in *O. sertatus*; 3) at the anterior region of the copulatory ducts on both sides of the epigyne there is a visible space in *O. thumboormuzhiensis* whereas it is very close or touching in *O. sertatus*; 4) the dorsal retrolateral tibial apophysis of the male palp is absent in *O. thumboormuzhiensis*.

Description: Holotype, Female (Fig. 27A) (CATE212627), Measurements: TL 7.04

(including pedicel); carapace length 3.04, width 2.32; abdomen length 3.99, width 1.71.

The carapace is light yellow, pear-shaped, with a pair of light green lines extending from PME to the posterior end of the carapace and a pair of distinctive, larger light green bands extending from PLE to the posterior end. Fovea longitudinal and reddish.

In dorsal view, the eyes are arranged in four rows, with the AER strongly recurved and the PER procurved. Clypeus high with two light green stripes from the AME margin to the front of each chelicera. Ocular area length 0.47, width 0.39. Eye diameters and inter-

distances: AME 0.08, ALE 0.20, PME 0.18, PLE 0.16; eye sizes: ALE > PME > PLE > AME; AME-AME 0.39, AME-ALE 0.25, PME-PME 0.16, PME-PLE 0.19, ALE-

PLE 0.22, ALE-ALE 0.40, PLE-PLE 0.26. Clypeus height: 0.46; Chelicera downward with one pro-marginal tooth and two retro-marginal teeth. The fang is broad at the base and narrows towards the tip, but is less pointed. Endite and labium longer than wide.

Sternum with scattered long and short hairs. The abdominal fusiform is whitish, longitudinal, and shaped, and the central band is bifurcated in the anterior region of the abdomen and covered with golden patches on its inner and lateral sides. The innermost part of the bifurcated region is whitish. The lateral region is black-golden coloured with two pairs of narrow white lines. In ventral view, a broad, dark longitudinal band extends

from the epigastric furrow to the spinnerets. Legs are covered with many conspicuous long spines with black stripes, one on each dorsal side from the femur to the

metatarsus—two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 3.25 (1.19 + 0.22 + 0.52 + 1.32), I 11.68 (3.13 + 1.07 +

3.07 + 2.81 + 1.60), II 10.71 (3.08 + 0.99 + 2.56 + 2.90 + 1.18), III 8.67 (2.67 + 0.59 +

2.08 + 2.45 + 0.88), IV 9.27 (2.78 + 0.80 + 2.67 + 2.28 + 0.74). Leg formula:

I>II>IV>III.

Genitalia: (Fig. 27B-C) Vulva highly sclerotised. Spermathecae are rounded and arranged anterior to the copulatory duct. The copulatory duct is thick and question-mark shaped. In ventral view, the anterior end of the copulatory duct, a triangular, narrowed tip, opens into the spermathecae. The epigastric plate is sclerotised. The fertilisation duct opens in front of the copulatory duct. A slightly transparent space between the fertilisation duct and the copulatory duct.

Description: Paratype, Male (Fig. 28A) (CATE212628), Measurements: TL 6.36 (including pedicel); CL 2.11, CW 1.73; AL 4.21, AW 0.95. The carapace is yellow and pear-shaped, with a pair of narrow orange lines extending from PME to the posterior end of the carapace and a pair of distinctive, narrow orange bands extending from PLE to the posterior end of the carapace. Fovea longitudinal and reddish. In dorsal view, the eyes are arranged in four rows, with the AER strongly recurved and the PER procurved. Clypeus high with black stripes from the AME margin to the front of each chelicera. Ocular area length 0.43, width 0.48; Eye diameters and inter-distances: AME 0.07, ALE 0.11, PME 0.09, PLE 0.89; eye sizes: $ALE > PME > PLE > AME$; AME-AME 0.34, AME-ALE 0.35, PME-PME 0.14, PME-PLE 0.15, ALE-PLE 0.31, ALE-ALE 0.48, PLE-PLE 0.33. Clypeus height 0.09; Chelicera downward with one pro-marginal tooth and two retro-marginal teeth. The fang is broad at the base and narrows towards the tip, but is less pointed. Sternum yellow without hair. Abdomen fusiform-shaped, yellow-coloured with discontinuous orange and light green patches. The distal end of the abdomen contains a dark black band just above the spinneret. In ventral view, the abdomen is yellow coloured. Legs are covered with many conspicuous long spines. Two tarsal claws. Measurements of legs: I 14.49 (3.42 + 0.63 + 4.15 + 4.35 + 1.94), II 13.58 (3.8 + 0.66 + 3.44 + 4.09 + 1.59) III 10.82 (3.29 + 0.57 + 2.81 + 2.77 + 1.38), IV 11.25 (2.61 + 0.82 + 3.41 + 2.67 + 0.74). Leg formula: $I > II > IV > III$.

Pedi palp: (Fig. 28B-D) The pedipalp's tegular region protruded from the cymbium. The conductor and the embolus are close, and their tips are arranged in parallel. The whitish, transparent medium tegular apophysis extends broadly from the middle of the prolateral side of the tegula, is strongly curved and narrowed in the posterior region of the tegulum, then extends linearly, expands, and ends just below the conductor. Embolus at the 1 o'clock position. The sperm duct, a convex tubular structure, is arranged on the retrolateral side of the pedipalp. Retrolateral tibial apophysis is a narrow black horizontal ridge. Dark, broad ventral tibial apophysis convex towards the tegulum.

Distribution: India.

Plate 29

Fig 27

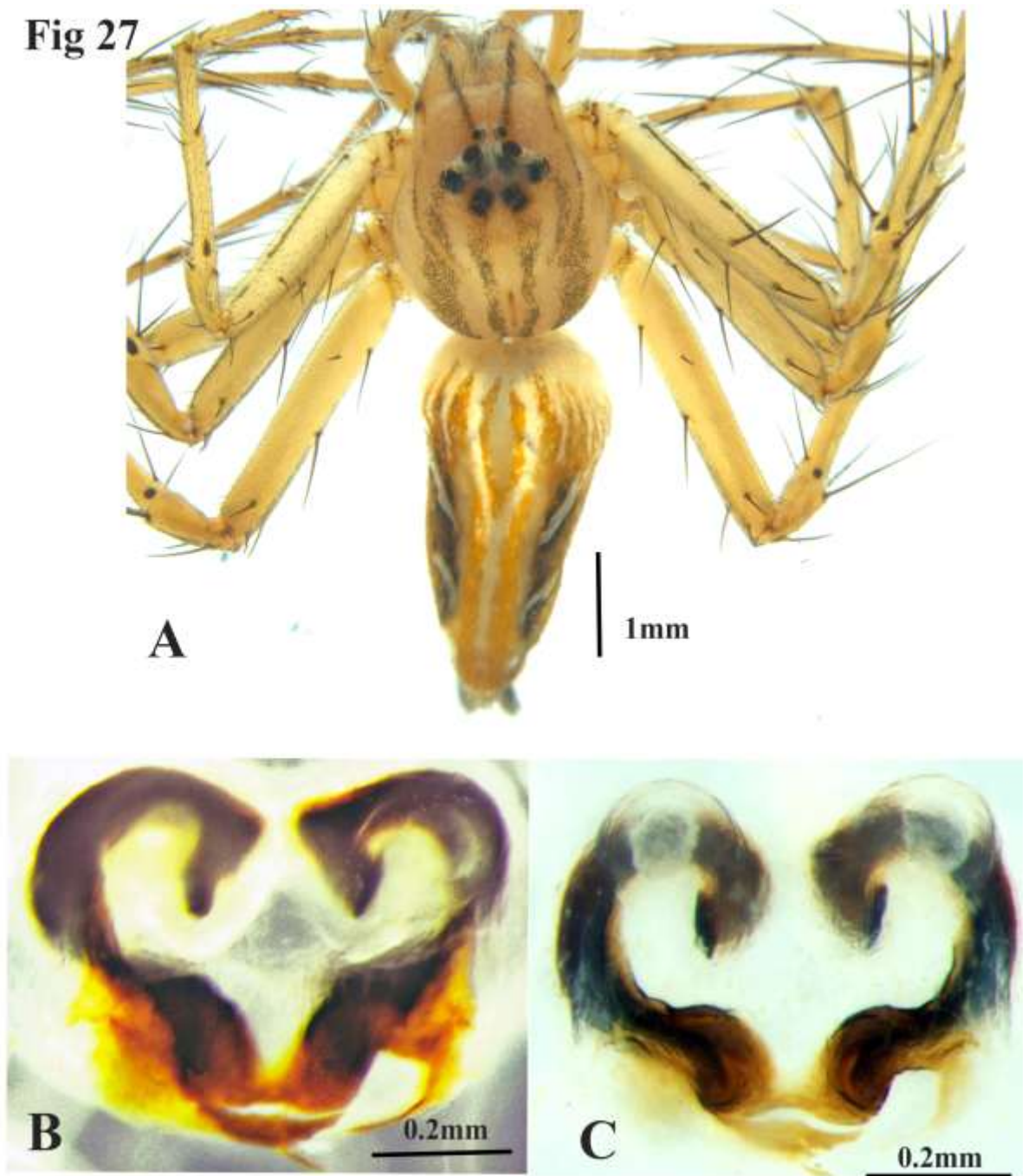


Fig. 27: *Oxyopes thumboormushiensis* sp. nov. Amulya, Sebastian & Sudhikumar 2022, Holotype, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

Plate 30

Fig 28

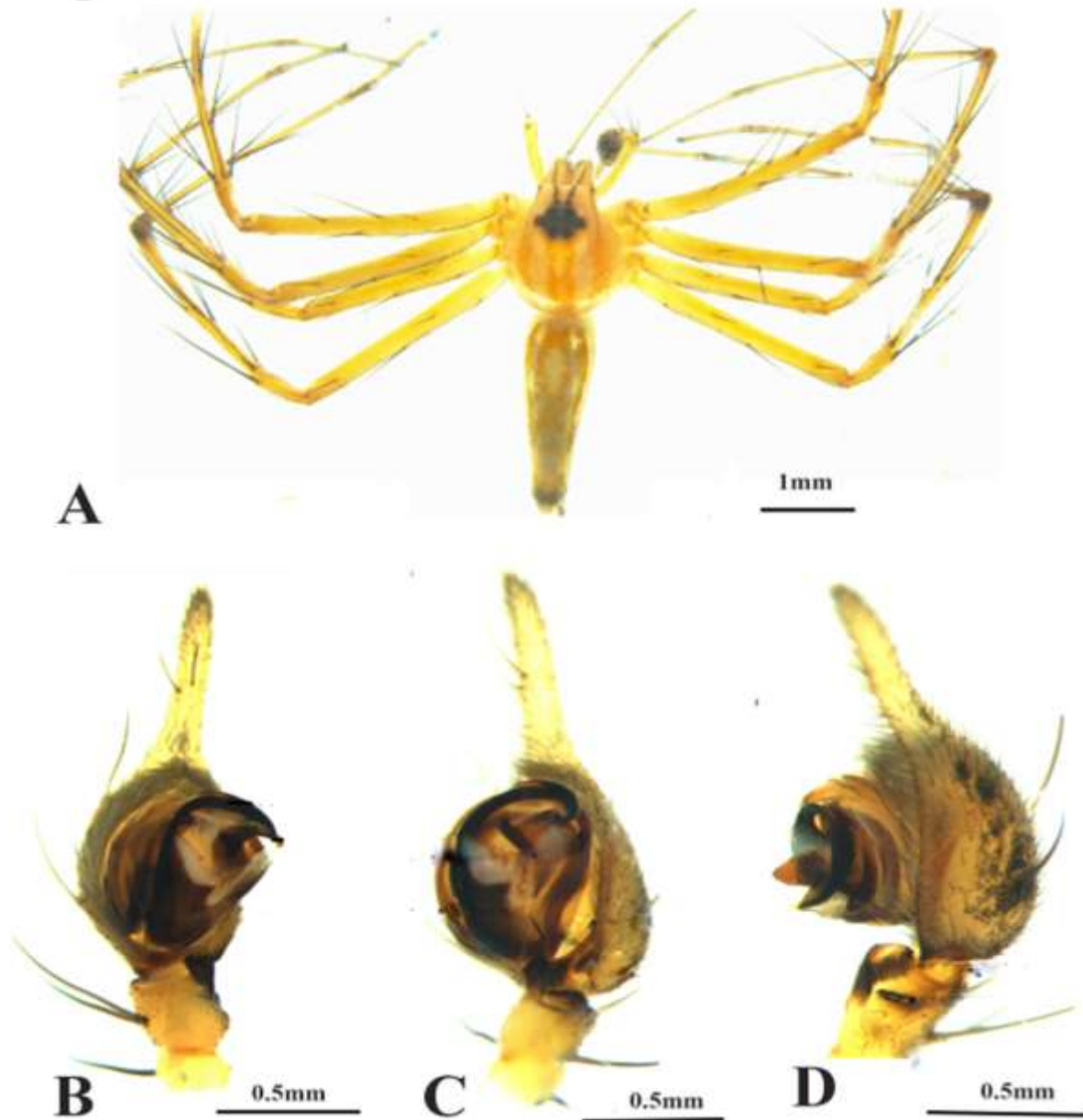


Fig. 28: *Oxyopes thumboormuzhiensis* sp. nov. Amulya, Sebastian & Sudhikumar 2022, Paratype, male: **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.2.23. *Oxyopes tigris* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 31, Figs. 29A-C; Plate 32, 30A-D]

Materials Examined: 1 Holotype female adult ♀ (**Fig. 29A**) 1 paratype male ♂ (**Fig. 30A**), collected at the locality, Ayiramtengu mangrove forest, 09°07'12.04"N, 76°28'53.85"E, 23/11/23; 1 paratype female adult ♀, Pathiamanal Island, 09°37'07.11"N, 76°23'04.95"E 28/06/2022; 1 paratype female adult ♀, Krishnapuram palace, 09°09'00.57"N, 76°30'32.69"E, 22/01/23; 1 paratype female adult ♀, 1 paratype male ♂, Hill palace Kochi 09°57'09.37"N, 76°21'44.90"E, 25/01/23.

Etymology: The specific name is a pronoun derived from the Latin word “Tigris” (Tiger) and refers to a tiger-like abdominal pattern.

Diagnosis: *O. tigris* resembles *Oxyopes sertatus* L. Koch, 1878 in its epigyne structure. However, it can be distinguished from the latter species by the following characters: 1) Spermatheca located inside the copulatory duct (it bulges out above the copulatory duct in *O. sertatus*). 2) There is a visible space between the anterior ends of the copulatory duct (it closed or almost touched in *O. sertatus*). 3) The Posterior end of the copulatory duct shows a slight twist (it is straight in *O. sertatus*). 4) Posterior cymbial apophysis is long (short in *O. sertatus*), 5) Sperm duct is a narrow tubular structure (flattened in *O. sertatus*).

Description: Holotype, Female (Fig. 29A) (CATE212629), Measurements: TL 6.41 (including pedicel); CL 2.41, CW 2.48; AL 3.64, AW 1.62. The carapace is light brown, pear-shaped, with two light green central lines from PME extending to the posterior margin, and a pair of lines along the margin from the anterior tip to the posterior end. A pair of short, greenish lines between the marginal and submarginal lines, extending

from the PLE to the middle of the carapace. Fovea longitudinal reddish colour. Clypeus high, with two black stripes from the AME margin to the front of each chelicera. Eye diameters and inter-distances: AME 0.15, ALE 0.20, PME 0.19, PLE 0.19; eye sizes: $ALE > PME = PLE > AME$; AME-AME 0.16; AME-ALE 0.38; PME-PME 0.28; PME-PLE 0.10. Eye row width measurement: I 0.20, II 0.30, III 0.82, IV 0.22. Clypeus height 0.73. Chelicerae 1.36, downward, with one pro-marginal tooth and one retro-marginal tooth. Endite and labium longer than wide. The sternum is yellowish with tiny hair in the middle and long hair on the lateral sides. The abdomen is fusiform, yellowish-brown with a longitudinal white band, starting from the posterior margin and bifurcating in the anterior region, with an orange shade inside the edge of the bifurcated region. The lateral side of the abdomen is orange-coloured, with three pairs of parallel white stripes and a black band along its anterior edge. In ventral view, a broad, dark longitudinal band extends from the epigastric furrow to the spinnerets. Legs clothed with many conspicuous long spines, distinct black stripes on the venter of femur I–III. Three claws, palps, no apical claw. Measurements of palps and legs: Palp 3.01 (1.26, 0.27, 0.63, 0.85), leg I 11.89 (1.54, 1.08, 3.35, 4.35, 1.57), leg II 10.19 (1.66, 0.95, 2.28, 3.93, 1.37), leg III 8.37 (1.54, 0.88, 2.05, 3.04, 0.86), leg IV 9.21 (0.94, 1.08, 3.19, 2.97, 1.03). Leg formula: $I > II > IV > III$.

Genitalia: (Fig. 29B-C) Epigyne sclerotised and question mark-shaped. Spermatheca round-shaped. The anterior end of the copulatory duct is smoothly curved and opens into the spermatheca. The posterior tip of the copulatory duct shows a slight twist. Spermatheca is not projected out of the copulatory duct. Fertilisation ducts are slender, elongated and forward.

Description: Paratype, Male (Fig. 30A) (CATE212630), Measurements: TL 5.29 (including pedicel); CL 1.75, CW 1.87; AL 3.13, AW 1.99. The carapace is light brown and pear-shaped, without any lines or bands. Fovea longitudinal, red colour. Clypeus high, with two black stripes from AME to the front of each chelicera. Eye diameters and inter-distances: AME 0.14, ALE 0.20, PME 0.16, PLE 0.17; eye sizes: ALE > PLE > PME > AME; AME-AME 0.19; AME-ALE 0.17; PME-PME 0.25; PME-PLE 0.23; Eye row width measurement: I 0.19, II 0.21, III 0.66, IV 0.23. The eyes are hexagonally arranged, with anterior eyes strongly recurved and posterior eyes procurved. Clypeus height 0.45. Chelicerae 0.75, downward, with one pro-marginal tooth and one retro-marginal tooth. Fang broad at the base, narrowing and curving towards the mouth at the tip. Endite and labium longer than wide. The sternum is yellowish with tiny hair. Abdomen fusiform, pale yellow in colour, without any characteristic marks. In ventral view, it is entirely yellow coloured. Legs clothed with many conspicuous long spines, without any distinct black stripes. Two tarsal claws. Measurements of legs: leg I 12.03 (3.47, 0.81, 3.22, 3.42, 1.11), leg II 9.18 (3.47, 0.40, 2.67, 1.75, 0.89), leg III 5.51 (2.62, 0.55, 0.85, 0.86, 0.63), leg IV 8.60 (3.48, 0.63, 2.04, 1.75, 0.70). Leg formula: I > II > IV > III.

Pedipalp: (Fig. 30B-D) sclerotised, anterior cymbial apophysis long. Embolus 1 ‘O’clock in position. The median tegular apophysis narrowed on the prolateral side, was slightly curved at the posterior end, ventrolaterally expanded, and ended parallel to the left side of the embolus. The sperm duct is a narrow tube convex to the ventral side. The embolus and conductor are arranged in parallel. There is a small, dark projection on the distal prolateral side of the cymbium. The tibia has two ventral retrolateral, separate apophyses. The upper one is larger, expanded, and convex towards the prolateral side, and the lower one is triangular in its ventral view.

Distribution: India.

Plate 31

Fig 29

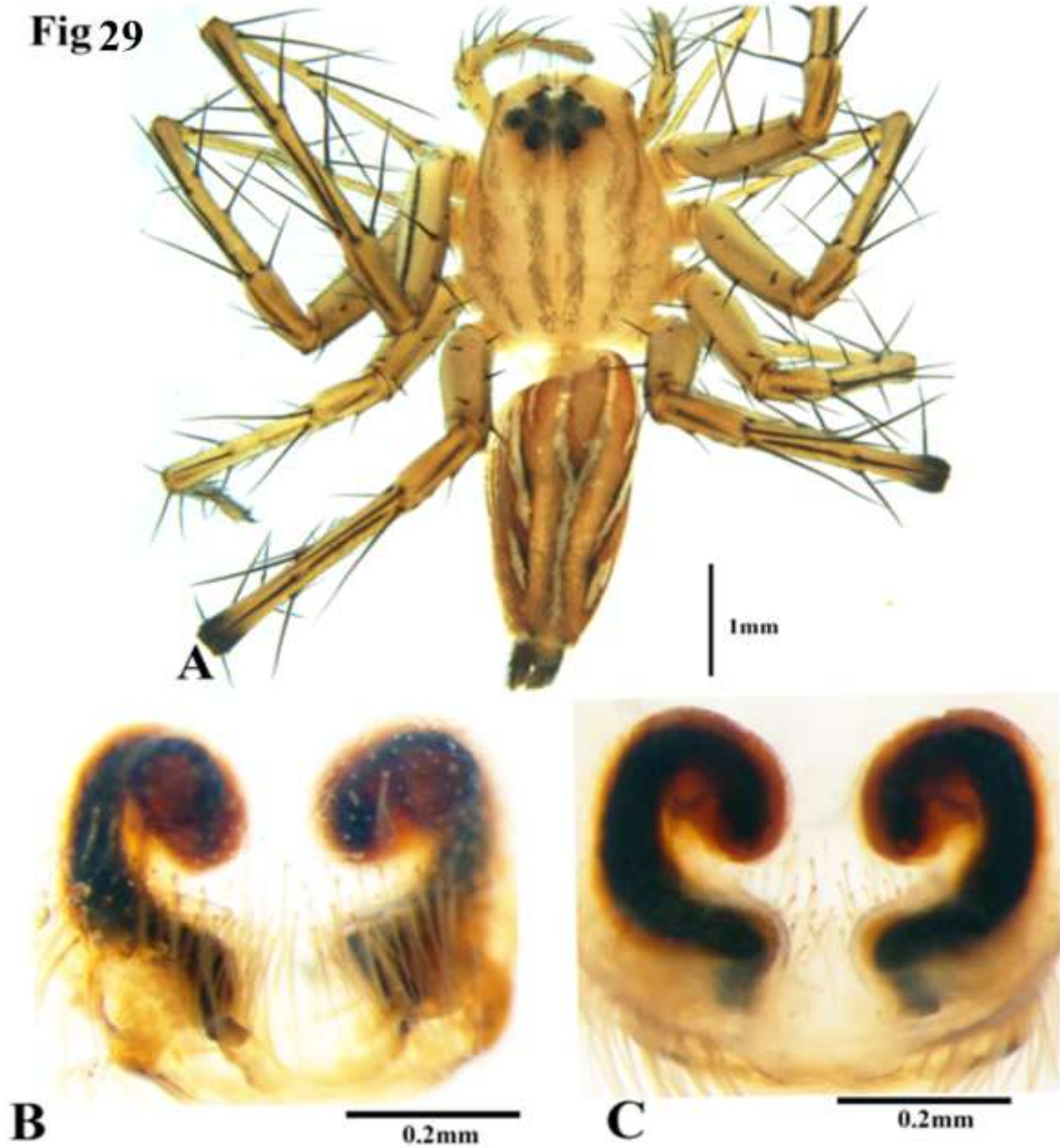


Fig. 29: *Oxyopes tigris* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

Plate 32

Fig 30

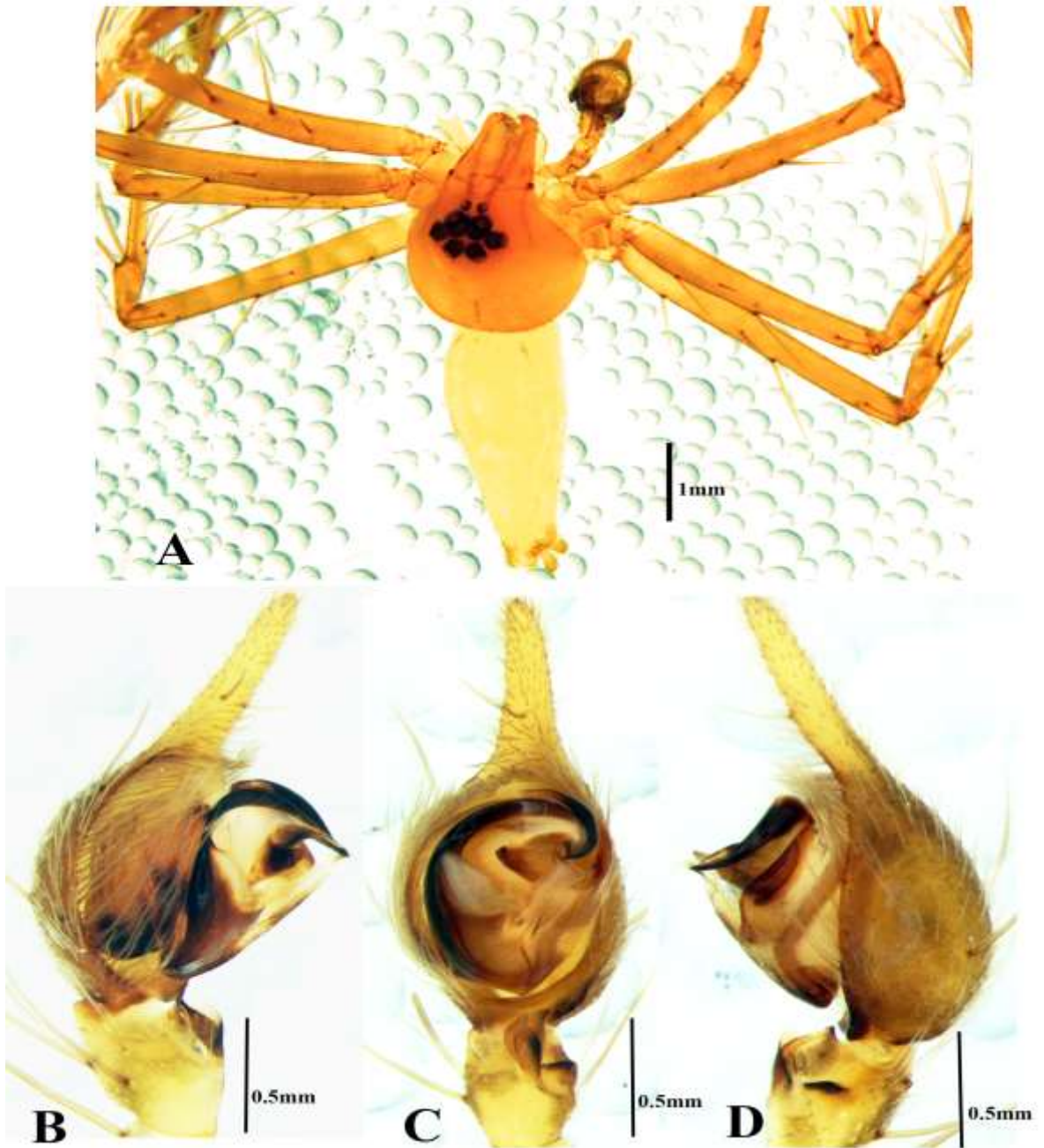


Fig. 30: *Oxyopes tigris* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Paratype, male. **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.3. Genus *Hamataliwa* Keyserling, 1887

Five species of this genus identified from various parts of Kerala. Four of them have female representatives only, and one has male. All are new species from India.

Diagnosis

Members of this group have hexagonally arranged eyes (2-2-2-2) and spiny legs; hence, they belong to the family Oxyopidae. Profuse hair on the eye and clypeus region, smaller size, muddy appearance, and hair on the legs and a weakly developed fourth pair of legs confirmed their genus identity (Zhang et al., 2005).

4.1.2.1. *Hamataliwa crista* sp. nov., Amulya, Sebastian & Sudhikumar, 2022 [Plate 33, Figs.31A-C]

Materials Examined: 1 Holotype female adult ♀ (**Fig. 31A**), 1 paratype female adult ♀, collected at the locality Pathiamanal Island, 09°37'07.11"N, 76°23'04.95"E, 28/06/2022; 2 paratype female adult ♀, Poomala dam, 10°36'8.98"N, 76°14'21.74"E, 02/06/21; 1 paratype female adult ♀, Peechi dam garden, 10°31'53.38"N, 76°22'13.11"E, 09/10/22; 3 paratype female subadult ♀, Harison tea plantation, 11°34'12.94"N, 76° 3'51.00" E, 13/01/22.

Etymology: The noun “Crista” denotes the comb-like extension of the copulatory duct; it is from Latin for “crest” or “plume.” Hence the name *H. crista*.

Diagnosis: This species can be distinguished from other congeneric species by the structure of the epigyne. The external morphology of *Hamataliwa crista* sp. n. is more or less similar to that of *Hamataliwa foveata* Tang & Li, 2012. At the same instant, there is a remarkable difference in the structure of the epigyne. The epigyne structure

is similar to that of *Hamataliva pentagona* Tang & Li, 2012. 1) The spermatheca is large in *H. pentagona* but small and oval-shaped in *H. crista*. 2) A comb-like structure on the posterior end of the epigyne is absent in *H. pentagona*. 3) The void space in epigyne is pentagon-shaped in *H. pentagona* but nearly spade-shaped in *H. crista*.

Description: Holotype, Female (Fig. 31A) (CATE212631), Measurements: TL 4.48, CL 1.86, CW (at the middle) 1.93, AL 2.62, AW 1.65; ocular area length 0.48, width 0.23, ocular diameters AME 0.07, ALE 0.28, PME 0.184, PLE 0.19, ocular inter distances: AME–AME 0.17, AME–ALE 0.20, PME–PME 0.38 PME–PLE 0.38, ALE–PLE 0.28, ALE–ALE 0.13, PLE–PLE 0.41. Clypeus height 0.43. Length of chelicera 1.33. Palp and leg measurements: palp 2.66 (0.72, 0.356, 0.52, 1.06), leg I 5.87 (1.80, 0.73, 1.40, 1.16, 0.78), II 6.13 (2.05, 0.66, 1.21, 1.57, 0.64), III 9.24 (3.14, 0.85, 2.52, 1.80, 0.93), IV 8.27 (2.62, 0.72, 2.33, 1.77, 0.83). Leg formula I>II>IV>III. The cephalothorax is yellowish-brown in colour, and the ocular region is densely covered with tiny hairs. Chelicerae are extended with one retromarginal tooth, and the pro-marginal teeth are absent. The abdomen is slightly triangular anteriorly. Yellowish colour with dark brown patches on the lateral and middle of the abdomen. The anterior end of the abdomen is highly convex.

Genitalia (Fig. 31B-C): Epigyne highly sclerotised; spermatheca oval; fertilisation duct and copulatory duct short, with their openings in parallel positions. The copulatory duct extends with a comb-like structure.

Male: Unknown. **Distribution:** India.

Plate 33

Fig 31

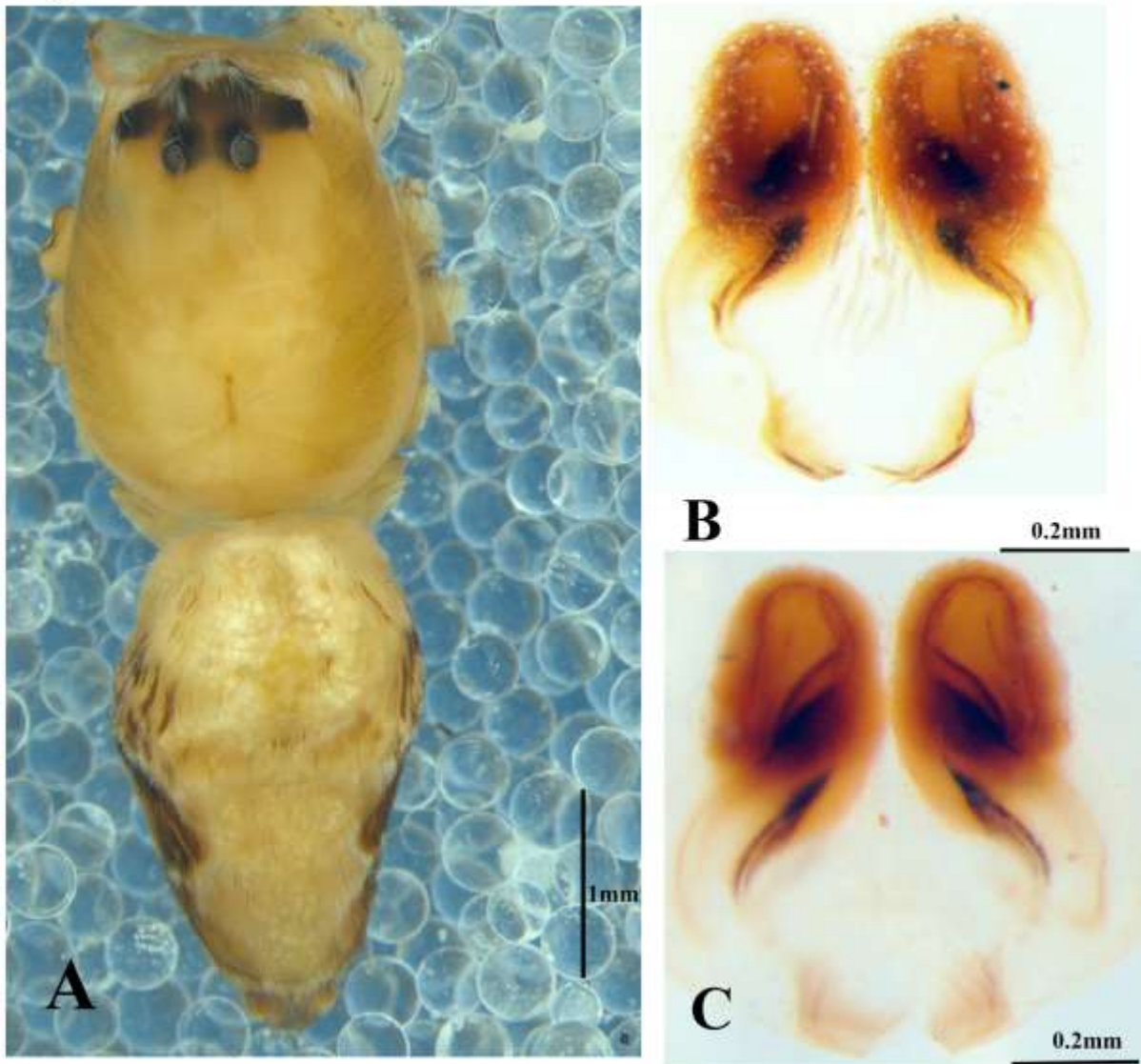


Fig. 31: *Hamataliwa crista* sp. nov. Amulya, Sebastian & Sudhikumar 2022, Holotype female **A)** Habitus, dorsal view **B)** Vulva, ventral view **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.3.2. *Hamataliwa quadrata* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 34, Figs.32A-C]

Materials Examined: 1 Holotype female adult ♀ (**Fig. 32A**), 1 paratype female adult ♀, collected at the locality Jathavan kotta , 11°10'23.34"N, 75°50'7.17"E , 11/11/22; 1 paratype female adult ♀, Kuttiyadi mangroove forest, 11°16'28.43"N, 75°47'39.59"E, 11/11/22; 1 paratype female adult ♀, Kadalundy mangrove ecosystem, 11°07'51.22"N, 75°49'44.17"E, 11/11/22.

Etymology: The noun “Quadrata” is derived from the Latin word for square. The void space between the copulatory duct forms a square shape, hence the name *H. quadrata*.

Diagnosis: *H. quadrata* sp. nov. is somewhat like *H. rhombiae* Amulya, 2022. However, it can be distinguished from the latter by the following characters: 1) copulatory duct narrowed at the posterior end and joined together at its tip. whereas the posterior end slightly splits into two and is not joined together in *H. rhombiae*. 2) The spermatheca is nearly pear-shaped in *H. quadrata*, whereas it is rounded in *H. rhombiae* in transparency. 3) The void space in between the copulatory duct forms a square shape in *H. quadrata*, whereas it is rhombus-shaped in *H. rhombiae*.

Description: Holotype, Female (Fig. 32A) (CATE212632), Measurements: TL 4.69 (including pedicel); CL 1.76, CW 2.01; AL 2.69, AW 1.60. The carapace is light brown, pear-shaped, and profusely haired. The posterior edge of the carapace has black patches. Fovea longitudinal and reddish. In dorsal view, the eyes are arranged in four rows, with the AER strongly recurved and the PER procurved. The eye region is covered with whitish hair. Clypeus is high without lines and densely whitish-haired. Ocular area length 0.45, width 0.88. Eye diameters and inter-distances: AME 0.09, ALE 0.18, PME 0.15, PLE 0.17, eye sizes ALE>PLE>PME>AME; AME-AME 0.10, AME-ALE 0.13,

PME-PME 0.20, PME-PLE 0.27, ALE-PLE 0.23, ALE-ALE 0.27, PLE-PLE 0.88. Clypeus height is 0.23; Chelicera length is 0.33, downward brownish, without lines. Presence of one pro marginal tooth and one retro marginal tooth. The fang is broad at the base, narrowed towards the tip, and pointed. Endite and labium longer than wide. Sternum with scattered short hair. Abdomen inverted pear-shaped, densely haired, light brown with creamy white cardiac mark at the centre with a dark brown base. Both Lateral middle of the abdomen have black patches. A broad, black-colored longitudinal band extends from the epigastric furrow to the spinnerets in ventral view. Legs are covered with many conspicuous short spines. Two tarsal claws. Absence of apical claws in pedipalp. Measurements of pedipalps and legs: pedipalp 1.01(0.31+ 0.17 + 0.23 + 0.30), I 6.68 (2.62 + 0.89 + 1.55+ 0.96+ 0.66), II 6.05 (2.26 + 0.76+ 1.58 + 0.73 + 0.71), III 3.66 (0.78 + 0.68 + 1.27 + 0.50 + 0.43), IV 3.97 (0.80 + 0.65 + 1.26 + 0.61 + 0.65). Leg formula: I>II>III>IV.

Genitalia: (Fig. 32B-C) Vulva is highly sclerotised. Spermatheca elongated oval shaped. The copulatory duct originates just below the spermatheca. The void space between the copulatory ducts of the vulva forms a square shape. It is thick in the middle of the epigyne, narrowed towards the posterior end, and connected by its tip. The fertilisation duct is narrow and situated on the lateral side of the copulatory duct. It is curved towards the void space and forward to the anterior of the epigyne.

Male: Unknown.

Distribution: India.

Plate 34

Fig 32

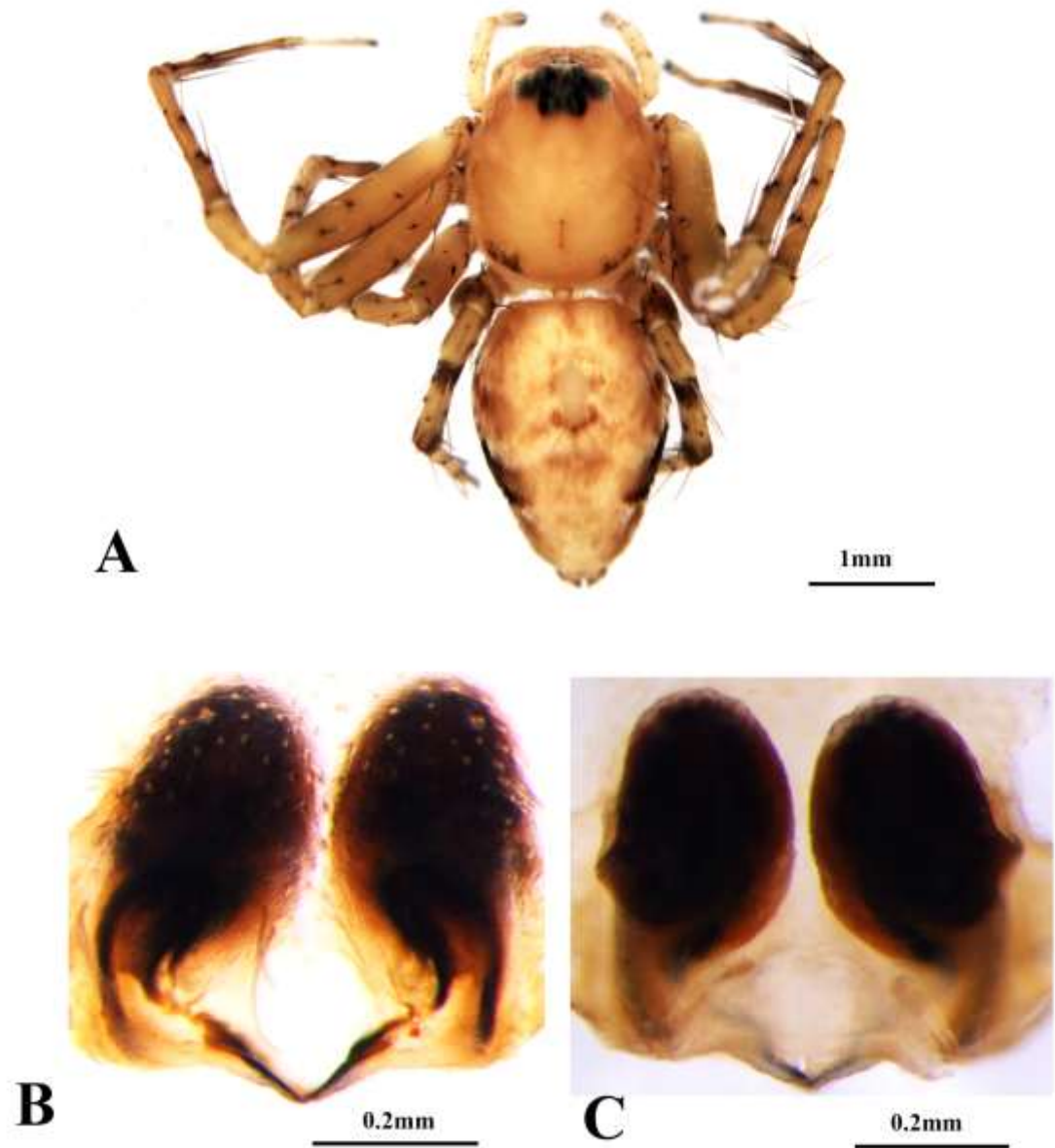


Fig. 32: *Hamataliwa quadrata* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.3.3. *Hamataliwa rhombiae* sp. nov., Amulya & Sudhikumar, 2022 [Plate 35, Figs. 31A-C]

Materials Examined: 1 Holotype female adult ♀ (**Fig. 33A**), 2 paratype female adult ♀, collected at the locality Vazhani dam, 10°38'28.37"N, 76°18'30.12"E, 05/06/21, 07/10/22; 1 paratype female adult ♀, Kuttiyadi mangroove forest, 11°16'28.43"N, 75°47'39.59"E, 12/02/23; 1 paratype female adult ♀, Kadalundy mangrove ecosystem, 11°07'51.22"N, 75°49'44.17"E, 11/11/22 ; 1 paratype female subadult ♀, Pathiamanal Island, 09°37'07.11"N, 76°23'04.95"E, 28/02/24.

Etymology: The plural noun “Rhombi” is the Latin word for rhombus shape. The void space between the copulatory ducts is rhombus shaped.

Diagnosis: *H. rhombiae*'s epigyne resembles *H. crista* Amulya, Sebastian, and Sudhikumar, 2022 (Amulya et al., 2022). However, it can be distinguished from the latter by the following combination of characters: 1) The void space between the copulatory duct is “Rhombus” shaped in *H. rhombiae*, whereas it is nearly like a “spade” in shape in *H. crista*. 2) The extension of the copulatory duct is “conical” in *H. rhombiae*, whereas it is comb-shaped in *H. crista*. 3) The shape of the spermatheca is “single inverted comma-shaped” in *H. rhombiae*, whereas it is inverted pear-shaped in *H. crista*.

Description: Holotype, Female (Fig. 33A) (CATE212633), Measurements: TL 6.10 (including pedicel); CL 1.89, CW 1.86; AL 3.64, AW 2.82. The carapace is dark brown, profusely haired, and oblong shaped. The entire lateral sides of the carapace, excluding the eye region, are narrowly covered with black patches. Fovea longitudinal and blackish. In dorsal view, eyes are arranged in four rows with AER strongly recurved and PER procurved. Clypeus high without lines. Ocular area length 0.55, width 0.83.

Eye diameters and inter-distances: AME 0.08, ALE 0.18, PME 0.14, PLE 0.17, eye sizes ALE > PLE > PME > AME; AME-AME 0.13, AME-ALE 0.06, PME-PME 0.28, PME-PLE 0.31, ALE-PLE 0.29, ALE-ALE 0.37, PLE-PLE 0.82. Clypeus height is 0.25; Chelicera is 0.44, and it is downward with one pro marginal tooth and one retro marginal tooth. Fang is broad at the base, narrowed towards the tip, and pointed. Endite and labium longer than wide. Sternum with scattered long and short hairs. Abdomen inverted pear-shaped, densely haired, creamy coloured with the entire abdomen covered with dark brown patches densely covered on the lateral sides. Legs covered with conspicuous long spines. Three tarsal claws. Absence of apical claws in pedipalp. Measurements of pedipalps and 98 legs: pedipalp 1.42 (0.39 + 0.41 + 0.17 + 0.45), I 7.31 (2.52 + 0.97 + 2.24 + 0.81 + 0.77), II 6.90 (1.95 + 0.76 + 2.25 + 1.22 + 0.72), III 4.94 (1.60 + 0.63 + 1.33 + 0.83 + 0.55), IV 4.28 (1.72 + 0.65 + 0.85 + 0.60 + 0.46). Leg formula: I > II > III > IV.

Genitalia: (Fig. 33B-C) Epigyne highly sclerotised. Spermathecae is a single inverted comma-shaped, arranged on the anterior of the copulatory duct. The copulatory duct just below the spermatheca is slightly thickened and narrowed towards the distal side, and it is short with a conical extension. The fertilisation duct is a narrow tube parallel to the copulatory duct. The void space between the copulatory duct “Rhombus” is shaped.

Male: Unknown.

Distribution: India.

Plate 35

Fig 33

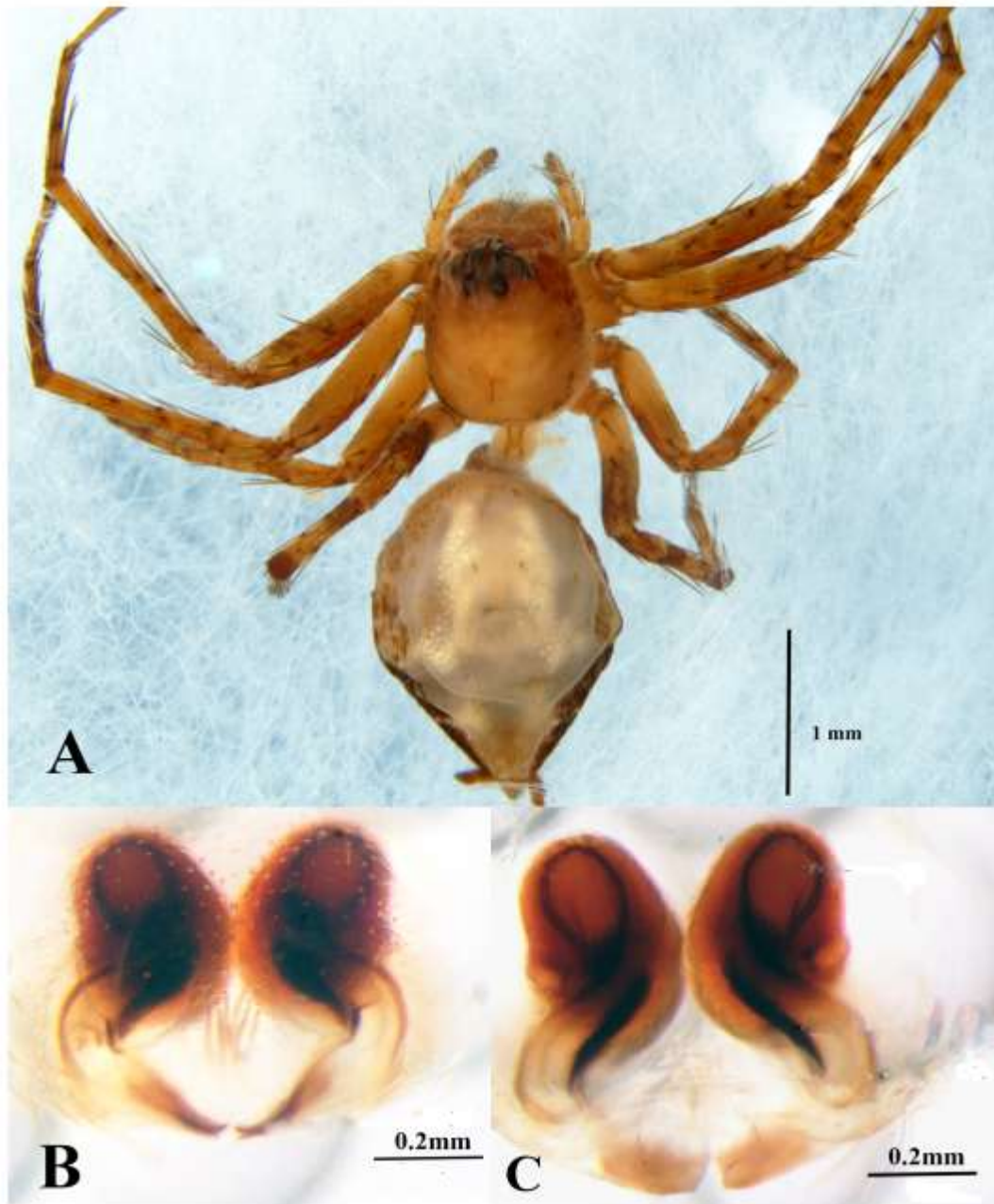


Fig. 33: *Hamataliwa rhombiae* sp. nov. Amulya & Sudhikumar 2022, Holotype female **A)** Habitus, dorsal view **B)** Vulva, ventral view **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.3.4. *Hamataliwa sagitta* sp. nov., Amulya, Sebastian & Sudhikumar, 2024 [Plate 36, Figs. 34A-C]

Materials Examined: 1 Holotype female adult ♀ (**Fig. 34A**), 1 paratype female adult ♀, 2 paratype female subadults ♀ collected at the locality Vazhani dam, 10°38'28.37"N, 76°18'30.12"E, 05/06/21, 07/10/22; 3 paratype female subadult ♂, Adyanpara waterfalls, 11°21'16.47"N, 76°12'10.82", 04/11/22, 02/03/23.

Etymology: The noun “Sagitta” is the Latin word for arrow. The arrangement of the eyes in this species is arrow-shaped. Hence the name *H. sagitta*.

Diagnosis: *H. sagitta* sp. nov. is somewhat like *H. ovata* (Biswas et al., 1996). However, it can be distinguished from the latter by the following combination of characters: 1) The copulatory duct forms a “V” shaped and short in *H. sagitta*, whereas it is “U” shaped and long in *H. ovata*. 2) The distal end of the copulatory duct, the “spoon head”, is shaped in *H. sagitta*, whereas it is “oval-shaped” in *H. ovata*. 3) The shape of spermatheca is oblong in *H. sagitta*, whereas it is elongated in *H. ovata*. 4) The fertilization duct is long and non-curved in *H. sagitta*, whereas it is long and curved in *H. ovata*.

Description: Holotype, Female (Fig. 34A) (CATE212634), Measurements: TL 3.50 (including pedicel); CL 1.06, width 1.79; abdomen length 2.44, width 1.47. Carapace dark brown, profusely haired, pear-shaped with the light brown region extending between PME to the posterior end of the carapace. Fovea longitudinal and reddish. In dorsal view, eyes are arranged in four rows with AER strongly recurved and PER procurved. Clypeus high without lines. Ocular area length 0.67, width 1.08. Eye diameters and inter-distances: AME 0.09, ALE 0.19, PME 0.15, PLE 0.17, eye sizes

ALE>PLE>PME>AME; AME-AME 0.15, AME-ALE 0.13, PME-PME 0.56, PME-
PLE 0.31, ALE-PLE 0.24, ALE-ALE 0.37, PLE-PLE 1.08. Clypeus height 0.29;
Chelicera length 0.44, downward with one pro marginal tooth and two retro marginal
teeth. Fang is broad at the base and narrowed towards the tip but less pointed. Endite
and labium longer than wide. Sternum with scattered long and short hair. Abdomen
inverted ancient pot-shaped, densely haired, light brown, black band with slightly dark
brown border on the lateral sides. The broad coffee-coloured longitudinal band extends
from the epigastric furrow to the spinnerets in ventral view. Legs are covered with many
conspicuous long spines. Two tarsal claws. Absence of apical claws in pedipalp.
Measurements of pedipalps and legs: pedipalp 1.31 (0.19 + 0.35 + 0.46 + 0.31), I 6.83
(2.03 + 0.79 + 1.68 + 1.48 + 0.85), II 6.50 (2.17 + 0.74 + 1.67 + 1.13 + 0.79), III 4.62
(1.62 + 0.70 + 0.84 + 0.88 + 0.58), IV 3.02 (0.56 + 0.97 + 0.55 + 0.49 + 0.45). Leg
formula: I>II>III>IV.

Genitalia: (Fig. 34B-C) Epigyne is highly sclerotised; oval-shaped with an anterior
margin W-shaped; copulatory duct distant ends are connected with a narrow tube-like
structure. Spermathecae is oval-shaped and arranged on the anterior of the copulatory
duct. The copulatory duct starts from the spermatheca thickens towards the distal side
and has spoon headed opening. The fertilisation duct is a narrow tube whose end faces
towards the copulatory ducts from the lateral sides.

Male: Unknown.

Distribution: India.

Plate 36

Fig 34

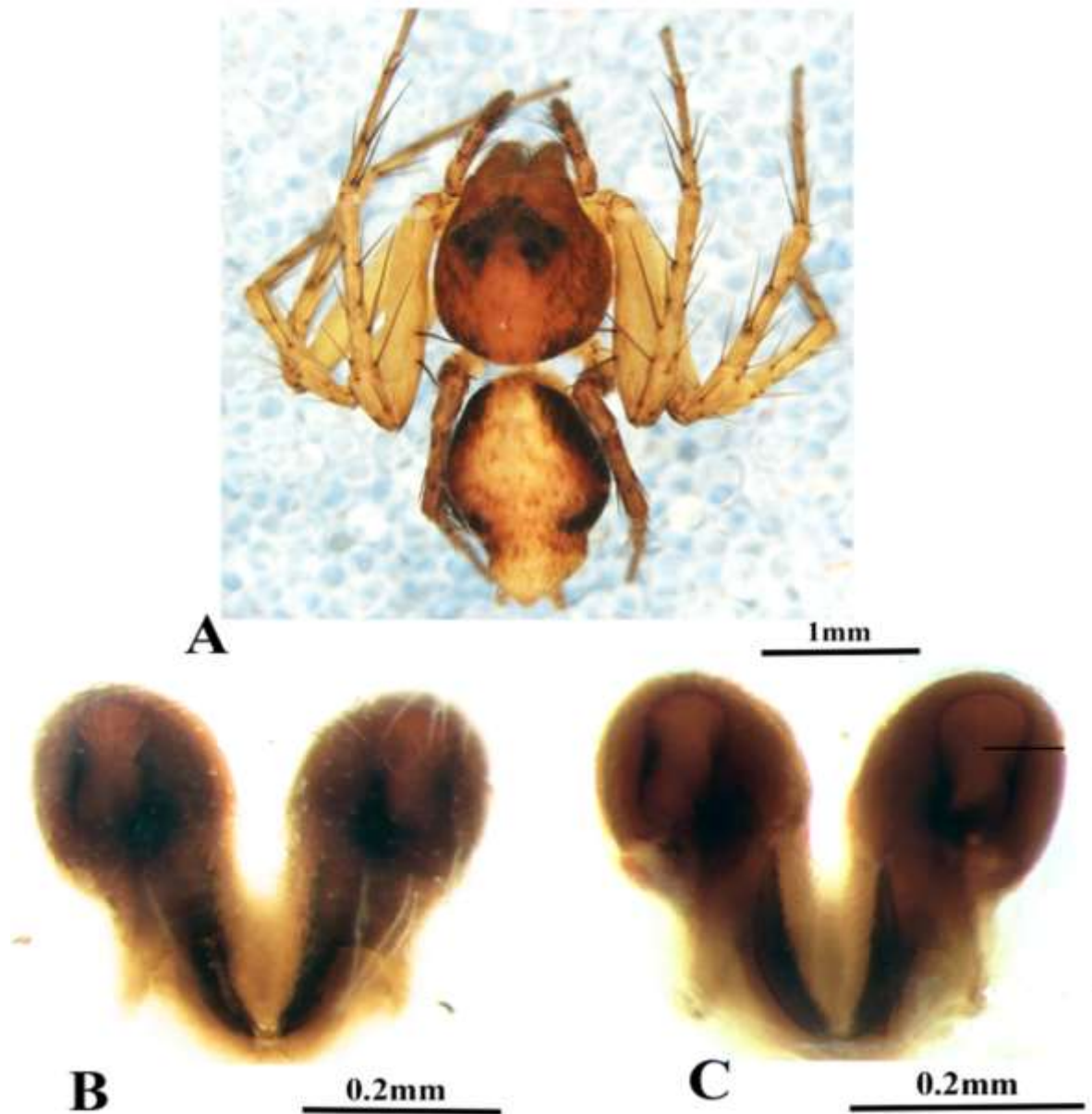


Fig. 34: *Hamataliwa sagitta* sp. nov. Amulya, Sebastian & Sudhikumar 2024, Holotype female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.3.5. *Hamataliwa triangulus* sp. nov., Amulya, Sebastian & Sudhikumar, 2026 [Plate 37, Figs. 35A-D]

Materials Examined: 1 Holotype male adult ♂ (**Fig. 35A**), 1 paratype male adult ♂, collected at the locality Cabbage garden Nileswaram, 12°15'21.81"N, 76°40'54.05"E, 07/01/22, 04/05/23; 1 paratype male adult ♂, Tobacco plantation Kanjagad, 12°19'56.36"N, 76°38'50.27"E, 02/05/23.

Etymology: The noun “Triangulus” is the Latin word for Triangular shape. The palp of this species has a triangular depression in the anterior tibia. Hence, the name *Hamataliwa triangulus*.

Diagnosis: *H. triangulus* sp. nov. is somewhat like *H. foveata* Tang & Li, 2012. However, it can be distinguished from the latter by the following characters: 1) The anterior tibia has a deep triangular depression in the retrolateral side view of *H. triangulus*, whereas it is smaller and shallower in *H. foveata*; 2) The embolus is curved in the prolateral side and forms a “V” shape in *H. triangulus*, whereas it is semicircular in *H. foveata*; 3) The distal end of the embolus is flattened with a pointed tip, which is not pointed in *H. foveata*.

Description: Holotype, Male (Fig. 35A) (CATE212635). Measurements: TL 5.25 (including pedicel); CL 1.94, CW 2.12; AL 3.00, AW 1.68. Carapace coffee bean-coloured, profusely haired, pear-shaped, without any characteristic marks. Fovea longitudinal and blackish. In dorsal view, the eyes are arranged in four rows, with the AER strongly recurved and the PER procurved. Clypeus high without lines. Ocular area length 0.55, width 1.17. Eye diameters and inter-distances: AME 0.10, ALE 0.19, PME 0.17, PLE 0.18; eye sizes: ALE > PLE > PME > AME; AME-AME 0.14, AME-ALE

0.78, PME-PME 0.43, PME-PLE 0.32, ALE-PLE 0.22, ALE-ALE 0.37, PLE-PLE 1.16. Clypeus height is 0.25; Chelicera length is 0.46, and the chelicerae are downward, with one pro-marginal tooth and two retro-marginal teeth. The fang is broad at the base and narrows towards the tip, but is less pointed. Endite and labium longer than wide. Sternum yellowish with short hair. Abdomen fusiform-shaped, densely haired, brownish-black in colour with a narrow white border. The lateral side of the abdomen is black. The whitish longitudinal band extends from the anterior to the spinnerets in the ventral view. Legs are covered with less conspicuous long spines. Two tarsal claws. Absence of apical claws in pedipalp. Measurements of legs: I 7.65 (2.37 + 0.69 + 1.69 + 2.14 + 0.76), II 6.16 (2.07 + 0.68 + 1.33 + 1.50 + 0.58), III 4.84 (1.73 + 0.51 + 0.73 + 1.28 + 0.59), IV 5.95 (2.19 + 0.64 + 0.62 + 1.69 + 0.81). Leg formula: I>II>IV>III.

Pedipalp:(Fig. 35B-D) The Tibia with a deep triangular depression and a less pointed finger-like projection on the ventral side. In the retrolateral view, the posterior end of the cymbium has a blackish, non-pointed protrusion. The embolus originates from the posterior left of the tegulum as a narrow tube and forms a “V” shape on the prolateral side. It moves forward, turns at the 2 o'clock position, becomes more flattened, and ends with a pointed tip. The conductor is small, flattened and covers the embolus. The MTA is a transparent, flattened flap.

Female: Unknown.

Distribution: India.

Plate 37

Fig 35

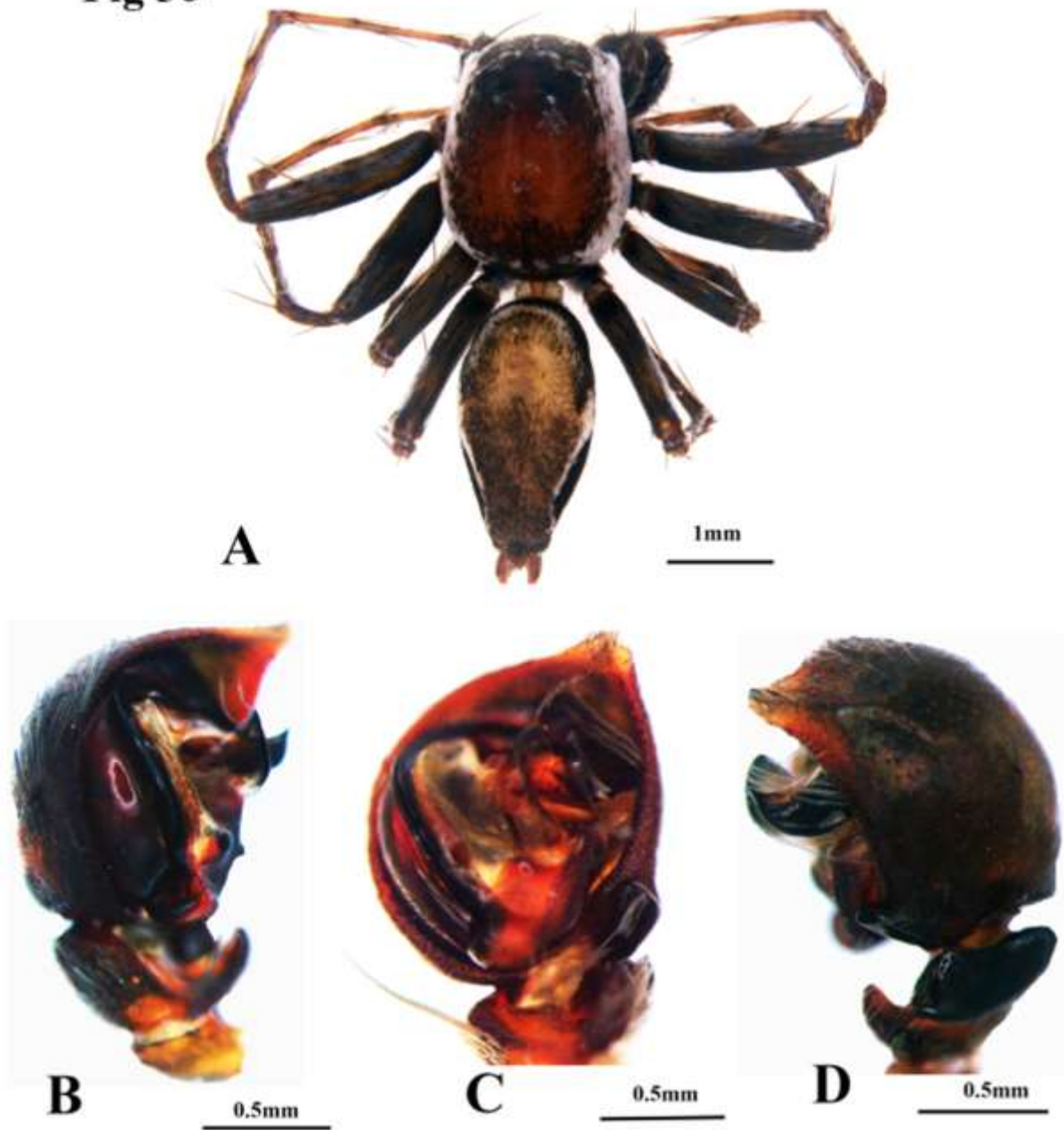


Fig. 35: *Hamataliwa triangulus* sp. nov. Amulya, Sebastian & Sudhikumar, 2026, Holotype, male; **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.4. Genus *Hamadruas* Deeleman-Reinhold, 2009

Two species have been identified in this genus; one has male representatives, and the other has female representatives only.

Diagnosis

The species collected have hexagonally arranged (2-2-2-2) eyes and spiny legs, which confirms that they belong to the family Oxyopidae. The collected species have a carapace with a dorsal saddle, the posterior side of the carapace is sloping, and the abdomen is 50-100% larger than the carapace, which are the characters confirming their genus (Deeleman-Reinhold, 2004).

4.1.4.1. *Hamadruas hieroglyphica* Thorell, 1887 [Plate 38, Figs. 36A-C]

Oxyopes hieroglyphicus Thorell, 1887: 332 (♀)

Tapponia insulana Thorell, 1891: 73 (♀). New synonym

Hamadruas insulana Deeleman-Reinhold 2009: 693

Materials examined: 1 Paratype female adult ♀ (**Fig. 36A**), 2 paratype female adult ♀, 4 paratype subadult ♀ collected at the locality Nilamboor teak museum garden, 11°18'0.29"N, 76°15'1.63"E, 02/07/21, 02/03/23; 2 paratype female adult ♀, Nedumgayam rain forest, 11°17'32.82"N, 76°20'25.19"E, 04/11/22, 02/03/23; 1 paratype female adult ♀, 2 paratype female subadult ♀, Pazhassi dam, 11°58'47.28"N, 76°5'27.12"E, 13/07/21, 13/02/23; 1 paratype female subadult ♀, Kanthanpara, 11°31'25.22"N, 76°9'9.86"E, 11/05/24.

Description: Female (Fig. 36A) (CATE212636), Measurements: TL 8.21 (including pedicel); CL 2.33, width 3.53; Abdomen length 5.24, width 1.63. The carapace is pear-shaped, brownish and entirely covered with white hairs. Fovea longitudinal and reddish. The eyes were arranged in four rows, with AER recurved and PER procurved, and covered with white hair. Clypeus high without stripes. Ocular area length 0.75, width 1.15. Eye diameters and inter-distances: AME 0.25, ALE 0.20, PME 0.22, PLE 0.23, eye sizes ALE>PME>PLE>AME; AME-AME 0.14, AME-ALE 0.12, PME-PME 0.27, PME-PLE 0.28, ALE-PLE 0.32, ALE-ALE 0.33, PLE-PLE 1.15. Clypeus height 0.37; Chelicera downward and brownish, with two pro-marginal teeth and one retro-marginal tooth. Fang brownish with a broad base and narrow, less pointed tip. Endite and labium longer than wide and yellowish brown. Sternum covered with short hair. The abdomen is fusiform and greenish, with dot-like white patches scattered throughout. These patches form a slightly flattened sphere anteriorly, with two parallel lines towards the spinnerets. Inside the flattened sphere, a patch of yellowish round surrounded by reddish colour is present. The lateral sides of the abdomen are reddish. The ventral side of the abdomen has a broad, dark patch extending from the epigastric furrow to the spinnerets in a non-parallel fashion. Legs with many conspicuous long spines without any black stripes. Two tarsal claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 2.84 (0.85+ 0.38 + 0.39+ 1.22), I 17.35 (4.75 + 1.53 + 5.15 + 4.05 + 1.87), II 16.01 (4.57+ 1.68 + 4.73 + 3.88 + 1.15), III 12.65 (3.92+ 1.70 + 4.09+ 2.09 + 0.85), IV 12.79 (4.11+ 1.48 + 3.99 + 2.20 + 1.01). Leg formula: I>II>IV>III.

Genitalia: (Fig. 36B-C) Epigyne highly sclerotised, with a significant rounded central depression, the atrium, and a circular posterior edge. Spermathecae are round-shaped, Copulatory ducts are curved and thick, and fertilisation ducts are long and narrow.

Distribution: India, Myanmar, China, Taiwan.

Plate 38

Fig 36

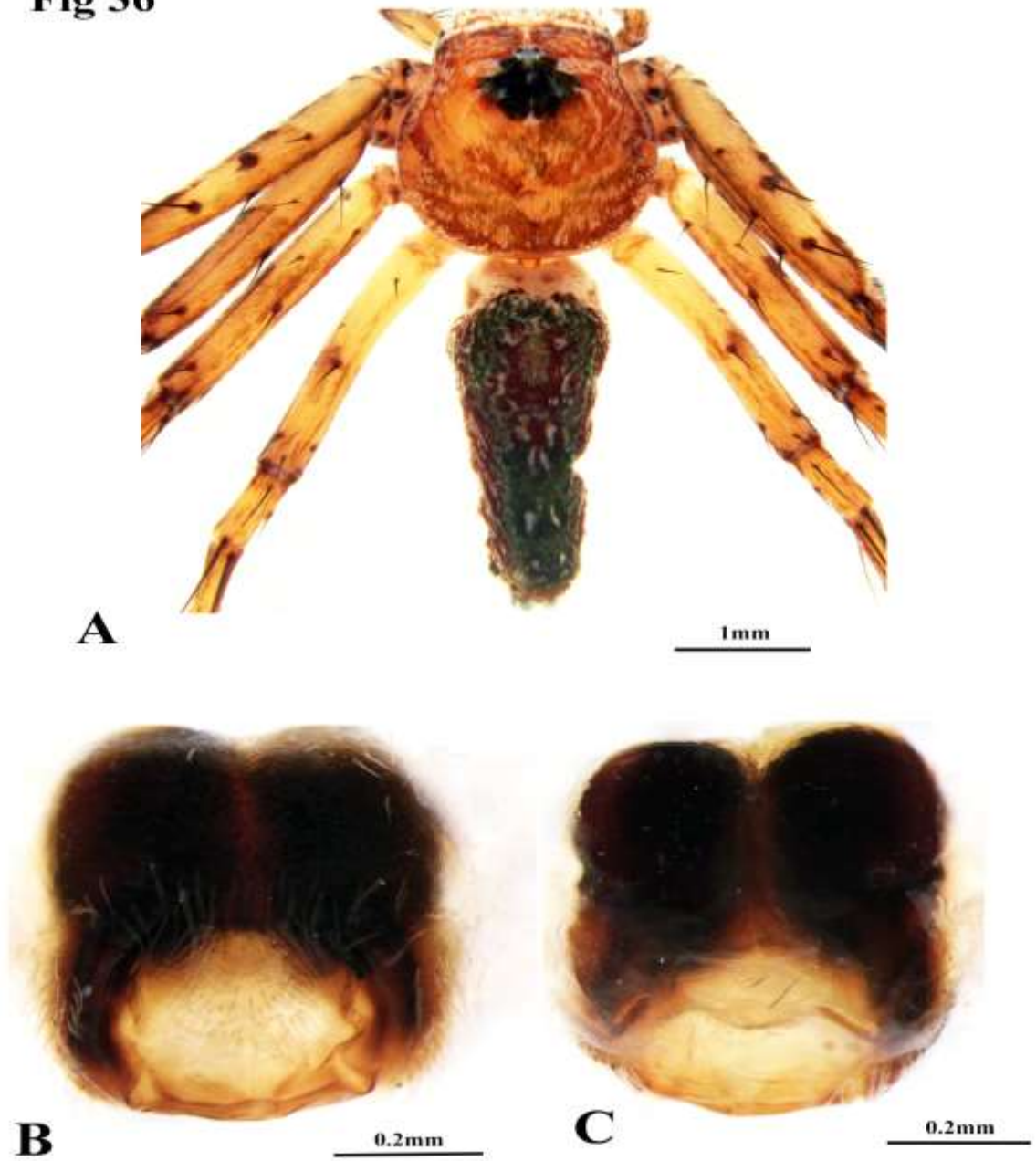


Fig. 36: *Hamadruas hieroglyphica* Thorell, 1887, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

4.1.4.2 *Hamadruas sikkimensis* Thorell, 1887 [Plate 39, Figs. 37A-D]

Materials examined: 1 Paratype male adult ♂ (Fig. 37A), 1 paratype male adult, 2 paratype subadult ♂ collected at the locality Neeliyar Kottam sacred grove, 11°59'5.94"N, 75°21'49.04"E, 23/08/22; 3 paratype Male subadult ♂ Carborandam factory, 10°16'06.12"N, 76°18'26.63"E 18/10/ 2022; 2 paratype male adult ♂, 3 paratype male subadult ♂, Chalakkudi river region, 10°17'18.89"N, 76°25'56.16"E, 12/01/2023, 12/10/ 2023; 1 paratype male adult ♂, Dhoni ecotourism, 10°51'34.76"N, 76°37'22.24"E, 22/9/2023.

Description: Male (Fig. 37A) (CATE212637), Measurements: TL 6.19 (including pedicel); CL 1.78, CW 2.95; AL 3.99, AW 1.58. The carapace is pear-shaped, yellowish and entirely covered with black hairs. A “V” mark at the centre of the carapace. In dorsal view, the eyes are arranged in four rows, with the AER recurved and the PER procurved. Clypeus is high without two black stripes. Ocular area length 0.93, width 0.92. Eye diameters and inter-distances: AME 0.12, ALE 0.22, PME 0.17, PLE 0.18, eye sizes ALE>PME>PLE>AME; AME-AME 0.19, AME-ALE 0.19, PME-PME 0.30, PME-PLE 0.29, ALE-PLE 0.18, ALE-ALE 0.42, PLE-PLE 0.92. Clypeus height is 0.56; Chelicera is 0.68, and it is downward, with two pro-marginal teeth and two retro-marginal teeth. Fang with a broad base and a narrow, pointed tip. Endite and labium longer than wide. Sternum with short hair. Abdomen fusiform shaped, centre region light green surrounded by dark green dark sides. Dot-like white patches are distributed throughout the abdomen, forming a flattened, round patch at the centre. Measurements legs: I 13.67 (3.73 + 1.42 + 4.06 + 3.51 + 0.95), II 13.01 (3.74 + 1.41 + 2.62 + 3.79 + 1.54), III 11.70 (3.20 + 1.32 + 3.19 + 2.92 + 1.07), IV 12.61 (3.18 + 2.03 + 3.02 + 3.36 + 1.02). Leg formula: I>II>IV>III.

Pedipalp: (Fig. 37B-D) VTA shaft shaped in ventral view. Dorsal RTA is prominent and Wad-shaped. The ventral tibia has a finger-like projection. The prolateral and retrolateral sides of the cymbial base have triangular outgrowths. The tegulum has a solidly curved tegular lobe. The embolus is deviant and markedly wide anterior to the tegulum. The conductor is distally curved and thick. MTA is transparent. The presence of a distal triangular process.

Distribution: India, Bangladesh, China.

Plate 39

Fig 37

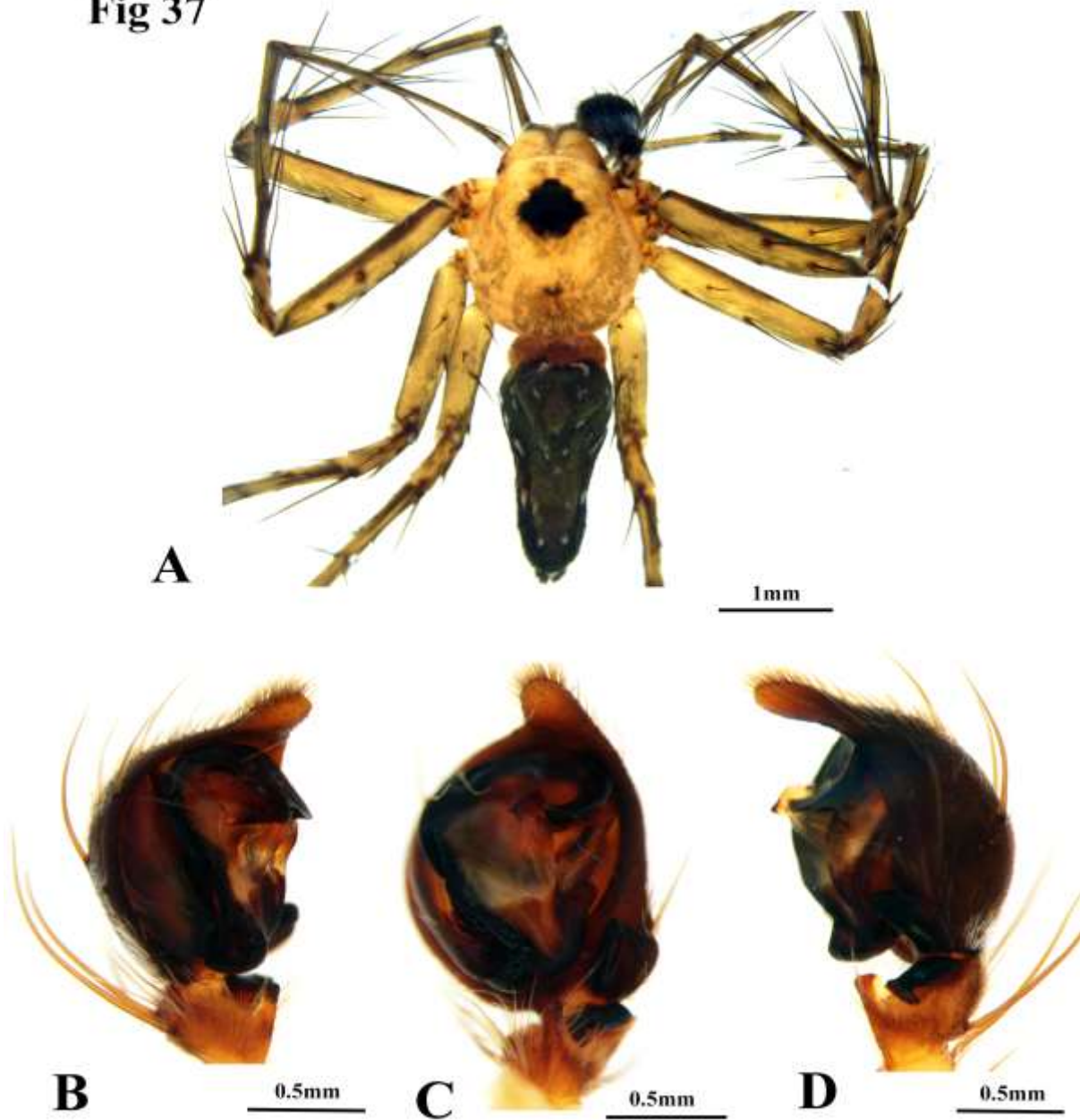


Fig. 37: *Hamadruas sikkimensis* Tikader, 1970, male: **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

4.1.5. Genus *Peucetia* Thorell, 1869

Only one member of the genus could be collected from various parts of Kerala, and both sexes were present.

Diagnosis

The specimens collected possess hexagonally arranged eyes (2-2-2-2) and spiny legs; hence, they belong to the family Oxyopidae. This genus could be differentiated from other genera by the following characters: larger size, greenish appearance, a wider AER than PER, and a pinkish line on the first pair of legs (Gajbae, 2008).

4.1.5.1. *Peucetia latikae* Tikader, 1970 [Plate 40, Figs. 38A-C; Plate 41, Figs. 39A-D]

Materials Examined: 1 Paratype female adult ♀ (**Fig. 38A**) 1 paratype male ♂ (**Fig. 39A**) , 4 paratype female adult ♀, 3 paratype male adult ♂ collected at the locality, Mangalam dam 10°28'44.19"N , 76°35'0.60"E, 13//06/21, 01/10/22; 4 paratype female adult ♀, 1 paratype male adult ♂, Cashew plantation in Periyar, 12°23'58.13"N, 76°35'0.60"E, 02/05/23; 2 paratype female adult ♀, Tobacco plantation Kanhangad, 12°19'56.36"N, 76°38'50.27"E 08/09/2021, 05/01/22; 1 paratype female subadult ♀, Irinjalakuda paddy field, 10°23'4.53"N, 76°9'25.18"E 08/10/22; 1 paratype male adult ♂, Kalashamala ecotourism 10°40'27.51"N, 76°5'27.12"E 14/10/22.

Description: Female (Fig. 38A) (CATE212638), Measurements: TL 11.84 (including pedicel); CL 3.46, CW 4.09; AL 7.33, AW 3.60. The carapace is yellowish, pear-shaped, with scattered black patches. Radial furrows merge towards the fovea. The fovea is blackish and longitudinal. The ocular region is covered with dense, pale black hair. Clypeus high with black lines extends from AME to the anterior of the

chelicera. Eyes are arranged in four rows with AER strongly recurved and PER slightly procurved. Ocular area length 0.61, width 1.08. Eye diameters and inter-distances: AME 0.12, ALE 0.32, PME 0.24, PLE 0.24; eye sizes: $ALE > PME = PLE > AME$; AME-AME 0.16, AME-ALE 0.15, PME-PME 0.20, PME-PL 0.19, ALE-PL 0.26, ALE-ALE 0.43, PLE-PL 1.08.; clypeus height 0.68. Chelicerae are yellowish, toothless, downward-directed, with two pairs of black longitudinal stripes that start at the ends of the clypeus. Endite and labium longer than wide. Sternum is yellowish, with a few erect hairs. The abdomen is oval-shaped, greenish in the middle and pale yellowish on the lateral sides, with a yellowish inverted “U” shaped cardiac mark. Legs are light yellowish with some pink patches on the ventral sides, clothed with many conspicuous long, erect spines and scattered black spots. Three claws. Pedipalps bear an apical claw. Measurements of pedipalps and legs: pedipalp 8.75 (2.61, 1.02, 1.98, 3.14), leg I 18.31 (6.79, 1.03, 3.77, 3.71, 3.01), leg II 18.8 (5.60, 0.83, 3.89, 5.99, 2.49), leg III 15.63 (5.50, 1.30, 1.39, 4.95, 2.49), leg IV 16.28 (3.84, 3.18, 3.44, 2.58, 3.24). Leg formula: $I > II > IV > III$.

Genitalia: (Fig. 38B-C) Epigyne transparent and yellowish. Its posterior end has a pair of sclerotised projections arranged downward. The copulatory duct is notch-like, large and thick. The anterior end of the epigyne contains a horn-like protuberance. The anterior region of the copulatory duct contains the round spermatheca. The fertilisation duct is narrow and curved.

Description: Male (Fig. 39A) (CATE212639), Measurements: TL 10.70; CL 3.26; CW 4.02; AL 6.88; AW 3.45. The carapace is pale yellow, pear-shaped, with scattered black patches. A light green-coloured “V”- shaped mark in the centre of the carapace. The fovea is blackish and longitudinal. The ocular region is covered with pale black

hair. Clypeus high with black lines extends from AME to the anterior of the chelicera. Eyes are dorsally arranged in four rows with AER strongly recurved and PER strongly procurved. Ocular area length 0.59, width 0.98. Eye diameters and inter-distances: AME 0.13, ALE 0.29, PME 0.25, PLE 0.25; eye sizes: $ALE > PME = PLE > AME$; AME-AME 0.19, AME-ALE 0.16, PME-PME 0.24, PME-PLE 0.22, ALE-PLE 0.27, ALE-ALE 0.45, PLE-PLE 1.02.; clypeus height 0.63. Chelicerae are pale yellow, toothless, downward-facing, with two pairs of black longitudinal stripes that start at the ends of the clypeus. Endite and labium longer than wide. Sternum is yellowish, without erect hair. The abdomen is oval-shaped and greenish, with light green and pale yellow patches, without cardiac marks. The entire abdomen is covered with a few erect hairs. Legs are light yellowish with some pink patches on the ventral sides, clothed with many conspicuous long, erect spines and scattered black spots. Three claws. Pedipalps bear an apical claw. Measurements of legs: leg I 18.97 (6.50, 0.99, 3.67, 3.82, 3.99), leg II 16.86 (5.28, 0.74, 3.39, 5.30, 2.15), leg III 14.49 (5.35, 1.15, 1.28, 4.50, 2.21), leg IV 15.96 (3.76, 3.10, 3.39, 2.49, 3.22). Leg formula: $I > II > IV > III$.

Pedipalp: (Fig. 39B-D) Palpal tibia elongated and swollen, with a triangular projection on the anterior ventral surface, surrounded by long bristles. Paracymbium is long-arcuated and pointed distally. MTA elongated and projected downward outside the tegulum, with a concave dorsal surface and a spoon-like tip. The conductor is short and broad at its base and covers the thin embolus.

Distribution: India, China, Taiwan.

Plate 40

Fig 38

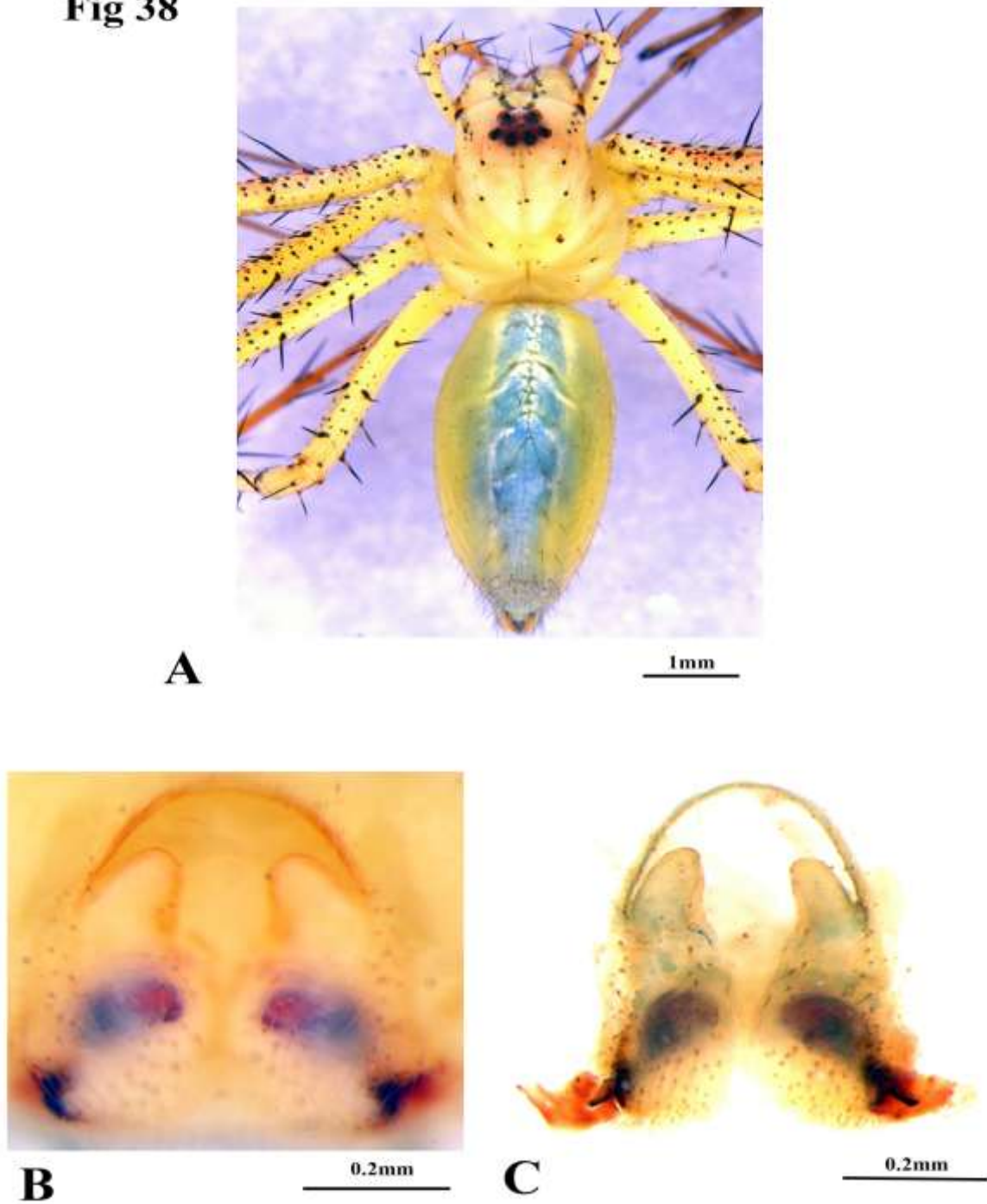


Fig. 38: *Peucetia latikae* Tikader, 1970, female: **A)** Habitus, dorsal view; **B)** Vulva, ventral view; **C)** Epigyne, dorsal view. Scale bars = 1 mm (A), 0.2 mm (B–C).

Plate 41

Fig 39

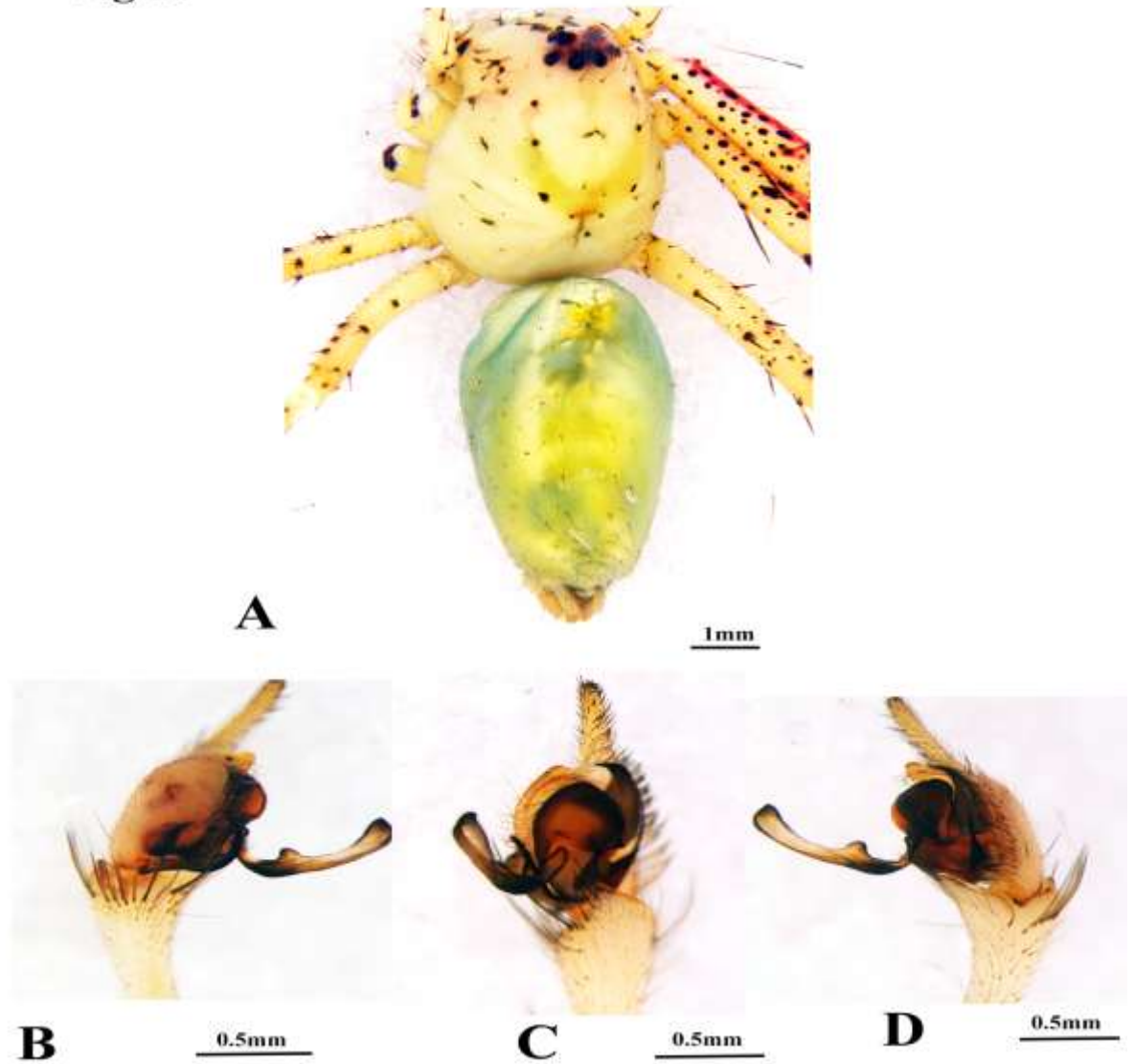


Fig. 39: *Peucetia latikae*, Tikader, 1970.male: **A)** habitus, dorsal view; **B)** pedipalp, prolateral view; **C)** same, ventral view; **D)** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

OBJECTIVE 2

4.2. DNA Barcoding and phylogenetic analysis of Lynx spiders of Kerala with their worldwide counterparts

4.2.1. COI molecular barcode of collected species from Kerala

Among the 31 species of Lynx spiders subjected to barcoding, 19 species could be sequenced very well and were excellent for analysis. Contiguous partial sequences were obtained for the COI region after trimming off low-quality bases, and good consensus sequences were obtained. The sequences were converted into the FASTA format and deposited in NCBI-GenBank to get the accession number (**Table 1**), which is tabulated below.

SL.NO	SPECIMEN NAME	ACCESSION NUMBER
1	<i>Oxyopes aquilae</i>	PX055946
2	<i>Oxyopes auris</i>	PX055947
3	<i>Oxyopes birmanicus</i>	PX055948
4	<i>Oxyopes circum</i>	PX055949
5	<i>Oxyopes hindostanicus</i>	PX055950
6	<i>Oxyopes javanus</i>	PX055951
7	<i>Oxyopes macilentus</i>	PX055952
8	<i>Oxyopes mirabilis</i>	PX055953
9	<i>Oxyopes peetham</i>	PX055954
10	<i>Oxyopes ramulus</i>	PX055955
11	<i>Oxyopes sertatus</i>	PX055956
12	<i>Oxyopes shweta</i>	PX055957
13	<i>Oxyopes solea</i>	PX055959
14	<i>Oxyopes thumboormuzhiensis</i>	PX055960
15	<i>Hamataliwa crista</i>	PX055961
16	<i>Hamaataliwa rhombiae</i>	PX055962
17	<i>Hamataliwa triangulus</i>	PX055963
18	<i>Peucetia latikae</i>	PX055964
19	<i>Hamadruas hieroglyphica</i>	PX055965

Table1: Oxyopidae species collected from Kerala and DNA Barcoding sequence accession number deposited in NCBI Genbank.

4.2.2. Genetic distance calculations

GENUS 1	GENUS 2	AVERAGE GENETIC DISTANCE
<i>Oxyopes</i>	<i>Oxyopes</i>	0.0832
<i>Oxyopes</i>	<i>Hamataliwa</i>	0.13767
<i>Oxyopes</i>	<i>Peucetia</i>	0.19864
<i>Oxyopes</i>	<i>Hamadruas</i>	0.13024
<i>Hamataliwa</i>	<i>Hamataliwa</i>	0.06527
<i>Hamataliwa</i>	<i>Peucetia</i>	0.17328
<i>Hamataliwa</i>	<i>Hamadruas</i>	0.12457
<i>Peucetia</i>	<i>Hamadruas</i>	0.17493

Table 2: Intergeneric genetic distance between the Oxyopid genera from Kerala

The average inter-generic distance of the genus collected from Kerala, calculated by the Kimura 2 parameter model (**Table 2**), reveals that the genus *Oxyopes* is more closely related to the genus *Hamadruas* and *Hamataliwa* with a lower genetic distance than that of *Peucetia*, which has higher value. The genus *Hamataliwa* is closer to *Hamadruas*.

4.2.3. COI molecular barcode of Oxyopids, all over the world

COI Molecular barcodes for 45 species across five genera of the family Oxyopidae, worldwide, were collected and mined from GenBank/BOLD systems, along with the Outgroup *Parabatinga brevipes*, given below.

SL NO	SPECIMEN NAME	ACCESSION NUMBER
1	<i>Oxyopes aglossus</i>	BBUSE1482-12
2	<i>Oxyopes apollo</i>	BBUSA461-10
3	<i>Oxyopes aspirasi</i>	MTSPD534-18
4	<i>Oxyopes Azhari</i>	HQ991572.1
5	<i>Oxyopes bothai</i>	SPIZA1308-21
6	<i>Oxyopes chenabensis</i>	MK153932.1
7	<i>Oxyopes globifer</i>	AMSPK020-15
8	<i>Oxyopes gracilipes</i>	NZSPI394-14
9	<i>Oxyopes heterophthalmus</i>	KY703483.1
10	<i>Oxyopes hoggi</i>	KBGPS145-18
11	<i>Oxyopes jacksoni</i>	MATRX1470-22
12	<i>Oxyopes kohaensis</i>	KT383748.1
13	<i>Oxyopes licenti</i>	MT578811.1
14	<i>Oxyopes lineatipes</i>	KX587521.1
15	<i>Oxyopes lineatus</i>	TURAR1222-10
16	<i>Oxyopes longispinosus</i>	ETKS467-13
17	<i>Oxyopes matiensis</i>	MK154140.1
18	<i>Oxyopes nigripalpis</i>	MT607846.1
19	<i>Oxyopes oryzae</i>	HQ991568.1
20	<i>Oxyopes pandae</i>	KT383683.1
21	<i>Oxyopes pingasus</i>	MTSPD543-18
22	<i>Oxyopes ramosus</i>	KY269293.1
23	<i>Oxyopes salticus</i>	KP657113.1
24	<i>Oxyopes scalaris</i>	KP649377.1
25	<i>Oxyopes sunandae</i>	KX587523.1
26	<i>Oxyopes sushilae</i>	PP054131.1
27	<i>Oxyopes tiengianensis</i>	MTSPD532-18
28	<i>Hamataliwa crocata</i>	PANBE057-17
29	<i>Hamataliwa cordivulva</i>	PP054080.1
30	<i>Hamataliwa flebilis</i>	SPIPA941-10
31	<i>Hamataliwa foveata</i>	GBAAW50026-24
32	<i>Hamataliwa incompta</i>	GBMIN114573-17
33	<i>Hamataliwa leporauris</i>	PP054113.1
35	<i>Peucetia crucifera</i>	SPIZA782-21
36	<i>Peucetia nicolae</i>	SPIZA571-21

37	<i>Peucetia rangathanani</i>	MK154968.1
38	<i>Peucetia rubrolineata</i>	KM225118.1
39	<i>Peucetia striata</i>	SPIZA1445-23
40	<i>Peucetia viridana</i>	GBCAB31267-24
41	<i>Peucetia viridans</i>	AASFB409-10
42	<i>Peucetia viridis</i>	SPIZA1460-23
43	<i>Tapponia auriola</i>	PP054159.1
44	<i>Tapponia parva</i>	PP054163.1
45	<i>Tapponia rarobulbus</i>	PP054164.1
46	<i>Parabatinga brevipes</i> (Outgroup)	MW376188

Table 3: Oxyopidae species, DNA Barcode and sequence accession number mined from NCBI GenBank and BOLD.

4.2.3. Phylogenetic analysis of Lynx spiders collected from Kerala with their worldwide counterparts

Phylogenetic analysis was done by constructing phylogenetic trees using the data containing COI molecular DNA barcodes of 19 lynx spiders from Kerala and 45 lynx's COI barcodes mined from NCBI-GENBANK and BOLD and the out-group *Parabatinga brevipes* in fasta format. Partial COI sequencing resulted in an MSA of 635 bp, which was trimmed to 529 (83%) Gblock alignment. According to the J-model test, GTR+I+G is the best nucleotide substitution model for this data set based on AIC, with an -ln likelihood score of 8290.5206. Maximum Likelihood (ML) analysis (**Fig. 1**) was conducted using the GTR+G+I model with 100000 bootstrap replicates. A final ML tree was obtained with an ML Optimisation Likelihood score of -8291.277210 and took 12.304563 hours to complete, including Combined Bootstrap and ML search. An accuracy up to 0.0010000000 Log Likelihood units is estimated through GAMMA+P-Invar Model parameters. The proportion of Invariant sites is 0.4050. GAMMA with 4-character states was used, with shape parameter $\alpha = 0.5900$ and substitution rates λ (A–

C=0.1247, A–G=12.3512, A–T=1.2431, C–G=1.2252, C–T=1.3581, G–T=1.0000). Most nodes in the resulting tree have high bootstrap values, clearly indicating accurate phylogenetic relationships among them.

The Neighbour-Joining (NJ) tree (**Fig. 2**) was constructed using MEGA11 software with 1000 bootstrap replicates. The 1000 bootstrap replicas give a node-to-node confidence level of (>95%). Hence, the resulting tree is more reliable. The NJ tree was generated using the TN93 substitution model with a gamma distribution (+G = 0.98) because MEGA11 does not support the GTR model for NJ analysis. Pairwise deletion was selected to solve the missing data in the MSA. All three codon positions were included in the analysis.

Bayesian Inference (BI) analysis (**Fig. 3**) was performed using MrBayes with 1 million MCMC parameter generations for the MSA. This analysis is based on the GTR+G+I substitution model. Every 100th tree was saved, and the posterior probability is 1 in almost all clades. A Bayesian inference tree with a posterior probability of 1 indicates that the clade is supported with complete certainty under this model. This means the grouping appeared in every sampled tree during the analysis, reflecting maximum statistical confidence. Hence, the resulting tree has higher resolution.

Maximum Parsimony (MP) analysis (**Fig. 4**) was done by using a sixty-four-nucleotide sequence MSA in MEGA XI software. The most parsimonious tree inferred after taking 10000 replicates to understand the phylogeny of Oxyopids of Kerala with the species all over the world. The percentage of these 10000 replicates in which the studied species are grouped in the bootstrap test noted. This MP tree was obtained using the Subtree-Pruning-Regrafting (SPR) algorithm (Nei & Kumar, 2000) with search level 1, in which the initial trees were obtained by the random addition of sequences.

Use of 10,000 bootstrap replicates in a Maximum Parsimony tree ensures that the support values for each clade are highly stable and precise, which minimises random variation. This large number of replicates provides stronger confidence in well-supported branches and makes weakly supported clades clearly identifiable. Overall, it improves the credibility of the analysis

All four trees reveal the evolutionary positions of Oxyopids worldwide. Both the MP and NJ trees are more similar in species alignment. In both trees, the genus *Oxyopes* and *Peucetia* formed monophyletic clades. This trend is disturbed in both the BI and ML trees, which are based on a substitution model. In these trees, some members of the genus *Peucetia* form a monophyletic clade in both the ML and BI trees. The members of the genus *Oxyopes* are rich in these trees, which are scattered among other genera in BI tree. Some of the *Oxyopes* form a monophyletic clade in the ML tree. The genus *Tapponia* forms a sister group with *Hamataliwa*, as per MP, ML, and NJ Trees. The genus *Hamadruas* shares a common ancestor with *Hamataliwa* in the NJ and MP trees. Whereas in the BI and ML trees, *Hamadruas* do not form any sister groups.

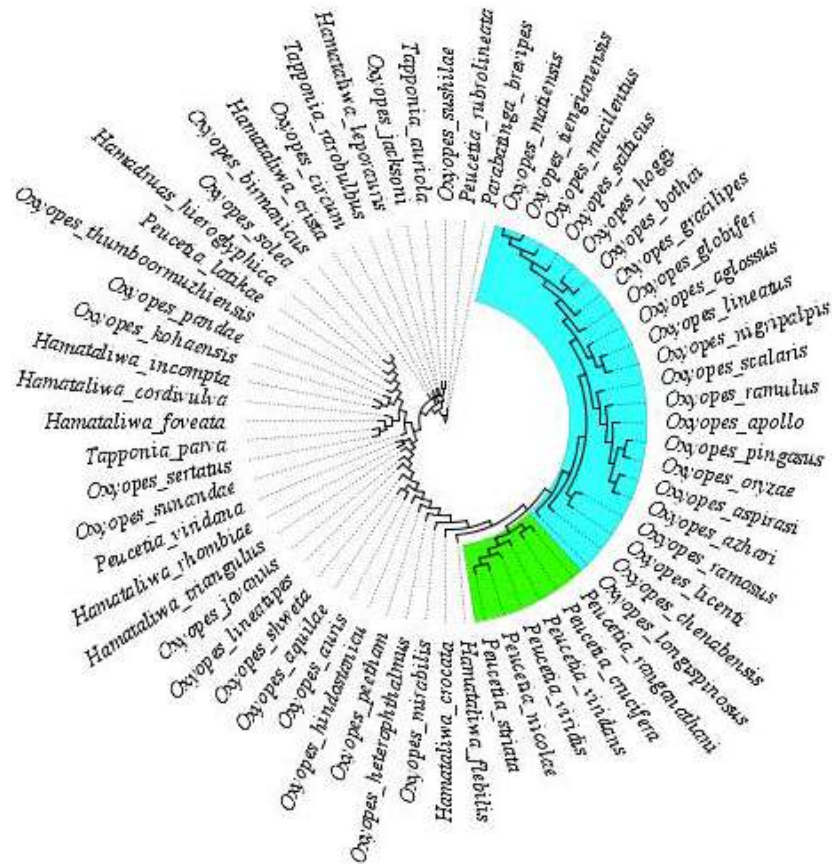


Figure 1: Maximum Likelihood phylogenetic tree of nineteen Oxyopids collected from various parts of Kerala with 100000 bootstrap replicas, including species among Genus *Oxyopes*, Genus *Peucea*, Genus *Hamataliwa*, Genus *Hamadruas* and Genus *Tapponia* with an out group of *Parabatinga brevipes*

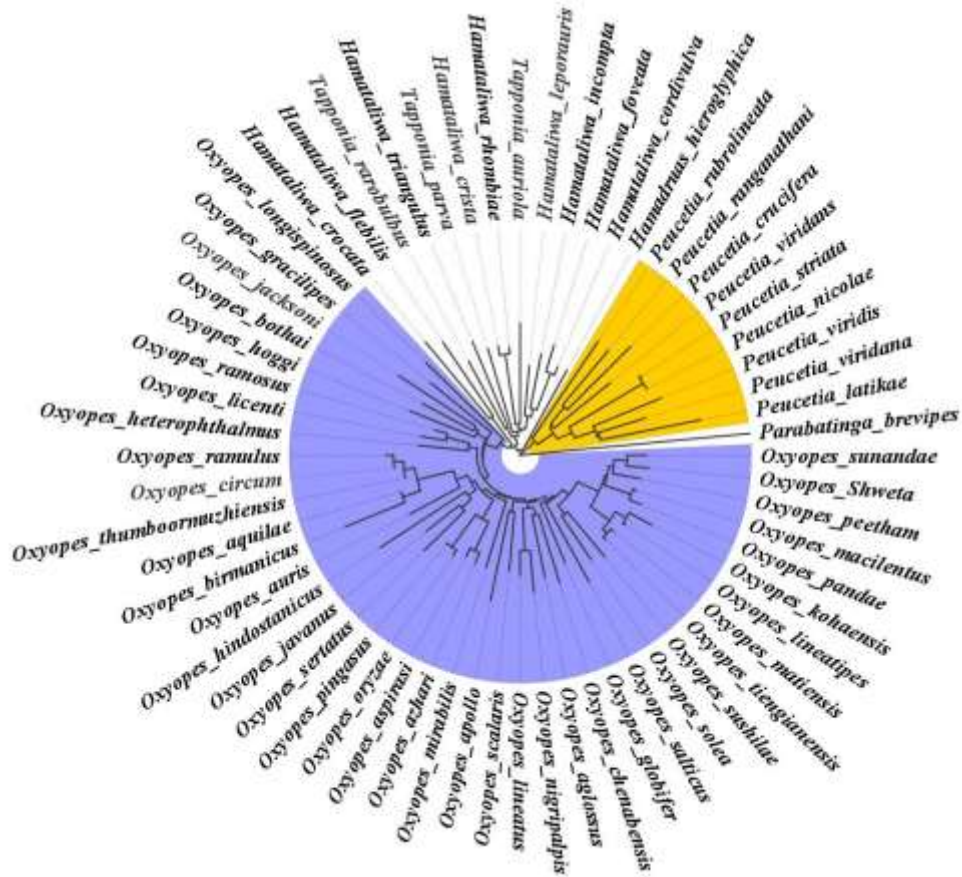


Figure 2: Neighbour-joining phylogenetic tree of nineteen Oxyopids collected from various parts of Kerala with 1000 bootstrap replicas, including species among Genus *Oxyopes*, Genus *Peucetia*, Genus *Hamataliwa*, Genus *Hamadruas* and Genus *Tapponia* with an outgroup of *Parabatinga brevipes*.

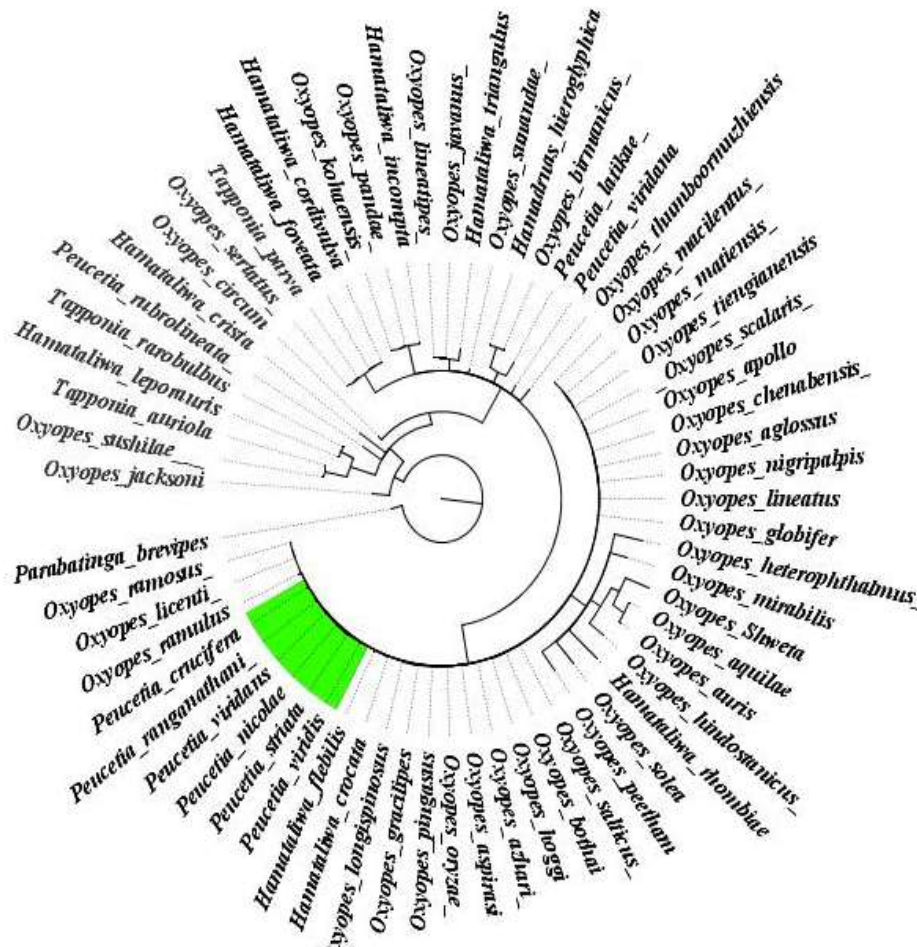


Figure 3: Bayesian inference phylogenetic tree of nineteen Oxyopids collected from various parts of Kerala based on the GTR+G+I substitution model, having a posterior probability of 1 in each clade, including species among Genus *Oxyopes*, Genus *Peucea*, Genus *Hamataliwa*, Genus *Hamadruas* and Genus *Tapponia* with an outgroup of *Parabatinga brevipex*.

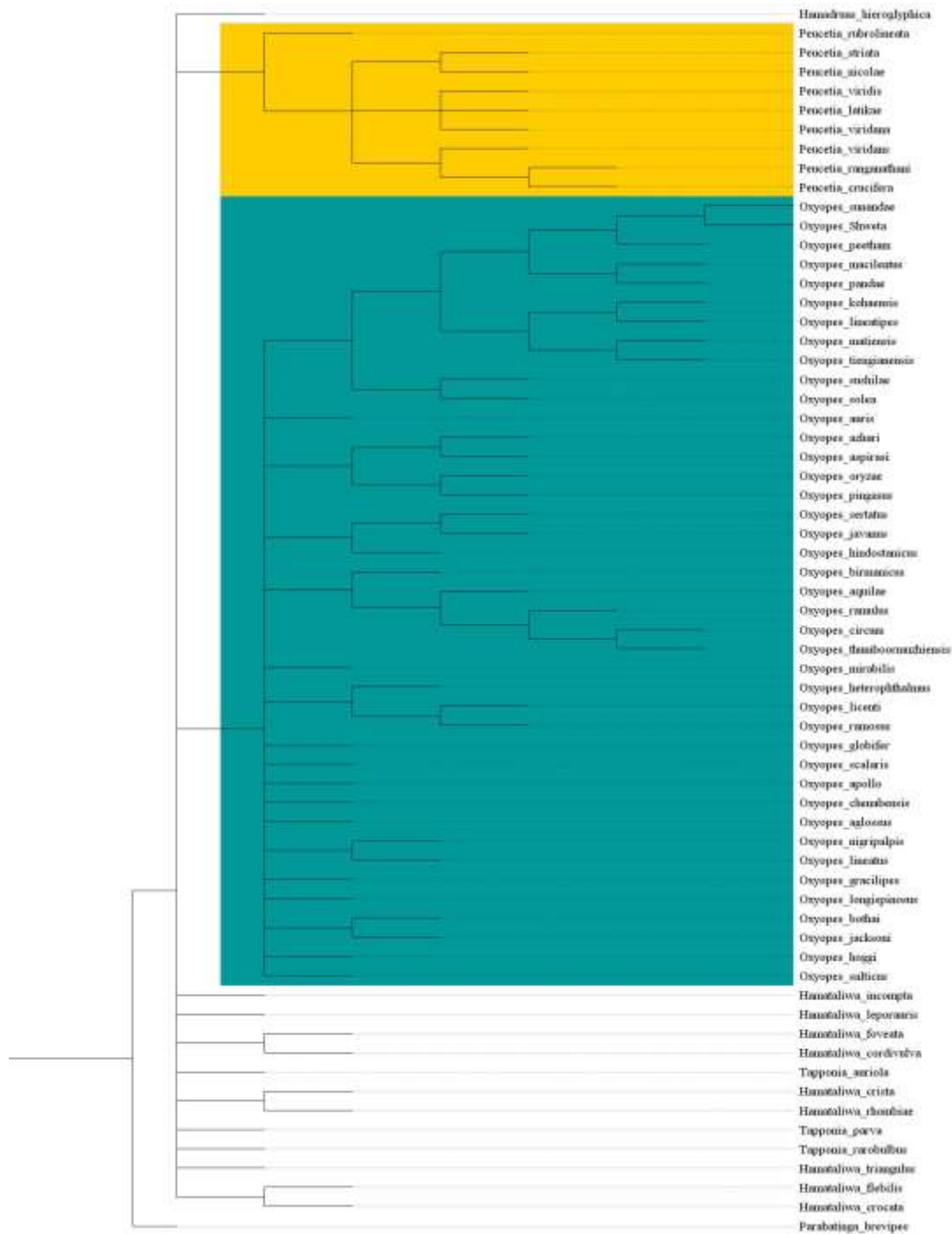


Figure 4: Maximum parsimony phylogenetic tree of nineteen Oxyopids collected from various parts of Kerala with 10000 bootstrap replicas using the Subtree-Pruning-Regrafting (SPR) algorithm (Nei & Kumar, 2000) with search level 1, including species among Genus *Oxyopes*, Genus *Peucetia*, Genus *Hamataliwa*, Genus *Hamadruas* and Genus *Tapponia* with an outgroup of *Parabatinga brevipes*.

OBJECTIVE 3

- 4.3. Study the host plant preference in Lynx spiders of Kerala

Sl. NO	Plant Name	Family	Plant type	Name of the species collected	No of species	No of specimens
1	<i>Allamanda cathartica</i>	Apocynaceae	EXOTIC	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O.javanus,O.tigris</i>	6	30
2	<i>Alternanthera sessilis</i>	Amaranthaceae	NATIVE	<i>O.shweta, O.birmanicus,O.bharathae,O.mirabilis, O.hindostanicus,O.javanus,O.tigris, O. shakilae</i>	8	18
3	<i>Amaranthus viridis</i>	Amaranthaceae	NATIVE	<i>O. bharathae, O. shweta, O. birmanicus</i>	3	24
4	<i>Araucaria heterophylla</i>	Araucariaceae	EXOTIC	<i>O. shweta, O. hindostanicus, O. birmanicus, O. peetham, O. sertatus, O. tigris, O. javanus</i>	7	12
5	<i>Aristolochia indica</i>	Aristolochiaceae	NATIVE	<i>O. shweta, O. longiquus, O. mirabilis, O. macilientus, O. bharathae</i>	5	19
6	<i>Asystasia gangetica</i>	Acanthaceae	INVASIVE	<i>O.shweta, O. birmanicus,O .peetham,O .hindostanicus,O. javanus, O. tigris,O. longiquus, O. mirabilis, O. macilientus, O. bharathae,</i>	10	34
7	<i>Avicennia marina</i>	Acanthaceae	NATIVE	<i>O. aquilae, H. rhombiae, O. hindostanicus</i>	3	5
8	<i>Baliospermum montanum</i>	Euphorbiaceae	NATIVE	<i>O. birmanicus , O. shweta</i>	2	9
9	<i>Bambusa tuldoidea</i>	Poaceae	EXOTIC	<i>O. shweta, O. mirabilis, O. thumboormuzhiensis, O. kasaragodensis, O. macilientus,H. crista, O. javanus</i>	7	22
10	<i>Benkara malabarica</i>	Rubiaceae	NATIVE	<i>O. shakilae, O,shweta, O. javanus</i>	3	18
11	<i>Blachia umbellata</i>	Euphorbiaceae	NATIVE	<i>O. hindostanicus, O. macilientus</i>	2	13
12	<i>Boerhavia diffusa</i>	Nyctaginaceae	NATIVE	<i>O. birmanicus</i>	1	14

13	<i>Bougainvillea glabra</i>	Nyctaginaceae	INVASIVE	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O.javanus,O.tigris,O. longiquus, O. mirabilis, O. macilientus, O. bharathae,O.thumboormuzhiensis, O. circum</i>	12	52
14	<i>Bougainvillea spectabilis shubra</i>	Nyctaginaceae	INVASIVE	<i>O. hippocampus, O. auris, O. sertatus,O.shweta, O.birmanicus, O.peetham, O.hindostanicus,O.tigris,O. longiquus, O. mirabilis, O. macilientus, O. bharathae,O.thumboormuzhiensis,O. javanus</i>	14	49
15	<i>Brachiara mutica</i>	Poaceae	INVASIVE	<i>H. hieroglyphica, O.hindostanicus,O. sertatus,O.shweta, O.mirabilis, O. birmanicus, O. peetham</i>	7	57
16	<i>Caesalpinia coriaria</i>	Fabaceae	EXOTIC	<i>O. striagatus, O. hindostanicus, O. mirabilis, O. birmanicus</i>	4	24
17	<i>Camonea umbellata</i>	Convolvulaceae	INVASIVE	<i>O. hindostanicus, O. macilientus,O. sertatus,O.shweta,H. hieroglyphica,O. bharathae,O. ramulus</i>	7	61
18	<i>Capsicum annuum</i>	Solanaceae	EXOTIC	<i>H. crista, H.rhombiae</i>	2	15
19	<i>Cayratia pedata</i>	Vitaceae	NATIVE	<i>O. birmanicus, O. shweta, O. javanus, O. longiquus</i>	4	16
20	<i>Centratherum intermedium</i>	Asteraceae	EXOTIC	<i>O. shakilae, O,shweta, O. javanus, O.sertaus, O. bharathae</i>	5	26
21	<i>Chamaecrista absus</i>	Fabaceae	INVASIVE	<i>O. hindostanicus, O. striagatus. O.shweta, H. hireoglyphica, H. sagitta, O.javanus, O. peetham, O. thumboormuzhiensis, O. mirabilis</i>	9	59
22	<i>Chamaecrista kleinii</i>	Fabaceae	NATIVE	<i>O. shweta, O. birmanicus</i>	2	17
23	<i>Chloris barbata</i>	Poaceae	INVASIVE	<i>O.shweta, O. birmanicus, O. bharathae, O. shakilae, O. hippocampus,O.peetham, O. mirabilis, O. hindostanicus</i>	8	51
24	<i>Chromolaena odorata</i>	Asteraceae	INVASIVE	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O. javanus,O.tigris,O. longiquus, O. mirabilis, O. macilientus, O.</i>	18	110

				<i>bharathae, O. thumboormuzhiensis, O. circum, O. aquilae, O. ramulus, O. auris, O. shakilae, O. striagatus, O. fabae</i>		
25	<i>Cissus vitigenea</i>	Vitaceae	NATIVE	<i>P. latikae, H. quardata</i>	2	24
26	<i>Clerodendrum paniculatum</i>	Lamiaceae	EXOTIC	<i>O. shweta, O. birmanicus, O. hindostanicus</i>	3	31
27	<i>Clidemia hirta</i>	Melastomataceae	INVASIVE	<i>O. shweta, O. birmanicus, O. peetham, O. hindostanicus, O. javanus, O. tigris, O. longiquus, O. mirabilis, O. macilientus, O. bharathae, O. thumboormuzhiensis, O. circum, O. aquilae, O. ramulus, O. auris, O. shakilae</i>	16	47
28	<i>Coronopus didymus</i>	Brassicaceae	INVASIVE	<i>O. tigris, O. longiquus, O. mirabilis, O. macilientus, O. bharathae, O. thumboormuzhiensis, O. circum, O. aquilae, O. ramulus, O. auris, O. shakilae, O. kasaragodensis</i>	12	62
29	<i>Cosmos sulphureus</i>	Asteraceae	INVASIVE	<i>O. shweta, O. birmanicus, O. peetham, O. hindostanicus, O. javanus, O. tigris, O. macilientus, O. bharathae, O. thumboormuzhiensis, O. circum, O. aquilae, O. ramulus, O. shakilae, O. kasaragodensis, H. sikkimensis</i>	15	41
30	<i>Croton hirtus</i>	Euphorbiaceae	INVASIVE	<i>P. latikae, O. hippocampus, O. mirabilis, O. macilientus, O. bharathae, O. thumboormuzhiensis, O. circum, O. aquilae, O. ramulus</i>	9	29
31	<i>Cyanchum laeve</i>	Apocynaceae	EXOTIC	<i>O. shweta, O. birmanicus, O. peetham, O. hindostanicus, O. mirabilis</i>	5	26
32	<i>Cynodon dactylon</i>	Poaceae	NATIVE	<i>O. hindostanicus, O. javanus, O. longiquus, O. mirabilis, O. circum, O. aquilae, O. auris, O. shakilae, O. striagatus</i>	9	34
33	<i>Datura ferox</i>	Solanaceae	EXOTIC	<i>P. latikae, O. shweta, O. birmanicus, O. peetham, O. hindostanicus, O. bharathae</i>	6	42

34	<i>Delonix regia</i>	Fabaceae	INVASIVE	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O. javanus,O.tigris, O. macilientus, O. bharathae,O. thumboormuzhiensis.O. mirabilis</i>	10	55
35	<i>Dichanthelium clandestinum</i>	Poaceae	EXOTIC	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O. javanus</i>	5	26
36	<i>Digitaria bicornis</i>	Poaceae	INVASIVE	<i>O. bharathae,O. thumboormuzhiensis, O. circum, O. aquilae,O. ramulus,O.hindostanicus,O. mirabilis, O.sertatus,O. auris, O. shakilae,O. longiquus</i>	11	43
37	<i>Eugenia mooniana</i>	Myrtaceae	NATIVE	<i>O. patera, P.latikae, O. sertatus</i>	3	25
38	<i>Euryops pectinatus</i>	Asteraceae	INVASIVE	<i>O. fabae, O. solea, O. mirabilis, O. kasaragodensis, O. shakilae,O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O. javanus,O.tigris, O. macilientus, O. bharathae</i>	13	46
39	<i>Hibiscus aculeatus</i>	Malvaceae	EXOTIC	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O.javanus</i>	5	37
40	<i>Hibiscus ovalifolius</i>	Malvaceae	NATIVE	<i>O.shweta, O.birmanicus,O.bharathae,O.mirabilis</i>	4	17
41	<i>Hibiscus radiatus</i>	Malvaceae	EXOTIC	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O.javanus</i>	5	18
42	<i>Hyptis capitata</i>	Lamiaceae.	INVASIVE	<i>O. javanus,O.tigris, O. macilientus, O. bharathae,O. thumboormuzhiensis.O. mirabilis</i>	6	27
43	<i>Hyptis suaveolens</i>	Lamiaceae	INVASIVE	<i>O.shweta, P. latikae, O. fabae, O. solea, O.sertatus,O. auris, O. shakilae,O. longiquus,O.hindostanicus,O.javanus, O. aquilae,O. ramulus</i>	12	32
44	<i>Impatiens walleriana</i>	Balsaminaceae	NATIVE	<i>O.shweta, O.birmanicus</i>	2	6
45	<i>Jasminum sambac</i>	Oleaceae	NATIVE	<i>O.shweta, O.birmanicus, O.hindostanicus,O.javanus, H. hieroglyphica</i>	5	34

46	<i>Lantana Camera</i>	Verbenaceae	INVASIVE	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O. javanus,O.tigris, O. macilientus, O. bharathae,O. mirabilis, O. thumboormuzhiensis, O. shakilae, O. kasaragodensis, H. sikkimensis.</i>	13	38
47	<i>Lantana montevidensis</i>	Verbenaceae	INVASIVE	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O. javanus,O. mirabilis, O. macilientus, O. bharathae,O. thumboormuzhiensis, O. circum, O. aquilae,O. ramulus, O. auris, O. shakilae, O. striagatus, O. fabae</i>	16	34
48	<i>Lantana trifolia</i>	Verbenaceae	INVASIVE	<i>O.shweta, O. birmanicus, O. bharathae, O. shakilae, O. hippocampus,O.peetham, O. mirabilis, O. hindostanicus, O. mirabilis</i>	9	29
49	<i>Leucaena leucocephala</i>	Fabaceae	EXOTIC	<i>O. bharathae, O. shakilae,P. latikae</i>	3	18
50	<i>Melastoma candidum</i>	Melastomataceae	INVASIVE	<i>O.shweta, O.birmanicus, O.hindostanicus,O. javanus,O.tigris, O. macilientus, O. bharathae, O. kasaragodensis, H. sikkimensis, O. mirabilis</i>	10	39
51	<i>Microcos paniculata</i>	Malvaceae	NATIVE	<i>H. sagitta, P. latikae,O.shweta,O. javanus</i>	4	11
52	<i>Mikania micrantha</i>	Asteraceae	INVASIVE	<i>O. circum, O. aquilae,O. ramulus, O. auris, O. shakilae, O. striagatus, O. fabae</i>	7	29
53	<i>Mimosa pudica</i>	Fabaceae	EXOTIC	<i>O. javanus,O.tigris, O. macilientus, O. bharathae,O. hindostanicus.O. sertatus</i>	6	23
54	<i>Moringa oleifera</i>	Moringaceae	NATIVE	<i>O.shweta, O.birmanicus, O.hindostanicus,O. javanus,O. bharathae, O. kasaragodensis</i>	6	17
55	<i>Muccuna bracteata</i>	Fabaceae	INVASIVE	<i>P. latikae, O. shweta,O. javanus,O. mirabilis, O. macilientus, O. bharathae, O. solea, O. ramulus, O. hindostanicus</i>	9	36

56	<i>Muntingia calabura L</i>	Muntingiaceae	EXOTIC	<i>O. kasaragodensis, O. macilientus, O. bharathae, O. circum, O. aquilae, O. ramulus, O. auris</i>	7	31
57	<i>Mussaenda frondosa</i>	Rubiaceae	EXOTIC	<i>O. shweta, O. birmanicus</i>	2	13
58	<i>Myriactis nepalensis</i>	Rubiaceae	NATIVE	<i>O. shweta, O. birmanicus, O. hindostanicus, O. javanus</i>	4	21
59	<i>Nerium oleander</i>	Apocynaceae	EXOTIC	<i>O. shweta, O. birmanicus, O. hindostanicus, O. javanus, O. bharathae, O. solea, O. kasaragodensis</i>	7	24
60	<i>Nicotiana tabacum</i>	Solanaceae	EXOTIC	<i>H. triangulus, H. crista, H. rhombiae</i>	3	24
61	<i>Ocimum tenuiflorum</i>	Lamiaceae	NATIVE	<i>O. shweta, O. birmanicus, O. hindostanicus, O. javanus, O. longiquus, O. mirabilis, O. macilientus</i>	7	22
62	<i>Oscimum gratissimum</i>	Lamiaceae	NATIVE	<i>H. sikkimensis, P. latikae, O. shweta, O. hindostanicus</i>	4	19
63	<i>Otacanthus caeruleus</i>	Plataginaceae	EXOTIC	<i>O. sertatus, O. auris, O. shweta, O. birmanicus, O. hindostanicus, O. javanus</i>	6	37
64	<i>Passiflora vesicaria</i>	Passifloraceae	NATIVE	<i>P. latikae, O. shweta, O. javanus</i>	3	18
65	<i>Pennisetum clandestinum</i>	Poaceae	INVASIVE	<i>O. shweta, O. birmanicus, O. peetham, O. hindostanicus, O. javanus, O. tigris, O. longiquus, O. mirabilis, O. macilientus, O. bharathae, O. thumboormuzhiensis, O. circum</i>	12	57
66	<i>Pennisetum pedicellatum</i>	Poaceae	INVASIVE	<i>O. shweta, O. birmanicus, O. peetham, O. hindostanicus, O. javanus, O. mirabilis, O. macilientus, O. bharathae, O. aquilae, O. ramulus, O. auris, O. shakilae, O. fabae</i>	13	39
67	<i>Pennisetum polystachion</i>	Poaceae	INVASIVE	<i>O. macilientus, O. bharathae, O. thumboormuzhiensis, O. circum, O. aquilae, O. ramulus, O. auris, O. shakilae</i>	8	51

68	<i>Phyllanthus myrtifolius</i>	Phyllanthaceae	INVASIVE	<i>O.shweta, O.birmanicus,O.hindostanicus,O. javanus,O.tigris, O. macilientus, O. bharathae,O. thumboormuzhiensis, O. circum, O. aquilae,O. shakilae, O. kasaragodensis</i>	12	37
69	<i>Phyllanthus reticularis</i>	Phyllanthaceae	INVASIVE	<i>O.shweta, O.birmanicus,O.peetham, O.hindostanicus,O. javanus, O. sertatus, O. mirabilis</i>	7	31
70	<i>Pueraria phaseoloides</i>	Fabaceae	INVASIVE	<i>O. macilientus, O. bharathae, O. aquilae,O. ramulus, O. auris, O. shakilae, O.shweta, O.birmanicus,O.hindostanicus,O. javanus,O. longiquus</i>	11	35
71	<i>Rosa alba</i>	Rosaceae	INVASIVE	<i>O.shweta, O.birmanicus,O.hindostanicus,O. javanus,O.tigris, O. macilientus, O. bharathae,O. thumboormuzhiensis,</i>	8	21
72	<i>Rosa rubiginosa</i>	Rosaceae	EXOTIC	<i>O.shweta, O.birmanicus,O.bharathae, O.hindostanicus,O. javanus, O. sertatus</i>	6	20
73	<i>Ruellia elegans</i>	Acanthaceae	EXOTIC	<i>H. quardata, H. crista, H. hieroglyphica</i>	3	17
74	<i>Sida cordifolia</i>	Malvaceae	NATIVE	<i>P. latikae,O.birmanicus,O.bharathae, O.hindostanicus,O. javanus</i>	5	16
75	<i>Sphaeranthus indicus</i>	Asteraceae	NATIVE	<i>O.shweta, O.birmanicus,O.bharathae</i>	3	13
76	<i>Sphagneticola trilobata</i>	Asteraceae	INVASIVE	<i>O. longiquus, O. mirabilis, O. macilientus, O. bharathae,O. thumboormuzhiensis, O. circum</i>	6	29
77	<i>Strobilanthes lanatus</i>	Acanthaceae	NATIVE	<i>O.shweta, O.birmanicus,O.bharathae, O. solea</i>	4	27
78	<i>Stachytarpheta indica</i>	Verbenaceae	INVASIVE	<i>O.shweta, O.birmanicus, O.hindostanicus,O. javanus,O.tigris, O. macilientus, O. bharathae,O. thumboormuzhiensis, O. shakilae, O. kasaragodensis</i>	10	31
79	<i>Tagetes erecta</i>	Asteraceae	EXOTIC	<i>O.shweta, O.birmanicus, O.hindostanicus,O. javanus,O.tigris, O. macilientus, O. bharathae,O. hippocampus</i>	8	19

80	<i>Tibouchina urbilleana</i>	Melastomataceae	INVASIVE	<i>O.shweta, O.birmanicus, O.peetham, O.hindostanicus, O. javanus, O. mirabilis, O. macilentus, O. bharathae, O. aquilae, O. ramulus, O. auris</i>	11	34
81	<i>Tradescantia zebrina</i>	Melastomataceae	EXOTIC	<i>O. striagatus, H. sagitta, O. fabae, O.shweta,</i>	4	10
82	<i>Trema orientalis</i>	Cannabaceae	NATIVE	<i>O.shweta, O.birmanicus, O.hindostanicus, O. javanus</i>	4	22
83	<i>Tridax procumbens</i>	Asteraceae	INVASIVE	<i>O. bharathae, O. thumboormuzhiensis, O. shakilae, O. kasaragodensis, O. mirabilis</i>	5	37
84	<i>Urena lobata</i>	Malvaceae	INVASIVE	<i>P. latikae, O.birmanicus, O.bharathae, O.hindostanicus, O. javanus, O.hindostanicus</i>	6	36
85	<i>Wrightia antidysenterica</i>	Apocynaceae	EXOTIC	<i>O. bharathae, O. thumboormuzhiensis</i>	2	12
86	<i>Xanthostemon chrysanthus</i>	Myrtaceae	EXOTIC	<i>O.shweta, O.birmanicus</i>	2	19
87	<i>Xanthium strumarium</i>	Asteraceae	EXOTIC	<i>O. auris, O.shweta, O.birmanicus</i>	3	10
88	<i>Ziziphus oenoplia</i>	Rhamnaceae	INVASIVE	<i>O.shweta, O.birmanicus, O.bharathae, O.hindostanicus</i>	4	34

Table 4: Shows the host plants of Lynx spiders, host plant family, plant type, and name of species collected. No. of species and No. of specimens collected from each host plant.

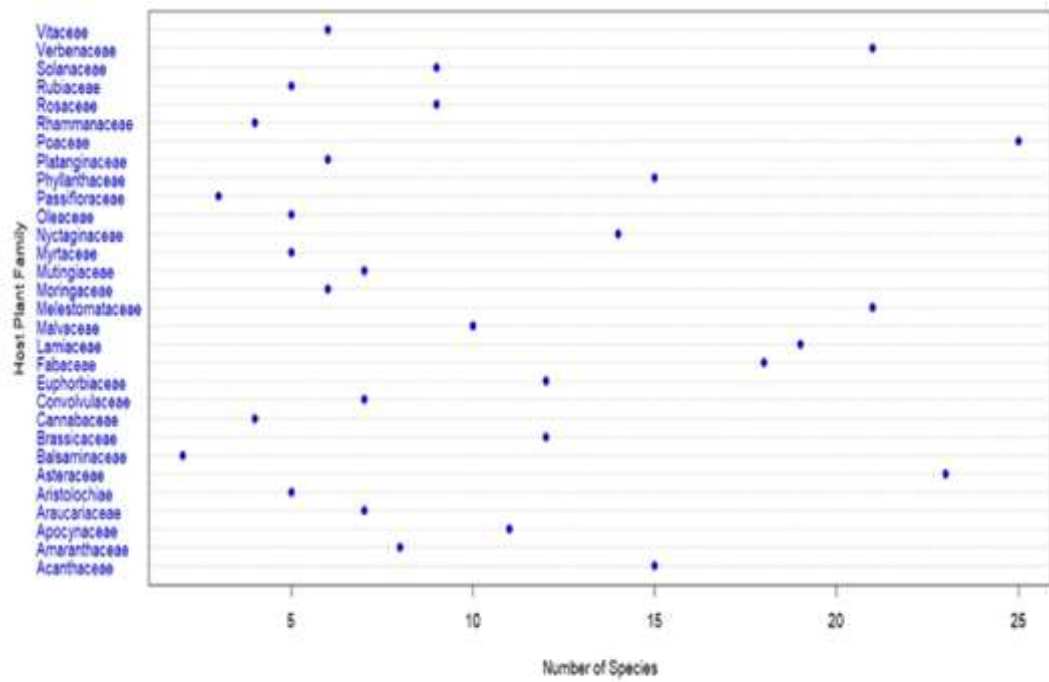


Figure 5: Dot Plot of Number of species by Host plant Family

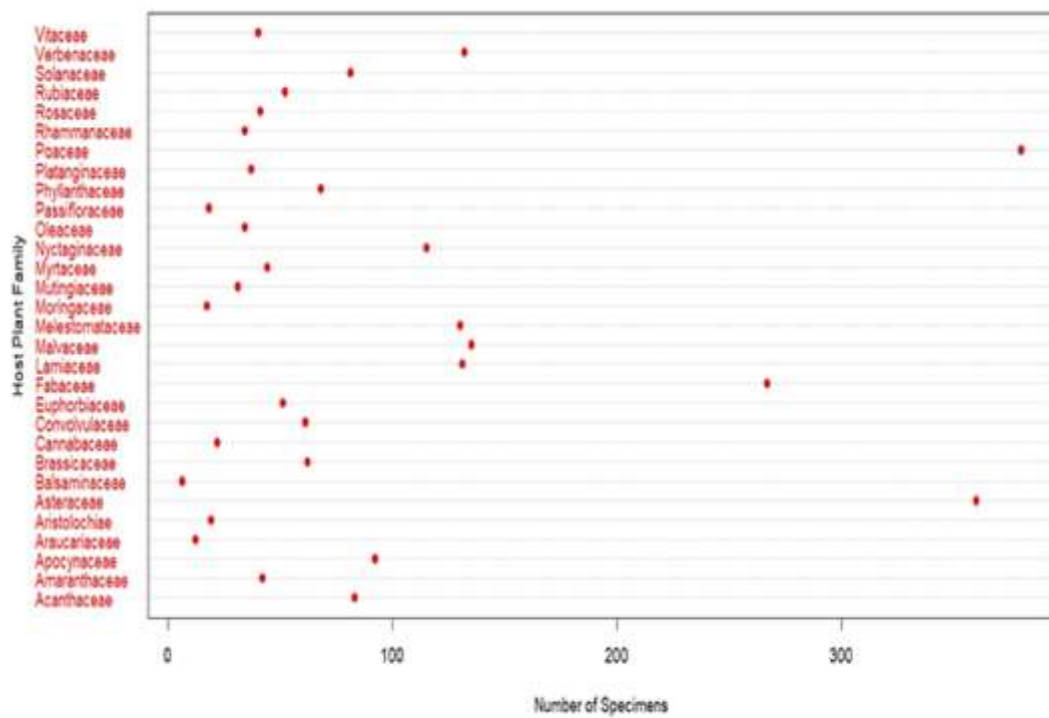


Figure 6 :Dot Plot of Number of Specimens by Host plant family

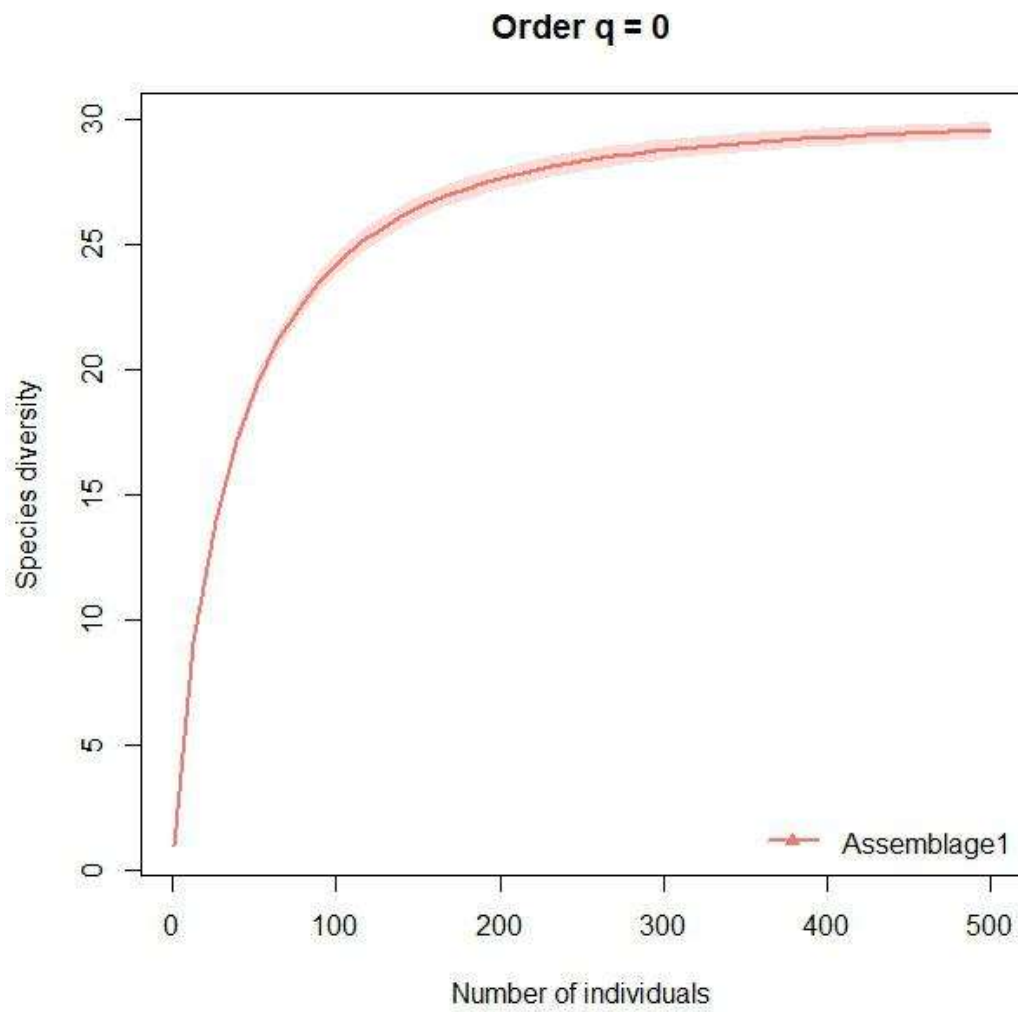


Figure 7: Species accumulation curve

Diversity indices	Shannon index	Simpson index	Evenness	Chao 1
Host plant families	2.972612	0.9286975	0.8739898	318.1667

Table 5: Results of alpha diversity indices in host plant families

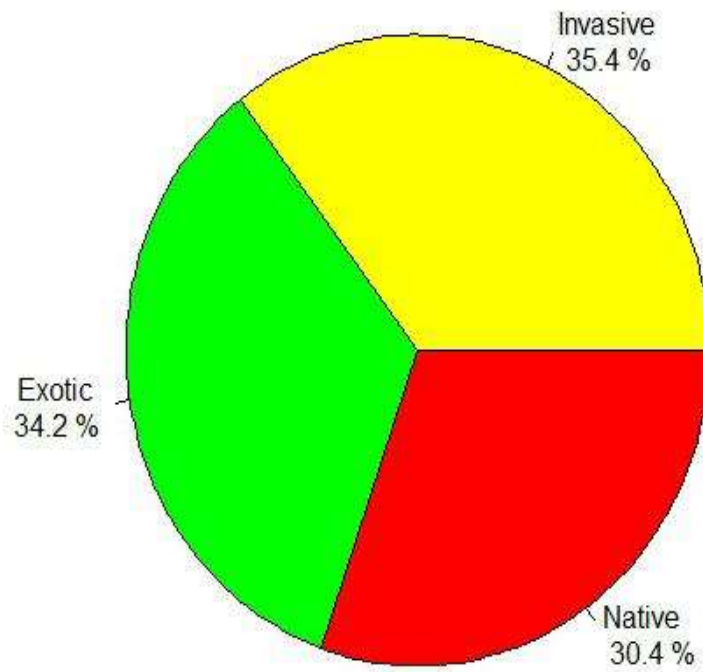


Figure 8: Pie diagram showing species distribution in plant types

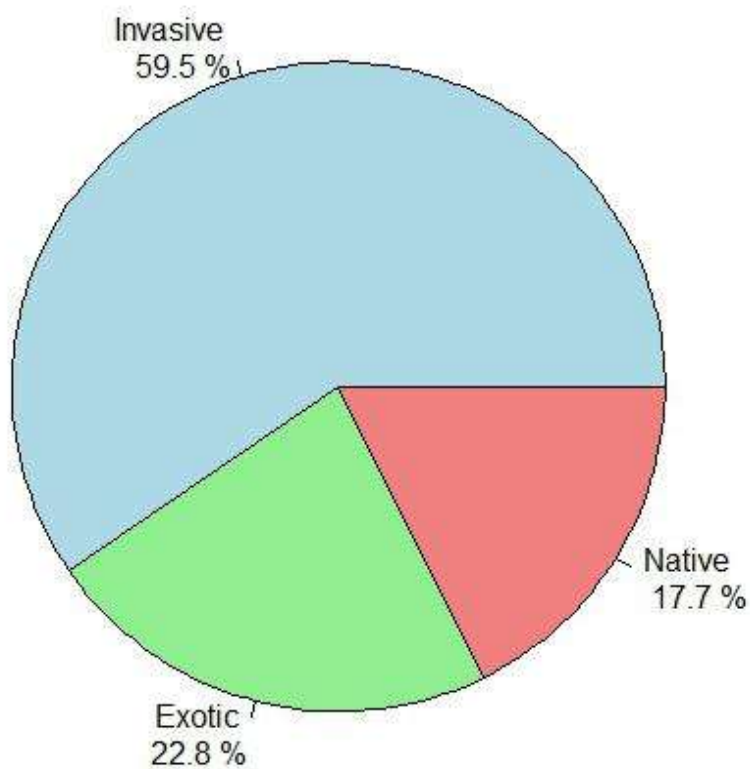


Figure 9: Pie diagram showing specimen distribution in plant types

Plant type	Shannon index	Simpson index	Evenness	Chao1
Invasive	3.266959	0.9599621	0.984198	28
Exotic	3.200472	0.9563942	0.9710645	27
Native	3.075420	0.9501821	0.9677056	24

Table 6: Results of alpha diversity indices of the number of specimens in the host plant type

4.3.1. Host plant preference of Oxyopids

A total of 88 host plants (**Table 4**) belong to 30 plant families and were identified across 68 collection sites in various parts of Kerala. Among the identified host plants, the highest number of Oxyopid specimens and species was collected from *Chromolaena odorata* (Asteraceae). Only one species of the *Oxyopes* genus, *O. birmanicaus*, could be collected from *Boerhavia diffusa* of the Nyctaginaceae family. The fewest specimens were collected from *Avicennia marina* in the family Acanthaceae. The host plants include three plant types: Native, Exotic and Invasive. Dot plots of species richness (**Fig. 5**) and species abundance (**Fig. 6**) at the host plant family level, plotted using the R programme, reveal that the Poaceae family has the highest richness(25) and abundance(380), and the Balsaminaceae has the lowest richness(2) and abundance(6). The species accumulation curve (**Fig. 7**), plotted in R at the host plant family level, indicates efficient sampling. In the graph, there is an initial rapid increase followed by a plateau, indicating high species richness and sampling completeness. Also estimates the presence of approximately 30 distinct species. The alpha diversity indices of species distribution across host plant families were calculated using the R programme (**Table 5**). The Shannon index is 2.92, and the Simpson index is 0.93, indicating a diverse and more balanced distribution of species in this host plant family, with no single species dominant. The Evenness value (0.87) indicates a balanced abundance of species across the host plant families. The Chao 1 (318.1667)

indicates the chance of getting rarer and cryptic species. Also noted differences in species diversity and distribution by plant type. The pie diagrams of species (**Fig. 8**) and specimen (**Fig. 9**) distribution and alpha diversity indices (**Table 6**) strongly supported that the Lynx spiders' host plant preference decreases from invasive to native (Invasive>Exotic>Native).

SL. NO	Plant Name	Species position in Host plants					
		Flower		Leaf		Stem	
		Above	Below	Above	Below	Above	Below
1	<i>Allamanda cathartica</i>	✓	✓	X	✓	X	X
2	<i>Alternanthera sessilis</i>	X	X	✓	✓	X	✓
3	<i>Amaranthus viridis</i>	X	X	✓	✓	X	X
4	<i>Araucaria heterophylla</i>	X	X	✓	✓	X	✓
5	<i>Aristolochia indica</i>	X	X	✓	✓	X	X
6	<i>Asystasia gangetica</i>	✓	✓	✓	✓	X	✓
7	<i>Avicennia marina</i>	X	X	X	✓	✓	X
8	<i>Baliospermum montanum</i>	X	X	✓	✓	X	X
9	<i>Bambusa tuldoidea</i>	X	X	X	✓	✓	X
10	<i>Benkara malabarica</i>	X	X	✓	✓	✓	✓
11	<i>Blachia umbellata</i>	X	X	X	✓	X	X
12	<i>Boerhavia diffusa</i>	X	X	✓	✓	✓	✓
13	<i>Bougainvillea glabra</i>	✓	✓	X	✓	X	X
14	<i>Bougainvillea spectabilis shruba</i>	✓	✓	X	✓	X	X
15	<i>Brachiara mutica</i>	X	X	✓	✓	X	✓
16	<i>Caesalpinia coriaria</i>	X	X	✓	✓	X	X
17	<i>Camonea umbellata</i>	X	✓	X	✓	X	✓
18	<i>Capsicum annuum</i>	X	X	✓	✓	✓	✓
19	<i>Cayratia pedata</i>	X	✓	✓	X	✓	X
20	<i>Centratherum intermedium</i>	✓	✓	✓	✓	X	✓
21	<i>Chamaecrista absus</i>	X	X	✓	✓	X	X
22	<i>Chamaecrista kleinii</i>	✓	✓	✓	✓	X	X
23	<i>Chloris barbata</i>	✓	✓	X	X	✓	✓
24	<i>Chromolaena odorata</i>	X	X	✓	✓	✓	✓
25	<i>Cissus vitigenea</i>	✓	✓	✓	✓	X	X
26	<i>Clerodendrum paniculatum</i>	✓	X	X	X	X	X
27	<i>Clidemia hirta</i>	X	X	✓	✓	X	✓
28	<i>Coronopus didymus</i>	X	X	✓	✓	✓	X
29	<i>Cosmos sulphureus</i>	✓	✓	✓	✓	✓	X

30	<i>Croton hirtus</i>	X	X	X	✓	X	X
31	<i>Cyanchum laeve</i>	X	X	X	✓	X	X
32	<i>Cynodon dactylon</i>	X	X	✓	✓	X	✓
33	<i>Datura ferox</i>	X	X	X	✓	X	X
34	<i>Delonix regia</i>	X	X	✓	✓	X	X
35	<i>Dichanthelium clandestinum</i>	X	X	✓	✓	✓	✓
36	<i>Digitaria bicornis</i>	X	X	✓	✓	X	X
37	<i>Eugenia mooniana</i>	X	X	X	✓	X	✓
38	<i>Euryops pectinatus</i>	X	X	✓	✓	X	X
39	<i>Hibiscus aculeatus</i>	✓	✓	✓	✓	✓	✓
40	<i>Hibiscus ovalifolius</i>	✓	✓	✓	✓	✓	✓
41	<i>Hibiscus radiatus</i>	✓	✓	✓	✓	X	X
42	<i>Hyptis capitata</i>	X	X	✓	✓	X	X
43	<i>Hyptis suaveolens</i>	✓	✓	✓	✓	✓	✓
44	<i>Impatiens walleriana</i>	X	✓	✓	✓	X	X
45	<i>Jasminum sambac</i>	X	✓	✓	✓	X	✓
46	<i>Lantana Camera</i>	✓	✓	✓	✓	X	✓
47	<i>Lantana montevidensis</i>	✓	✓	✓	✓	X	✓
48	<i>Lantana trifolia</i>	✓	✓	✓	✓	X	✓
49	<i>Leucaena leucocephala</i>	X	X	✓	✓	✓	X
50	<i>Melastoma candidum</i>	✓	✓	✓	✓	X	X
51	<i>Microcos paniculata</i>	X	X	✓	✓	X	X
52	<i>Mikania micrantha</i>	X	X	✓	✓	X	X
53	<i>Mimosa pudica</i>	X	X	✓	✓	✓	✓
54	<i>Moringa oleifera</i>	X	X	✓	✓	X	X
55	<i>Muccuna bracteata</i>	X	X	X	✓	X	X
56	<i>Muntingia calabura L</i>	X	X	✓	✓	✓	✓
57	<i>Mussaenda frondosa</i>	✓	✓	✓	✓	X	✓
58	<i>Myriactis nepalensis</i>	✓	✓	✓	✓	X	X
59	<i>Nerium oleander</i>	X	X	✓	✓	X	X
60	<i>Nicotiana tabacum</i>	X	X	✓	✓	X	✓
61	<i>Ocimum tenuiflorum</i>	✓	✓	✓	✓	✓	✓
62	<i>Oscimum gratissimum</i>	X	X	✓	✓	X	✓
63	<i>Otacanthus caeruleus</i>	X	X	✓	✓	✓	✓
64	<i>Passiflora vesicaria</i>	X	X	✓	✓	✓	✓
65	<i>Pennisetum clandestinum</i>	X	X	✓	✓	X	✓
66	<i>Pennisetum pedicellatum</i>	✓	✓	✓	✓	X	✓
67	<i>Pennisetum polystachion</i>	✓	✓	✓	✓	X	X
68	<i>Phyllanthus myrtifolius</i>	X	X	✓	✓	✓	✓
69	<i>Phyllanthus reticularis</i>	X	X	✓	✓	X	X
70	<i>Pueraria phaseoloides</i>	X	X	X	✓	X	✓
71	<i>Rosa alba</i>	✓	✓	✓	✓	X	✓

72	<i>Rosa rubiginosa</i>	✓	✓	✓	✓	X	✓
73	<i>Ruellia elegans</i>	✓	✓	X	✓	X	✓
74	<i>Sida cordifolia</i>	✓	✓	✓	✓	X	X
75	<i>Sphaeranthus indicus</i>	X	X	X	✓	X	✓
76	<i>Sphagneticola trilobata</i>	✓	X	✓	✓	X	✓
77	<i>Strobilanthus lanatus</i>	X	X	✓	✓	X	✓
78	<i>Stachytarpheta indica</i>	X	X	✓	✓	X	X
79	<i>Tagetes erecta.</i>	✓	✓	✓	✓	X	X
80	<i>Tibouchina urvilleana</i>	✓	✓	✓	✓	✓	✓
81	<i>Tradescantia zebrina</i>	X	X	✓	✓	✓	X
82	<i>Trema orientalis</i>	X	✓	✓	✓	X	X
83	<i>Tridax procumbens</i>	✓	✓	✓	✓	X	X
84	<i>Urena lobata</i>	X	X	✓	✓	✓	X
85	<i>Wrightia antidysenterica</i>	X	X	✓	✓	X	X
86	<i>Xanthostemon chrysanthus</i>	✓	✓	✓	✓	X	X
87	<i>Xanthium strumarium</i>	✓	✓	X	✓	X	✓
88	<i>Ziziphus oenoplia</i>	X	X	✓	✓	X	X

Table 7: Shows the host plant and the plant part where the Lynx spider is located

4.3.2. Host plants and Oxyopid position in each plant

The relative position of the lynx spider in their host plant parts (**Table 7**) is noted. The preferred position of the lynx spider is not the same on all of its host plants. The position of the lynx spider on its host plants varies among species and among their respective host plants. Most of the Lynx spiders prefer to sit on the lower side of the leaf as well as on the upper side. Except for *Cayratia pedata*, *Chloris barbata* and *Clerodendrum paniculatum*, Oxyopids are common on the ventral sides of leaves. Stems are a less preferred plant part for lynx to occupy. The members of the genus *Oxyopes* favoured both leaves and flowers due to their vibrant body colour, which could mimic those plant parts. Members of *Peucetia* and *Hamadryas* prefer the upper and lower sides of the leaves because of their greenish appearance. The *Hamataliwa* prefers to occupy the stems and leaves of its host plant.

OBJECTIVE 4

- 4.4. Compare the Gut microbial diversity of *Oxyopes birmanicus* from 4 selected ecosystems

4.4.1. The abundance of Gut Microbiota at each taxonomic level

After importing the demultiplexed sequence, a summary is generated to assess sequence quality. OBRM1 has the highest number of reads (3,78,148), the most data (94.54 Mb), and an average GC% of 55.5%, indicating deeper sequence coverage and GC bias. OBRM4 maintains high quality despite a lower number of reads (2,31,410) and data (57.85 Mb). The values for OBRM2 and OBRM3 fall between those of OBRM1 and OBRM4. The sequence quality is $\geq 89\%$ Q30, indicating that the sequences are suitable for further analysis. The remaining specimens have a GC% between 52% and 53%, which is ideal. All specimens with a $\sim 72\%$ filtration rate showed better raw data quality. Denoising is performed to eliminate sequence errors without altering biological variation, resulting in a feature count showing that OBRM3 has the highest microbial diversity (19,929) and OBRM1 the lowest (3,406). OBRM2 and OBRM4 remain between these values (15,740, 8,135).

A graphical representation of microbial abundance in each taxonomic level was prepared. Among the sequences isolated from the specimen's guts, only OBRM1 is contaminated with other sequences (Fig. 10). The gut microbial community of OBRM1 is abundant in Proteobacteria at the phylum level (Fig. 11), whereas OBRM3 is dominated by Firmicutes. An abundance of Proteobacteria and Firmicutes is almost equal in OBRM2 and OBRM4. In the class level (Fig. 12), OBRM3 has the highest abundance of clostridia, whereas the remaining have the highest abundance of alphaproteobacteria. At the order level (Fig. 13), OBRM1 has the highest concentrations of Rhizobiales and Rhodobacterales. This trend changes in OBRM2 and OBRM4, where Mycobacteriales and Caulobacterales have the highest concentration. In the family level (Fig. 14), OBRM1 has the highest concentration of Rhodobacteriaceae. In OBRM2 and OBRM4, Dermabacteraceae is abundant, and

Lachnospiraceae is abundant in OBRM3. *Methylobacterium* is the abundant genus in OBRM1, and it is *Brevundimonas* in the remaining ones (**Fig. 15**). There is no noticeable abundance at the species level (**Fig. 16**) in all the specimens.

4.4.2. Krona plot analysis

The Krona plot of microbial abundance across the four specimens shows the percentage abundance of each species. *Hungateiclostridium straminisolvans* (35%) is the abundant species in OBRM1 (**Fig. 17**). *Sphingomonas*_L_486704 sp001421805, OLB17 sp001464665, *Brevundimonas faecalis*, *Micrococcus antarcticus*, *Corynebacterium pseudodiphtheriticum*, *Sphingorhabdus*_B_483718 contaminans, and *Ensifer adhaerens* are common in all specimens except OBRM1 (**Fig. 18-20**). *Nanosynbacter lyticus*, *Leptotrichia*_A_993758 buccalis, *Corynebacterium accolens*, *Rothia terrae*, *Eggerthella sinensis*, *Sphingobium*_A_485959 scionense, *Pelagibacterium lentulum*, *Bosea vestrisii*, and *Hyphomicrobium*_A facile are common in OBRM2 and OBRM3. *Acidipropionibacterium microaerophilum*, *Pseudobdellovibrio exovorus*, *Deinococcus*_B murrayi, and *Sphaerobacter thermophilus* are common species in OBRM3 and OBRM4.

4.4.3. Alpha diversity indices in each specimen from four ecosystems

Alpha diversity indices (**Table 8**) were calculated using the R programme. Based on the table, OBRM3 has the highest values, indicating greater gut microbial diversity, whereas OBRM1 has the lowest values, indicating lower microbial diversity.

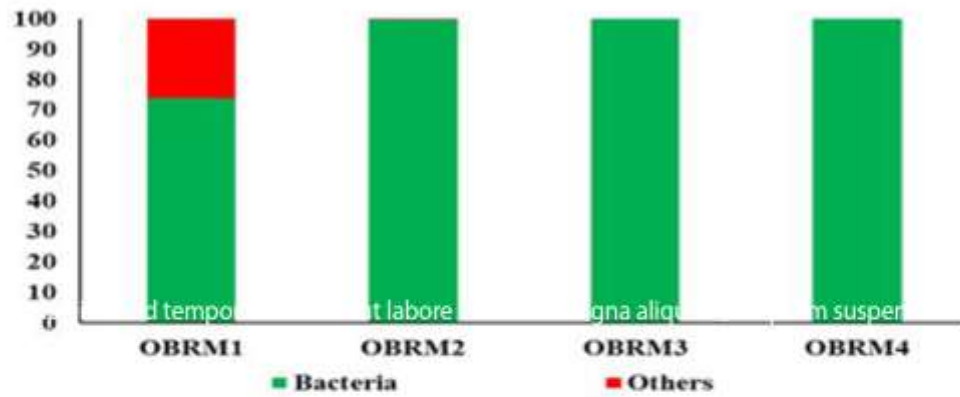


Figure 10: Abundance in Kingdom level

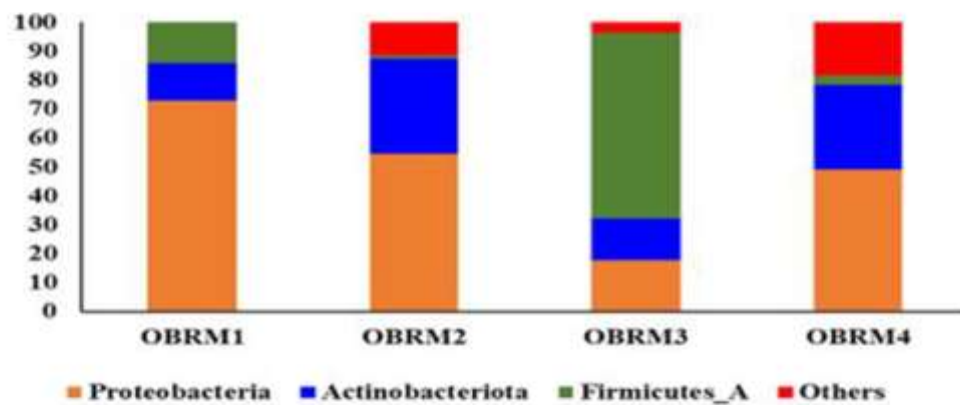


Figure 11: Abundance in Phylum level

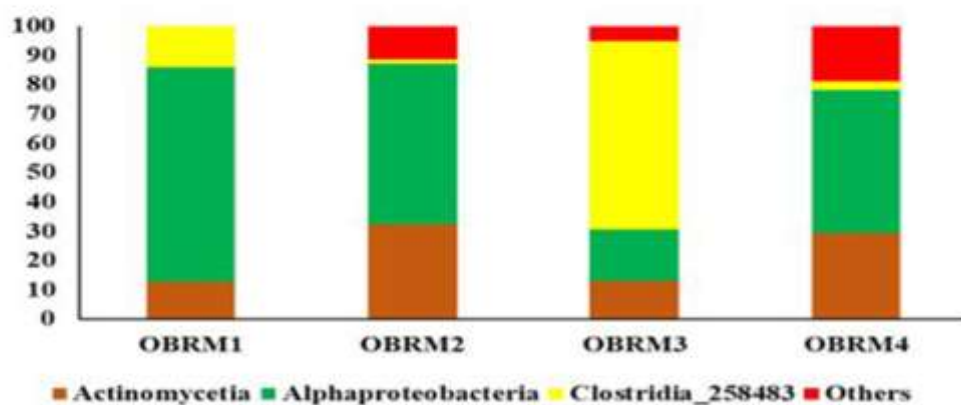


Figure 12: Abundance in Class level

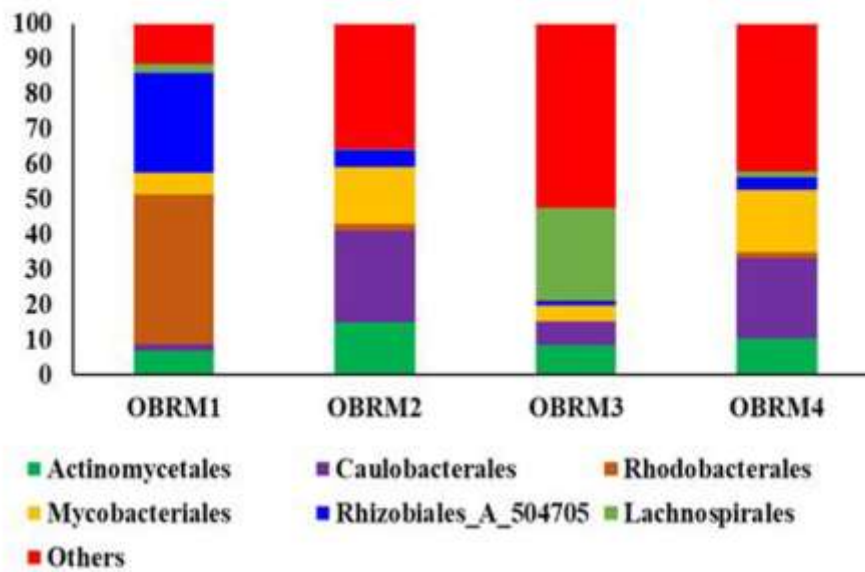


Figure 13: Abundance in Order level

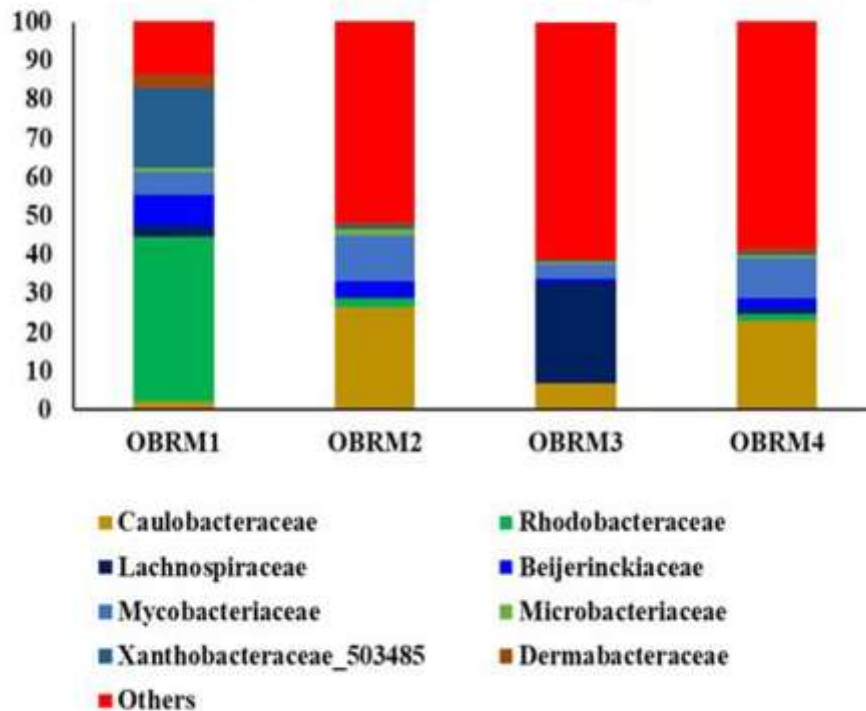


Figure 14: Abundance in Family level

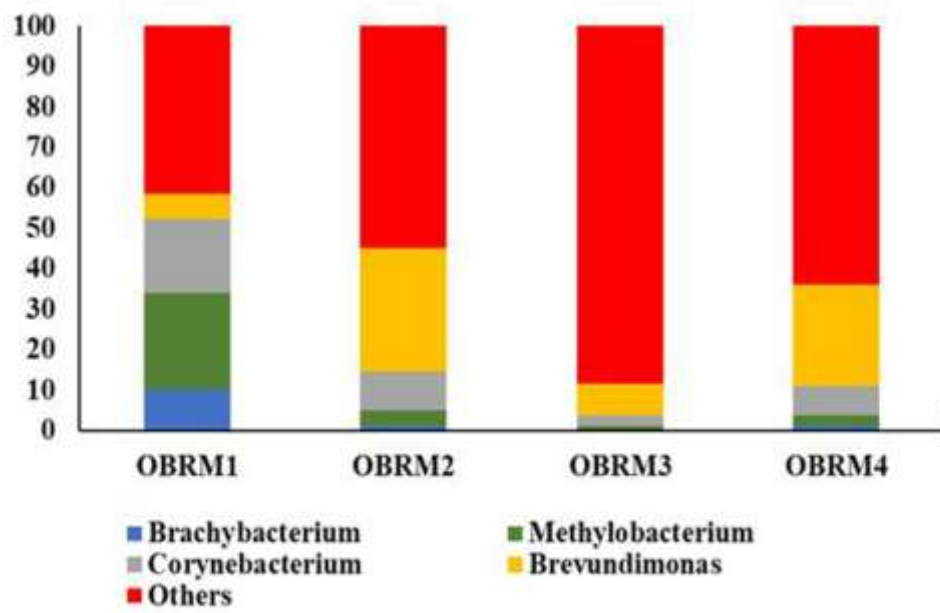


Figure 15: Abundance in Genus level

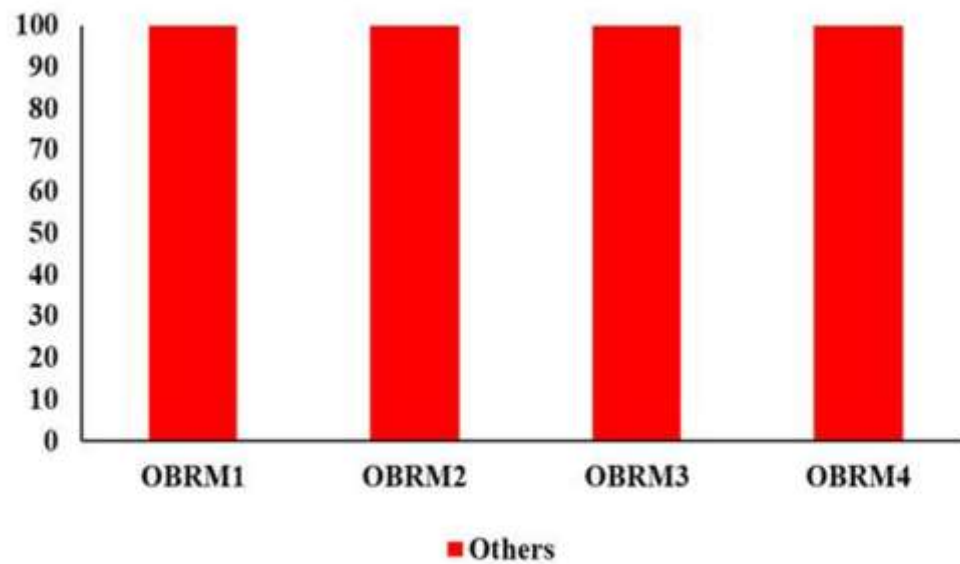


Figure 16: Abundance in Species level

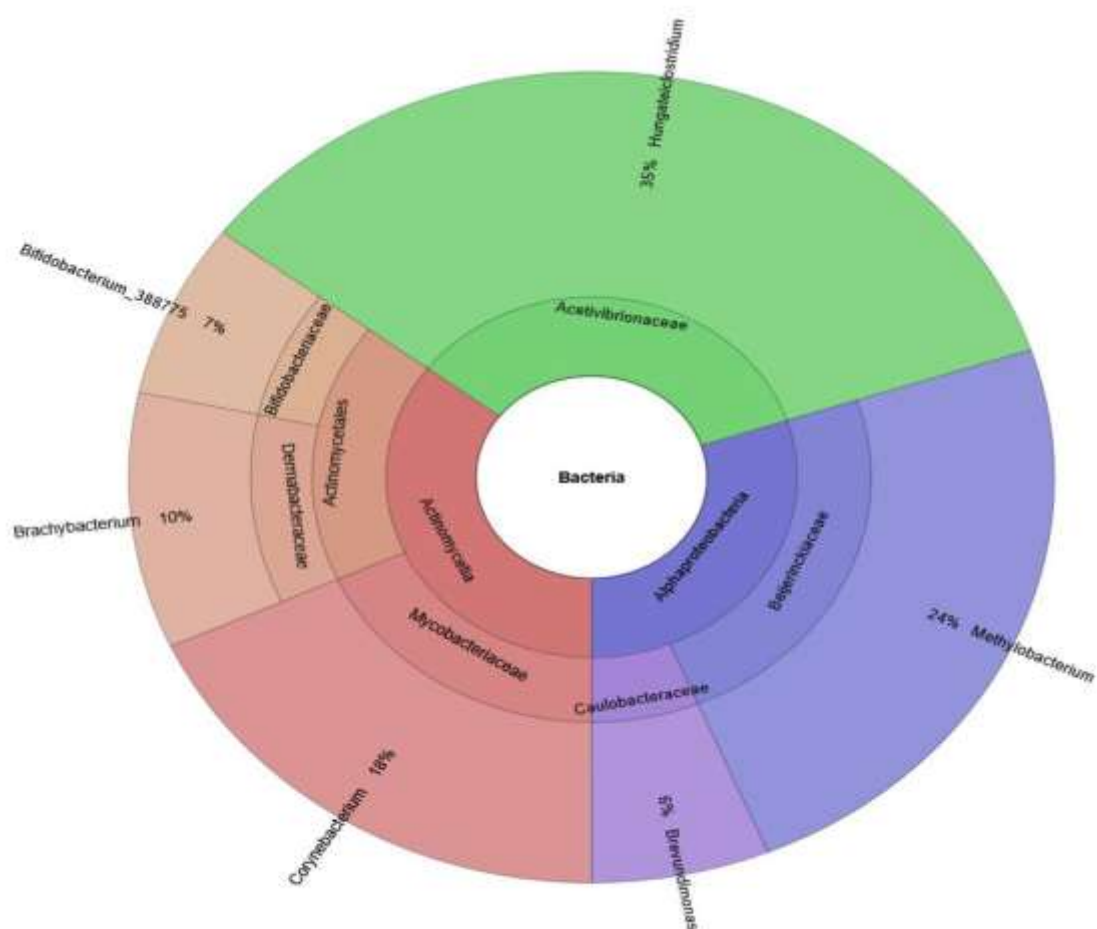


Figure 17: Krona plot of sample OBRM1

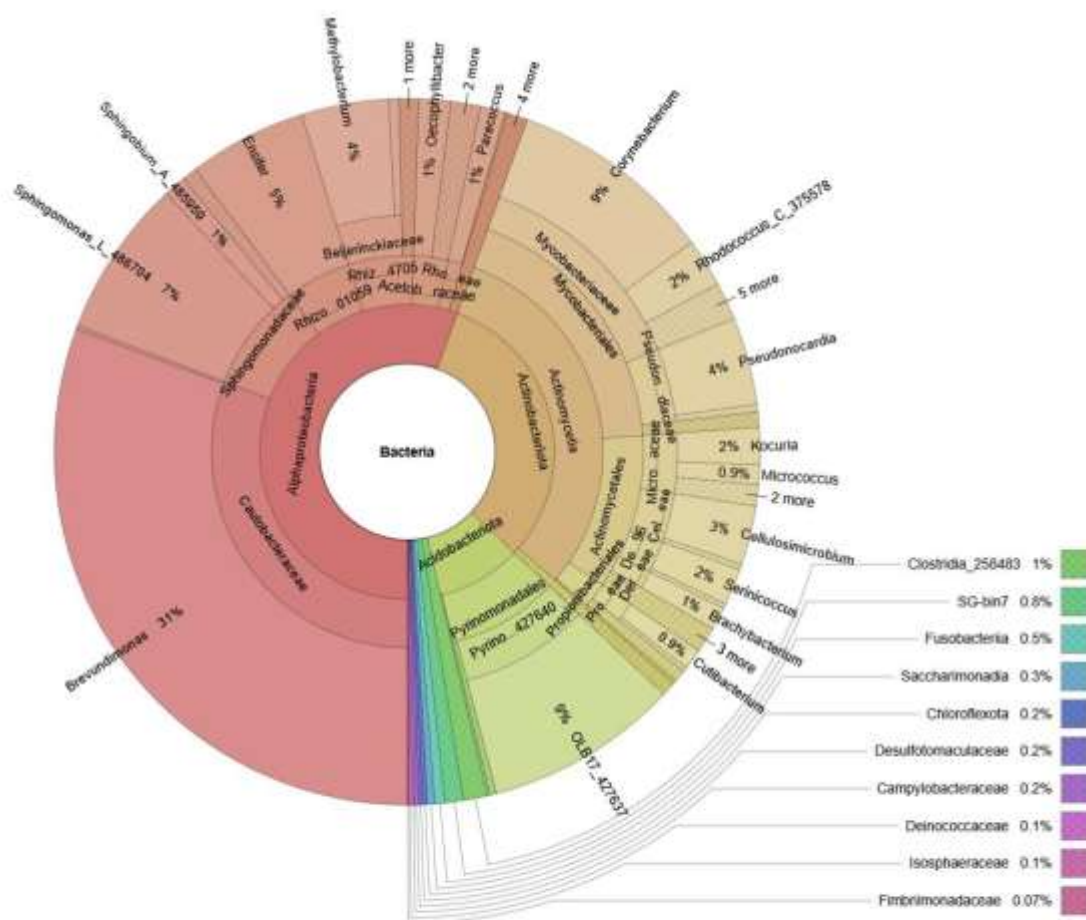


Figure 18: Krona plot of sample OBRM2

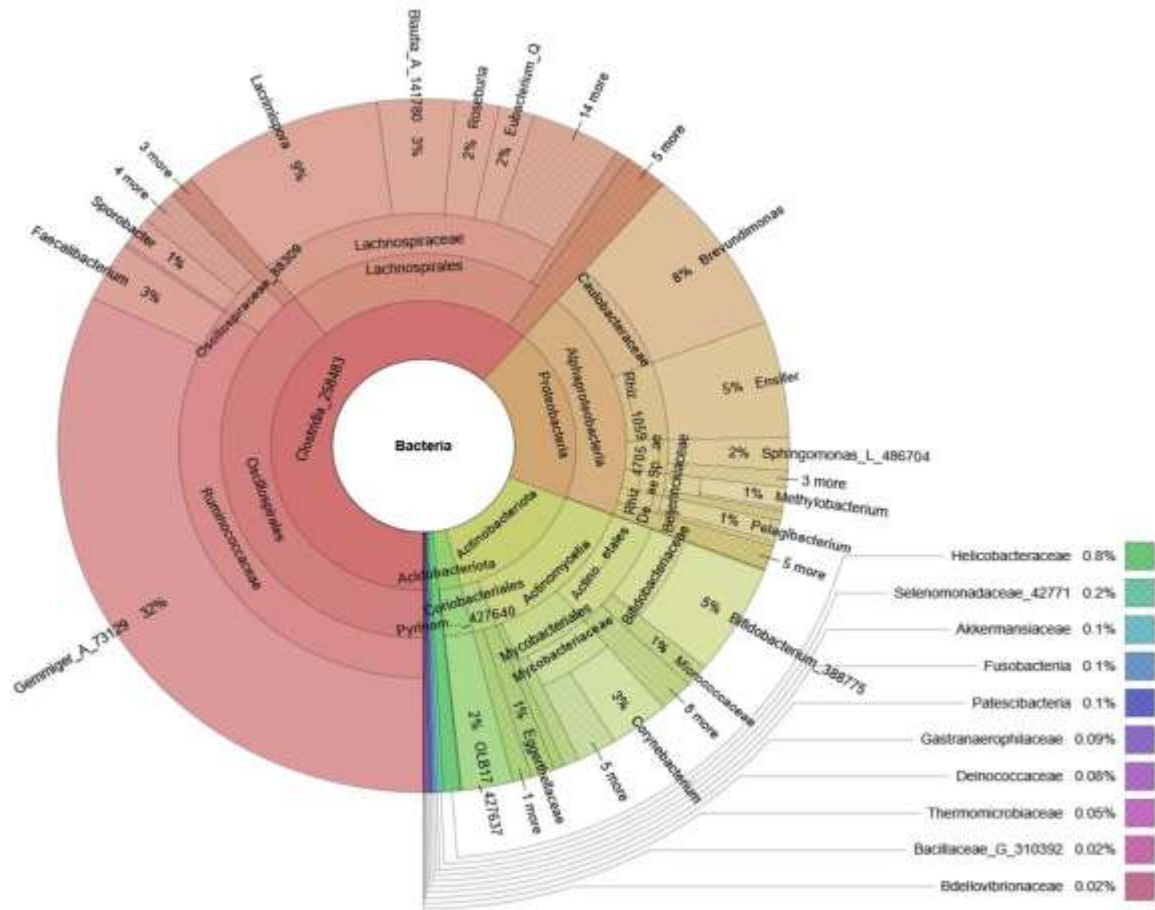


Figure 19: Krona plot of sample OBRM3

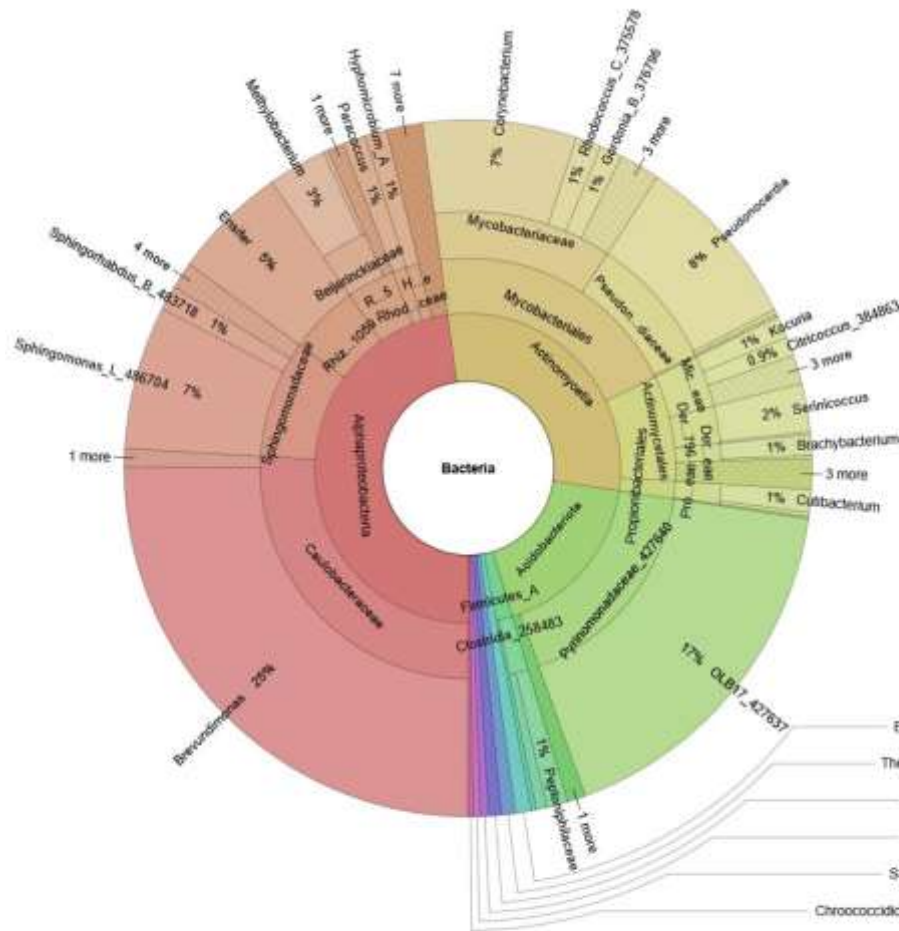


Figure 20: Krona plot of sample OBRM4

Sample	chao1	observed_features	shannon	simpson
OBRM1	28	28	4.17203	0.92672
OBRM2	230	230	6.03253	0.95282
OBRM3	323	323	6.71819	0.9728
OBRM4	160	160	5.5747	0.94716

Table 8: Alpha diversity indices in each sample



CHAPTER 5

DISCUSSION

Chapter 5: Discussion

5.1. Introduction

Oxyopids, or lynx spiders, are hunting arachnids that jump on prey like wild cats and consume them. They are known for their large, spiny legs and keen eyesight, and they rely on speed and stealth to capture prey. They do not spin webs. These spiders prey on smaller insects like moths, butterflies, grasshoppers, beetles, and bees, helping maintain balance in confined ecosystems by preventing overcrowding of pest insects. This predatory behaviour is valuable in agricultural settings. They also serve as prey for larger predators, contributing to the food web. Their roles as both prey and predator highlight their integral position in maintaining biodiversity and ecosystem stability.

Investigations of lynx spiders in India, especially in Kerala, remain relatively rudimentary compared with those of other arachnid species. Because Oxyopids act as natural pest controllers in agroecosystems, research on these groups has gained greater recognition in recent years. Studies on lynx spiders from India have mainly focused on taxonomy, behaviour, and ecology. Kerala's rich biodiversity, tropical climate, and diverse ecosystems provide distinct settings for studying lynx spiders. A few studies have examined the lynx's role as a biocontrol agent in agroecosystems. Research on lynx spiders in India, including Kerala, is still ongoing. This study focuses on four pioneering aspects of Oxyopids in Kerala.

5.2. Identification and taxonomic description of Lynx spiders of Kerala

Taxonomy is a branch of science that deals with the morphology of organisms. Accurate computation of species diversity is fundamental to conservation and the implementation of species (Lo et al., 2024). The family Oxyopidae comprises 9 genera, including *Hamadruas*, *Hamataliwa*, *Hostus*, *Oxyopes*, *Peucetia*, *Pseudohostus*, *Schaenicoscelis*, *Tapinillus*, and *Tapponia*. A total of 448 species among the above genera have been identified from different parts of the world (World Spider Catalogue, 2026). As per the checklist by Caleb & Sankaran (2026), members of only four genera, *Hamadruas*, *Hamataliwa*, *Peucetia*, and *Oxyopes*, were identified from India, which included 89 species collected from different states of India. An updated checklist by Singh (2021) noted that oxyopids were identified from all the states of India except Nagaland, Daman and Diu, Dadra and Nagar Haveli, and Ladakh. The highest number of Oxyopids was identified in Maharashtra (34). 27 species of Lynx spider have been recorded from Kerala which include *H. insulana* Thorell, 1891, *H. sikkimensis* Tikader, 1970, *Hamadruas* sp., *H. pentagona* Tang & Li, 2012, *O. armatipalpis* Strand, 1912, *Hamataliwa* sp., *O. ashae* Gajbe, 1999, *O. birmanicus* Thorell, 1887, *O. hindostanicus* Pocock, 1901, *O. javanus* Thorell, 1887, *O. kumarae* Biswas & Roy, 2005, *O. lineatipes* Koch, 1847, *O. pandae* Tikader, 1969, *O. quadridentatus* Thorell, 1895, *O. ratnae* Tikader, 1970, *O. rukminiae* Gajbe, 1999, *O. sakuntalae* Tikader, 1970, *O. salticus* Hentz, 1845, *O. saradae* Biswas & Roy, 2005, *O. shweta* Tikader, 1970, *O. sitae* Tikader, 1970, *O. sunandae* Tikader, 1970, *O. travancoricola* Strand, 1912, *O. wroughtoni* Pocock, 1901, *Oxyopes* sp., *P. ananthakrishnani* Murugesan et al., 2006, *P. rangathanani* Biswas & Roy, 2005, *P. viridana* Stoliczka, 1869, *Peucetia* sp.,

Tapponia sp. The present study deals with the taxonomic identification and description of Oxyopids from Kerala. Oxyopids were collected from 68 ecosystems in Kerala. 31 species of oxyopids from four different genera, *Oxyopes*, *Peucetia*, *Hamataliwa*, and *Hamadruas*, were identified. 76 new Oxyopid members were contributed by India (Caleb & Sankaran, 2025). Sixteen species were newly identified from Kerala during the study and named *O. thumboormuzhiensis* sp. nov. Amulya et al., 2022, *O. peetham* sp. nov. Amulya et al., 2022, *O. aquilae* sp. nov., *O. solea* sp. nov., *O. kasaragodensis* sp. nov., *O. ramulus* sp. nov., *O. auris* sp. nov., *O. hippocampus* sp. nov., *O. circum* sp. nov., *O. patera* sp. nov., *O. tigris* sp. nov., *H. triangulus* sp. nov., *H. quadrate* sp. nov., *H. sagitta* sp. nov. Amulya et al., 2024, *H. crista* sp. nov., *H. rhombiae* sp. nov.

H. pentagona Tang & Li, 2012, newly reported by Asalatha & Prasad (2020) from the Kareem Forest of Kasaragod. Tikader (1970), in his study of the fauna of Sikkim, first recorded *O. hindostanicus* Pocock, 1901 from India. Later in 2022, Caleb & Wijesinghe synonymised *Oxyopes nilgiricus*, *O. pankaji* and *O. ratnae* as *O. hindostanicus*. The presence of *O. hotingchiehi* Schenkel, 1963, in the reserve forests of the Dooars and Gorumara National Park was documented by Sen et al. (2015), 52 years after its discovery. *Oxyopes javanus* Thorell, 1887, was first reported from India in 1981 by Tikader & Biswas. It is one of the most widely distributed Lynx species in India, especially in Kerala. *Oxyopes lepidus* Blackwall, 1864 was first reported by Gajbe in 2008. Recently, Sankaran (2024) synonymised *O. decorosus* Zhang et al., 2005, with *O. longinquus* Thorell, 1891, and Sudhin & Sen (2023) recorded *O. mirabilis* Zhang, Yang & Zhu, 2005, from Shendurney Wildlife Sanctuary in the Kollam district of Kerala. *O. ryvesi* Pocock, 1901, *O. sertatus* Koch, 1878, and *O. wroughtoni* Pocock, 1901 are the remaining species recorded from India (Gajbe, 2008, & Palita et al., 2020). The present study recorded two new species of lynx spider from Kerala. *O.*

shakilae, a new species discovered in Punjab, Pakistan, by Mukhtar in 2013. This species has never been recorded anywhere in the world. After 12 years, this species was recorded from various ecosystems in Kerala, including the Munnar Government Botanical Garden, the Kothamangalam Forest Region, Kanthan Para, and Poomala Dam. Another lynx spider newly recorded from Kerala is *O. striagatus*, discovered by Song in 1991 in China. Later, this species was found in Taiwan (Song et al., 1997; Yin et al., 2003; Dong, 2018; Lo et al., 2021). 34 years later, this species was found again in the Chengara pineapple plantation in the Pathanamthitta district of Kerala. Later, this species was also identified in the Nilamboor Teak Museum Garden in the Malappuram district of Kerala.

Agroecosystems are considered the most favourable habitats for the Lynx spider (Young & Lockley, 1985). Kerala's geographic attributes make it a viable location for a variety of crops. The species composition of spiders in each ecosystem differs and is specific to the predation of certain pest groups within that ecosystem (Oberg et al., 2007). Also, the species composition of a particular ecosystem is related to changes in the vegetation structure in the habitat (Kajak, 1965). The recent study was not only confined to agroecosystems but also included other ecosystem types, such as gardens, hills, dams, ecotourism areas, and forests in Kerala. Do et al. (2024) explored the diversity and distribution of Lynx spiders across various natural and semi-natural habitats and found that Oxyopid spiders were more abundant in homogeneous ecosystems, whereas Oxyopid richness was higher in heterogeneous ecosystems similar trend was observed in the current study, where the number of specimens collected was higher in ecosystems with homogeneous vegetation, including agroecosystems, Chengara pineapple plantation, Pala rubber plantation in Kottayam, Irinjalakuda paddy field in Thrissur, Pullu paddy field in Thrissur, Aaralam farm in Kannur, cashew

plantation in Periyar Kasaragod, tobacco plantation in Kanhangad, cabbage garden in Nileswaram, and rubber plantation in Periyar. The number of species collected was higher in heterogeneous ecosystems like gardens and dam sites, including Neyyar Dam in Thiruvananthapuram, Thenmala Butterfly Park in Kollam, Munnar government botanical garden in Idukki, Hill Palace Kochi, Peechi dam garden in Thrissur, Poomala Dam of Thrissur, Thumboormuzhi Butterfly Park in Thrissur, Nilamboor Teak Museum in Malappuram, Calicut University garden, Mangalam Dam of Palakkad, Malampuzha Dam garden, Pazhassi Museum garden of Kozhikode, Neeliyar Kottam sacred grove of Kannur, and Pazhassi Dam of Kannur.

Lynx spider habitat selection is significantly influenced by habitat type, whether open or dense (Lo, 2024). Oxyopids are more abundant in open forests than in their dense counterparts. We can collect more specimens from open areas such as forest edges and dam sides, while lynx spiders are comparatively less frequent in the forests. Additionally, a similar trend was observed during our collection from the hillsides, where Oxyopid species richness and abundance are low at the Ponmudi Hills, Ranipuram Hills, and Ellikalkallu. Murphy & Romanuk (2014) conducted a global meta-analysis of the relationship between human disturbance and species richness, finding an 18.3% decline in species richness. Changes in land use and habitat loss are major drivers of declines in species richness and diversity. In this study, we began specimen collection in 2021 and concluded in 2023. The first two years coincided with a period of partial COVID-19 pandemic lockdown. During this time, most of our collection sites experienced little to no human interference, whereas in the third year, most collection sites were subjected to human disturbance. We observed that species richness and abundance were very high in the first year of collection, followed by a gradual decline in subsequent years. It is essential to understand why and how specific

taxa are being lost from ecosystems (Barnosky et al., 2012). This observation is completely based on the number of specimens and species collected from different ecosystems during the 3 years of collection, which is the first of its kind of extensive investigation on lynx spiders from Kerala, also signifying an elaborative investigation on the diversity of lynx spiders and how present environmental conditions impact the distribution of this species.

According to a study on the diversity and composition of spider assemblages across five vegetation types in India, Hore & Uniyal (2008) compared species composition among sites and found that species composition within the same vegetation type is more similar than that across different vegetation types. Oxyopids collected from the dam sides show this inclination. The Mangalam, Vazhani, and Poomala dams have similar vegetation, and most of the lynx collected across these dams are similar. Among the 68 collection sites, Nilamboor Teak Museum Garden, Malappuram and Hill Palace, Kochi, have the highest Lynx diversity. Both collection sites share common features, including a garden area with various flowering plants and adjacent forest vegetation.

Among the 31 species collected and identified from Kerala, 23 are from the genus *Oxyopes*, 5 from *Hamataliwa*, and 2 from *Hamadruas*. One representation from the genus *Peucetia*. Hence, based on the current investigation, the genus *Oxyopes* is widely distributed across Kerala and exhibits the highest species richness. The genera *Peucetia* and *Hamadruas* are narrowly distributed in Kerala. Compared to other spider families, Lynx spiders enjoy a wide distribution in Kerala's ecosystems.

5.3. DNA barcoding and phylogenetic analysis of lynx spiders in Kerala

Classical, or orthodox, taxonomy is a traditional approach that uses morphological and anatomical features to identify and describe organisms. This method is widely accepted, simple, easy to use, and inexpensive for classifying organisms. However, this method is prone to subjective errors (Martinez & Arguelles, 2020). This observation is particularly relevant to lynx spiders, which exhibit high levels of cryptic behaviour and sexual dimorphism and lack taxonomic keys for juveniles (Tyagi et al., 2019). Rodríguez et al. (2022) studied colour variations in the sit-and-wait predator *P. viridans*, found at the top of the inflorescence for prey capture. This species was collected from three different plant types, providing distinct original colour backgrounds. These three species possess a range of colours to facilitate hiding within their host for protection and prey capture. This phenomenon is also observed in another genus of the Oxyopidae family collected from Kerala during our study.

In 2001, Townsend and his colleagues conducted a comparative study of the genital morphology of eight species of Australian *Oxyopes* spiders- *O. amoenus*, *O. dingo*, *O. gracilipes*, *O. molarius*, *O. rubicundus*, and *O. variabilis*- in comparison with the same species from Asia, discovering that they share multiple genitalic characteristics, complicating the discernment of their evolutionary origin. We observed the features described above in the Oxyopid species of Kerala. The palpal cymbial structures of *O. hindostanicus* are like those of *O. solea* sp. nov. and *O. ramulus* sp. nov.; however, they differ in the tibial apophysis. The genital structure of *O. striagatus* resembles that of *O. macilientus*. These similarities may lead to the misidentification of the species. Spiders vary significantly in size and morphology based on sex, a

phenomenon known as sexual dimorphism. They also display differences in juvenile and adult morphological features (Raso et al., 2014). During our study, we faced the same challenge. For new species identification, males and females of the same species are confirmed only when collected together. In many instances, the morphology of juveniles and adults is entirely different; for example, juvenile *O. birmanicus* have an orange-coloured abdomen with black dots, whereas these dots completely vanish when they become adults. Molecular taxonomy using DNA barcodes is an optimal solution for the above impediments. Species identification using DNA barcoding is relatively new in Indian taxonomic research, especially in spider taxonomy. In this investigation, we combined classical and molecular approaches for species identification.

5.3.1. DNA barcoding of lynx spiders in Kerala

DNA barcoding plays a crucial role in species identification, regardless of a species' cryptic nature, sexual dimorphism, or developmental stages. Nevertheless, species identification in Oxyopids using DNA barcodes is still in its early stages compared to other spider families, such as Araneidae and Lycosidae (Gaikwad et al., 2017). According to WSC 448, species of Oxyopidae from nine different genera have been identified globally using classical taxonomic tools. Unfortunately, based on the sequence data available in NCBI GenBank and the Barcode of Life Data Systems (BOLD), only 64 Oxyopids have DNA barcoding data for the partial Cytochrome Oxidase 1 (CO1) marker (Table 3). A few DNA sequences from the H3 and 28S markers have also been deposited in GenBank. Therefore, we selected the partial CO1 marker for DNA barcoding and Lynx species identification. Thirty-one Oxyopids identified from Kerala have undergone DNA barcoding using the CO1 marker. After repeated trials, we obtained the consensus sequence of 19 species (Table 1). The CO1 marker is considered an effective tool for DNA barcoding, and in most cases, a universal primer

is used (Folmer et al., 1994). However, the success rate of obtaining a consensus sequence varies with primer design, sample quality, sequencing protocols, and taxonomic group (Thaenkham et al., 2022).

Wang and his colleagues evaluated the potency of mitochondrial COI for DNA barcoding of farmland spiders in China in 2018. This study involved 289 barcodes from 56 farmland spider species across 14 families and reported that the COI marker could distinguish nearly 98% of the species. For Gaikwad and his coworkers (2017), the success rate of species discrimination among 60 spider species from the Western Ghats using DNA barcoding is 99%. In 2018, Naseem and Tahir used the COI marker to distinguish Salticidae and Lycosidae species, and among the 160 species subjected to barcoding, they obtained 600 bp for 156 species. Here, the success rate is 98%. The success rate of obtaining a consensus sequence in DNA barcoding using the COI marker for the family Oxyopidae is poorly documented in the literature. The current investigation involves family-specific (Oxyopidae) DNA barcoding to distinguish species from Kerala. Such studies have never been conducted before in India and have a success rate of 61.29%.

5.3.2. Phylogenetic analysis of lynx spiders in Kerala with other counterparts across the tropics and subtropics.

Phylogenetic analysis reveals the evolutionary history and relationships among species (Fernandez, 2014). Lynx spiders possess a multitude of morphological and behavioural traits. The lynx experiences convergent evolution and morphological plasticity, making classical taxonomy for species identification a challenging task (Pan et al., 2019). Phylogenetic analysis using molecular data provides greater reliability in accurately classifying lynx spiders (Yang et al., 2019). This analysis uncovers the

evolutionary relationships among species, which further aids in forecasting reproductive strategies and habitat preferences in lynx spiders. Thus, phylogenetic analysis not only assists in taxonomic identification but also contributes to ecology, conservation, and applied biological research.

The computation of intergeneric distance using DNA sequences is sufficient to reveal evolutionary relationships and improve classification (Barrett & Hebert, 2005). It helps uncover cryptic diversity and refine taxonomic misidentifications. Intergeneric distance also aids in distinguishing how closely or distantly related these groups are based on their genetic sequences (Colgan, 2002). In 2021, Lo and his co-workers conducted a taxonomic revision of *Oxyopes* from Taiwan. Based on interspecific distance, they identified the closely related species within the Oxyopidae family. The interspecific genetic divergence between *O. sertatus* and *O. taiwanensis* was relatively low ($1.28 \pm 0.43\%$). This low value indicates that these two species are closely related. The interspecific genetic divergence between *O. fujianicus* and *O. sushilae* was relatively high (7.08 ± 1.13), indicating that they are distantly related. Lo et al., in 2024, identified eight morphological species: *H. cordivulva* sp. nov., *H. leporauris* sp. nov., *T. auriola* sp. nov., *T. parva* sp. nov., *T. rarobulbus* sp. nov., *H. hieroglyphica*, *H. foveata* and *P. latikae*. They assessed the genetic distance between these species and noted that the mean interspecific distance ranged between 0.05% to 4.77%, and interspecific distances ranged between 1.88% to 18.33%, with an exception in the case of *H. cordivulva* sp. nov. and *H. foveata*, in which the interspecific distance is 1.88% and mean interspecific distance is above 5.77%. In the current study, we used the Kimura Two-Parameter model to find the intergeneric distance between the Oxyopid genera collected from Kerala (Table 2) to understand how closely and distantly they related to each other. The intergeneric distance within genus, *Oxyopes* –

Oxyopes (0.0832) and *Hamataliwa* – *Hamataliwa* (0.06527). These are baseline distances within a single genus showing how much individuals within the same genus differ genetically. These values are relatively low. Resulting close relation within the genus. Regarding between-genus distances, *Oxyopes* – *Hamataliwa* (0.13767), they were moderately close genera. When we consider the intergeneric distance of *Oxyopes* with *Hamadruas* (0.13024) and *Peucetia* (0.19864), *Hamadruas* is slightly closer to *Oxyopes* than *Hamataliwa*, and *Peucetia* is the most distant genus for *Oxyopes*. The *Hamataliwa* and *Hamadruas* (0.12457) have a close relationship. *Peucetia* is the genus which is distant from *Hamataliwa* (0.17328) and *Hamadruas* (0.17493). In a nutshell, *Hamataliwa* and *Hamadruas* are the most closely related genera among the different genera, hence, they can be called sister genera. *Oxyopes* is more closely related to *Hamadruas* and *Hamataliwa* than to *Peucetia*. *Peucetia* appears to be the most genetically distinct genus in this group because it has the highest average distances from others. Intra-genus variation is lower than inter-genus variation, which supports the validity of these genera as distinct taxonomic groups. Among the 31 lynx species identified, only ninety species could be sequenced, which is inadequate to explain the species-to-species genetic distance because of the missing sequences of closely related species.

According to Shapiro et al. (2006), accurately estimating the best nucleotide substitution model is essential for deciphering evolutionary relationships during phylogenetic analyses. The appropriate model interprets differences in mutation rates and base frequencies, thereby enhancing the reliability of tree topology and branch lengths; utilising an inaccurate model results in biased evolutionary inferences. We employed the jModel test to determine the optimal nucleotide substitution model. Based on our DNA sequence data, GTR+I+G (GTR Invariant Gamma) is the best nucleotide

substitution model, indicated by its low AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) values. This highly flexible and complex model is a common choice for large and variable datasets.

Phylogenetic trees reveal the evolutionary status of a species (Zou, 2024). Different phylogenetic methods—Neighbour Joining (distance-based), Maximum Parsimony (minimum changes), Maximum Likelihood (maximum probability of the data), and Bayesian Inference (maximum posterior probability)—are commonly used to construct phylogenetic trees. Each of these methods yields different phylogenetic trees owing to fundamental differences in algorithmic design, statistical modelling, and assumptions about evolution (Gevers & Coenye, 2007). Lo and his colleagues (2021) applied maximum likelihood and Bayesian phylogenies to elucidate the evolutionary relationships among seven *Oxyopes* spiders: *O. hasta* sp. nov., *O. taiwanensis* sp. nov., *O. fujianicus*, *O. striagatus*, *O. macilentus*, *O. sushilae*, and *O. sertatus*. They found a close relationship between *O. sertatus* and *O. taiwanensis*. In 2024, Lo et al. constructed a maximum likelihood tree to decipher the evolutionary status of eight Oxyopids from the genera *Hamataliwa*, *Hamadruas*, *Tapponia*, and *Peucetia*, including *H. cordivulva*, *H. leporauris*, *T. auriola*, *T. parva*, *T. rarobulbus*, *H. hieroglyphica*, *H. foveata*, and *P. latikae* identified from Taiwan. They pinpointed that all eight morphological species show reciprocally monophyletic lineages. *H. cordivulva* and *H. foveata* exhibit slight genetic differentiation in the COI but have highly distinguishable genital structures. In 2019, Jalajakshi and Usha performed phylogenetic analysis using COI in the dominant female spiders *Argiope aemula*, *Nesticodes rufipes*, *Oxyopes lineatype*, *Leucauge decorata*, *Nephila kuchli*, and *Nephila philipis*. They built a maximum-likelihood tree in which *Oxyopes lineatype* appears as the outgroup. An investigation involves the superfamily Lycosoidea, a superfamily to which Oxyopidae

belongs. A phylogenetic analysis of 61 terminal taxa within the RTA clade (retrolateral tibial apophysis in male palpal tibia) was conducted by constructing maximum-likelihood and Bayesian inference trees, in which *Oxyopes* and *P. rubrolineata* formed a sister group (Polotow et al., 2015). A large-scale phylogenetic analysis of a dataset comprising 932 spider species from 115 families and 700 known genera was performed by Wheeler et al. (2017), who grouped Oxyopidae within the Oval Calamistrum clade, along with Zoropsidae, Udubidae, Ctenidae, Senoculidae, Pisauridae, Trechaleidae, Lycosidae, Psecridae, and Thomisidae. Phylogenetic analysis of spiders from the Asian continent is not well-established. Afzal et al. (2020) conducted a phylogenetic analysis of spiders from wheat agroecosystems using maximum-likelihood inference, revealing a monophyletic origin of Oxyopid members. Mehmood et al. (2021) performed a neighbour-joining phylogenetic analysis of spiders from rice agroecosystems of Punjab, Pakistan, using the mitochondrial COI marker. They analysed 90 specimens, including *O. tiengianensis*, *O. aspirasi*, *O. javanus*, *O. oryzae*, and *O. hindostanicus*, and confirmed their monophyletic origin. Most of the previous literature on phylogenetic analysis used one or, rarely, two methods to elucidate evolutionary status among spiders, especially in Oxyopids. Using multiple phylogenetic tree methods is pivotal in phylogenetic inference, as it improves the reliability and robustness of evolutionary inferences and helps identify consistent patterns. Provides a more comprehensive understanding of evolutionary status among the species. The application of multiple methods is considered the best approach in phylogenetics to eliminate overreliance on a single analytical framework and potential biases from any one approach. In the present study, we used four phylogenetic methods to accurately assess the evolutionary status of oxyopids from Kerala and their counterparts across the tropics and subtropics.

The Maximum Likelihood tree (ML tree) (Fig. 1) uses nucleotide substitution models to identify the tree with the highest likelihood of producing the observed data. It evaluates all possible tree topologies and selects the best one (Felsenstein, 1981). The ML tree constructed from the lynx spider sequence data has a clear base and is rooted. *Parabatinga brevipes*, the outgroup, is the basal taxon, representing the earliest diverging lineage in this group. Bootstrap values exceeding 100% at each node indicate strong support. Species in the genus *Oxyopes* are distributed across multiple clades, suggesting paraphyly and possibly polyphyly. The internal branches of *Oxyopes* have high bootstrap values, providing strong confidence in the division of *Oxyopes* members into different clades. All *Oxyopes* species, except *O. jacksoni*, *O. sushilae*, *O. sertatus*, *O. circum*, *O. pandae*, *O. kohaensis*, *O. thumboormuzhiensis*, *O. birmanicus*, *O. sunandae*, *O. javanus*, and *O. lineatipes*, form a monophyletic subgroup. The scattered distribution of *Oxyopes* suggests that either the genus is oversplit or its current definition is too broad or outdated, warranting revision based on molecular data. Hence, the genus needs re-evaluation. The genus *Peucetia* appears in separate clades. All remaining *Peucetia* species, excluding *P. rubrolineata*, *P. latikae*, and *P. viridana*, cluster as a monophyletic subgroup, indicating a consistent evolutionary lineage. This clade is positioned close to *H. flebilis* and is separated from *Oxyopes*. Some members of *Peucetia* are close to *Oxyopes* and *Tapponia*, making paraphyly possible. The *Peucetia* clade exhibits strong statistical support, as indicated by its high bootstrap values. The result calls for revising this taxon by comparing the morphological and molecular data. The genus *Hamataliwa* is polyphyletic in the tree. Some species are closer to *Peucetia*, while others are more closely related to *Oxyopes* and *Tapponia*. The branches have high confidence because of strong bootstrap values. In this tree, the genus *Hamataliwa* may be taxonomically erroneous in its current composition,

suggesting that some species may need reassignment. *T. parva* and *T. rarobulbus* are branches very close to the genus *Hamataliwa*, indicating a shared ancestral lineage. *H. hieroglyphica* forms a sgroup with *O. birmanicus* and *O. solea* by sharing common ancestor. *H. triangulus* and *O. rhombiae*, *O. auris* and *O. aquilae*, *O. solea* and *O. birmanicus* are the sister groups of the new species.

Neighbour Joining (NJ) tree (Fig. 2) is considered the fastest method for phylogenetic tree construction. According to the neighbor joining tree constructed using DNA barcodes of the mitochondrial CO1 marker, we could confirm that all five genera of Oxyopidae, *Oxyopes*, *Hamataliwa*, *Hamadruas*, *Peucetia* and *Tapponia* share a common ancestor. *Parabatinga brevipes* Polotow & Brescovit, 2014 (family Ctenidae) appears as the outgroup, with a large genetic distance of 12.547%, the longest among the distances. The genus *Oxyopes*, *Hamataliwa*, *Tapponia*, and *Hamadruas* are more closely related, sharing a common ancestor, whereas the genus *Peucetia* is distantly related, with other forms forming a separate branch. As per the above tree, the genus *Oxyopes* forms a monophyletic clade. The *Hamataliwa* and *Tapponia* intermingled and were arranged in branches from the same nodes as a sister group. Here, *Hamataliwa* forms a paraphyletic clade. *Hamataliwa* and *Oxyopes* did not share an immediate common ancestor, so they form a polyphyletic clade. *Peucetia* forms a monophyletic clade with an ancestor exclusive to their lineage. This clade branched from the base of the tree, indicating that the genus *Peucetia* diverged earlier from the common ancestor shared with *Oxyopes* and *Hamataliwa*. Its long branch length and high bootstrap values in this clade confirm its evolutionary distinction from these closely related genera. *Peucetia* members are unique in their hunting behaviour and venom composition, which may distinguish them from other genera (Luddecke et al., 2022). The genus *Hamadruas* forms a monophyletic clade with a common ancestor

exclusively for their lineage and recently diverged from their common ancestor shared with other genera. *Tapponia* branched near *Hamataliwa*, indicating their close evolutionary relationship. *Tapponia* undergo speciation from *Hamataliwa* while maintaining some genetic similarities. The genetic distance and bootstrap values of the clades *Hamataliwa* and *Tapponia* strongly support their distinct but close relationship. The new species from Kerala, *O. peetham*, *O. auris*, and *O. thumboormuzhiensis*, do not form any sister clade with an immediate common ancestor. Other groups of new species, including *O. solea* and *O. sushilae*, *O. aquilae* and *O. birmanicus*, *O. circum* and *O. ramulus*, *O. triangulus* and *T. rarobulbus*, and *H. crista* and *H. rhombiae*, are sister groups.

The Bayesian Inference Tree (Figure 3) was constructed using a probability distribution that incorporates prior knowledge (Wagenmakers et al., 2018). The Phylogenetic tree built using Bayesian inference in the present study gives the following implications. This tree confirms a well-rooted phylogeny, rooted with *Parabatinga brevipes* as the outgroup. Also, it has good resolution with a posterior probability of 1.0 for nearly all clades. The *Oxyopes* is a species-rich genus of trees. But they are not forming a single monophyletic clade as we observed in the NJ and MP trees. The members of *Oxyopes* are scattered among other clades like *Peucetia*, *Hamataliwa* and *Tapponia*. There is no single clade that exclusively contains all *Oxyopes* species, but localised monophyletic subgroups exist. This positioning indicates the paraphyletic origin of members of this genus. The genus *Peucetia* is also paraphyletic, with one monophyletic subgroup. The monophyletic subgroup includes *P. viridis*, *P. striata*, *P. nicolae*, *P. viridans* and *P. rangathanani*. The remaining *Peucetia* members, *P. rubrolineata*, form a separate lineage without any sister group. *P. latikae* is close to *O. birmanicus*, and *P. viridana* is near *O. heterophthalmus*. The

genus *Hamataliwa* is polyphyletic, lacking any monophyletic subgroups; its members are arranged in multiple positions near *Oxyopes* and *Peucetia*. The genus *Tapponia* is the only taxon that shows paraphyly. The genus *Hamadruas* forms a sister group with *O. birmanicus*; this positioning is highly inconvenient. *O. aquilae* and *O. auris* form sister clades. The above tree indicates that morphological taxonomy doesn't align with molecular phylogeny, so there is a need for taxonomic revision among these genera.

The Maximum Parsimony tree (MP tree) (Figure 4) is the simplest method for deciphering the evolutionary pathway. It considers the minimum number of changes necessary to explain the interconnections among species. The maximum parsimonious tree is susceptible to long-branch attraction and does not account for variations in mutation rates (Yang et al., 2017). According to the constructed MP tree, the genera *Oxyopes* and *Peucetia* form monophyletic clades with a common ancestor, and all species are grouped. The genus *Hamataliwa* and *Tapponia* form a paraphyletic clade. *H. foveata* and *H. cordivulva*, *H. crista* and *H. rhombiae*, and *H. crocata* and *H. fleblis* cluster as sister groups. This paraphyly indicates adaptive radiation among the species, where species evolve specific traits that create separations in the tree. Sometimes it may result from incomplete lineage sorting, in which descendants are excluded by classification methods. The genus *Hamadruas* forms a separate lineage while sharing with a common ancestor with other genera, suggesting they diverged earlier. The new species collected, *O. solea* and *O. sushilae*, *O. circum* and *O. thumboormuzhiensis*, have immediate common ancestors and are hence called sister groups. The remaining species, *O. thumboormuzhiensis*, *O. peetham*, *O. aquilae*, and *O. auris*, do not share an immediate common ancestor; hence, they do not have sister groups. The maximum parsimony tree is similar to the neighbour-joining tree, with some differences in sister-group positioning.

In the present study, we employed four distinct methods for constructing phylogenetic trees, each utilising different algorithms for the analysis; thus, the likelihood of obtaining a similar tree is low. The Neighbour-joining tree and the Maximum parsimony tree indicate the monophyletic origin of the genera *Oxyopes*, *Peucetia*, *Hamataliwa*, and *Tapponia*. In contrast, Bayesian inference and maximum-likelihood trees show deviations from this trend. Here, the Oxyopid genera appear more paraphyletic than monophyletic, with species from different genera forming sister groups. This inference suggests a detailed molecular taxonomic analysis using DNA barcoding, as among the 448 identified species of Oxyopids globally, only 64 species have barcoded data according to NCBI Genbank and BOLD systems v5. This limited barcoding may explain the deviations in the taxonomic positioning of the species in the phylogenetic tree. The small subset of barcoded species can significantly restrict the accuracy and reliability of the phylogenetic tree. Low barcode coverage impacts species positioning and the overall tree, providing only a partial view of evolutionary relationships and potentially misrepresenting clade structures. Species represented in the barcoded data might show close relations if data for their closely related species is absent, leading to distorted clustering. In the current study, we included barcodes for 19 species, including 10 new additions, which also altered the existing tree topology. Consequently, further analyses, such as divergence time estimation, trait evolution, or biogeographic patterns, will be incomplete or inaccurate due to the lack of barcode data.

5.4. Study the host plant preference in Lynx spiders of Kerala.

Lynx spiders are non-web-making hunters (Mishra et al., 2021) that use host plants as hunting grounds to capture prey. The host plant and the Lynx form a mutualistic relationship in which the spider obtains its prey, and the plant receives protection from its pest (Jacobucci et al., 2009). This host-plant association is central

to understanding lynx spiders, as it is as important as taxonomic identification for their economic applications (Hanna & Hanna, 2013). In general, members of the Lynx spiders prefer host plants with compound leaves and glandular trichomes (Neto et al., 2017; De-Sousa et al., 2019). In 2014, Krimmel studied how plants with glandular trichomes influence the predatory efficiency of hunting spiders. He reviewed 47 studies and concluded that spiders like Lynx spiders, which have high biocontrol potential, effectively forage in trichome-bearing plants and prefer host plants with high glandular trichome densities. According to Romero et al. (2008) & Krimmel & Pearse (2013), host plants with glandular trichomes provide greater protection to specialists than to generalist predators. A Neotropical glandular shrub, *Trichogoniopsis adenantha*, is protected from leaf-mining and chewing herbivores by closely associated Oxyopids, *Peucetia flava* and *P. rubrolineata* (Romero et al., 2008). Neto et al. (2017) also examined the close association between the two *Peucetia* members in 55 trichome-bearing plants from Neotropical, Nearctic, Afrotropical, and Palearctic regions. Brazilian plants, *Mimosa setosa* var. *paludosa*, *Rhynchanthera dichotoma*, *Solanum thomasiifolium* and *Chamaecrista neesiana* host *P. flava* to provide protection from herbivores and exhibit facultative mutualism (De Sousa et al., 2019; Morais & Romero, 2008; Jacobucci et al., 2009; Lacerda, 2018). *P. viridans* inhabited *Croton ciliatoglandulifer* Ortega, *Lantana camara* Linnaeus, *Solanum mitlense* Dunal, and *Wigandia urens* (Ruiz and Pav.) Kunth (Guzman & García, 2024; Jimenez & Corcuera, 2008). *P. maculifera*, *P. nicolae*, *P. viridis*, *P. transvaalica* and *P. striata* are closely associated with trichome-bearing host plants like *Melolobium candicans* because they specialise in preying on the pest that sticks to the glandular trichomes (Dippenaar et al., 2023). *P. phantasma* exclusively inhabits *Sterculia urens* (Ahmed et al., 2015). *O. javanus* is closely associated with tea plants and tuber plants (Basnet & Mukhopadhyay,

2014; Sari et al., 2019; Jayaprakas, 2014). *O. scalaris* is common in pear and apple orchards (Miliczky & Horton, 2005). The cotton plant hosts *O. salticus* (Lockley & Young, 1986), and the maize and ginger plants host *O. birmanicus* (Firake & Behere, 2020). *O. shweta* inhabits green gram (Choragudi, 2015).

5.4. 1. Lynx spider richness and abundance in the host plants

In the present investigation, we focus on the host plant associations of Oxyopids in Kerala, representing a novel approach from India. After reviewing the previous literature, it is evident that host plant associations of Lynx spiders are limited, with most studies focusing on the Oxyopid genus *Peucetia*. Research on the genus *Oxyopes* is scarce, and the remaining genera have been entirely overlooked. In line with our first objective, we identified 31 Oxyopidae species across Kerala. Among these 31 species, the representation of the genus *Oxyopes* is 23, *Hamataliwa* is five, *Hamadruas* is two, and *Peucetia* is one, indicating that *Oxyopes* is the most abundant genus in Kerala's ecosystems. The biocontrol potential of *Oxyopes* has already been recognised in various parts of the world. In 2014, Basnet and Mukhopadhyay discovered the bioprotection potential of *O. javanus* against the tea mosquito bug, *Helopeltis theivora*. Shivakumar & Kumar (2010) identified *O. shweta* as an effective biocontrol agent against the polyphagous insect pest *Spodoptera litura*. *O. salticus* is effective against the tarnished plant bug, *Lygus lineolaris* (Young & Lockley, 1986), and also against cotton pests (Lockley & Young, 1986). Choragudi and his co-workers identified *O. javanus*, *O. shweta*, and *P. viridana* as natural enemies of *Maruca vitrata* in Blackgram and Green gram. *O. hindostanicus* is an effective natural control agent for aphids (Kale et al., 2020). These previous studies suggest that Oxyopids are more widely distributed in Kerala, an agriculturally oriented state. Unfortunately, these kinds of species-specific

studies have never been done before in Kerala. Identification of host plants of Lynx spiders is the pioneering step for such studies.

In the present study, we identified 88 host plants of Oxyopids from different parts of Kerala (**Table 4**) and counted the number of species and specimens collected from each host plant. Eighty-four plants identified are hosted by *Oxyopes*. Eighteen species and 110 specimens were collected from the host plant *Chromolaena odorata* (Asteraceae), making it the most species-rich and abundant host. This plant is common in most Kerala ecosystems and supports the genus *Oxyopes*. Only one species, *O. birmanicus*, was collected from *Boerhavia diffusa* (Nyctaginaceae), indicating its lower species richness. The mangrove species *Avicennia marina* (Acanthaceae) has low species abundance, with only 5 specimens of *O. aquilae*, *H. rhombiae*, and *O. hindostanicus* collected from this plant. The new species, *O. patera*, was collected solely from *Eugenia mooniana*, which is not very abundant in Kerala's ecosystems. For the new species, *O. hippocampus* and *O. solea*, fewer host plants were identified. Host plants of *O. hippocampus* include *Tagetes erecta* (Asteraceae), *Lantana trifolia* (Verbenaceae), *Croton hirtus* (Euphorbiaceae), *Chloris barbata* (Poaceae), and *Bougainvillea spectabilis* Shubra (Nyctaginaceae), while the host plants of *O. solea* comprise *Euryops pectinatus* (Asteraceae), *Hyptis suaveolens* (Lamiaceae), *Mucuna bracteata* (Fabaceae), *Nerium oleander* (Apocynaceae), and *Strobilanthus lanatus* (Acanthaceae). Two species of *Oxyopes* were reported for the first time from India during our study. The first one is *O. striagatus*, and five host plants of this species have been identified. The second one is *O. shakilae*, and 23 host plants of this species have also been identified.

Capsicum annum, *Chamaecrista absus*, *Cissus vitigenea*, *Nicotiana tabacum*, *Ruellia elegans*, and *Tradescantia zebrina* are the plants that host the genus

Hamataliwa. Among these plants, *Capsicum annum* (Solanaceae) and *Nicotiana tabacum* (Solanaceae) host only the *Hamataliwa* species. Presence of *H. crista* observed in *Capsicum annum*, *Nicotiana tabacum*, and *Ruellia elegans* (Acanthaceae), whereas *H. quardata* is collected from *Ruellia elegans* and *Cissus vitigena*. *Capsicum annum* and *Nicotiana tabacum* are the host plants of *H. rhombiae*. *H. sagitta* inhabits *Tradescantia zebrina* (Melastomataceae) and *Chamaecrista absus* (Fabaceae). *H. triangulus* was collected exclusively from *Nicotiana tabacum*.

During our study, we identified only one species of the genus *Peucetia*, *P. latikae*, and we documented 12 host plants for this species, including *Cissus vitigena* (Vitaceae), *Croton hirtus* (Euphorbiaceae), *Datura ferox* (Solanaceae), *Eugenia mooniana* (Myrtaceae), *Hyptis suaveolens* (Lamiaceae), *Leucaena leucocephala* (Fabaceae), *Microcos paniculata* (Malvaceae), *Mucuna bracteata* (Fabaceae), *Ocimum gratissimum* (Lamiaceae), *Passiflora vesicaria* (Passifloraceae), *Sida cordifolia* (Malvaceae), and *Urena lobata* (Malvaceae). *Hyptis suaveolens* has the highest abundance of *P. latikae* among these host plants. This plant is common in cashew plantations and along dam sides.

Two *Hamadruas*, *H. hieroglyphica* and *H. sikkimensis*, were collected in Kerala, where their host plants were identified. There is no previous literature regarding the biocontrol potential and host plant associations of *Hamadruas*, but their contribution to pest control is undeniable. In the current investigation, nine host plants of this genus were identified. *H. hieroglyphica* shows a close association with *Brachiaria mutica* (Poaceae), *Camonea umbellata* (Convolvulaceae), *Chamaecrista absus* (Fabaceae), *Jasminum sambac* (Oleaceae), and *Ruellia elegans* (Acanthaceae). Meanwhile, *H. sikkimensis* is associated with *Cosmos sulphureus* (Asteraceae), *Lantana camara*

(Verbenaceae), *Melastoma candidum* (Melastomataceae), and *Ocimum gratissimum* (Lamiaceae). The above host plants also host members of *Oxyopes*.

Most host plants are occupied by *Oxyopes* species, including *O. shweta*, *O. hindostanicus*, and *O. birmanicus*. In 2017, Kim explained how a host plant neighbourhood's vegetation influences the distribution of spiders and proved that the density of surrounding vegetation positively influences species distribution. We also observed a similar pattern: species abundance is higher in host plants surrounded by vegetation than in isolated ones, because the surrounding vegetation provides a suitable hiding place for spiders.

Lynx spiders select plants based on structural features that provide good hunting perches and concealment. They prefer vegetation that attracts abundant insect prey, especially flowering plants rich in pollinators. Microclimatic conditions, such as sunlight and humidity, can enhance the activity and survival of certain plants. Textured leaves and dense foliage offer camouflage and protection from predators. Altogether, these plant preferences support their ecological role as natural pest controllers and maintain ecosystem balance.

5.4.2. Lynx spider richness and abundance in the host plant families

As mentioned in existing research, the lynx spiders are usually associated with several plant families, including Fabaceae, Euphorbiaceae, Verbenaceae, Solanaceae, Asteraceae, Melastomataceae, Malvaceae, Apocynaceae, Myrtaceae, and Poaceae (Nyffeler & Benz, 1987; Nyffeler et al., 1992; Romero, 2008; Corcuera et al., 2010; Neto et al., 2017; Sousa et al., 2019; Vásquez & García, 2024). Most of the lynx's host plants belong to the Asteraceae family. During the study, 88 host plants (**Plates 42 to 50**) were identified, belonging to 31 plant families, which include all the

aforementioned families. In addition, the remaining plant families identified are Acanthaceae, Amaranthaceae, Araucariaceae, Aristolochiaceae, Balsaminaceae, Brassicaceae, Cannabaceae, Convolvulaceae, Lamiaceae, Moringaceae, Muntingiaceae, Nyctaginaceae, Oleaceae, Passifloraceae, Phyllanthaceae, Platanaceae, Rhamnaceae, Rosaceae, Rubiaceae, and Vitaceae. The present study shows that the family Poaceae has the highest species richness, with 25 species collected from this family (**Fig. 5**). The Asteraceae family hosts 23 species of lynx spiders. The Balsaminaceae family has the lowest species richness, with only 2 species identified. When considering species abundance, a similar pattern emerges. The Poaceae family has the highest species abundance (**Fig. 6**), with 380 specimens collected. From the Asteraceae family, 360 specimens were collected. The Balsaminaceae family have the lowest species abundance.

The species accumulation curve shows the relationship between the number of individuals and species diversity (**Fig. 7**). Initially, the curve rises rapidly, indicating that many new species are discovered with each additional specimen. Then the curve levels off and reaches a plateau, suggesting that sampling is probably sufficient and that most species in the habitat have been documented. The present study estimated four alpha diversity indices (**Table 5**) based on the number of specimens across different host plant families: Shannon Index, Simpson Index, Evenness, and Chao1. The Shannon index measures species richness and is 2.972612, indicating high species diversity among host plant families, with few species dominating. The Simpson index quantifies species dominance; a value of 0.9286975, close to 1, indicates high species diversity and a more even distribution of species. Evenness is 0.8739898, close to 1, indicating perfect evenness and an even distribution of the specimens. The total species richness, including hidden species, can be estimated using the Chao1 estimator. The

Chao1 value is 318.1667, suggesting that the true species richness may be higher than observed and that more rare species remain to be discovered.

5.4.3. Lynx spider richness and abundance in the host plant types (Native, Invasive and Exotic)

In 2018, Gomes and his co-workers investigated the impact of invasive species at higher trophic levels, a crucial step in forecasting future changes in native communities. They found that the presence of invasive species in an ecosystem changes the habitat structure by altering the taxonomic and functional diversity and composition of predator communities. *Acacia longifolia* invaded the grey dunes, leading to the immigration of more generalist species from neighbouring habitats. In this study, we classified the 88 host plants into Invasive (36), Exotic (26) and Native (26). The species richness (Fig. 8) and abundance (Fig. 9) are highest in Invasive host plants. 28 (35.4%) species and 1532 (59.5%) specimens were collected from invasive host plants. The richness and abundance are lowest in Native hostplants, with 24 (30.4%) species and 456 (17.7%) specimens collected from these plants. These invasive plants usually surround the crops and forest premises.

The alpha diversity indices (Table 6), Shannon, Simpson, Evenness, and Chao1, have higher values for invasive host plants (3.266, 0.959, 0.984, 28) than the native plants (3.200, 0.956, 0.9710, 27), and the exotic plants have intermediate values for all the indices. These indices also strongly supported the hypothesis that Lynx spiders' host plant preference decreases from invasive to native (Invasive > Exotic > Native). The invasive host plants host diverse and evenly distributed lynx spiders, which may be due to their complex structure, pheromones or high prey density. The exotic plants act as transitional habitats that may provide niches for lynx spider communities, but they are

not well distributed as invasive plants. The native host plants have lower spider diversity, possibly because they host specialist spiders that are essential for ecosystem stability. Higher lynx spider diversity in invasive plants is a sign of ecological homogenization, which adversely affects the healthy balance of an ecosystem. Even though the invasive host plant provides a prey-rich environment for lynx spiders to forage, it alters the natural predator–prey dynamics.

When lynx spiders show a preference for invasive plants, the ecological reasons are tied to the structural and resource traits these plants provide. Many invasive species grow vigorously, producing dense foliage, tall stems, and abundant flowers, creating ideal hunting perches and camouflage for spiders. Their flowers often attract large numbers of pollinators and herbivorous insects, ensuring a steady supply of prey that sustains predator populations. Invasive plants also alter microclimates by providing shaded, humid niches that benefit spider survival and activity. However, this preference has broader ecological consequences: by concentrating on invasive vegetation, lynx spiders may indirectly protect these plants from herbivores, reinforcing their dominance and reducing the ecological role of native flora. This can shift predator–prey dynamics, weaken natural pest control in native plant communities, and contribute to biodiversity imbalance. Thus, the ecological reasons for plant selection lie in the structural complexity, prey richness, and microclimatic benefits of invasive plants, yet the outcome is a paradox—spiders thrive while ecosystems risk losing native diversity and resilience. In agricultural and conservation contexts, understanding this preference is crucial, as it highlights both the adaptive strategies of lynx spiders and the unintended ecological support given to invasive species.

5.4.4. Host plants and Oxyopid position in each plant

The Lynx spiders are dominant predators in agroecosystems and play a greater role in integrated pest management as a biocontrol agent (Young & Lockley, 1985). Lynx spiders occupied various parts of the host plants. They are usually seen in plant leaves. They were also present in other parts, such as the stem and the flower (Whitcomb et al., 1966; Whitehouse et al., 2011). It is essential to identify the relative positions of Lynx spiders to support target-specific pest control for future applications. Unfortunately, as noted in the literature, such studies have not yet been conducted.

The host plants and the lynx's position within each plant are the first of their kind in India, especially in Kerala. During the study, we identified the relative position of the Lynx spider in different parts of the host plants (**Table 7**). Excluding *Cayratia pedata*, *Chloris barbata* and *Clerodendrum paniculatum*, Oxyopids are found on the ventral sides of leaves. This position provides a perfect hiding place for the species; hence, it is the most favourable. *Oxyopes* occupied the dorsal sides of the host plant, excluding *Allamanda cathartica*, *Avicennia marina*, *Bambusa tuldoidea*, *Blachia umbellata*, *Bougainvillea glabra*, *Bougainvillea spectabilis* shubra, *Camonea umbellata*, *Chloris barbata*, *Clerodendrum paniculatum*, *Croton hirtus*, *Cyanchum leave*, *Datura ferox*, *Eugenia mooniana*, *Muccuna bracteata*, *Pueraria phaseoloides*, *Ruellia elegans* and *Xanthium strumarium*. In this position, the Oxyopids get more exposure to their prey. At the same time, they are more vulnerable to predators because of their greater visibility. Lynx spiders were collected from all three parts (leaf, stem, and flower) of host plants such as *Hibiscus aculeatus*, *Hibiscus ovalifolius*, *Hyptis suaveolens*, *Ocimum tenuiflorum*, and *Tibouchina urvilleana*. In *Blachia umbellata*, spiders are only collected from the ventral side of the leaves. In *Cosmos sulphureus*, the lynx is occupied only below the stem.

The host plant part “flower” is another preferred habitat for Lynx spiders, which mimic the flower's colour. In *Allamanda cathartica*, *Asystasia gangetica*, *Bougainvillea glabra*, *Bougainvillea spectabilis shubra*, *Centratherum intermedium*, *Chamaecrista kleinii*, *Chloris barbata*, *Cissus vitigenea*, *Cosmos sulphureus*, *Hibiscus aculeatus*, *Hibiscus ovalifolius*, *Hibiscus radiatus*, *Lantana Camera*, *Lantana montevidensis*, *Lantana trifolia*, *Melastoma candidum*, *Mussaenda frondosa*, *Myriactis nepalensis*, *Pennisetum pedicellatum*, *Pennisetum polystachion*, *Rosa alba*, *Rosa rubiginosa*, *Ruellia elegans*, *Sida cordifolia*, *Tagetes erecta*, *Tibouchina urvilleana*, *Tridax procumbens*, *Xanthostemon chrysanthus* and *Xanthium strumarium* Lynx occupied above and below the flowers. In *Sphagneticola trilobata* and *Clerodendrum paniculatum*, Oxyopids are found only above the flower. In the case of *Camonea umbellate*, *Cayratia pedata*, *Impatiens walleriana*, *Jasminum sambac*, and *Trema orientalis*, Lynx spiders are only seen below the flowers.

Compared to the flowers and leaves, the host plant part, the stem, is a less preferred position for Oxyopid to occupy. In *Benkara malabarica*, *Boerhavia diffusa*, *Capsicum annuum*, *Chloris barbata*, *Chromolaena odorata*, *Mimosa pudica*, *Muntingia calabura* L., *Otacanthus caeruleus*, *Passiflora vesicaria* and *Phyllanthus myrtifolius* spiders were collected from above and below the stems. Lynx spider is collected only from the upper region of the stems of *Avicennia marina*, *Bambusa tuldoidea*, *Cayratia pedata*, *Coronopus didymus*, *Cosmos sulphureus*, *Leucaena leucocephala*, *Tradescantia zebrina*, and *Urena lobata*. Meanwhile, Oxyopid occupies below the stems of *Xanthium strumarium*, *Sphaeranthus indicus*, *Sphagneticola trilobata*, *Strobilanthes lanatus*, *Pueraria phaseoloides*, *Rosa alba*, *Rosa rubiginosa*, *Ruellia elegans*, *Pennisetum clandestinum*, *Pennisetum pedicellatum*, *Nicotiana tabacum*, *Oscimum gratissimum*, *Mussaenda frondosa*, *Jasminum sambac*, *Lantana Camera*, *Lantana montevidensis*,

Lantana trifolia, *Eugenia mooniana*, *Cynodon dactylon*, *Clidemia hirta*, *Centratherum intermedium*, *Camonea umbellata*, *Brachiara mutica*, *Asystasia gangetica*, *Araucaria heterophylla* and *Alternanthera sessilis*.

During our study, we observed that members of the genus *Oxyopes* generally prefer to inhabit the flowers and leaves of host plants. This may be due to their ability to mimic the colouration of flowers and leaves. At the same time, they prefer the leaves to be more or less visible on the stems. In the case of *Peucetia*, only one species, *P. latikae*, has been identified from Kerala. This species is greenish in appearance and prefers to reside beneath the leaves of host plants, which helps them hide from predators; some specimens were collected from the stems as well. Most of the *Hamataliwa* are collected from the ventral side of the leaves. They usually prefer to sit in the leaves on the lower side of the host plants. *H. sikkimensis* and *H. hieroglyphica* were collected from the dorsal side of the host plants.

Our investigation into the relative placement of Lynx spiders across 88 host plants from various ecosystems in Kerala revealed notable differences at both the species and genus levels. We found multiple species residing on the same host plant; however, we did not collect individuals of different genera or species from the same area of a single host plant. This suggests the potential for niche partitioning among the spiders. These findings could be beneficial for implementing species- and position-based natural pest control strategies involving Lynx spiders.

5.5. Comparison of the Gut microbial diversity of *Oxyopes birmanicus* from 4 selected ecosystems.

Understanding the diversity of gut microbes in Lynx spiders is vital for revealing their ecological roles and evolutionary connections (Avivar et al., 2024). Klepzig and

his coworkers in 2009, and Engel & Moran in 2013, investigated the crucial role of gut microbes in digestion, nutrient absorption, and immune regulation, which directly impacts spiders' survival and fitness. Like other spider species, Lynx spiders utilise extracellular digestion, where enzymes break down prey for nutrient absorption. Gut microbes help break down complex biomolecules, thereby improving nutrient assimilation (Foelix, 1996; Gloríkova, 2022). A study by Marc et al. in 1999 showed that some spiders, such as Oxyopidae, are more significant in pest control. Exploring microbial diversity reveals how different prey types shape gut microbiota composition, offering insights into dietary specialisation and trophic interactions. Additionally, gut microbes contribute to toxin resistance, antimicrobial defence, and metabolic efficiency, enabling Lynx spiders to flourish in diverse habitats (Jin et al., 2017). Research on microbial diversity also sheds light on host-microbe coevolution, revealing potential symbiotic relationships that bolster survival. From a conservation perspective, gut microbiota may act as bioindicators of environmental health (Scharff et al., 2020). Alterations in microbial composition resulting from habitat disturbance or climate change can affect spider populations, underscoring the importance of microbial studies for evaluating ecosystem stability. Moreover, comparative analyses of gut microbiota across different Lynx species clarify phylogenetic relationships and evolutionary adaptations. Investigating microbial diversity within these spiders enhances our understanding of ecological and evolutionary dynamics, carrying significant implications for conservation and environmental monitoring.

Recently, in 2021, Wu and his colleagues found that spiders' Gut microbiome can convert polysaccharides into a source of energy. This finding has significant ramifications for spider digestion, silk production, and behaviour. According to research by Krawczyk and colleagues in 2022, the diversity of the spider gut

microbiome shows geographical variation due to changes in environmental conditions and locally available foraging substrates. Tiede et al. (2017) noted that gut microbial diversity varies with changes in ecosystems and pests. In the present study, we are comparing gut microbial diversity among *O. birmanicus* collected from four ecosystems in Kerala: Damsides, paddy fields, forests, and urban areas. This study identified 107 bacterial species, 162 genera, 88 families, 56 orders, and 27 classes belonging to 18 phyla.

To date, the gut microbial diversity of three *Oxyopes* species, *P. viridans*, *O. javanus*, and *O. birmaincus*, has been reported (Kumar et al., 2020; Vinolia & Agnes, 2023). Predatory spiders have a simple gut, and Paula et al. (2015) classified gut microbes into core bacterial communities and prey-derived microbes. Core microbes may be common across species within the same family, and prey-derived communities vary with diet (Anderson et al., 2012; Funaro, 2011). Kumar et al. (2020) identified five core bacterial communities in spiders, including the genera *Acinetobacter*, *Staphylococcus*, *Corynebacterium*, *Cutibacterium*, and *Pseudomonas*.

In the present study, we chose *O. birmanicus*, which is one of the most abundant *Oxyopes* species in Kerala's ecosystem, has higher biocontrol potential, and can be used as an ecological indicator, as per previous literature (Clausen, 1986; Churchill, 1997; Marc et al., 1999). We identified the gut microbial diversity of *O. birmanicus*, OBRM1 (from Urban area), OBRM2 (from Forest), OBRM3 (from Damsides), and OBRM4 (from Paddy field) at various taxonomic levels. OBRM1 has the highest total reads (378,148), while OBRM4 has the lowest (231,410), suggesting variation in sequencing depth across samples. The sequence quality is $\geq 89\%$ Q30, indicating that all specimens are suitable for further analysis. All the specimens with a filtering rate of $\sim 72\%$ suggest raw data quality. OBRM3 has the highest percentage of merged reads (23.9%) and thus

better sequence overlap, while OBRM1 has the lowest (1.92%). The highest feature count designates the richest microbial diversity. The OBRM3 has a higher feature value, resulting in greater diversity. OBRM 1 has a lower feature count and lower microbial diversity. The OBRM 2 and OBRM 4 fall in between.

5.5.1. Gut microbial abundance in different taxonomic levels

At the kingdom level (**Fig. 10**), OBRM1 is contaminated with non-bacterial and bacterial communities. The remaining samples, OBRM2, OBRM3, and OBRM4, show stable bacterial communities with no contamination. Kennedy et al. (2020) reported that the phylum Firmicutes was dominant within the family Oxyopidae. In the present investigation, OBRM2, OBRM3, and OBRM4 show a more diverse distribution at the phylum level (**Fig. 11**), with Actinobacteriota and Firmicutes_A. OBRM1 deviates from this trend, with Proteobacteria as the dominant phylum, indicating a shift in bacterial composition. This variation may be due to environmental conditions or host interactions influencing microbial diversity. At the class level (**Fig. 12**), OBRM1 has a high abundance of Alphaproteobacteria. OBRM2 has a slightly higher abundance of Alphaproteobacteria than OBRM4, and the lowest abundance in OBRM3. OBRM2 and OBRM4 have higher, nearly equal abundances of Actinomycetia, whereas OBRM1 and OBRM3 have the lowest abundance. OBRM3 is abundant in Clostridia_258483, whereas OBRM2 is narrowly abundant. The remaining two samples are intermediate. At the order level (**Fig. 13**), OBRM1 has the highest abundance of Rhodobacterales and Rhizobiales_A_504705. Rhizobiales_A_504705 is a symbiotic nitrogen-fixing bacterial group that may be involved in nutrient assimilation or detoxification in spiders. Its abundance appears to be equal in OBRM2 and OBRM4 and reduced in OBRM3. Caulobacterales is abundant in OBRM1 and minimal in the remaining samples. Mycobacteriales are equally abundant in OBRM2 and OBRM4.

Lachnospirales are dominant in OBRM3 compared with the others. At the family level (**Fig. 14**), OBRM1 shows a high proportion of Rhodobacteriaceae and Mycobacteriaceae. Rhodobacteriaceae exhibit metabolic flexibility, which helps them thrive in fluctuating environments, and they are involved in bioremediation (Pohlner et al., 2019). They form symbiotic relationships. Mycobacteriaceae contribute to bioremediation and environmental adaptation owing to their high lipid content, which enables them to survive in extreme conditions. They possess biotechnological applications such as enzyme production and pollutant degradation (Batt et al., 2020). OBRM1 also has Dermabacteraceae. OBRM2 and OBRM3 display a more balanced distribution, with an abundance of Caulobacteriaceae, Beijerinckiaceae, Rhodobacteriaceae, Microbacteriaceae, and Lachnospiraceae. These microbes play notable roles in nutrient cycling, microbial interactions, and environmental adaptation (Newton et al., 2011; Morawe et al., 2017; Berrios, 2022). OBRM4 has a notable presence of Caulobacteriaceae, Beijerinckiaceae, Rhodobacteriaceae, Microbacteriaceae, and Lachnospiraceae. Lachnospiraceae have high environmental resilience. At the genus level (**Fig. 15**), *Brachybacterium*, *Corynebacterium*, *Methylobacterium* and *Brevundimonas* were abundant in OBRM1. *Corynebacterium*, *Methylobacterium* and *Brevundimonas* were also highly represented in OBRM2 and OBRM4. *Corynebacterium* and *Brevundimonas* are abundant in OBRM3. At the species level (**Fig. 16**), 107 species were identified. None of the species was overdominant or more abundant than the others.

5.5.2. Krona plot analysis

The Krona plot reveals the percentage of genus occurrence in each sample. In OBRM1 (**Fig. 17**), six microbial genera were identified: *Bifidobacterium_388775* (7%), *Corynebacterium* (18%), *Brachybacterium* (10%), *Hungateiclostridium* (35%),

Brevundimonas (6%), and *Methylobacterium* (24%). In OBRM2 (Fig. 18), among the 80 microbial genera identified, *Brevundimonas* (31%) has the highest occurrence, while the remaining genera are below 9%. In OBRM3 (Fig. 19), 103 microbial genera were identified, with *Gemmiger_A_73129* (32%) occurring at the highest frequency, and all others at frequencies below 8%. In OBRM4 (Fig. 20), 67 microbial genera were identified, with *Brevundimonas* (25%) and *OLB17_426821* (17%) having the highest percentages, while the others are below 7%.

5.5.3. Gut microbial species diversity in each sample

In the above analysis, we identified 107 microbial species across four samples from different ecosystems. Only one species-level identification, *Hungateiclostridium straminisolvens*, was identified from OBRM1. This species could thrive in low-oxygen environments and have industrial applications, such as biofuel production and waste recycling (Zhang et al., 2018). *Sphingomonas_L_486704* sp001421805, *OLB17* sp001464665, *Brevundimonas faecalis*, *Micrococcus antarcticus*, *Corynebacterium pseudodiphtheriticum*, *Sphingorhabdus_B_483718* *contaminans*, and *Ensifer adhaerens* are common in OBRM2, OBRM3 and OBRM4. *Brevundimonas faecalis* is known for nitrogen fixation, soil fertility enhancement and organic matter decomposition (Friedrich et al., 2021). *Micrococcus antarcticus* has a role in metal tolerance (Doytchinov & Dimov, 2022). *Corynebacterium pseudodiphtheriticum* is a human respiratory microbiota that causes respiratory infections, whereas *Sphingorhabdus contaminans* is found in contaminated environments (Burkovski, 2015; Yang, 2017). *Ensifer adhaerens* has symbiotic relationships with plants (Zhumakayev et al., 2021).

Pseudoruminococcus massiliensis, *Rickettsia hoogstraalii*, *Oribacterium parvum*, *Nocardioides_A_392796 rotundus*, *Eubacterium_Q ruminantium*, *Agathobaculum desmolans*, *Peptostreptococcus stomatis*, *Eubacterium_O_258268 barkeri*, *Senegalimassilia anaerobia*, *Roseburia sp001940165*, *Coprocola sp000364165*, *Devosia_A_501803 elaeis*, *Schaedlerella sp000403295*, 14-2 *sp000403315*, *Helicobacter_C_479931 hepaticus*, *Dietzia psychrhalcaliphila*, *Anaerotruncus sp000403395*, *Butyribacter sp003612285*, *Brevundimonas staleyii*, *Roseomonas_A_507227 aerofrigidensis*, *Romboutsia_B maritimum*, *Clostridium_AP scindens*, *Clostridium viride*, *Nocardioides_A_392796 zhouii*, *Acinetobacter sp000632455*, *Akkermansia sp001580195*, *Pelagibacterium lacus*, *Lachnospira sp000436535*, *Fusobacterium_C canifelinum*, and *Eubacterium_R faecavium* identified only from OBRM3. Most of the bacteria identified have a crucial role in fibre degradation and butyrate production, intestinal microbiota stability, anti-inflammatory functions, nutrient cycling, short-chain fatty acid production, bioremediation and organic matter decomposition (Woese, 1985; Kamra, 2005; Lagier et al., 2013; Afouda et al., 2020; Talwar et al., 2020; Nie et al., 2021). Some of the microbes are pathogenic as well. *Rickettsia hoogstraalii* is a tick-associated bacterium, cause vector-borne diseases. *Helicobacter_C_479931 hepaticus* causes chronic liver inflammation and gut disorders, and *Clostridium_AP scindens* has pathogenic resistance (Fox et al., 1994; Reeves et al., 2020; Daniel & Ridlon, 2025).

Novosphingobium oryzae, *Tundrisphaera lichenicola*, *Sphingomonas_N morindae*, *Geminicoccus roseus*, *Methylobacterium komagatae*, *Iamia majanohamensis*, *Xanthobacter viscosus*, *Ancylobacter_C lacus*, *Amaricoccus kaplicensis*, *Methylobacterium aerolatum*, *Geodermatophilus_A endophyticus*, *Nakamurella multipartite*, *VXMT01 sp009840945*, *Terriglobus_A aquaticus*,

Anaerococcus degeneri, *Fonticella tunisiensis*, *Sphingobium_A_485959 bisphenolivorans*, *Anaerocolumna xylanovorans*, *Brevundimonas lutea*, *Asaccharospora irregularis*, *Williamsia_A serinedens*, *Oecophyllibacter sp004843345*, *Campylobacter_A pinnipediorum*, *Gemmiger_A_73129 formicilis_72321*, and *Deinococcus_B taklimakanensis* discovered only from OBRM2. These microbes are associated with nitrogen fixation and bioremediation, lichen-derived organic matter decomposition, biodegradation of aromatic compounds, carbon cycling, and abiotic stress tolerance, extreme environment adaptation, polysaccharide accumulation, biodegradation of bisphenol pollutants, cellulose breakdown, and exopolysaccharide production (Kulichevskaya et al., 2017; Smith & Bar-Peled, 2017; Rangjaroen et al., 2017; Sun et al., 2015; Liu et al., 2023; Paudel et al., 2023). *Oecophyllibacter sp004843345* identified in OBRM2 is a symbiotic microbe of weaver ants, this evident that how pest microbiota influences the gut composition of the predator (Chua et al., 2020), and *Anaerococcus degeneri* is usually a part of human microbiota (Veloo et al., 2015).

Phenylobacterium koreense, *Rothia amarae*, *Sandarakinorhabdus cyanobacteriorum*, *Rothia mucilaginoso*, *UBA1020 sp002348615*, *Corynebacterium lipophiloflavum*, *Reyranella massiliensis*, *Clostridium_T saccharoperbutylacetonicum*, *Dermabacter hominis*, *Wolbachia sp003516275*, *Micropruina glycogenica*, *Lawsonella clevelandensis*, *Sphingorhabdus_C buctiana*, *Natranaerovirga pectinivora*, *Ancalomicrobium adetum* found only in OBRM4. These microbes are involved in the biodegradation of aromatic compounds, symbiotic properties, nutrient cycling, and butyrate production, lignocellulose degradation, insect reproduction modification and suppress vector-borne diseases, biodegradation and nutrient cycling (Aslam et al., 2005; Hoffmann et al., 2015; Cai et al., 2018; Sokolov et al., 2020; Baur et al., 2022).

Corynebacterium lipophiloflavum and *Dermabacter hominis* are inhabitants of the human microbiome, the former associated with bacterial vaginosis and the latter a rare human pathogen, found in blood cultures (Funke et al., 1997; Garces et al., 2001). *Lawsonella clevelandensis* is associated with abscess formation in humans (Morton et al., 2023).

Both OBRM2 and OBRM3 share several common microbes, including *Nanosynbacter lyticus*, *Leptotrichia_A_993758 buccalis*, *Corynebacterium accolens*, *Rothia terrae*, *Eggerthella sinensis*, *Sphingobium_A_485959 scionense*, *Methylobacterium jeotgali*, and *Hyphomicrobium_A facile*. Additionally, OBRM3 and OBRM4 also contain some overlapping microbes, specifically *Acidipropionibacterium microaerophilum*, *Pseudobdellovibrio exovorus*, *Deinococcus_B murrayi*, and *Sphaerobacter thermophilus*. Among these gut microbiomes, *Eggerthella sinensis* is part of the human gut microbiota and is associated with ulcerative colitis and intra-abdominal infections. The other members significantly contribute to host-microbe interactions, environmental detoxification, nutrient cycling, and the regulation of microbial communities (Urakami et al., 1995; Stackebrandt et al., 1997; Kertesz & Kawasaki, 2010; Davis et al., 2024)

The ecological role of gut microbes in lynx spiders can be interpreted as a hidden but crucial factor shaping their survival, feeding efficiency, and ecological interactions. These microbes help in digesting complex prey components, such as chitin and proteins, thereby allowing spiders to extract maximum nutrition from diverse insect diets. They also contribute to detoxification, breaking down harmful compounds ingested from prey that feed on chemically defended plants. By influencing nutrient absorption and metabolic balance, gut microbes indirectly affect spider growth, reproduction, and hunting success. On a broader scale, they mediate the spider's role in food webs—supporting its effectiveness as a predator and stabilising insect populations.

In essence, gut microbes act as ecological partners, enabling lynx spiders to thrive in varied habitats and reinforcing their role in maintaining ecosystem balance.

Studying gut microbial diversity in lynx spiders of Kerala is important because it reveals how these predators adapt to local ecological conditions and prey communities. Diverse gut microbes enhance the digestion of complex insect tissues, improve nutrient absorption, and detoxify harmful compounds, thereby supporting spider health and hunting efficiency. In Kerala's varied agroecosystems and natural habitats, microbial diversity may influence how lynx spiders contribute to natural pest control, making them valuable allies in sustainable agriculture. Such studies also provide insights into co-evolutionary processes, showing how microbes and spiders together shape predator-prey dynamics and ecosystem stability. Ultimately, understanding gut microbial diversity in these spiders helps link microbial ecology with biodiversity conservation, offering both scientific knowledge and practical applications for maintaining ecological balance in Kerala.

5.5.4. Alpha diversity indices

During the study, four Alpha diversity indices (**Table 8**) were calculated for each sample, including Chao1, Observed features, Shannon, and Simpson. In OBRM1, the Chao1 value is 28, the lowest among the samples; thus, it has low species richness. The observed features (28) indicate the actual number of species detected in the sample, thereby validating richness estimates. This means only a few species are detected. The Shannon index is 4.17203, a low value that indicates low diversity and uneven species distribution. The Simpson index is 0.92672. This is a high value, suggesting dominance of a few species. These values in OBRM1 indicate that this sample was collected from

an ecosystem with limited species diversity, which may be due to harsh conditions, strong competition, or a dominant species subduing others.

In OBRM2, Chao1 (360) have a moderate value, hence intermediate richness. The observed feature (230) indicates reliable sampling. The Shannon Index (6.03235) indicates moderate diversity, and the Simpson Index is lower than OBRM1, indicating less dominance. OBRM2 has a more balanced species distribution and has a more favourable environment than OBRM1.

The OBRM3 high Chao1 (323), Observed feature (323), Shannon index (6.71819), and Lower Simpson index (0.9728) suggest high species richness, a most diverse and evenly distributed community, and minimal dominance. OBRM3 is occupied in a favourable environment. OBRM4 has moderate Chao1(160) and observed feature (160), Shannon index (5.5747) and Lower Simpson index (0.94716), indicating intermediate richness, reliable sampling, and moderate sampling with few dominant species.

From the above data, it was revealed that, in terms of gut microbial diversity, the OBRM3 (collected Damsides) has the most diverse and species-rich gut microbiome and is found in a stable environment. Environmental stress or competitive exclusion may have made the gut microbiome of OBRM1(collected from an urban area) less diverse. OBRM4 (from Paddy field) is similar to OBRM2 (from forest) but may have slightly more dominance effects, and both are inhabitants of stable ecosystems.

In this study, it is clear that the microbial composition of a species varies with changes in the ecosystem. Despite some shared gut microbes, most spider species were identified as specific to a particular sample, and some arthropod symbionts were present in the spider gut. These arthropods act as prey to the Lynx spiders. The above inference

strengthens the concept of classifying the gut microbiome as core and pest-derived. *O. birmanicus* collected from dam sides has the highest diversity, where they have more diverse diet options due to more heterogeneous vegetation than the Urban area, which has the lowest diversity because of fewer host plant options. The *O. birmanicus* collected from the forest and paddy fields have comparatively homogeneous vegetation; hence, they have a moderate dietary option, showing an intermediate microbial composition. Some spider gut microbes are part of the human microbiota and are pathogenic. How these microbes are transmitted between the spider and the human remains a subject of future study.

The statistical data on gut microbial diversity of lynx spiders collected from four ecosystems in Kerala provide a clear ecological picture of how habitat quality influences microbial richness and, in turn, spider health and ecological function. In the urban area (OBRM1), the lowest Chao1, Shannon, and Simpson values reflect poor microbial diversity, likely due to pollution, reduced prey variety, and pesticide residues. This limited microbial community may weaken digestion and reduce the ecological resilience of spiders in urban habitats. In contrast, the forest sample (OBRM2) shows high richness and diversity, indicating a stable environment with abundant prey that supports a balanced gut microbiome. Such diversity enhances nutrient absorption, detoxification, and overall predator fitness. The damside sample (OBRM3) records the highest diversity indices, highlighting how heterogeneous semi-aquatic habitats foster microbial variety. This equips spiders with greater adaptability to fluctuating prey and microclimatic conditions, strengthening their ecological role in stabilising food webs. The paddy field sample (OBRM4) shows moderate diversity, suggesting that agricultural ecosystems provide microbial support but are influenced by human practices such as pesticide use, which reduce richness compared to natural habitats.

Ecologically, these findings emphasise that gut microbial diversity is not only a reflection of habitat quality but also a determinant of predator efficiency, survival, and ecosystem balance. Forests and dam sides support high microbial diversity, which in turn supports strong predator functions, while urban and agricultural habitats show reduced diversity due to anthropogenic pressures. Thus, conserving diverse habitats in Kerala is essential for maintaining both spider populations and the microbial dimension of biodiversity that underpins ecosystem stability and natural pest regulation.

SUMMARY

Lynx spiders are prevalent in the ecosystems of Kerala and play a crucial role in controlling crop pests. They safeguard their host plants by preying on pests while the plants shelter them. Despite the clear biocontrol benefits of Lynx spiders, their taxonomy and ecology, particularly within Oxyopids, are often overlooked by the scientific community in India, especially in Kerala. This study examines various aspects of Lynx spiders in Kerala and outlines four specific objectives. Accurate taxonomic identification is vital for future applications and conservation efforts regarding any species. The first objective involves taxonomically identifying and detailing Lynx spiders from different ecosystems in Kerala, marking a first of its kind for the region. A total of 31 Lynx spider species have been documented in Kerala, including 16 previously unseen species and two new records for India.

Given advancements in molecular taxonomy and the often cryptic characteristics of Oxyopids, there is a pressing need for an integrated approach combining classical and molecular taxonomic methods. Utilizing DNA barcoding and phylogenetic analysis of Kerala's Lynx spiders alongside global Oxyopid data through the CO1 gene (mitochondrial marker) not only validates species identification but also reveals the evolutionary relationships among these species. This constitutes the second objective of the research. To analyze the phylogenetic relationships among Oxyopids collected from Kerala and globally, four phylogenetic trees - Neighbor Joining, Maximum Parsimony, Bayesian Inference, and Maximum Likelihood were

constructed. Each tree displayed varying taxonomic positions, indicating an insufficiency of DNA sequence data for closely related groups.

Lynx spiders are non-web-building predators that remain stationed on their host plants until prey approaches, at which point they leap to seize it. Thus, the host plants serve as feeding grounds for the spiders. Identifying the host plants of Lynx spiders is the initial step toward utilising them for natural pest control, which is especially significant in an agricultural state like Kerala. The third objective focused on determining the host plant preferences of Lynx spiders. The study identified 88 host plants across 30 plant families. The plant species *Chromolaena odorata* is particularly abundant in Kerala's ecosystems, boasting the highest species richness (18) and abundance (110). In contrast, *Boerhavia diffusa* has the least species richness (1), while *Avicennia marina* shows the lowest abundance (5). Notably, the *Poaceae* family yielded the highest number of species and specimens, whereas the *Balsaminaceae* family exhibited the least richness and abundance. Lynx spiders displayed a stronger preference for invasive plants compared to exotic and native species. Alpha diversity indices, including Shannon, Simpson, Evenness, and Chao 1, were also calculated. Host plant associations of Lynx spiders demonstrate how vegetation structure shapes predator distribution, hunting efficiency, and their role in regulating herbivore populations, thereby supporting ecosystem stability and sustainable agriculture. At the same time, shifts in host plant preference can highlight keystone plants for biodiversity conservation or serve as ecological indicators of habitat change and environmental stress. Lynx spiders' preference for invasive plants as hosts can strengthen the persistence of those plants by reducing herbivore pressure through effective predation. This shift alters food web dynamics, potentially diminishing the ecological role of native plants in supporting

predator populations. Consequently, biological control strategies may be undermined, as predator services that could benefit native or crop plants end up reinforcing invasive plant dominance.

Understanding of the Lynx spider gut microbiome, along with taxonomic and host plant preference studies, enhances implementations in biodiversity assessments and sustainable pest management strategies, thus benefiting ecological research and agricultural applications. Gut microbiomes play a crucial role in spider ecology, digestion, environmental resilience and shaping the host plant interactions as well. Comparing the gut microbiomes of *O. birmanicus* collected from four different ecosystems of Kerala, including urban area, forest, dam side and paddy field, is the fourth objective of the study. During this study, the *O. birmanicus* collected from the dam sides had the highest gut microbial diversity, and the *O. birmanicus* from the urban area had the lowest gut microbial diversity. The gut microbial composition in spiders varies with the differences in ecosystems. Also measured the alpha diversity indices.

This study integrates four global perspectives on Lynx spiders, while the innovative approach from Kerala can improve ecological and economic applications related to them.

CONCLUSION

A comprehensive investigation on taxonomic description, DNA barcoding and phylogenetic analysis, host plant association and gut microbial analysis of Oxyopidae members in Kerala has provided a multi-faceted understanding of species diversity, ecological interactions and physiological adaptations of these species. The all-inclusive taxonomic characterisation supported by DNA barcoding has contributed to the identification and classification of Lynx's species in Kerala's ecosystems, many of which were previously unreported or poorly identified. Combination of classical and molecular taxonomic techniques strengthens the credibility of the species delineation and lays the groundwork for future taxonomic research within the Oxyopid genus.

Phylogenetic analysis carried out in this study revealed the evolutionary relationships among the Lynx spider members and provided profound insights on their taxonomic position and revealed patterns of diversification and adaption within this group. These findings will aid in refining taxonomic classification and understanding the evolutionary processes that drive speciation in spiders, particularly in the context of their environmental interactions and adaptive strategies.

A critical aspect of this study has been the investigation of the host plant associations, which uncovered the intricate relationship between Lynx spiders and their host plants. Understanding these relationships is crucial for comprehending the spiders' ecological roles, including their distribution, Feeding behaviour and interaction with other herbivorous and predatory species. This inference can be used in ecosystem

management and conservation efforts, particularly in preserving habitats where these spiders play a key role in controlling insect populations.

Additionally, the gut microbial analysis has highlighted the complex microbiome of *Lynx* spiders, providing a glimpse into the symbiotic relationships that exist between these spiders and their gut microbiomes. The microbiome plays a significant role in their health, digestion, and overall fitness, suggesting a potential area for future research in spider physiology and behaviour. By studying the gut microbiome, one can further explore the ecological and evolutionary implications of these microbial partnerships, including their impact on the spider host interactions and their response to environmental changes.

The findings of this study have broad applications across multiple fields. In taxonomy and biodiversity conservation, DNA barcoding can be utilised to quickly and accurately identify and catalogue *Lynx* species, aiding in the preservation of genetic diversity and the protection of endangered species. This study's insights into host plant associations also offer applications in integrated pest management. Furthermore, investigating the gut microbial communities in spiders opens up new avenues for research in the microbiome science, with potential applications in health and disease management in Arthropods.

Looking forward, the future studies could expand on these findings by exploring the broader ecological interactions of *Lynx* spiders within different habitats and investigating the impact of environmental factors such as climate change on their populations and behaviour. Additionally, integrating advanced genomic techniques could offer a more detailed understanding of the genetic underpinnings of adaptations, host specificity and microbial interactions. Overall, this study lays the groundwork for

future ecological, evolutionary, and applied research in spider biology, emphasising the importance of interdisciplinary approaches in understanding the complexities of biodiversity and ecological interactions.

RECOMMENDATIONS

- During the research, 16 new species and 2 reports of Lynx spiders were identified from 64 selected ecosystems of Kerala. There are more chances to discover new species from Kerala in the remaining ecosystems. Hence, further diversity studies are needed on Lynx spiders.
- Among the 31 species, only 19 species could be barcoded after multiple trials, and barcoded data on Oxyopids globally is also very limited. This is insufficient for deciphering the divergent time in this family. This impediment points to the need for further barcoding of Lynx spiders using COI and other markers.
- The present study only identifies the Host plants of Lynx spiders. Further investigations are needed to determine how the pest population and environmental factors influence the host plant selection in Lynx spiders.
- The current investigation discovered that the gut microbial composition of a species varies with variations in the ecosystems. This study only concentrated on one species of Lynx spider and needs to elaborate on the oxyopid members for their future applications in natural pest control.



CHAPTER 6

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APPENDIX

LIST OF PUBLICATIONS

Journal articles

- **Amulya, K. B.** & Sudhikumar, A. V. (2022). New species of genus *Hamataliwa* Keyserling, 1887 (Araneae: Oxyopidae) from India. *Serket* 19(1): 95-99.
- **Amulya, K. B.**, Honey, S. & Sudhikumar, A. V. (2022). A new species of lynx spider (Araneae: Oxyopidae) from the Western Ghats, India. *Arachnology* 19(3): 678-680. doi:10.13156/arac.2022.19.3.678.
- **Amulya, K. B.**, Sebastian, H. & Sudhikumar, A. V. (2022). A new species of *Oxyopes* Latreille, 1804 (Araneae: Oxyopidae) from Calicut University Campus, Kerala, India. *Serket* 18(3): 299-304.
- **Amulya, K. B.**, Sebastian, H. & Sudhikumar, A. V. (2022). A new lynx spider of the genus *Hamataliwa* Keyserling, 1887 (Araneae: Oxyopidae) from Kerala, India. *Serket* 18(4): 447-450.
- **Amulya, K. B.**, Sebastian, H. & Sudhikumar, A. V. (2024). Description of new species of genus *Hamataliwa* (Araneae, Oxyopidae) from India. *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa"* 67(2): 235-241. doi:10.3897/travaux.67.e 97171.

Articles in conference proceedings

- **Amulya, K. B.**, & Sudhikumar, A.V. (2023). Habitat preference of lynx spiders (Araneae: Oxyopidae) on invasive plants, Proceedings of the National Seminar on recent trends in floral and faunal Invasion In Kerala, *Christ College (Autonomous), Irinjalakuda, Publications*, 1: 1- 9, ISBN: 978-93-5813-425-4. (June 2023).

- **Amulya, K.B.**, Sebastian, H., & Sudhikumar, A. V. (2021). Application of molecular taxonomy in lynx (Oxyopidae) spiders. *Modern trends in biological research by Vimala college (Autonomous), Thrissur*. 1: 56-60. ISBN: 978-81-7255-134-6 (April 2021).

LIST OF PRESENTATIONS

- **Amulya, K.B.** (2021). The oral presentation titled “Application of molecular taxonomy in lynx (Oxyopidae) spiders, in the National Level Virtual Scientific Paper Presentation Competition” on 9th January, organised by ZOOTOPIA - The Journal Club, Department of ZOOLOGY Vimala College (Autonomous), Thrissur
- **Amulya, K.B.** (2022). The oral presentation titled “A preliminary study on the habitat association of lynx spiders from the Western Ghats of India” at the 33rd European Congress of Arachnology in Greifswald, Germany, from 4th to 9th September.
- **Amulya, K.B.** (2023). The oral presentation titled “Habitat preference of lynx spiders (Araneae: Oxyopidae) on invasive plants, In the National seminar on “Recent trends in floral and faunal invasion in Kerala”, 8th and 9th February. Sponsored by KSBB and KSCSTE.
- **Amulya, K.B.** (2025). The oral presentation titled “Comparison of lynx spider diversity in selected agroecosystems and dam ecosystems in Kerala, in the two-day international conference on nourishing the future: Economic Prosperity, Nutrition, Climate Change and Sustainable Development, 1st and 2nd August. Jointly organised by the Departments of Economics, History and Political Science.

RESEARCH ARTICLE

Description of new species of Genus *Hamataliwa* (Araneae, Oxyopidae) from India

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Abstract

New species of Lynx spider, *Hamataliwa sagitta* sp. nov. is described from Vazhani dam area, a part of Western Ghats of Kerala, India. Detailed morphological description, diagnostic features and illustration of the female of this species is given.

Keywords

Lynx spider, Kerala, Taxonomy.

Introduction

Hamataliwa is a genus of lynx spiders and was established by Keyserling (1887) with the type species *H. grisea* Keyserling 1887. *Hamataliwa* Keyserling, 1887 is the second largest genus of the family Oxyopidae and currently contains 87 species (World Spider Catalog 2023) with 9 species reported from India. Taxonomic works on *Hamataliwa* from India are not enough. Only a few works are available. Dhali et al. (2017) did taxonomic works on spiders which inhabit the litter and ground of the Reserve forests of Dooars, West Bengal. They identified a new species of *Hamataliwa* called *H. hellia* and redescribed *H. incompta*. Amulya et al. (2022) identified two *Hamataliwa* species

from Kerala, including *H. crista* and *H. rhombiae*. Sen & Sureshan (2022), located *H. indica* in the Western Ghat of India and redescribed *H. ovata* and *H. reticulata* as well. Tang & Li (2012), gave the first report on *H. subhadrae* identified by Tikader (1970) as *O. subhadrae*. Asalatha & Prasad (2020) did the first report of *H. pentagona* Tang & Li, 2012 which was only identified from China earlier. Members of these spider genus do not make webs and remain hidden in the low shrubs; therefore, it is difficult to capture (Mouly et al. 2018) also most of them are cryptic to the soil colour. This genus is distinguished from other genera by following characteristics such as legs III and IV subequal or III longer than IV. Eyes of the posterior row, in most, with the medians closer to the laterals than to each other (Gajbe 2008). Brady (1964) redefined *Hamataliwa* by giving more importance to the structure of male and female genitalia. Many *Hamataliwa* members are morphologically similar but different in genitalic structure. This caused the misidentification of the *Hamataliwa* members in its preliminary observation. The present study deals with the record and description of a new species of the genus *Hamataliwa* female collected from the Vazhani dam of Kerala, India.

Material and methods

Specimens were collected from the premises of tropical rain forests of the Western Ghats of Kerala, India. Collection is done by hand picking. The specimens were preserved in 70% ethanol and studied with a Leica M205 C stereomicroscope. The microphotographic images were taken using a Leica DMC4500 digital camera attached to a Leica M205 C stereomicroscope, with the software package Leica Application Suite (LAS), version 4.3.0. LAS montage facility. The image plates were prepared using Adobe Photoshop CC version 14.0 x 64.

Epigyne was dissected and cleared in a 10% potassium hydroxide (KOH) solution. It cleared and photographed. Leg measurements are shown as total length (femur, patella, tibia, metatarsus, tarsus). All measurements are in millimetres (mm). The studied specimen was deposited in the reference collection at the Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala, India.

Abbreviations used in the text and figures are as follows (Tang & Li, 2012; Baehr et al., 2017; Lo et al., 2021): AL = abdomen length, ALE = anterior lateral eye, AME = anterior median eye, AW = abdomen width, CD = copulatory duct, CL = cephalothorax length, CO = copulatory opening, CW = cephalothorax width, E = epigastric plate, FD = fertilization duct, PLE = posterior lateral eye, PME = posterior median eye, S = spermatheca, TL = total length.

Spination abbreviations: do = dorsal, pl = prolateral, rl = retrolateral, v = ventral.

Results

Taxonomy

Hamataliwa Keyserling, 1887

Type species: *Hamataliwa grisea* Keyserling, 1887

Hamataliwa sagitta sp. nov.

(Figs 1–2)

Etymology: The noun *Sagitta* is the Latin word for arrow. The arrangement of the eyes in this species is arrow shaped.

Materials examined

Holotype: India •Kerala •Thrissur• Vazhani Dam (Fig. 3); ♀; 10.6412° N, 76.3084° E; 28.IX.2021; Amulya Baji K leg.; Original number CATE 809273. **Paratypes:** same location; ♀; 25.X.2021; Amulya Baji K leg.; Original number CATE 809274 • 1 subadult ♀; 22. X. 2021; Amulya Baji K leg.; Original number CATE 809275 • 1 subadult ♀; 20.X. 2021; Amulya Baji K leg; Original number CATE 809276.

Diagnosis: *H. sagitta* sp. nov. somewhat similar to *H. ovata* (Biswas, Kundu, Kundu, Saha & Raychaudhuri, 1996). However, it can be distinguished from the latter by the following combination of characters: 1) The copulatory duct forms a “V” shaped and short in *H. sagitta* whereas it “U” shaped and long in *H. ovata*. 2) The distal end of the copulatory duct “spoon head” shaped in *H. sagitta* whereas it “oval shaped” in *H. ovata*. 3) The shape of spermatheca oblong shaped in *H. sagitta* whereas it elongated in *H. ovata*. 4) Fertilisation duct long and non-curved in *H. sagitta* whereas it long and curved in *H. ovata*.

Description: Description of holotype female (Fig. 1A-B): TL 3.50; CL 1.06, width 1.79; abdomen length 2.44, width 1.47. Carapace dark brown, profusely haired, pear-shaped with the light brown region extending between PME to the posterior end of the carapace. Fovea longitudinal and reddish. In dorsal view, eyes are arranged in four rows with AER strongly recurved and PER procurved. Clypeus high without lines. Ocular area length 0.67, width 1.08. Eye diameters and inter-distances: AME 0.09, ALE 0.19, PME 0.15, PLE 0.17, eye sizes ALE > PLE > PME > AME; AME-AME 0.15, AME-ALE 0.13, PME-PME 0.56, PME-PLE 0.31, ALE-PLE 0.24, ALE-ALE 0.37, PLE-PLE 1.08. Clypeus height 0.29; Chelicera length 0.44, downward with one promarginal tooth, two retromarginal teeth. Fang is broad at the base and narrowed towards the tip but less pointed. Endite and labium longer than wide. Sternum with scattered long and short hair. Abdomen inverted ancient pot-shaped, densely haired, light brown, black band with slightly dark brown border on the lateral sides. In ventral

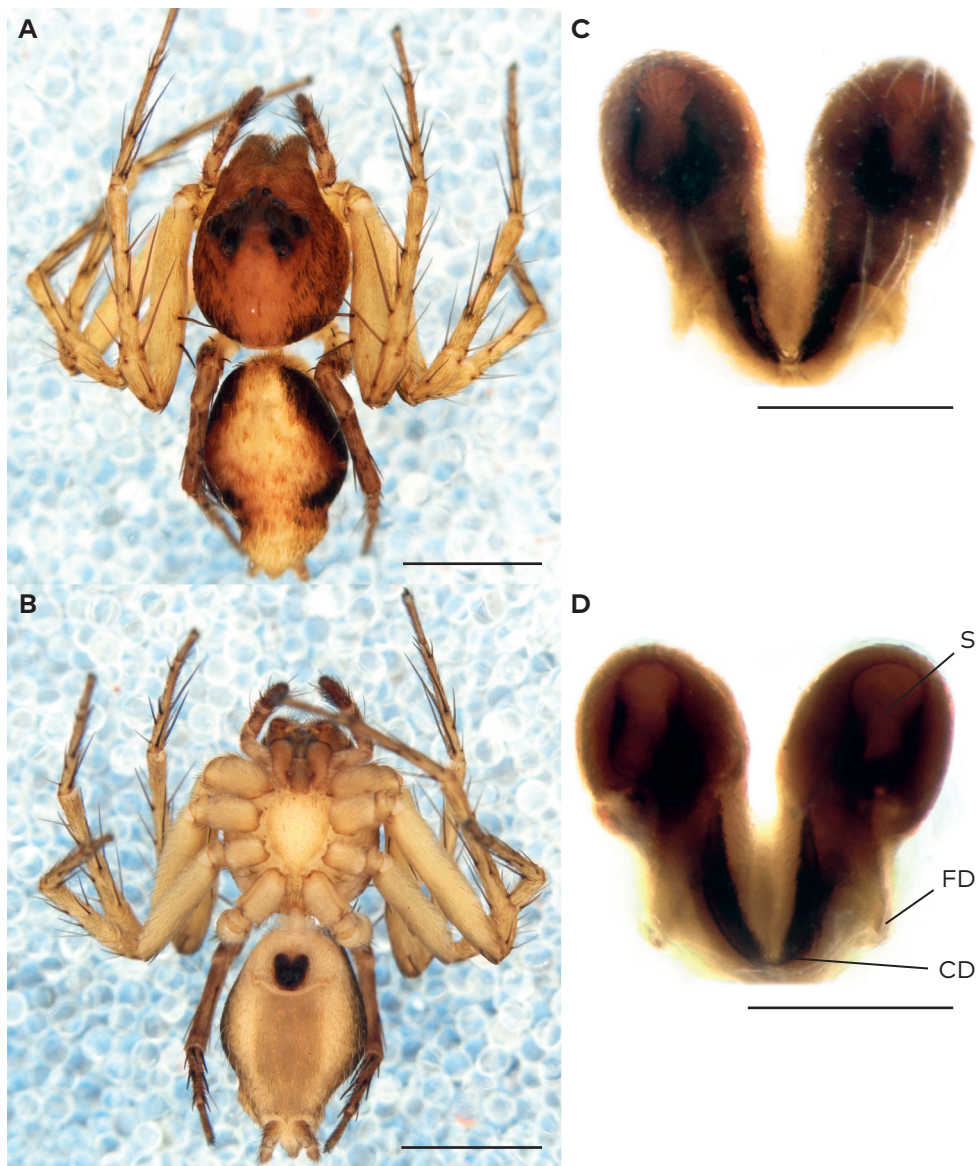


Figure 1. *Hamataliwa sagitta* sp. nov., holotype female: **A** habitus, dorsal view; **B** same, ventral view; **C** Epigyne; **D** Vulva. Scale bars: **A**, **B** = 1 mm; **C**, **D** = 0.2 mm.

view, the broad coffee-coloured longitudinal band extends from the epigastric furrow to the spinnerets. Legs are covered with many conspicuous long spines. Two tarsal claws. Absence of apical claws in pedipalp. Measurements of pedipalps and legs: pedipalp 1.31 (0.19 + 0.35 + 0.46 + 0.31), I 6.83 (2.03 + 0.79 + 1.68 + 1.48 + 0.85), II 6.50 (2.17 + 0.74 + 1.67 + 1.13 + 0.79), III 4.62 (1.62 + 0.70 + 0.84 + 0.88 + 0.58), IV 3.02 (0.56 + 0.97 + 0.55 + 0.49 + 0.45). Leg formula: I>II>III>IV. See Table 1 for spination.

Genitalia (Fig. 1C–D, Fig. 2A–B). Epigyne is highly sclerotised; oval shaped with anterior margin is W-shaped; copulatory duct distant ends are connected with a

Table 1. Spination of leg podomeres of *Hamataliwa sagitta* sp. nov

♀	Leg I	Leg II	Leg III	Leg IV	Palp
Femur	pl 2 do1 rl 2 v 0	pl1 do2 rl 1v0	pl 2 do2 rl 2v0	pl1 do1 rl1 v0	pl1 do1 rl1 v0
Patella	pl 1 do1 rl 1 v 0	pl 2 do 2 rl2 v0	pl 3 do2 rl 2 v0	pl2 do2 rl1 v0	pl2 do2 rl 2v0
Tibia	pl 3 do 3 rl 3 v 0	pl 3do2 rl3 v0	pl2 do 2 rl 2v 0	pl2 do1 rl2 v0	pl3 do3 rl1 v0
metatarsus	pl 3 do1 rl 2 v 0	pl2 do2 rl2 v0	pl2 do 2rl 0 v0	pl2 do 2rl 2v0	
Tarsus	spineless	spineless	spineless	spineless	Spineless

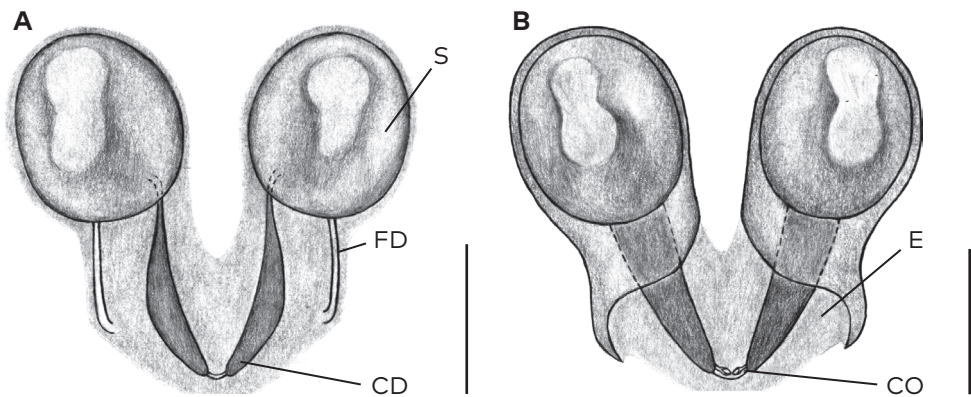


Figure 2. *Hamataliwa sagitta* sp. nov.: A Vulva; B Epigyne. Scale bars: A, B = 0.2 mm.

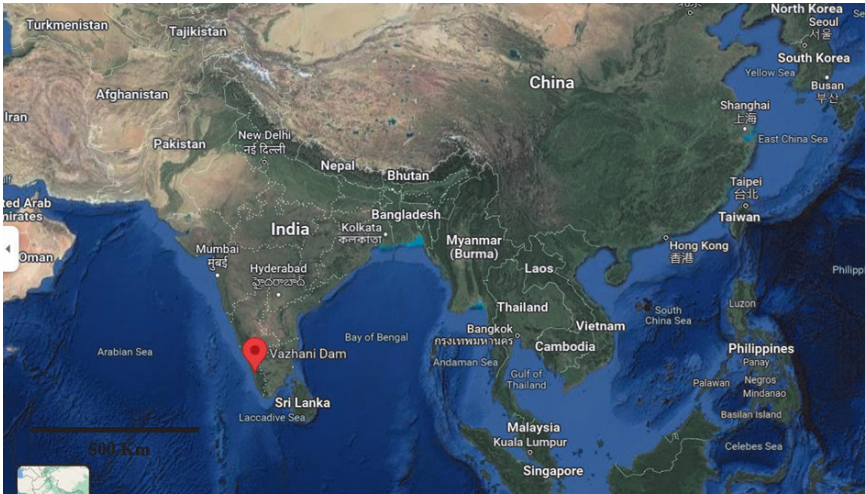


Figure 3. Type locality of *Hamataliwa sagitta* sp. nov. © Google.

narrow tube-like structure. Spermathecae is oval-shaped and arranged on the anterior of the copulatory duct. Copulatory duct starts from the spermatheca and thickened towards the distal side and have spoon headed opening. The fertilisation duct is a narrow tube and its end faces towards the copulatory ducts from lateral sides.

Male: Unknown

Variations: Four female specimens were measured to quantify the morphological variations. Values are mean $\pm$ SD of females. Total length 3.50 ± 0.4 ; cephalothorax length 1.06 ± 0.2 , width 1.79 ± 0.2 ; abdomen length 2.44 ± 0.3 , width 1.47 ± 0.2 . Diameters and inter-distances-AME 0.09 ± 0.02 , ALE 0.19 ± 0.02 , PME 0.15 ± 0.02 , PLE 0.17 ± 0.01 . AME -AME 0.15 ± 0.02 , AME-ALE 0.13 ± 0.03 , PME-PME 0.56 ± 0.01 , PME-PLE 0.31 ± 0.02 , ALE-PLE 0.24 ± 0.04 , ALE-ALE 0.37 ± 0.03 , PLE-PLE 1.08 ± 0.02 . Clypeus height 0.29 ± 0.09 . Palp 1.31 ± 0.2 , leg I 6.83 ± 0.4 , leg II 6.50 ± 0.1 , leg III 4.62 ± 1.2 , leg IV 3.02 ± 0.3 .

Distribution: India (Kerala).

Acknowledgements

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New species of genus *Hamataliwa* Keyserling, 1887 (Araneae: Oxyopidae) from India

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Abstract

New species of Lynx spider, *Hamataliwa rhombiae* sp. n. is described from Perepara dam area, a part of western Ghats of Kerala, India. Detailed morphological description, diagnostic features, and illustrations of the female of this species is given.

Keywords: *Hamataliwa rhombiae*, Taxonomy, New species, Kerala, India.

Introduction

The spiders of family Oxyopidae are easily recognized by six of their eight eyes arranged in a hexagon-like pattern. They are diurnally active, and many species are found running swiftly or jumping with great agility among low shrubs and herbs. The habits of these spiders and their relatively keen eyesight have earned for them the name lynx spiders (Brady, 1964). *Hamataliwa* Keyserling, 1887 is the second largest genus of the family Oxyopidae, and currently contains 86 species (World Spider Catalog, 2022) with so far 8 species are reported from India. The copulatory organs of *Hamataliwa* and genus *Tapponia* appeared to be uniform, whereas the somatic characters were much diverse (Deeleman-Reinhold, 2009). The general form of the epigyne in *Hamataliwa* is a semi-circular or U-shaped, heavily sclerotized rim surrounding a shallow median depression with a characteristic shape in each species (Brady, 1970). The current study deals with the record and description of a new species of genus *Hamataliwa* female collected from Perepara dam of Kerala, India.

Material and Methods

Lynx spider specimens were collected from the premises of tropical rain forests of Western Ghats of Kerala, India. Collection was done by hand picking. The specimens were preserved in 70% ethanol and studied with a Leica M205 C stereomicroscope. The microphotographic images were taken by means of Leica DMC 4500 digital camera attached to Leica M205 C stereomicroscope, with the software package Leica Application Suite (LAS), version 4.3.0. LAS montage facility. The image plates were prepared using Adobe Photoshop CC version 14.0 x 64.

Epigyne was dissected and cleared in 10% potassium hydroxide (KOH) solution. It was cleared and photographed. Leg measurements are showed as: total length (femur, patella, tibia, metatarsus, tarsus). All measurements are in millimetres (mm). The studied specimens were deposited in the reference collection at the Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala, India.

Abbreviations used in the text and figures are as follows (according to: Tang & Li, 2012; Baehr *et al.*, 2017; Lo *et al.*, 2021): AER = anterior eye row, AL = abdomen length, ALE = anterior lateral eye, AME = anterior median eye, AW = abdomen width, CD = copulatory duct, CL = cephalothorax length, CW = cephalothorax width, ECD = extension of copulatory duct, FD = fertilization duct, PER = posterior eye row, PLE = posterior lateral eye, PME = posterior median eye, S = spermatheca, TL = total length. Spination abbreviations: do = dorsal, pl = prolateral, rl = retrolateral, v = ventral.

Taxonomy

Hamataliwa Keyserling, 1887

Type species: *Hamataliwa grisea* Keyserling, 1887

***Hamataliwa rhombiae* sp. n.** (Fig. 1A-C)

Material examined: holotype ♀ (Fig. 1A), 1 paratype adult ♀, 1 paratype subadult ♀ collected at the locality Perepara Dam, Kerala, India, 10°39'9"N, 76°17'21"E, 2 October 2021. (Both holotype ♀ & paratype adult ♀ are deposited in CATE).

Etymology: The plural noun “rhombi” is the Latin word for rhombus shape. The void space between the copulatory ducts is rhombus shaped.

Diagnosis: *H. rhombiae*'s epigyne somewhat similar to *H. crista* Amulya, Sebastian & Sudhikumar, 2022 (Amulya *et al.*, 2022). However, it can be distinguished from the latter by the following combination of characters: 1) The void space between the copulatory duct is “Rhombus” shaped in *H. rhombiae* whereas it is nearly like “spade” in shape in *H. crista*. 2) The extension of the copulatory duct is “conical” in *H. rhombiae* whereas it is comb shaped in *H. crista*. 3) The shape of the spermatheca is “single inverted comma shaped” in *H. rhombiae* whereas it is inverted pear shaped in *H. crista*.

Description: Holotype female (CATE 809278): TL 6.10; CL 1.89, CW 1.86; AL 3.64, AW 2.82. Carapace dark brown, profusely haired, oblong shaped. Entire lateral sides of the carapace excluding the eye region covered with black patches narrowly. Fovea longitudinal and blackish. In dorsal view, eyes arranged in four rows with AER strongly recurved and PER procurved. Clypeus high without lines. Ocular area length 0.55, width 0.83. Eye diameters and inter-distances: AME 0.08, ALE 0.18, PME 0.14, PLE 0.17, eye sizes ALE > PLE > PME > AME; AME-AME 0.13, AME-ALE 0.06, PME-PME 0.28, PME-PLE 0.31, ALE-PLE 0.29, ALE-ALE 0.37, PLE-PLE 0.82. Clypeus height 0.25;

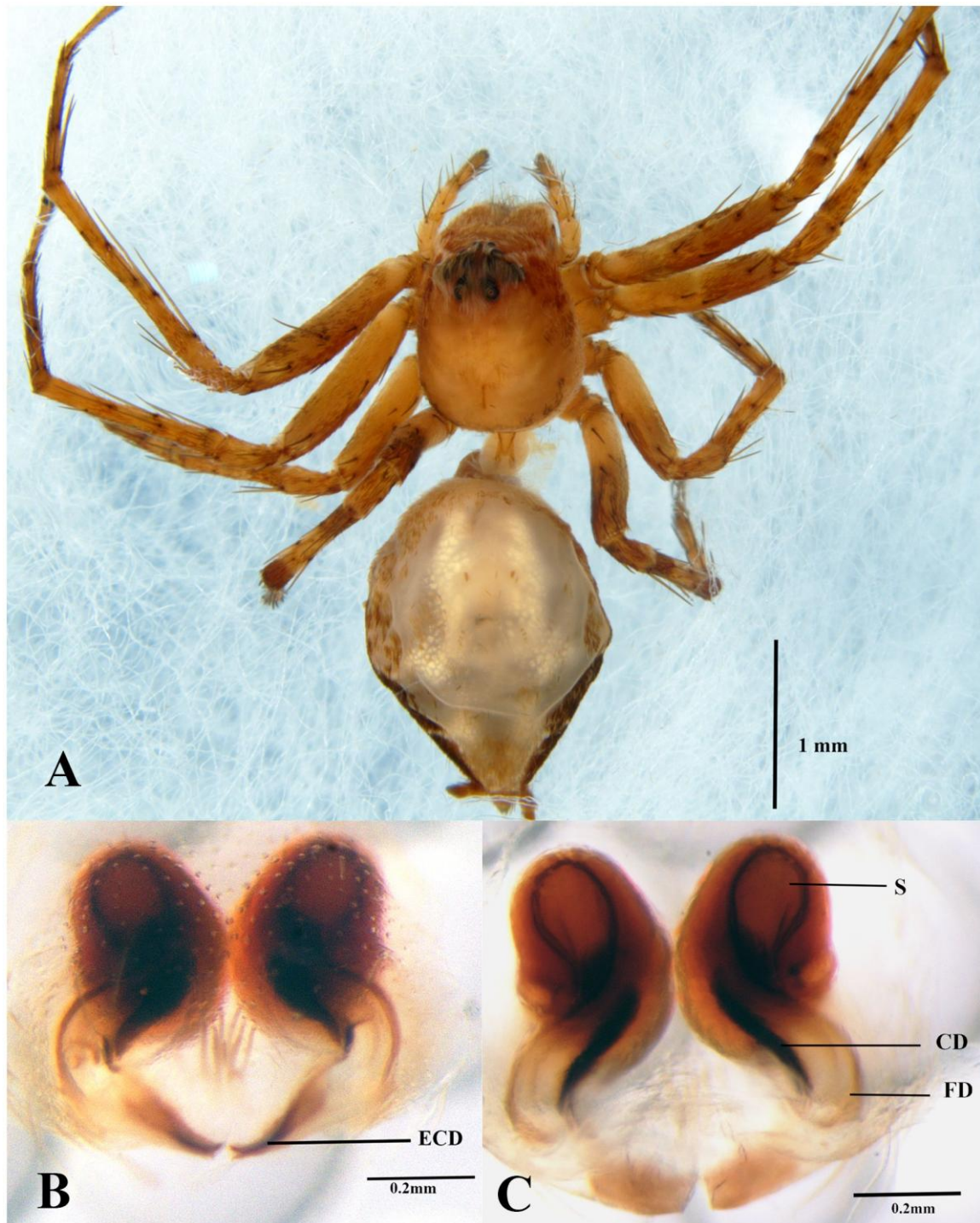


Fig. 1. *Hamataliwa rhombiae* sp. n., holotype female. A. Habitus, dorsal view. B-C. Epigyne. B. ventral view. C. dorsal view.

Chelicera 0.44, downward with one promarginal tooth, one retromarginal tooth. Fang is broad at the base and narrowed towards the tip and pointed. Endite and labium longer than wide. Sternum with scattered long and short hairs. Abdomen inverted pear shaped, densely haired, creamy coloured with the entire abdomen covered with dark brown patches densely covered on the lateral sides. Legs covered with conspicuous long spines. Three tarsal claws. Absence of apical claws in pedipalp. Measurements of pedipalps and

legs: pedipalp 1.42 (0.39 + 0.41 + 0.17 + 0.45), I 7.31 (2.52 + 0.97 + 2.24 + 0.81 + 0.77), II 6.90 (1.95 + 0.76 + 2.25 + 1.22 + 0.72), III 4.94 (1.60 + 0.63 + 1.33 + 0.83 + 0.55), IV 4.28 (1.72 + 0.65 + 0.85 + 0.60 + 0.46). Leg formula: I>II>III>IV. See Table (1) for spination.

Table 1. Spination of leg segments of *Hamataliwa rhombiae* sp. n.

♀	Leg I	Leg II	Leg III	Leg IV	Palp
Femur	pl 3 do 3 rl 2 v 0	pl 2 do 3 rl 2 v 0	pl 1 do 1 rl 1 v 0	pl 1 do 1 rl 1 v 0	pl 0 do 2 rl 0 v 0
Patella	pl 1 do 1 rl 1 v 0	pl 1 do 1 rl 1 v 0	pl 2 do 3 rl 2 v 0	pl 2 do 2 rl 2 v 0	pl 1 do 1 rl 2 v 0
Tibia	pl 4 do 2 rl 3 v 0	pl 2 do 0 rl 2 v 0	pl 2 do 2 rl 2 v 0	pl 2 do 1 rl 1 v 0	pl 1 do 1 rl 1 v 0
Metatarsus	pl 2 do 1 rl 2 v 0	pl 2 do 2 rl 2 v 1	pl 2 do 2 rl 2 v 0	pl 2 do 1 rl 2 v 0	
Tarsus	spineless	spineless	spineless	spineless	spineless

Epigyne (Figs. 1B-C) highly sclerotised. Spermathecae single inverted comma shaped, arranged on the anterior of copulatory duct. Copulatory duct just below the spermatheca slightly thickened and narrowed towards distal side and it is short with a conical extension. Fertilisation duct narrow tube parallel to the copulatory duct. The void space between the copulatory duct “Rhombus” shaped.

Male: Unknown

Variations: Three female specimens were measured to quantify the morphological variations. Values are mean $\pm$ SD. Total length 6.10 ± 0.2 ; CL 1.89 ± 0.2 , CW 1.86 ± 0.1 ; AL 3.64 ± 0.2 , AW 2.82 ± 0.2 . Diameters and inter-distances: AME 0.08 ± 0.01 , ALE 0.18 ± 0.02 , PME 0.14 ± 0.01 , PLE 0.17 ± 0.03 . AME-AME 0.13 ± 0.02 , AME-ALE 0.06 ± 0.01 , PME-PME 0.28 ± 0.02 , PME-PL 0.31 ± 0.02 , ALE-PL 0.29 ± 0.03 , ALE-ALE 0.37 ± 0.03 , PLE-PL 0.082 ± 0.01 . Clypeus height 0.25 ± 0.05 . Palp 1.42 ± 0.3 , leg I 7.31 ± 0.3 , leg II 6.90 ± 0.3 , leg III 4.94 ± 1.5 , leg IV 4.28 ± 0.2 .

Distribution: India (Kerala).

Acknowledgments

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***Hamataliwa rhombiae* Amulya & Sudhikumar, 2022**

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A new species of lynx spider (Araneae: Oxyopidae) from the Western Ghats, India

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Abstract

Oxyopes thumboormuzhiensis sp. nov. is described from the Western Ghats of Kerala, India. A detailed morphological description, diagnostic features, and illustrations of the copulatory organs of both sexes of this new species are presented.

Keywords: Kerala • Thumboormuzhi Butterfly Park • taxonomy

Introduction

Members of the spider genus *Oxyopes* Latreille, 1804, are diurnal hunters that are commonly found in all terrestrial habitats throughout the world (Baehr *et al.* 2017). The name of this family comes from Greek words meaning ‘sharp sighted’ and its members called lynx spiders, for some species jumping from twig to twig, hunt down their prey with great rapidity (Gajbe 2008). As per the World Spider Catalog (2022), Oxyopidae contains nine genera and 445 species, with four genera and 87 species recorded from India. The distinction of *Oxyopes* is commonly based on a conspicuous strongly procurved posterior row of eyes, retromargin of the chelicerae fang furrow with one tooth, and leg IV > leg III (Goyal & Malik 2020). At the same time, in recent years, morphological differences in copulatory organs have gained more acceptance, and they are considered more helpful than other features for taxonomic identification (Jocqué 2002). However, the taxonomy and species diversity of many regional lynx spider fauna worldwide are still little known (Tang & Li 2012; Mukhtar 2017). This study deals with the taxonomic identification, description, and illustration of a new species of *Oxyopes* collected from Kerala, India.

Materials and methods

A mating pair (♂ & ♀), one adult ♀ and subadults (2♂♂) were collected from the Thumboormuzhi Butterfly Park region of the Western Ghats by hand picking. The specimens were directly transferred to 70% ethanol. Photographs and measurements were taken using a Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver.4.12). The epigyne was dissected and cleared in 10%

KOH solution. The left male pedipalp was dissected, cleared and photographed. Leg measurements are showed as: total length (femur, patella, tibia, metatarsus, tarsus). All measurements are in millimetres (mm). The studied specimens are deposited in the reference collection at the Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala, India.

Abbreviations used in the text and figures are as follows (Tang & Li 2012; Baehr *et al.* 2017; Lo, Cheng & Lin 2021): ALE = anterior lateral eye, AME = anterior median eye, C = conductor, CD = copulatory duct, E = epigastric furrow, Em = embolus, FD = fertilization duct, MTA = median tegular apophysis, PLE = posterior lateral eye, PME = posterior median eye, RTA = retrolateral tibial apophysis, S = spermatheca, SD = sperm duct, ST = subtegulum, T = tegulum, VRTA = ventral retrolateral tibial apophysis. Spination abbreviations: do = dorsal, pl = prolateral, rl = retrolateral, v = ventral.

Oxyopidae Thorell, 1869

Oxyopes Latreille, 1804

Type species: *O. heterophthalmus* (Latreille, 1804)

Oxyopes thumboormuzhiensis sp. nov. (Figs. 1–3)

Etymology: The specific epithet refers to Thumboormuzhi Butterfly Park in which *O. thumboormuzhiensis* sp. nov. was collected.

Materials examined: holotype ♀ (Fig. 1), 1 paratype adult ♂ (Fig. 2), 1 paratype adult ♀, 2 paratype subadult ♂♂ collected at the locality Thumboormuzhi Butterfly Park, 10°17'56.1"N 76°27'00.8"E, 18 October 2021. Holotype ♀ & paratype adult ♂ are deposited in CATE.

Diagnosis: *O. thumboormuzhiensis* somewhat similar to *O. sertatus* L. Koch, 1878. However, it can be distinguished from the latter by the following combination of characters: 1) the anterior end of the copulatory duct is triangle shaped in ventral view in *O. thumboormuzhiensis* whereas it is smoothly curved in *O. sertatus*; 2) the shape of the spermatheca is rounded in *O. thumboormuzhiensis* whereas it is elliptical in *O. sertatus*; 3) at the anterior region of the copulatory ducts on both sides of the epigyne there is a visible space in *O. thumboormuzhiensis* whereas it is very close or touching in *O. sertatus*; 4) the dorsal retrolateral tibial apophysis of the male palp is absent in *O. thumboormuzhiensis*.

Description of holotype female (CATE7904292): Total length 7.04; carapace length 3.04, width 2.32; abdomen length 3.99, width 1.71. Carapace light yellow, pear shaped with a pair of light green lines extending from PME to posterior end of carapace, pair of distinctive, larger light green band extending from PLE to posterior end of carapace. Fovea longitudinal and reddish. In dorsal view, eyes arranged in four rows with AER strongly recurved and PER procurved. Clypeus high with two light green stripes from AME margin to front of each chelicera. Ocular area length

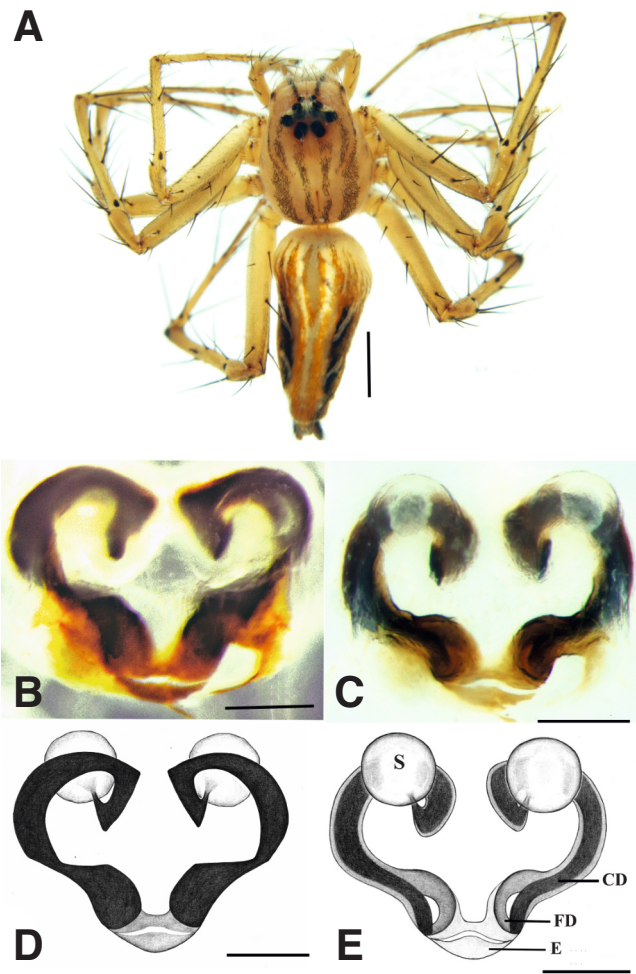


Fig. 1: *Oxyopes thumboormuzhiensis* sp. nov., holotype female. **A** habitus, dorsal view; **B** epigyne, ventral view; **C** same, dorsal view; **D** same dorsal view; **E** same, ventral view. Scale bars = 1 mm (A), 0.2 mm (B–E).

0.47, width 0.39. Eye diameters and inter-distances: AME 0.08, ALE 0.20, PME 0.18, PLE 0.16, eye sizes ALE>PME >PLE>AME; AME-AME 0.39, AME-ALE 0.25, PME-PME 0.16, PME-PLE 0.19, ALE-PLE 0.22, ALE-ALE 0.40, PLE-PLE 0.26. Clypeus height 0.46; Chelicera downward with one promarginal tooth, two retromarginal teeth. Fang is broad at the base and narrowed towards the tip but less pointed. Endite and labium longer than wide. Sternum with scattered long and short hairs. Abdomen fusiform shaped, whitish, longitudinal, central band bifurcated in the anterior region of the abdomen and it covered with golden coloured patches on its inner and lateral sides. Inner most of the bifurcated region whitish. Lateral region black-golden coloured with two pairs of narrow white lines. In ventral view, broad



Fig. 2: *Oxyopes thumboormuzhiensis* sp. nov., paratype male. **A** habitus, dorsal view; **B** pedipalp, prolateral view; **C** same, ventral view; **D** same, retrolateral view. Scale bars = 1 mm (A), 0.5 mm (B–D).

dark longitudinal band extends from epigastric furrow to spinnerets. Legs covered with many conspicuous long spines with black stripes one in each dorsal side of femur to metatarsus. Two tarsal claws. Pedipalps bear apical claw. Measurements of pedipalps and legs: pedipalp 3.25 (1.19 + 0.22 + 0.52 + 1.32), I 11.68 (3.13 + 1.07 + 3.07 + 2.81 + 1.60), II 10.71 (3.08 + 0.99 + 2.56 + 2.90 + 1.18), III 8.67 (2.67 + 0.59 + 2.08 + 2.45 + 0.88), IV 9.27 (2.78 + 0.80 + 2.67 + 2.28 + 0.74). Leg formula: I>II>IV>III. See Table 1 for spination.

Epigyne (Fig. 1B–E) highly sclerotized. Spermathecae rounded, arranged on the anterior of copulatory duct. Copulatory duct thick and question mark shaped. In ventral view the anterior end of the copulatory duct triangle shaped and narrowed tip opens to the spermathecae. Epigastric plate less sclerotised. Fertilization duct opens in front of the copulatory duct. A slightly transparent space between the fertilization duct and the copulatory duct.

Description of paratype male (CATE7904293): Total length 6.36; carapace length 2.11, width 1.73; abdomen

	Leg I	Leg II	Leg III	Leg IV	Palp
♀ Femur	pl2 do3 rl 2 v0	pl2 do 2 rl3 v0	pl 2 do3 rl 2v0	pl3 do3 rl1 v0	pl 0 do2 rl 0v0
♀ Patella	pl 1do2 rl 1v0	pl 0 do2 rl0 v0	pl 1do2 rl 2 v0	pl 1 do1 rl 2v0	pl 3 do 3 rl3 v0
♀ Tibia	pl 3do2 rl1 v0	pl3 do 2 rl3 v0	pl 3do2 rl 2 v0	pl 2do2 rl2 v1	pl 2 do3rl 3 v0
♀ Metatarsus	Pl3 do3 rl3 v0	pl 3do 3 rl3 v0	pl2 do3 rl3 v0	pl 2 do2 rl2 v0	pl 1 do1 rl 1v0
♀ Tarsus	spineless	spineless	spineless	spineless	spineless
♂ Femur	pl2 do3 rl 3 v0	pl2 do3 rl2 v0	pl1 do3 rl0 v0	pl 3 do3 rl3v0	
♂ Patella	pl 0 do3 rl3 v0	pl3 do2 rl3 v0	pl 2 do2 rl2 v0	Pl 2 do1 rl1v0	
♂ Tibia	pl3 do 2rl3 v0	pl3 do2 rl 3v0	pl 2 do2 rl 2 v0	pl 2 do2 rl 2v0	
♂ Metatarsus	pl 2 do2 rl 2v0	pl2 do3 rl2 v0	pl 3 do3 rl 3 v0	pl3 do3 rl3 v0	
♂ Tarsus	spineless	spineless	spineless	spineless	

Table 1: Spination of leg podomeres of *O. thumboormuzhiensis* sp. nov.

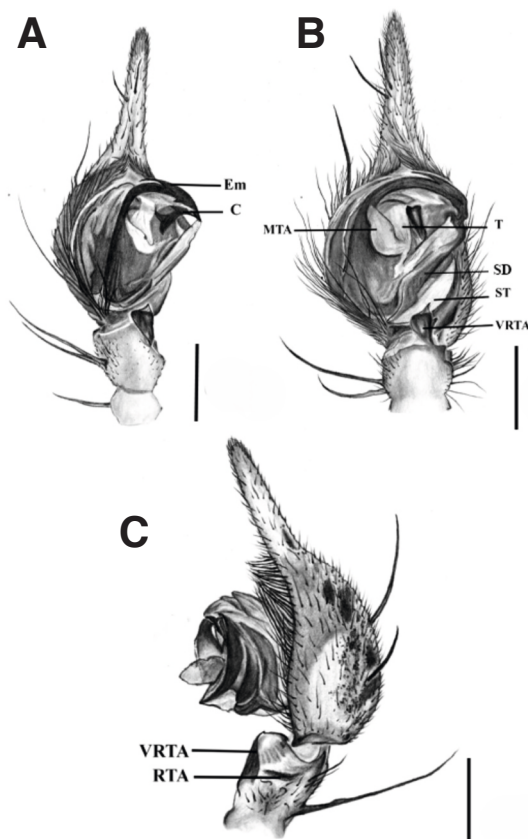


Fig. 3: *Oxyopes thumboormuzhiensis* sp. nov., paratype male. **A** pedipalp, prolateral view; **B** same, ventral view; **C** same, retrolateral view. Scale bars = 0.5 mm

length 4.21, width 0.95. Carapace yellow, pear shaped with pair of narrow orange lines extending from PME to posterior end of carapace and a pair of distinctive, narrow orange band extending from PLE to posterior end of carapace. Fovea longitudinal and reddish. In dorsal view, eyes arranged in four rows with AER strongly recurved and PER procurved. Clypeus high with a pair of black stripes from AME margin to front of each chelicera. Ocular area length 0.43, width 0.48; Eye diameters and inter-distances: AME 0.07, ALE 0.11, PME 0.09, PLE 0.89, eye sizes ALE > PME > PLE > AME; AME-AME 0.34, AME-ALE 0.35, PME-PME 0.14, PME-PLE 0.15, ALE-PLE 0.31, ALE-ALE 0.48, PLE-PLE 0.33. Clypeus height 0.09, Chelicera downward with one promarginal tooth, two retromarginal teeth. Fang is broad at the base and narrowed towards the tip but less pointed. Sternum yellow without hairs. Abdomen fusiform shaped, yellow coloured with orange and light green discontinuous patches. Distal end of the abdomen contains a dark black band just above the spinneret. In ventral view, the abdomen yellow coloured. Legs covered with many conspicuous long spines. Two tarsal claws. Measurements of legs: I 14.49 (3.42 + 0.63 + 4.15 + 4.35 + 1.94), II 13.58 (3.8 + 0.66 + 3.44 + 4.09 + 1.59) III 10.82 (3.29 + 0.57 + 2.81 + 2.77 + 1.38), IV 11.25 (2.61 + 0.82 + 3.41 + 2.67 + 0.74). Leg formula: I>II>IV>III. See Table 1 for spination.

Pedipalp (Figs. 2B–D, 3A–C) the tegular region of pedipalp protruded out from the cymbium. The conductor and the embolus are close and their tip arranged parallelly. Presence of whitish transparent medium tegular apophysis extending broadly from middle of the prolateral side of the

tegulum, strongly curved and narrowed in posterior region of the tegulum again extends linearly, expand and ends just below the conductor. Embolus at 1 o'clock position. Sperm duct convex tubular structure arranged in retrolateral side of the pedipalp. Retrolateral tibial apophysis a narrow black horizontal ridge. Dark, broad ventral tibial apophysis convex towards the tegulum.

Variation: Two female and three male specimens were measured to quantify the morphological variations. Values are mean $\pm$ SD of females (with the male in parentheses). Total length 7.04 $\pm$ 0.6 (6.36 $\pm$ 0.2); cephalothorax length 3.04 $\pm$ 0.5 (2.11 $\pm$ 0.3), width 2.32 $\pm$ 0.2 (1.73 $\pm$ 0.1); abdomen length 3.99 $\pm$ 0.4 (4.21 $\pm$ 0.3), width 1.71 $\pm$ 0.2 (0.95 $\pm$ 0.1). Diameters and inter-distances- AME 0.08 $\pm$ 0.01 (0.20 $\pm$ 0.02), ALE 0.20 $\pm$ 0.00 (0.11 $\pm$ 0.00), PME 0.18 $\pm$ 0.01 (0.09 $\pm$ 0.01), PLE 0.16 $\pm$ 0.01 (0.89 $\pm$ 0.02). AME-AME 0.39 $\pm$ 0.01 (0.34 $\pm$ 0.00), AME-ALE 0.25 $\pm$ 0.02 (0.35 $\pm$ 0.02), PME-PME 0.16 $\pm$ 0.01 (0.14 $\pm$ 0.02), PME-PLE 0.19 $\pm$ 0.02 (0.15 $\pm$ 0.02), ALE-PLE 0.22 $\pm$ 0.01 (0.31 $\pm$ 0.01), ALE-ALE 0.40 $\pm$ 0.03 (0.48 $\pm$ 0.01), PLE-PLE 0.26 $\pm$ 0.02 (0.33 $\pm$ 0.01). Clypeus height 0.46 $\pm$ 0.09 (0.09 $\pm$ 0.04). Palp 3.25 $\pm$ 0.1, leg I 11.68 $\pm$ 1.4 (14.49 $\pm$ 0.2), leg II 10.71 $\pm$ 0.1 (13.58 $\pm$ 0.1), leg III 8.67 $\pm$ 1.2 (10.82 $\pm$ 0.3), leg IV 9.27 $\pm$ 1.3 (11.25 $\pm$ 0.1).

Acknowledgements

We express our deepest gratitude to the Principal, Christ College (Autonomous), Irinjalakuda, Kerala for providing laboratory facilities and University Grants Commission Junior Research Fellowship (920/CSIR UGC NET DEC 2017) for their financial support. The authors also acknowledge the funding rendered by DST-SERB for the facilities used in this study (Major Research Project: EEQ/2021/000453). We thank Asha T. Joy for the illustrations.

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A new species of *Oxyopes* Latreille, 1804 (Araneae: Oxyopidae) from Calicut University Campus, Kerala, India

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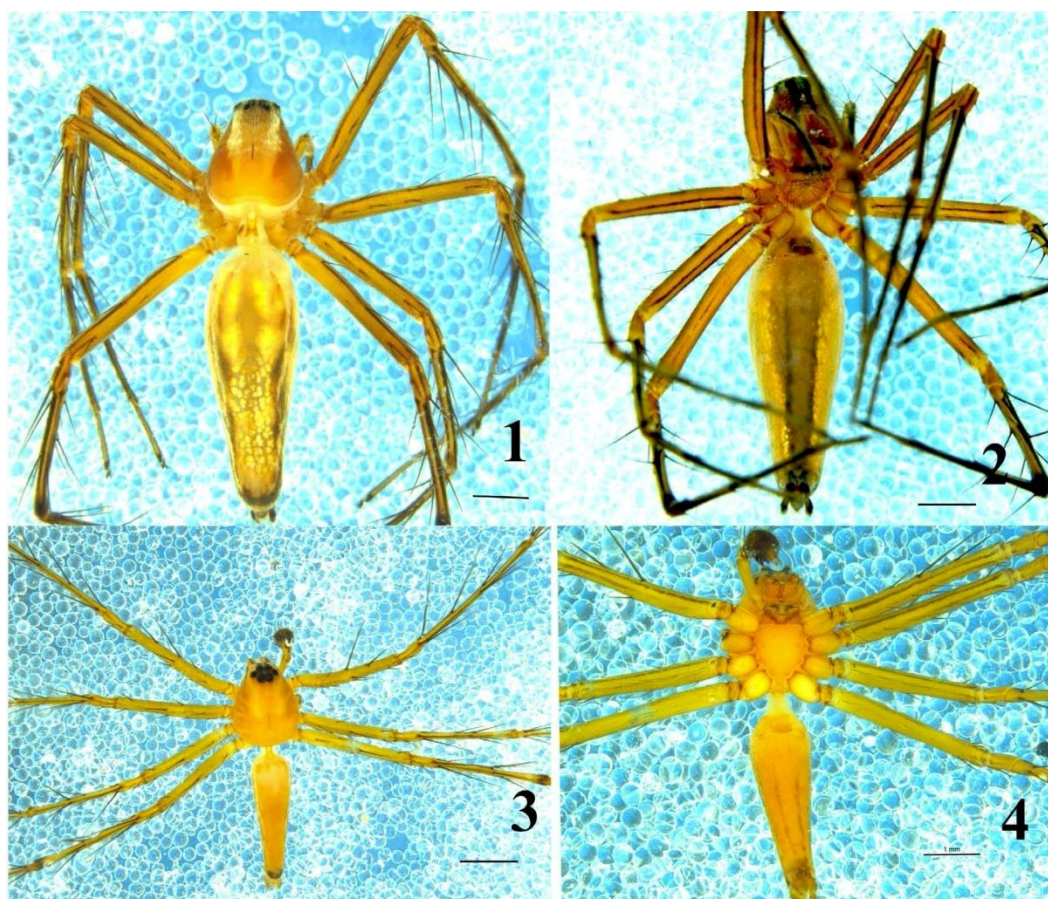
Abstract

A new species from the spider genus *Oxyopes* Latreille, 1804, *Oxyopes peetham* n. sp., is diagnosed and described from the Calicut University Campus, Kerala, India. A detailed morphological description, diagnostic features, and illustrations of the copulatory organs of both sexes of this new species are presented.

Keywords: Oxyopidae, *Oxyopes*, lynx spider, new species, description, Kerala, India.

Introduction

Members of family Oxyopidae are spiny legged hunting spiders which are capable of running very fast and jumping on their prey like a wild cat. Hence, they have got the name lynx spiders. Eight eyes arranged in hexagonal shape with wide clypeus and prominent spines on the legs are the general identifying features of this family. The lynx spider family Oxyopidae Thorell, 1869 is a small family comprising of nine genera and 443 species in the world; of which, 84 species under four genera viz., *Hamadruas* Deeleman-Reinhold, 2009, *Hamataliwa* Keyserling, 1887, *Oxyopes* Latreille, 1804, and *Peucetia* Thorell, 1869, have been reported from India (Gajbe, 2008; World Spider Catalog, 2022). While examining the spider collection from Calicut university campus, we came across a new species of the genus *Oxyopes* which is described and illustrated herein.



Figs. 1-4. *Oxyopes peetham* sp. n., Habitus. 1-2. Holotype Female. 3-4. Paratype Male. 1,3. dorsal view. 2,4. ventral view. (Scale bar: 1 mm).

Material and Methods

A mating pair (♂ & ♀) was collected from the Calicut university campus by handpicking. The specimens were directly transferred to 70% ethanol. The photographs and measurements were taken by using Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver.4.12). Epigyne was dissected and cleared in 10% potassium hydroxide (KOH) solution for one day. Ocular measurements were taken, after placing the specimen, from the dorsal side. The left male pedipalp was dissected and photographed. Leg measurements are showed as: total length (femur, patella, tibia, metatarsus, tarsus). All measurements are in millimetres (mm). The studied specimens are deposited in the reference collection at the Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala, India.

Abbreviations used in the text and figures are as follows: AL = abdomen length, ALE = anterior lateral eye, AME = anterior median eye, AW = abdomen width, C = conductor, CD = copulatory duct, CL = cephalothorax length, CW = cephalothorax width, dRTA = dorsal retrolateral tibial apophysis, dTA = distal tegular apophysis, Em = embolus, FD = fertilization duct, MTA = median tegular apophysis, PLE = posterior lateral eye, PME = posterior median eye, S = spermatheca, SC = scape, SD = sperm duct, ST = subtegulum, T = tegulum, TL = total length, vRTA = ventral retrolateral tibial apophysis (Tang & Li, 2012; Baehr *et al.*, 2017; Lo *et al.*, 2021). Spination abbreviations: do = dorsal, pl = prolateral, rl = retrolateral, v = ventral.

Description

Family Oxyopidae Thorell, 1869

Genus *Oxyopes* Latreille, 1804

Type species *O. heterophthalmus* (Latreille, 1804)

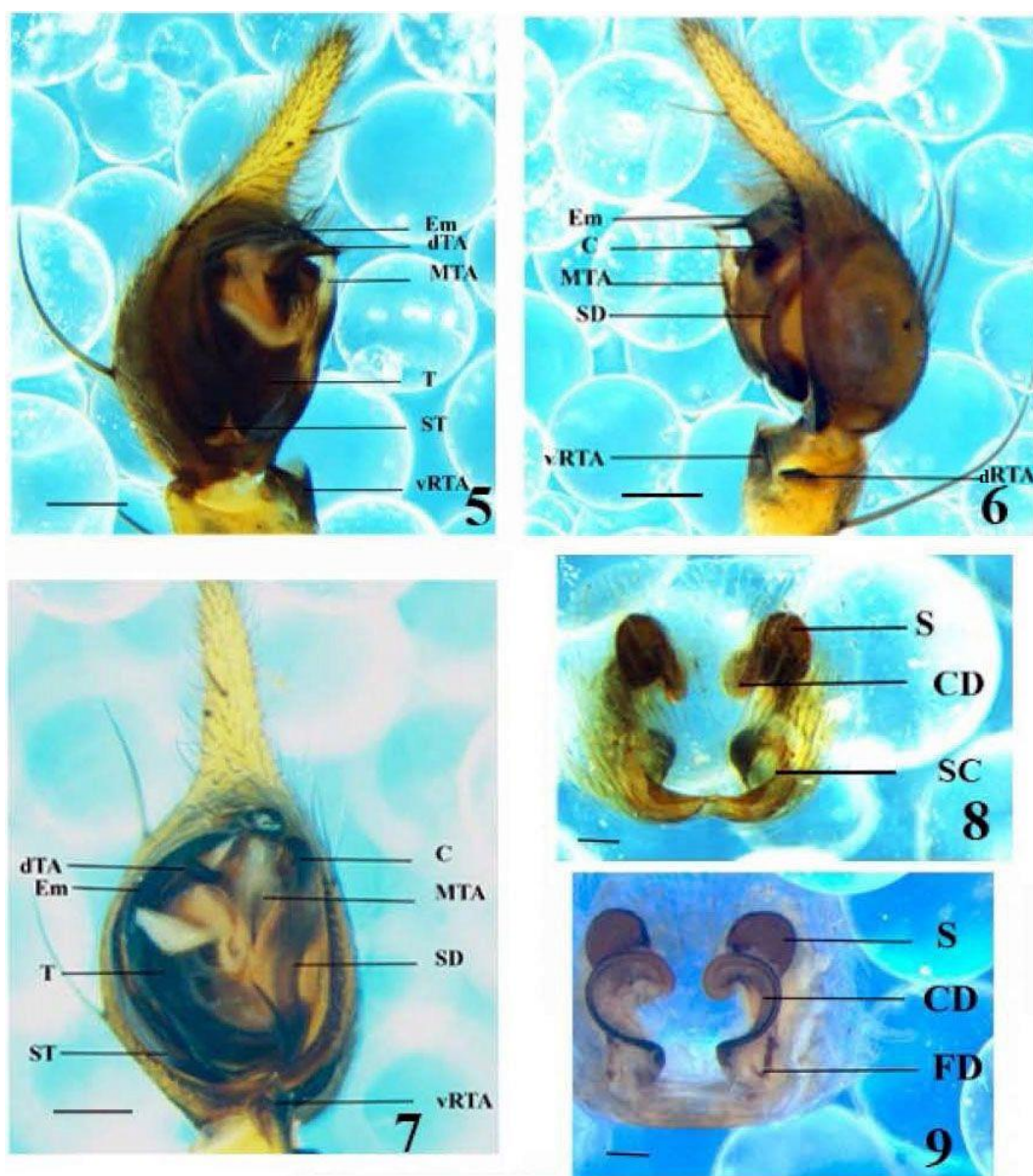
***Oxyopes peetham* sp. n.** (Figs. 1-14)

Material examined: 1♀ (Holotype) (CATE - 800494A), Kerala, Malappuram, Calicut University campus, (11.1340°N, 75.8952°E), 32 m a.s.l., 18.09.2021 K.B. Amulya. 1♂ (Paratype) (CATE - 800494 B), same data of the holotype.

Etymology. The specific name is an adjective in Sanskrit that refers to the yellow coloured body in both sexes.

Diagnosis. *Oxyopes peetham* sp. n. somewhat similar to *O. bharatae* Gajbe, 1999 in epigyne morphology. It could be distinguished from the latter species by the following characters: i) copulatory duct eroteme shaped "?" in ventral view which is coiled into one turn towards the dorsal side and end to spermatheca (this turn absent in *O. bharatae*). ii) Male pedipalp having a prominent ventral tibial apophysis and a pitcher shaped median tegular apophysis. Median tegular apophysis triangular and less prominent in *O. bharatae*. iii) Embolus short and distinguishingly separated from the conductor. Embolus longer and covered with the conductor in *O. bharatae* [cf. figs. 27-30 (Gajbe, 1999), figs. 76-79 (Gajbe, 2008), plates 1A-D, 2A-B (Malik *et al.*, 2016)].

Description. Female (Holotype) (Figs. 1-2, 8-9, 13-14). Measurements: TL 7.45, CL 2.02, CW (at the middle) 1.73, AL 4.54, AW (at the middle) 1.56; ocular area length 0.397, width 0.280; ocular diameter: AME 0.075, ALE 0.149, PME 0.115, PLE 0.0147; ocular inter distance: AME-AME 0.147, AME-ALE 0.076, PME-PME 0.193, PME-PLE 0.277, ALE-PLE 0.248, ALE-ALE 0.109, PLE-PLE 0.748. Clypeus height 0.45. Length of chelicera 0.87. Leg measurements: I 12.17 (3.29, 0.77, 3.44, 3.31, 1.36), II 11.11 (3.34, 0.72, 2.94, 3.09, 1.02), III 8.79 (2.61, 0.63, 2.20, 2.50, 0.85), IV 10.43 (3.19, 0.63, 2.42, 3.23, 0.96). Leg formula 1243. Palp 2.32 (0.85, 0.15, 1.32)[femur, patella+tibia, tarsus]. Spination: Palp: patella do 2, tibia rl 2 pl 2; Legs: femur I-II rl 3 do 3 pl 3, III rl 4 do 2 v 3 pl 4, IV rl 2 do 3 pl 2; patella I rl 1 do 1 pl 1, II rl 2 do 2 rl 2 do 2 pl 2, III rl 1 do 2 v 1 pl 1, IV rl 2 do 2 pl 2; tibia I rl 3 do 3 pl 3, II rl 2 do 2 pl 2, III rl 2 do 2 v 2 pl 2, IV rl 2 do 2 pl 3; metatarsus I-II rl 2 rlv 2 do 2 pl 2, III rl 3 do 3 v 1 pl 3, IV rl 3 do 3 pl 3; tarsus I-IV spineless. Cephalothorax, abdomen and legs yellowish brown in colour, legs with black lines both in dorsal and ventral sides with spines. Cephalothorax posteriorly broad and raised than anterior, narrowly curved anterior tip, carapace with median single and two lateral white bands. Pale red markings on the distal side of carapace. Chelicerae downward with two promarginal teeth, first larger than second, four retromarginal tooth arranged as a distorted quadrangle. Fang is broad at the base and narrowed towards the tip but less pointed. Endite and labium longer than wide. Sternum semi pointed dome shaped with disproportionately arranged setae and yellowish in colour. Abdomen fusiform. Anterior dorsal region is convex and with a distinguishable creamy white marking on the centre. Dark broad bands on lateral and tip of the abdomen. In ventral view, broad dark longitudinal band extends from epigastric furrow to spinnerets. Two tarsal claws. Epigyne less sclerotized with central depression. Copulatory ducts thick and eroteme shaped "?" with anterior end coiled into one turn towards the dorsal side and end with the rounded spermathecae. Fertilization ducts slender and elongated downwards and pointed with a transparent flap at the tip, clearly visible as a separated tube from the copulatory duct (Figs. 8-9, 13-14).



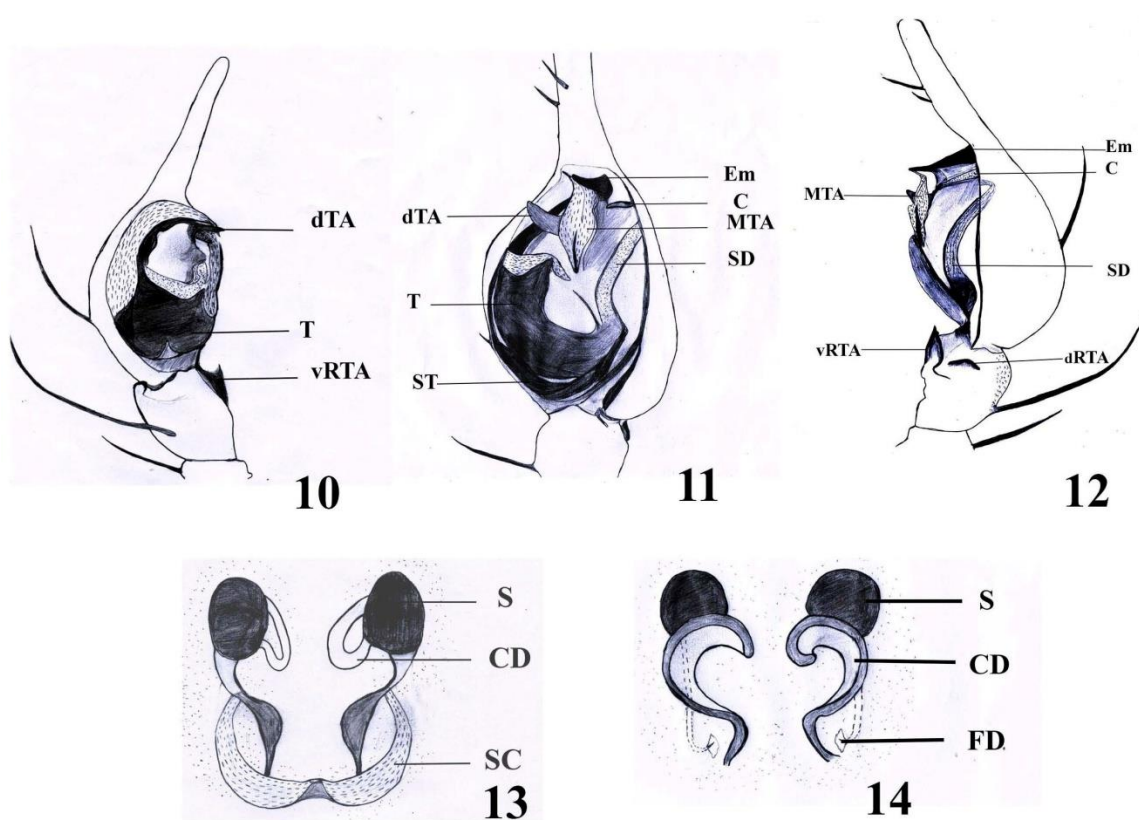
Figs. 5-9. Copulatory organs of *Oxyopes peetham* sp. n. 5-7. Paratype Male, left palp. 5. prolateral view. 6. retrolateral view. 7. ventral view. 8-9. Holotype Female, epigyne. 8. ventral view. 9. dorsal view. (Scale bar: (5-7) 0.5 mm, (8-9) 0.2 mm).

Male. (Paratype) (Figs. 3-7, 10-12). Measurements: TL 5.25, CL 1.58, CW 1.68, AL 2.90, AW 0.82; ocular diameter: AME 0.080, ALE 0.162, PME 0.122, PLE 0.158; ocular distance: AME-AME 0.107, AME-ALE 0.069, PME-PME 0.191, PME-PL 0.188, ALE-PL 0.156, ALE-ALE 0.156, PLE-PL 0.290; Clypeus height 0.38. Length of chelicera 0.85. Leg measurements: I 14.07 (3.58, 0.78, 3.97, 4.02, 1.72), II 11.41 (3.24, 0.61, 3.39, 3.08, 1.09), III 10.12 (2.09, 0.59, 2.90, 3.52, 1.02), IV 10.64 (3.34, 0.57, 1.98, 3.63, 1.12); leg formula 1243. Spination: Legs: femur I-II rl 3 do 3 pl 3, III rl 4 do 2 v 3 pl 4 IV rl 2 do 3 pl 2, patella I rl 1 do 1 pl 1, II rl 2 do 2 pl 2, III rl 1 do 2 v 1 pl 1, IV rl 2 do 2 pl 2, tibia I rl 3 do 3 pl 3, II rl 2 do 2 pl 2, III rl 2 do 2 v 2 pl 2, IV rl 2 do 2 pl 3; metatarsus I-II rl 2 rlv 2 do 2 pl 2, III rl 3 do 3 v 1 pl 3, IV rl 3 do 3 pl 3, tarsus I-IV spineless. Cephalothorax and abdomen pale yellow in colour without any characteristic markings. Abdomen narrowed and in ventral view, two narrow dark longitudinal lines extend from epigastric furrow to spinnerets. Legs pale yellow in colour. Chelicera downwards and has

one promarginal and one retromarginal teeth. The sternum is oil lantern chimney shaped without any setae. Palp: tibia with distinct retrolateral depression between the two adjacent apophyses; ventral retrolateral tibial apophysis large pointed, retrolateral apophysis smaller and ridge shaped; cymbium with elongated anterior apophysis; conductor black not coiled with embolus; embolus slender, originating at 5.30 o'clock position and encompassing prolateral side of genital bulb to 1 o'clock position; median tegular apophysis white pitcher shaped, distal tegular apophysis sclerotized (Figs. 5-7, 10-12).

Distribution. Known only from the type locality.

Natural History. *Oxyopes* species are usually occupied in garden areas and grasslands. Mostly they occur in open vegetation. Mature males and females can be collected during August-September months.



Figs. 10-14. Copulatory organs of *Oxyopes peetham* sp. n. 10-12. Paratype Male, left palp. 10. prolateral view. 11. ventral view. 12. retrolateral view. 13-14. Holotype Female, epigyne. 13. ventral view. 14. dorsal view. (Scale bar: (5-7) 0.5 mm, (8-9) 0.2 mm).

Acknowledgments

We express our deepest gratitude to the Principal, Christ College (Autonomous), Irinjalakuda, Kerala for providing laboratory facilities and University Grants Commission Junior Research Fellowship (920/CSIR UGC NET DEC 2017) for their financial support. The authors also acknowledge the funding rendered by DST-SERB for the facilities used in this study (Major Research Project: EMR/2016/006401).

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A new lynx spider of the genus *Hamataliwa* Keyserling, 1887 (Araneae: Oxyopidae) from Kerala, India

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Abstract

Hamataliwa crista sp. n. female is collected from Pathiramanal Island of Alappuzha district of Kerala. This species is somewhat resembling to *Hamataliwa foveata* Tang & Li, 2012 by considering its external morphology. At the same time, it shows greater variance from its counterpart in their epigyne structure. A detailed morphological description, diagnostic features of the copulatory organ of the new species *Hamataliwa crista* sp. n. collected from Pathiramanal Island are given.

Keywords: Oxyopidae, *Hamataliwa*, Lynx spider, new species, description, Kerala, India.

Introduction

Thorell (1869) established the family Oxyopidae. It is a fairly small family hosting 9 genera, 437 species, and 5 subspecies (World Spider Catalog, 2022) including genus *Hamataliwa* Keyserling, 1887. These small to large sized spiders are distinguished by three tarsal claws, prominent setae on legs, and four distinct rows of eyes (2-2-2-2), mainly inhabiting panicles of plants, leaves of the grasses and on other weeds found along field margins (Zhang & Zhu, 2005). Only seven species of *Hamataliwa* were identified from India (Caleb & Sankaran, 2022; World Spider Catalog, 2022). Many species of this genus are arboreal in habit and found on barks of trees and twigs or woody

shrubs (Brady, 1970), with relatively drab body colour, long hairs on the legs and opisthosoma, and weakly developed last two pairs of legs (Zhang *et al.*, 2005). The aim of the present study is to present the record and description of a new species of genus *Hamataliwa* collected from Pathiramanal Island of Kerala, India.

Material and Methods

One specimen was collected from Pathiramanal Island by handpicking and directly transferred to 70% ethanol. The photographs and measurements were taken by using Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver.4.12). Epigyne was dissected and cleared in 10% potassium hydroxide (KOH) solution for one day. Ocular measurements were taken from the dorsal side. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). All measurements are in millimetres (mm). The studied specimen was deposited in the reference collection at the Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala, India.

Abbreviations used in the text and figures are as follows: AL = abdomen length, ALE = anterior lateral eye, AME = anterior median eye, AW = abdomen width, CD = copulatory duct, CL = cephalothorax length, CW = cephalothorax width, ECD = extension of the copulatory duct, FD = fertilization duct, PLE = posterior lateral eye, PME = posterior median eye, S = spermatheca, TL = total length (Tang & Li, 2012; Baehr *et al.*, 2017; Lo *et al.*, 2021). Spination abbreviations: do = dorsal, pl = prolateral, rl = retrolateral, v = ventral.

Results

Hamataliwa crista sp. n.

Material examined: ♀ (Holotype) from Pathiramanal Island (9°37'7.82"N, 76°23'7.04"E), Kerala, India, collected on 27 December 2021, K.B. Amulya.

Etymology: The noun *Crista* denotes to the comb like extension of the copulatory duct; it is from the Latin for *crest* or *plume*.

Diagnosis: This species can be separated from other congeneric species on the basis of the structure of the epigyne. External morphology of *Hamataliwa crista* sp. n. more or less similar to *Hamataliwa foveata* Tang & Li, 2012. At the same instant there is a remarkable difference in the structure of the epigyne. The structure of epigyne shows some similarity with *Hamataliwa pentagona* Tang & Li, 2012. The spermatheca is large in *H. pentagona* but it is small and oval shaped in *H. crista*. Presence of a comb like structure on posterior end of the epigyne which is absent in *H. pentagona*. The void space in epigyne is pentagon shaped in *H. pentagona* but it nearly spades shaped in *H. crista*.

Description. Female (Holotype, Fig. 1A): Measurements: TL 4.487, CL 1.869, CW (at the middle) 1.932, AL 2.618, AW (at the middle) 1.649; ocular area length 0.484, width 0.228, ocular diameters AME 0.072, ALE 0.281, PME 0.184, PLE 0.193, ocular inter distances: AME–AME 0.172, AME–ALE 0.200, PME–PME 0.382, PME–PLE 0.377, ALE–PLE 0.284, ALE–ALE 0.125, PLE–PLE 0.407. Clypeus height 0.427. Length of chelicera 1.331. Palp and leg measurements: palp 2.662 (0.720, 0.358, 0.523, 1.061), leg I 5.873 (1.801, 0.734, 1.403, 1.160, 0.775), II 6.130 (2.051, 0.663, 1.212, 1.566, 0.638), III 9.239 (3.138, 0.850, 2.521, 1.803, 0.927), IV 8.274 (2.617, 0.724, 2.329, 1.771, 0.833). Leg formula III-IV-II-I. Spination of legs: femur I rl 2 do 3 pl 3, II rl 1 do 1 pl 2, III rl 0

do 2 v 3 pl 2, IV rl 1 do 3 pl 1; patella I rl 1 do 2 pl 2, II rl 1 do 2 pl 0, III rl 1 do 2 pl 2, IV rl 0 do 3 pl 0; tibia I rl 2 do 3 pl 2, II rl 3 do 3 pl 2, III rl 3 do 2 pl 2, IV rl 0 do 3 pl 2; metatarsus I rl 2 do 3 pl 2, II rl 3 rlv 2 do 3 pl 3, III rl 3 do 3 v 1 pl 3, IV rl 3 do 3 pl 3 rlv 2; tarsus I–IV spineless and two clawed. Cephalothorax yellowish brown in colour, ocular region profusely covered with tiny hairs. Chelicerae is long with one retromarginal tooth, promarginal teeth absent. Abdomen is slightly triangular towards the anterior end. Yellowish colour with dark brown patches on the lateral and middle of the abdomen. Anterior end of the abdomen highly convex.

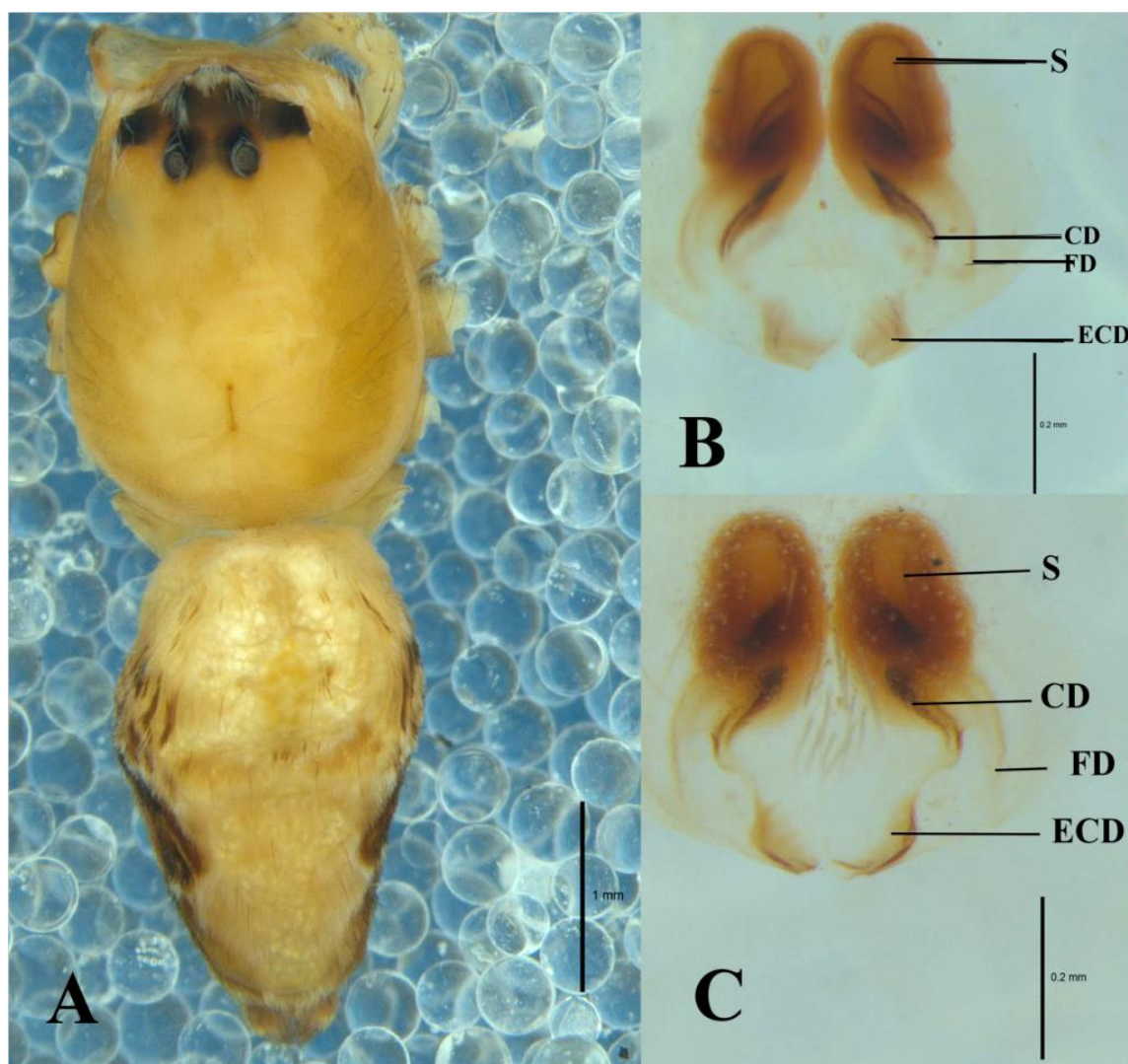


Fig. 1. *Hamataliwa crista* sp. n. ♀ Holotype. A. Habitus, dorsal view. B-C. Epigyne. B. dorsal view. C. ventral view.

Epigyne (Figs. 1B-C): highly sclerotised, spermatheca oval in shape, fertilization duct and copulatory duct short and their opening in parallel positions. The copulatory duct extends with a comb like structure.

Natural History: The specimen was collected from low level grass, and shrubs (vegetable plants in the wild) in December. *Hamataliwa* species was found in a cage made up of rotten leaf like material. Hence, it shows a mimicking behaviour. It is difficult to identify the species from its surroundings.

Acknowledgments

We express our deepest gratitude to the Principal, Christ College (Autonomous), Irinjalakuda, Kerala for providing laboratory facilities and University Grants Commission Junior Research Fellowship (920/CSIR UGC NET DEC 2017) for their financial support. The authors also acknowledge the funding rendered by DST-SERB for the facilities used in this study (Major Research Project EEQ 2021/00453).

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Plate 42



Fig.1 *Allamanda cathartica* **Fig.2** *Alternanthera sessilis* **Fig.3** *Amaranthus viridis*



Fig.4 *Araucaria heterophylla* **Fig.5** *Aristolochia indica* **Fig.6** *Asystasia gangetica*

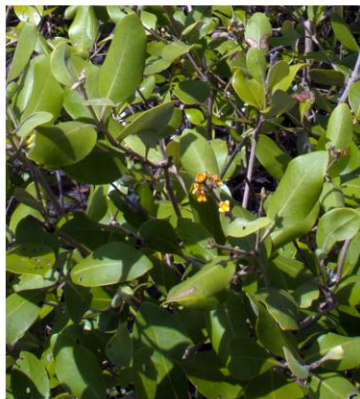


Fig.7 *Avicennia marina* **Fig.8** *Baliospermum montanum* **Fig.9** *Bambusa tuldoidea*

Plate 43



Fig.10 *Benkara malabarica*



Fig.11 *Blachia umbellate*



Fig.12 *Boerhavia diffusa*



Fig.13 *Bougainvillea glabra*



Fig.14 *B. spectabilis shubra*



Fig.15 *Brachiara mutica*



Fig.16 *Caesalpinia coriaria*



Fig.17 *Camonea umbellata*



Fig.18 *Capsicum annum*

Plate 44



Fig.19 *Cayratia pedata*



Fig.20 *C. intermedium*



Fig.21 *Chamaecrista absus*



Fig.22 *Chamaecrista kleinii*



Fig.23 *Chloris barbata*



Fig.24 *Chromolaena odorata*



Fig.25 *Cissus vitiginea*



Fig.26 *Clerodendrum paniculatum*



Fig.27 *Clidemia hirta*

Plate 45



Fig.28 *Coronopus didymus*



Fig. 29 *Cosmos sulphureus*



Fig.30 *Croton hirtus*



Fig.31 *Cyanchum laeve*



Fig.32 *Cynodon dactylon*



Fig.33 *Datura ferox*



Fig.34 *Delonix regia*



Fig.35 *D. clandestinum*



Fig. 36 *Digitaria bicornis*

Plate 46



Fig.37 *Eugenia mooniana*



Fig.38 *Euryops pectinatus*



Fig.39 *Hibiscus aculeatus*



Fig.40 *Hibiscus ovalifolius*



Fig.41 *Hibiscus radiatus*



Fig.42 *Hyptis capitata*



Fig.43 *Hyptis suaveolens*



Fig.44 *Impatiens walleriana*

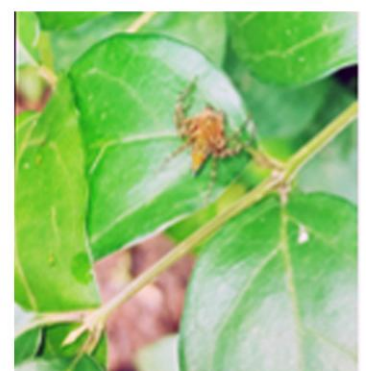


Fig.45 *Jasminum sambac*



Fig.46 *Lantana Camera*



Fig.47 *Lantana montevidensis*



Fig.48 *Lantana trifolia*

Plate 47



Fig.49 *L. leucocephalia* Fig.50 *Melastoma candidum* Fig.51 *Microcos paniculata*



Fig.52 *Mikania micrantha*

Fig.53 *Mimosa pudica*

Fig.54 *Moringa oleifera*

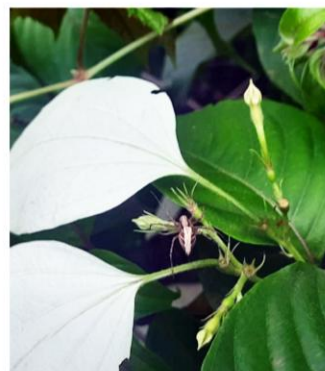


Fig.55 *Muccuna bracteata* Fig.56 *Muntingia calabura* Fig.57 *Mussaenda frondosa*



Fig.58 *Myriactis nepalensis*

Fig.59 *Nerium oleander*

Fig.60 *Nicotiana tabacum*

Plate 48



Fig.61 *O. tenuiflorum*



Fig.62 *O. gratissimum*



Fig.63 *Otacanthus caeruleus*



Fig.64 *Passiflora vesicaria*



Fig.65 *P. clandestinum*



Fig.66 *P. pedicellatum*



Fig.67 *P. polystachion*



Fig.68 *Phyllanthus myrtifolius*



Fig.69 *P. reticularis*



Fig.70 *Pueraria phaseoloides*



Fig.71 *Rosa alba*



Fig.72 *Rosa rubiginosa*

Plate 49



Fig.73 *Ruellia elegans*



Fig.74 *Sida cordifolia*



Fig.75 *Sphaeranthus indicus*



Fig.76 *Sphagneticola trilobata*



Fig.77 *S. lanatus*



Fig. 78 *Stachytarpheta indica*



Fig. 79 *Tagetes erecta.*



Fig.80 *Tibouchina urbilleana*



Fig.81 *Tradescantia zebrina*

Plate 50



Fig.82 *Trema orientalis*



Fig.83 *Tridax procumbens*



Fig.84 *Urena lobata*



Fig. 85 *W. antidysenterica*



Fig.86 *X. chrysanthus*



Fig. 87 *Xanthium strumarium*



Fig. 88 *Ziziphus oenoplia*