MOLECULAR TAXONOMY AND PHYLOGENETICS OF WOLF SPIDERS (ARANEAE: LYCOSIDAE) IN KERALA

Thesis submitted for the degree of

DOCTOR OF PHILOSOPHY IN ZOOLOGY

Under the Faculty of Science
University of Calicut

by

ABHIJITH R.S.
Department of Zoology
Christ College (Autonomous)
Irinjalakuda, Thrissur, Kerala-680125

Under the supervision of

Prof. (Dr.) SHEEBA P.
Professor
Department of Zoology
Vimala College (Autonomous)
Thrissur, Kerala
&
Dr. SUDHIKUMAR A.V. (Co-guide)
Associate Professor
Department of Zoology
Christ College (Autonomous)
Irinjalakuda, Kerala

September 2025

DECLARATION

I, **Abhijith R. S.,** hereby declare that the work embodied in this thesis, "**MOLECULAR TAXONOMY AND PHYLOGENETICS OF WOLF SPIDERS (ARANEAE: LYCOSIDAE) IN 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 Prof.(Dr.) Sheeba P., Professor, Vimala College (Autonomous), Thrissur and Dr. Sudhikumar A. V., Associate Professor, Department of Zoology, Christ College (Autonomous), Irinjalakuda, affiliated to the 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 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.

Signature:

Name of the Scholar: **Abhijith R. S.**

Signature of the Supervisor:

Name: **Prof. (Dr.) Sheeba P.**

Prof. (Dr.) SHEEBA P
Professor & Research Guide
Department of Zoology
Vimala College (Autonomous)
Thrissur

Signature of Co-supervisor:

Name: **Dr. Sudhikumar A. V.**

Dr. SUDHIKUMAR A.V.
ASSISTANT PROFESSOR & RESEARCH SUPERVISOR
CENTRE FOR ANIMAL TAXONOMY & ECOLOGY
DEPARTMENT OF ZOOLOGY
CHRIST COLLEGE, IRINJALAKUDA, KERALA - 680 125

Place: Irinjalakuda

Date: 16/09/2025

CERTIFICATE

This is to certify that the thesis titled “**MOLECULAR TAXONOMY AND PHYLOGENETICS OF WOLF SPIDERS (ARANEAE: LYCOSIDAE) IN KERALA**” submitted to the University of Calicut in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Zoology is an authentic record of the research work carried out by **Mr. Abhijith R. S.** under my supervision in the Department of Zoology, Christ College (Autonomous), Irinjalakuda, affiliated to the 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. It is further certified that the corrections/suggestions recommended by the adjudicators have been incorporated into the thesis and the contents of the thesis and the softcopy are one and the same.

Signature of Research Supervisor:

Prof. (Dr.) SHEEBA P
Professor & Research Guide
Department of Zoology
Vimala College (Autonomous)
Thrissur

CERTIFICATE

This is to certify that the thesis titled "**MOLECULAR TAXONOMY AND PHYLOGENETICS OF WOLF SPIDERS (ARANEAE: LYCOSIDAE) IN KERALA**" submitted to the University of Calicut in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Zoology is an authentic record of the research work carried out by **Mr. Abhijith R. S.** under my supervision in the Department of Zoology, Christ College (Autonomous), Irinjalakuda, affiliated to the 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. It is further certified that the corrections/suggestions recommended by the adjudicators have been incorporated into the thesis and the contents of the thesis and the softcopy are one and the same.

Signature of Research Co-Supervisor:

Dr. SUDHIKUMAR A.V.
ASSISTANT PROFESSOR & RESEARCH SUPERVISOR
CENTRE FOR ANIMAL TAXONOMY & ECOLOGY
DEPARTMENT OF ZOOLOGY
CHRIST COLLEGE, IRINJALAKUDA, KERALA - 680 125

CERTIFICATE

This is to certify that **Mr. Abhijith R.S.** has completed the research work for the entire period prescribed under the PhD ordinance of the University of Calicut. This thesis, "**MOLECULAR TAXONOMY AND PHYLOGENETICS OF WOLF SPIDERS (ARANEAE: LYCOSIDAE) IN KERALA**", embodies the results of his investigations conducted during the period in which he worked as a research scholar. I recommend that the thesis be submitted for evaluation for the Doctor of Philosophy in Zoology degree award from the University of Calicut.

Head of the Institution

Fr. Dr. Jolly Andrews
Associate Professor -
In-Charge of Principal
Christ College (Autonomous)
Irinjalakuda

Irinjalakuda

16/09/2025

UNIVERSITY OF CALICUT

CERTIFICATE ON PLAGIARISM CHECK

<table>
<tr><td>1.</td><td>Name of the Research Scholar</td><td colspan="2">Abhijith R.S.</td></tr>
<tr><td>2.</td><td>Title of thesis / dissertation</td><td colspan="2">Molecular Taxonomy and Phylogenetics of Wolf Spiders (Araneae: Lycosidae) In Kerala</td></tr>
<tr><td>3.</td><td>Name of the Supervisor</td><td colspan="2">Dr. Sheeba P.
Dr. Sudhikumar A. V. (Co-guide)</td></tr>
<tr><td>4.</td><td>Department/Institution</td><td colspan="2">Department of Zoology, Christ College (Autonomous), Irinjalakuda, Thrissur</td></tr>
<tr><td rowspan="4">5.</td><td rowspan="3">Similar content (%) identified</td><td>Non-Core</td><td>Core</td></tr>
<tr><td>Introduction/ Theoretical overview/Review of literature/ Materials & Methods/ Methodology</td><td>Analysis/Result/Discussion/ Summary/Conclusion/ Recommendations</td></tr>
<tr><td>7</td><td>6</td></tr>
<tr><td>Acceptable maximum limit (%)</td><td>10</td><td>10</td></tr>
<tr><td>6.</td><td>Software used</td><td colspan="2">iThenticate</td></tr>
<tr><td>7.</td><td>Date of verification</td><td colspan="2">Mon May 05 2025 00:00:00 GMT+0530 (India Standard Time)</td></tr>
</table>

**Report on plagiarism check, specifying included/excluded items with % of similarity to beattached.*

Checked by (with name, designation & signature)

Dr. Nasirudheen. T
Assistant Librarian
University of Calicut, Kerala.

Name and signature of the Researcher

ABHIJITH R.S.

Name and signature of the Supervisor.

Dr. Sheeba P.

Dr. Sudhikumar A. V.

The Doctoral Committee* has verified the report on plagiarism check with the contents of the thesis, as summarized above and appropriate measures have been taken to ensure originality of the Research accomplished herein.

Prof. (Dr.) SHEEBA P
Professor & Research Guide
Department of Zoology
Vimala College (Autonomous)
Thrissur

Dr. SUDHIKUMAR A. V.
ASSISTANT PROFESSOR & RESEARCH SUPERVISOR
CENTRE FOR ANIMAL TAXONOMY & ECOLOGY
DEPARTMENT OF ZOOLOGY
CHRIST COLLEGE, IRINJALAKUDA, KERALA - 680 125

Name & Signature of the HoD/HoI (Chairperson of the Doctoral Committee)

**In case of languages like Malayalam, Tamil etc..on which no software is available for plagiarism check, a manual check shall be made by the Doctoral Committee, for which an additional certificate has to be attached.*

Fr. Dr. Jolly Andrews
Associate Professor -
In-Charge of Principal
Christ College (Autonomous)
Irinjalakuda

ACKNOWLEGEMENTS

I would like to begin by sincerely thanking all those who have supported and guided me throughout the course of this research. I am especially grateful to my research supervisors, ***Prof. (Dr) Sheeba P.*** *and* ***Dr. Sudhikumar A. V.****, for their invaluable guidance, constant encouragement, and insightful feedback, which have been instrumental in shaping the direction and depth of my work.*

I also wish to express my heartfelt gratitude to ***Rev. Dr. Jolly Andrews CMI****, Principal of Christ College (Autonomous), Irinjalakuda, for his inspiration and support. My sincere thanks go to all the* ***faculty members of the Department of Zoology, Christ College (Autonomous), Irinjalakuda****, for their academic and moral support throughout this journey.*

I am indebted to ***Prof. (Dr) Nasser M.****,* ***Prof. (Dr) Pushpalatha E.****, and* ***Dr. Binu Ramachandran****, all present and former subject experts at the University of Calicut, for their constructive suggestions and valuable guidance, which significantly contributed to the quality of this research.*

I am deeply grateful to all my teachers—from kindergarten to post-graduation—whose dedication and wisdom have helped shape me into the person I am today. In particular, I would like to acknowledge ***Dr. Hashim M. S.****, all my teachers from the* ***Department of Zoology at Sacred Heart College, Thevara****, and the faculty of the* ***Department of Zoology at DB Pampa College, Parumala****, for laying a strong academic foundation.*

This research has greatly benefitted from the collaborative spirit and support of my fellow researchers at Christ College and beyond. Their camaraderie and insights created a peaceful and intellectually stimulating environment. I am especially thankful to my colleagues in the ***CATE Lab****,* ***SERL****,* ***Entomo Lab****, and* ***Immutox Lab****. A few individuals deserve special mention for their exceptional support:* ***Dr. Sudhin P. P.****,* ***Ms. Athira Jose****,* ***Mr. Suryanarayanan T. B.****,* ***Mr. Adarsh P. K.****,* ***Mr. Sibi K. K.****,* ***Ms. Reshma R.****,* ***Ms. Anjana, Ms. Anju K. Baby, Mrs. Aswathy Sivaraman*** *and* ***Ms. Sushama V.*** *Their companionship and collaboration have enriched my experience in numerous ways.*

I extend my sincere thanks to the ***Council of Scientific and Industrial Research (CSIR)*** *for providing* ***JRF/SRF financial assistance****, without which this research would not have been possible.*

Most importantly, this thesis would not have come to fruition without the unwavering support and love of my family. I will forever cherish the strength and patience of my beloved wife, ***Gayathri A. M.****, who stood by me during difficult times, sacrificing her time and enduring my moments of frustration with grace and understanding. My heartfelt thanks also go to my loving parents,* ***Mr. Raveendran Nair*** *and* ***Mrs. Sudha Kumari****, for their lifelong encouragement and constant support during this phase. I am equally grateful to my sister,* ***Aparna R. S.****, for her affection and encouragement throughout this journey. I would also like to thank my in-laws—* ***Mr. Raghavan Nair****,* ***Mrs. Shyamala****, and* ***Mr. Shivaprasad****—for their unwavering support, especially during the final stages of my work. The prayers, blessings and helps of my grandparents, aunts, uncles and cousins especially* ***Mr. Vinay M. U.*** *and* ***Mr. Adarsh S.*** *have been a constant source of strength, and I am deeply thankful for their presence in my life. I cannot forget to acknowledge my dear friend,* ***Ms. Shabna Nair****, whose companionship and emotional support helped lighten the mental burden during challenging times.*

A special thanks to my pet dog, ***Simba****, whose comfort and presence, especially during the isolating days of the COVID-19 pandemic, offered much-needed solace and joy.*

Above all, I am deeply thankful to ***Nature****—for allowing me to live, for guiding me through this journey, and for providing the inspiration and resources that made this work possible. In this spirit, I humbly acknowledge the* ***'Sarva Charaacharam'****—all living and non-living beings around me—whose silent presence and interconnectedness played a profound role in making this journey possible.*

Abhijith R.S.

“The Spider is a repairer. If you bash into the web of a spider, she doesn’t get mad. She weaves and repairs it.”

- Louise Bourgeois, *French-American artist*

Contents

Chapter 5

APPENDIX

LIST OF FIGURES

LIST OF TABLES

Objectives

The study is focussed on following objectives:

1) Collection and description of Lycosidae from Kerala.
2) Barcoding of collected lycosids using molecular markers.
3) Study the interrelationship between collected members of Lycosidae in Kerala.
4) Study the relationship of Lycosids of Kerala with other selected Lycosids across the world.
5) Investigate the monophyly of lycosids in Kerala.

Structure of thesis

Chapter 1: Introduction

Chapter 2: Review of literature

Chapter 3: Methodology

Chapter 4: Results

4.1: Systematics of collected species

This sub-chapter deals with the classical taxonomy of collected spiders. Description of all identified species, new species, new reports and redescriptions are provided.

4.2: Molecular barcode of collected species

Partial genomic sequence of Cytochrome C Oxidase subunit I of all the identified specimens are presented here.

4.3: Phylogenetic analysis

Last three objectives of the studies are addressed in this sub-chapter. The molecular data are analysed with Maximum Parsimony, Maximum Likelihood and Bayesian Inference. The resulting phylogenetic trees are analysed to infer the evolutionary relationship between lycosids in Kerala and with lycosids around the world. The chapter also investigates whether the lycosids found in Kerala are monophyletic or not.

Chapter 5: Discussion

Summary and Conclusion

Recommendations

References

Appendices: A map of collection location, all research papers and presentations that were carried out during the course of this study are presented here.

സംഗ്രഹം

ലൈക്കോസിഡേ എന്ന ചെന്നായ ചിലന്തി കുടുംബം ലോകത്തിലെ അഞ്ചാമത്തെ വലിയ ചിലന്തി കുടുംബമായി പരിഗണിക്കപ്പെടുന്നു. കേരളത്തിലെ വിവിധ ആവാസവ്യവസ്ഥകളിൽ നിന്നുള്ള ചെന്നായ ചിലന്തികളുടെ തന്മാത്രാ ജീവശാസ്ത്രപരമായ വർഗ്ഗീകരണവും പരിണാമ പഠനവും ആണ് ഈ ഗവേഷണത്തിലൂടെ ഉദ്ദേശിച്ചിരിക്കുന്നത്. രൂപപരമായി ഏറെ സാമ്യങ്ങളുള്ള ഇവയുടെ പരമ്പരാഗത വർഗീകരണം പ്രയാസകരമാണ്. ഈ പ്രശ്നങ്ങൾ മറികടക്കുന്നതിന് പരമ്പരാഗത രൂപപരിശോധനയും ആധുനിക മോളിക്യൂലർ സാങ്കേതിക വിദ്യകളും സംയോജിപ്പിച്ച സമന്വിത വർഗീകരണം ആണ് ഈ പഠനത്തിൽ കൈക്കൊണ്ടിരിക്കുന്നത്. പഠനത്തിൽ ആകെ ആറു ജനുസ്സുകളിലായി 25 ജീവജാതികൾ ശേഖരിക്കപ്പെട്ടു. ഇവയിൽ രണ്ട് പുതിയ ജീവജാതികളെ (ഡ്രാപോസ സെബാസ്റ്റിയാനി, വാഡികോസ ഇന്റർമീഡിയേറ്റാ) ആദ്യമായി കണ്ടെത്തപ്പെട്ടു. പാർഡോസ മുകുന്ദി എന്ന സ്പീഷീസിനെ ട്രോക്കോസ ജനുസിലേക്ക് മാറ്റുകയും, പാർഡോസ മൈസോറൻസിസ് എന്ന സ്പീഷീസിനെ പാർഡോസ സുമാത്രാനായുമായി സംയോജിപ്പിക്കുകയും ചെയ്തു. മൂന്ന് ചിലന്തികൾ ഇന്ത്യയിൽ നിന്ന് (പാർഡോസ ഓറിയൻസ്, പാർഡോസ ചാപ്പിനി, ട്രോക്കോസ ഹോംഗിയാനാ), രണ്ട് സ്പീഷീസുകൾ പശ്ചിമഘട്ടത്തിൽ നിന്ന് (പാർഡോസ പരതോംപ്സോനി, ട്രോക്കോസ മുകുന്ദി), ഒൻപത് സ്പീഷീസുകൾ കേരളത്തിൽ നിന്നും ആദ്യമായി രേഖപ്പെടുത്തപ്പെട്ടു. അപൂർണ്ണവും അസ്പഷ്ടവുമായ വിവരണങ്ങളുള്ള നാല് സ്പീഷീസുകൾ (പാർഡോസ സുമാത്രാനാ, പാർഡോസ ഓറിയൻസ്, ഡ്രാപോസ ബുറാസന്തിയൻസിസ്, ട്രോക്കോസ മുകുന്ദി) പുനർവിവരിക്കപ്പെട്ടു. ജനിതക വിശകലനത്തിന് മൈറ്റോകോണ്ട്രിയൽ സൈറ്റോക്രോം സി ഓക്സിഡേസ് സബ് യൂണിറ്റ് 1 ജനിതകം ഉപയോഗിച്ചു. മാക്സിമം പാർസിമണി, മാക്സിമം ലൈക്ലിഹുഡ്, ബയേഷ്യൻ ഇൻഫറൻസ് എന്നിവ ഉപയോഗപ്പെടുത്തി പരിണാമ ചരിത്രവും ബന്ധവും പഠന വിധേയമാക്കി. ഇവയുടെ ഫലങ്ങൾ ട്രോക്കോസ മുകുന്ദിയുടെ ജനുസ് മാറ്റം സ്ഥിരീകരിക്കുകയും, ഹിപ്പാസിനേ, സോയിസിനേ,

വെനോണിനേ എന്ന ഉപകുടുംബങ്ങളുടെ പുനഃസ്ഥാപനം പിന്തുണയ്ക്കുകയും, വാഡികോസിനേ ഉപകുടുംബത്തെ പാർഡോസിനേയുമായി സംയോജിപ്പിക്കുന്നത് ശരിവെക്കുകയും ചെയ്തു. എന്നാൽ പാർഡോസിനേയെ ലൈക്കോസിനേയിൽ സംയോജിപ്പിക്കാനുള്ള നിലവിലുള്ള ചില കാഴ്ചപ്പാടുകൾക്ക് ഈ പഠനം പിന്തുണ നൽകുന്നില്ല. പാർഡോസ നെബുലോസ ഗ്രൂപ്പ് പാർഡോസിനേ ഉപകുടുംബത്തിൽ തന്നെ നിലനിൽക്കപ്പെടുമെന്നും പഠനം വ്യക്തമാക്കുന്നു. ഇതുകൂടാതെ, കേരളത്തിലെ ലൈക്കോസിഡുകൾ ഒരേ വംശത്തിൽ നിന്നുള്ളവയല്ലെന്നതും ഫലങ്ങൾ തെളിയിക്കുന്നു.

കേരളത്തിലെ ചെന്നായ ചിലന്തികളെ പറ്റിയുള്ള ആദ്യ സമഗ്ര പഠനമായ ഈ ഗവേഷണം ഇന്ത്യൻ ചിലന്തികളുടെ അപൂർണമായ മോളിക്യൂലർ വിവര ശേഖരത്തിൽ വലിയ സംഭാവന നൽകുന്നു. ഇന്ത്യയിലെ ചിലന്തി ജൈവവൈവിധ്യത്തെ കൂടുതൽ മനസ്സിലാക്കാനും ഈ പഠനം നിർണായകമാണ്.

ABSTRACT

Lycosidae, wolf spiders are the fifth largest spider family in the world. The present study investigates the molecular taxonomy and phylogeny of wolf spiders from diverse habitats across Kerala, India. Lycosids, a highly diverse and ecologically significant group of ground-dwelling spiders, are often morphologically similar, making species-level identification using classical taxonomy alone problematic. To overcome these limitations, this study employed an integrative taxonomic approach combining traditional morphological identification with modern molecular techniques. The study resulting in the collection of 25 species representing six. Among them two new species were reported to science (*D. sebastiani* and *W. intermediata*). One of the species was transferred from the genus *Pardosa* to *Trochosa* (*T. mukundi*). Another species *P. mysorensis* is synonymized with *P. sumatrana*. Three species were first reported from India (*P. oriens, P. chapini* and *T. hongianna*) and two species were first reported from Western Ghats region (*P. parathompsoni* and *T. mukundi*). Nine species were reported from state of Kerala for the first time. Four species, with inadequate and obscure descriptions were redescribed during the study (*P. sumatrana, P. oriens, D. burasantiensis* and *T. mukundi*). The mitochondrial Cytochrome C Oxidase subunit I (COI) gene was used for DNA barcoding. Phylogenetic relationships were inferred using Maximum Parsimony (MP), Maximum Likelihood (ML), and Bayesian Inference (BI) methods. Phylogenetic analyses provided accurate subfamily and genera level grouping of lycosids. Phylogeny results confirmed the genus transfer of *T. mukundi*. The results support the revalidation of sub-family Hippasinae, Zoicinae and Venoniinae and the synonymization of sub-family Wadicosinae to Pardosinae. The phylogeny trees disagree with the synonymization of the sub-family Pardosinae with Lycosinae and confirm the positioning of *P. nebulosa* species group within Pardosinae. The phylogenetic study also found that the lycosids in Kerala are not monophyletic in origin. This research represents one of the first exclusive taxonomic and phylogenetic studies on wolf spiders in Kerala and contributes significantly to the sparse molecular data available for Indian lycosids. The results emphasize the utility of combining morphological and molecular methods to resolve cryptic species complexes and enhance our understanding of spider biodiversity.

Key words: Wolf spiders, Lycosidae, Phylogeny, COI, Kerala

Chapter 1

Introduction

INTRODUCTION

Our home, the Earth is going through an unprecedented biodiversity crisis. Many reasons can be stated but, the role of humans in it is much evident. Every organism is selfish and greedy in its way. Unknowingly all of them try to propagate maximum and establish continuity of their genome. But, apart from humans all others do it in a natural way, without completely destroying everything around them. In other words, nature has direct control over its selfishness and propagation. But, in the case of humans, we try to overcome that control through various methods. Even though it is not completely possible, prevailing over this control sometimes creates havoc around us. It's an irony that, we are the only organisms who can understand the science behind the working principle of nature and doing everything to disrupt it. In the Jurassic era reptiles ruled the earth and now humans are dominating. Reptiles in the Jurassic era may have gained some characteristics through random mutations which got selected by natural selection. In the same way humans also gain dominance. But there are differences in these two reigning. Jurassic reptiles just lived their life, ate, propagated and died. They never deliberately try to interfere the natural way; they never try to postpone their death and they did not even desire to dominate the world. The conditions put them into that position. But in the case of humans, after gaining an advantage from natural selection, we continuously try to alter these conditions. It directly and indirectly poked the nature. Simplistically all other dominant creatures in their own respective periods rule the earth, but we humans try to rule the earth as well as nature and this created all the differences.

Nature has ways to mend its anomalies. It recovered from so many mass extinctions, calamities etc. We usually proclaim about protecting nature. Who are we to protect? Are we strong enough to do so? The answer is "no". As Chief Seattle once said we are a mere strand in the web of nature. The first knowledge that should be inculcated in our minds is about the limitations of the human race. We are part of nature, probably a very unimportant part. So never try to 'protect' it, just 'step back' from the wrongdoings, all the restorations would be done by the nature itself. We should back-track so that the normality of nature can be restored. Still, we should not surrender our enthusiasm, we need to know about the fellow organisms around us, we need the data about the negative impact we are radiating into the biota. For that we need persons who have interest in nature and document it.

Taxonomy, the art of classification can be considered as the base of all biological researches. Every application-level biological research which benefits nature or mankind initiates from a taxonomic work. Figuratively styled, enthusiasm of taxonomists, through butterfly-effects result in most of the advancements in the life sciences. Developments and lack of confusions in taxonomic field will aid in the betterment of applied research.

Each and every organism in the biota is essential for the maintenance of the ecosystem. We humans may categorize them as more or less beneficial according to anthropocentric perspective. Truly we cannot make such a distinction. Here comes the importance of taxonomy, the science of identification and classification of organisms. These studies are needed to make a quantitative data for the organisms and make realize the human about the degree of destruction they make. Classification of living organisms has immense importance in current scenario where rate of species loss is at an alarming scale. A precise database of every organism is necessary to estimate this loss as well as design various proactive and reactive strategies. The extent of undescribed species will be much higher for invertebrates. Using novel technologies of molecular biology in combination with classical taxonomy, the aim of quantification of biodiversity of our nature is very likely.

The usage of molecular technologies in taxonomy will improve the credibility of the identification. This will also make the phylogenetic studies easier. Morphological classification alone and may lead to incomplete or wrong conclusions. These cons can be overcome to an extent by the aid of molecular techniques.

1.1. Incredible Spiders

Spiders can be found everywhere. They belong to the phylum Arthropoda, the most diverse and dominant phylum. The reason behind the dominance of arthropods is adaptations acquired by them to survive in diverse and adverse conditions. Spiders also inherit these adaptations, results in their success. Spiders are usually seen as a scary creature around the world. Still, they are part of various folk stories, epics and comics in various cultures. The Greek mythological story of Athena and Arachne, about the origin of spiders is the most famous one. The story of spider and Scotland's King Robert Bruce is one of the famous inspirational stories for kids around the world. Let us not forget about the modern hero like Spiderman. These all indicate the influence of spider morphology and ethology on various cultures around the world. According to large scale sculpturer Louise Bourgeois, spider is a direct metaphor for care and protection of mother towards her family. Her famous spider sculptures are stored in various countries like Brazil, Russia, France etc.

Spiders are arthropods belong to the order Araneae, which constitutes seventh largest order in the living world (Coddington & Levi, 1991). The order further divided into Mesothelae and Opisthothelae. Mesothelae contains only an extant family, Liphistiidae, the most basal living spiders. Opisthothelae contains infraorders Mygalomorphae and Araneomorphae. Mygalomorphs are comparatively ancient with two pairs of spinnerets and upward-downward movement of chelicerae. Araneomorphs include a lion share of spiders, characterized by opposing vertical movement of chelicerae and three pairs of spinnerets.

Spider's body is divided into cephalothorax (prosoma) and abdomen (opisthosoma), connected by a pedicel. Cephalothorax is the fusion of head and thorax, which houses eyes, chelicerae, mouthparts and five pairs of appendages. The anterior end of carapace bears simple eyes. The number, spacing, size and arrangement of eyes are important in family level identification. For example, lycosids have 8 eyes, arranged as three rows, 2-2-4. The chelicerae have multiple functions such as prey capture, courtship display and defence. Each chelicera has a paturon and a fang. Spider venom gland is connected to the fang. Spiders have five pairs of appendages, one pair pedipalp and four pairs of legs. Each leg is composed of coxa, trochanter, femur, patella, tibia, metatarsus and tarsus. Claws present on the tarsal segment. Claw number and arrangement differ with lifestyle of the spider. The abdomen holds the external openings of different systems such as respiratory, digestive, reproductory and silk glands. Female spiders have external genitalia called epigyne present on the ventral side of abdomen. Spinnerets are present on the posterior end of abdomen through which spider silk is being secreted. Modern spiders usually have three pairs of spinnerets.

Mating of spiders occur when a mature male with sperm-charged palp transfer sperm into the epigyne of female. Usually females are larger than males, but, in groups like Lycosidae, sexual dimorphism is less evident. Various kinds of copulatory behaviours are present among spiders. Mating dance, nuptial gifts, mate binding, mating plugs etc. can be observed (Zhang et al., 2011). Fertilized eggs are secreted and stored in a silk-woven egg case. This egg case protects the eggs from desiccation and other external adversities. Parental care can be observed in many groups of spiders. For example, wolf spiders especially members of genus *Pardosa* carry their young ones on abdomen. Lycosids even help the spiderlings to hatch from the egg case by cutting the rim of the cocoon using chelicerae a few days prior to hatching. Once directly disturbed, the spiderlings scatter to the surroundings and regroup on the abdomen after a while. Some other spiders guard egg cases and carry them along themselves. Ways in which egg case being carried also differ among families. Lycosidae attach the egg case on the spinnerets and carry it along, Pisauridae members attach the case to chelicera and Sparassidae hold it close to sternum. The spiderlings after several moulting reach adulthood with developed copulatory organs. The characteristics of copulatory organs are the most accurate factors in species level identification. Even the colouration and patterns may differ in early moults making classical taxonomical identification difficult.

To escape from predators and for capturing food spiders exhibit camouflage and mimicry. Various members of Thomisidae and Salticidae have colouration similar to flowers and leaves which make them almost impossible to detect. Lycosids are very dull coloured, but this might help them to be in camouflage with the ground. Various spiders mimic various living and non-living things such as sticks, bird droppings, ants etc. Ant-mimicking spiders can be seen in various families such as Salticidae, Corinnidae etc.

They are incredible creatures found in various habitats around the world. Because of their foraging behaviour, they are considered to be a voracious predator in terrestrial ecosystem. They control the insect population and thus indirectly help the mankind by reducing pest population (Nyfeller, 1982). Spiders are amongst the main predators in most of the ecosystems (Whitehouse & Lawrence, 2001). Spiders are one of the most abundant insectivorous predators of terrestrial ecosystems (Nyffeler & Benz, 1987; Wise, 1993). They have been reported to occur in peak numbers of more than 1,000 individuals per m^2

(Nyffeler & Birkhofer, 2017). Not only abundant, but they are one of the most diverse arthropod orders, with diverse species and exhibit a great variety of foraging strategies (Coddington & Levi, 1991; Foelix, 1996). The various foraging strategies can be attributed to better predatory control of insects and ecological importance. Because of their high abundance and insectivorous feeding habits, spiders are expected to play an important role in the balance of nature (Whitcomb, 1974; Gertsch, 1979; Luczak, 1979; Young & Edwards, 1990; Wise, 1993; Nyffeler et al., 1994a, b). In agro-ecosystems also they play an immense role as natural predators of insect pests.

They also manifest an immense role in food web and maintain the decorum of the ecosystem. Another important aspect of spiders is spider silk and its immense applications (Lewis, 2006). Another promising field of research is spider venom therapeutics. Most spider venoms are dominated by disulfide-rich peptides that typically have high affinity and specificity for particular subtypes of ion channels and receptors (Saez et al., 2010). Research on spider silk and venom along with ecological and phylogenetic studies will gain much importance in research scenario due to its direct application to mankind. These may make the spider more charismatic to general public and led to the avoidance of unwanted killing and destruction of habitat.

1.2. Lycosidae- the wolf spiders

A wide diversity of spider lives in arable lands, of which wolf spiders are one of the most abundant families (Sebastian & Peter, 2009). Lycosidae Sundevall, 1833 constitute the fifth largest spider family, with 2491 species described in 135 genera (World Spider Catalog (WSC), 2025). Various sub-family classification can be seen throughout history, but, most reliable one proposes 10 subfamilies, viz. Pardosinae, Lycosinae, Evippinae, Hippasinae, Tricassinae, Sossipinae, Artoriinae, Allocosinae, Venoniinae and Zoicinae. (Piacentini & Ramirez, 2019). Their adult body size ranges from 1 to 30 mm. They occupy various terrestrial habitats and one of the most dominant predators. They are most common in grasslands where insect food supply is abundant. Some wolf spiders build retreats, leave them only for hunting and mating (Barrion & Litsinger, 1995).

Pardosa, Wadicosa, Draposa etc. are the most common ground dwelling lycosids present in our area. Among these *Pardosa* is the largest genus which includes many species with more similarity and can be distinguished only by thorough examination. *Draposa* is relatively newly described genus, which includes *Pardosa*-like spiders. Even the name *Draposa* is an anagram of *Pardosa*, which stipulates their similarity (Kronestedt, 2010). Most of the *Wadicosa* species were once placed in *Pardosa* and many more *Wadicosa* species may still be present in *Pardosa* (Kronestedt, 2023). Many species were synonymized and genera transferred in this family. Synonymizations are not only limited to species, even sub-families got synonymized. In 2019, Piacentini & Ramirez synonymized subfamily Wadicosinae with Pardosinae and Piratinae with Zoicinae. These similarities result in making the morphological taxonomy of this group a difficult one. Each specimen requires individual attention and detailed examination of genitalia. Members of genus *Hippasa* construct funnel web, a dense woven sheet on ground or dense vegetation with a funnel in the middle. Unlike other lycosid genera, *Hippasa* species have large posterior spinnerets, clearly linking towards the web construction (Platnick, 2020). Among these, only *Lycosa* and *Hippasa* can be easily identifiable on field, every other requires laboratory examination.

They pursue an array of different prey capture strategies, from permanently vagrant hunters to permanently burrowing species, and some genera are known to build permanent sheet-webs (Murphy et al., 2006). Wolf spiders also differ in their diurnal activity patterns, which mean that they only forage on insects, which are active at the same time during the day (Marshall et al., 2002). Wolf spiders may also show very specific microhabitat preferences and may be susceptible to changes in habitat structure (Marshall & Rypstra, 1999; Jogar et al., 2004). This ecological diversity may make them suitable for the control of a wide variety of insect pests. They also manifest an immense role in the food web and maintain the decorum of the ecosystem. Web building spiders are generally thought to be most primitive among lycosids, this postulation has never been tested by an authentic phylogeny study.

Fossil records of lycosids are sparse compared to other families, indicating that they evolved as a separate family recently (Wunderlich, 2004). Extreme abundance of them in grasslands, absence in deep forests and morphological similarity between species stipulate that they had a recent origin and may have co-evolved with grasslands since Miocene (Piacentini & Ramirez, 2019). It is almost impossible to separate members of *Pardosa*, which is the largest lycosids genus (Platnick, 2020).

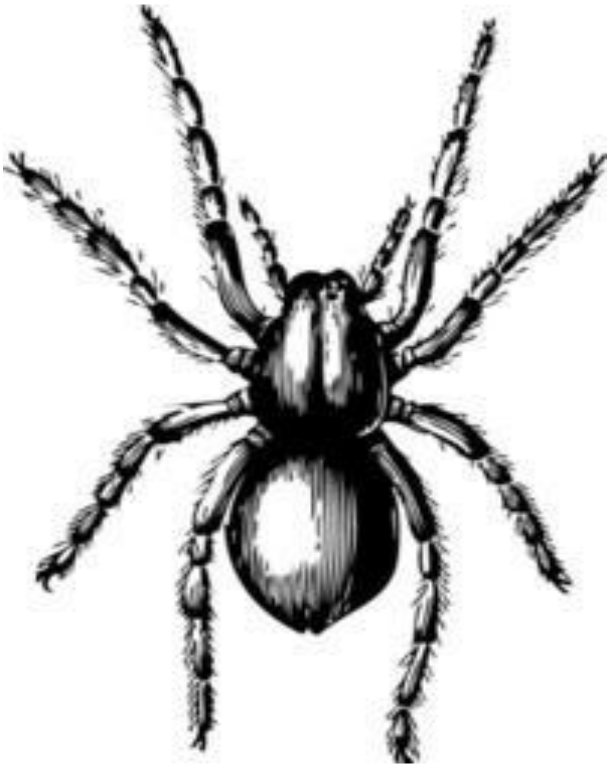
The monophyly of the Lycosidae is well supported, but relationships within the family are poorly understood and a stable subfamily level classification does not exist, as current schemes are almost exclusively based upon the structure of genitalia (Griswold, 1993; Zyuzin, 1993; Sierwald, 2000; Yoo & Framenau, 2006).

Climate change and global warming has influential effects on behaviour and ecology of lycosids. It is found that some of the wolf spider species start to increase its foraging quantity in order to maintain body moisture during increasing ambient temperature (Drisya-Mohan et al., 2019). So, the classification and phylogeny of wolf spider is very important and will serve as a direct indicator of ecosystem health.

1.3. Molecular taxonomy and phylogeny of spiders in India

Morphological taxonomy or classical taxonomy is a well-established field and never loses its importance in the field of biodiversity. However, sole reliability on the morphology can led to the misidentification, results in synonymy. The aid of molecular techniques can somewhat overcome the problem and help the classical taxonomy to reach a newer height of increased credibility. Initially DNA based taxonomy was much costlier than classical taxonomy. Now a lot of optimisations are happening so that costs will reduce, but still, it is costlier than traditional taxonomy. However, the benefits of molecular taxonomy outweigh the cost. Molecular taxonomy utilizes various molecular markers for the creation of molecular barcodes. Many molecular markers are in use but, Cytochrome C Oxidase subunit 1 (COI) is considered to be the best and hence it is widely used as a molecular marker. As a normal barcode uniquely defines a product, a molecular barcode can represent a whole organism. This concept already altered the taxonomic view point in a positive way. Still a lot of species are unknown. It is the duty of taxonomists to identify them and report them to the scientific world before they extinct from the biosphere. In India the use of molecular taxonomy is still coping up the pace. Use of molecular techniques with traditional taxonomy will make a paradigm shift in the taxonomic field in India. Preparation of DNA barcode will ease the comparison of species and will aid in the removal of discrepancies from the taxonomy.

Current status of molecular taxonomy of spiders especially lycosids in India is not appreciable. Compared to many other countries the entries to BOLD systems from India are much lesser. Recently most of the taxonomists are showing interests in addition of molecular techniques along with classical approach. So, it is evident that in the near future the contribution from India to BOLD systems will increase considerably.



Chapter 2

Review of Literature

REVIEW OF LITERATURE

Lycosids are group of spiders which require very thorough examinations for identification. Many species and genera within this family are look-alike resulting in various misinterpretations. So even though many studies are present related to lycosids, many of the early classical studies lack merit in current scenario. Only in-detail morphological works and recent molecular works can take into consideration with full confidence while surveying the literature. A large number of synonymisations and genus transfers can be observed in their taxonomical studies. They are the direct indicators of above-mentioned factors. But still, we could not rely solely on molecular data. As suggested by Zamani et al. (2022) molecular barcodes alone are not enough to describe a new taxon. Morphological descriptions with details are required along with molecular data for further affirmation and analysis. In many general diversity studies species level or even genus level identification of lycosids often omitted because of these difficulties.

Large scale taxonomic works on lycosids can be seen in late 1800s and early 1900s. Gravely (1924) conducted a wide-ranging study on Indian lycosids. He described various genera including *Lycosa, Pardosa, Hippasa* etc. with taxonomic keys and genitalic illustrations. B.K. Tikader, former director of Zoological Survey of India, contributed immensely towards the lycosid taxonomy. He discovered various new species and deposited the types in ZSI, Kolkata. Tikader & Malhothra (1980) published Fauna India (Araneae) series with an exclusive chapter for Lycosidae, which describes almost all the lycosid species recorded from Indian subcontinent along with new species descriptions. This can be considered as a pioneer work in Indian lycosid taxonomy after independence.

Many students of Tikader from ZSI also contributed to Indian lycosid taxonomy in further years.

To date, no remarkable study on diversity and taxonomy of wolf spiders has been reported from the state of Kerala. In most of the general faunistic study of spiders, diversity of wolf spiders mentioned in the form of checklists. Sebastian et al. (2005) explored the spider fauna of Mangalavanam, an eco-sensitive urban forest in Kochi and reported 2 species of lycosids belonging to 2 genera. Sudhikumar et al. (2005) studied the spider fauna of Mannavan Shola of Kerala, and reported 6 species of lycosids under 3 genera. Sudhikumar & Sebastian (2005) studied the spider fauna of Kuttanad paddy fields of Kerala, and reported 9 species of lycosids under 4 genera. Sunil et al. (2008) reported 12 species of lycosids under 5 genera from Parambikulam wildlife sanctuary of Kerala. Sudhin et al. (2015) reported 6 species of wolf spiders under 4 genera from the banks of Chaliyar River. Sudhikumar & Nafin (2018) studied the spider fauna of Muriyad kol wetlands and reported 4 species of wolf spiders under 3 genera. Sudhin et al. (2018) reported 12 species of wolf spiders under 4 genera from Wayanad wildlife sanctuary. Sudhikumar et al. (2008) reported 20 species of lycosids under 6 genera from the Western Ghats region of India. Sebastian & Peter (2009) listed 126 species of wolf spiders under 17 genera all over India. Recently Lu et al. (2016) redescribed 4 species of wolf spiders from India. Sankaran et al. (2021a, b) and Sankaran & Caleb (2023a, b) reviewed museum specimens of lycosids from India. Compared to Indian research much more studies are done all over the world. Even though the studies exclusively focusing on Lycosidae are less compared to other families of spiders. Dondale (1986) divided the Lycosidae into five subfamilies and examined the relationships between them, but only 25 of the 99 currently recognised lycosid genera were explicitly assigned to these subfamilies. Other subfamilies have since been added (Alderweireldt & Jocque, 1993) but they are all based on Holarctic and African species. Heimer & Nentwig (1991) revised European lycosids at generic level. Dondale & Redner (1978a, b), Russell-Smith (1982), Dondale & Redner (1983a, b), Alderweireldt & Jocque (1991) and Alderweireldt (1999) revised Nearctic and African genera.

2.1. Phylogenetic studies on wolf spiders

Various classical taxonomic works on lycosids can be traced from 18th century. Works in lycosids using modern techniques can be traced back to 1980s when Elliot et al. (1982) examined allozymic variation of nine protein producing loci in three species of *Pardosa* using starch gel electrophoresis. They published the study quoting genetic variation among three species of *Pardosa.*

Griswold (1993) studied about evolution of Lycosoidae and its kins. It was not an exclusive study on lycosids and also not based on molecular data. Purely morphological analysis based on SEM analysis still proved the monophyletic origin of lycosids.

Jiman & Song (1996) studied the phylogeny of Chinese wolf spiders. This study was based on morphological and ecological parameters. The result shows that Lycosidae can be divided into five subfamilies: Hippasinae, Hygrolycosinae, Arctosinae, Lycosinae and Pardosinae. Hippasinae found to be the most primitive of all, then *Hygrolycosa*, *Arctosa* and *Trochosa*, Lycosinae and Pardosinae being the most advanced. They suggested that *Arctosa* and *Trochosa* should be separated from Lycosinae and grouped together as a new subfamily Arctosinae. They also recommended establishing a new subfamily Hygrolycosinae to accommodate the genus *Hygrolycosa*.

The pioneer work in molecular phylogeny of lycosids was done by Zehethofer & Sturmbauer (1998). They utilized the 12S rRNA molecular marker to study interrelationship between 27 lycosid species belongs to 6 genera and 4 sub-families from central Europe. *Pirata* emerged as the most ancient branch and *Arctosa* appeared as sister group of *Alopecosa, Trochosa* and *Pardosa*. They concluded that, among the three different types of predations in Lycosids, tube builders appear to be the most ancient, from which burrow dwellers branched out and from which two groups of hunters evolved in parallel.

Vink (2002) studied the molecular phylogeny of lycosids in New Zealand and Australia which highly enriched the molecular phylogeny database of lycosids. Vink utilized data from nuclear gene NADH Dehydrogenase subunit 1 (ND1) and mitochondrial genes Cytochrome C Oxidase subunit 1 (CO1) and 12S rRNA gene. These data were combined with molecular data of Asian, European and North American lycosids to perform phylogeny studies. Studies confirmed that Australasian species form distinct clade from other groups. Vink's studies also revealed the utility of 12S rRNA gene data for examining closely related genera and its limitation to study deeper generic relationships.

One of the greatest spider palaeontologists Wunderlich (2004) proposed that the Lycosids are relatively younger spider family. Jocqué & Alderweireldt (2005) backed the proposal. They also hypothesized that lycosids co-evolved with grasslands. Abundance of lycosids in habitats with low vegetation, rareness in forests, fossil record from Miocene onwards etc. backed this hypothesis.

Murphy et al. (2006) studied lycosid molecular data from Africa, Asia and Neotropics using 28S rRNA, 12S rRNA and ND1 as molecular markers. Along with Parsimony analysis, they also utilized Bayesian analysis for phylogenetic studies. They were sceptical about the usage of 28S rRNA as it gave implausible results and omitted it from final analysis. They also sequenced paralogous copies of the gene and suggested cautionary approach for its further usage in lycosid phylogeny. Dimitrov et al. (2017)

reinstated the usage of this marker in studies of ecribillate spiders. But, as Murphy questioned the credibility of 28S rRNA marker specifically in lycosids, it will be better to use other markers in lycosids until further modifications in 28S rRNA analysis.

Systematics of the new Australian wolf spider genus *Tuberculosa* was done by Framenau & Yoo (2006). Although the study was based on morphological data, phylogenetic analysis was performed on four *Tuberculosa* species based on 12 morphological characters. Various evolutionary data of the *Tuberculosa* genus were revealed. Yoo & Framenau (2006) also studied the phylogeny of genus *Venonia* and suggested the revalidation of subfamily Venoniinae and Zoicinae.

Yan & Yan (2007) studied phylogenetic relationships of *Wadicosa* in China. Mitochondrial 16S rRNA gene sequence was utilized to analyse 26 species from 6 genera of Lycosidae. Bayesian and Maximum Parsimony analyses were used for phylogenetic analysis. The results indicated that *Wadicosa* has the closest phylogenetic relationship with *Pardosa*. *Pardosa* and *Wadicosa* form a monophyletic group. They suggested the merging of *Pardosa* and *Wadicosa* to a subfamily.

Chang, Song & Zhou (2007) investigated the genetic structure of mitochondrial DNA (COI and 16S rRNA) and nuclear DNA (ITS2) variations among and within populations of *Pardosa astrigera* in China.

Ramírez et al. (2010) tested species boundaries in *Pardosa sierra* using female morphology and mitochondrial COI data. This study removed the synonymy of two species with *P. sierra* and revalidated the species status of *P. atromedia* and *P. sura*.

Polotow et al. (2015) studied the total evidence analysis of the phylogenetic relationships of Lycosoidea spiders. The study was so extensive, which include molecular and morphological data from 7 families in Lycosoidea superfamily. The morphological–

behavioural matrix comprised 96 characters, and four gene fragments were used: 28S rRNA (~737 base pairs), actin (~371 base pairs), COI (~630 base pairs) and H3 (~354 base pairs). Monophyly of the Lycosidae family and evolution of grate shaped tapetum concluded in the study.

An extensive and elaborate molecular work was carried out by Astrin et al. (2016) as a part of German Barcode of Life Campaign (GBOL). In this study they created DNA barcode reference database for spiders and harvestmen of Germany. Even though the study was a great success, it was found almost impossible to distinguish some of the Lycosidae, especially species within a species-group, from each other using DNA barcodes. They hypothesised this shallow mitochondrial divergence may be due to complex sexual behaviour which led to quick speciation through sexual selection.

A morphologically similar species from *Pardosa lugrubis*- group is found to be a novel species through molecular techniques by Nadolny et al. (2016). The new species has very similar copulatory organs with another species in the group. Some other somatic characters are different and the confirmation of new species was solely by molecular data.

Albo et al. (2017) conducted molecular phylogenetic analyses to show that family Trechaleidae and Lycosidae are sister groups. Morphological and behavioural studies gave contradictory findings on evolutionary relationships. So, they have done the molecular phylogeny using five mitochondrial and 3 nuclear genes to reach the conclusion.

Blagoev, deWaard & Hebert (2017) formulated a DNA barcode reference library for Nearctic wolf spiders. 170 morphospecies were barcoded in this study. The results state that Nearctic lycosids can be effectively identified by DNA barcoding.

Framenau & Hudson (2017) studied the morphological and ecological phylogeny of halo-tolerant wolf spider genus *Tetralycosa* in Australia. The analysis resulted in a monophyletic clade of 8 species that are endemic to barren lands of Salt lakes. It suggests that a single evolutionary radiation may happened into this highly inhospitable environment. Many of them are highly specialized to inhabit only single Salt Lake which increases the importance of protecting these ecosystems also.

Just et al. (2019) studied molecular phylogeny of genus *Alopecosa* from central Europe to compare it with reproductive behaviour. They sequenced one mitochondrial (COI) and two nuclear genes (28S, H3) to reconstruct their phylogeny. The results of the phylogenetic analyses were largely incompatible with classical morphology-based grouping. The monophyly of *Alopecosa* could not be recovered by the study. Both Bayesian Inference and Maximum Likelihood were conducted. In both the genus showed to split into two different clades.

Mito-nuclear discordance is defined as a significant difference in levels of differentiation between nuclear and mitochondrial markers. It can happen with both biological or induced by operational factors and complicate the process of species identification and delimitation. Ivanov, Lee & Mutanen (2018) studied molecular discordance in wolf spiders using ddRADseq. The results indicated that the observed cases of mito-nuclear discordance were not due to operational reasons but from biological processes.

Piacentini & Ramírez (2019) conducted a broad phylogenetic analysis of wolf spiders with extensive geographic sampling from all the known Lycosidae subfamilies. They introduced two new molecular markers to lycosid molecular phylogeny, H3 and COI. This study synonymized subfamilies Piratinae and Wadicosinae with Zoicinae and Pardosinae, respectively. They also revalidated the subfamily Hippasinae. The study revealed that lycosids are relatively young group of spiders which diversified with reduction of forests and advancement of open habitats like grasslands. In other words, lycosids co-evolved with grasslands.

Tahir et al. (2019) formulated DNA barcodes of spiders in agricultural fields. They retrieved 658 COI base pair sequence of 90 specimens belong to 47 species from agriculture fields of district Layyah, Punjab, Pakistan. They found that 88% of the morpho-species are accurate and used molecular data to correctly place misplaced species. Ivanov et al. (2021) studied the relevance of ddRAD sequencing method for species and population delimitation of two closely related *Pardosa* species, *P. riparia* and *P. palustris.* Allopatric population of these two species were sampled from entire Europe including Russia and analysed by morphological, DNA barcoding and double-digest restriction site associated DNA sequencing. This study proved ddRAD sequencing as a powerful tool for taxonomy and change the status of Russian species to subspecies.

Differences in number and location of 18S rRNA gene sites and heterochromatic blocks of three *Lycosa* species were analysed by Cavenagh et al. (2022). The study concluded that a wide variation exists in chromosomal features among and within *L. erythrognatha*, *L. sericovittata* and *L. nordenskjoldi.*

Divergence time estimation was utilized to found out origin of Hogna species by Crespo et al. (2022) by analysing samples from Madeira Island endemics. Species boundaries of Hogna were also examined by integrating molecular and morphological data. This study validated the co-evolution of wolf spiders with expansion of grasslands. The origin of these organisms found to have occurred in late Miocene, when the earth was cooling off and associated expansion of grasslands.

Starrett et al. (2022) employed phylogenomic approach using anchored hybrid enrichment to generate a data set comprising about 400 loci representing a sample of 23 species of Nearctic *Schizocosa*. They utilized various other lycosid genera as outgroups. The study concluded that new-world *Schizocosa* are not forming a monophyletic group and many of the species are not genetically exclusive, thus their status becomes doubtful.

2.2. Spider molecular taxonomy works from India

Caleb et al. (2017) utilized the scope of molecular taxonomy in the discovery of two new species of jumping spider (Salticidae) *Epocilla* and *Mogrus* from India. After morphological assessment, molecular data of mitochondrial COI was also utilized to confirm the uthenticity of identification. The species were named *Epocilla sirohi* sp. nov. and *Mogrus rajasthanensis* sp. nov. The resulted sequence was submitted in GenBank, NCBI and BOLD.

Kulkarni et al. (2017) conducted the phylogenetic analysis of Theridiid genus *Meotipa* to understand the placement of the genus. A previously published set of 242 morphological characters for Theridiidae phylogeny (Agnarsson, 2004) with simple modifications were scored for these species. Parsimony and Bayesian analysis were done. The analysis revealed the monophyletic nature of the taxa.

Chatterjee et al. (2017) prepared the molecular barcode of *Menemerus nigli* during the first report of the species from India. DNA barcode was utilized to confirm the identity of the specimen collected from West Bengal, India. Partial amplification of Cytochrome C Oxidase subunit I (COI) was carried out for the purpose of barcoding. The sequencing was done at ZSI and sequence was uploaded to Barcode of life Data System (BOLD). The sequence obtained in the study showed perfect similarity with sequences of *M. nigli* from Pakistan.

Chatterjee et al. (2018) prepared the sequence of mitochondrial Cytochrome C Oxidase subunit 1 in the first report of *Psechrus inflatus* Bayer (Psechridae) from India. The species origianlly known from China is reported for the first time from India. COI sequence data was generated and is submitted in BOLD. The barcode which is generated from 650 bp of COI was used for a similarity search in NCBI and found to be 98% similar to the specimen from China. Chatterjee et al. in the same year confirmed the identity of *Hyptiotes affinis* Bösenberg & Strand, 1906 by sequencing COI and results in the first report of the species from India. This species was previously known from China, Japan and Taiwan. During this study they found the species from Assam and utilized molecular techniques for the conformation.

Tyagi et al. (2019) done the first large scale attempt on DNA barcoding of spiders from India with 101 morphospecies of 72 genera under 21 families. Cryptic species and species complex are also analysed during the study. Data from this study showed that DNA barcoding is a valuable tool for species identification and species discovery.

Molecular investigation of cave dwelling organisms from a cave in Eastern Ghats was done by Laskar et al. (2021). The study was conducted in Kotumsar Cave, Chhattisgarh. This was a broad study investigating organisms from different taxa. Huntsman spider *Heteropoda venatoria* was already reported from the cave and the morphological-molecular integrated approach confirmed the existence of *H. leprosa* in the cave. Both the spiders were initially identified morphologically and further investigated with molecular data. The generated COI sequence (605bp) of *H. leprosa* showed 91.33% similarity with *H. venatoria* in GenBank. The Neighbour Joining phylogeny showed *H. leprosa* is the sister taxa of *H. venatoria* with 9% to 9.4% genetic distance.

Cryptic diversity in the individuals of *Lycosa bistriata* was studied using Bayesian analysis by Prasad et al. (2021), while redescribing the species they studied individuals from two districts in Odisha. These two groups exhibited morphological differences, which led to the confirmation by molecular taxonomy and phylogeny. 9.0% genetic distance was observed between two clades. The species shows high genetic distance forming two distinct clades. Cryptic diversity might be the probable cause of this high genetic distance. All the specimens collected from district of Ganjam exhibit pale yellow of legs, while specimens from Khordha district have brown colour.

Caleb, Parag & Roy (2023) studied phylogenetic relationships among *Siler* species. They utilized Maximum Likelihood analysis of the unpartitioned partial COI gene. During the analysis it is revealed that the new species *Siler niser* is sister to a Southeast Asian *Siler* clade. The low bootstrap value during the study indicated presence of various cryptic species within *S. semiglaucus*.

Chapter 3

Methodology

METHODOLOGY

3.1. Study Area

Random collections were carried out in the different geographical regions of all fourteen districts of Kerala from August, 2019 to April, 2023 (Table 1, Figure 28).

Sampling was carried out in the morning between 7.00 am to 10.00 am and the evening between 4.00 pm to 6.30 pm during when the spiders are most active.

	District	**Collection locations**
1	Thiruvananthapuram	• Karyavattom • Kattakkada • Sreekaryam • Palode
2	Kollam	• Oachira • Mannadi • Thenmala • Madathara
3	Pathanamthitta	• Gavi • Adoor • Parumala
4	Alappuzha	• Chettikulangara • Vallikunnam • Ramapuram

		• Vandanam • Pathiramanal island
5	Kottayam	• Illikkalkallu • Ilaveezhapoonchira • Poonjaar
6	Idukki	• Kottappara • Thodupuzha • Kallippara hills • Rajamala • Munnar
7	Ernakulam	• Karukutty • Kochi • Iringole Kavu
8	Thrissur	• Athirapilly • Irinjalakuda • Vynthala ox-bow lake • Pariyaram • Pullu
9	Malappuram	• Kodikuthimala • Perinthalmanna • Ponnani
10	Palakkad	• Chalisserry • Parambikulam

		• Muthalamada • Mannarkkad
11	Kozhikode	• Peruvannamuzhi • Kadalundi • Thusharagiri • Kakkayam
12	Wayanad	• Meppadi • Mananthavadi • Kanjirangad • Kurumbalakotta • Muneeswaram hills • Thirunelly
13	Kannur	• Thalassery • Parassinikkadavu • Payyannur
14	Kasaragode	• Malliyodan Kavu • Kammadam Kavu • Payyamkulam • Mannampurathu Kavu • Neeleeswaram • Periya

Table 1: Sampling locations from 14 districts of Kerala

3.2. Taxonomic study

3.2.1. Collection techniques

Lycosids can be collected by a variety of methods. As lycosids are mostly ground runners they are mostly found in grasslands and vast areas with small herbs.

Pitfall trapping and Winkler bag method were expected to be effective methods for these ground dwellers, but the samples obtained were very few in number or if found to be sub-adults. The most useful method found to be hand searching and picking, either by directly looking for spiders on the ground or by picking up substrate (e.g., leaf litter, clumps of grass etc.) and shaking them onto a large white surface like paper or cloth sheet. The following methods were mainly used to collect lycosids for the study.

1. Pitfall trap: A glass or plastic bottle was placed in a pit which covers up to the brim of the bottle. It was partially covered with a plastic sheet. The bottle was filled with 20 ml of 70% ethyl alcohol. The set-up was placed undisturbed overnight and collect the bottle contents and check for specimens.

2. **Winkler bag method**: The litter is collected after sieving through a coarse mesh to remove large sticks or particles. The litter is suspended in a Winkler bag with thin mesh. Below the mesh a cup of ethanol is placed. Tie the top of the bag and suspended in an undisturbed location. Collect and check the alcohol after 24 or 48 hours.

Both these methods were found less effective for our study.

3. Hand picking: It was found to be the most effective method. Spotting the specimen, follow it and pick it with hand or any empty bottle. If the ground litter or grass cover is thick, disturb the area slightly with a stick or with our legs, and then to spot the running lycosids.

4. Bottle method: Mainly used to collect members of the genus *Hippasa*. As they are funnel web makers, it is nearly impossible to hand pick. Sometimes the web is too narrow and deep and with escape routes behind. So, if disturbed, they may escape. In this method, an open collection bottle is placed on the back side of the web. Then disturb the web opening, the spider would run directly to the bottle.

3.2.2. Photographic documentation

The collected specimens were duly labelled and measurements taken into account. Generic placement of species was based on the latest catalogues (World Spider Catalogue, 2025). Illustrations, digital images, measurements and colour pattern descriptions of new species or redescriptions were made from a designated holotype male and an allotype female. Habitus and external genitalia images were examined, photographed and measured using a Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver.4.13). Epigynes were dissected and internal genitalia were cleared in 10% potassium hydroxide (KOH) solution for a few hours to one day, based on the content of tissue. Male palp was separated and photographed. Ocular measurements were taken after placing the specimen dorsally. Leg measurements are shown as: total length (femur, patella + tibia, metatarsus, tarsus). All measurements are taken in millimetres (mm).

3.2.3. Abbreviations used in the main text are: ALE = anterior lateral eye, AME = anterior median eye, BS = base of septum, CD = copulatory duct, CO = copulatory opening, E = embolus, FD = fertilization duct, Ho = hood, MA = median apophysis, MOQ = median ocular quadrangle, Pa = palea, PLE = posterior lateral eye, PME = posterior median eye, Sp = spermatheca, SS = septal stem, St = subtegulum, TA = tegular apophysis, T = tegulum.

3.2.4. Preservation

All the specimens were preserved in absolute ethyl alcohol and stored at -20°C. Holotypes and paratypes were labelled separately and stored in glass bottles. Separated epigyne and pedipalps were labelled accordingly in micro vials.

3.2.5. Identification

Identification was made by the help of taxonomic keys, catalogues and websites (Tikader & Malhothra, 1980; Sebastian & Peter, 2009; World Spider Catalogue, 2025).

3.3. Molecular techniques

DNA extracted, desired gene is amplified and sequenced. Specimens were cleaned to remove debris from field before DNA extraction. DNA was extracted by homogenising legs (including coxae) from selected specimens using DNA extraction kit. Cytochrome C Oxidase subunit I (COI) was selected as a molecular marker for the barcoding role because its mutation rate is fast enough to distinguish between closely related species, along with the sequence is conserved among conspecifics. PCR amplification of this gene was carried out with specific primer combinations.

As already stated, COI marker is the most common and accurate molecular marker and hence it is important in this study than any other molecular marker. In the case of this study, there is an objective to compare our molecular data with other already published molecular data of lycosids. Through this research, it was found that most of the molecular data of lycosids available is in COI sequence data. So, it was decided to focus the molecular study on this one particular marker, as it is only available comparable data to meet our objectives.

3.3.1. Experimental Method

1. Spider legs were separated (including coxae, as it is tissue-rich) and stored in absolute alcohol.

2. DNA was isolated from the sample using QIAGEN DNeasy UltraClean Microbial Kit (Cat. No. / ID: 12224-50). Its quality was evaluated on 1.0 % agarose gel; a single band of high-molecular weight DNA has been observed.

3. Fragment (~ 650 bp) of Cytochrome C Oxidase subunit I was amplified by set of primers (Table 2). The reaction was done in 25µL cocktails containing genomic (template) DNA (2 µL/~ 50ng of DNA), Taq DNA polymerase (0.05 U/µL), 1× buffer, $MgCl_2$ (3 mM), dNTPs (200µM), 1 µL (~ 2.5 pmol) of each forward and reverse primer.

4. Thermal cycle conditions: The polymerase chain reaction (PCR) initial denaturation was set at 95°C for 1 minute, followed by 40 cycles of 95°C for 1 min, 40°C for 1 min, 72°C for 1.5 min and final extension at 72°C for 3 minutes were followed for COI amplification.

5. A single discrete PCR amplicon band of ~600 bp was observed when resolved on 1.5% agarose gel.

6. The PCR amplicon was purified to remove contaminants QIAGEN QIAquick PCR Purification Kit (Cat. No. / ID: 28104).

7. Forward and reverse DNA sequencing (Sanger di-deoxy chain termination method) reaction of PCR amplicon was carried out with specific primers using Big Dye ™ Terminator V3.1 Cycle sequencing kit on Applied Biosystems™ MiniAmp™ Plus Thermal cycler and analysed on Applied Biosystems 3730xL Genetic Analyzer with Pop7 polymer.

Primers	Sequences (5'- 3')	Reference
1. LCO1490 (F1)	GGTCAACAAATCATAAAGAT ATTGG	Folmer et al. (1994)
2. Chelicerate forward1 (F2)	TACTCTACTAATCATAAAGAC ATTGG	Hebert et al. (2003)
3. HCO2198 (R1)	TAAACTTCAGGGTGACCAAA AAATCA	Folmer et al. (1994)
4. Chelicerate reverse1 (R2)	CCTCCTCCTGAAGGGTCAAA AAATGA	Hebert et al. (2003)

Table 2: Primers used in the study

3.4. Molecular Phylogenetic studies

Along with COI sequences of 25 lycosid species from Kerala, COI molecular sequences of another 45 lycosid species worldwide and one outgroup are mined from NCBI GenBank and BOLD Systems (Table 3). These sequences are compared for phylogenetic studies. These already available lycosid sequences are selected from databases that include representatives from all ten Lycosidae subfamilies and biogeographical realms.

3.4.1. Outgroup selection

For this analysis, a putatively closer member from the sister families of Lycosidae was considered. Based on phylogeny, the family Pisauridae can be considered as a sister family of wolf spiders (Polotow, 2015). *Pisaura novicia* belonging to the family Pisauridae and superfamily Lycosoidea selected as an outgroup for the study.

Sl. No.	Species	Location	GenBank Accession number/BOLD Id
1	*Allocosa funerea*	North America	SBCFAIO627-21
2	*A. senex*	South America	MN544478
3	*Arctosa alpigena*	N. America & Europe	AALAR114-18
4	*A. cineria*	Eurasia & Africa	SPICR440-11
5	*A. insignita*	N. America & Europe	KC502080

6	*A. littoralis*	America	BBUSE2604-12
7	*Artoria flavimana*	Australia	CHEFI1816-19
8	*A. seperata*	Australia	AY059993
9	*Evippa araneria*	Africa & Middle east	MT560596
10	*Evippoma squamulatum*	Africa	CHEFI1854-19
11	*Hippasa australis*	Africa	KMPUH1180-19
12	*H. cinerea*	Africa	MT449508
13	*H. pantherina*	Asia	KT383726
14	*H. madraspatna*	Asia	KP172156
15	*H. deserticola*	Asia	HQ991587
16	*H. holmerae*	Asia	MTSP0514-18
17	*Hogna burti*	Australia	CHEFI1634-18
18	*H. crispipes*	Australia	ASMII13875-22
19	*H. kuyani*	Australia	DQ295870
20	*Lycosa ariadnae*	Australia	CHEFI1616-18
21	*L. balyuni*	Africa	KC550809
22	*L. bistriata*	Asia	KP874182
23	*L. erythrognatha*	South America	CUSC0002-18
24	*Pardosa paludicola*	Eurasia	KX537193
25	*P. pseudoannulata*	Eurasia	ON817273
26	*P. timudula*	Eurasia	JX307081
27	*P. wagleri*	Eurasia	KX537377
28	*P. clavipalpis*	Africa	SAKDA1333023
29	*P. injucunda*	Africa	MT462246
30	*P. albomaculata*	North America	KP648530
31	*P. groenlandica*	North America	KP653457
32	*Pirata piraticus*	N. America & Eurasia	ANBIO166-19
33	*P. subpiraticus*	Asia	KY467117
34	*Sosippus michoacanus*	Central America	SPDAR1388-16
35	*S. placidus*	North America	DQ151823
36	*Trochosa abdita*	North America	ARBCM760-14
37	*T. aquatica*	Asia	MK154189
38	*T. hispanica*	Eurasia	OQ644647
39	*T. ruricola*	Eurasia & America	GU395030
40	*T. sepulchralis*	North America	ARBCM739-14
41	*T. terricola*	N. America & Eurasia	KP649155
42	*T. urbana*	Africa & Asia	TSMTE2785-22
43	*Venonia micans*	Asia	MTSP0503-18
44	*V. micarioides*	Australia	SPDAR1393-16
45	*Wadicosa oncka*	Africa	TSMTE4702-23
46	*Pisaura novicia* (Out group)	Eurasia	SPIEU1313-11

Table 3: List of lycosid species and one outgroup species mined from NCBI GenBank and BOLD Systems for comparison

3.4.2. Molecular phylogenetic methods

Through phylogenetic analysis, a phylogenetic tree representing optimal evolutionary history between taxa could be obtained. Maximum Likelihood, Maximum Parsimony and Bayesian Inference are typical methods used to assess how accurately a phylogenetic tree topology describes the sequence data (Wheeler et al., 2017).

Maximum Likelihood (ML) is the process of finding the phylogenetic tree with the highest probability based on the data, while Maximum Parsimony (MP) is the method which finds trees with the least number of evolutionary changes to explain the sequence data. Bayesian Inference (BI) can be used to produce phylogenetic trees in a manner closely related to the maximum likelihood methods. It assumes a prior probability distribution of all the possible trees at the starting stage of analysis. Based on this probability distribution, the appropriate tree is presented (Felsenstein, 2004).

Monophyly of lycosids in Kerala was investigated based on analysing all the obtained phylogenetic trees and checking whether they form a separate clade with high bootstrap value.

1. **Quality check and editing**: Both forward and reverse sequences of each species were checked for quality in BioEdit Version 7.7.1. After trimming the ends with low quality, both these sequences merged to form the consensus sequence. This merging compliments the trimming of low-quality ends, so that a long consensus sequence unique for each specimen is obtained. Each of these consensus sequences was translated and analysed with MEGA XI software for premature stop codons. If present, they can be resolved with the 'Select & edit gene/domain' function by altering the codon frame. All these results in quality consensus sequences of approximately 600 to 650 base pairs for each of the specimens. These were used for further analysis.

2. **Multiple sequence alignment (MSA)**: All the sequences (both from our study and mined from web) were subjected to MSA. These aligned sequences were used for further analysis, by checking similarities, gaps etc. considering each of them as evolutionary significant alterations. MSA done with MUSCLE in MEGAXI software.

3. **Model selection**: Model selection is an unavoidable step in statistical phylogenetics (Kelchner & Thomas, 2007). The J Model test software programme was performed to estimate the best substitution and rate heterogenicity model for nucleotide sequences using statistical selection. These nucleotide substitution models allow the quantification of probabilities of change between nucleotides along the branches of a phylogenetic tree. The use of a specific substitution model may change the final outcome of the phylogenetic analysis (e.g., Buckley, 2002; Buckley & Cunningham, 2002; Lemmon & Moriarty, 2004). These kind of statistical model selection has become an essential step for the estimation of evolutionary history from DNA sequence alignments. The model search was done under Akaike Information Criterion (AIC) scores and Bayesian Information Criteria score (BIC).

4. **Maximum Parsimony (MP)**: The MP method was used to create a phylogenetic tree that minimizes the total number of character-state changes is to be preferred. Under the maximum-parsimony criterion, the optimal tree will minimize the amount of homoplasy (i.e., convergent evolution, parallel evolution, and evolutionary reversals) (Alonso et al., 2012). It was performed using MEGAXI with 10000 bootstrap values (Tamura et al., 2021).

5. **Maximum Likelihood (ML)**: ML analysis was performed using the software programme RAxML ver. 8.2.10 on COI gene datasets after converting the sequences to

phylip (.phy) format using Mesquite software ver. 3.81. ML was done with 100000 bootstrap replicates.

6. **Bayesian Inference (BI)**: Bayesian Inference was carried out in MrBayes ver.3.2.7 software after converting the sequences to nexus (.nex) file with Mesquite software ver. 3.81.

7. **Tree presentation**: Finally, the trees were viewed and edited using Fig Tree v. 1.4.3 with all relevant parameters. Obtained trees were rooted with outgroup.

Chapter 4
Results

RESULTS

4.1. Systematics of Collected Spiders

A total of 25 species belonging to six genera were collected from various locations of Kerala. Twenty of them are adults which are identified up to species level. Five of them are sub-adults, which were identified up to genus level. The collection includes new species; new reports to India, Western Ghats and Kerala; redescriptions; genus transfer etc.

4.1.1. Genus *Pardosa* C.L. Koch, 1847

***Pardosa nebulosa*-group**

All the seven species in *Pardosa* collected in this study are coming under *Pardosa nebulosa* species-group (Marusik & Ballarin, 2011; Abhijith & Sudhikumar, 2022).

Diagnosis

The eye pattern (2-2-4) and positioning confirmed they belong to family Lycosidae. Specimens are identified as genus *Pardosa* by the shape of cephalothorax, long oval abdomen. Males diagnosed as *Pardosa nebulosa*-group by palp with sclerotized, hook-shaped TA without secondary branch and females by epigynum with inverted T-shaped septum (Marusik & Ballarin, 2011).

4.1.1.1. *Pardosa oriens* (Chamberlin, 1924) [Figs. 1 A–E]

Orinocosa oriens Chamberlin, 1924; *Pardosa oriens* Song, 1988; Tanaka, 1989; Chen & Zhang, 1991; Tanaka, 1993; Song et al., 1997; Yin et al., 1997; Yang & Chai, 1998; Song et al., 1999; Hu, 2001; Tanaka, 2009; Buchar & Dolejš, 2021; Abhijith & Sudhikumar, 2022.

Materials examined

INDIA, Kerala: 4♀ 3♂ from grasslands in Gavi, Pathanamthitta district (9°43.49' N, 77°16.01' E; 1035.9 m a.s.l.) October, 8, 2021, coll. R.S. Abhijith.

Diagnosis

Somatic features of both sexes morphologically identical to other *Pardosa nebulosa*-group members. *P. oriens* is highly similar to *P. parathompsoni*, but differs by following set of characters.; ventral view of epigynum with longer SS and lateral arrangement of CD; vulva unique with laterally positioned CD and much wider Sp; male palp different with longer hook shaped TA; shorter, more curved MA and lack of paleal protrusion towards MA (Abhijith & Sudhikumar, 2022).

Redescription of the species

Male specimen: Total length 2.80, Prosoma 1.43 long, 1.25 wide, Opisthosoma 1.37 long, 0.87 wide; Carapace yellowish brown with distinct vertical fovea; Fovea non-uniform in width, wider posteriorly, a stripe extends from anterior end of fovea to ocular area; Broader median band, greenish yellow, different colouration near ocular area and narrow at the posterior end of thorax; Paramedian bands much broader, dark greenish brown, uniformly wide, continuous; Ocular area black with thick protuberances; Smooth clypeus with 0.10 height; Eye sizes and inter-distances: AME 0.06, ALE 0.04, PME 0.16, PLE 0.12, AME–AME 0.06, AME–ALE 0.03, PME–PME 0.23, PME–PLE 0.27; MOQ wider on posterior end; Labium longer than wide; Chelicera with 3 promarginal and 2 retromarginal teeth; Chelicerae teeth placed apart compared to females; Sternum heart-shaped, wider, covered sparsely with dark hairs; Black wide stripe along the sternum margin; Sternum in some male specimens covered completely with black hairs without any markings; Legs yellowish with several greenish yellow annuli; Leg measurements: I 4.90 (1.19, 1.83, 0.99, 0.89); II 4.98 (1.04, 2.19, 0.99, 0.76); III 4.27 (1.00, 1.38, 1.16, 0.73); IV 6.13 (1.36, 1.99, 1.90, 0.88); Leg formula: 4213; Opisthosoma long and oval, narrower than female; Dorsum dark brown in colour with several lateral bands; Venter side yellow; Posterior spinnerets larger (Abhijith & Sudhikumar, 2022).

Palp: Large tegulum (T) with a projection medially, Tegular apophysis (TA) beak shaped with a downwardly directed tapered tip, extend just beyond median apophysis (MA); Small, oval sub-tegulum (St) placed prolaterally; Large paleae (Pa), tent shaped; MA longer than wide, extended horizontally and distally curved; Embolus (E) with a broad tip seemed to be originate prolateral side, extend retrolaterally, masked by T (Abhijith & Sudhikumar, 2022).

Female: Total length 3.51, Prosoma 1.67 long, 1.24 wide, Opisthosoma 1.84 long, 1.10 wide; Carapace yellowish brown with distinct longitudinal fovea; Fovea non-uniform in width, wider posteriorly; A stripe extends from anterior end of fovea to ocular area; Broader median band, greenish yellow; Median band extended into the ocular area as a bifurcation; Paramedian bands much broader, dark greenish brown, uniformly wide, continuous with two triangle-shaped patterns near ocular region; Ocular area black with thick protuberances; Clypeus smooth with 0.11 height; Eye sizes and inter-distances: AME 0.06, ALE 0.04, PME 0.16, PLE 0.12, AME–AME 0.06, AME–ALE 0.03, PME–PME 0.23, PME–PLE 0.27; Posterior MOQ wider; Labium longer than wide; Chelicera with 3 promarginal and 2 retromarginal teeth, arranged closely packed; Heart shaped sternum, covered with a few black hairs; Dark band along the sternum margin; Legs yellow with greenish yellow annuli, Leg measurements: I 4.25 (1.12, 1.54, 0.83, 0.76); II 3.88 (0.99, 1.39, 0.82, 0.68); III 3.81 (1.01, 1.26, 0.94, 0.60); IV 5.94 (1.50, 1.80, 1.69, 0.95); Leg formula: 4123; Palp 1.57 (0.49, 0.60, 0.48); Opisthosoma long and oval, wider than in males; Dorsum dark brown in colour with several lateral bands; Venter side yellow; Posterior spinnerets larger (Abhijith & Sudhikumar, 2022).

Epigynum: Two hoods present; vase-shaped SS, wider near hood, narrow towards bottom and widens near BS; globular CD and lateral to SS; Upright Sp, parallel to SS, longer than wide, tip parallel to and above the hood; FD covered by CD (Abhijith & Sudhikumar, 2022).

Distribution

Bhutan, China, Japan, **new report from India.**

Remarks

P. oriens is a lycosid found in China, Bhutan and Japan (WSC, 2025). Genital photographs in Buchar & Dolejš (2021) are similar to our specimens. Genitalic figures in Yin et al. (1997) and Hu (2001) also confirmed our species. We identified the species by comparison of photographs and illustrations only. As the detailed descriptions of the species based on genitalic characters are not available authors attempted to redescribe the species to make future identifications easier.

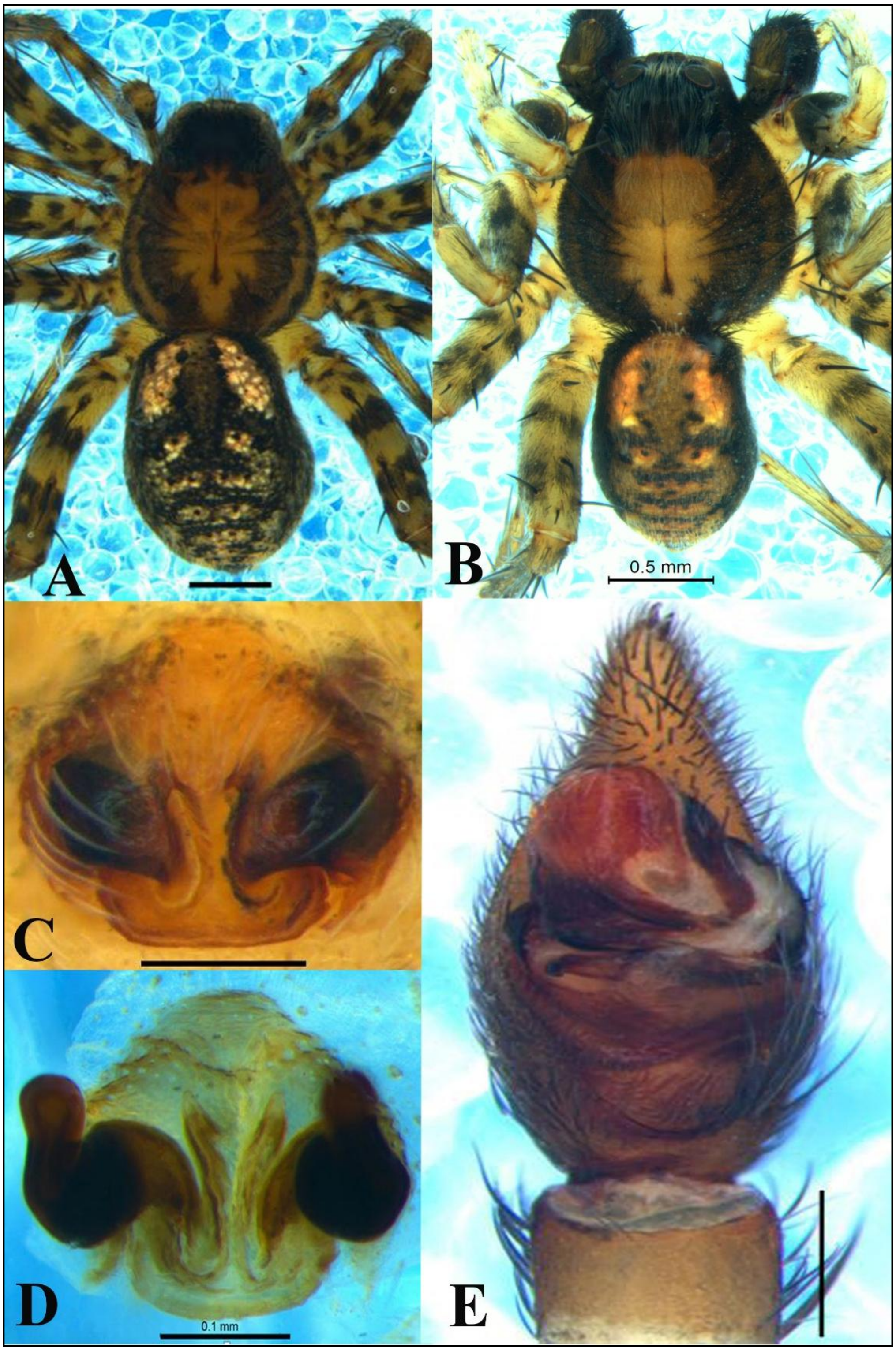


FIGURE 1. *Pardosa oriens* (Chamberlin, 1924): **A**, Female habitus; **B**, Male habitus; **C**, Epigyne cleared ventral view; **D**, same cleared dorsal view **E**. Palp. Scales: A, 1mm; B, 0.5mm; C–E, 0.1mm.

4.1.1.2. *Pardosa parathompsoni* Wang & Zhang, 2014 [Figs. 2 A–E]

Wang & Zhang, 2014; Prasad et al., 2022; Abhijith et al., 2022a.

Materials examined

INDIA, Kerala: 5 ♀ 1♂ from grasslands in Gavi, Pathanamthitta (9˚43. 49' N, 77˚16.01' E; 1035.9 m a.s.l.) October 8, 2021, coll. R.S. Abhijith.

Diagnosis

The genitalia similar to *P. sumatrana*, distinguished by following set of characters. Epigynum with a short vase-shaped septum; SS broader both in anteriorly and posteriorly, with small hoods; Sp vertical with tip positioned inwardly; Male palp with a TA having a protrusion; Pa with tiny sharp protrusion mid-retrolaterally towards the MA; MA stout with a curved tip (Abhijith et al., 2022a).

Description

Male: Total length 3.91, Prosoma 2.01 long, 1.59 wide, Opisthosoma 1.90 long, 1.09 wide; Carapace yellowish brown with distinct vertical fovea; Fovea non-uniform in width, wider posteriorly; A stripe extends from anterior end of fovea to ocular area; Broader median band, greenish yellow; Median band extended into the ocular area as a bifurcation; Paramedian bands much broader, dark greenish brown, uniformly wide, projections towards median band; Ocular area black with thick protuberances; Clypeus smooth with 0.20 height; Green spots along the margins of carapace, continuous than in female; Eye sizes and inter-distances: AME 0.06, ALE 0.05, PME 0.17, PLE 0.13, AME–AME 0.06, AME–ALE 0.04, PME–PME 0.24, PME–PLE 0.28; Anterior row of eyes procurved; MOQ wider posteriorly; Grey labium, equally long and wide; Chelicera with 3 promarginal and retromarginal teeth, one of the promarginal teeth small; Heart shaped sternum, covered with a few black hairs; Dark band along the sternum margin; Yellow legs with green annuli; Leg measurements: I 5.01 (1.41, 1.80, 1.11, 0.69); II 4.93 (1.36, 1.76, 1.01, 0.80); III 4.63 (1.25, 1.55, 1.20, 0.63); IV 7.23 (1.75, 2.30, 2.17, 1.01); Leg formula: 4123; Opisthosoma long and oval, slender; Dorsum dark brown with lateral stripes; Venter yellow with a dark brown spot closer to pedicel; Posterior spinnerets larger (Abhijith et al., 2022a).

Palp: hairy; large T; small TA, tapered and downwardly directed tip; prolaterally positioned small St; Retrolaterally positioned large globular Pa with tiny sharp protrusion mid-retrolaterally towards the MA; MA stout with a curved tip; E with tapered end, upwardly directed, originate prolaterally and extended retrolaterally (Abhijith et al., 2022a).

Female: Total length 4.92, Prosoma 2.58 long, 1.60 wide, Opisthosoma 2.23 long, 1.45 wide; Carapace yellowish brown with distinct vertical fovea; Fovea non-uniform in width, wider at ends; A stripe extends from anterior end of fovea to ocular area; Broader median band, greenish yellow; Median band extended into the ocular area as a bifurcation; Paramedian bands much broader, dark greenish brown, uniformly wide, projections towards median band; Ocular area black with thick protuberances; Clypeus smooth with 0.22 height; Two comma-shaped spots in the ocular regions; Eye sizes and inter-distances: AME 0.08, ALE 0.05, PME 0.18, PLE 0.13, AME–AME 0.06, AME–ALE 0.03, PME–PME 0.24, PME–PLE 0.26; MOQ wider posteriorly; Grey labium, equally long and wide; Chelicera with 3 promarginal and retromarginal teeth, one of the promarginal teeth small; Heart shaped sternum, covered with a few black hairs, V- shaped band present; Dark band along the sternum margin; Yellow legs with dark green annuli; Leg measurements: I 4.43 (1.15, 1.60, 0.87, 0.81); II 4.16 (0.99, 1.50, 0.97, 0.70); III 4.01 (1.07, 1.31, 0.98, 0.65); IV 6.05 (1.52, 1.84, 1.71, 0.98); Leg formula: 4123; Palp 1.69 (0.56, 0.64, 0.49); Wider opisthosoma, long and oval; Dorsum dark brown with lateral stripes and lanceolate pattern; Venter light yellow; Posterior spinnerets larger (Abhijith et al., 2022a).

Epigynum: Septum short with non-prominent hood; Internally anchor-shaped septum, SS medially tapered; CD lateral to SS with an upward angle; Sp longer than wide, vertically positioned with an inward angle, the proximal end angled outwards, distal end angled towards septum, positioned above hoods; small FD, closer to the CD base (Abhijith et al., 2022a).

Distribution

China, India (**new to Western Ghats region**)

Remarks

Pardosa parathompsoni was first described from China by Wang & Zhang (2014). The original description is well constructed and based on genitalic characters with clear photographs and figures. This is the second ever spotting of this species from India and first from Western Ghats region. Body sizes of the collected specimens are smaller than the Chinese specimens, female body size is somewhat comparable, but size of male is much lesser (Abhijith et al., 2022a). Differences between both habitats may play a role in this size disparity. Promarginal teeth number in chelicerae is different from the original description, one among them is tiny and submerged under hairs. So, it is assumed that either original authors missed identifying this tooth or this species shows difference in cheliceral teeth number (Abhijith et al., 2022a).

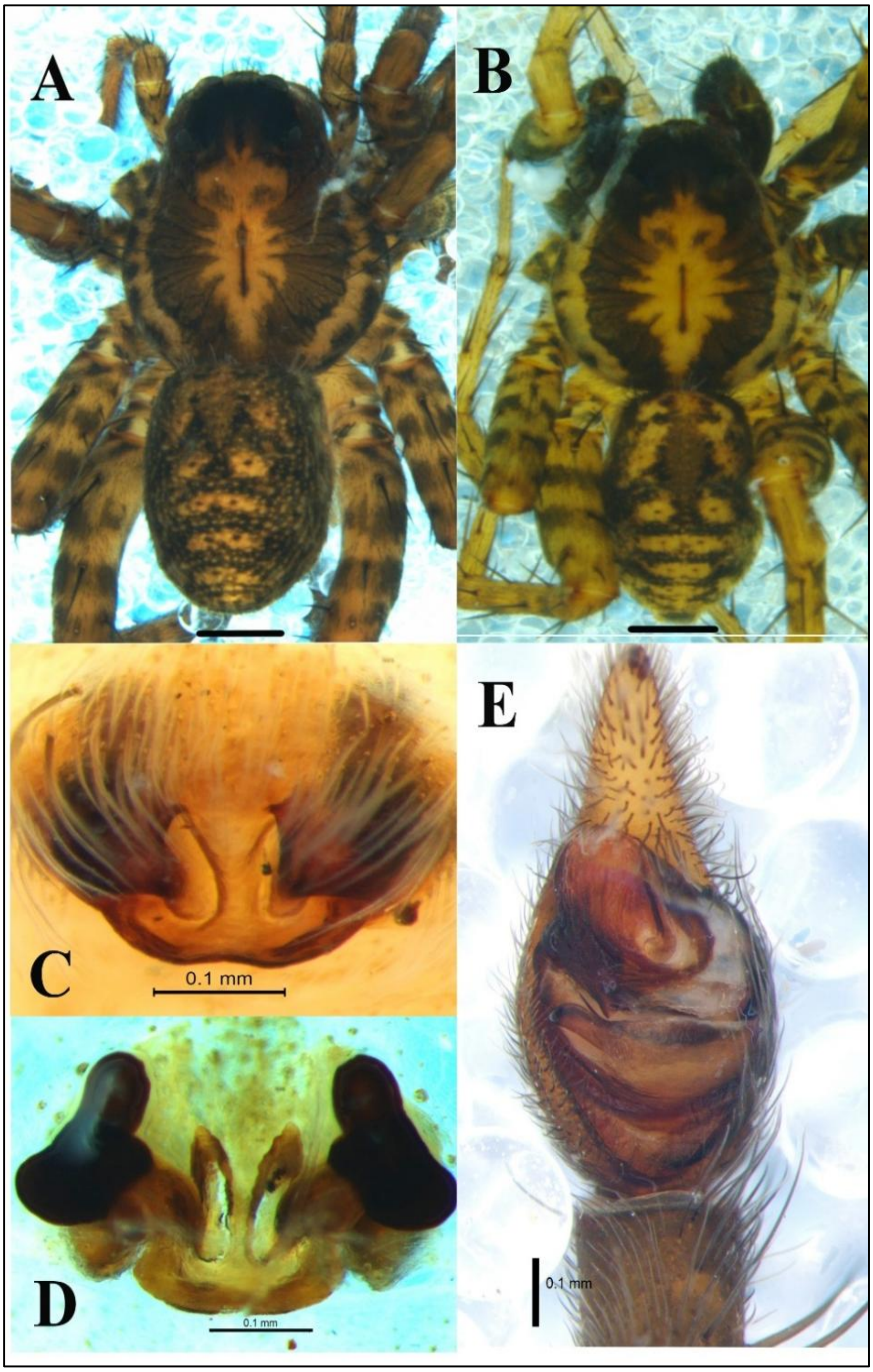


FIGURE 2. *Pardosa parathompsoni* Wang & Zhang, 2014: **A**, Female habitus; **B**, Male habitus; **C**, Epigyne ventral view; **D**, same cleared dorsal view **E**. Palp. Scales: A–B, 0.5 mm; C–E, 0.1mm.

4.1.1.3. *Pardosa pusiola* (Thorell, 1891) [Figs. 3 A–C]

Lycosa pusiola Thorell, 1891.

Pardosa pusiola Sen et al., 2015; Dhali, Saha & Raychaudhuri, 2017; Tyagi et al., 2019; Omelko & Marusik, 2020; Buchar & Dolejš, 2021; Wang et al., 2021.

Materials examined

INDIA, Kerala: 2 ♀ from Mannampurathukavu, Kasaragod, Kerala (12° 15' 29.52" N, 75° 7' 55.92" E, alt. 15 m a.s.l.) January 8, 2020, coll. R.S. Abhijith.

Diagnosis

Female are similar to other members of *Pardosa nebulosa* species-group, but distinguished by the wider and shorter SS, wider BS and the round Sp.

Description

Female: Total length 3.20, Prosoma 1.36 long, 1.30 wide; opisthosoma 1.79 long, 1.01 wide; Carapace yellowish brown with vertical, uniformly wide fovea; Green spots along lateral edges of carapace; Median band yellow, extend into the ocular area as a bifurcation; Paramedian bands much broader, dark greenish brown, uniformly wide, projections towards median band; Ocular area black with thick protuberances; Clypeus smooth with 0.43 height; Two comma-shaped spots in the ocular regions; Eye sizes and inter-distances: AME 0.12, ALE 0.10, PME 0.25, PLE 0.20, AME–AME 0.02, AME–ALE 0.02, PME–PME 0.21, PME–PLE 0.27; Grey labium, equally long and wide; Chelicera with 3 promarginal and retromarginal teeth, one of the promarginal teeth small; Heart shaped sternum, covered with a few black hairs, V- shaped band present; Dark band along the sternum margin; Yellow legs with dark green annuli; Leg measurements: I 4.15 (1.10, 1.51, 0.81, 0.73); II 3.85 (0.98, 1.37, 0.82, 0.68); III 3.61 (0.96, 1.21, 0.90, 0.54);

IV 5.84 (1.47, 1.78, 1.67, 0.92); Leg formula: 4123; Wider opisthosoma, long and oval; Dorsum dark yellow brown with lateral stripes and lanceolate pattern; Venter light yellow; Posterior spinnerets larger.

Epigyne with a pair of short hoods anteriorly. SS short and medially wide. BS wider than long, stretched ‘U’-shaped. Sp sphere-shaped, slightly longer than wide.

Distribution

China, Sri Lanka, Nepal, Bhutan, Bangladesh, Myanmar, Laos, Malaysia, Indonesia (Java), India (**first report from state of Kerala**).

Remarks

P. pusiola is a common lycosid found in south and south-east Asian countries including India. But it was not reported from south Indian state of Kerala. The description and photographs of types (Holotypes and syntypes) by Wang et al. (2021), Wang & Zhang (2014) and Buchar & Dolejš (2021) are similar to our specimen.

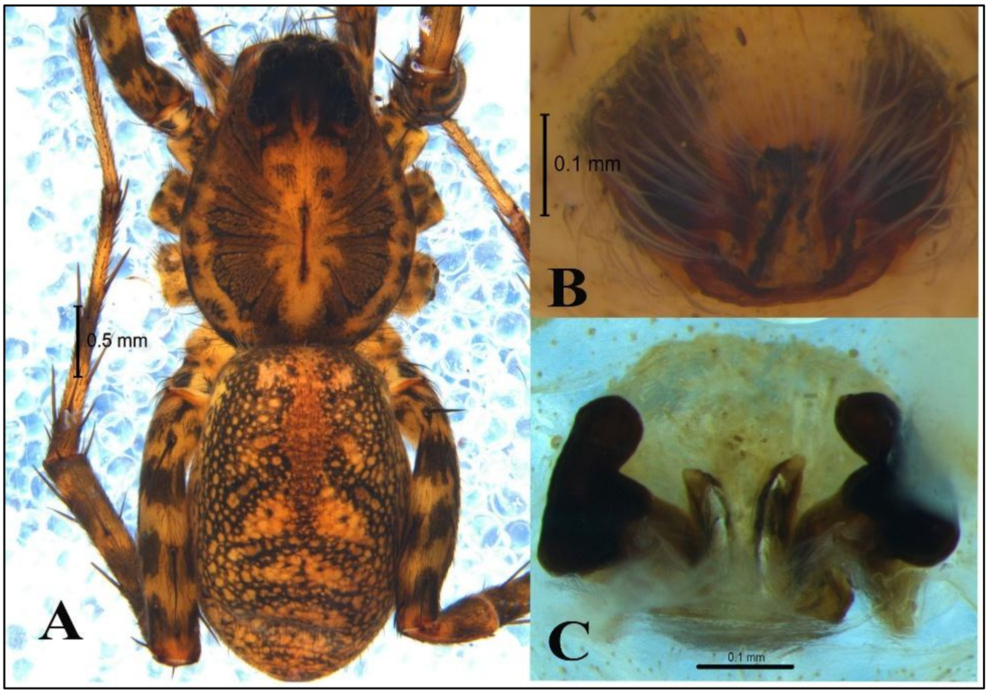


FIGURE 3. *Pardosa pusiola* (Thorell, 1891): **A**, Female habitus; **B**, Epigyne ventral view; **C**, same cleared dorsal view**.** Scales: A, 0.5 mm; B–C, 0.1mm.

4.1.1.4. *Pardosa shyamae* (Tikader, 1970) [Figs. 4 A–C]

Lycosa shyamae Tikader, 1970; Biswas & Raychaudhuri, 2014; *Pardosa shyamae* Tikader & Malhotra, 1980; Yin et al., 1997; Song et al., 1999; Biswas & Raychaudhuri, 2003.

Materials examined

INDIA, Kerala: 3 ♀ Meppadi, Wayanad (11°31'26.18"N, 76°9' 9.8"E; alt. 874 m a.s.l) 9 October 2021, 2 ♀ Thodupuzha, Idukki (9° 53' 44.16" N; 76° 42' 43.56" E; alt. 233 m a.s.l) 12 September 2022; coll. R.S. Abhijith.

Diagnosis

Female are similar to other members of *Pardosa nebulosa* species-group, especially *P. sumatrana*, but distinguished by the shape of SS, lateral positioning of hoods and straight BS.

Description

Female: Total length 4.10, Prosoma 2.16 long, 1.40 wide, opisthosoma 1.89 long, 1.11 wide; Carapace yellowish brown with vertical, distally prominent, anteriorly fade, uniformly wide fovea; Carapace edges with several green spots; Median band yellow, extend into the ocular area as a bifurcation, with different shape from other *Pardosa* species; Paramedian bands much broader, dark greenish brown, uniformly wide, projections towards median band; Ocular area black with thick protuberances; Clypeus smooth with 0.45 height; Eye sizes and inter-distances: AME 0.14, ALE 0.12, PME 0.28, PLE 0.23, AME–AME 0.03, AME–ALE 0.02, PME–PME 0.25, PME–PLE 0.28; Clypeus height 0.45; Dark grey labium, equally long and wide; Chelicera with 3 promarginal and retromarginal teeth; Heart shaped sternum, covered with a few black hairs; Yellow legs with dark green annuli; Leg measurements: I 4.45 (1.15, 1.61, 0.86, 0.83); II 4.05 (1.03, 1.47, 0.92, 0.73); III 3.81 (0.98, 1.29, 0.96, 0.58); IV 6.14 (1.57, 1.88, 1.72, 0.97); Leg formula: 4123; Wider opisthosoma, long and oval; Dorsum dark yellow brown with lateral stripes and lanceolate pattern; Venter light yellow; Posterior spinnerets larger.

Epigyne with a pair of hoods positioned anteriorly than medially. SS vase-shaped, anteriorly wide, medially narrow, distally same as mid-region and wide in some specimens. BS almost straight. Sp longer than wide, twisted medially.

Distribution

India, Bangladesh, China (**first report from state of Kerala**).

Remarks

P. shyamae was first described from India, but it was not reported from south Indian state of Kerala. The original description by Tikader, 1970, illustrations by Yin et al., 1997 and Song et al., 1999 confirmed the identity of our specimen.

4.1.1.5. *Pardosa songosa* Tikader & Malhotra, 1976 [Figs. 5 A–B]

Tikader & Malhotra, 1976; Tikader & Malhotra, 1980; Hu & Li, 1987; Hu, 2001; Biswas & Raychaudhuri, 2003; Sen et al., 2015; Dhali et al., 2017.

Materials examined

INDIA, Kerala: 2 ♀ Athirapilly, Thrissur (10° 17' 21.12 "N, 76° 28' 41.88"E; alt. 180 m a.s.l) 11 October 2022, coll. R.S. Abhijith.

Diagnosis

Female are similar to other members of *Pardosa nebulosa* species-group, *especially P. sumatrana*, but distinguished by short SS and slightly posteriorly positioned septum, upward positioning of Sp.

Description

Female: Total length 4.25; Prosoma 2.36 long, 1.50 wide; opisthosoma 1.79 long, 1.02 wide; Carapace light yellowish with a distinct longitudinal fovea, which is thicker and darker anteriorly; Dark green spots along lateral edges of carapace; Median band yellow, extend into the ocular area as a bifurcation, with different shape from other *Pardosa* species; Paramedian bands much broader, dark greenish brown, uniformly wide, projections towards median band; Ocular area black with thick protuberances; Clypeus smooth with 0.47 height; Eye sizes and inter-distances: AME 0.15, ALE 0.11, PME 0.30, PLE 0.22; AME–AME 0.05, AME–ALE 0.04, PME–PME 0.35, PME–PLE 0.28; Dark grey labium, equally long and wide; Chelicera with 3 promarginal and retromarginal teeth; Heart shaped sternum, covered with a few black hairs; Yellow legs with light green annuli; Leg measurements: I 4.65 (1.20, 1.66, 0.90, 0.89); II 4.35 (1.13, 1.52, 0.99, 0.81); III 3.85 (0.98, 1.30, 0.98, 0.59); IV 6.54 (1.58, 1.90, 1.78, 0.99); Leg formula: 4123; Wider opisthosoma, long and oval; Dorsum dark yellow brown with lateral stripes and non- prominent lanceolate pattern; Venter light yellow; Posterior spinnerets larger (Tikader & Malhotra, 1980).

Epigyne with a pair of hoods. SS inverted T-shaped, uniformly wide. BS inwardly curved. Sp longer, twisted medially, seem to originated from mid region of SS.

Distribution

India, Bangladesh, China (**first report from state of Kerala**).

Remarks

P. songosa was first described from India by Tikader & Malhothra (1976). The original description, illustrations by Hu & Li (1987) and Hu (2001) confirmed the identity of our specimen.

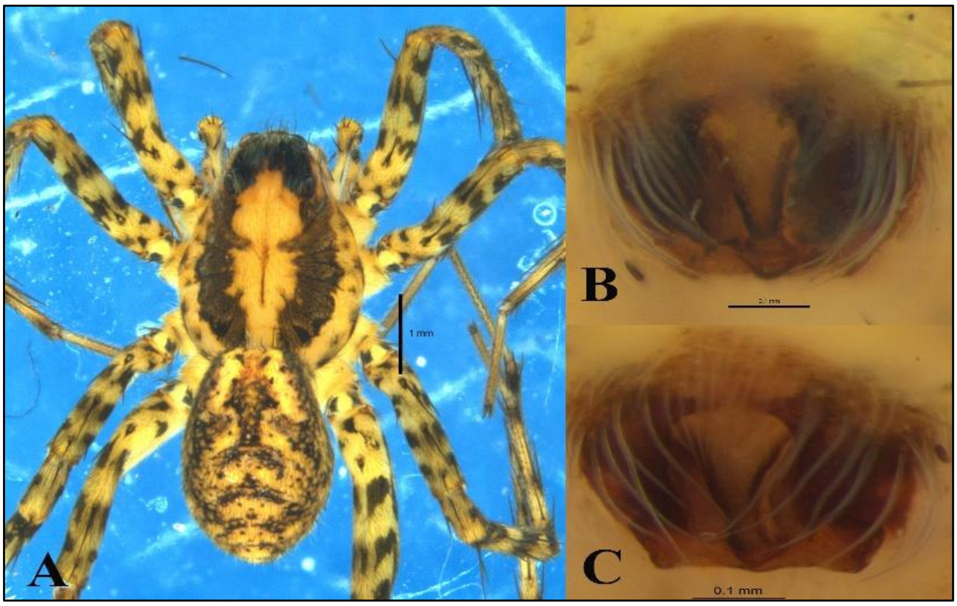


FIGURE 4. *Pardosa shyamae* (Tikader, 1970): **A**, Female habitus; **B**, Epigyne ventral view; **C**, same from another specimen**.** Scales: A, 1 mm; B–C, 0.1mm.

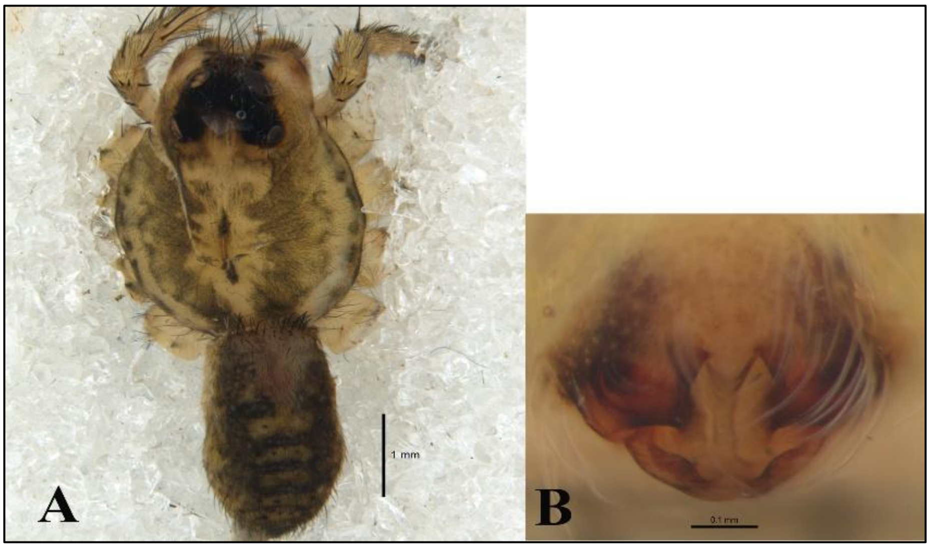


FIGURE 5. *Pardosa songosa,* Tikader & Malhotra, 1976: **A**, Female habitus; **B**, Epigyne ventral view**.** Scales: A, 1 mm; B, 0.1mm.

4.1.1.6. *Pardosa sumatrana* (Thorell, 1890) [Figs. 6 A–E]

Lycosa sumatrana Thorell, 1890; Gravely, 1924; Sherriffs, 1939. *Pardosa sumatrana* Hogg, 1919; Buchar, 1976; Buchar, 1980; Tikader & Malhothra, 1980; Tikader & Biswas, 1981; Chen & Gao, 1990; Okuma et al., 1993; Zhao, 1993; Barrion & Litsinger, 1994; Barrion & Litsinger, 1995; Yin et al., 1997; Yang & Chai, 1998; Song et al., 1999; Hu, 2001; Biswas & Raychaudhuri, 2003; Gajbe, 2007; Yin et al., 2012; Sen et al., 2015; Dhali et al., 2017; Tyagi et al., 2019; Wang et al., 2021. *Lycosa mysorensis* Tikader & Mukerji, 1971 – New synonym; ***Pardosa mysorensis*** Tikader & Malhotra, 1980 – New synonym (Abhijith et al., 2021).

Material examined

INDIA, Kerala: 3♀, 2♂ from Chettikulangara, Alappuzha district (9º22.37'N, 76º51.85'E, alt. 9 m a.s.l) February 8, 2021, coll. R.S. Abhijith; 4 ♀ from Christ College campus, Irnjalakuda, Thrissur (10º35.57'N, 76º21.32'E, alt. 12m a.s.l.) January 31, 2021, coll. R.S. Abhijith; 2 ♀ from paddy fields of Ochira, Kollam (9º13.25'N, 76º51.68'E, alt. 8 m a.s.l.) December 2, 2020, coll. R.S. Abhijith & Vinay M.U.

Diagnosis

Males are distinguished by the internal structure of pedipalp; The TA flat and with a bifurcated hook shaped process at the end. Females are morphologically similar to other members of *Pardosa*, but, differ in the genitalia structure; The epigyne in ventral view shows an inverted T shaped uniform SS; Internally CD shows a distinguishable in folding and tip of spermatheca points towards hood; FD resembles a horizontally placed kidney (Abhijith et al., 2021).

Description

Male**:** Total length 3.14, Prosoma 1.71 long, 1.4 wide, Opisthosoma 1.43 long, 1.12 wide; Overall, males are almost same sized or slightly smaller than females; Abdomen is slightly narrower in males; Cephalic region is narrower than thoracic region; Longitudinal fovea presents on carapace; Anterior end of fovea is lighter compared to posterior end; General colouration, median and lateral bands of carapace are similar to females; The colour of lateral band ranges from light greenish brown to extremely dark brown in individuals examined; Ocular area black and hairy; Colouration of eye area also shows variability between individuals; Eye arrangement same as in females; Eye sizes and inter-distances: AME 0.082, ALE 0.06, PME 0.206, PLE 0.187, AME–AME 0.109, AME–ALE 0.091, PME–PME 0.380, PME–PLE 0.306; Clypeus height 0.143; Dark, longer labium; Chelicerae dark in colour and possess 3 promarginal and 3 retromarginal teeth; Sternum heart shaped, yellow, without any spots or markings; Tiny hairs are present on sternum; Legs generally yellow with greenish patches; In some individuals anterior pair of legs, especially coxa segment is much darker than posterior ones; Leg measurements: I 5.10 (1.36, 1.81, 1.11, 0.82); II 4.84 (1.30, 1.65, 1.17, 0.72); III 4.75 (1.33, 1.50, 1.27, 0.65); IV 7.30 (1.77, 2.18, 2.22, 1.13); Leg formula: 4123; Oval, slender opisthosoma, narrower in appearance compared to females; Still some individuals possess slightly broader abdomens; Dorsum dark yellowish brown with several lateral band-like patterns; Several lateral spots probably sigilla present dorsally; Ventral side yellow with a small narrow trapezium shaped pattern on the anterior side; The pattern is lighter and indistinguishable in a few individuals; Posterior spinnerets larger than anterior pair; Spinnerets are darker in colouration than ventral side of abdomen (Abhijith et al., 2021). Palp: Cymbium is darker in colour with two claws. The apical end is slightly lighter. Pa is well developed with a protuberance to outside, appears to be pyramidal is promarginal view. TA if flat, longer than wide. It possesses distally with a hook shaped extension, which in closer examination seem to be slightly bifurcated. This extension is clearly visible in promarginal view of pedipalp. Proximal end of embolus is visible in ventral view, tapering distal end seemed to be covered by TA. T is slightly broader than St and both are clearly separated. St possess a distinguishable bulging on promarginal side.

Female: Total length 3.72, Prosoma 1.99 long, 1.5 wide, Opisthosoma 1.73 long, 1.14 wide; Carapace light yellowish with a longitudinal fovea; Anterior end of fovea is lighter compared to posterior end; Dark green spots along lateral edges of carapace; Median band yellow, extend into the ocular area as a bifurcation, with different shape from other *Pardosa* species; Paramedian bands much broader, dark greenish brown, uniformly wide, projections towards median band; Ocular area black with thick protuberances; Clypeus smooth with 0.15 height; Cephalic region is narrower than thoracic region; Eye sizes and inter-distances: AME 0.087, ALE 0.07, PME 0.216, PLE 0.192, AME–AME 0.117, AME–ALE 0.094, PME–PME 0.383, PME–PLE 0.310; Dark, longer labium; Chelicerae dark in colour and possess 3 promarginal and 3 retromarginal teeth; Sternum heart shaped, yellow, without any spots or markings; Tiny hairs are present on sternum; Legs generally yellow with greenish patches; Leg measurements: I 5.60 (1.56, 1.91, 1.26, 0.87); II 5.24 (1.40, 1.85, 1.22, 0.77); III 5.20 (1.43, 1.68, 1.38, 0.71); IV 7.70 (1.87, 2.28, 2.37, 1.18); Leg formula: 4123; Wider opisthosoma, long and oval; Dorsum dark yellow brown with lateral stripes and non- prominent lanceolate pattern; Venter light yellow; Posterior spinnerets larger (Abhijith et al., 2021).

Epigyne: Inverted T-shaped SS; Two hoods present anteriorly; Elongated, narrow SS slightly wider near hood; BS longer than wide; CO closer to BS and CD; CD bend inwardly; Sp longer than wide, tip pointed to hoods; Kidney-shaped FD near CD (Abhijith et al., 2021).

Distribution

India, Indonesia, China, Bhutan, Myanmar, Sri Lanka, Philippines, Nepal, Bangladesh.

Synonimization of *P. mysorensis* with *P. sumatrana*

Analysing various publications and type photograph of *P. mysorensis* we are confident that *P. mysorensis* was a misidentification and is a junior synonym of *P. sumatrana* (Abhijith et al., 2021). Further explanations are discussed in the next chapter.

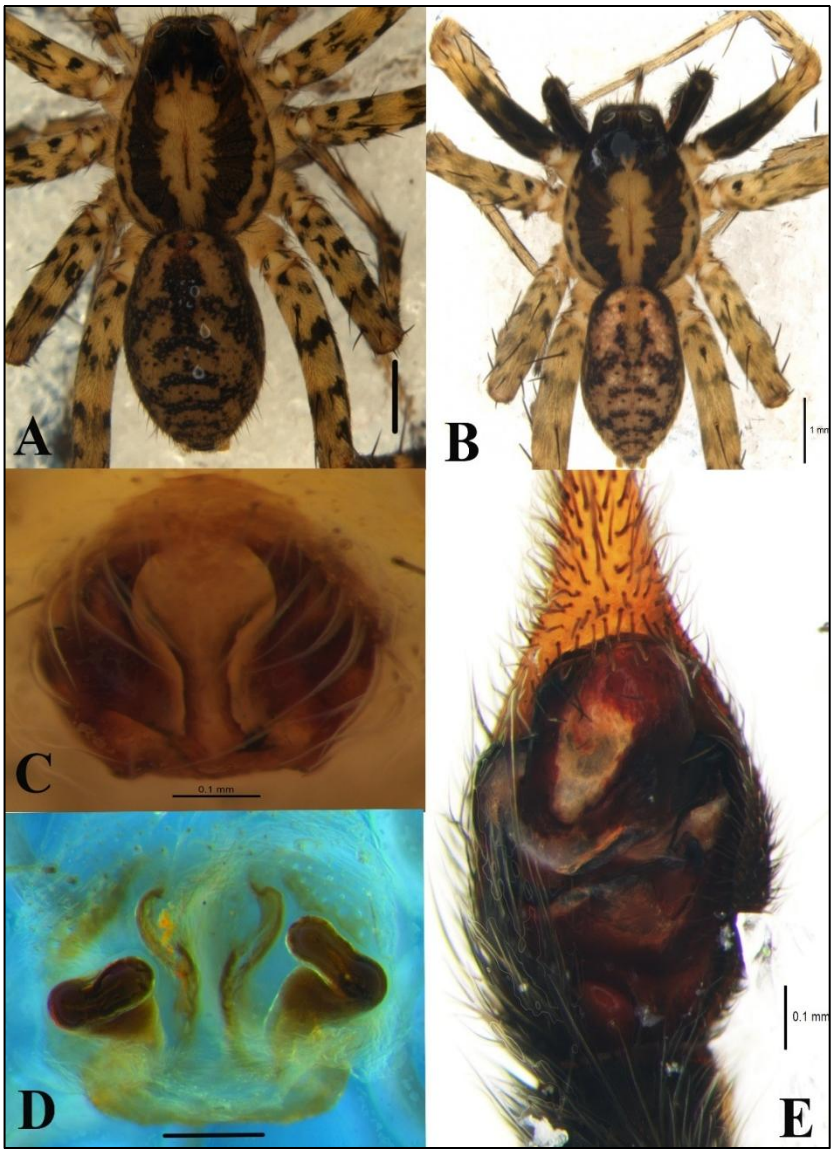


FIGURE 6. *Pardosa sumatrana* (Thorell, 1891): **A**, Female habitus; **B**, Male habitus; **C**, Epigyne ventral view; **D**, same cleared dorsal view **E**. Palp. Scales: A–B, 1mm; C–E, 0.1mm.

4.1.1.7. *Pardosa chapini* (Fox, 1935) [Figs. 7 A–C]

Lycosa chapini Fox, 1935; *Pardosa chapini* Hu, 2001; Song et al., 2001; Zhu & Zhang, 2011; Yin et al., 2012; Wang & Zhang, 2014; Yuan et al., 2019; Zhang et al., 2022.

Materials examined

INDIA, Kerala: 1♀ Gavi, Pathanamthitta (9˚43.49' N, 77˚16.01' E; 1035m a.s.l.) October, 8, 2021; 1 ♀ Meppadi, Wayanad (11°31'26.18"N, 76°9' 9.8"E; alt. 874m a.s.l) October, 9, 2022, coll. R.S. Abhijith.

Diagnosis

Female are similar to other members of *Pardosa nebulosa* species-group, but distinguished by unusually long SS.

Description

Female. Total length 3.25. Prosoma 1.55 long, 1.40 wide; opisthosoma 1.63 long, 1.11 wide.

Carapace dark yellow with vertical, posteriorly wide fovea. Carapace edges with several dark green spots. Median band yellow, extend into the ocular area as a faded bifurcation. Paramedian bands much broader, dark greenish brown, medially wide. Ocular area black with thick protuberances. Clypeus smooth with 0.37 height. Eye sizes and inter-distances: AME 0.10, ALE 0.08, PME 0.21, PLE 0.16; AME–AME 0.04, AME–ALE 0.03, PME–PME 0.31, PME–PLE 0.22. Brown labium, equally long and wide. Chelicera with 3 promarginal and retromarginal teeth. Heart shaped yellow sternum, covered with a few black hairs. Yellow legs with dark green annuli. Leg measurements: I 4.55 (1.16, 1.64, 0.90, 0.85); II 4.20 (1.11, 1.46, 0.95, 0.79); III 3.80 (0.96, 1.30, 0.96, 0.58); IV 6.44 (1.56, 1.90, 1.73, 0.96). Leg formula: 4123. Wider opisthosoma, long and oval. Dorsum dark yellow brown with lateral stripes and lanceolate pattern. Venter yellow anteriorly, black hairs posteriorly. Posterior spinnerets larger.

Epigyne with a pair of hoods. SS inverted T-shaped, uniformly wide and longer. BS inwardly curved. Sp longer than wide, twisted medially, seem to originated from mid region of SS. Distal tip of spermathecae reach only up to the mid-region of septal stem.

Distribution

China, India (**First report from India**).

Remarks

P. chapini was first described from China by Fox (1935). The illustration of Hu (2001), genitalic photograph comparison of Wang & Zang (2014) and Zhang, Peng & Zhang (2022) confirmed our specimen. Habitus images of Wang & Zang (2014) differ considerably from our species in colour and shape, but similar genitalic characters. But, Zhang, Peng & Zhang (2022) specimens almost similar to our specimens.

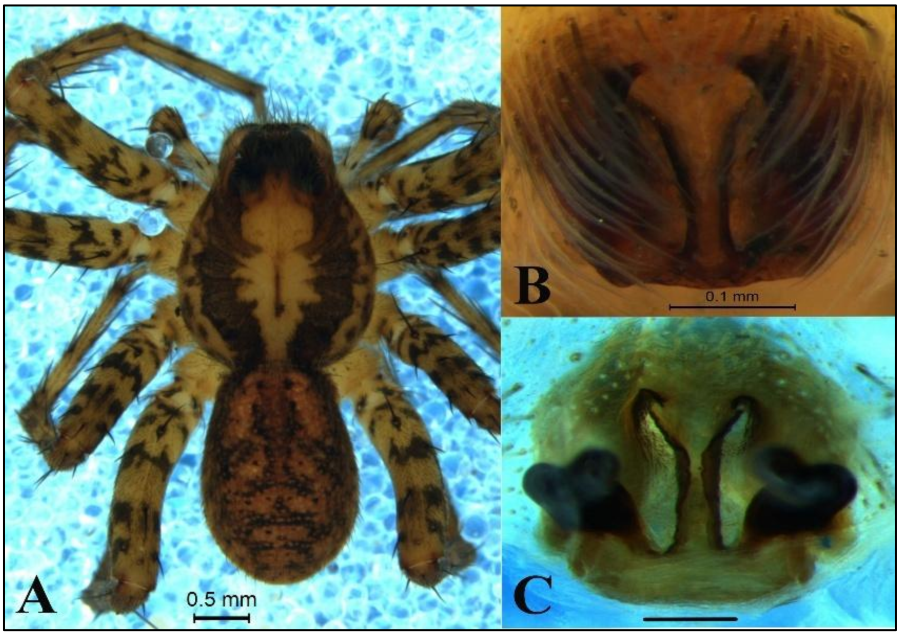


FIGURE 7. *Pardosa chapini* (Fox, 1935): **A**, Female habitus; **B**, Epigyne ventral view; **C**, same cleared dorsal view**.** Scales: A, 0.5 mm; B–C, 0.1mm.

4.1.2. Genus *Draposa* Kronestedt, 2010

Diagnosis

The male specimens diagnosed as genus *Draposa* by the following character combinations in palp: sub-paleal sclerite with two processes, transverse tegular apophysis with two projections, distal part with sub-apical protrusion and paleal apophysis (Abhijith & Sudhikumar, 2023). The female specimens identified as *Draposa* by the presence of a tongue-like septum in front of epigynal cavity (Abhijith & Sudhikumar, 2023).

4.1.2.1 *Draposa atropalpis* (Gravely, 1924) [Figs. 8 A–C]

Pardosa atropalpis Gravely, 1924; Tikader & Malhotra, 1980. *Draposa atropalpis* Kronestedt, 2010.

Materials examined

India, Kerala**:** 1♀ from Meppadi, Wayanad (11°31'26.18"N, 76°9' 9.8"E; alt. 874 m a.s.l) October 9, 2021, coll. R.S. Abhijith; 1♀ from Vandanam, Alappuzha (9°24' 48.30"N, 76°20' 59.63"E; alt 6m a.s.l) February 20, 2023, coll. R.S. Abhijith.

Diagnosis

Females are morphologically similar to other members of *Draposa*, but differ by short tongue-like median septum in front of epigyne.

Description

Female: Total length 4.17. Prosoma 2.12 long, 1.72 wide. Opisthosoma 2.05 long, 1.27 wide. Yellow brown carapace with indistinct vertical, thick fovea. Carapace edges with several faded green spots. Broad and yellow median; paramedian bands much broader, dark greenish brown, narrower towards ocular area. Ocular area black with thick protuberances. Clypeus smooth with 0.17 height.

Eye sizes and inter-distances: AME 0.079, ALE 0.057, PME 0.179, PLE 0.144, AME–AME 0.073, AME–ALE 0.047, PME–PME 0.276, PME–PLE 0.288. Procurved anterior row; MOQ wider posteriorly**.** Brown, long labium. Chelicera teeth similar to *Pardosa*. Heart-shaped yellow sternum, covered with a few black hairs. Yellow legs with dark green annuli.

Leg measurements: I 5.59 (1.57, 1.94, 1.25, 0.83); II 5.42 (1.48, 1.90, 1.12, 0.92); III 5.39 (1.49, 1.74, 1.36, 0.80); IV 7.79 (1.90, 2.44, 2.34, 1.11). Leg formula: 4123. Palp 1.98 (0.67, 0.76, 0.55). Wider opisthosoma, long and oval. Dorsum yellow brown with lateral stripes and a faded lanceolate pattern; bright guanocytes present. Venter yellow. Large posterior spinnerets.

Epigyne with deep central cavity, median cavity opening narrow, in front tongue-like short narrow septum. In ventral in-situ view spermatheca and copulatory duct butterfly wing-shaped. Base of the uniquely 'U'- shaped when viewed dorsally.

Distribution

India, Sri Lanka.

Remarks

Like other *Draposa* species, they are also very similar to *Pardosa*. Both the specimens are collected from ecosystems with good green vegetation. Altitude and climate of two collection locations are considerably different. It indicates its cosmopolitan distribution throughout Kerala.

4.1.2.2. *Draposa burasantiensis* (Tikader & Malhotra, 1976) [Figs. 9 A–C]

Pardosa burasantiensis Tikader & Malhotra, 1976; Tikader & Malhotra, 1980; Tikader & Biswas, 1981; Yin et al., 1997; Song et al., 1999; Yin et al., 2012.

Draposa burasantiensis Dhali et al., 2012; Sen et al., 2015; Dhali et al., 2017; Abhijith et al., 2022b.

Material examined

India, Kerala**:** 2♀ from grassland in Gavi, Pathanamthitta (9º43.49'N, 77º16.01'E; alt. 1036 m) October 8, 2021, coll. R.S. Abhijith. Deposited in CATE, Christ College, Irinjalakuda, Kerala, India (CATE583912).

Diagnosis

Specimen morphologically very similar to *Pardosa* genus, but, differ considerably in the genitalia structure. Ventral view of the epigyne shows *Draposa* genus characteristic tongue- like septum; SS uniform in width with a ‘V’ shape hood (Abhijith et al., 2022b).

Redescription

Female: Total length 4.07, Prosoma 2.04 long, 1.62 wide, Opisthosoma 2.03 long, 1.21 wide; Carapace yellowish brown with vertical fovea, broader on ends; Green spots along lateral edges of carapace; Uneven median band, yellow green, extend into the ocular area as a bifurcation; Paramedian bands much broader, greenish brown, uniformly wide, with inward projections; Ocular area black with thick protuberances Clypeus smooth with 0.15 height; Eye sizes and inter-distances: AME 0.069, ALE 0.051, PME 0.178, PLE 0.140, AME–AME 0.070, AME–ALE 0.042, PME–PME 0.256, PME–PLE 0.290; Procurved anterior row; MOQ wider posteriorly; Grey, longer labium; Chelicera with all three promarginal teeth of same size and middle one of the three retromarginal teeth large and distinct; Heart shaped sternum flanked by dark margin; a few black hairs present; Yellow legs with dark green annuli; Leg measurements: I 5.49 (1.55, 1.90, 1.24, 0.80); II 5.38 (1.47, 1.89, 1.11, 0.91); III 5.09 (1.37, 1.66, 1.31, 0.75); IV 7.69 (1.87, 2.40, 2.33, 1.09); Leg formula: 4123; Palp 1.96 (0.66, 0.76, 0.54); Wider opisthosoma, long and oval;

dorsum dark yellow brown with lateral stripes and lanceolate pattern; guanocytes present; venter light yellow; Posterior spinnerets larger (Abhijith et al., 2022b).

Epigyne distinct from other species of Lycosidae by presence of short tongue-like septum and V-shaped hood; Internally uniformly wide, short and tubular SS; wider BS; CD globular, lateral to septum; Sp, parallel to SS, upright, equally wide and long, slight inward folding, tip above and parallel to hoods; Globular FD positioned at the base of CD (Abhijith et al., 2022b).

Distribution

China, India (**first report from the state of Kerala**).

Remarks

Female genitalia figures of *Pardosa burasantiensis* (later transferred to *Draposa*) in Tikader & Malhotra (1980) and Yin et al. (2012) shows similarity with our specimen. Especially view of internal genitalia and the arrangement of SS with V-shaped hoods in Tikader & Malhotra (1980) resembles our specimens in question (Abhijith et al., 2022b). Previous studies mainly dealt with external morphology, not the crucial genitalic characters. In order to provide an accurate account for future studies, the female specimen is redescribed with genitalic characters and photographs.

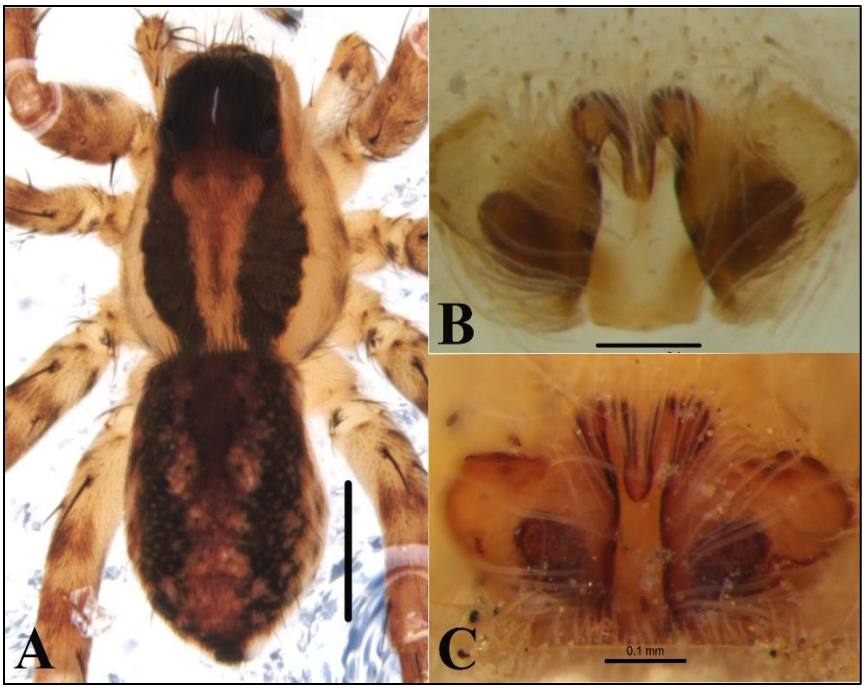


FIGURE 8. *Draposa atropalpis* (Gravely, 1924): **A**, Female habitus; **B**, Epigyne ventral view; **C**, same from another specimen**.** Scales: A, 1 mm; B–C, 0.1mm.

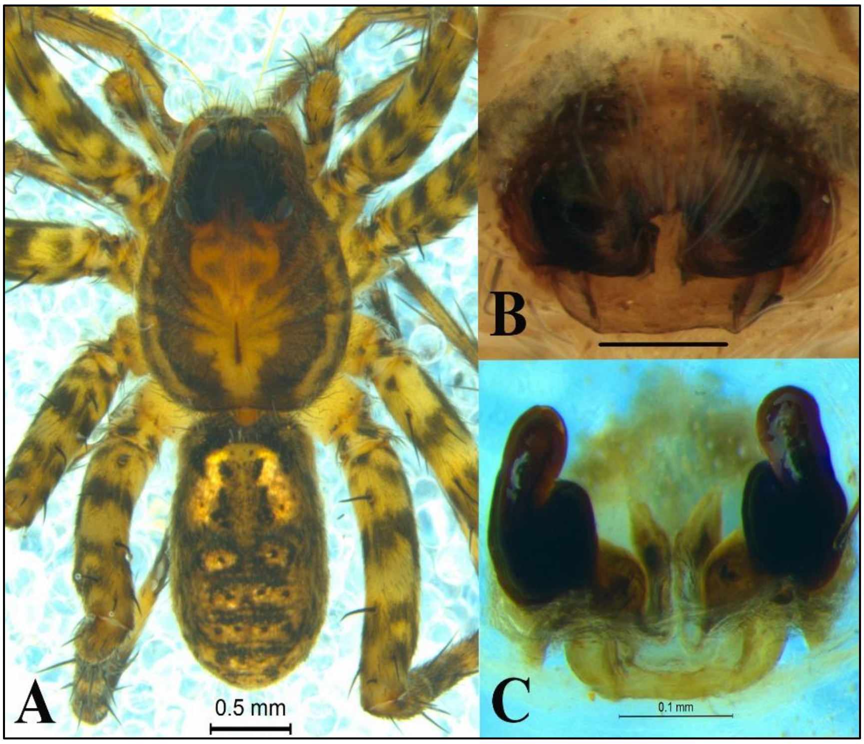


FIGURE 9. *Draposa burasantiensis* (Tikader & Malhotra, 1976): **A**, Female habitus; **B**, Epigyne ventral view; **C**, same cleared dorsal view**.** Scales: A, 0.5 mm; B–C, 0.1mm.

4.1.2.3. *Draposa sebastiani* sp. nov. Abhijith & Sudhikumar, 2023 [Figs. 10 A–E]

[urn:lsid:zoobank.org:act: 52753126-81E9-4158-87FB-975BA8FBF38E]

Draposa sebastiani Abhijith & Sudhikumar, 2023.

Materials examined

INDIA, Kerala: *Holotype*, 1♂, CATE583911a; *Paratypes*, 5♂ and 8♀; Wayanad (11°47'52.8"N, 75°59'27.6"E; alt. 1,036 m a.s.l) April 25, 2021; coll. R.S. Abhijith.

Diagnosis

Male pedipalp of *D. sebastiani* sp. nov. similar to that of *D. lyrivulva* (Bösenberg & Strand, 1906) known from Pakistan, India and Sri Lanka, but differs by having the following set of characters: shorter tegular apophysis (vs. longer); prominent sub-apical protrusion (vs. minute); narrow and linear tegular apophysis tip (vs. curved and hook-like); embolus parallel to tegular apophysis (vs. forming an upward angle). The male copulatory organs of the new species are comparable with those of *D. atropalpis* (Gravely, 1924) and *D. oakleyi* (Gravely, 1924), but differ by having a prominent sub-apical protrusion and a gap between tegular apophysis tip and paleal apophysis [vs. sub-apical protrusion is non-prominent and paleal apophysis is partially covered by tegular apophysis; see figures 8, 10, 33 in Kronestedt 2010] (Abhijith & Sudhikumar, 2023). Female epigyne of *D. sebastiani* sp. nov. similar to those of *D. amkhasensis* (Tikader & Malhotra, 1976), but differ by having the following set of characters: shorter tongue-like median septum (vs. septum longer and close to the base of epigynal cavity), epigynal cavity wider medially (vs. cavity narrow and completely covered by septum), CD and Sp closer to epigynal cavity (vs. positioned further away), stalk and head of spermatheca wider (vs. narrower); epigyne of the new species is compared to *D. atropalpis* and *D. oakleyi*, but different with the Sp arrangement, shape of median septum and epigynal cavity [see figures 9, 11 in Kronestedt (2010) and figures 176, 178 in Tikader & Malhotra, 1980] (Abhijith & Sudhikumar, 2023).

Description

Male: Total length 4.10, Prosoma 2.16 long, 1.64 wide, Opisthosoma 1.94 long, 1.33 wide; Carapace, greenish-brown with vertical fovea; Median band, wider anteriorly, yellow, extend into the ocular area as a bifurcation; Green broken stripes along lateral edges of carapace; Paramedian bands broader, yellow, covered with white hairs; Ocular area clothed with black pubescence and a few white hairs; Clypeus smooth, yellow with 0.15 height; Eyes and inter-distances: AME 0.13, ALE 0.09, PME 0.26, PLE 0.23. AME–AME 0.05, AME–ALE 0.03, PME–PME 0.31, PME–PLE 0.29; Posteriorly wider MOQ; Chelicerae yellowish with light brown coloured fangs and dorsal area; number of teeth similar to other *Draposa*, distal promarginal tooth much smaller; Wider labium with darker base; Yellow legs without any annuli; Femur of first pair of legs darker; Leg measurements: I 5.16 (1.48, 1.86, 1.29, 0.97, 0.85); II 4.51 (1.56, 1.22, 1.10, 0.63); III 4.04 (1.39, 0.99, 1.07, 0.59); IV 7.61 (2.14, 2.33, 2.23, 0.91); Leg formula 4123; Greenish brown opisthosoma, long and oval; dorsum dark yellow brown with lateral stripes and lanceolate pattern; guanocytes present; venter yellow; Posterior spinnerets larger **(**Abhijith & Sudhikumar, 2023).

Palp tibia with oblique black setae patch prolaterally; Cymbium wide medially, dark with thick black hairs dorsally; Pa prominent, cone-shaped in retrolateral view; St wide positioned prolaterally; TA short with two well separated, downward projections medially, prominent sub-apical protrusions and tapering end; Sub-paleal sclerite with short anterior and long posterior processes; paleal apophysis close to E apex; Starting of E with wide apex filiform **(**Abhijith & Sudhikumar, 2023).

Female: Total length 4.47, Prosoma 2.15 long, 1.54 wide, Opisthosoma 2.23 long, 1.52 wide; Carapace, greenish-brown with shorter vertical fovea; Median band, wider anteriorly, yellow, extend into the ocular area as a bifurcation; Faded green broken stripes along lateral edges of carapace; Lateral bands yellow, wider than in male; Paramedian bands wider than in males, yellow; Ocular area clothed with black pubescence and a few white hairs; Clypeus smooth, yellow; Eyes and inter-distances: AME 0.15, ALE 0.08, PME 0.31, PLE 0.27, AME–AME 0.04, AME–ALE 0.03, PME–PME 0.37, PME–PLE 0.31; Chelicerae similar to males except brown colouration of fangs; Yellow legs without any annuli; Femur of first pair of legs light yellow; Leg measurements: I 5.38 (1.53, 1.95, 1.01, 0.89); II 4.61 (1.58, 1.27, 1.11, 0.65); III 4.35 (1.48, 1.15, 1.09, 0.63); IV 8.02 (2.25, 2.45, 2.32, 1.00); Leg formula 4123; Light greenish brown opisthosoma, long and oval; dorsum dark yellow brown with lateral stripes and narrow lanceolate pattern; guanocytes with adjacent dark dots present; venter yellow, guanocytes present posteriorly; Larger posterior spinnerets (Abhijith & Sudhikumar, 2023).

Epigyne: Medially wide, deep central cavity with a short-stalked globular 'uvula' shaped septum extended up to mid-region; Sp and CD appear bean-shaped in ventral view; Internally Sp broader and positioned closer to central cavity; Bottom of epigynal central cavity extended laterally, covering entire Sp and CD; inwardly turned CD; FD cylindrical and swollen (Abhijith & Sudhikumar, 2023).

Etymology

The species name is a noun, honouring Late Dr. P.A. Sebastian, Sacred Heart College, Kochi, Kerala, one of the pioneer South Indian arachnologists, for his invaluable contributions to Indian arachnology.

Distribution

Known only from the type locality (Wayanad, Kerala, India).

Remarks

The collection location was an arable grassland with coconut and vegetable plantation, adjacent to forest. The collection was done during dusk (Abhijith & Sudhikumar, 2023). Femora I is slightly darker in all males collected, which is absent in females. The study infer that this dark patch may be used as a visual enhancer of dark palp while copulatory dance. This would be an interesting topic for ethologists, which need experimental results to confirm.

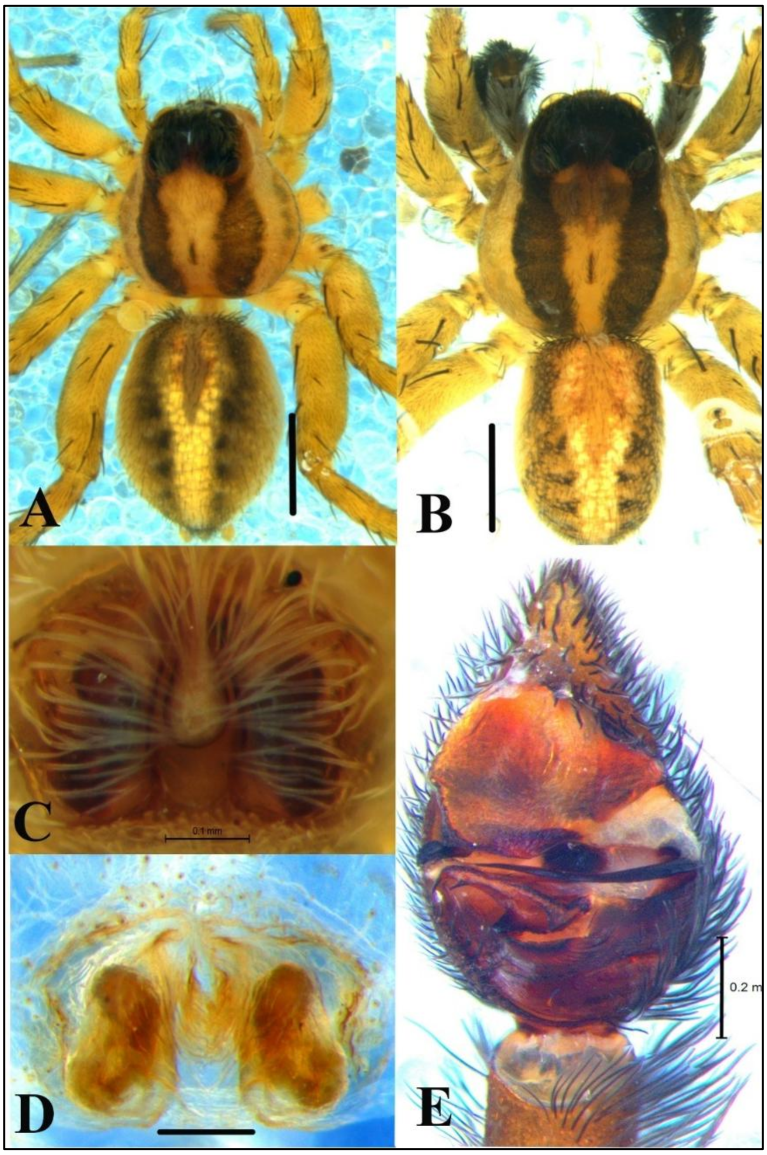


FIGURE 10. *Draposa sebastiani* Abhijith & Sudhikumar, 2023: **A**, Female habitus; **B**, Male habitus; **C**, Epigyne ventral view; **D**, same cleared dorsal view **E**. Palp. Scales: A–B, 1 mm; C–D, 0.1mm; E, 0.2mm.

4.1.3. Genus *Wadicosa* Zyuzin, 1985

Diagnosis

Male specimens diagnosed as members of genus *Wadicosa* by tegulum with ventrally pointed anterior retrolateral process; Pa above conductor and embolus; Female spiders identified as *Wadicosa* by epigyne with two closer foveolae (Abhijith & Sudhikumar, 2024).

4.1.3.1. *Wadicosa fidelis* (O. Pickard-Cambridge, 1872) [Figs. 11 A–E]

Lycosa fidelis O. Pickard-Cambridge, 1872

Wadicosa fidelis Buchar & Dolejš, 2021; Wang et al., 2021; Sankaran et al., 2021a; Al-Yacoub & Najim, 2023; Seropian et al., 2023; Abdel-Ghani et al., 2023.

Material examined

India, Kerala**:** 1♂ from grassland in Gavi, Pathanamthitta district, Kerala (9º43.49'N, 77º16.01'E; alt. 1036 m) October 8, 2021, coll. R.S. Abhijith; 2♂ and 1♀ from Kodikuthimala, Malappuram district, Kerala (10° 58.47'N, 76°17.32'E, alt. 522m) July 26, 2021, coll. R.S. Abhijith.

Diagnosis

Males are distinguished by shape of MA, numerous small projections on its lower branch, crest-shaped sclerotized posterior retrolateral tegular process; females by the configuration and structure of the epigynal cavity.

Description

Male: Total length 3.51. Prosoma 2.12 long, 2.84 wide. Opisthosoma 1.31 long, 2.12 wide. Prosoma: Carapace, blackish brown with numerous short black hairs. Slender, vertical fovea with light colour region around apex. Dark and continuous paramedian bands. Ocular area clothed with white pubescence. Black-coloured, smooth clypeus with 0.26 height. Wider labium with darker base. Dark brown chelicera, 3 retrolateral teeth. Black, heart-shaped sternum densely clothed with black hairs. Eye measurements: AME 0.16, ALE 0.10, PME 0.26, PLE 0.24. AME–AME 0.12, AME–ALE 0.06, PME–PME 0.33, PME–PLE 0.20, PME–AME 0.10. Posteriorly wider MOQ Yellow legs with grey annuli. Leg measurements: I 6.02 (2.13, 2.37, 1.21, 0.31); II 6.33 (2.02, 2.06, 1.16, 1.09); III 5.55 (1.97, 2.68, 0.51, 0.39); IV 9.22 (2.51, 2.83, 2.51, 1.37). Leg formula 4213. Light brown opisthosoma, long and oval; dorsum with ambiguous lanceolate pattern; venter yellow with a dark patch.

Palp: Cymbium darker. TA retrolaterally pointed, distal part ventral. E long, bend over upper branch of TA; apically rounded with transparent extension, narrowed tip. Anterior part of T with a retrolateral process projecting ventrad and heavily scelorotized posterior reterolateral process. A gap present between tip of E and retrolateral process. Pa small and sclerotized, positioned anterior to E and conductor.

Female: Total length 4.82. Prosoma 2.11 long, 2.54 wide. Opisthosoma 2.33 long, 2.52 wide. Prosoma: Carapace similar to that of males. Black-coloured, smooth clypeus with 0.26 height. Wider labium with darker base. Dark brown chelicera, 3 retrolateral teeth. Sternum lighter than in males. Eye measurements: AME 0.30, ALE 0.24, PME 0.37, PLE 0.39. AME–AME 0.20, AME–ALE 0.11, PME–PME 0.42, PME–PLE 0.29, PME–AME 0.15. Posteriorly wider MOQ. Colouration and markings of legs similar to male. Leg measurements: I 7.38 (2.40, 2.68, 1.60, 0.70); II 8.33 (2.56, 2.56, 1.97, 1.24); III 7.13 (2.25, 3.14, 0.94, 0.80); IV 11.23 (3.12, 3.12, 3.32, 1.67). Leg formula 4213. Opisthosoma similar to males except yellow spots; venter yellow with scattered dark spots.

Epigynal septum longer than wide, anteriorly with two close pockets (foveolae) forming continuous arch. SS shorter.

Distribution

Indian Sub-continent, North Africa, South Europe, Middle-east and Central Asia, China, Japan, Philippines, Indonesia.

Remarks

W. fidelis is one of the most common *Wadicosa* species with numerous citing throughout the world. In Kerala it seemed to be outnumbered by other species especially *Pardosa*. Both citing of the species was from high altitudes with high green vegetations.

4.1.3.2. *Wadicosa intermediata* sp. nov. Abhijith & Sudhikumar, 2024 [Figs. 12 A–E]

Wadicosa quadrifera-species group

Materials Examined

INDIA, Kerala: 2♂, 1♀; Kottappara, Idukki (10°1. 38' N, 76°58. 11' E; 2194 m a.s.l) October 15, 2021, coll. R.S. Abhijith.; Holotype: 1♂ CATE591225a, Paratypes: 1♂ 1♀ CATE591225b.

Diagnosis

Males differ from other *Wadicosa* species except *W. quadrifera* and *W. ghatica* having a cork-screw shaped embolus; Male distinguished from *W. ghatica* by following set of characters; E with conspicuous medial bulge and tapering tip [no such bulging and blunter tip in *W. ghatica*], noticeable gap between E tip and tegular retrolateral process [no gap in *W. ghatica*], tegular reterolateral process blunt [tapered in *W. ghatica*] (Abhijith & Sudhikumar, 2024). Female diagnosed by, posterior median quadrangular depression broader than long [almost wide as long in *W. ghatica*] and sclerotized finger-like extension of CD [no such extension in *W. ghatica*] (Abhijith & Sudhikumar, 2024).

Description

Male: Total length 5.51, Prosoma 3.12 long, 2.84 wide, Opisthosoma 2.31 long, 2.12 wide; Prosoma: Carapace, blackish brown with numerous short black hairs; Slender, vertical fovea with light colour region around apex; Dark and continuous paramedian bands; Ocular area clothed with white pubescence; Black-coloured, smooth clypeus with 0.35 height; Eye diameters and inter-distances: AME 0.18, ALE 0.11, PME 0.29, PLE 0.28, AME–AME 0.14, AME–ALE 0.08, PME–PME 0.36, PME–PLE 0.22, PME–AME 0.12; Posteriorly wider MOQ; Wider labium with darker base; Dark brown chelicera, 3 retrolateral teeth; Black, heart-shaped sternum densely clothed with black hairs; Yellow legs with grey annuli; Leg measurements: I 7.02 (2.33, 2.67, 1.41, 0.61); II 7.43 (2.27, 2.31, 1.66, 1.19); III 6.55 (2.17, 2.98, 0.71, 0.69); IV 10.72 (3.11, 3.13, 2.91, 1.57); Leg formula 4213; Opisthosoma colouration similar to carapace except shiny spots, long and oval; dorsum with brown, ambiguous lanceolate pattern; venter yellow with a dark patch (Abhijith & Sudhikumar, 2024).

Palp: Darker cymbium with white pubescence; Anteriorly pointed, crescent-shaped TA with ventral curvature, narrow upper process and broad blunt basal process; Tapering, cork screw- shaped E, with a noticeable mid-protrusion; T with anterior blunt end, and ventrally projected triangle shaped retrolateral process; Noticeable gap between E tip and retrolateral process; Sclerotized, dorsally curved Conductor; Moderately sclerotized Pa, frontal to E and conductor; Prolaterally placed St (Abhijith & Sudhikumar, 2024).

Female: Total length 6.62, Prosoma 3.11 long, 2.54 wide, Opisthosoma 3.13 long, 2.52 wide; Prosoma: Carapace, blackish brown with numerous short black hairs; Slender, vertical fovea without light colour region around apex; Dark and continuous paramedian bands; Ocular area clothed with white pubescence; Black-coloured, smooth clypeus with 0.38 height; Eye diameters and inter-distances: AME 0.20, ALE 0.14, PME 0.31, PLE 0.29, AME–AME 0.16, AME–ALE 0.09, PME–PME 0.39, PME–PLE 0.25, PME–AME

0.14; Posteriorly wider MOQ; Wider labium with darker base; Dark brown chelicera, 3 retrolateral teeth; Black, heart-shaped sternum densely clothed with black hairs; Yellow legs with grey annuli; Leg measurements: I 7.68 (2.43, 2.88, 1.62, 0.75); II 8.33 (2.56, 2.56, 1.97, 1.24); III 7.23 (2.29, 3.15, 0.97, 0.82); IV 11.53 (3.22, 3.17, 3.42, 1.72); Leg formula 4213; Opisthosoma light brown with obscure shiny dots, long and oval; venter yellow with numerous dark patches (Abhijith & Sudhikumar, 2024).

Epigyne: Ventrally with a posterior median quadrangular depression wider than long; Median septum with elongated SS, with two foveolae making a continuous arch; Sp bulbous; Sclerotized finger-shaped projections in CD closer to CO; Septal arch in dorsal view with disconnected lobes (Abhijith & Sudhikumar, 2024).

Etymology

The females of new species have features of both *W. ghatica* and *W. quadrifera*. This intermediate condition of the epigyne is described by the specific epithet.

Distribution

The new species only known from its type locality, Kottappara, Idukki, Kerala.

Remarks

This is the latest member of *W. quadrifera*-species group. Currently this species-grouping has no taxon status (Abhijith & Sudhikumar, 2024). Three species in this group (new species along with *W. ghatica* and *W. quadrifera*) distributed continuously signifying that they may diverge recently. Along with unique diagnosing features, intermediary condition of the epigyne is evident by the presence of septal arch resembles that of *W.*

quadrifera, foveolae similar to that of *W. ghatica;* Sp connection as in *W. ghatica* (Kronestedt, 2017; Abhijith & Sudhikumar, 2024).

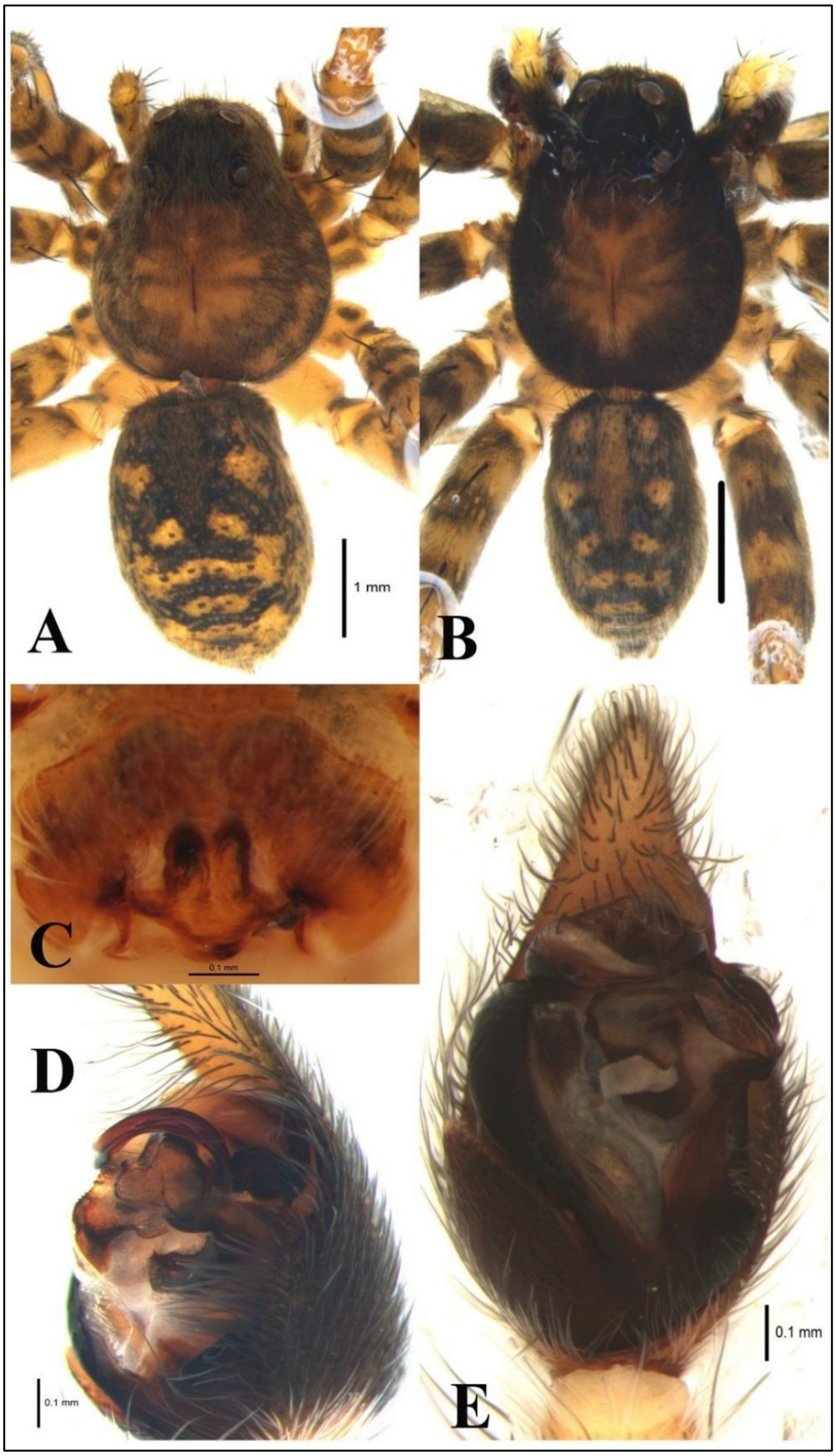


FIGURE 11. *Wadicosa fidelis* (O. Pickard-Cambridge, 1872): **A**, Female habitus; **B**, Male habitus; **C**, Epigyne ventral view; **D**, Palp retrolateral view **E**. Same ventral view. Scales: A–B, 1 mm; C–E, 0.1mm.

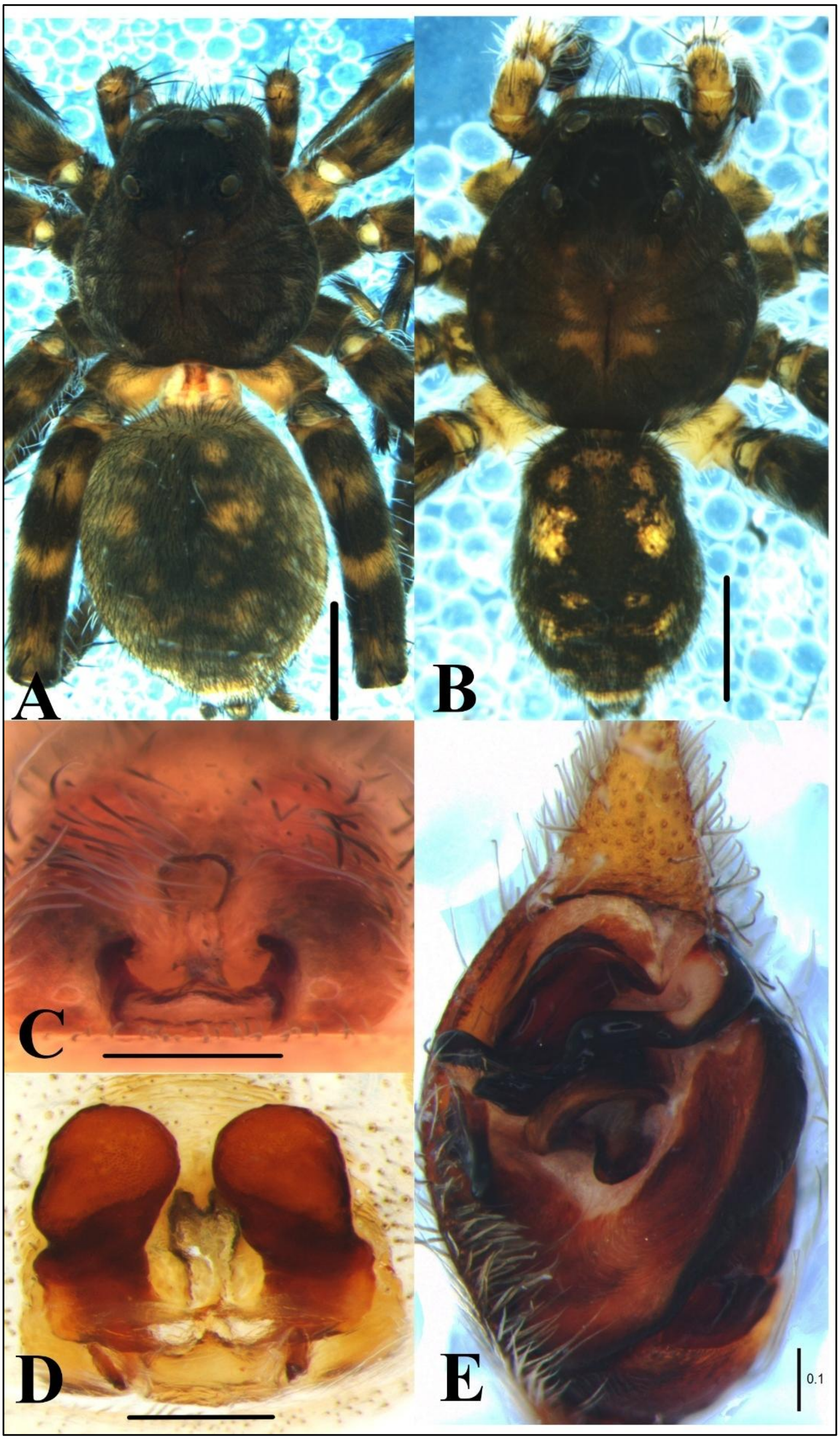


FIGURE 12. *Wadicosa intermediata* sp. nov.: **A**, Female habitus; **B**, Male habitus; **C**, Epigyne ventral view; **D**, same cleared dorsal view **E**. Palp. Scales: A–B, 1 mm; C–E, 0.1mm.

4.1.4. Genus *Hippasa* Simon, 1885

Diagnosis

Genus *Hippasa* differs from other lycosids having slender body with striped patterns. They usually found in funnel-like webs. Sternum contains dark longitudinal band. Spinnerets are bi-segmented with elongated basal segments.

4.1.4.1. *Hippasa agelenoides* (Simon, 1884) [Figs. 13 A–E]

Pirata agelenoides Simon, 1884; *Diapontia agelenoides* Thorell, 1887; *Hippasa partita* Ahmed et al., 2015; *Hippasa agelenoides* Tikader & Malhotra, 1980; Sen et al., 2015; Dhali et al., 2017; Sankaran & Caleb, 2023a.

Materials examined

India, Kerala**:** 1♀ from Kanjirangad, Wayanad (11°44'55.42"N, 75°54' 24"E, alt. 792 m) April 18, 2022, coll. R.S. Abhijith; 1♀ from Kurumbalakotta, Wayanad (11° 41' 48.12"N, 76° 2' 3.48"E; alt. 991 m) October 21, 2021, coll. R.S. Abhijith; 2♀ from Vynthala ox-bow lake, Mala, Thrissur (10° 15' 36.74"N, 76° 17' 42.99"E; alt. 5 m a.s.l.), September 21, 2021, coll. R.S. Abhijith; 1♂ from Karyavattom, Thiruvananthapuram (8° 33' 41.76" N, 76° 53' 33.36" E; 12 m a.s.l.) June 22, 2023, coll. R. S. Abhijith.

Diagnosis

Males can be distinguished by wide conductor and retrolaterally placed median arm of TA. Female of the species can be identified by the presence of inverted ‘U’-shaped atrium.

Description

Female: Total length 5.61. Prosoma 2.63 long, 1.74 wide. Opisthosoma 2.87 long, 2.12 wide. Carapace greenish yellow, distinct short longitudinal fovea. Lateral band inconspicuous. Several faded green patterns radiated towards fovea. Eye region, dark. Chelicerae, labium dark yellowish; dorsum of opisthosoma light green with paired sigilla, venter pale yellow with paired dark bands near pedicel; legs with dark green annulations. Sternum with black setae, with a broad median longitudinal black band extend towards pedicel. Opisthosoma ovoid with numerous patterns and sigilla. Spinnerets greenish yellow, long and bi-segmented. Eye diameters and inter-distances: AME 0.14, ALE 0.13, PME 0.19, PLE 0.16. AME–AME 0.07, AME–ALE 0.06, PME–PME 0.19, PME–PLE 0.21, PME–AME 0.12. Clypeus yellow 0.17. Legs yellow slender and have pale annulations. Leg measurements I 10.98 (3.95, 3.88, 2.80, 1.30); II 9.53 (3.21, 2.99, 1.99, 1.34); III 7.13 (1.95, 2.94, 1.84, 1.40); IV 12.30 (4.41, 3.48, 3.56, 0.85). Leg formula: 4123. Epigyne: Covered in dark hairs, wider short epigynal plate with median atrium. Spermathecal stalks positioned horizontally than vertically. Oval Sp with slender long, S-shaped stalks.

Male: Total length 5.41. Prosoma 2.60 long, 1.73 wide. Opisthosoma 2.69 long, 2.01 wide. All other features similar to female except leg annulations are much darker and much more guanocytes on ventrum of abdomen. Pedipalp dark yellow, tegulum large, oval, semi-sclerotized paleae, slender and pointed embolus. E tip pointed distally. TA prominent with two arms. Higher arm large positioned ventrally and retrolaterally. Distal part of the lower arm pointed reterolaterally.

Distribution

India, Pakistan, Myanmar.

Remarks

Most common *Hippasa* species in our collection. Found from all different kinds of altitudes and habitats. Common feature of the habitats is that they all were undisturbed or semi-disturbed.

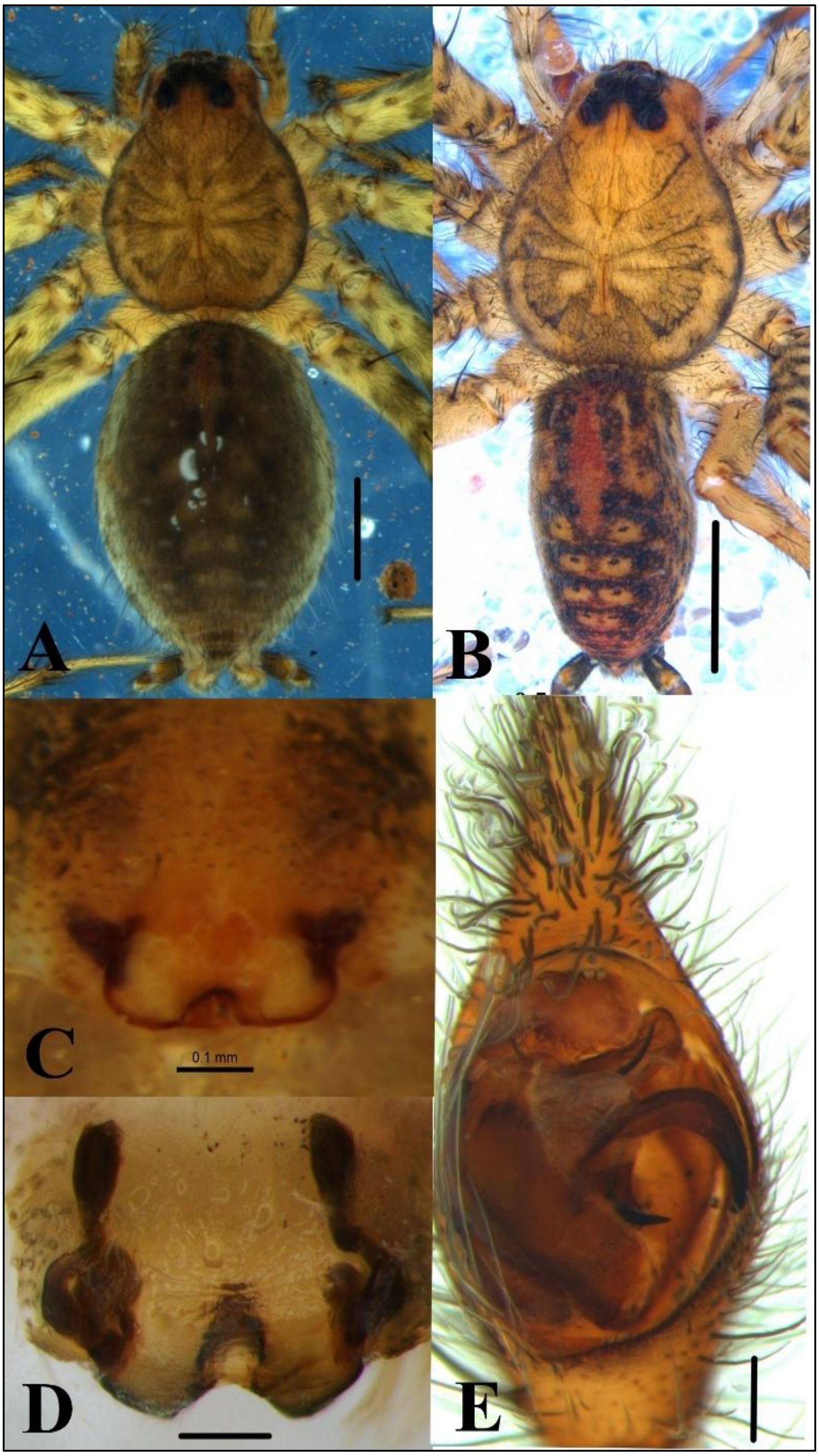


FIGURE 13. *Hippasa agelenoides* (Simon, 1884): **A**, Female habitus; **B**, Male habitus; **C**, Epigyne ventral view; **D**, same cleared dorsal view **E**. Palp. Scales: A–B, 1 mm; C–E, 0.1mm.

4.1.4.2. *Hippasa lycosina* Pocock, 1900 [Figs. 14 A–C]

Hippasa lycosina Pocock, 1900; Tikader & Malhotra, 1980; Song, 1988; Wang et al., 2015; Ahmed et al., 2015; Marusik & Nadolny, 2021; Sankaran & Caleb, 2023a..

Materials examined

India, Kerala**:** 1♀ from Kanjirangad, Wayanad (11°44'55.42"N, 75°54' 24"E; alt. 792 m) April 18, 2022, coll. R.S. Abhijith.

Diagnosis

Females are distinguished from other *Hippasa* by the presence of wide triangular epigynal atrium.

Description

Female: Total length 11.52. Prosoma 5.12 long, 3.84 wide. Opisthosoma 6.31 long, 2.72 wide. Carapace light yellow, distinct longitudinal dark fovea with a bifurcated pattern on anterior end. White continuous lateral band. Several green patterns radiated towards fovea. Eye region, clypeus dark. Chelicerae, labium brownish; dorsum of opisthosoma dark brown, venter pale brown; legs with pale annulations. Sternum with black setae, with an anteriorly broad median longitudinal black band. Opisthosoma elongated oval with numerous white dots lanceolate pattern same colour as background, thus indistinguishable. Spinnerets long and bi-segmented. Eye diameters and inter-distances: AME 0.24, ALE 0.22, PME 0.40, PLE 0.34. AME–AME 0.11, AME–ALE 0.06, PME–PME 0.22, PME–PLE 0.31, PME–AME 0.14. Clypeus 0.24. Legs yellow slender and have pale annulations. Leg measurements I 16.38 (5.40, 5.68, 3.60, 1.70); II 15.33 (4.56, 5.56, 2.97, 2.24); III 13.13 (3.75, 4.64, 2.44, 2.30); IV 19.35 (6.12, 5.19, 5.37, 2.67). Leg formula: 4123.

Epigyne: Covered in dark strong hairs, median plate wide triangular, narrow lateral plates with large atrium. Triangular hood present.

Distribution

China, Laos, India (**first report from state of Kerala**).

Remarks

These are comparatively large spiders found on large funnel web. The construction of the funnel web is so intriguing that the collection from the web was extremely difficult. The web was found on the basal part of a kind of long grass.

4.1.4.3. *Hippasa valiveruensis* Patel & Reddy, 1993 [Figs. 15 A–C]

Hippasa valiveruensis Patel & Reddy, 1993; Sankaran & Caleb, 2023a.

Materials examined

India, Kerala: 1♀ from Meppadi, Wayanad (11°31'26.18"N, 76°9' 9.8"E; alt. 874 m) October 9, 2021, coll. R.S. Abhijith.

Diagnosis

Females are distinguished from other *Hippasa* by lack of epigynal atrium and horizontally positioned Sp.

Description

Female: Total length 4.71. Prosoma 2.16 long, 1.84 wide. Opisthosoma 2.37 long, 1.22 wide. Carapace light yellow, distinct longitudinal red fovea. Yellow discontinuous lateral band. Several light green patterns radiated towards fovea. Eye region, dark. Chelicerae, labium light brownish; dorsum of opisthosoma light green, venter pale yellow; legs with green annulations. Sternum with black setae, with a broad median longitudinal black band and thin black line around the margin. Opisthosoma much elongated than wide with numerous light dots lanceolate pattern present. Spinnerets light yellow, long and bi-segmented. Eye diameters and inter-distances: AME 0.11, ALE 0.10, PME 0.17, PLE 0.14. AME–AME 0.06, AME–ALE 0.05, PME–PME 0.19, PME–PLE 0.20, PME–AME

0.10. Clypeus yellow 0.15. Legs yellow slender and have pale annulations Leg measurements I 10.38 (3.94, 3.70, 2.50, 1.24); II 9.33 (3.16, 2.96, 1.97, 1.24); III 6.13 (1.75, 2.64, 1.44, 1.30); IV 11.30 (4.11, 3.18, 3.36, 0.65). Leg formula: 4123.

Epigyne: Covered in dark hairs, atrium absent, narrow long epigynal plates. Spermathecal stalks horizontally placed.

Distribution

India (**first report from Western Ghats region**).

Remarks

This is the first report of the species from a place other than type locality. Comparatively small *Hippasa* species found on funnel web. Webs were found on flat surface and were much smaller and shallower than other funnel webs.

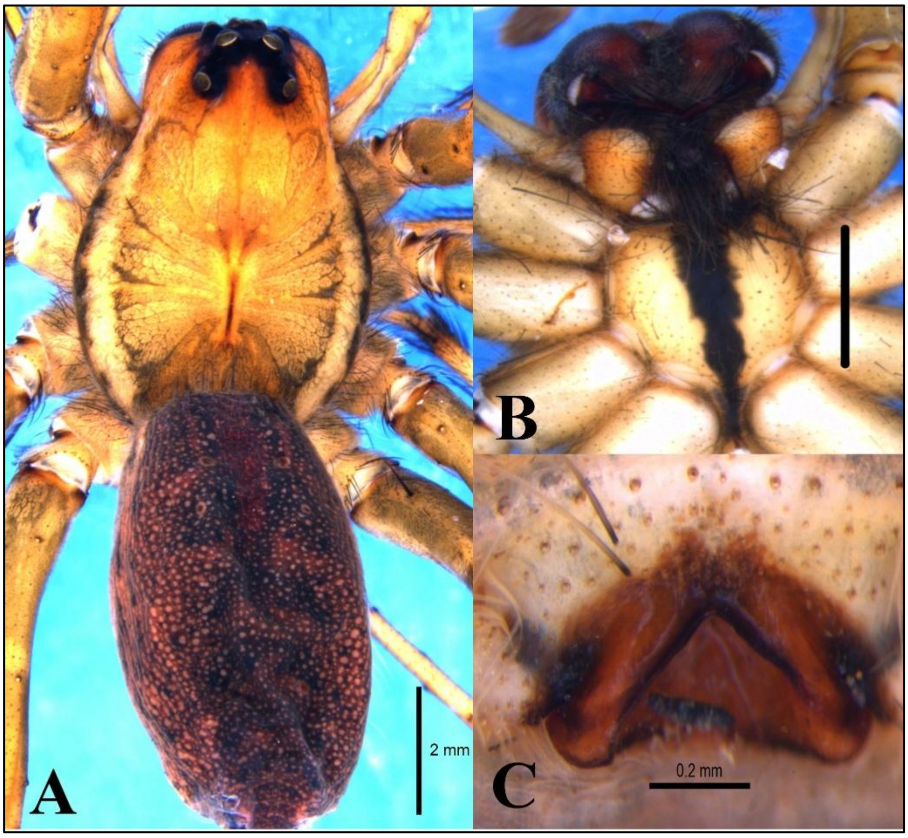


FIGURE 14. *Hippasa lycosina* Pocock, 1900: **A**, Female habitus; **B**, Sternum; **C**, Epigyne ventral view**.** Scales: A–B, 2 mm; C, 0.2mm.

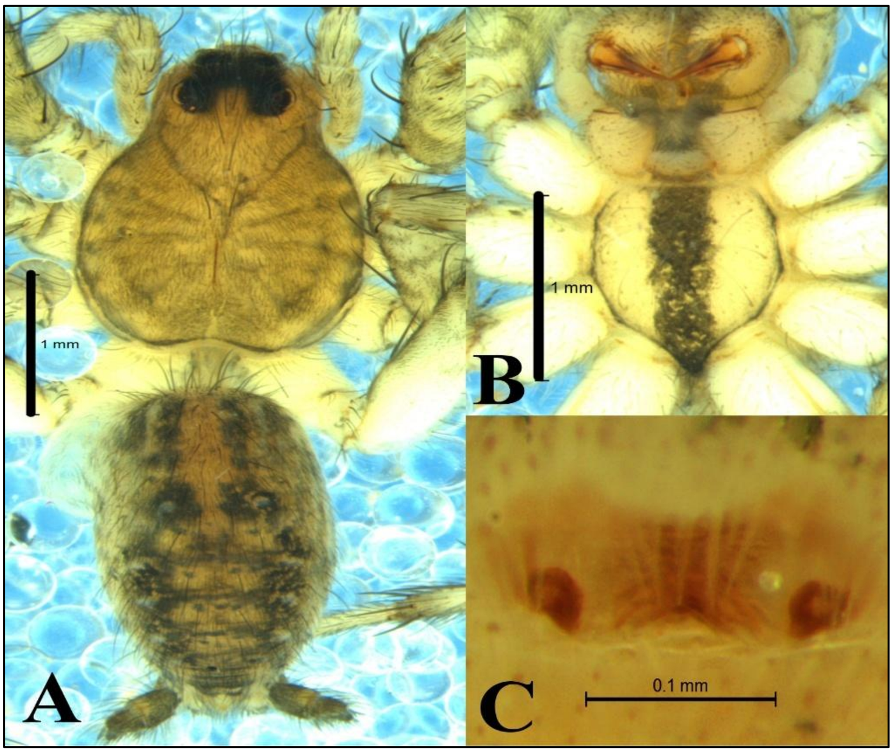


FIGURE 15. *Hippasa valiveruensis* Patel & Reddy, 1993: **A**, Female habitus; **B**, Sternum; **C**, Epigyne ventral view**.** Scales: A–B, 1 mm; C, 0.1mm.

4.1.5. Genus *Trochosa* C. L. Koch, 1847

Diagnosis

Many of the diagnostic features of the genus are inconclusive and challenged by various authors in various time period. In general appearance they can be diagnosed by large size, dark brownish red colour and two longitudinal stripes on median area of carapace. Epigynes are also identifiable by large epigynal plate, prominent hoods and inverted T-shape. Males can be identified by parallel placed E and synembolus; dagger shaped TA.

4.1.5.1 Trochosa dentichelis Buchar, 1997 [Figs. 16 A–D]

Trochosa dentichelis Buchar, 1997; Marusik et al., 2020; Sankaran & Caleb, 2023b.

Materials examined

INDIA, Kerala: 1♀ from Wayanad (11°47'52.8"N, 75°59'27.6"E; alt. 1036 m) 16 April 2021, coll. R.S. Abhijith; 1♂ from Chalisserry, Palakkad (10° 43.45' N, 76° 5.18'E) July 26, 2021 coll. R.S. Abhijith.

Diagnosis

Males are similar to other *Trochosa* species especially *T. ruricoloides,* but differs by the shape of TA and E. TA with a protrusion anteriorly; parallelly placed E and synembolus. Females are extremely similar to *T. ruricoloides* and *T. urbana,* distinguished slightly by the in-situ view of epigyne.

Description

Female: Total length 6.90. Prosoma 4.11 long, 3.04 wide. Opisthosoma 2.75 long, 2.62 wide. Carapace green yellowish. Paired longitudinal median stripes present, throughout the carapace. Fovea longitudinal, thin, short, black, placed mid-posteriorly, another long stripe present anterior to fovea up to ocular area. Lateral band continuous. Sternum round shaped, yellow. Eye region dark with light mid area. Chelicerae, labium brown. Opisthosoma slender ovoid, dorsum greyish brown paired sigilla, venter yellow. Spinnerets greenish yellow, posterior ones large. Eye diameters and inter-distances: AME 0.21, ALE 0.15, PME 0.30, PLE 0.26. AME–AME 0.11, AME–ALE 0.08, PME–PME 0.22, PME–PLE 0.27, PME–AME 0.08. Clypeus yellow 0.39. Legs yellow without annulations, white pubescence on Tibia I. Leg measurements I 12.98 (3.95, 4.78, 3.10, 2.10); II 10.53 (3.27, 3.93, 1.95, 1.38); III 9.13 (2.45, 3.44, 2.54, 1.70); IV 15.30 (4.44, 5.45, 3.57, 2.84). Leg formula: 4123.

Epigyne: Anterior hoods, inwardly curved, converging tips, inverted T-shaped septum. Septum as longer than wide, stalk narrowest medially.

Male: Total length 5.49. Prosoma 3.10 long, 2.34 wide. Opisthosoma 2.27 long, 2.42 wide. Patterns, colours and other bodily features similar to that of female.

Palp: Round shaped Cymbium. E and synembolus parallelly placed. TA with anterior protrusion, TA dagger shaped with pointed end. Spines present on Cymbium.

Distribution

Bhutan, India (**first report from state of Kerala**).

Remarks

Most common *Trochosa* in Kerala. But most of the identification become obscure because of the on-field similarity with common *Pardosa* species. Female was collected from a grassland in Wayanad and male from riparian habitat in Thrissur-Palakkad border.

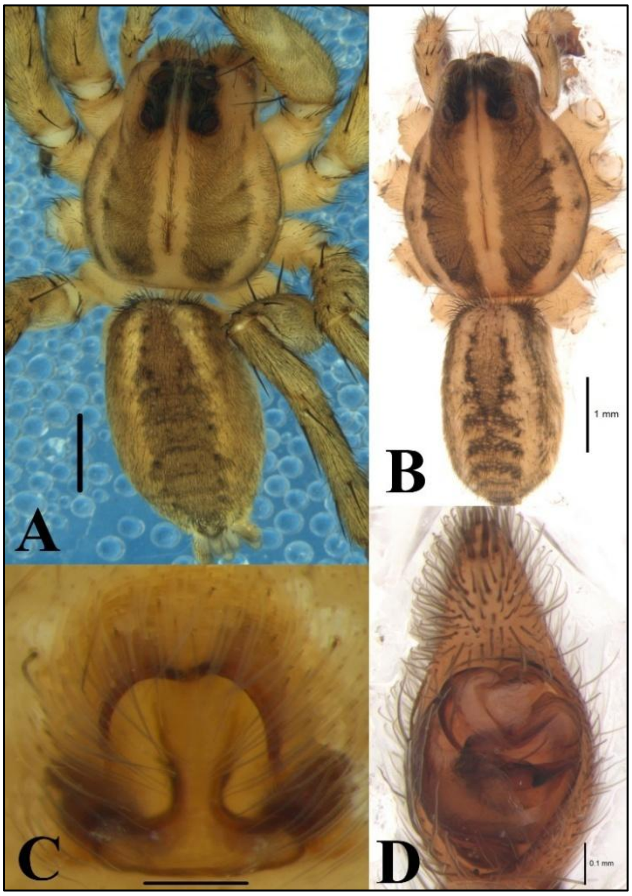


FIGURE 16. *Trochosa dentichelis* Buchar, 1997: **A**, Female habitus; **B**, Male habitus; **C**, Epigyne ventral view; **D**, Palp. Scales: A–B, 1mm; C–D, 0.1mm.

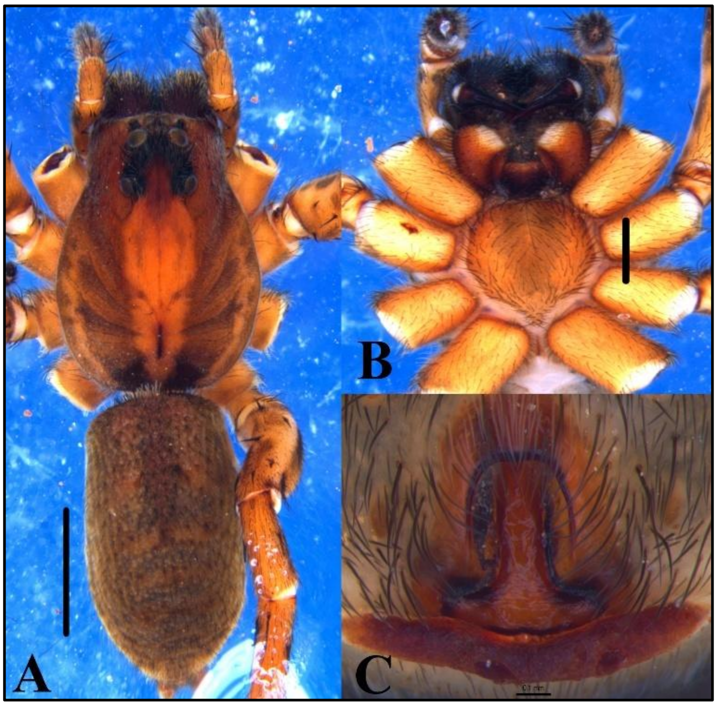


FIGURE 17. *Trochosa honggiana* Barrion, Barrion-Dupo & Heong, 2012: **A**, Female habitus; **B**, Sternum; **C**, Epigyne ventral view**.** Scales: A, 2 mm; B, 1mm; C, 0.2mm.

4.1.5.2. *Trochosa honggiana* Barrion, Barrion-Dupo & Heong, 2012 [Figs. 17 A–C]

Trochosa honggiana Barrion et al., 2012; Wang et al., 2021.

Materials examined

INDIA, Kerala: 1♀ from Muneeswaram hills, Wayanad (11° 51' 48.24"N, 75° 57' 33.11"E; alt. 1125 m) October 16, 2021, coll. R.S. Abhijith.

Diagnosis

Females are similar to other *Trochosa* species especially *T. ruricoloides* and *T. dentichelis* but differs by the epigyne. Septum is robust, septal walls without any curvature medially, septal hood continuous.

Description

Female: Total length 13.61. Prosoma 6.62 long, 3.74 wide. Opisthosoma 6.87 long, 2.92 wide. Dark brown carapace with pale median area. Paired longitudinal median stripes present, but faded. Fovea longitudinal, thin, short, black. Lateral band continuous. Sternum heart shaped, dark orange. Eye region dark. Chelicerae, labium dark brown. Opisthosoma long ovoid, dorsum greyish brown paired sigilla, venter black posterior to epigynal plate. Spinnerets light brown; posterior ones large. Eye diameters and inter-distances: AME 0.24, ALE 0.17, PME 0.40, PLE 0.36. AME–AME 0.17, AME–ALE 0.12, PME–PME 0.22, PME–PLE 0.41, PME–AME 0.29. Clypeus yellow 0.51. Legs yellow without annulations. Leg measurements: I 18.01 (4.96, 6.88, 4.81, 2.30); II 15.53 (4.21, 5.99, 2.99, 2.34); III 14.13 (3.95, 4.94, 3.84, 2.40); IV 22.30 (6.41, 7.48, 5.56, 3.85). Leg formula: 4123.

Epigyne: Broad, robust, inverted T-shaped septum. Septal walls straight. Hoods continuous.

Distribution

China, (**first report from India**).

Remarks

First report of the species from Indian sub-continent. Female *Trochosa* species are very similar to each other with minute differences in epigyne results in species segregation. The specimen was collected from a high-altitude grassland with minimal disturbance early in the morning.

4.1.5.3. *Trochosa mukundi* (Tikader & Malhotra, 1980) comb. nov. [Figs. 18 A–C]

Pardosa mukundi Tikader & Malhotra, 1980; Buchar & Dolejš, 2021; Abhijith et al., 2022b.

Diagnosis

Females are diagnosed as the species by comparing genitalic pictures of Buchar & Dolejš. (2021).

Material examined

INDIA, Kerala: 2♀ (CATE588504) from Gavi, Pathanamthitta (9º43.49'N, 77º16.01'E; alt. 1036 m) October 8, 2021, coll. R.S. Abhijith.

Redescription

Female: Total length 4.18, Prosoma 2.28 long, 1.77 wide, Opisthosoma 1.90 long, 1.71 wide; Carapace yellowish brown with vertical uniformly wide fovea; Carapace edge with light brown spots; Uniform median band, brown, extend into the ocular area as a bifurcation; Paramedian bands obscure; Ocular area black with white pubescence, two among them long and sturdy; Clypeus smooth with 0.23 height; Eye sizes and inter-distances: AME 0.079, ALE 0.049, PME 0.183, PLE 0.131, AME–AME 0.067, AME–ALE 0.037, PME–PME 0.248, PME–PLE 0.266; Anteriorly narrow MOQ; Brown, wider labium; Chelicera with all three promarginal and retromarginal teeth of same size; Heart-shaped sternum, light brown; a few black hairs; Brown legs with dark femur; Leg measurements: I 3.92 (1.10, 1.37, 0.97, 0.48); II 3.88 (0.70, 1.83, 0.74, 0.61); III 3.70 (0.77, 1.89, 0.72, 0.32); IV 5.06 (1.22, 1.54, 1.32, 0.98); Leg formula: 4123; Long, oval opisthosoma, dorsum brown with lateral stripes and yellow lanceolate patch; venter brownish yellow; Posterior spinnerets larger (Abhijith et al., 2022b).

Epigyne septum vase-shaped; well-defined hoods; BS with two swellings on ends. Internally heart-shaped septum, apically wider SS wider, narrower near BS; CD, bulbous, lateral to distal end of septum; Long slender stalked Sp with spherical head, placed near CD (Abhijith et al., 2022b).

Distribution

Bhutan, India (**first report from Western Ghats**).

Remarks

T. mukundi comb. nov. is a rare lycosid designated as a *Pardosa* species by the original authors reported only from north India and Bhutan. Based on the female specimen and photographs and details in Buchar & Dolejš (2021), it is confident to place the species in the genus *Trochosa*. Further explanations are discussed in the next chapter.

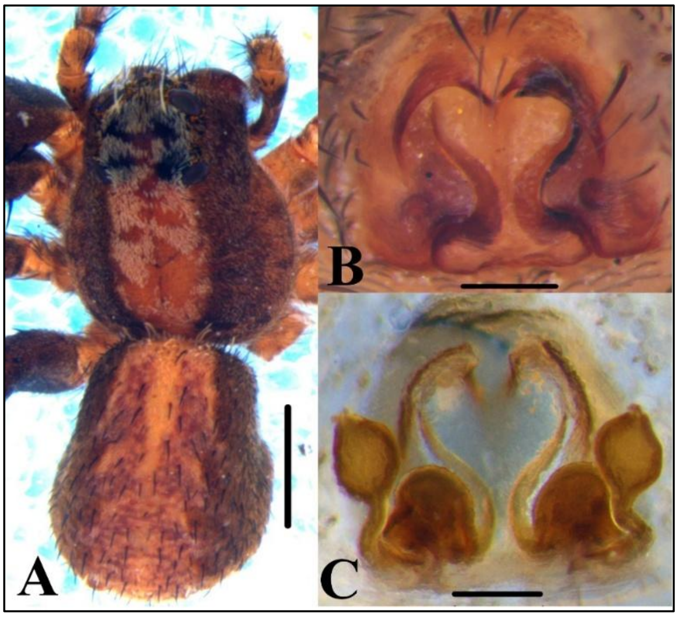


FIGURE 18. *Trochosa mukundi* (Tikader & Malhotra, 1980) comb. nov.: **A**, Female habitus; **B**, Epigyne ventral view; **C**, same cleared dorsal view**.** Scales: A, 1 mm; B–C, 0.1mm.

4.1.6. Genus *Arctosa* C.L. Koch, 1847

Diagnosis

They are medium sized lycosids with wider carapace than long. Males are diagnosed by TA sclerotized, long and grooved distally and presence of terminal apophysis. Females can be diagnosed by epigyne with clear atrium separated by median septum and without hoods.

4.1.6.1. *Arctosa dhikala* Sankaran & Caleb, 2023 [Figs. 19 A–C]

Trochosa himalayensis Tikader & Malhotra, 1980; *Arctosa dhikala* Sankaran & Caleb, 2023b.

Materials examined

India, Kerala: 1 ♂ from Chalisserry, Palakkad (10° 43.45' N, 76° 5.18'E; alt. 36 m a.s.l.) 26 July 2021 coll. R.S. Abhijith.

Diagnosis

Males are similar to *A. indica*, but differs by MA with pointed apex and without any lateral processes.

Description

Male: Total length 3.57. Prosoma 1.84 long, 2.05 wide. Opisthosoma 1.53 long,1.33 wide. Prosoma green yellow. Fovea longitudinal, thin, short, dark green, placed mid-posteriorly. Area around fovea without any bands and patterns. Lateral band dark green, continuous. Sternum heart shaped, yellow. Eye region dark. Chelicerae, labium light brown. Opisthosoma long ovoid, dorsum yellowish with green patterns and guanocytes, venter yellow. Spinnerets yellow. Eye diameters and inter-distances: AME 0.17, ALE 0.11, PME 0.24, PLE 0.21, AME–AME 0.08, AME–ALE 0.07, PME–PME 0.20, PME–PLE 0.24. Clypeus yellow 0.31. Legs yellow without annulations, white pubescence on Tibia I. Leg measurements I 9.88 (2.75, 3.68, 2.60, 1.80); II 8.73 (2.77, 2.93, 1.45, 1.08); III 8.13 (2.15, 3.14, 2.34, 1.50); IV 12.30 (3.44, 4.45, 3.07, 2.34). Leg formula: 4123.

Palp: Cymbium round. E, long, brown, distal end inconspicuous. MA long, pointed apex, without any lateral process. St prolaterally placed.

Distribution

India (**first report from state of Kerala**).

Remarks

This is the first report of the species outside type locality. It was found in a riparian ecosystem shared by other lycosids and ground runner spiders.

4.1.6.2. *Arctosa lesserti* Reimoser, 1934 [Figs. 20 A–B]

Arctosa lesserti Reimoser, 1934; Sankaran et al., 2021a.

Materials examined

3♀ from Peruvannamuzhi, Kozhikode (11°34.58'N, 75° 48.57'E; 60 m a.s.l.) December 2, 2021; coll. R.S. Abhijith.

Diagnosis

Females are similar to *A. indica*, but differs by narrow anterior part of epigynal septum and pear-shaped atria.

Description

Female: Total length 5.07. Carapace 2.64 long, 2.25 wide. Opisthosoma 2.43 long,1.83 wide. Carapace light green yellowish. Fovea longitudinal, thin, short, dark red. Green radiating patterns present around fovea. Lateral band dark green, continuous. Sternum heart shaped, yellow with numerous black pubescence. Eye region dark with light mid area. Chelicerae, labium light brown. Opisthosoma long ovoid, dorsum light greenish with green patterns, venter yellow. Spinnerets yellow. Eye diameters and inter-distances: AME 0.17, ALE 0.13, PME 0.25, PLE 0.24, AME–AME 0.11, AME–ALE 0.09, PME–PME 0.27, PME–PLE 0.20. Clypeus yellow 0.43. Legs yellow without annulations. Leg measurements I 11.02 (3.01, 4.02, 2.99, 2.01); II 8.93 (2.87, 2.98, 1.49, 1.09); III 8.43 (2.25, 3.19, 2.38, 1.61); IV 13.80 (3.94, 4.85, 3.17, 2.84). Leg formula: 4123.

Epigyne: epigynal plate same colour as of abdominal ventrum. Two pear-shaped atria forming a median septum with narrow anterior part. Spermathecal stalks slender with bulbous Sp. Slender stalk can be seen as a bulbous shadow in the ventral in-situ view.

Distribution

India (**first report from state of Kerala**).

Remarks

Specimen collected from banks of a dam reservoir. The habitat can be termed as a riparian habitat with median anthropogenic disturbances.

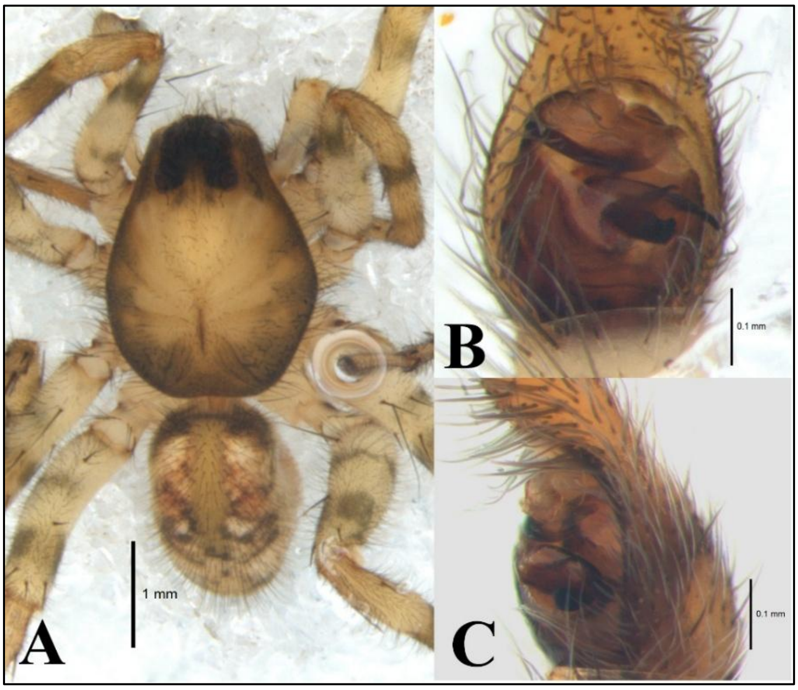


FIGURE 19. *Arctosa dhikala* Sankaran & Caleb, 2023: **A**, Male habitus; **B**, Palp ventral view; **C**, same retrolateral view**.** Scales: A, 1 mm; B–C, 0.1mm.

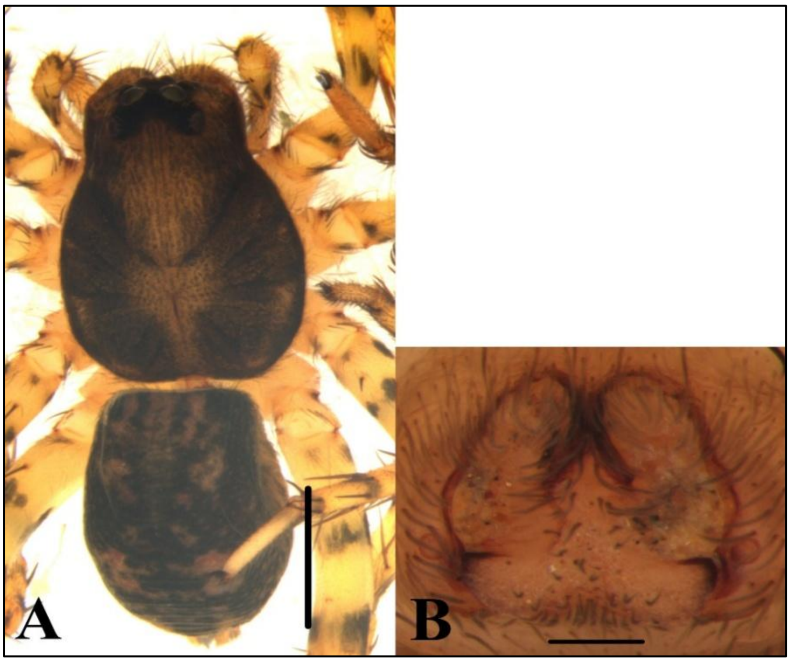


FIGURE 20. *Arctosa lesserti* Reimoser, 1934: **A**, Female habitus; **B**, Epigyne ventral view. Scales: A, 1mm; B, 0.1mm.

4.1.7. Sub-adult specimens [Figs. 21 A–E]

Apart from the adult specimens, 5 sub-adult specimens are also collected. As the genitalia of them are under developed, it is nearly impossible to identify them up to species level. Based on other somatic characters and molecular phylogeny, one of them identified as *Hippasa* sub-adult, two of them belong to *Arctosa*, one to *Wadicosa* and another one belongs to *Trochosa*.

Hippasa **sub-adult [Fig. 21 A]**

Diagnosis: The specimen is identified as *Hippasa* by the slender body, dark longitudinal band on sternum and funnel webs.

Materials examined: 1 juvenile from Kurumbalakotta, Wayanad (11° 41' 48.12"N, 76° 2' 3.48"E; alt. 991 m) October 21, 2021, coll. R.S. Abhijith.

Arctosa **sub-adults [Fig. 21 B–C]**

Diagnosis: Both are identified as *Arctosa* by the overall similarity of shape and colouration of cephalothorax with *A. lesserti* and *A. dhikhala,* but different enough to consider as another taxon. The identification is justified by the placement of both these species in the phylogenetic tree. Both these sub-adults differ by the colouration of sternum. One of them with dark dots on the margin of light yellow-coloured sternum and other with sternum covered with dark pubescence.

Materials examined: 1 juvenile from Kanjirangad, Wayanad (11°44'55.42"N, 75°54' 24"E, alt. 792 m) April 18, 2022, coll. R.S. Abhijith; 2 juveniles from Outskirts of Chimney, Thrissur, October 10, 2019, coll. R.S. Abhijith

Wadicosa **sub-adult [Fig. 21 D]**

Diagnosis: The specimen is identified as *Wadicosa* by overall colouration, patterns and dark patch on ventral side of abdomen similar to *W. fidelis*, but differs by the shape of cephalothorax.

Materials examined: 2 juveniles from Chalisserry, Palakkad (10° 43.45' N, 76° 5.18'E; alt. 36 m a.s.l.) July 26, 2021 coll. R.S. Abhijith.

Trochosa **sub-adult [Fig. 21 E]**

Diagnosis: The specimen is identified as *Trochosa* by general appearance, by large size, dark brownish colour and two longitudinal stripes on median area of carapace. The identification is backed by phylogenetic analysis.

Materials examined: 2 juveniles from Muneeswaram hills, Wayanad (11° 51' 48.24"N, 75° 57' 33.11"E; alt. 1125 m) October 16, 2021, coll. R.S. Abhijith.

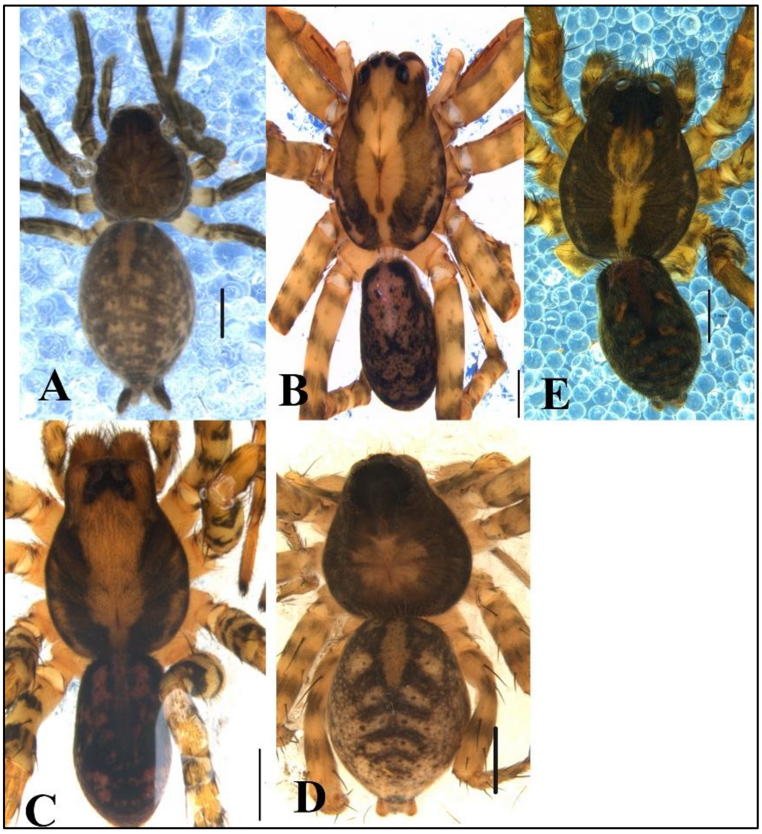


FIGURE 21. Sub-adult species: **A**, *Hippasa*; **B–C**, *Arctosa*; **D**, *Wadicosa* **E**, *Trochosa*. Scales: 1mm.

4.2. COI molecular barcode of collected species

Trimmed Consensus partial sequences of COI gene in FASTA format of all the 25 species are presented here.

1. *Pardosa oriens* (553 bp). Accession No.: PV290315

>PV290315.1 Pardosa oriens

ATTCGTATAGAATTAGGGAATCCTGGTAGATTATTAGGTGATGATCATTTAT
ATAATGTGATAGTTACTGCTCATGCTTTTGTAATGATTTTTTTTATGGTAATG
CCAATTCTTATTGGAGGTTTCGGAAATTGATTAGTTCCTTTAATATTAGGGA
CTCCTGATATATCTTTTCCTCGTATAAATAATCTTTCTTTTTGGTTGTTACCA
CCTTCTTTGTTTTTATTATCAATATCTTCAATAGTGGAGATAGGTGTTGGTGC
TGGTTGAACTGTTTATCCTCCATTAGCCTCTACAGTGGGACATATGGGAAGT
TCAATGGATTTTGCTATTTTTTCTCTTCACTTAGCTGGGGCTTCTTCTATTAT
AGGGGCTGTAAATTTTATTTCTACTATTATTAATATGCGAATATTAGGAATG
TCTATGGAAAAGGTTCCTCTTTTTGTTTGGTCAGTATTGATTACTGCAGTTTT
ATTATTACTTTCTTTACCTGTTTTAGCGGGAGCTATTACTATATTGTTGACGG
ATCGTAATTTTAATACTTCTTTTTTTG

2. *P. parathompsoni* (644 bp). Accession No.: PV478721

> PV478721 Pardosa parathompsoni

CATAAAGATATTGGTACTTTATATTTAATATTTGGGGTTTGATCAGCTATAATAG
GAACTGCTATAAGAGTATTAATTCGAATGGAATTAGGTAATCCTGGAAGATTG

TTAGGTGATGATCATTTATATAATGTAATAGTTACTGCTCATGCTTTTGTGATGA

TTTTTTTTATAGTAATACCAATTCTTATTGGTGGTTTTGGAAATTGATTAGTTCC

TTTAATATTAGGGGCTCCTGATATATCTTTTCCTCGAATAAATAATCTTTCTTTT

TGATTGTTACCTCCTTCTTTATTTTTATTATCAATGTCTTCAATGGTGGAGATAG

GTGTTGGTGCTGGTTGAACTGTTTATCCTCCGTTGGCGTCTACAGTAGGTCAT

ATGGGAAGTTCAATAGATTTTGCTATTTTTTCTCTTCATTTGGCTGGAGCTTCT

TCTATTATAGGAGCTGTTAATTTTATTTCTACTATTATTAACATACGGATGTTAG

GAATATCTATAGAGAAGGTTCCTCTTTTTGTTTGATCAGTATTAATTACTGCAG

TTTTATTATTACTTTCTTTACCTGTTTTAGCAGGAGCTATTACTATATTATTAACT

GATCGGAATTTTAATACTTCATTTTTTGACCCTTCAGGAGGAGG

3. ***P. pusiola*** **(629 bp). Accession No.: PV290518**

>PV290518.1 Pardosa pusiola

ACTTTATATTTAATATTTGGGGTTTGATCAGCTATAATAGGAACTGCTATAA

GAGTATTAATTCGAATGGAATTAGGTAATCCTGGAAGATTGTTAGGTGATG

ATCATTTATATAATGTAATAGTTACTGCTCATGCTTTTGTGATGATTTTTTTT

ATAGTAATACCAATTCTTATTGGTGGTTTTGGAAATTGATTAGTTCCTTTAAT

ATTAGGGGCTCCTGATATATCTTTTCCTCGAATAAATAATCTTTCTTTTTGAT

TGTTACCTCCTTCTTTATTTTTATTATCAATGTCTTCAATGGTGGAGATAGGT

GTTGGTGCTGGTTGAACTGTTTATCCTCCGTTGGCGTCTACAGTAGGTCATA

TGGGAAGTTCAATAGATTTTGCTATTTTTTCTCTTCATTTGGCTGGAGCTTCT

TCTATTATAGGGGCTGTTAATTTTATTTCTACTATTATTAACATACGGATGTT

AGGAATATCTATAGAGAAGGTTCCTCTTTTTGTTTGATCAGTATTAATTACT

GCAGTTTTATTATTACTTTCTTTGCCTGTTTTAGCAGGAGCTATTACTATATT

ATTAACTGATCGGAATTTTAATACTTCATTTTTTGACCCTTCAGGAGGAGG

4. *P. shyamae* (605 bp). Accession No.: PV476685

> PV476685 Pardosa shyamae

ACATTATATTTAATATTTGGGGTTTGATCGGCTATAATAGGTACTGCTATAAGAG

TATTAATTCGAATAGAATTAGGGAATCCTGGAAGATTATTAGGTGATGATCATT

TATATAATGTGATGGTTACTGCACATGCTTTTGTAATAATTTTTTTCATAGTAAT

ACCAATTCTTATTGGAGGTTTTGGTAATTGATTAGTTCCGTTAATATTGGGAGC

TCCTGATATATCTTTTCCTCGGATGAATAATCTTTCTTTTTGATTATTACCTCCTT

CTTTGTTTTTATTATCAATATCTTCTATAGTGGAGATAGGTGTTGGTGCGGGTT

GAACTGTTTATCCACCATTAGCATCTACAGTAGGGCATATAGGAAGTTCTATG

GATTTTGCTATTTTTTCTCTTCATTTAGCTGGAGCTTCATCTATTATAGGGGCTG

TAAATTTTATTTCTACTATTATTAATATACGAATAATAGGAATATCTATAGAAAA

GGTACCTCTTTTTGTTTGATCAGTATTGATTACTGCAGTTTTATTATTACTTTCT

TTACCTGTTTTAGCAGGTGCTATTACTATATTATTGACGGATCGGAATTTTAATA

CTTC

5. *P. songosa* (642 bp). Accession No.: PV287683

>PV287683.1 Pardosa songosa

AATCATAAAGATATTGGTACTTTATATTTAATATTTGGGGTTTGATCAGCCA

TAATAGGAACTGCTATAAGAGTATTAATTCGAATGGAATTAGGTAATCCTG

GAAGATTGTTAGGTGATGATCATTTATATAATGTAATAGTTACTGCTCATGC

TTTTGTAATGATTTTTTTTATAGTAATGCCAATTCTTATTGGTGGTTTTGGAA

ATTGATTAGTTCCTTTAATATTAGGGGCTCCTGATATATCTTTTCCTCGAATA

AATAATCTTTCTTTTTGATTGTTACCTCCTTCTTTATTTTATTATCAATATCT

TCAATGGTGGAGATAGGTGTTGGTGCTGGTTGAACTGTTTATCCTCCGTTAG

CGTCTACAGTAGGTCATATGGGAAGTTCAATAGATTTTGCTATTTTTCTCTT

CATTTGGCTGGAGCTTCTTCTATTATGGGGGCTGTTAATTTTATTTCTACTAT

TATTAATATACGAATGTTAGGGATATCTATAGAGAAGGTTCCTCTTTTTGTT

TGATCAGTATTAATTACTGCAGTTTTATTATTACTTTCTTTACCTGTTTTAGC

AGGAGCTATTACTATATTATTAACTGATCGGAATTTTAATACTTCATTTTTTG

ACCCTTCAGGA

6. *P. sumatrana* (614 bp). Accession No.: PV290313

>PV290313.1 Pardosa sumatrana

ACATTATATTTAATATTTGGGGTTTGATCGGCTATAATAGGTACTGCTATAA

GAGTATTAATTCGAATAGAATTAGGGAATCCTGGAAGATTATTAGGTGATG

ATCATTTATATAATGTAATGGTTACTGCGCATGCTTTTGTAATGATTTTTTTC

ATAGTAATACCAATTCTTATTGGAGGTTTTGGTAATTGATTAGTTCCGTTAA

TACTAGGAGCTCCTGATATATCTTTTCCTCGGATAAATAATCTTTCTTTTTGA

TTATTACCTCCTTCTTTGTTTTTGTTATCAATATCTTCTATAGTGGAGATAGG

TGTTGGTGCGGGTTGAACTGTTTATCCACCATTAGCATCTACAGTGGGGCAT

ATAGGAAGTTCTATGGATTTTGCTATTTTTTCTCTTCATTTAGCTGGGGCTTC

ATCTATTATAGGGGCTGTAAATTTTATTTCTACTATTATTAATATACGAATA

ATAGGAATATCTATAGAAAAAGTTCCTCTTTTTGTTTGATCGGTATTAATTA

CTGCAGTTTTATTATTACTTTCTTTACCTGTTTTAGCAGGTGCTATTACTATA

TTATTAACGGATCGGAATTTTAATACTTCATTTTTTGA

7. *P. chapini* (618 bp). Accession No.: PV290705

>PV290705.1 Pardosa chapini

ACATTATATTTAATATTTGGGGTTTGATCGGCTATAATAGGTACTGCTATAA
GAGTATTAATTCGAATAGAATTAGGGAATCCTGGAAGATTATTAGGTGATG
ATCATTTATATAATGTAATGGTAACTGCACATGCTTTTGTAATAATTTTTTC
ATAGTAATACCAATTCTTATTGGAGGTTTTGGTAATTGATTAGTTCCATTAA
TATTGGGAGCTCCTGATATATCTTTTCCTCGGATGAATAATCTTTCTTTTTGA
TTATTACCTCCTTCTTTGTTTTTATTATCAATATCTTCTATAGTGGAGATAGG
TGTTGGTGCGGGTTGAACTGTTTATCCACCATTAGCATCTACAGTAGGGCAT
ATAGGAAGTTCTATGGATTTTGCTATTTTTTCTCTTCATTTAGCTGGAGCTTC
ATCTATTATAGGGGCTGTAAATTTTATTTCTACTATTATTAATATACGAATA
ATAGGAATATCTATAGAAAAGGTACCTCTTTTTGTTTGATCAGTATTGATTA
CTGCAGTTTTATTATTACTTTCTTTACCTGTTTTAGCAGGTGCTATTACTATA
TTATTGACGGATCGGAATTTTAATACTTCATTTTTTGACCCT

8. *Draposa atropalpis* (661 bp). Accession No.: PV274470

>PV274470.1 Draposa atropalpis

TGTTGGTCAACAAATCATAAAGATATTGGTACTTTATATTTAATATTTGGGG
TTTGATCAGCCATAATAGGAACTGCTATAAGAGTATTAATTCGAATGGAATT
AGGTAATCCTGGAAGATTGTTAGGTGATGATCATTTATATAATGTAATAGTT
ACTGCTCATGCTTTTGTAATGATTTTTTTATAGTAATGCCAATTCTTATTGG
TGGTTTTGGAAATTGATTAGTTCCTTTAATATTAGGGGCTCCTGATATATCTT
TTCCTCGAATAAATAATCTTTCTTTTTGATTGTTACCTCCTTCTTTATTTTTAT
TATCAATATCTTCAATGGTGGAGATAGGTGTTGGTGCTGGTTGAACTGTTTA

TCCTCCGTTACCGTCTACAGTAGGTCATATGGGAAGTTCAATAGATTTTGCT

ATTTTTTCTCTTCATTTGGCTGGAGCTTCTTCTATTATGGGGGCTGTTAATTT

TATTTCTACTATTATTAATATACGAATGTTAGGGATATCTATAGAGAAGGTT

CCTCTTTTTGTTTGATCAGTATTAATTACTGCAGTTTTATTATTACTTTCTTTA

CCTGTTTTAGCAGGAGCTATTACTATATTATTAACTGATCGGAATTTTAATA

CTTCATTTTTTGACCCTTCAGGAGGAGGAG

9. *D. burasantiensis* (553 bp). Accession No.: PV474182

> PV474182 Draposa burasantiensis

ATTCGAATGGAATTAGGTAATCCTGGAAGATTGTTAGGTGATGATCATTTATAT

AATGTAATAGTTACTGCTCATGCTTCCGTAATGATTTTTTTTATAGTAATGCCAA

TTCTTATTGGTGGTTTTGGAAATTGATTAGTTCCTTTAATATTAGGGGCTCCTG

ATATATCTTTTCCTCGAATAAATAATCTTTCTTTTTGATTGTTACCTCCTTCTTTA

TTTTTATTATCAATATCTTCAATGGTGGAGATAGGTGTTGGTGCTGGTTGAGCT

GTTTATCCTCCGTTACCGTCTACAGTAGGTCATATGGGAAGTTCAATAGATTTT

GCTATTTTTTCTCTTCATTTGGCTGGAGCTTCTTCTATTATGGGGGCTGTTAATT

TTATTTCTACTATTATTAATATACGAATGTTAGGGATATCTATAGAGAAGGTTCC

TCTTTTTGTTTGATCAGTATTAATTACTGCAGTTTTATTATTACTTTCTTTACCT

GTTTTAGCAGGAGCTATTACTATATTATTAACTGATCGGAATTTTAATACTTCAT

TTTTTG

10. *D. sebastiani* (619 bp). Accession No.: PV478722

> PV478722 Draposa sebastiani

TACTTTATATTTAATATTTGGGATTTGATCAGCCATAATAGGAACTGCTATAAGA
GTATTAATTCGAATGGAATTAGGTAATCCTGGAAGATTGTTAGGTGATGATCAT
TTATATAATGTGGATAGTTACTGCTCATGCTTTTGTAATGATTTTTTCCATAGTA
ATGCCAATTCTTATTGGTGGTTTTGGAAATTGATTAGTTCCTTTAATATTAGGG
GCTCCTGATATATCTTTTCCTCGAATAAATAATCTTTCTTTTTGATTGTTACCTC
CTTCTTTATTTTTATTATCAATATCTTCAATGGTGGAGATAGGTGTTGGTGCTGG
TTGAACTGTTTATCCTCCGTTACCGTCTACAGTAGGTCATATGGGAAGTTCAAT
AGATTTTGCTATTTTTTCTCTTCATTTGGCTGGAGCTTCTTCTATTATGGGGGCT
GTTAATTTTATTCTTACTATTATTAATATACGAATGTTAGGGATATCTATAGAGA
AGGTTCCTCTTTTTGTTTGATCAGTATTAATTACTGCAGTTTTATTATTACTTTC
TTTACCTGTTTTAGCAGGAGCTATTACTATATTATTAACTGATCGGAATTTTAAT
ACTTCATTTTTTGACCCT

11. *Wadicosa fidelis* (632 bp). Accession No.: PV290309

>PV290309.1 Wadicosa fidelis

AACGTTATATTTAATATTTGGTGTTTGATCGGCTATAATGGGAACTGCTATA
AGAGTTTTGATTCGAATGGAATTAGGAAATCCTGGTAGATTATTAGGGAAT
GATCATATATATAATGTTATAGTTACTGCTCATGCTTTTGTAATAATTTTTTT
TATGGTAATACCAATTCTTATTGGAGGGTTTGGAAATTGATTGGTACCTTTA
ATGTTAGGAGCTCCTGATATATCTTTTCCTCGAATGAATAATCTTTCTTTTTG
ATTATTACCTCCTTCTTTGTTTTTATTATCTATATCTTCTATAGTGGAAATAG
GAGTTGGTGCTGGATGAACTGTTTATCCTCCTTTAGCATCAACGGTTGGTCA
TATAGGAAGTTCTATAGATTTTGCTATTTTTTCTTTACATTTAGCTGGAGCTT
CTTCTATTATAGGAGCTGTTAATTTTATTTCTACTATTATTAATATACGAGTG

GTAGGAATGTCTATAGAAAAGGTTCCTCTTTTTGTTTGATCAGTTTTAATTAC
AGCAGTTTTATTATTACTTTCTTTACCTGTGTTAGCAGGAGCTATTACTATAT
TGTTAACTGATCGTAATTTTAATACTTCATTTTTTGACCCTTCAGGAGGAGG
AG

12. *W. intermediata* (645 bp). Accession No.: PV300857

>PV300857.1 Wadicosa intermediata

CATAAAGATATTGGAACATTATATTTAATATTTGGTGTTTGATCGGCTATAA
TGGGGACTGCTATAAGAGTTTTGATTCGAATAGAATTAGGAAATCCTGGGA
GATTATTAGGGAATGATCATATATATAATGTTATAGTAACTGCTCATGCTTT
TGTAATAATTTTTTTCATAGTAATACCGATTCTTATCGGAGGATTTGGTAATT
GATTAGTACCTTTGATATTGGGAGCTCCTGATATATCTTTTCCTCGAATAAA
TAATCTTTCTTTTTGATTATTACCTCCTTCTTTGTTTTTGTTATCTATATCTTC
AATAGTAGAGATAGGAGTTGGTGCTGGATGAACTGTTTATCCACCGTTGGCT
TCAACGGTTGGTCATATAGGAAGTTCTATGGATTTTGCTATTTTTTCTTTACA
TTTAGCTGGGGCTTCTTCTATTATAGGGGCTGTTAATTTTATTTCTACCATTA
TTAATATACGAGTGGTGGGAATATCTATAGAAAAGGTTCCTCTTTTTGTTTG
ATCGGTTTTGATTACAGCAGTATTATTATTACTTTCTTTGCCTGTATTAGCGG
GTGCTATTACTATATTGTTGACTGATCGAAATTTTAATACTTCATTTTTTGAC
CCTTCAGGAGGAGGG

13. *Hippasa ageneloides* (629 bp). Accession No.: PV300860

>PV300860.1 Hippasa agelenoides

ACTTTATATTTAATATTTGGAGTTTGATCGGCTATAGTTGGTACTGCTATAA
GAGTATTAATTCGAATGGAATTAGGAAATTCTGGAAGATTATTAGGTGATG
ATCATTTATATAATGTAATTGTTACTGCTCATGCTTTTGTTATAATTTTTTTA
TAGTTATACCTATTATAATTGGTGGTTTTGGAAATTGGTTAGTTCCTTTAATG
TTAGGTGCTCCTGATATATCTTTTCCTCGAATAAATAATCTCTCATTTTGGTT
ACTTCCTCCTTCTTTATTTTTATTATTTATATCTTCTATAGTGGAAATAGGGG
TGGGGGCAGGATGAACTGTTTATCCTCCTTTGGCTTCTAGAATGGGTCATAT
AGGAAGATCAATAGATTTTGCTATTTTTTCTCTTCATTTAGCTGGGGCTTCTT
CTATTATAGGAGCTGTTAATTTTATTTCTACTATTATTAATATACGATTAGTA
GGAATAAAAATAGAAAAGATTCCTTTATTTGTTTGATCAGTTTTAATTACTG
CTATTTTATTATTACTTTCTTTACCAGTATTAGCTGGTGCTATTACTATATTG
TTGACTGATCGTAATTTTAATACTTCATTTTTTGACCCTTCAGGAGGAGG

14. *H. lycosina* (710 bp). Accession No.: PV276958

>PV276958.1 Hippasa lycosina

TGGTCAACAAATCATAAAGATATTGGGACTTTATATTTAGTGTTTGGAATTT
GATCAGCTATAGTTGGTACTGCTATAAGAGTATTGATTCGAATAGAATTAGG
AAATCCTGGGAGATTATTAGGTGATGATCATTTATATAATGTTATTGTTACT
GCACATGCTTTTGTAATAATTTTTTTATAGTTATACCTATTTTAATTGGAGG
TTTTGGAAATTGATTAGTTCCATTAATATTAGGGGCTCCTGATATATCGTTTC
CTCGAATAAATAATCTTTCGTTTTGGTTATTACCTCCTTCTTTATTTTTATTAT
TTATATCTTCTATAGTGGAAATAGGAGTAGGAGCAGGATGAACTGTTTATCC
TCCTTTAGCTTCTAGAATAGGACATATAGGAAGATCAATAGATTTTGCTATT
TTTTCTTTACATTTGGCTGGAGCTTCTTCTATTATAGGAGCGGTTAATTTTAT
TTCAACTATTATTAATATACGATTAATAGGAATAAAAATAGAGAGGGTTCCT

TTATTTGTTTGATCGGTTTTAATTACTGCAATTTTATTGTTGCTTTCTTTACCT
GTTTTAGCAGGTGCTATTACTATATTATTAACAGATCGTAACTTTAATACTTC
ATTTTTTGATCCTGCAGGGGGTGGAGATCCAATTTTATTTCAACATTTATTTT
GATTTTTTGGTCACCCTGAAGTTTA

15. ***H. valiveruensis*** **(656 bp). Accession No.: PV287681**

>PV287681.1 Hippasa valiveruensis

ACTTCTACCTATCATAAAGACATTGGAACTTTATATTTAATGTTTGGAGTTT
GATCGGCTATAGTTGGTACTGCTATAAGAGTATTAATTCGAATGGAATTAGG
AAATTCTGGAAGATTATTAGGTGATGATCATTTATATAATGTAATTGTTACT
GCTCATGCTTTTGTTATAATTTTTTTTATAGTTATACCTATTTTAATTGGTGGT
TTTGGAAATTGGTTAGTTCCTTTAATGTTAGGTGCTCCTGATATATCTTTTCC
TCGAATAAATAATCTTTCATTTTGGTTACTTCCTCCTTCTTTATTTTTATTATT
TATATCTTCTATAGTGGAGATAGGGGTGGGGGCAGGATGAACTGTTTATCCT
CCTTTGGCTTCTAGAATAGGTCATATAGGAAGATCAATAGATTTTGCTATTT
TTTCCCTTCATTTAGCTGGGGCTTCTTCTATTATAGGAGCTGTTAATTTTATT
TCTACTATTATTAATATACGATTAGTAGGAATAAAAATAGAAAAGATTCCTT
TATTTGTTTGATCAGTTTTAATTACTGCTATTTTATTATTACTTTCTTTACCAG
TATTAGCTGGTGCTATTACTATATTATTGACTGATCGTAATTTTAATACTTCA
TTTTTTGACCCTTCAGGAGGAGG

16. ***Trochosa dentichelis*** **(631 bp). Accession No.: PV477000**

> PV477000 Trochosa dentichelis

AACTTTATATTTAATGTTTGGTGTATGATCTGCTATAATGGGAACTGCTATAAG

AGTATTGATTCGGATAGAATTAGGTAATCCTGGAAGTTTATTAGGAGATGATCA

TTTATATAATGTTATAGTTACTGCTCATGCTTTTGTCATAATTTTTTTATGGTAA

TACCTATTCTTATTGGAGGTTTTGGGAATTGATTAGTTCCTTTAATATTAGGAG

CTCCTGATATATCATTTCCTCGAATAAATAATCTTTCTTTTTGATTGTTACCTCC

TTCTTTGTTTTTATTATCTATATCTTCTATAGTAGAAATAGGAGTAGGGGCTGGT

TGAACAGTTTATCCTCCTTTAGCTTCTAGAATAGGTCATATAGGGAGTTCTATA

GATTTTGCTATTTTTTCTCTTCATTTAGCTGGTGCTTCTTCTATTATAGGGGCAG

TTAATTTTATTTCTACTATTATTAATATACGTATATTAGGGATATCTATAGAAAAG

GTTCCTTTATTTGTATGATCTGTGTTAATTACAGCTGTTTTATTACTTCTTTCTTT

ACCTGTATTAGCAGGTGCGATTACTATGTTGTTGACGGATCGAAATTTTAATAC

TTCATTTTTTGACCCTTCAGGAGGAGGG

17. *T. hongianna* (568 bp). Accession No. PV477002

> PV477002 Trochosa honggiana

TGGTCAACAAATCATAAAGATATTGGTACTTTATATTTAATATTTGGGGTTTGAT

CAGCTATAATAGGAACTGCTATAAGAGTATTAATTCGAATGGAATTAGGTAATC

CTGGAAGATTGTTAGGTGATGATCATTTATATAATGTAATAGTTACTGCTCATG

CTTTTGTGATGATTTTTTTTATAGTAATACCAATTCTTATTGGTGGTTTTGGAAA

TTGATTAGTTCCTTTAATATTAGGGGCTCCTGATATATCTTTTCCTCGAATAAAT

AATCTTTCTTTTTGATTGTTACCTCCTTCTTTATTTTTATTATCAATGTCTTCAAT

GGTGGAGATAGGTGTTGGTGCTGGTTGAACTGTTTATCCTCCGTTGGCGTCTA

CAGTAGGTCATATGGGAAGTTCAATAGATTTTGCTATTTTTTCTCTTCATTTGG

CTGGAGCTTCTTCTATTATAGGGGCTGTTAATTTTATTTCTACTATTATTAACAT

ACCGATGTTAGGAATATCTATAGAGAAGGTTCCTCTTTTATTTGATCAGGATT
AATTACTGCAATTCGATTATTAC

18. *T. mukundi* (630 bp). Accession No. PV477003

> PV477003 Pardosa mukundi

AACTTTATATTTAATGTTTGGTGTATGATCTGCTATAATGGGAACTGCTATAAG
AGTGTTGATTCGGATAGAATTAGGTAATCCTGGAAGTTTATTGGGAGATGATC
ATTTATATAATGTTATAGTTACTGCTCATGCTTTTGTTATAATTTTTTTATAGTG
ATACCTATTCTTATTGGAGGTTTTGGGAATTGATTGGTTCCTTTAATATTAGGA
GCTCCTGATATATCATTTCCTCGAATAAATAATCTTTCTTTTTGATTATTGCCTC
CTTCTTTGTTTTTATTATCTATATCTTCTATAGTAGAAATAGGAGTAGGGGCTGG
TTGAACAGTTTATCCTCCTTTAGCTTCTAGAATAGGTCATATAGGGAGTTCTAT
AGATTTTGCTATTTTTTCTCTTCATTTAGCTGGTGCTTCTTCTATTATAGGGGCA
GTTAATTTTATTTCTACTATTATTAATATACGTATATTAGGGATGTCTATAGAAAA
GGTTCCTTTATTTGTATGATCTGTGTTAATTACAGCTGTTTTATTACTTCTTTCT
TTACCTGTATTAGCCGGTGCAATTACTATATTGTTGACGGATCGAAATTTTAAT
ACTTCATTTTTTGACCCTTCAGGAGGAGG

19. *Arctosa dhikhala* (551 bp). Accession No. PV300859

>PV300859.1 Arctosa dhikala

TGGTCAACAAATCATAAAGATATTGGTACTTTATATTTAATATTTGGGGTTT
GATCAGCTATAATAGGAACTGCTATAAGAGTATTAATTCGAATGGAATTAG
GAAATCCTGGAAGATTGTTAGGAGATGATCATTTATATAATGTAATAGTTAC

TGCTCATGCTTTTGTGATGATTTTTTTATAGTAATACCAATTCTTATTGGTG

GTTTTGGAAATTGATTAGTTCCTTTAATATTAGGGGCTCCTGATATATCTTTT

CCTCGAATAAATAATCTTTCTTTTTGATTGTTACCTCCTTCTTTATTTTTATTA

TCAATGTCTTCAATGGTGGAGATAGGTGTTGGTGCTGGTTGAACTGTTTATC

CTCCGTTGGCGTCTACAATAGGTCATATGGGAAGTTCAATAAATTTTGCTAG

TTTTTCTCTTCATTTGGCTGGAGCTTCTTCTATTATAGGAGCTGTTAATTTTA

TTTCTACTATTATTAACATACGGATGTTAGGAATATCTATAGAGAAGGTTCC

TCTTTTTGTTTGATCAGTATTAATTAC

20. *A. lesserti* (624 bp). Accession No. PV287682

>PV287682.1 Arctosa lesserti

AACTTTATATTTAATATTTGGAATTTGAGCTGCAATAGTAGGTACCGCAATA

AGAGTATTAATTCGTATAGAATTAGGTCATTCTGGAAGTCTTTTAGGAAATG

ATCATTTATATAATGTGGTGGTTACTGCTCATGCTTTTGTTATGATTTTTTT

ATAGTAATACCTATTATAATTGGAGGATTTGGAAATTGATTAGTACCTTTGA

TATTAGGAGCTCCAGATATATCTTTTCCTCGAATAAATAATCTTTCTTTTTGA

TTATTACCTCCTTCTTTATTTCTTTTATTTATGTCTTCCATGGTAGAAGTAGG

GGTTGGAGCGGGATGGACTGTTTATCCTCCTTTAGCGTCTAGAATTGGGCAT

ATAGGAAGTTCTATAGATTTCGCTATTTTTTCTTTACATTTAGCTGGTGCTTC

TTCTATTATAGGAGCAGTGAATTTTATTACTACTATTATTAATATACGATTAT

TGGGTATAAAGATAGAAAAAATTTCTTTATTCGTTTGATCTGTATTGATTAC

AGCTATTTTATTATTATTGTCTTTACCAGTATTAGCTGGGGCTATTACTATAC

TATTAACTGATCGAAATTTTAATACTTCATTTTTTGACCCTTCAGG

21. *Hippasa* sub-adult (573 bp). Accession No. PV300858

>PV300858.1 Hippasa sp

TGGGATTTGATCGGCTATAGTTGGTACTGCTATAAGAGTATTAATTCGAATG

GAATTAGGAAATTCTGGGAGATTATTAGGTGATGATCATTTATATAATGTAA

TTGTTACTGCTCATGCTTTTGTTATAATTTTTTTATAGTTATGCCTATTTTAA

TTGGTGGTTTTGGAAATTGGTTAGTTCCTTTAATGTTAGGTGCTCCTGATATA

TCGTTTCCTCGAATAAATAATCTTTCATTTTGGTTACTTCCTCCTTCTTTATTT

TTATTATTTATATCTTCTATAGTAGAAATAGGGGTGGGGGCAGGATGAACTG

TTTATCCTCCTTTGGCTTCTAGAATAGGTCATATAGGAAGATCAATAGATTT

TGCTATTTTTTCTCTTCATTTGGCTGGAGCTTCTTCTATTATAGGAGCTGTTA

ATTTTATTTCTACTATTATTAATATACGGTTAGTGGGAATAAAAATGGAAAA

AATTCCTTTATTTGTTTGATCGGTTTTAATTACTGCTATTTTATTATTGCTTTC

TTTACCAGTATTAGCTGGTGCTATTACTATATTATTGACTGATCG

22. *Arctosa* sub-adult 1 (535 bp). Accession No. PV477001

> PV477001 Arctosa sp.

TGGTCAACAAATCATAAAGATATTGGTACTTTATATTATATATTTGGGGTTTGAT

CAGCTATAATAGGAACTGCTATAAGAGTATTAATTCGAATGGAATTAGGTAATC

CTGGAAGATTGTTAGGTGATGATCATTTATATAATGTAATAGTTACTGCTCATG

CTTTTGTGATGATTTTTTTTATAGTAATACCAATTCTTATTGGTGGTTTTGGAAA

TTGATTAGTTCCTTTAATATTAGGGGCTCCTGATATATCTTTTCCTCGAATAAAT

AATCTTTCTTTTTGATTGTTACCTCCTTCTTTATTTTTATTATCAATGTCTTCAAT

GGTGGAGATAGGTGTTGGTGCTGGTTGAACTGTTTATCCTCCGTTGGCGTCTA

CAGTAAGTCATATGGGAAGTTCAATAGATTTTGCTATTTTTTCTCTTCATTTGG

CTGGAGCTTCTTCTATTATAGGGGCTGTTAATTTTATTTCTACTATTATTGACAT

ACGGATGTTAGGAATATCTATAGAGAAGGTTCCTCTTTTTGTTT

23. *Arctosa* sub-adult 2 (641 bp). Accession No. PV477235

> PV477235 Arctosa sp.

AAAGATATTGGAACGTTATATTTAATATTTGGGGTGTGATCAGCTATAGCTGGC
ACTGCTATAAGAGTATTGATTCGGATAGAGTTAGGTCATTCTGGGAGTCTTTTA
GGAGACGATCATTTGTATAATGTTGTTGTAACTGCTCATGCTTTTGTTATGATT
TTTTTTATAGTAATGCCAATTCTAATTGGTGGGTTTGGAAATTGATTAGTTCCT
TTAATATTAGGAGCTCCTGATATATCATTTCCTCGAATAAATAATCTTTCTTTTT
GATTACTACCACCTTCTTTATTTTTATTGTTTATATCATCTATGGTTGAGATAGG
GGTAGGGGCTGGTTGAACAGTTTATCCTCCTTTGGCTTCTAGAGTAGGACATA
TAGGGAGTTCAATAGATTTTGCTATTTTTTCTCTTCATCTTGCTGGGGCTTCTT
CTATTATGGGTGCGGTTAATTTTATTACTACTATTATTAATATACGATTGTTAGGA
ATAACAATAGAGAGGGTTCCTTTGTTTGTTTGATCAGTTTTTATTACTGCTATT
TTATTGTTGTTGTCTTTACCTGTATTAGCAGGTGCTATTACTATATTATTAACTG
ATCGAAATTTTAATACTTCATTTTTTGACCCTTCAGGAGGAGG

24. *Wadicosa* sub-adult (630 bp). Accession No. PV477004

> PV477004 Wadicosa sp.

AACGTTATATTTAATATTTGGTGTTTGATCGGCTATAATGGGAACTGCTATAAG
AGTTTTGATTCGAATGGAATTAGGAAATCCTGGTAGATTATTAGGGAATGATC
ATATATATAATGTTATAGTTACTGCTCATGCTTTTGTAATAATTTTTTTTATAGTA
ATACCAATTCTTATTGGAGGGTTTGGAAATTGATTGGTACCTTTAATGTTAGGA
GCTCCTGATATATCTTTTCCTCGAATGAATAATCTTTCTTTTTGATTATTACCTC

CTTCTTTGTTTTTATTATCTATATCTTCTATAGTGGAAATAGGAGTTGGTGCTGG

ATGAACTGTTTATCCTCCTTTAGCATCAACGGTTGGTCATATAGGAAGTTCTAT

AGATTTTGCTATTTTTTCTTTACATTTAGCTGGAGCTTCTTCTATTATAGGAGCT

GTTAATTTTATTTCTACTATTATTAATATACGAGTGGTAGGAATGTCTATAGAAA

AGGTTCCTCTTTTTGTTTGATCAGTTTTAATTACAGCAGTTTTATTATTACTTTC

TTTACCTGTGTTAGCAGGAGCTATTACTATATTGTTAACTGATCGTAATTTTAAT

ACTTCATTTTTTGACCCTTCAGGAGGAGG

25. *Trochosa* sub-adult (541 bp). Accession No. PV478723

> PV478723 Trochosa sp.

ACTTTATATTTAATATTTGGGGTTTGATCAGCTATAATAGGAACTGCTATAAGA

GTATTAATTCGAATGGAATTAGGTAATCCTGGAAGATTGTTAGGTGATGATCAT

TTATATAATGTAATAGTTACTGCTCATGCTTTTGTGATGATTTTTTTATAGTAAT

ACCAATTCTTATTGGTGGTTTTGGAAATTGATTAGTTCCTTTAATATTAGGGGC

TCCTGATATATCTTTTCCTCGAATAAATAATCTTTCTTTCCGATTGTTACCTCCT

TCTTTATTTTTATTATCAATGTCTTCAATGGTGGAGATAGGTGTTGGTGCTGGT

TGAACTGTTCATCCTCCGTTGGCGTCTACAGTAGGTCATATGGGAAGTTCAAT

AGATTTTGCTATTTTTTCTCTTCATTTGGCTGGAGCTTCTTCTATTATAGGGGCT

GTTAATTTTATTCCTACTATTATTAACATACCGATGTTAGGAATATCTATAGAGA

AGGTTCCTCTTTTTATTTGATCAGGATTAATTACTGCAATTCGATTATTAC

4.3. MOLECULAR PHYLOGENETIC ANALYSIS

4.3.1. Interrelationship between collected members of Lycosidae in Kerala

All the collected specimens were subjected to partial COI sequencing (approximately 650 bp) and the subsequent alignment resulted in an MSA of 722 bp. These sequences along with the outgroup COI sequence were considered to study the phylogenetic relationship. J-model test analysis pointed out that GTR+G was the most suitable model for this nucleotide dataset based on AIC with -In likelihood score of 12833.4794. Maximum Likelihood analysis under GTR+G model with 100000 bootstrap replicates generated a tree with final ML Optimization Likelihood score of -12826.859508 (Fig. 22). Combined Bootstrap and ML search took 31521.042301 secs or 8.755845 hours. An accuracy of 0.1000000000 Log Likelihood units estimated by GAMMA Model parameters. GAMMA with 4-character states were considered with shape parameter α = 1.041918 and substitution rate λ (A–C, A–G, A–T, C–G, C–T, G–T) = 0.927173, 8.910987, 2.744699, 1.392445, 2.299234, 1.000000. Most nodes were well supported by high bootstrap value and clearly propose accurate phylogenetic relationships between them.

Maximum Parsimony analysis was done for the twenty-six-nucleotide sequence MSA using MEGA XI software. Most parsimonious tree inferred from 10000 replicates is taken to represent the phylogeny of lycosids from Kerala (Fig. 23). The percentage of these 10000 replicates in which the studied species grouped together in the bootstrap test is also 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 (10 replicates). The most parsimonious tree is almost congruent to ML tree with similar genus level separation.

Bayesian Inference tree was obtained by analysing the MSA using Mr. Bayes software with 1000000 MCMC parameter generations (Fig. 24). Posterior probability scores were also noted. BI tree is most congruent with ML tree.

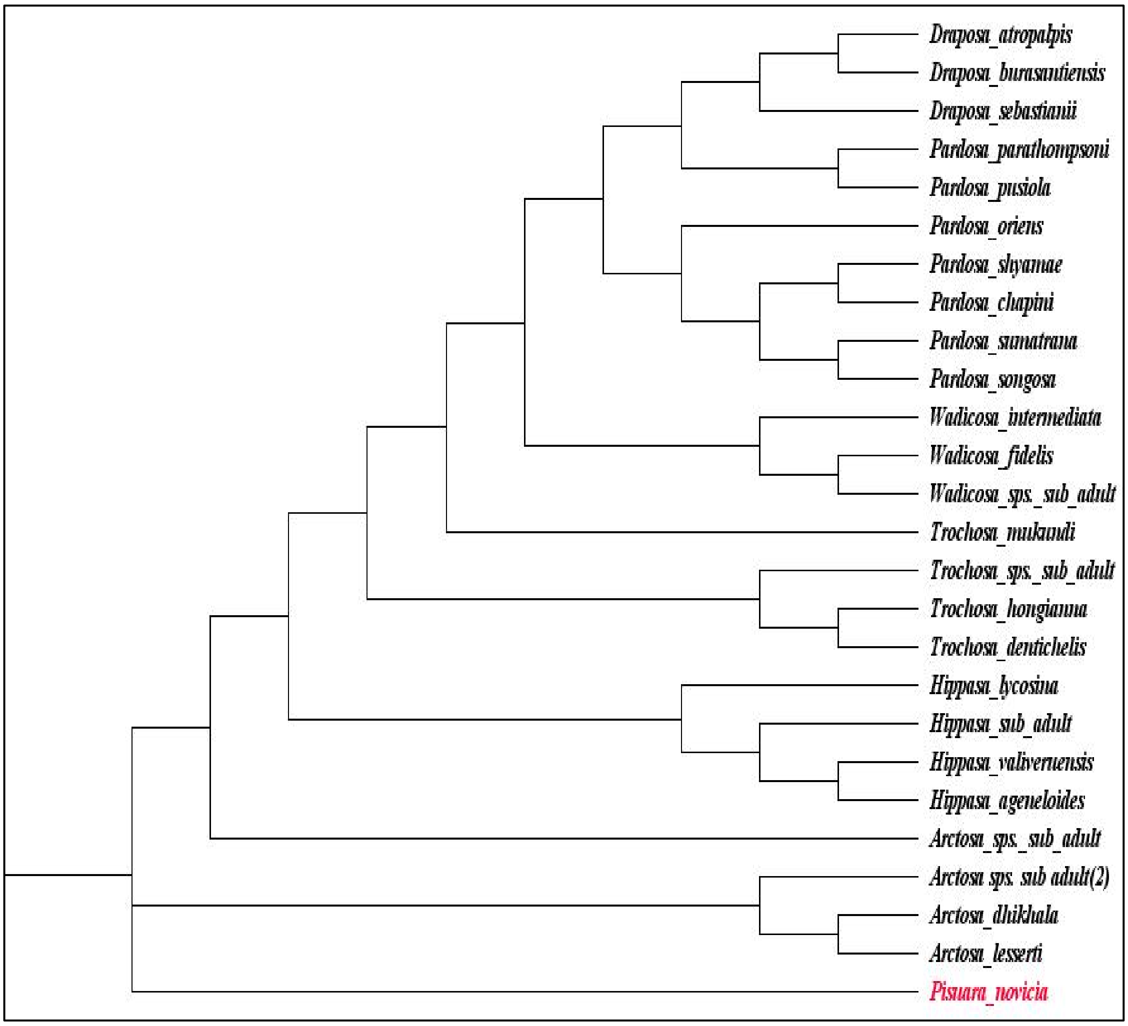


FIGURE 22. Single most likely tree obtained by Maximum Likelihood analysis of the COI sequence data set of collected lycosids from Kerala.

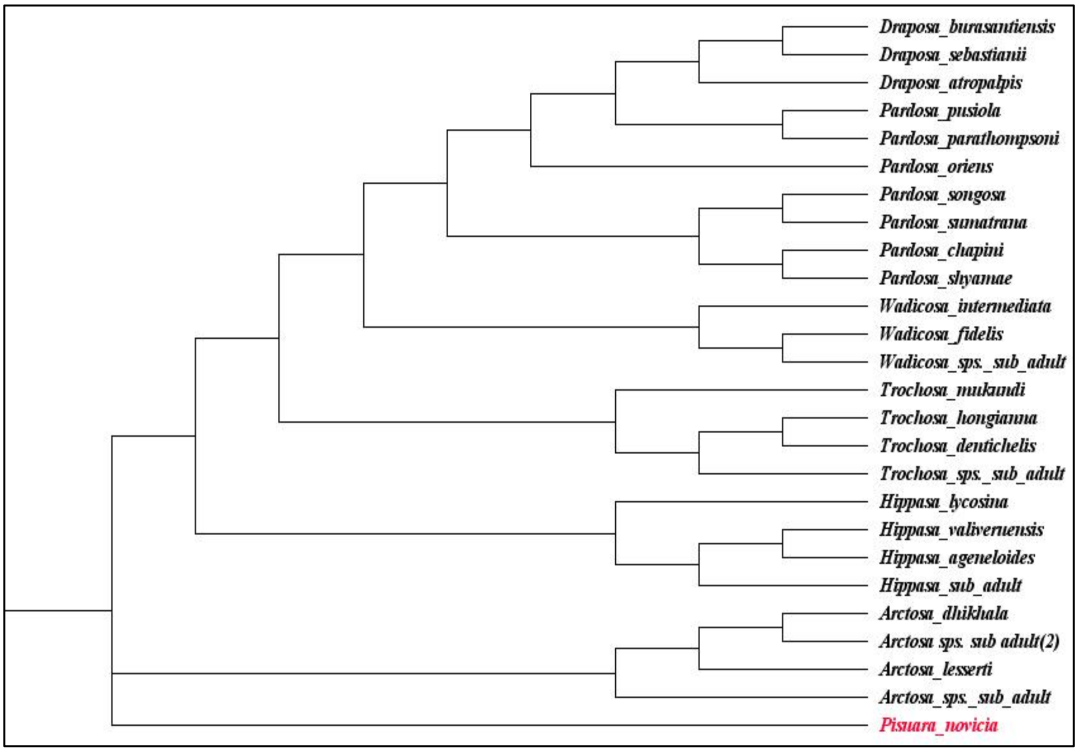


FIGURE 23. Single most parsimonious tree obtained by Maximum Parsimony analysis of the COI sequence data set of collected lycosids from Kerala.

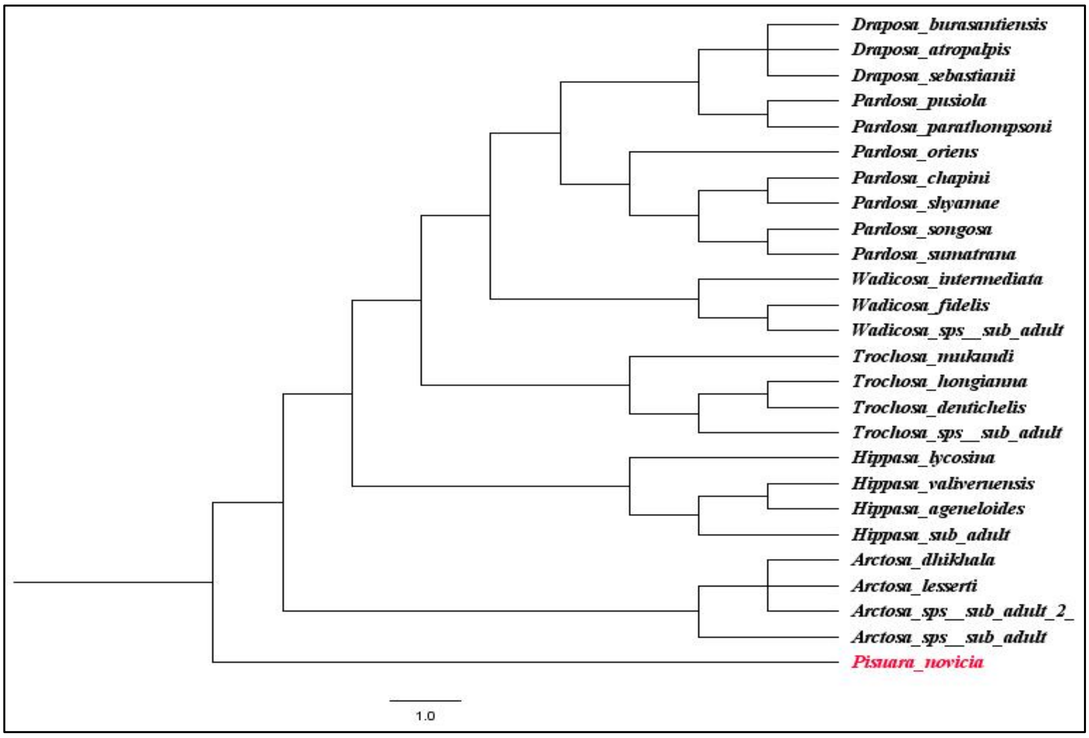


FIGURE 24. Phylogenetic tree obtained by Bayesian analysis of the COI sequence data set of collected lycosids from Kerala.

4.3.2. Phylogenetic relationship of Lycosids of Kerala with other selected Lycosids around the world

COI molecular data of 25 collected lycosids from Kerala subjected to phylogenetic analysis along with COI data of 45 randomly selected lycosids all around the world. These 70 sequences along with the outgroup aligned resulted in an MSA with 743 positions.

J-model test analysis indicated that GTR+I+G was the most suitable model for this nucleotide dataset based on AIC with -In likelihood score of 8650.3039. ML analysis under GTR+I+G model with 100000 bootstrap replicates generated a tree with final ML Optimization Likelihood score of -8664.277210 (Fig. 25). Combined Bootstrap and ML search took 31101.497654 secs or 8.639305 hours. An accuracy up to 0.0010000000 Log Likelihood units is estimated by GAMMA+P-Invar Model parameters. Proportion of Invariant sites = 0.397971, GAMMA with 4-character states were considered with shape parameter α = 0.662917 and substitution rate λ (A–C, A–G, A–T, C–G, C–T, G–T) = 0.397170, 18.754283, 2.892591, 1.173983, 2.873936, 1.000000. Most of the nodes of phylogenetic tree were well resolved and supported by high bootstrap. Maximum Parsimony analysis was carried out with 71 nucleotide sequence MSA using MEGA XI software. Most parsimonious tree inferred from 10000 replicates is taken to represent the phylogeny of 71 spiders analysed (Fig. 26). The percentage of these 10000 replicates in which the studied species grouped together in the bootstrap test is also noted. The most parsimonious 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 (10 replicates). The MP tree is almost agreeable to the ML tree in genus level grouping. Bayesian Inference tree was obtained by analysing the MSA using Mr. Bayes software with 1000000 MCMC parameter generations (Fig. 27). BI tree is most congruent with the MP tree. All three phylogenetic trees are resolved in a way that species under consideration are grouped into their respective subfamily.

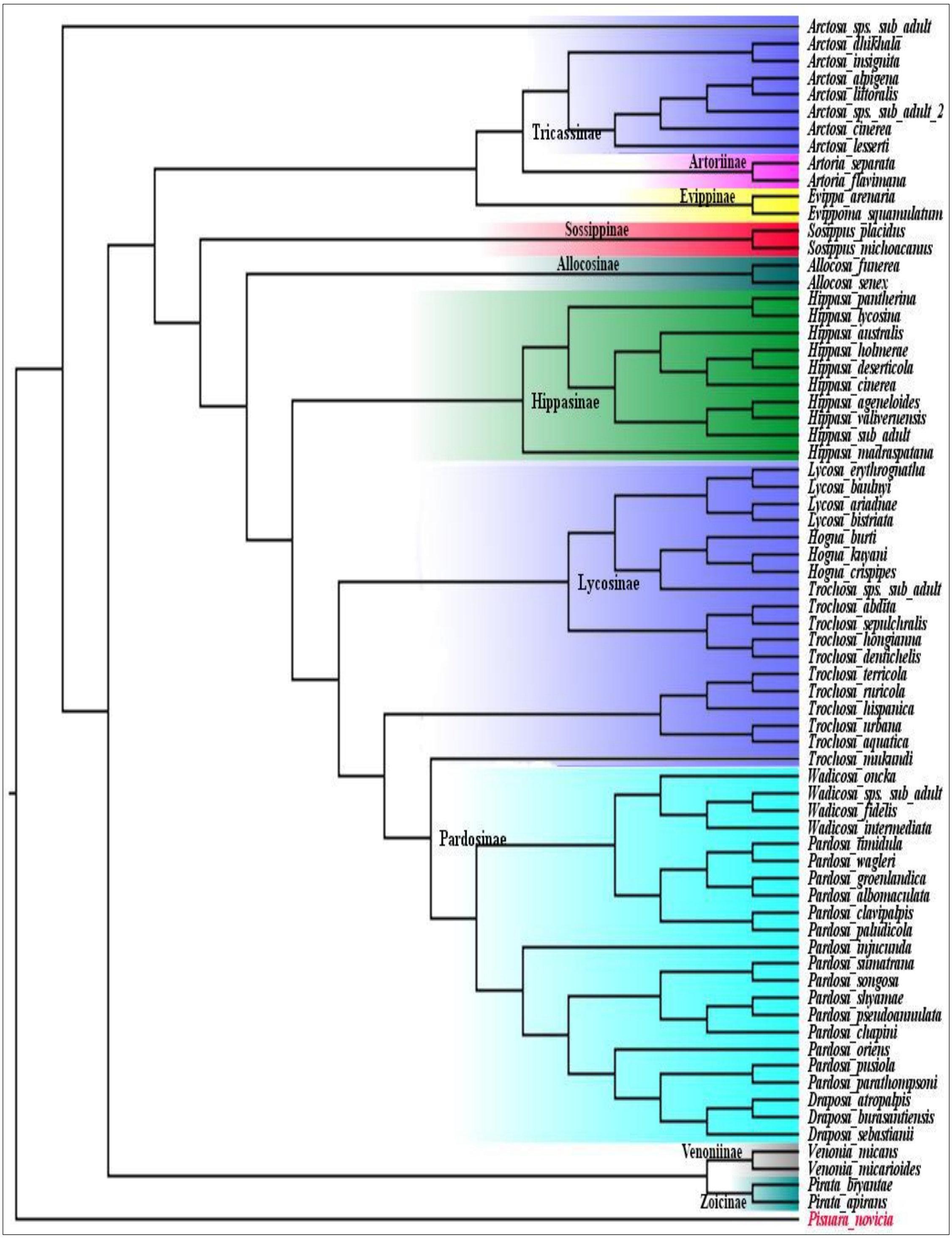


FIGURE 25. ML tree representing phylogenetic relationship of Lycosids of Kerala with other selected Lycosids around the world. Highlighted part represents each sub-family

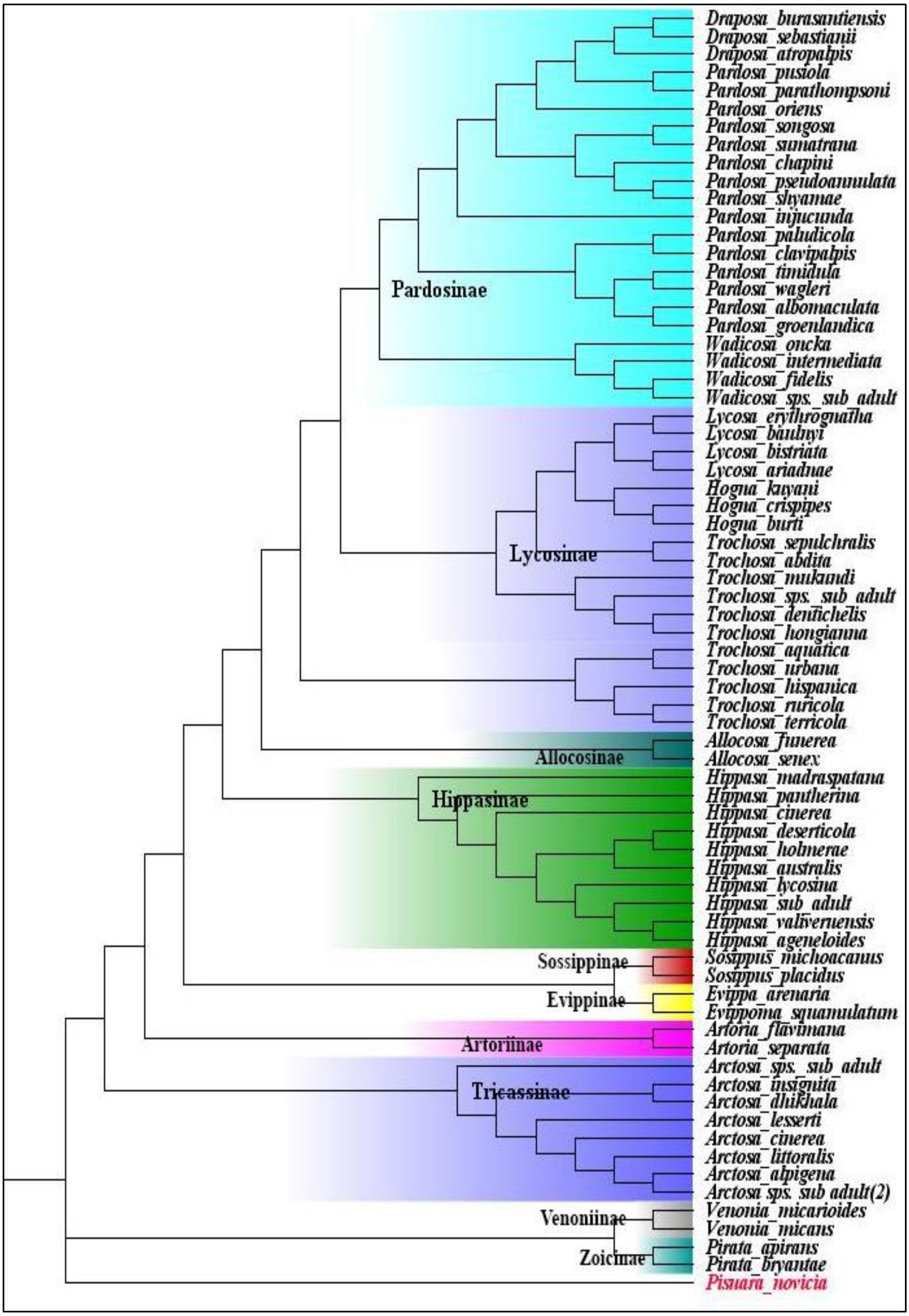


FIGURE 26. Single most parsimonious tree representing phylogenetic relationship of Lycosids of Kerala with other selected Lycosids around the world

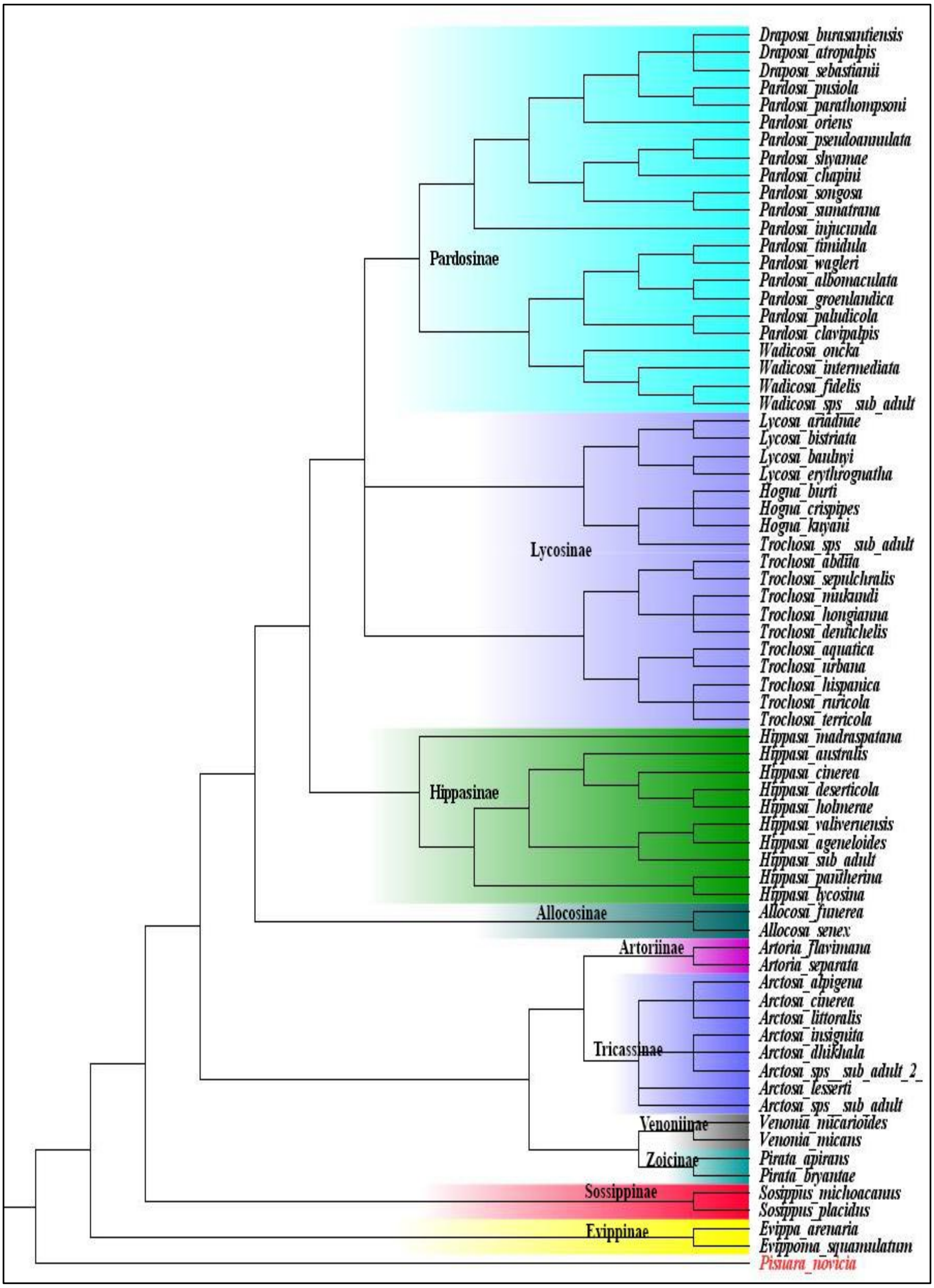


FIGURE 27. Phylogenetic tree obtained by Bayesian analysis portraying phylogenetic relationship of Lycosids of Kerala with other selected Lycosids around the world

4.3.3. Monophyly of Lycosids in Kerala

A comparison of all the trees concluded that there is not enough proof to state the monophyly of lycosids in Kerala. All three different kinds of phylogenetic analyses comparing collected lycosids and other selected lycosids around the globe indicate that lycosids collected from Kerala do not form a separate clade. So, it is evident that lycosids in Kerala do not have a monophyletic origin. Other analysed lycosids from various other geographical locations also not form separate clades based on their collection location.

Rather, the study states that all the ten sub-families within Lycosidae have monophyletic origin irrespective of geographical distribution.

Chapter 5
Discussion

DISCUSSION

The molecular taxonomy of spiders in India is still in the budding stage. In the case of family Lycosidae, even the classical taxonomic studies are much obscure. Unlike other spiders, the wolf spiders, especially genus *Pardosa* and *Draposa* can only be identified accurately by thorough lab examination of genitalia. In some cases, male specimens can only be used to distinguish between species. Other somatic features like patterns and shapes are of less taxonomic value, which make it almost impossible to identify them in the field. This clearly states that, an exclusive study concentrating on lycosids can only identify them accurately. Unfortunately, many of the early studies, most of which are general spider diversity studies or surveys inaccurately identified them as various species.

So, the importance of molecular techniques in lycosid taxonomy along with classical taxonomy is very much appreciable for the accurate identification and removal of already existing discrepancies in the field. The molecular data could further be explored to generate phylogenetic relationships between taxa. Phylogenetic studies in lycosids of India are yet to be explored.

5.1. Taxonomic studies

The study collected 25 species of family Lycosidae from Kerala, out of which 5 are sub-adults. Two of them are new to science (*D. sebastiani* and *W. intermediata*). One species was transferred from genus *Pardosa* to *Trochosa* (*T. mukundi*). *P. mysorensis* is synonymized with *P. sumatrana*. Three species are first reported from India (*P. oriens, P. chapini* and *T. hongianna*), two are first reported from the Western Ghats (*P. parathompsoni* and *T. mukundi*) and nine species are first reported from Kerala. Four species, with inadequate and obscure descriptions and genitalic figures are also redescribed during the study (*P. sumatrana, P. oriens, D. burasantiensis* and *T. mukundi*).

Synonimization of *P. mysorensis* with *P. sumatrana*

P. sumatrana is a very common lycosid in the oriental region. Original description of the species is mainly based on somatic morphology rather genitalic features. Pictures of the same were not provided in the earlier studies. Morphological features other than genitalia are of less taxonomic value in Lycosidae, especially in genus *Pardosa* (Abhijith et al. 2021). Morphological descriptions by Tikader & Malhothra (1980) are congruent with our specimens. The picture of female genitalia by Tyagi et al. (2019) also shows similarity. *P. mysorensis* was described based on the female sex only. Only two taxonomic references were available on the species collected from the same location (Tikader & Mukerji, 1971). The original description by Tikader & Mukerji (1971) is almost similar to the descriptions of *P. sumatrana*. But, genitalic description is absent and figures are obscure and non-conclusive to distinguish it as a separate species. The epigyne pictures by the original author in a different publication (Tikader & Malhotra, 1980) show similarity to the genitalia of *P. sumatrana*. SS, CD and spermathecae are similar to *P. sumatrana*, other morphological descriptions are also identical (Abhijith et al., 2021). So, it is confident to say that *P. mysorensis* is a junior synonym of *P. sumatrana.*

Transfer of *P. mukundi* to genus *Trochosa*

T. mukundi comb. nov. is a lycosid designated as a *Pardosa* species by the original authors reported only from north India and Bhutan. This was the first report of the species from the South India. No males were reported from India yet (WSC, 2025). The description and illustration by Tikader & Malhotra (1980) are similar to our specimen. But it lacks taxonomically important genitalic information. Buchar & Dolejš (2021). provided photographs of the female type of the species, which is identical to our specimen. The study provides detailed descriptions along with photographs to get an actual account of the species (Abhijith et al., 2022b).

The somatic and genitalic characters are very different from *Pardosa*. When the study analysed the epigyne in detail, it was justifiable to transfer the organism into the genus *Trochosa.* Reddish brown body; shape of epigynal plate; shape of tegular apophysis in male palp (Buchar & Dolejš, 2021) indicates its inclusion in the genus *Trochosa*.

Buchar & Dolejš (2021) also reported their doubt about the placement of this species in *Pardosa*, but refused to do the transfer because of the following characters. Longitudinal carapace strips missing or inconspicuous (the female specimen collected in the study lacks these stripes and Buchar & Dolejš (2021) reported faint markings on male. According to Dondale & Miller (2020), it is not a diagnosing feature of *Trochosa*). Another feature lacking is the absence of white pubescence on Tibia I (according to Marusik & Nadalony (2020), this is not an exclusive feature of the genus).

Based on the female specimen and photographs and details in Buchar & Dolejš (2021), it is confident to place the species in the genus *Trochosa*.

5.2. Molecular phylogenetic studies

Phylogenetic trees obtained as a result of this study considered COI molecular data of collected specimens and other selected lycosids. As discussed in earlier chapters, genitalic structure is the most and only reliable morphological feature in lycosid taxonomy. But, as suggested by Murphy et al. (2006), lycosid phylogenetic information only based on genitalic morphology is not reliable for studying interrelationships. As a well-established morphological classification is absent in various taxa within Lycosidae and non-reliability of genitalic morphology in phylogeny, the study refrains from considering morphology in phylogenetic analysis. Piacentini & Ramírez (2019) considered several life history traits and dispersion capacity also as traits with phylogenetic value. But it was beyond the scope of this study to consider such traits because, it requires extensive collection from a large geographical area (for example, the Indian sub-continent) and must consider various ecological factors. So, the study focussed on phylogeny based on molecular data, especially COI as it was the only available molecular marker with sizable entries in databases, which are essential for the comparison.

5.2.1. Molecular phylogenetic analysis of collected species of Lycosidae in Kerala

COI trees formulated with Maximum Likelihood, Maximum Parsimony and Bayesian analysis reveals the phylogenetic relationship of lycosids in Kerala. Phylogenetic analysis based on these three methods produced similar results indicating the authenticity of the results. 25 taxa are included in the study; all the trees were rooted with the outgroup.

Congruence of trees

Phylogenetic trees based on three different analyses mostly agree with the conclusions deducted from classical taxonomy. Most of the genera-wise classification is maintained well in all three trees. Piacentini & Ramírez (2019) classified ten different sub-families under Lycosidae removing discrepancies from previous studies. In this study of phylogenetic analysis of collected lycosids from Kerala, 25 species belong to four different sub-families are included. Sub-family Pardosinae with 13 representatives belongs to *Pardosa, Draposa* and *Wadicosa*; sub-family Lycosinae with 4 representatives belongs to *Trochosa*; Hippasinae with 4 *Hippasa* species and sub-family Tricassinae with 4 *Arctosa* species.

Three species of *Draposa* clubbed together in all the phylogenetic trees. Bayesian analysis opened a single branch with the highest posterior probability of 1 for all the

Draposa species. In ML tree, *D. atropalpis* and *D. burasantiensis* seemed to share most recent common ancestor and in MP tree, *D. burasantiensis* and *D. sebastiani* to share the same. Both trees provide high bootstrap value indicating that much detailed phylogeny of the genus *Draposa* can only be revealed by analysing molecular data of other species in the genus, which are not available presently. Yet, the study strongly suggests monophyly of the genus *Draposa*.

Seven representatives of genus *Pardosa* from Kerala form two distinct branches in all three trees. These seven species belong to the *P. nebulosa-species* group (Esyunin et al, 2007; Abhijith & Sudhikumar, 2022). Morphologically these seven along with other 60 odd species form a distinctive group within *Pardosa*. However, this study suggests the paraphyletic origin of this species group as *P. pusiola* and *P. parathompsoni* form distinct branches closer to *Draposa* with high probability.

Genus *Wadicosa* also formed a distinct clade with *W. fidelis* and sub-adult specimen share a most recent common ancestor. The new species obtained from the study *W. intermediata* branches out before this common ancestor. All the trees from different phylogenetic analyses yielded the same result for *Wadicosa*. Yan & Yan (2007) suggested and Piacentini & Ramírez (2019) abolished the sub-family Wadicosinae and included genus *Wadicosa* into Pardosinae. Both Bayesian and ML trees agree with that finding by providing a node consisting of *Pardosa, Draposa* and *Wadicosa* with high posterior probability (1.000) and medium-high bootstrap value (0.752). MP tree also provides the same kind of node, but, with only a 56% confidence. Considering all three, the study agrees with the synonymization of Wadicosinae. All the already discussed genera belong to Pardosinae and share a common ancestor. All three analyses produced congruent trees validate this classification.

Trochosa is the only genus that belongs to Lycosinae obtained from Kerala during the study. Both BI and MP analyses resulted in trees with four *Trochosa* species forming a clade. In ML tree, even though *T. mukundi* comb. nov. placed near other *Trochosa* species, it forms a separate branch sharing a node with Pardosinae. As the bootstrap value of this branching is very low (0.380), it could not be considered a true branching. On the contrary, the other two analyses club together the four species under a node. Earlier *T. mukundi* was placed in *Pardosa*. Buchar & Dolejš (2021) doubted the inclusion of this species in *Pardosa*. Based on the morphological features of our female specimens, the description of male specimens by Buchar & Dolejš (2021) and notes of Dondale & Miller (2020) and Marusik & Nadalony (2021), this study transferred the species into the genus *Trochosa*. These phylogenetic analyses vouch for this transfer.

Four species of *Hippasa* also form separate clade in all three phylogenetic trees in an identical way. *H. valiveruensis* and *H. ageneloides* found to be the closest species, the sub-adult species is closer to this clade and *H. lycosina* forms separate branch.

Arctosa species formed a distinct clade in both BI tree and MP tree with sufficient probability. In ML tree alone, one of the sub-adult species formed a different branch with a low bootstrap value below 0.5. A low value indicates that this branching is obscure.

In general, three different phylogenetic analyses on collected lycosids of Kerala yielded similar phylogenetic trees. MP and BI trees are most congruent to each other. ML tree is also similar with small differences which are common among different type of analyses.

5.2.2. Molecular phylogenetic analysis of Lycosids of Kerala with other selected Lycosids around the world

Maximum Likelihood, Maximum Parsimony and Bayesian analysis used to analyse the 70 species of family Lycosidae based on COI molecular data. The trees formulated reveals the phylogenetic interrelationship of these lycosids. The analysis provided almost identical result which club together species on their respective genus and subfamily.

Congruence of trees

Phylogenetic trees based on different analyses mostly agree with the conclusions of Piacentini & Ramírez (2019) on classifying ten different sub-families under Lycosidae. They also suggested that, even though both family and sub-family classification are well supported in lycosids, relationships between sub-families are often variable. This study unequivocally supports this claim by providing clear subfamily-wise classification in all phylogenetic trees and exhibits variability in the placement of these subfamilies across different analyses.

In this study of phylogenetic analysis of collected Kerala lycosids and selected lycosids across the world, 70 species belonging to ten different sub-families are included. Sub-family Pardosinae with 22 representatives belongs to *Pardosa, Draposa* and *Wadicosa*; sub-family Lycosinae with 18 representatives belongs to *Trochosa, Lycosa* and *Hogna*; Hippasinae with 10 *Hippasa* species; Tricassinae with 8 *Arctosa* species; Allocosinae, Artoriinae, Venoniinae, Zoicinae, Sossippinae and Evippinae with two representatives each.

Analysing the trees obtained from different analyses, it is evident that the subfamily level classification within Lycosidae is accurate. All 70 species formed into distinct clades under their respective subfamily. Both BI and MP trees portrayed perfect phylogeny supported with high posterior probability values. ML tree is also congruent with other trees except for two anomalous branches of *T. mukundi* and one of the *Arctosa* sub-adults. Both these inconsistent branches have low bootstrap value (0.05), indicating that the branching is not valid in ML analysis. The positioning of these species was also contradicted in ML analysis of lycosids of Kerala alone. In both cases, MP and BI trees gave the expected phylogenetic positioning of these species with high probability scores.

Zoicinae represented in this study by the genus *Pirata* and Venoniinae represented by *Venonia* were found to have evolved from a recent common node. The result is consistent in all the three analyses. The findings agree with Piacentini & Ramírez (2019) on this phylogenetic positioning. Yoo & Framenau (2006) studied the phylogeny of genus *Venonia* and suggested the revalidation of subfamily Venoniinae and Zoicinae and Piacentini & Ramírez (2019) synonymised subfamily Piratinae to Zoicinae, which placed genus *Pirata* under Zoicinae. The results do not contradict these findings. However, it is not wise to say that the results of this study support them unless more members of these subfamilies are analysed.

Evippinae and Sossipinae were also found to be closer subfamilies in all three trees. However, the position of them differs in each tree with respect to other clades. This can be viewed as a result of variance among lycosid subfamilies as suggested by Piacentini & Ramírez (2019).

Phylogenetic trees obtained from all the analyses elucidate that Artoriinae represented by *Artoria* and Tricassinae represented by *Arctosa* share a close relationship. In both the BI tree and ML tree, these two subfamilies share a recent evolutionary divergence. It is supported by a decent probability value of 0.859. In the MP tree also, they are closer to each other, but diverged from two different nodes. The results contradict Piacentini & Ramírez (2019) because of the presence of Hippasinae between these two taxa. Their study analysed much more representatives in Artoriinae, but only two species from Hippasinae. On the other hand, this study involves ten different species of *Hippasa*, but the representation of Artoriinae is lesser. So, further studies with many wider sampling and sequencing are required to analyse whether this is a genuine contradiction or simple variance existing among the phylogeny of lycosids.

Representatives of Hippasinae gave identical phylogeny in all the different analyses. All three trees agree with Murphy et al. (2006) and Piacentini & Ramírez (2019) on the revalidation of the sub-family Hippasinae, by providing a well-resolved and distinct clade for species of *Hippasa* with high bootstrap (0.984) and posterior probability values (0.998). BI and MP analyses separate Hippasinae and Lycosinae with many divergences in between. The result also disagrees with Dondale (1986) on the placement of *Hippasa* under Lycosinae based on a few genitalic characters, which were later found to be synapomorphies.

The phylogenetic position of Allocosinae is non-conclusive from the study. Three analyses placed the subfamily in different regions of trees. Two of the three analyses placed the clade closer to Hippasinae with high probability values. True positioning of the subfamily can only be resolved by improving the availability of molecular data in a wider aspect.

Genera *Lycosa*, *Hogna* and *Trochosa* represented Lycosinae in this study. All the analyses provided trees with *Lycosa* and *Hogna* sharing closer node, *Trochosa* (except one member of *Trochosa* in BI and ML tree) forming separate two branches. Zyuzin (1993) suggested various tribes within Lycosinae based on burrowing characters. He placed *Hogna* and *Trochosa* in Trochosini and placed *Lycosa* in Lycosini. Piacentini & Ramírez (2019) discarded this classification based on molecular phylogeny. This study also repudiates these tribes based on the close association of *Lycosa* and *Hogna* in resulted trees. Transfer of *T. mukundi* from *Pardosa* is also confirmed by the phylogeny results by the placement of the species within *Trochosa* clade (except in the ML tree, but the branching is non-valid because of the very low bootstrap value of 0.05).

Subfamily Pardosinae is represented in this study by *Pardosa*, *Draposa* and *Wadicosa*. They formed a distinct clade in all the analyses with high probability values. Murphy et al. (2006) and Piacentini & Ramírez (2019) suggested synonymization of Pardosinae with Lycosinae. The phylogenetic analysis of Piacentini & Ramírez (2019) produced a tree with Pardosinae within Lycosinae clade. As there is no morphology to back the hypothesis, the synonymization was not carried forward. This study provides a clear-cut distinction between Pardosinae and Lycosinae. Along with seven members of *P. nebulosa* species-group collected from Kerala, two more members in the group, *P. pseudoannulata* and *P. injucunda* analysed in this study. All these nine species form a separate group along with *Draposa*, separating other species of *Pardosa*. Marusik & Ballarin (2011), refuted the placement of this species-group in Pardosinae and placed the *nebulosa*-group in Lycosinae. Piacentini & Ramírez (2019) contradicted this and placed the species group separated from *Pardosa*, but within the Pardosinae, suggesting a genus status to the group. The results of this study contradict with Marusik & Ballarin (2011) and partially agree with Piacentini & Ramírez (2019). The separate placement of *P. nebulosa*-group within Pardosinae is supported by these results. But the status of the genus should be finalized by further analysis.

5.2.3. Monophyly of Lycosids in Kerala

The study also analysed the results of the phylogenetic analysis to check whether the lycosids of Kerala have a monophyletic origin. If the species collected from Kerala formed a separate clade with high bootstrap or posterior probability value, the monophyly could have been stated. But no such results were obtained in the study. Even lycosids endemic to Kerala or Western Ghats grouped to their respective taxon irrespective of geographical location. Murphy et al. (2006) suggested phylogenetic grouping of members of Lycosinae based on geography rather than morphology. Piacentini & Ramírez (2019) observed this trend in South American members of Lycosinae and not in spiders from other geographical locations. In this study, it is observed that two species endemic to North America, *T. sepulchralis* and *T. abdita* formed a separate clade in all trees with high posterior probability (1.00). However, as these species belong to the same genus, it is impossible to conclude the trend proposed by Murphy et al. (2006). Three *Hogna* species and *L. ariadnae*, which are from Australia are closer in trees, but *Hogna* forms a separate clade and *L. ariadnae* is part of another clade. So, the study is non-conclusive about this trend in Lycosinae. The study also could not find any such geographical grouping in any subfamilies or genera within Lycosidae.

SUMMARY AND CONCLUSION

A total of 25 different species of Lycosidae collected from various districts of Kerala. Among them two new species were reported to science (*D. sebastiani* and *W. intermediata*). One of the species was transferred from the genus *Pardosa* to *Trochosa* (*T. mukundi*). Another species *P. mysorensis* is synonymized with *P. sumatrana*. Three species were first reported from India (*P. oriens, P. chapini* and *T. hongianna*) and two species were first reported from Western Ghats region (*P. parathompsoni* and *T. mukundi*). Nine species were reported from state of Kerala for the first time. Four species, with inadequate and obscure descriptions were redescribed during the study (*P. sumatrana, P. oriens, D. burasantiensis* and *T. mukundi*). Phylogenetic analyses provided accurate subfamily and genera level grouping of lycosids.

Phylogeny results confirmed the genus transfer of *T. mukundi*. The results support the revalidation of sub-family Hippasinae, Zoicinae and Venoniinae and the synonymization of sub-family Wadicosinae to Pardosinae. The phylogeny trees disagree with the synonymization of the sub-family Pardosinae with Lycosinae and confirm the positioning of *P. nebulosa* species group within Pardosinae. The phylogenetic study also found that the lycosids in Kerala are not monophyletic in origin. The molecular results also suggested that no geographical grouping occurs among lycosids. The usage of COI molecular marker in phylogenetic studies of Oriental lycosids is found to be effective through this study.

RECOMMENDATIONS

This study can be considered as the pioneer of molecular phylogeny of lycosids in Kerala. Based on the light of this further research can develop. Still, a lot of gaps can be seen in the area of lycosid taxonomy, phylogeny and applied research.

- Further investigations into the ecology and diversity of wolf spiders from Kerala would reveal the importance of them as climate change bio-indicators.
- Investigation into the reproductive behavior of *Draposa* focusing on dark Femora I in males and guanocytes on females would be an interesting topic for ethologists.
- The study recommends more molecular studies from various locations to obtain the accurate taxonomic positioning of *P. nebulosa* species- group.
- The need for more morphological evidence to merge sub-families Pardosinae and Lycosinae is also be expected to fulfilled by future studies.
- Reliable and accurate phylogeny of genus *Draposa* will be a prominent topic for future studies with extensive collection and molecular barcoding of all the known *Draposa* species around the globe.
- More molecular phylogenetic studies on lycosids and other spider taxa from different regions of India will provide more authentic Indian spider phylogeny.
- Deposition of molecular data of more spiders in NCBI GenBank will aid future studies accurate and error free.
- These basic researches may reflect as advancements in applied research like spider venomics, proteomics and silk genetics.

References

REFERENCES

1. Abdel-Ghani, D. M., Hassan, M. F. & Sallam, G. M. E. (2023). Spiders as a bio-agent factor in a mango greenhouse at Giza Governorate, Egypt. *Serket*, 20(1), 26-38.
2. Abhijith, R. S., Sheeba, P. & Sudhikumar, A. V. (2021). Synonymization of *Pardosa mysorensis* (Tikader & Mukerji, 1971) with *Pardosa sumatrana* (Thorell, 1890). *Serket,* 17(4), 406-412.
3. Abhijith, R. S. & Sudhikumar, A. V. (2022). First record and redescription of wolf spider *Pardosa oriens* (Araneae, Lycosidae) from India. *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa,"* 65(2), 7-13.
4. Abhijith, R. S., Sheeba, P. & Sudhikumar, A. V. (2022a). First record of *Pardosa parathompsoni* Wang & Zhang, 2014 (Araneae: Lycosidae) from biodiversity hotspot Western Ghats with additional information on cheliceral morphology. *Serket,* 19(1), 79-84.
5. Abhijith, R. S., Sheeba, P. & Sudhikumar, A. V. (2022b). Redescription of two wolf spiders *Pardosa mukundi* Tikader & Malhotra, 1980 and *Draposa burasantiensis* (Tikader & Malhotra, 1976) (Araneae: Lycosidae). *Serket,* 18(3), 338-344.
6. Abhijith, R. S. & Sudhikumar, A. V. (2023). Description of a new wolf spider species (Arachnida: Araneae: Lycosidae: *Draposa*) from Western Ghats, India. *Taprobanica,* 12(1), 1-4.
7. Abhijith, R. S., & Sudhikumar, A. V. (2024). A new wolf spider species of *Wadicosa* (Araneae, Lycosidae) from Western Ghats of India. *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa"*, 67(2), 173-181.
8. Agnarsson, I. (2004). Morphological phylogeny of cobweb spiders and their relatives (Araneae, Araneoidea, Theridiidae). *Zoological Journal of the Linnean Society*, 141(4), 447-626.
9. Ahmed, J., Satam, Y., Khalap, R. & Mohan, K. (2015). First record of *Portia albimana* (Simon, 1900) from Maharashtra, Mumbai (Araneae: Salticidae: Spartaeinae). *Peckhamia,* 129.1, 1-6.
10. Albo, M. J., Bidegaray-Batista, L., Bechsgaard, J., da Silva, E. L. C., Bilde, T., & Pérez-Miles, F. (2017). Molecular phylogenetic analyses show that Trechaleidae and Lycosidae are sister groups. *Arachnology*, 17(4), 169-176.

11. Alderweireldt, M. (1999). A revision of Central African Trabea (Araneae, Lycosidae) with the description of two new species from Malawi and a redescription of *T. purcelli*. *Journal of Arachnology*, 27(2), 449-457.
12. Alderweireldt, M., & Jocqué, R. (1991). A remarkable new genus of wolf spiders from southwestern Spain (Araneae, Lycosidae). *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Entomologie*, 61, 103-111.
13. Alderweireldt, M., & Jocqué, R. (1993). A Redescription of *Tricassa deserticola* Simon, 1910, representing the Tricassinae, A New Subfamily of Wolf Spiders (Araneae, Lycosidae). *Belgian Journal of Zoology*, 123(1), 27-38.
14. Alonso, R., Crawford, A. J., & Bermingham, E. (2012). Molecular phylogeny of an endemic radiation of Cuban toads (Bufonidae: Peltophryne) based on mitochondrial and nuclear genes. *Journal of Biogeography*, 39(3), 434-451.
15. Al-Yacoub, G. A. A. & Najim, S. A. (2023). A new record and a taxonomic review with checklist of wolf spiders (Araneae, Lycosidae) from Iraq. *Zoodiversity,* 57(5), 383-390.
16. Astrin, J. J., Höfer, H., Spelda, J., Holstein, J., Bayer, S., Hendrich, L.& Muster, C. (2016). Towards a DNA barcode reference database for spiders and harvestmen of Germany. *PloS one*, 11(9), e0162624.
17. Barrion, A. T., & Litsinger, J. A. (1994). Taxonomy of rice insect pests and their arthropod parasites and predators. In E. A. Heinrichs (Ed.), *Biology and management of rice insects* (pp. 283-359). Wiley Eastern.
18. Barrion, A. T. & Litsinger, J. A. (1995). *Riceland spiders of South and Southeast Asia*. CAB International, 700 pp.
19. Barrion, A. T., Barrion-Dupo, A. L. A., Catindig, J. L. A., Villareal M., O., Cai, D., Yuan, Q. H. & Heong, K. L. (2013). New species of spiders (Araneae) from Hainan Island, China. *UPLB Museum Publications in Natural History,* 3, 1-103.
20. Biswas, V. & Raychaudhuri, D. (2003). Wolf spiders of Bangladesh: genus *Pardosa* C. L. Koch (Araneae: Lycosidae). *Records of the Zoological Survey of India*, 101(1-2), 107-125.
21. Biswas, V. & Raychaudhuri, D. (2014). Wolf spiders of Bangladesh-II: genus *Lycosa* Latreille (Araneae: Lycosidae). *Records of the Zoological Survey of India,* 114(2), 295-306.
22. Blagoev, G. A., Dewaard, J. R., & Hebert, P. D. (2017). A DNA barcode reference library and ecoregion analysis of Nearctic wolf spiders (Araneae: Lycosidae). *Genome*, 60(11), 914-915.
23. Bösenberg, W. & Strand, E. (1906). Japanische Spinnen. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft,* 30, 93-422.

24. Buchar, J. (1976). Über einige Lycosiden (Araneae) aus Nepal. *Ergebnisse des Forschungsunternehmens Nepal Himalaya*, 5(1), 201-227.

25. Buchar, J. (1980). Lycosidae aus dem Nepal-Himalaya. II. Die *Pardosa nebulosa*- und *P. venatrix*-Gruppe (Araneae: Lycosidae: Pardosinae). *Senckenbergiana Biologica*, 61, 77-91.

26. Buchar, J. (1997). Lycosidae aus Bhutan 1. Venoniinae und Lycosinae (Arachnida: Araneae). *Entomologica Basiliensis*, 20, 5-32.

27. Buchar, J. & Dolejš, P. (2021). Lycosidae from Bhutan 2: Lycosinae, Pardosinae, and Hippasinae (Arachnida: Araneae). *Arachnology*, 18(8), 935-953.

28. Buckley, T. R. (2002). Model misspecification and probabilistic tests of topology: evidence from empirical data sets. *Systematic Biology*, 51(3), 509-523.

29. Buckley, T. R., & Cunningham, C. W. (2002). The effects of nucleotide substitution model assumptions on estimates of nonparametric bootstrap support. *Molecular biology and evolution*, 19(4), 394-405.

30. Caleb, J. T., Chatterjee, S., Tyagi, K., Kundu, S., & Kumar, V. (2017). Two new jumping spiders of the genera *Epocilla* Thorell, 1887 and *Mogrus* Simon, 1882 from India (Araneae: Salticidae). *Arthropoda Selecta*, 26(4), 329-334.

31. Caleb, J. T., Parag, A., & Roy, D. A. (2023). A new species of the genus *Siler* Simon, 1889 (Araneae, Salticidae, Chrysillini) from India. *Zoosystematics and Evolution*, 99(1), 209-216.

32. Cavenagh, A. F., Rincão, M. P., Dias, F. C., Brescovit, A. D., & Dias, A. L. (2022). Chromosomal diversity in three species of *Lycosa* Latreille, 1804 (Araneae, Lycosidae): Inferences on diversification of diploid number and sexual chromosome systems in Lycosinae. *Genetics and Molecular Biology*, 45(1), 11-20.

33. Chamberlin, R. V. (1924). Descriptions of new American and Chinese spiders, with notes on other Chinese species. *Proceedings of the United States National Museum,* 63(13), 1-38.

34. Chang, J., Song, D., & Zhou, K. (2007). Incongruous nuclear and mitochondrial phylogeographic patterns in two sympatric lineages of the wolf spider *Pardosa astrigera* (Araneae: Lycosidae) from China. *Molecular Phylogenetics and Evolution*, 42(1), 104-121.

35. Chatterjee, S., Caleb, J. T., Tyagi, K., Kundu, S., & Kumar, V. (2017). First report of *Menemerus nigli* (Araneae: Salticidae) from India. *Halteres*, 8, 109-111.

36. Chatterjee, S., Caleb, J. T., Tyagi, K., Kundu, S., & Kumar, V. (2018). First report of *Hyptiotes affinis* Bösenberg & Strand, 1906 (Araneae: Uloboridae) from India. *Munis Entomology and Zoology*, 13(1), 211-213.

37. Chen, X. E. & Gao, J. C. (1990). *The Sichuan farmland spiders in China*. Sichuan Science and Technology Publishing House, Chengdu, 226 pp.
38. Chen, Z. F. & Zhang, Z. H. (1991). *Fauna of Zhejiang: Araneida*. Zhejiang Science and Technology Publishing House, Hangzhou, 356 pp.
39. Coddington, J. A., & Levi, H. W. (1991). Systematics and evolution of spiders (Araneae). *Annual Review of Ecology and Systematics*, 22(1), 565-592.
40. Crespo, L. C., Silva, I., Enguídanos, A., Cardoso, P., & Arnedo, M. (2022). Island hoppers: Integrative taxonomic revision of *Hogna* wolf spiders (Araneae, Lycosidae) endemic to the Madeira islands with description of a new species. *ZooKeys*, 1086, 84.
41. Dhali, D. C., Roy, T. K., Sen, S., Saha, S. & Raychaudhuri, D. (2012). Wolf spiders (Araneae: Lycosidae) of the reserve forests of Dooars, West Bengal, India. *Munis Entomology and Zoology,* 7(2), 1199-1213.
42. Dhali, D. C., Saha, S. & Raychaudhuri, D. (2017). Litter and ground dwelling spiders (Araneae: Arachnida) of reserve forests of Dooars, West Bengal. *World Scientific News,* 63, 1-242.
43. Dimitrov, D., Benavides, L. R., Arnedo, M. A., Giribet, G., Griswold, C. E., Scharff, N., & Hormiga, G. (2017). Rounding up the usual suspects: A standard target-gene approach for resolving the interfamilial phylogenetic relationships of ecribellate orb-weaving spiders with a new family-rank classification (Araneae, Araneoidea). *Cladistics*, 33(3), 221-250.
44. Dondale, C. D. (1986). The subfamilies of wolf spiders (Araneae: Lycosidae). In *Actas X Congreso Internacional de Aracnología Jaca España,* 1, 327-332.
45. Dondale, C. D., & Redner, J. H. (1978a). Revision of the Nearctic wolf spider genus *Schizocosa* (Araneida: Lycosidae). *The Canadian Entomologist*, 110(2), 143-181.
46. Dondale, C. D., & Redner, J. H. (1978b). *The insects and arachnids of Canada. Part 5. The crab spiders of Canada and Alaska. Araneae: Philodromidae and Thomisidae.* Minister of Supply and services, Canada, 255 pp.
47. Dondale, C. D., & Redner, J. H. (1983a). Revision of the wolf spiders of the genus *Arctosa* CL Koch in North and Central America (Araneae: Lycosidae). *Journal of Arachnology*, 11(1), 1-30.
48. Dondale, C. D., & Redner, J. H. (1983b). The wolf spider genus *Allocosa* in North and Central America (Araneae: Lycosidae). *The Canadian Entomologist*, 115(8), 933-964.
49. Dondale, C. D., & Miller, P. (2020). Taxonomic problems in the genus *Trochosa* (Araneae: Lycosidae). *American Arachnology*, 85, 16-22.
50. Drisya-Mohan, O. M., Kashmeera, N. A. & Sudhikumar, A. V. (2019). Is cooperation in prey capture flexible in the Indian social spider *Stegodyphus sarasinorum*? *Arachnologische Mitteilungen: Arachnology Letters*, 58(1), 97-102.

51. Elliott, N. C., Wolff, R. J., Johnson, W. E., & Engemann, J. G. (1982). Genetic differentiation among three species of *Pardosa* (Arachnida: Lycosidae). *The Great Lakes Entomologist*, 15(1), 9.
52. Esyunin, S. L., Tuneva, T. K., & Farzalieva, G. S. (2007). Remarks on the Ural spider fauna (Arachnida, Aranei), 12. Spiders of the steppe zone of Orenburg Region. *Arthropoda Selecta*, 16(1), 43-63.
53. Felsenstein, J. (2004). *Inferring phylogenies*. Sinauer Associates, 664 pp.
54. Foelix, R. F. (1996). *Biology of Spiders*. Oxford University Press, 330 pp.
55. Folmer O., Black M., Hoeh W., Lutz R., Vrijenhoek R. (1994). DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology*, 3(5), 294-9.
56. Fox, I. (1935). Chinese spiders of the family Lycosidae. *Journal of the Washington Academy of Sciences* 25, 451-456.
57. Framenau, V. W., & Yoo, J. S. (2006). Systematics of the new Australian wolf spider genus *Tuberculosa* (Araneae: Lycosidae). *Invertebrate Systematics*, 20(2), 185-202.
58. Framenau, V. W., & Hudson, P. (2017). Taxonomy, systematics and biology of the Australian halotolerant wolf spider genus *Tetralycosa* (Araneae: Lycosidae: Artoriinae). *European Journal of Taxonomy*, 335, 1-72.
59. Gajbe, U. A. (2007). Araneae: Arachnida. In *Fauna of Madhya Pradesh (including Chhattisgarh), State Fauna Series* (Vol. 15, Part 1, pp. 419-540). Zoological Survey of India.
60. Gertsch, W. J. (1979). *American Spiders* (2nd ed). Van Nostrand Reinhold, 274 pp.
61. Gravely, F. H. (1924). Some Indian spiders of the family Lycosidae. *Records of the Indian Museum, Calcutta,* 26, 587-613.
62. Griswold, C. E. (1993). Investigations into the phylogeny of the lycosoid spiders and their kin (Arachnida: Araneae, Lycosoidea), *Smithsonian Contributions to Zoology*, 539, 1–39.
63. Hebert, P. D., Cywinska, A., Ball, S. L., & DeWaard, J. R. (2003). Biological identifications through DNA barcodes. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 270(1512), 313-321.
64. Heimer, S., & Nentwig,W. (1991). *Sipinnen Mitteleuropas*. Ein Bestimmungsbuch. Verlag Paul Parey, Berlin, 543 pp.
65. Hogg, H.R. (1919). Spiders collected in Korinchi, West Sumatra by Messrs H. C. Robinson and C. Boden Kloss. *Journal of the Federated Malay States Museums*, 8(3), 81-106.

66. Hu, J. L. & Li, A. H. (1987). The spiders collected from the fields and the forests of Xizang Autonomous Region, China (II). *Agricultural Insects, Spiders, Plant Diseases and Weeds of Xizang,* 2, 247-353.
67. Hu, J. L. (2001). *Spiders in Qinghai-Tibet Plateau of China*. Henan Science and Technology Publishing House, 658 pp.
68. Ivanov, V., Lee, K. M., & Mutanen, M. (2018). Mitonuclear discordance in wolf spiders: Genomic evidence for species integrity and introgression. *Molecular Ecology*, 27(7), 1681-1695.
69. Ivanov, V., Marusik, Y., Pétillon, J., & Mutanen, M. (2021). Relevance of ddRADseq method for species and population delimitation of closely related and widely distributed wolf spiders (Araneae, Lycosidae). *Scientific Reports*, 11(1), 1-14.
70. Jiman, H., & Song, D. (1996). The phylogenetic relationship of Chinese wolf spiders. *Zhuxing Xuebao*, 5(1), 3-20.
71. Jocqué, R., & Alderweireldt, M. (2005). Lycosidae: the grassland spiders. *Acta Zoologica Bulgarica*, 1, 125-130.
72. Jogar, K., Metspalu, L., & Hiiesaar, K. (2004). Abundance and dynamics of wolf spiders (Lycosidae) in different plant communities. *Agronomy Research*, 2(2), 145-152.
73. Just, P., Opatova, V., & Dolejš, P. (2019). Does reproductive behaviour reflect phylogenetic relationships? An example from Central European *Alopecosa* wolf spiders (Araneae: Lycosidae). *Zoological Journal of the Linnean Society*, 185(4), 1039-1056.
74. Kelchner, S. A., & Thomas, M. A. (2007). Model use in phylogenetics: nine key questions. *Trends in Ecology and Evolution*, 22(2), 87-94.
75. Kronestedt, T. (2010). *Draposa*, a new wolf spider genus from South and Southeast Asia (Araneae: Lycosidae). *Zootaxa*, 2637(1), 31-54.
76. Kronestedt, T. (2023). Species of *Wadicosa* (Araneae, Lycosidae): transfer of four species from Africa currently placed in *Pardosa*. *Zootaxa*, 5227(5), 531-548.
77. Kulkarni, S., Vartak, A., Deshpande, V., & Halali, D. (2017). The spiny theridiid genus *Meotipa* Simon, 1895 in India, with description of a strange new species with translucent abdomen and a phylogenetic analysis about the genus placement (Araneae, Theridiidae). *Zootaxa*, *4291*(3), 504-520.
78. Laskar, B. A., Kundu, S., Sulthana, R., Adimalla, H., Jaiswal, D., Tyagi, K., & Chandra, K. (2021). Molecular investigation of Cavernicoles from Kotumsar Cave in Northern Eastern Ghats, India. *Records of the Zoological Survey of India*, 121(3), 337-345.

79. Lemmon, A. R., & Moriarty, E. C. (2004). The importance of proper model assumption in Bayesian phylogenetics. *Systematic Biology*, 53(2), 265-277.

80. Lewis, R. V. (2006). Spider silk: ancient ideas for new biomaterials. *Chemical reviews*, 106(9), 3762-3774.

81. Lu, T., Wang, L. Y., Hadole, P. & Zhang, Z. S. (2016). Redescription of four wolf-spiders (Araneae: Lycosidae) from India. *Indian Journal of Arachnology,* 5, 130-142.

82. Luczak, J. (1979). Spiders in agrocoenoses. *Polish Ecological Studies*, 5(1), 151-200.

83. Marshall, S. D., & Rypstra, A. L. (1999). Spider competition in structurally simple ecosystems. *Journal of Arachnology*, 27(1), 343-350.

84. Marshall, S. D., Pavuk, D. M., & Rypstra, A. L. (2002). A comparative study of phenology and daily activity patterns in the wolf spiders *Pardosa milvina* and *Hogna helluo* in soybean agroecosystems in southwestern Ohio (Araneae, Lycosidae). *Journal of Arachnology*, 30(3), 503-510.

85. Marusik, Y. M., & Ballarin, F. (2011). Redescription of the Himalaian *Pardosa flavisterna* Caporiacco, 1935 (Aranei: Lycosidae) with notes of the *Pardosa nebulosa* species-group. *Proceedings of the Zoological Institute RAS,* 315(1), 63-69.

86. Marusik, Y. M., Nadolny, A. A. & Koponen, S. (2020). Redescription of *Trochosa urbana* (Araneae: Lycosidae) with notes on its distribution. *Arachnology,* 18(5), 482-489.

87. Marusik, Y. M. & Nadolny, A. A. (2021). Redescription of *Hippasa deserticola*, the northernmost species of *Hippasa* (Aranei: Lycosidae), with taxonomic notes on other species of the genus. *Zoosystematica Rossica,* 30(2), 222-235.

88. Murphy, N. P., Framenau, V. W., Donnellan, S. C., Harvey, M. S., Park, Y. C., & Austin, A. D. (2006). Phylogenetic reconstruction of the wolf spiders (Araneae: Lycosidae) using sequences from the 12S rRNA, 28S rRNA, and NADH1 genes: Implications for classification, biogeography, and the evolution of web building behavior. *Molecular Phylogenetics and Evolution*, 38(3), 583-602.

89. Nadolny, A. A., Omelko, M. M., Marusik, Y. M., & Blagoev, G. (2016). A new species of spider belonging to the *Pardosa lugubris*-group (Araneae: Lycosidae) from Far East Asia. *Zootaxa*, 4072(2), 263-281.

90. Nei M. & Kumar S. (2000). *Molecular Evolution and Phylogenetics*. Oxford University Press, 352 pp.

91. Nyffeler, M. (1982). *Field studies on the ecological role of the spiders as insect predators in agroecosystems (abandoned grassland, meadows, and cereal fields)* (Doctoral dissertation, ETH Zurich).

92. Nyffeler, M., & Benz, G. (1987). Spiders in natural pest control: a review 1. *Journal of Applied Entomology*, 103(1-5), 321-339.

93. Nyffeler, M., Sterling, W. L., & Dean, D. A. (1994a). How spiders make a living. *Environmental Entomology*, 23(6), 1357-1367.
94. Nyffeler, M., Sterling, W. L., & Dean, D. A. (1994b). Insectivorous activities of spiders in United States field crops. *Journal of Applied Entomology*, 118(1-5), 113-128.
95. Nyffeler, M., & Birkhofer, K. (2017). An estimated 400–800 million tons of prey are annually killed by the global spider community. *The Science of nature*, 104(3), 1-12.
96. Okuma, C., Kamal, N. Q., Hirashima, Y., Alam, M. Z. & Ogata, K. (1993). *Illustrated Monograph of the Rice Field Spiders of Bangladesh.* Institute of Postgraduate Studies in Agriculture (Salna, Gazipur, Bangladesh). Japan International Cooperation Agency Project Publication, 1, 93 pp.
97. Omelko, M. M. & Marusik, Y. M. (2020). A new species and new records of wolf spiders (Araneae: Lycosidae) from Laos. *Raffles Bulletin of Zoology,* 68, 479-487.
98. Patel, B. H. & Reddy, T. S. (1993). On some new species of spiders of the genera *Hippasa* Simon, *Lycosa* Latreille, *Pardosa* Koch and *Trochosa* Koch (family: Lycosidae) from coastal Andhra Pradesh, India. *Records of the Zoological Survey of India,* 90, 121-133.
99. Piacentini, L. N., & Ramírez, M. J. (2019). Hunting the wolf: a molecular phylogeny of the wolf spiders (Araneae, Lycosidae). *Molecular Phylogenetics and Evolution*, 136, 227-240.
100. Pickard-Cambridge, O. (1872). General list of the spiders of Palestine and Syria, with descriptions of numerous new species, and characters of two new genera. *Proceedings of the Zoological Society of London*, 40(1), 212-354.
101. Platnick, N. I. (2020). *Spiders of the world: a natural history* (Vol. 2). Princeton University Press, 496 pp.
102. Pocock, R. I. (1900). *The fauna of British India, including Ceylon and Burma. Arachnida*. Taylor and Francis, 279 pp.
103. Polotow, D., Carmichael, A., & Griswold, C. E. (2015). Total evidence analysis of the phylogenetic relationships of Lycosoidea spiders (Araneae, Entelegynae). *Invertebrate Systematics*, 29(2), 124-163.
104. Prasad, P., Tyagi, K., Kumar, V., & Kumar Saha, G. (2021). Redescription of *Lycosa bistriata* Gravely, 1924 (Araneae: Lycosidae) from India. *Munis Entomology and Zoology*, 16(2), 819-822.
105. Prasad, P., Saha, G. K., Kumar, V. & Tyagi, K. (2022). First report of the wolf spider *Pardosa parathompsoni* (Araneidae: Lycosidae) from India. *Munis Entomology and Zoology,* 17(supplement), 1590-1595.

106. Ramírez, C. M. M., Jiménez, M. L., & García-De León, F. J. (2010). Testing species boundaries in *Pardosa sierra* (Araneae: Lycosidae) using female morphology and COI mtDNA. *The Journal of Arachnology*, 38(3), 538-554.

107. Reimoser, E. (1934). Araneae aus Süd-Indien. *Revue Suisse de Zoologie* 41, 465-511.

108. Russell-Smith, A. (1982). A revision of the genus *Trabaea* Simon (Araneae: Lycosidae). *Zoological Journal of the Linnean Society*, 74(1), 69-91.

109. Saez, N. J., Senff, S., Jensen, J. E., Er, S. Y., Herzig, V., Rash, L. D., & King, G. F. (2010). Spider-venom peptides as therapeutics. *Toxins*, 2(12), 2851-2871.

110. Sankaran, P. M., Caleb, J. T. D. & Sebastian, P. A. (2021a). Revision of Indian wolf spiders: I. Genus *Arctosa* C.L. Koch, 1847 (Araneae: Lycosidae, Tricassinae). *Zootaxa,* 4908(4), 489-504.

111. Sankaran, P. M., Caleb, J. T. D. & Sebastian, P. A. (2021b). Notes on Indian wolf spiders: I. Genus *Evippa* Simon, 1882 (Araneae: Lycosidae, Evippinae). *Zootaxa,* 4975(1), 159-175.

112. Sankaran, P. M. & Caleb, J. T. D. (2023a). Notes on Indian wolf spiders: II. Genus *Hippasa* Simon, 1885 (Araneae: Lycosidae, Hippasinae). *Zootaxa,* 5230(2), 101-152.

113. Sankaran, P. M. & Caleb, J. T. D. (2023b). Notes on Indian wolf spiders: III. Genera *Acantholycosa* Dahl, 1908, *Evippomma* Roewer, 1959, *Hippasosa* Roewer, 1960 and *Trochosa* C.L. Koch, 1847 (Araneae: Lycosidae). *Zootaxa,* 5369(4), 533-552.

114. Sebastian, P. A., Murugesan, S., Mathew, M. J., Sudhikumar, A. V., & Sunish, E. (2005). Spiders in Mangalavanam, an ecosensitive mangrove forest in Cochin, Kerala, India (Araneae). *Acta Zoologica Bulgarica*, 1, 315-318.

115. Sebastian, P. A., & Peter, K. V. (2009). *Spiders of India*. Orient Blackswan, 614 pp.

116. Sen, S., Dhali, D. C., Saha, S. & Raychaudhuri, D. (2015). Spiders (Araneae: Arachnida) of reserve forests of Dooars: Gorumara National Park, Chapramari Wildlife Sanctuary and Mahananda Wildlife Sanctuary. *World Scientific News,* 20, 1-339.

117. Seropian, A., Bulbulashvili, N., Otto, S., Krammer, H.-J., Kachlishvili, N. & Datunashvili, A. (2023). Picking pearls from the Silk Road: insights into the spider (Arachnida, Araneae) diversity in Georgia from the Caucasus barcode of life project. Part II. *Caucasiana,* 2, 231-297.

118. Sherriffs, W. R. (1939). Hong-Kong spiders. Part V. *Hong-kong Naturalist*, 9, 135-140.

119. Sierwald, P. (2000). Description of the male of *Sosippus placidus*, with notes on the subfamily Sosippinae (Araneae, Lycosidae). *Journal of Arachnology*, 28(2), 133-140.

120. Simon, E. (1884). Arachnides recueillis en Birmanie par M. le chevalier J. B. Comotto et appartenant au Musée civique d'histoire naturelle de Gènes. *Annali del Museo Civico di Storia Naturale di Genova,* 20, 325-372.

121. Song, D. X. (1988). A revision of the Chinese spiders described by Chamberlin. *Sinozoologia,* 6, 123-136.

122. Song, D. X., Chen, J., & Zhu, M. S. (1997). Arachnida: Araneae. In X. K. Yang (Ed.), *Insects of the Three Gorge Reservoir area of Yangtze River* (Vol. 2, pp. 1704–1743). Chongqing Publishing House.

123. Song, D. X., Zhu, M. S. & Chen, J. (1999). *The spiders of China*. Hebei Science and Technology Publishing House, 640 pp.

124. Song, D. X., Zhu, M. S. & Chen, J. (2001). *The Fauna of Hebei, China: Araneae*. Hebei Science and Technology Publishing House, 510 pp.

125. Starrett, J., McGinley, R. H., Hebets, E. A., & Bond, J. E. (2022). Phylogeny and secondary sexual trait evolution in Schizocosa wolf spiders (Araneae, Lycosidae) shows evidence for multiple gains and losses of ornamentation and species delimitation uncertainty. *Molecular Phylogenetics and Evolution*, 169, 107397.

126. Sudhikumar, A. V., Mathew, M. J., Sunish, E., Murugesan, S., & Sebastian, P. A. (2005). Preliminary studies on the spider fauna in Mannavan shola forest, Kerala, India (Araneae). *European Arachnology*, 1, 319-327.

127. Sudhikumar A.V., & Sebastian, P. A. (2005). Diversity of spiders in Kuttanad rice agro-ecosystem, Kerala. *Journal of the Bombay Natural History Society*, 102(1), 66-68.

128. Sudhikumar, A. V., Maelfait, J. P., Lens, L., Hendrickx, F., & Sebastian, P. A. (2008). African and Southeast Asian elements in the spider fauna of Western Ghats of India. *European Arachnology*, 165-175.

129. Sudhikumar, A. V., & Nafin, K. S. (2018). Diversity of spiders in the organically cultivated paddy fields of Muriyad Kol wetlands, Kerala, India. *Perspectives On Biodiversity of India*, 232.

130. Sudhin, P. P., Nafin, K. S., Sobha, T. R., & Sudhikumar, A. V. (2015). A survey of spider fauna along the banks of Chaliyar River, Kerala, India. In A. V. Sudhikumar (Ed.), *Proceedings of the National Seminar on Biodiversity Conservation: Trends and Prospects* (pp. 73–78). Christ College Publishers.

131. Sudhin, P. P., Nafin, K. S., & Sudhikumar, A. V. (2018). A preliminary checklist of spiders (Araneae) from Wayanad Wildlife Sanctuary, Kerala, India. In A. V. Sudhikumar (Ed.), *Faunal diversity and recent trends in animal taxonomy* (pp. 107–111). Christ College Publishers.

132. Sunil, J. K., Sudhikumar, A., Davis, S., & Sebastian, P. (2008). Preliminary studies on the diversity of spider fauna (Araneae: Arachnida) in Parambikulam Wildlife Sanctuary in Western Ghats, Kerala, India. *Journal of the Bombay Natural History Society*, 105(3), 264-273.

133. Tahir, H. M., Summer, M., Mehmood, S., Ashraf, S., & Naseem, S. (2019). DNA barcoding of spiders from agricultural fields. *Mitochondrial DNA Part B*, 4(2), 4144-4151.

134. Tamura, K., Stecher, G., & Kumar, S. (2021). MEGA11: molecular evolutionary genetics analysis version 11. *Molecular Biology and Evolution*, 38(7), 3022-3027.

135. Tanaka, H. (1989). Two new records and a new synonymy in the genus *Pardosa* C. L. Koch, 1848, (Araneae, Lycosidae) of Japan. *Atypus,* 93, 10-15.

136. Tanaka, H. (1993). Lycosid spiders of Japan IX. The genus *Pardosa* C. L. Koch - *amentata*-group. *Sonoda Women's College Studies,* 27, 261-318.

137. Tanaka, H. (2009). Lycosidae. In: Ono, H. (ed.) *The spiders of Japan with keys to the families and genera and illustrations of the species*. Tokai University Press, Kanagawa, 222-248.

138. Thorell, T. (1887). Viaggio di L. Fea in Birmania e regioni vicine. II. Primo saggio sui ragni birmani. *Annali del Museo Civico di Storia Naturale di Genova,* 25, 5-417.

139. Thorell, T. (1890). Diagnoses aranearum aliquot novarum in Indo-Malesia inventarum. *Annali del Museo Civico di Storia Naturale di Genova*, 30, 132-172.

140. Thorell, T. (1891). Spindlar från Nikobarerna och andra delar af södra Asien. *Kongliga Svenska Vetenskaps-Akademiens Handlingar,* 24(2), 1-149.

141. Tikader, B. K. (1970). Spider fauna of Sikkim. *Records of the Zoological Survey of India,* 64, 1-83.

142. Tikader, B. K. & Mukerji, S. (1971). A new species of spider of the genus *Lycosa* (family Lycosidae) from India. *Science and Culture*, 37, 531.

143. Tikader, B. K. & Malhotra, M. S. (1976). Studies on some spiders of the genus *Pardosa* Koch from India (family: Lycosidae). *Proceedings of the Indian Academy of Science*, 83(3), 123-131.

144. Tikader, B. K. & Malhotra, M. S. (1980). Lycosidae (wolf-spiders). *Fauna India* (Araneae), 1, 248-447.

145. Tikader, B. K. & Biswas, B. (1981). Spider fauna of Calcutta and vicinity: Part-I. *Records of the Zoological Survey of India, Occasional Paper,* 30, 1-149.

146. Tyagi, K., Kumar, V., Kundu, S., Pakrashi, A., Prasad, P., Caleb, J. T., & Chandra, K. (2019). Identification of Indian spiders through DNA barcoding: cryptic species and species complex. *Scientific Reports*, 9(1), 1-13.

147. Vink, C. J. (2002). Lycosidae (Arachnida: Araneae). *Fauna of New Zealand*, *44*. Manaaki Whenus Press, 94 pp.

148. Wang, D. & Zhang, Z. S. (2014). Two new species and a new synonym in the *Pardosa nebulosa*-group (Lycosidae: *Pardosa*) from China. *Zootaxa,* 3856(2), 227-240.

149. Wang, L. Y., Li, Z. X., Zhou, K. X. & Zhang, Z. S. (2015). Redescription of three *Hippasa* species from China (Araneae: Lycosidae), with a proposed species group-division and diagnosis. *Zootaxa,* 3974(2), 231-244.

150. Wang, L.Y., Lu, T., Cai, D. C., Barrion, A. T., Heong, K. L., Li, S. Q. & Zhang, Z. S. (2021). Review of the wolf spiders from Hainan Island, China (Araneae: Lycosidae). *Zoological Systematics*, 46(1), 16-74.

151. Wheeler, W. C., Coddington, J. A., Crowley, L. M., Dimitrov, D., Goloboff, P. A., Griswold, C. E., & Zhang, J. (2017). The spider tree of life: phylogeny of Araneae based on target-gene analyses from an extensive taxon sampling. *Cladistics*, 33(6), 574-616.

152. Whitcomb, W. H. (1974). Natural populations of entomophagous arthropods and their effect on the agroecosystem. *In Proc. Miss. Symp. Biol. Control,* Jackson Univ. Press Miss.

153. Whitehouse, M. E. A. & Lawrence, L. (2001). Are spiders the perfect predator? *The Australian Cottongrower*, 30-33.

154. Wise, D. H. (1993). *Spiders in ecological webs.* Cambridge University Press, 328 pp.

155. World Spider Catalog (2025). World Spider Catalog. Version 26. Natural History Museum Bern, online at http://wsc.nmbe.ch, accessed on 20/3/2025. doi: 10.24436/2

156. Wunderlich, J. (2004). Fossil spiders of the family Pisauridae (Araneae) in Baltic and Dominican amber. *Beiträge zur Araneologie*, 3, 1532-1541.

157. Yan, Y., & Yan, H. (2007). Phylogenetic Relationships of Chinese Wolf Spiders (Lycosidae) Inferred from 16S rRNA Sequences. *Acta Arachnologica Sinica*, 16(2), 71.

158. Yang, X. F. & Chai, B. Q. (1998). A study on five wolf spiders of the group *Pardosa nebulosa* from China including a new species redescription. *Journal of Hunan Normal University, Natural Sciences,* 26, 60-64.

159. Yin, C. M., Peng, X. J., Xie, L. P., Bao, Y. H. & Wang, J. F. (1997). *Lycosids in China (Arachnida: Araneae)*. Hunan Normal University Press, Hunan, 317 pp.

160. Yin, C. M., Peng, X. J., Yan, H. M., Bao, Y. H., Xu, X., Tang, G., Zhou, Q. S. & Liu, P. (2012). *Fauna Hunan: Araneae in Hunan, China*. Hunan Science and Technology Press, Changsha, 1590 pp.

161. Yoo, J. S., & Framenau, V. W. (2006). Systematics and biogeography of the sheet-web building wolf spider genus *Venonia* (Araneae: Lycosidae). *Invertebrate Systematics*, 20(6), 675-712.

162. Young, O. P., & Edwards, G. B. (1990). Spiders in United States field crops and their potential effect on crop pests. *Journal of Arachnology*, 1-27.

163. Yuan, L., Zhao, L. J. & Zhang, Z. S. (2019). Preliminary study on the spider diversity of the Wanglang National Nature Reserve. *Acta Arachnologica Sinica,* 28(1), 7-36.

164. Zamani, A., Fric, Z. F., Gante, H. F., Hopkins, T., Orfinger, A. B., Scherz, M. D., & Pos, D. D. (2022). DNA barcodes on their own are not enough to describe a species. *Systematic Entomology*, 47, 385–389.

165. Zehethofer, K., & Sturmbauer, C. (1998). Phylogenetic relationships of Central European wolf spiders (Araneae: Lycosidae) inferred from 12S ribosomal DNA sequences. *Molecular Phylogenetics and Evolution*, 10(3), 391-398.

166. Zhang, F., Peng, J. Y. & Zhang, B. S. (2022). *Spiders of Mt. Xiaowutai*. Science Press, 387 pp.

167. Zhang, S., Kuntner, M., & Li, D. (2011). Mate binding: male adaptation to sexual conflict in the golden orb-web spider (Nephilidae: *Nephila pilipes*). *Animal Behaviour*, 82(6), 1299-1304.

168. Zhao, J. Z. (1993). *Spiders in the Cotton Fields in China*. Wuhan Publishing House, 552 pp.

169. Zhu, M. S. & Zhang, B. S. (2011). *Spider Fauna of Henan: Arachnida: Araneae*. Science Press, Beijing, 558 pp.

170. Zyuzin, A. A. (1993). Studies on the wolf spiders (Araneae: Lycosidae). I. A new genus and species from Kazakhstan, with comments on the Lycosinae. *Memoirs of the Queensland Museum*, 33(2), 693-700.

Appendix

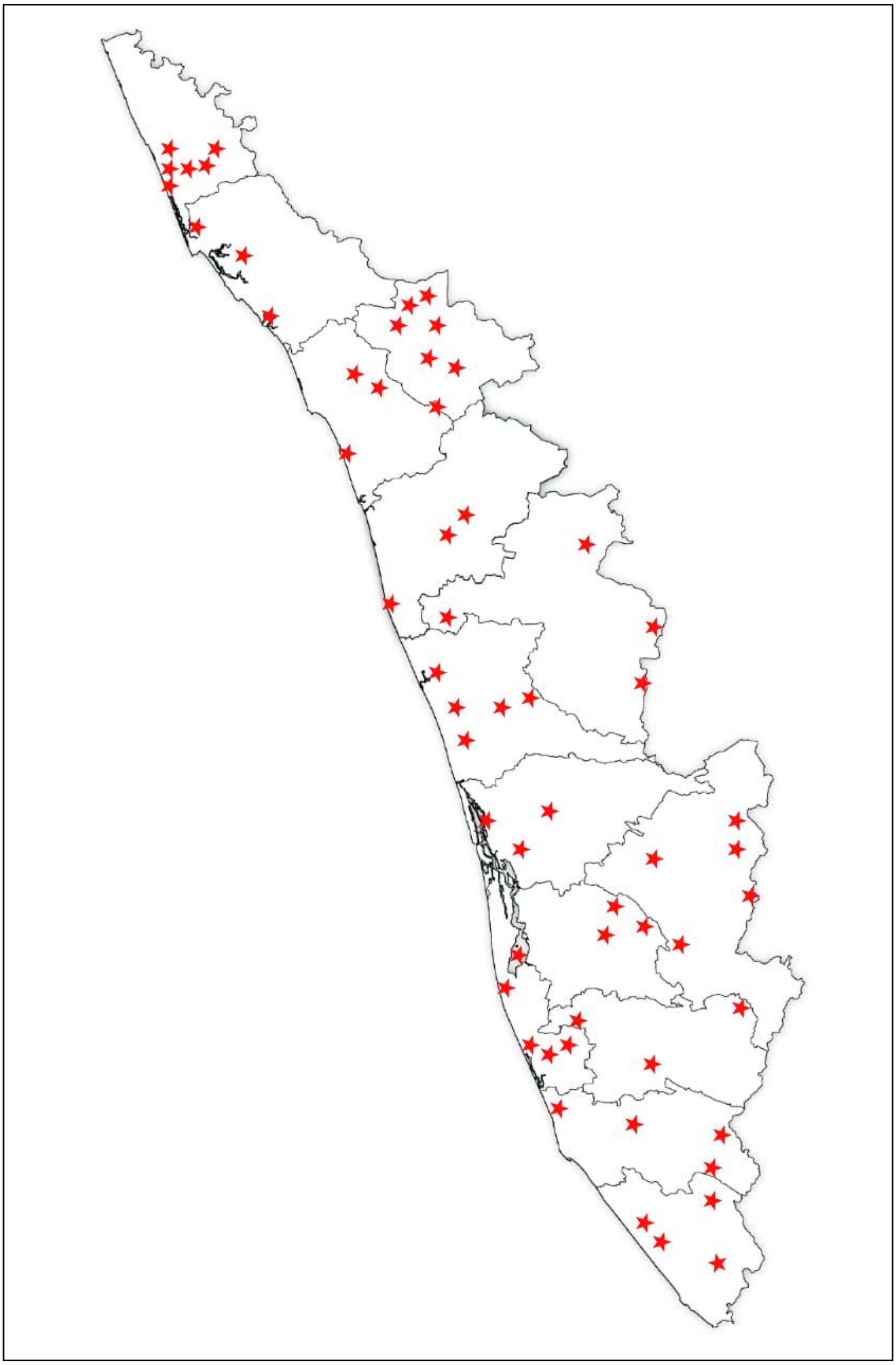


Figure 28: The map of Kerala highlighting the collection locations

List of Publications

Journal articles

1. **Abhijith, R. S**., Sheeba, P. & Sudhikumar, A. V. (2021). Synonymization of *Pardosa mysorensis* (Tikader & Mukerji, 1971) with *Pardosa sumatrana* (Thorell, 1890). *Serket,* 17(4), 406-412.
2. **Abhijith, R. S.** & Sudhikumar, A. V. (2022). First record and redescription of wolf spider *Pardosa oriens* (Araneae, Lycosidae) from India. *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa,"* 65(2), 7-13.
3. **Abhijith, R. S**., Sheeba, P. & Sudhikumar, A. V. (2022a). First record of *Pardosa parathompsoni* Wang & Zhang, 2014 (Araneae: Lycosidae) from biodiversity hotspot Western Ghats with additional information on cheliceral morphology. *Serket,* 19(1), 79-84.
4. **Abhijith, R. S**., Sheeba, P. & Sudhikumar, A. V. (2022b). Redescription of two wolf spiders *Pardosa mukundi* Tikader & Malhotra, 1980 and *Draposa burasantiensis* (Tikader & Malhotra, 1976) (Araneae: Lycosidae). *Serket,* 18(3), 338-344.
5. **Abhijith, R. S.** & Sudhikumar, A. V. (2023). Description of a new wolf spider species (Arachnida: Araneae: Lycosidae: *Draposa*) from Western Ghats, India. *Taprobanica,* 12(1), 1-4.
6. **Abhijith, R. S**., & Sudhikumar, A. V. (2024). A new wolf spider species of *Wadicosa* (Araneae, Lycosidae) from Western Ghats of India. *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa"*, 67(2), 173-181.

Articles in conference proceedings

1. **Abhijith R.S.** & Sudhikumar A.V. (2020). Molecular taxonomy of wolf spiders (Araneae: Lycosidae) – Current status. *Proceedings of the International Seminar: Biodiversity*

Conservation & Climate Change. (Eds.) St. Joseph's College (Autonomous), Devagiri, Calicut, Kerala, India. 1-6. ISBN: 979-8-5938-6048-4.

2. **Abhijith R.S**., Sheeba P. & Sudhikumar A.V. (2021). Current status of molecular taxonomy of spiders in India. *A Handbook in connection with the National Level Virtual Scientific Paper Presentation Competition* (Eds.) Vimala College Publications, Thrissur, Kerala. 51-55. ISBN: 978-81-7255-134-6.
3. **Abhijith R.S**., Sheeba P. & Sudhikumar A.V. (2022). An Overview of Wolf Spiders P (Araneae: Lycosidae) in Various Habitats of Gavi Eco-Tourism Region, Pathanamthitta, Kerala'. *A Handbook in connection with the National Level Virtual Scientific Paper Presentation Competition* (Eds.) Vimala College Publications, Thrissur, Kerala. 86-90. ISBN: 978-81-7255-134-6.

Serket (2021) vol. 17(4): 406-412.

Synonymization of *Pardosa mysorensis* (Tikader & Mukerji, 1971) with *Pardosa sumatrana* (Thorell, 1890)

Raveendran Sudha Abhijith [1*], Palissery Sheeba [2]
& Ambalaparambil Vasu Sudhikumar [1]
[1] Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala-680125, India
[2] Department of Zoology, Vimala College (Autonomous), Kerala, India
[*] Corresponding author e-mail address: abhijithrsabhiramam@gmail.com

Abstract

Pardosa is the largest genus in family Lycosidae. Many of the members in this family and genus show morphological similarity and intra-specific variation, which makes their taxonomy difficult. The conclusive method of genitalic analysis was limited in olden days might have resulted in misplacement of various taxa. In this paper, *Pardosa mysorensis* (Tikader & Mukerji, 1971) is synonymized with *Pardosa sumatrana* (Thorell, 1890) based on examination of specimen from southern Indian state of Kerala. Detailed genitalic photographs and habitus images are given.

Keywords: Wolf spiders, Lycosidae, *Pardosa*, synonym, Kerala, India.

Introduction

Lycosidae Sundevall, 1833, wolf spiders, are 6th largest spider family in the world with 2431 species and 125 genera and genus *Pardosa* C.L. Koch, 1847 is the largest group in this family (World Spider Catalog, 2021). Many of the members of genus *Pardosa* show genitalic polymorphism which results in misplacements of them as different species (Jocqué, 2002). Morphologically they are very similar but intra-specific variation also present. So, many of the morphological features are non-informative for species level identification (Wang & Zhang, 2021). The best way of genitalic analysis might be limited in the past and might have resulted in misplacement of many morphologically different individuals under different species. The correction of these errors will require great effort. The literature survey for these studies revealed about synonymization of so many species with *Pardosa sumatrana* (Thorell, 1890). In our studies themselves, various morphologically different specimens showed similarity in genitalic structures. These all points towards the importance of genitalic analysis of spiders for the classification, especially in families like Lycosidae. In the same time, genitalic polymorphism should be kept in mind. A taxonomist's prime job is to accurately classify an organism, not simply reporting new species.

Material and Methods

All specimens are preserved in 70% ethanol and were studied, photographed and measured using a Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver.4.12). Epigynes dissected and were cleared in potassium hydroxide (KOH) solution. Ocular measurements were taken after placing the specimen dorsally. Leg measurements are shown as: total length (femur, patella and tibia, metatarsus, tarsus). All measurements are given in millimetres (mm).

Abbreviations used in the main text are: ALE = anterior lateral eye, AME = anterior median eye, CATE = Center for Animal Taxonomy and Ecology, CD = copulatory duct, CO = copulatory opening, FD = fertilization duct, PLE = posterior lateral eye, PME = posterior median eye, SS = septal stem.

Taxonomy

Family **Lycosidae** Sundevall, 1833

Genus ***Pardosa*** C.L. Koch, 1847

Pardosa sumatrana Thorell, 1890

Lycosa sumatrana Thorell, 1890, 136 (♂♀); Gravely, 1924, 604, f. 4 C-E (♂♀); Sherriffs, 1939, 137, f. 3.

Pardosa sumatrana Hogg, 1919, 100 (♀); Buchar, 1976, 207, f. 4I-L (♀); Buchar, 1980, 80, f. 1-9, 11-14, 16-26 (♂♀); Tikader & Malhothra, 1980, 353, f. 211-215 (♂♀); Tikader & Biswas, 1981, 56, f. 90-91 (♀); Chen & Gao, 1990, 129, f. 161a-b (♂♀); Okuma *et al.*, 1993, 51, f. 45C (♀); Zhao, 1993, 101, f.41a-b (♂♀); Barrion & Litsinger, 1994, 311, f. 1622-1624 (♀); Barrion & Litsinger, 1995, 382, f. 226a-f, 227a-d (♂♀); Yin *et al.*, 1997, 258, f. 122a-h (♂♀); Yang & Chai, 1998, 63, f. 4a-d (♀); Song *et al.*, 1999, 334, f. 198k (♂♀); Hu, 2001, 203, f. 103.1-4 (♂♀); Biswas & Raychaudhuri, 2003, 119, f. 56-62 (♂♀); Gajbe, 2007, 501, f. 240-244 (♂♀); Yin *et al.*, 2012, 856, f. 429a-h (♂♀); Sen *et al.*, 2015, 50, f. 229-233, pl. 15 (♀); Dhali *et al.*, 2017, 75, f. 374-378, pl. 26 (♀); Tyagi *et al.*, 2019, Supplement, f. S2.30, S3.15-18 (♀); Wang *et al.*, 2021, 50, f. 47A-I, 48A-F (♂♀).

Lycosa chengta Fox, 1935, 453 f. 5 (♀) [synonymized by Chen & Gao, 1990]

Lycosa arorai Dyal, 1935, 140, pl 13, f. 40-41(♂) [synonymized by Barrion & Listinger, 1995]

Arkalosula chengta Roewer, 1955, 231 [Genus transfer from *Lycosa chengta* which is synonymized later]

Chorilycosa arorai Roewer, 1955, 237 [Genus transfer from *Lycosa arorai* which is synonymized later]

Pardosa davidi Schenkel, 1963, 378, f. 219 (♀); Hu, 1984, 235, f. 242-243 (♂♀); Zhao, 1993, 86, f. 36a-c (♂♀) [synonymized by Chen & Gao, 1990]

Lycosa mysorensis Tikader & Mukerji, 1971, 531, f. 1a-b (♀) – ***New synonym***

Pardosa mysorensis Tikader & Malhotra, 1980, 332, f. 168-170 (♀) [transferred from Lycosa] – ***New synonym***

Pardosa shyamae Hu & Li, 1987, 293, f. 25.3-4 (f, misidentified).
Pardosa tieshinglii Barrion *et al.*, 2013, 16, f. 17A-G (♂♀) [synonymized by Wang *et al.*, 2021]
Pardosa villarealae Barrion *et al.*, 2013, 17, f. 18A-E (♂) [synonymized by Wang *et al.*, 2021]

Material examined
INDIA, Kerala: 3 ♀♀ from agricultural lands of Erezha south, Alappuzha 9º22.37'N, 76º51.85'E, alt. 32.81 ft, February 8, 2021, Abhijith (CATE); 4 ♀♀ from Christ College campus, Thrissur, 10º35.57'N, 76º21.32'E, alt. 49.2 ft, January 31, 2021, Abhijith (CATE); 2 ♀♀ from paddy fields of Ochira, Kollam, 9º13.25'N, 76º51.68'E, alt. 29.53ft, December 2, 2020, Abhijith (CATE).

Diagnosis
Only female sex is being discussed here as the proposed junior synonym was described based only on female sex. Females are morphologically similar to other members of *Pardosa*, but, differ in the genitalia structure. The epigyne in ventral view shows an inverted T shaped uniform septal stem (SS). Internally copulatory duct (CD) shows a distinguishable in folding and tip of spermatheca points towards hood. Fertilization duct (FD) resembles a horizontally placed kidney (Fig. 1).

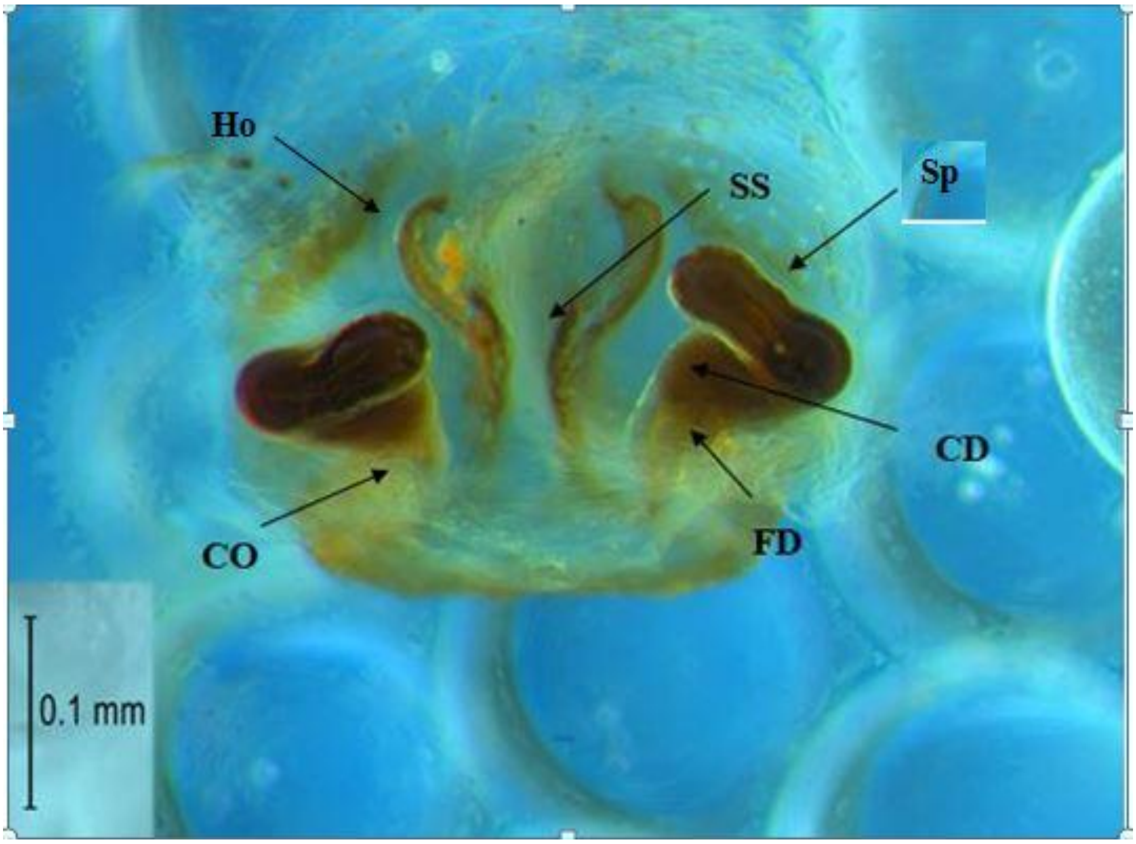


Fig. 1. *Pardosa sumatrana* (Thorell, 1890), female from Erezha south, Alappuzha, Kerala, cleared epigyne dorsal view. Abbreviations: CD = copulatory duct, CO = copulatory opening, FD = fertilization duct, Ho = hood, Sp = spermatheca, SS = septal stem.

Description

Female from Erezha south, Alappuzha (Fig. 2.A-B). Total length 3.72. Prosoma 1.99 long, 1.5 wide. Opisthosoma 1.73 long, 1.14 wide. Carapace yellowish brown with distinct longitudinal fovea. Dark greenish spots along lateral edges of carapace. Median band greenish yellow, broader near ocular area and narrower in thoracic area. Lateral band broad, dark greenish brown colour. Ocular area black and hairy. Head region flanks steep without any projections. Eye sizes and inter-distances: AME 0.087, ALE 0.07, PME 0.216, PLE 0.192, AME-AME 0.117, AME-ALE 0.094, PME-PME 0.383, PME-PLE 0.310. Clypeus height 0.154. Labium longer than wide. Chelicerae has 3 promarginal and 3 retromarginal teeth. Sternum heart shaped, clothed with sparse black hairs. Legs yellow with dark greenish yellow patches. Leg measurements: I 5.60 (1.56, 1.91, 1.26, 0.87); II 5.24 (1.40, 1.85, 1.22, 0.77); III 5.20 (1.43, 1.68, 1.38, 0.71); IV 7.70 (1.87, 2.28, 2.37, 1.18). Leg formula: 4123. Opisthosoma long oval. Dorsum dark yellowish brown with several lateral band like patterns. Ventral side yellow. Posterior spinnerets larger than anterior pair.

Epigyne in ventral view shows inverted T shaped SS (Fig. 2.C-D). In internal view two hoods present at anterior end (Fig. 2.E-F). SS is elongated, narrow throughout except a little broader near hood. Base of septum is elongate than broad. Copulatory opening (CO) near meeting point of base of septum and CD. CD has an interior bend visible as an in-folding. Spermatheca longer than wide and tip positioned towards hood in two dimensional view. FD which placed near CD has an in-folding, resembling a horizontally placed kidney.

Distribution: India, Indonesia, China, Bhutan, Myanmar, Sri Lanka, Philippines, Nepal, Bangladesh (World Spider Catalog, 2021).

Remarks

Pardosa sumatrana is a very common lycosid throughout India and neighbouring countries. Earlier descriptions of the species lack clear pictures or description of genital structures. Other morphological features are not much conclusive in Lycosidae, especially *Pardosa* which shares very similar morphology. Morphological descriptions by Tikader & Malhothra (1980) is similar to our specimens. Epigyne pictures by Tyagi *et al.* (2019) also shows similarity.

Pardosa mysorensis (Tikader & Mukerji, 1971) was described based on single sex and a few specimens. Only two taxonomic references were present on the species collected from a single location (Tikader & Mukerji, 1971, 1980). The original description by Tikader & Mukerji (1971) is similar to the description *of P. sumatrana*. But, epigyne description is absent and figures are obscure and non conclusive. The epigyne pictures by the original author in another publication (Tikader & Malhotra, 1980) shows similarity to epigyne pictures of *P. sumatrana*. SS structure, arrangement of CD and spermathecae are similar to *P. sumatrana*. Other morphological descriptions are also similar. By these comparisons we are confident that *P. mysorensis* was a misidentification and is a junior synonym of *P. sumatrana*. The small variations seen in the epigyne of this species may arise due to genitalic polymorphism as described by Jocqué (2002).

Acknowledgments

We express our deepest gratitude to Principal, Christ College (Autonomous), Irinjalakuda, Kerala for providing laboratory facilities and Junior Research Fellowship

[08/376(0013)EMR-1/2019] of Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology, Government of India, New Delhi for funding the research. We also express our sincere thanks to Zoological Survey of India (ZSI), Kolkata, India especially Dr. Shelly Acharya, Scientist-E, ZSI, Kolkata for providing type specimen photographs of junior synonym.

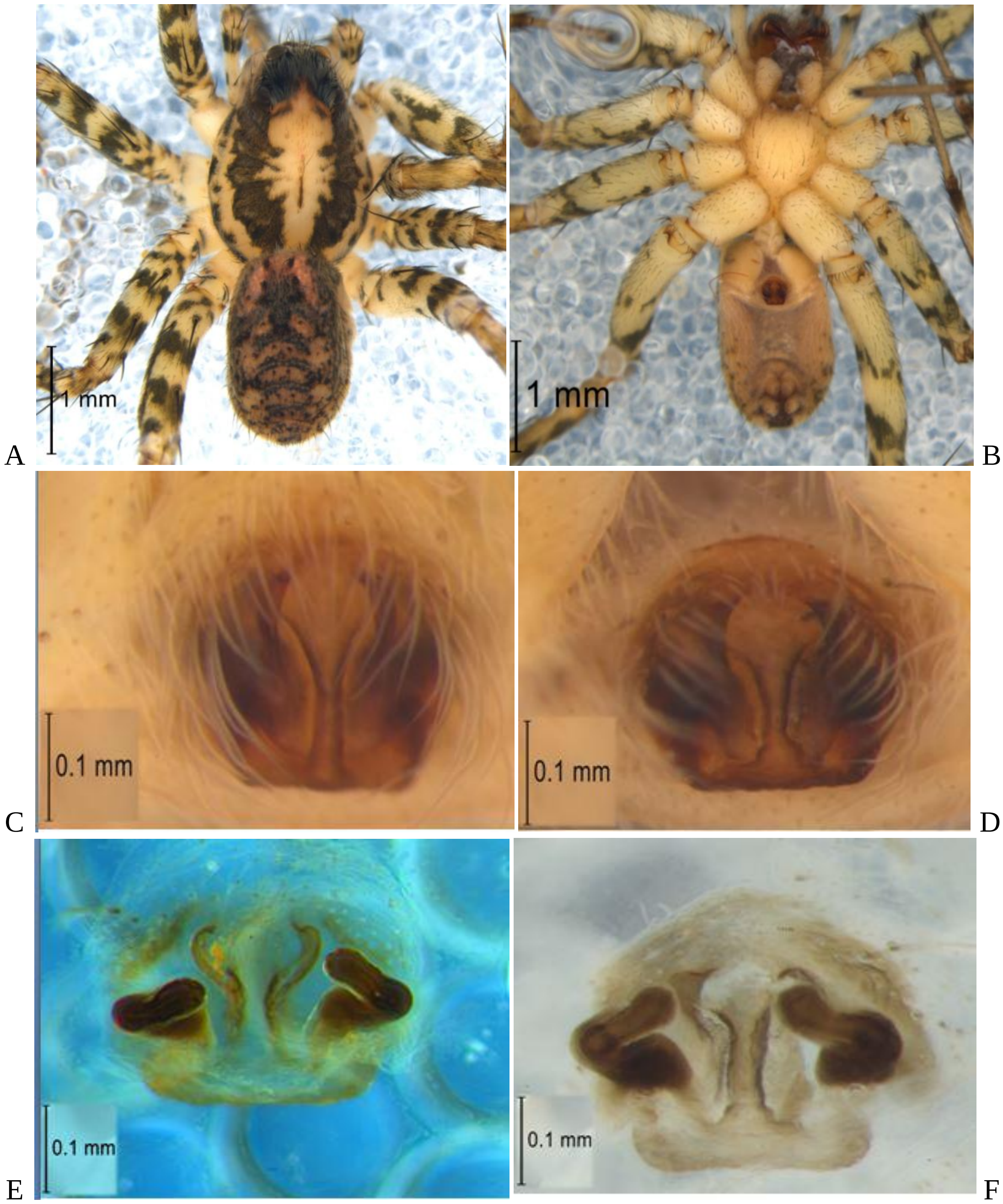


Fig. 2. *Pardosa sumatrana* (Thorell, 1890), females from Erezha South, Alappuzha, Kerala. A-B. Habitus. A. dorsal view. B. ventral view. C-F. Epigyne. C-D. ventral view. E-F. dorsal view, cleared. (C and E of the same specimen, D and F from another specimen).

References

Barrion, A.T. & Litsinger, J.A. 1994. Taxonomy of rice insect pests and their arthropod parasites and predators. In: Heinrichs, E.A. (ed.) Biology and Management of Rice Insects. Wiley Eastern, New Delhi, pp. 13-15, 283-359.

Barrion, A.T. & Litsinger, J.A. 1995. *Riceland spiders of South and Southeast Asia*. CAB International, Wallingford, UK, xix + 700 pp.

Barrion, A.T., Barrion-Dupo, A.L.A., Catindig, J.L.A., Villareal M., O., Cai, D., Yuan, Q. H. & Heong, K.L. 2013. New species of spiders (Araneae) from Hainan Island, China. *UPLB Museum Publications in Natural History*, 3: 1-103. [pp. 16-18]

Biswas, V. & Raychaudhuri, D. 2003. Wolf spiders of Bangladesh: genus *Pardosa* C. L. Koch (Araneae: Lycosidae). *Records of the Zoological Survey of India*, 101(1-2): 107-125.

Buchar, J. 1976. Über einige Lycosiden (Araneae) aus Nepal. *Ergebnisse des Forschungsunternehmens Nepal Himalaya*, 5: 201-227.

Buchar, J. 1980. Lycosidae aus dem Nepal-Himalaya. II. Die *Pardosa nebulosa*- und *P. venatrix*-Gruppe (Araneae: Lycosidae: Pardosinae). *Senckenbergiana Biologica*, 61: 77-91.

Chen, X.E. & Gao, J.C. 1990. *The Sichuan farmland spiders in China*. Sichuan Science and Technology Publishing House, Chengdu, 226 pp.

Dhali, D.C., Saha, S. & Raychaudhuri, D. 2017. Litter and ground dwelling spiders (Araneae: Arachnida) of reserve forests of Dooars, West Bengal. *World Scientific News*, 63: 1-242.

Dyal, S. 1935. Fauna of Lahore. 4.–Spiders of Lahore. *Bulletin of the Department of Zoology of the Panjab University*, 1: 119-252, pl. 11-17.

Fox, I. 1935. Chinese spiders of the family Lycosidae. *Journal of the Washington Academy of Sciences*, 25: 451-456.

Gajbe, U.A. 2007. Araneae: Arachnida. In: Fauna of Madhya Pradesh (including Chhattisgarh), State Fauna Series. Zoological Survey of India, Kolkata, 15(1), 419-540.

Gravely, F.H. 1924. Some Indian spiders of the family Lycosidae. *Records of the Indian Museum, Calcutta*, 26: 587-613.

Hogg, H.R. 1919. Spiders collected in Korinchi, West Sumatra by Messrs H. C. Robinson and C. Boden Kloss. *Journal of the Federated Malay States Museums*, 8(3): 81-106.

Hu, J.L. 1984. *The Chinese spiders collected from the fields and the forests*. Tianjin Science and Technology Press, 482 pp.

Hu, J.L. 2001. *Spiders in Qinghai-Tibet Plateau of China*. Henan Science and Technology Publishing House, 658 pp.

Hu, J.L. & Li, A.H. 1987. The spiders collected from the fields and the forests of Xizang Autonomous Region, China. (II). *Agricultural Insects, Spiders, Plant Diseases and Weeds of Xizang*, 2: 247-353.

Jocqué, R. 2002. Genitalic polymorphism—a challenge for taxonomy. *The Journal of Arachnology*, 30(2), 298-306.

Okuma, C., Kamal, N.Q., Hirashima, Y., Alam, M.Z. & Ogata, K. 1993. *Illustrated Monograph of the Rice Field Spiders of Bangladesh.* Institute of Postgraduate Studies in Agriculture (Salna, Gazipur, Bangladesh). Japan International Cooperation Agency Project Publication, 1, 93 pp.

Roewer, C.F. 1955. *Katalog der Araneae von 1758 bis 1940, bzw. 1954. 2. Band, Abt. a (Lycosaeformia, Dionycha [excl. Salticiformia]). 2. Band, Abt. b (Salticiformia, Cribellata)*

(Synonyma-Verzeichnis, Gesamtindex). Institut royal des Sciences naturelles de Belgique, Bruxelles, 1751 pp.

Schenkel, E. 1963. Ostasiatische Spinnen aus dem Muséum d'Histoire naturelle de Paris. *Mémoires du Muséum National d'Histoire Naturelle de Paris* (A, Zool.) 25: 1-481.

Sen, S., Dhali, D.C., Saha, S. & Raychaudhuri, D. 2015. Spiders (Araneae: Arachnida) of Reserve Forests of Dooars: Gorumara National Park, Chapramari Wildlife Sanctuary and Mahananda Wildlife Sanctuary. *World Scientific News*, 20: 1-339.

Sherriffs, W.R. 1939. Hong-Kong spiders. Part V. *Hong-kong Naturalist*, 9: 135-140.

Song, D.X., Zhu, M.S. & Chen, J. 1999. *The spiders of China*. Hebei Science and Technology Publishing House, Shijiazhuang, 640 pp.

Thorell, T. 1890. Diagnoses aranearum aliquot novarum in Indo-Malesia inventarum. *Annali del Museo Civico di Storia Naturale di Genova*, 30: 132-172.

Tikader, B.K. & Biswas, B. 1981. Spider fauna of Calcutta and vicinity: Part-I. *Records of the Zoological Survey of India, Occasional Paper*, 30: 1-149.

Tikader, B.K. & Malhotra, M.S. 1980. Lycosidae (wolf-spiders). *Fauna India* (Araneae), 1(2): 248-447.

Tikader, B.K. & Mukerji, S. 1971. A new species of spider of the genus *Lycosa* (family Lycosidae) from India. *Science and Culture*, 37: 531.

Tyagi, K., Kumar, V., Kundu, S., Pakrashi, A., Prasad, P., Caleb, J.T.D. & Chandra, K. 2019. Identification of Indian spiders through DNA barcoding: cryptic species and species complex. *Scientific Reports*, 9(14033): 1-13 & Supplement.

Wang, D. & Zhang, Z.S. 2014. Two new species and a new synonym in the *Pardosa nebulosa*-group (Lycosidae: *Pardosa*) from China. *Zootaxa*, 3856(2): 227-240.

Wang, L.Y., Lu, T., Cai, D.C., Barrion, A.T., Heong, K.L., Li, S.Q. & Zhang, Z.S. 2021. Review of the wolf spiders from Hainan Island, China (Araneae: Lycosidae). *Zoological Systematics*, 46(1): 16-74.

World Spider Catalog 2021. *World Spider Catalog*. Version 22.0. Natural History Museum Bern, online at http://wsc.nmbe.ch, accessed on April 2021.

Yang, X.F. & Chai, B.Q. [=B.Q. Tsai] 1998. A study on five wolf spiders of the group *Pardosa nebulosa* from China including a new species redescribetion [sic]. *Journal of Hunan Normal University, Natural Sciences*, 26: 60-64.

Yin, C.M., Peng, X.J., Xie, L.P., Bao, Y.H. & Wang, J.F. 1997. *Lycosids in China (Arachnida: Araneae)*. Hunan Normal University Press, 317 pp.

Yin, C.M., Peng, X.J., Yan, H.M., Bao, Y.H., Xu, X., Tang, G., Zhou, Q.S. & Liu, P. 2012. *Fauna Hunan: Araneae in Hunan, China*. Hunan Science and Technology Press, Changsha, 1590 pp.

Zhao, J.Z. 1993. *Spiders in the Cotton Fields in China*. Wuhan Publishing House, Wuhan, China, 552 pp.

TRAVAUX DU MUSÉUM NATIONAL D'HISTOIRE NATURELLE «GRIGORE ANTIPA»
THE JOURNAL OF "GRIGORE ANTIPA" NATIONAL MUSEUM OF NATURAL HISTORY

Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 65 (2): 7–13 (2022)
doi: 10.3897/travaux.65.e95756

SHORT COMMUNICATION

First record and redescription of wolf spider *Pardosa oriens* (Araneae, Lycosidae) from India

Raveendran Sudha Abhijith[1], Ambalaparambil Vasu Sudhikumar[1]

1 *Centre for Animal Taxonomy and Ecology, Department of Zoology, Christ College (Autonomous), Irinjalakuda 680125, Kerala, India*

Corresponding author: *Ambalaparambil Vasu Sudhikumar* (spidersudhi@gmail.com)

Received 28 September 2022 | Accepted 14 November 2022 | Published 31 December 2022

Citation: Abhijith RS, Sudhikumar AV (2022) First record and redescription of wolf spider *Pardosa oriens* (Araneae, Lycosidae) from India. Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 65(2): 7–13. https://doi.org/10.3897/travaux.63.e95756

Abstract
Genus *Pardosa* incorporates species morphologically resembling each other. As a result, a lot of discrepancies can be observed in the group. This paper reports and redescribes *Pardosa* species *Pardosa oriens* (Chamberlin 1924) for the first time from India.

Keywords
Kerala, new reports, taxonomy, Western Ghats.

Lycosidae Sundevall 1833, wolf spiders, are 5th largest spider family in the world with 2454 species and 127 genera (World Spider Catalog 2022). *Pardosa* C.L. Koch 1847 is the largest genus in the family, with 536 species from the world and 34 species from India. In this genus most of the morphological characters are less informative for species level identification (Wang and Zhang 2014). So, with in *Pardosa* at least thirty species groups were proposed, based on the similarity of genital characters (Zyuzin 1979; Wang and Zhang 2014). Zyuzin (1979) suggested 22 species-groups analyzing more than 100 Palearctic *Pardosa* species. The *P. nebulosa*-group is possibly the largest containing at least 66 species from the southern Palaearctic, southern and Southeast Asia, Africa and the Mediterranean regions (Marusik and Ballarin 2011). Out of this 66, five species belong to *P. nebulosa*-group were already reported from India. From literature survey, we are confident to assign 5 more species from India, *P. alli, P.*

bastarensis, P. rhenockensis, P.songosa and *P. parathompsoni* into this species group.The species mentioned in this paper is also an addition to Indian *P. nebulosa*-group. So, in India there are 11 species belong to this group. As the detailed genitalic descriptions with proper photographs or illustrations is lacking for *P. oriens*, there is necessity of redescribing it. This paper documents the first report and redescription *P. oriens* (Chamberlin 1924) from India based on specimens collected from Gavi, Kerala, India.

All specimens were collected by hand picking method and preserved in 70% ethanol and were studied, photographed and measured using a Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver. 4.13). Epigynes were dissected and internal genitalia were cleared in 10% potassium hydroxide (KOH) solution. Male palps were separated and photographed. Ocular measurements were taken after placing the specimen dorsally. Leg measurements are shown as: total length (femur, patella + tibia, metatarsus, tarsus). All measurements are given in millimetres (mm). The distribution map was produced by using the online mapping software SimpleMappr (Shorthouse 2010). Abbreviations used in the main text are: **ALE** = anterior lateral eye, **AME** = anterior median eye, **BS** = base of septum, **CD** = copulatory duct, **CO** = copulatory opening, **FD** = fertilization duct, **MA**= median apophysis, **MOQ** = median ocular quadrangle, **Pa** = palea, **PLE** = posterior lateral eye, **PME** = posterior median eye, **Sp** = spermathecae, **SS** = septal stem, **St** = subtegulum, **TA**= tegular apophysis, **T** = tegulum.

Family Lycosidae Sundevall 1833
Genus *Pardosa* C.L. Koch 1847
Pardosa nebulosa-group
Pardosa oriens (Chamberlin 1924) (Figs 1-2)

Materials examined: India • 4♀ 3♂; Gavi, Kerala; 9°43.49' N, 77°16.01' E; 1035.9 m a.s.l.; 8 October. 2021; R.S. Abhijith leg.; CATE558505.

Distribution**:** Bhutan, South west and south east China, Japan (including Ryukyu Islands), **new to India** (Fig. 3).

Males diagonised as *Pardosa nebulosa*-group by palp with sclerotized, hook-shaped TA without secondary branch and females by epigynum with inverted T-shaped septum. *P. oriens* is most similar to *P. parathompsoni*, but differs by following set of characters. Ventral view of epigynum with longer SS and lateral arrangement of CD; vulva unique with laterally positioned CD and much wider Sp. Male palp different with longer hook shaped TA; shorter, more curved MA and lack of paleal protrusion towards MA.

Redescription: Male. Total length 2.80. Prosoma 1.43 long, 1.25 wide. Opisthosoma 1.37 long, 0.87 wide. Carapace yellowish brown with distinct longitudinal fovea (Fig. 1C). Fovea non-uniform in width, rather wider in posterior end. A stripe extended from anterior part of fovea to ocular area. Median band greenish yellow, broader, slightly different colour near ocular area and narrower in the posterior end of thoracic area. Paramedian bands much broader than in female, dark greenish brown colour,

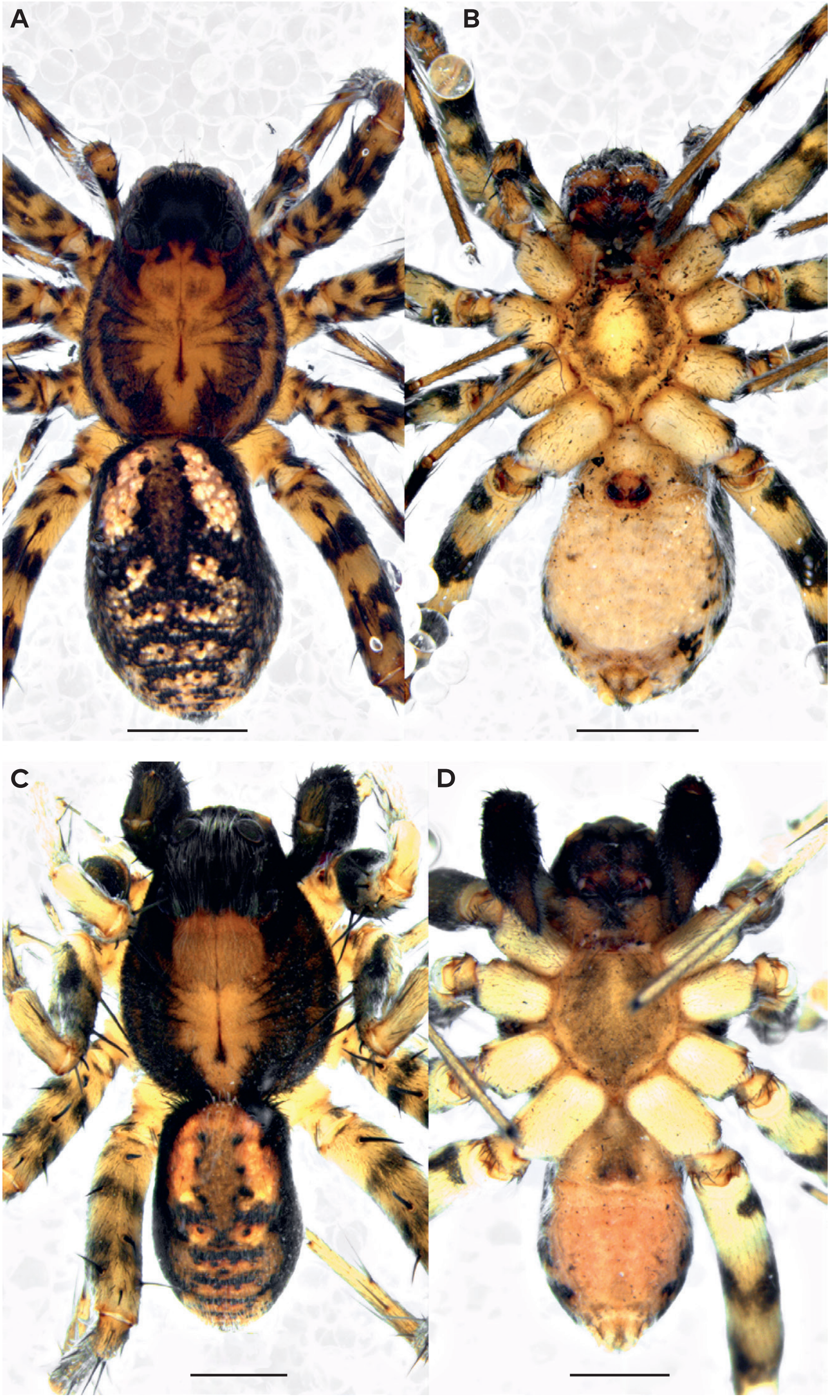


Figure 1. *Pardosa oriens* (Chamberlin, 1924), female (A–B) and male (C–D). **A** female habitus dorsal **B** same ventral **C** male habitus dorsal **D** same ventral. Scale bars: 1 mm (A, B); 0.5mm (C, D).

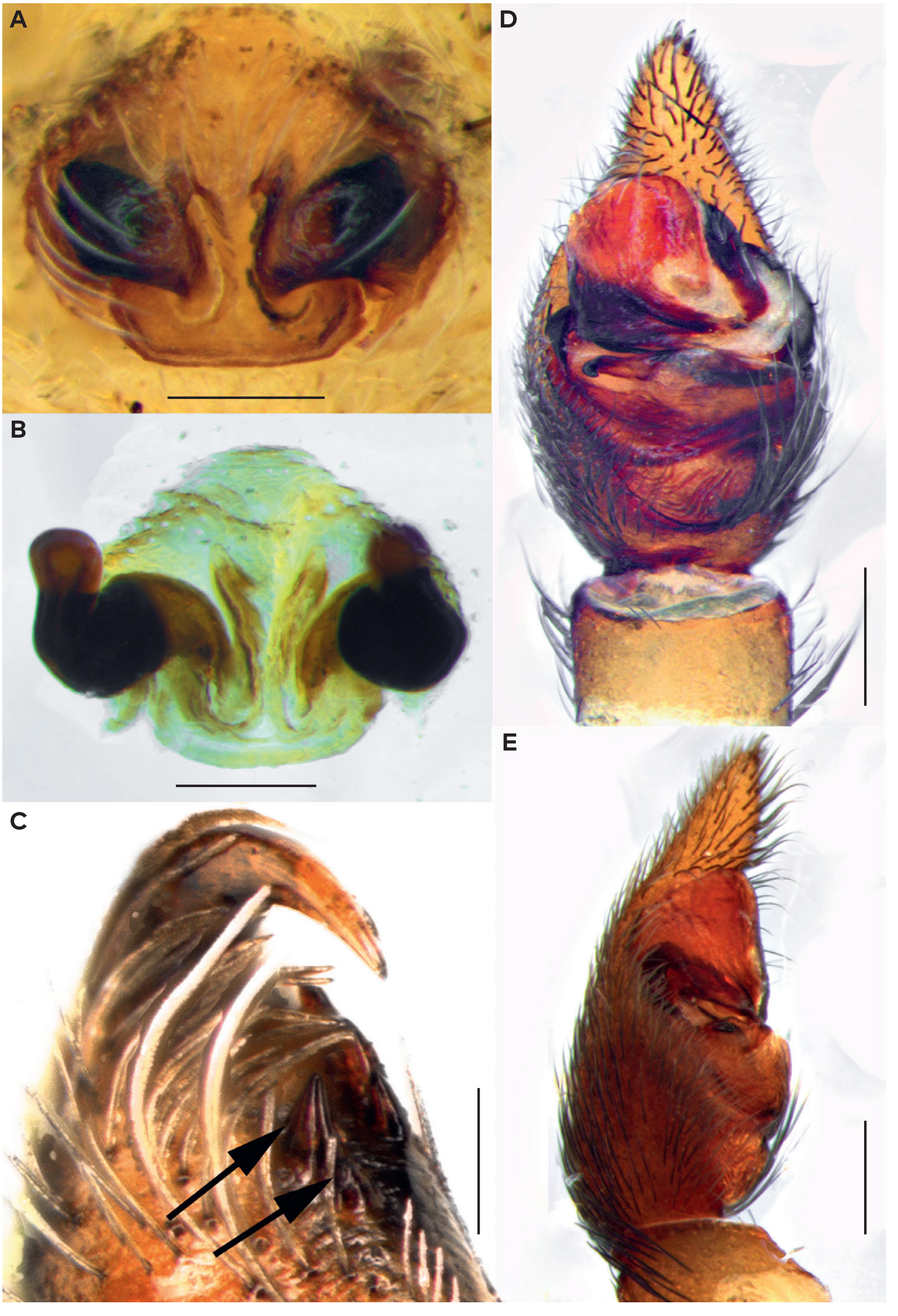


Figure 2. *Pardosa oriens*. **A** epigyne ventral **B** same cleared dorsal view **C** female right chelicerae (arrows indicate two retro-marginal teeth) **D** male palp ventral view E same retrolateral view. Scale bar : 0.1 mm.

uniform in width, continuous throughout the carapace. Ocular area black and hairy. Clypeus without any projections. Eye sizes and inter-distances: AME 0.06, ALE 0.04, PME 0.16, PLE 0.12, AME–AME 0.06, AME–ALE 0.03, PME–PME 0.23, PME–PLE 0.27. MOQ wider posteriorly. Clypeus height 0.10. Labium longer than wide. Chelicera with 3 promarginal and 2 retromarginal teeth. Cheliceral teeth placed separately compared to females. Sternum heart-shaped, wider than in female, clothed sparsely with black hairs (Fig. 1D). Dark wide band along the margin of sternum. Sternum in some males clothed with black hairs without markings. Legs yellow with dark greenish yellow annuli. Leg measurements: I 4.90 (1.19, 1.83, 0.99, 0.89); II 4.98 (1.04, 2.19, 0.99, 0.76); III 4.27 (1.00, 1.38, 1.16, 0.73); IV 6.13 (1.36, 1.99, 1.90, 0.88) Leg formula: 4213. Opisthosoma long oval, less wide than female. Dorsum dark brown with several lateral bands like patterns. Venter yellow. Posterior spinnerets larger than anterior ones. Palp (Figs. 2D–E): T large with a medial projection, TA beak shaped with a tapered tip directed downwards extended just beyond MA; St small and oval shaped, prolaterally placed; Pa large, tent shaped in retrolateral view; MA longer than wide, horizontally extended and curved distally; embolus with a comparatively broad tip originated prolaterally and extended retrolaterally, masked by T.

Female: Total length 3.51. Prosoma 1.67 long, 1.24 wide. Opisthosoma 1.84 long, 1.10 wide. Carapace yellowish brown with a distinct longitudinal fovea (Fig. 1A). Fovea non-uniform in width, rather wider in posterior end. Dark greenish continuous spots present along the margin of carapace. Median band greenish yellow, broader near ocular area and narrower in thoracic area. A small bifurcated extension of median band trespassed into the ocular area. Paramedian bands broad and dark greenish brown colour, uniform in width, continuous, two triangle-shaped patterns present near ocular area. Paramedian bands in join near pedicel in most specimens except in one. Ocular area black and hairy except bifurcated extension of the median band. Clypeus without any projections. Eye sizes and inter-distances: AME 0.06, ALE 0.04, PME 0.16, PLE 0.12, AME–AME 0.06, AME–ALE 0.03, PME–PME 0.23,

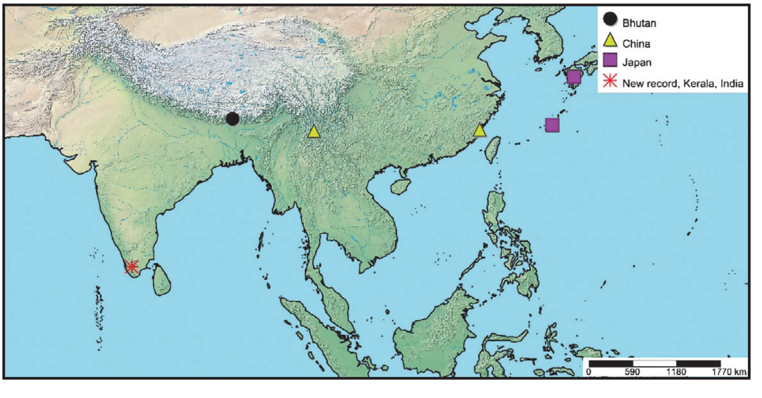


Figure 3. Distribution map of *Pardosa oriens.*

PME–PLE 0.27. MOQ wider posteriorly. Clypeus height 0.11. Labium longer than wide. Chelicera with 3 promarginal and 2 retromarginal teeth. All teeth arranged closely together in their respective sides (Fig. 2C). Sternum heart-shaped, clothed sparsely with black hairs (Fig. 1B). Dark coloured band along the margin of sternum. Legs yellow with dark greenish yellow annuli. Leg measurements: I 4.25 (1.12, 1.54, 0.83, 0.76); II 3.88 (0.99, 1.39, 0.82, 0.68); III 3.81 (1.01, 1.26, 0.94, 0.60); IV 5.94 (1.50, 1.80, 1.69, 0.95) Leg formula: 4123. Palp 1.57 (0.49, 0.60, 0.48). Opisthosoma long oval. Dorsum dark yellowish brown with several lateral bands like patterns. Venter yellow. Posterior spinnerets larger than anterior ones. Epigynum (Fig. 2A): Hood present. Vulva (Fig. 2B): SS vase-shaped, wider near hood, tapered towards bottom and widens near the BS; CD globular and positioned laterally to SS; Sp positioned upright and parallel to the SS, longer than wide, tip positioned parallel and just higher than the tip of hood. FD indistinct masked by CD.

Acknowledgements

Authors express deepest gratitude to Principal, Christ College (Autonomous), Irinjalakuda, Kerala for providing laboratory facilities and first author is especially thankful to Senior Research Fellowship [08/376(0013)EMR-1/2019] of Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology, Government of India, New Delhi for funding the research. We are expressing our gratitude to Kerala Forest and Wildlife department for granting field work permission [KFDHQ/1911/2021-CWW/WL10] in protected areas. Authors also acknowledge the funding rendered by DST-SERB Major Research Project EEQ/2021/000453, for the facilities used in the study. We are grateful to all co-researchers in CATE lab for their moral support.

References

Marusik YM, Ballarin F (2011) Redescription of the Himalaian *Pardosa flavisterna* Caporiacco, 1935 (Aranei: Lycosidae) with notes of the *Pardosa nebulosa* species-group. Proceedings of the Zoological Institute RAS 315(1): 63–69. https://wsc.nmbe.ch/reference/11789.

Shorthouse DP (2010) SimpleMappr: an online tool to produce pub-lication-quality point maps. http://www.sim-plemappr.net

Wang D, Zhang ZS (2014) Two new species and a new synonym in the *Pardosa nebulosa*-group (Lycosidae: *Pardosa*) from China. Zootaxa 3856: 227–240. http://dx.doi.org/ 10.11646/zootaxa.3856.2.4

World Spider Catalog (2022) World Spider Catalog: Version 23.0: Natural History Museum Bern http://wsc.nmbe.ch/

Zyuzin AA (1979) A taxonomic study of Palearctic spiders of the genus *Pardosa* (Aranei, Lycosidae): Part 1: The taxonomic structure of the genus. Entomologicheskoe Obozrenies 58: 431–447. https://wsc.nmbe.ch/reference/5243.

Serket (2022) vol. 18(3): 338-344.

Redescription of two wolf spiders *Pardosa mukundi* Tikader & Malhotra, 1980 and *Draposa burasantiensis* (Tikader & Malhotra, 1976) (Araneae: Lycosidae)

Raveendran Sudha Abhijith [1], Palissery Sheeba [2]
& Ambalaparambil Vasu Sudhikumar [1*]
[1] Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakkuda, Kerala-680125, India
[2] Department of Zoology, Vimala College (Autonomous), Kerala, India
[*] Corresponding author e-mail address: spidersudhi@gmail.com

Abstract

India always amazes with its ecological diversity and biological wealth. Western Ghats has a pivotal role in this. The southern Indian state of Kerala's major land area comes under Western Ghats. So the taxonomic findings from the state have high significance. Lycosidae Sundevall, 1833 or wolf spiders are amazing organisms which are important to maintain ecological balance. Systematics of this group require a lot of revisions as their external morphology has less taxonomic value. Genital morphology analysis is the best way to accurately classify the spiders, especially wolf spiders. This study reports *Pardosa mukundi* Tikader & Malhotra, 1980 and *Draposa burasantiensis* (Tikader & Malhotra, 1976) for the first time from the southern Indian state of Kerala. Redescriptions of females of both species are provided with clear photographs and brief natural history.

Keywords: Arachnology, Taxonomy, New reports, Western Ghats, Kerala, India.

Introduction

Kerala, a southern Indian state is considered as a myriad of biological wealth considering its tropical climate and presence of biodiversity hotspot Western Ghats. Recent climate change related problems in the state, escalated the importance of reporting organisms from the region. Lycosidae Sundevall, 1833 (wolf spiders) is the 5th largest spider family in the world with 2440 species and 126 genera (World Spider Catalog, 2022).

Their adult body size ranges from 1 to 30 mm. They pursue diverse prey capture strategies, from permanently vagrant hunters to permanently burrowing species, and some genera are known to build permanent sheet-webs (Murphy *et al.*, 2006). Wolf spiders may also show very specific microhabitat preferences and may be susceptible to changes in habitat structure (Jõgar *et al.*, 2004; Marshall & Rypstra, 1999). *Pardosa* C.L. Koch, 1847 is the most diverse genus and *Draposa* Kronestedt, 2010 is a relatively new lycosid genus. Morphologically, they are very similar, they only differ by genital characters. Because of the presence of a biodiversity hotspot, it is obvious that the lycosid diversity would be much higher than this. In this paper we are dealing with the redescription of *Draposa burasantiensis* (Tikader & Malhotra, 1976) and *Pardosa mukundi* Tikader & Malhotra, 1980. It is also the second ever report of the latter species from India.

Material and Methods

All specimens were collected by hand picking method and preserved in 70% ethanol and were studied, photographed, and measured using a Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver.4.13). Female epigynes were dissected and internal genitalia were cleared in 10% potassium hydroxide (KOH) solution. Ocular measurements were taken after placing the specimen dorsally. Leg measurements are shown as: total length (femur, patella and tibia, metatarsus, tarsus). All measurements are given in millimetres (mm).

Abbreviations used in the main text are: ALE = anterior lateral eye, AME = anterior median eye, BS = base of septum, CATE = Centre for Animal Taxonomy and Ecology, CD = copulatory duct, CO = copulatory opening, FD = fertilization duct, MOQ = median ocular quadrangle, PLE = posterior lateral eye, PME = posterior median eye, Sp = spermatheca, SS = septal stem.

Systematics

Family **Lycosidae** Sundevall, 1833

Genus ***Pardosa*** C.L. Koch, 1847

Pardosa mukundi Tikader & Malhotra, 1980 (Figs. 1A-D)
Pardosa mukundi Tikader & Malhotra, 1980: 326, f. 157-159 (♀); Buchar & Dolejš, 2021: 948, f. 17A-L (♂♀).

Distribution
Bhutan, India (First report of the species from the state of Kerala).

Material examined
India, Kerala: 2♀♀ from grassland Gavi, Pathanamthitta district, Kerala, 9º43.49'N, 77º16.01'E, alt. 3398.95 ft, 8 October 2021, coll. Abhijith, R.S. Deposited in CATE, Christ College, Irinjalakuda, Kerala, India (CATE588504).

Redescription
Female (Figs. 1A-B): Total length 4.18. Prosoma 2.28 long, 1.77 wide. Opisthosoma 1.90 long, 1.71 wide. Carapace brown with a non-prominent longitudinal fovea. Fovea long, uniform in width. Light brown spots along lateral edges of carapace. Median band dark brown, uniform throughout. Lateral bands indistinct. A small bifurcated mark in the ocular area, obscure by the presence of white pubescence. Ocular area dark, except bifurcated mark, black and white hairs present. Two long distinct, forward facing, white hairy

structure present near posterior median eyes. Head region flanked steep without any projections.

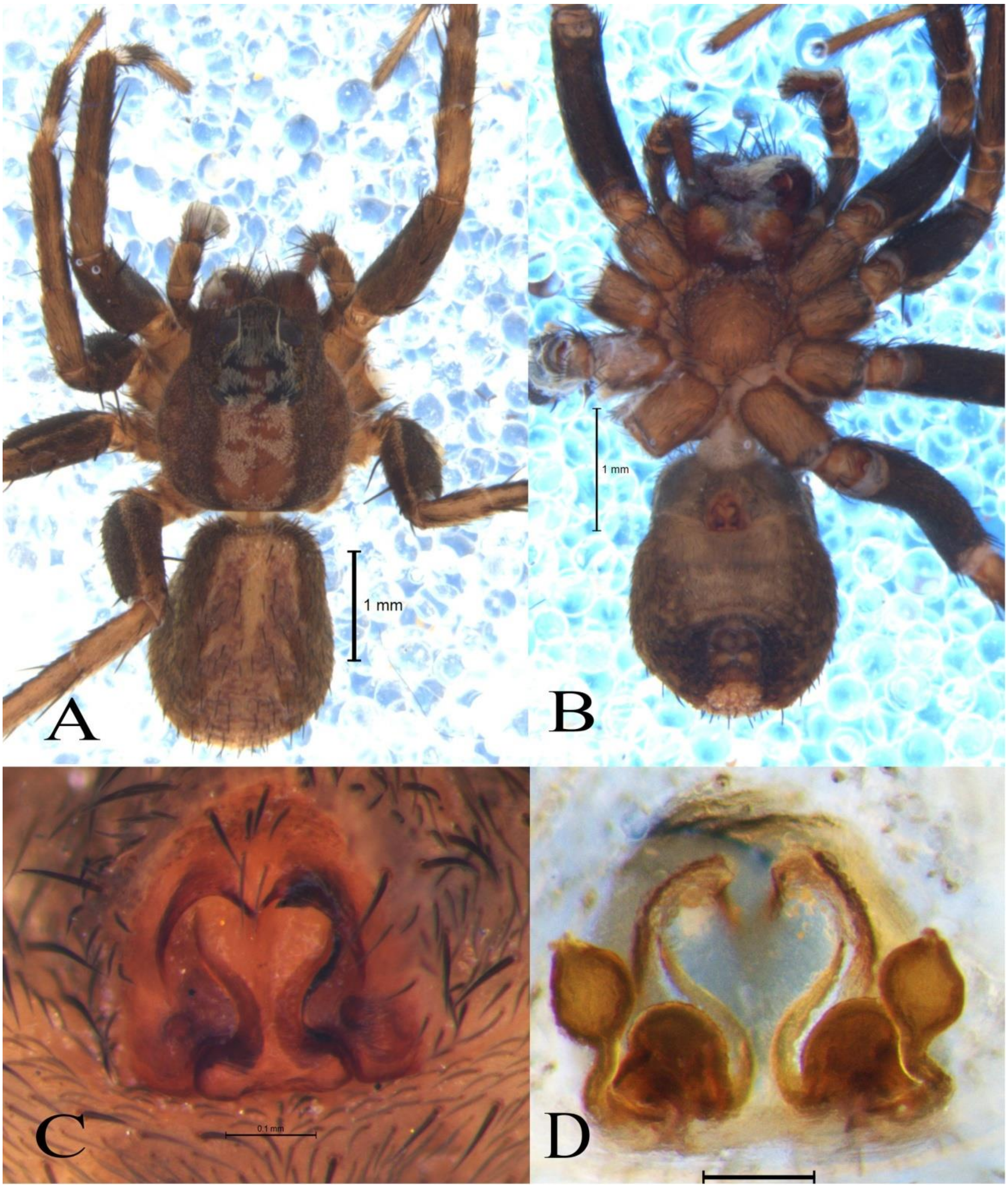


Fig. 1. *Pardosa mukundi* Tikader & Malhotra, 1980, female from Gavi, Pathanamthitta, Kerala. A-B. Female, habitus. A. dorsal view. B. ventral view, *in situ*. C-D. Epigyne. C. ventral view. D. dorsal view, cleared. (Scale bars: A-B. 1 mm, C-D. 0.1 mm).

Eye sizes and inter-distances: AME 0.079, ALE 0.049, PME 0.183, PLE 0.131, AME-AME 0.067, AME-ALE 0.037, PME-PME 0.248, PME-PLE 0.266. MOQ wider posteriorly**.** Clypeus height 0.23. Labium dark brown, wider than long. Chelicera with 3 promarginal and 3 retromarginal teeth. Sternum, light brown, heart-shaped, clothed sparsely with black hairs. Legs brown, femur darker. Leg measurements: I 3.92 (1.10, 1.37, 0.97, 0.48); II 3.88 (0.70, 1.83, 0.74, 0.61); III 3.70 (0.77, 1.89, 0.72, 0.32); IV 5.06 (1.22,

1.54, 1.32, 0.98). Leg formula: 4123. Palp 1.52 (0.49, 0.71, 0.32). Opisthosoma long oval. Dorsum dark brown with several lateral bands at downward angle. A slender yellow lanceolate pattern present medially. Venter light brown. Posterior spinnerets larger than anterior ones.
The female epigynum (Fig. 1E): distinct from other species of *Pardosa* by: long vase-shaped septum and two prominent hoods present, BS with bulges on both lateral ends. Internal genitalia (Fig. 1F): septum heart shaped, SS wider apically and medially, extreme narrow approaching BS; CD positioned laterally to lower end of SS, bulbous, opening to CO at base; Sp with long, slender stalk and globular head, positioned adjacent to CD.

Genus ***Draposa*** Kronestedt, 2010

Draposa burasantiensis (Tikader & Malhotra, 1976) (Figs. 2A-D)
Pardosa burasantiensis Tikader & Malhotra, 1976: 130, figs. 10-12 (♂♀); Tikader & Malhotra, 1980: 338, figs. 183-186 (♂♀); Tikader & Biswas, 1981: 55, figs. 88-89 (♀); Yin *et al.*, 1997: 239, figs. 112a-g (♂♀) (misidentified as per Kronestedt, 2010: 34); Song, Zhu & Chen, 1999: 330, fig. 194C (♀) (misidentified per Kronestedt, 2010: 34); Yin *et. al.*, 2012: 833, figs. 416a-g (♂♀).
Draposa burasantiensis Dhali *et al.*, 2012: 1202 (♂♀); Sen *et al.*, 2015: 48, figs. 198-202 (♀); Dhali, Saha & Raychaudhuri, 2017: 71, figs. 327-331, pl. 23 (♂).

Distribution
China, India (First report from the state of Kerala).

Material examined
India, Kerala: 2♀♀ from grassland in Gavi, Pathanamthitta district, Kerala, 9º43.49'N, 77º16.01'E, alt. 3398.95 ft, 8 October 2021, coll. Abhijith, R.S. Deposited in CATE, Christ College, Irinjalakuda, Kerala, India (CATE583912).

Redescription
Female (Figs. 2A-D): Total length 4.07. Prosoma 2.04 long, 1.62 wide. Opisthosoma 2.03 long, 1.21 wide. Carapace yellowish brown with distinct longitudinal fovea. Fovea non-uniform in width, rather wider at both ends. Green continuous spots along the margin of carapace. Median band greenish yellow, broader near ocular area and narrower around the pedicel. A small bifurcated extension of median band trespassed into the dark ocular area. Paramedian bands broad, dark greenish brown, uniform in width, with a few protrusions extended towards median band. Ocular area black and hairy except bifurcated extension of median band. Head region flanked steep without any projections. Eye sizes and inter-distances: AME 0.069, ALE 0.051, PME 0.178, PLE 0.140, AME-AME 0.070, AME-ALE 0.042, PME-PME 0.256, PME-PLE 0.290. Anterior eye row slightly procurved. MOQ wider posteriorly**.** Clypeus height 0.15. Labium longer than wide. Chelicera with 3 promarginal and 3 retromarginal teeth. All promarginal teeth subequal in length. Middle retromarginal teeth large and distinct. Sternum heart-shaped, clothed sparsely with black hairs. Dark band along the margin of sternum. Legs yellow with dark greenish yellow annuli. Leg measurements: I 5.49 (1.55, 1.90, 1.24, 0.80); II 5.38 (1.47, 1.89, 1.11, 0.91); III 5.09 (1.37, 1.66, 1.31, 0.75); IV 7.69 (1.87, 2.40, 2.33, 1.09). Leg formula: 4123. Palp 1.96 (0.66, 0.76, 0.54). Opisthosoma long oval. Dorsum dark yellowish brown with several lateral bands like patterns. Bright patterns visible on fresh specimens. Venter yellow. Posterior spinnerets larger than anterior ones.
Female epigynum (Fig. 2C): very distinct from other species of Lycosidae by presence of short tongue-like septum and V-shaped hood. Internal genitalia (Fig. 2D): SS, short,

cylindrical, uniformly wide; base of septum wider than usual; CD, globular, positioned laterally to SS; Sp subequal in length and width, positioned upright with a narrow inward angle and parallel to the SS, tip positioned parallel, much higher than the septal hood. FD small, globular near the base of CD.

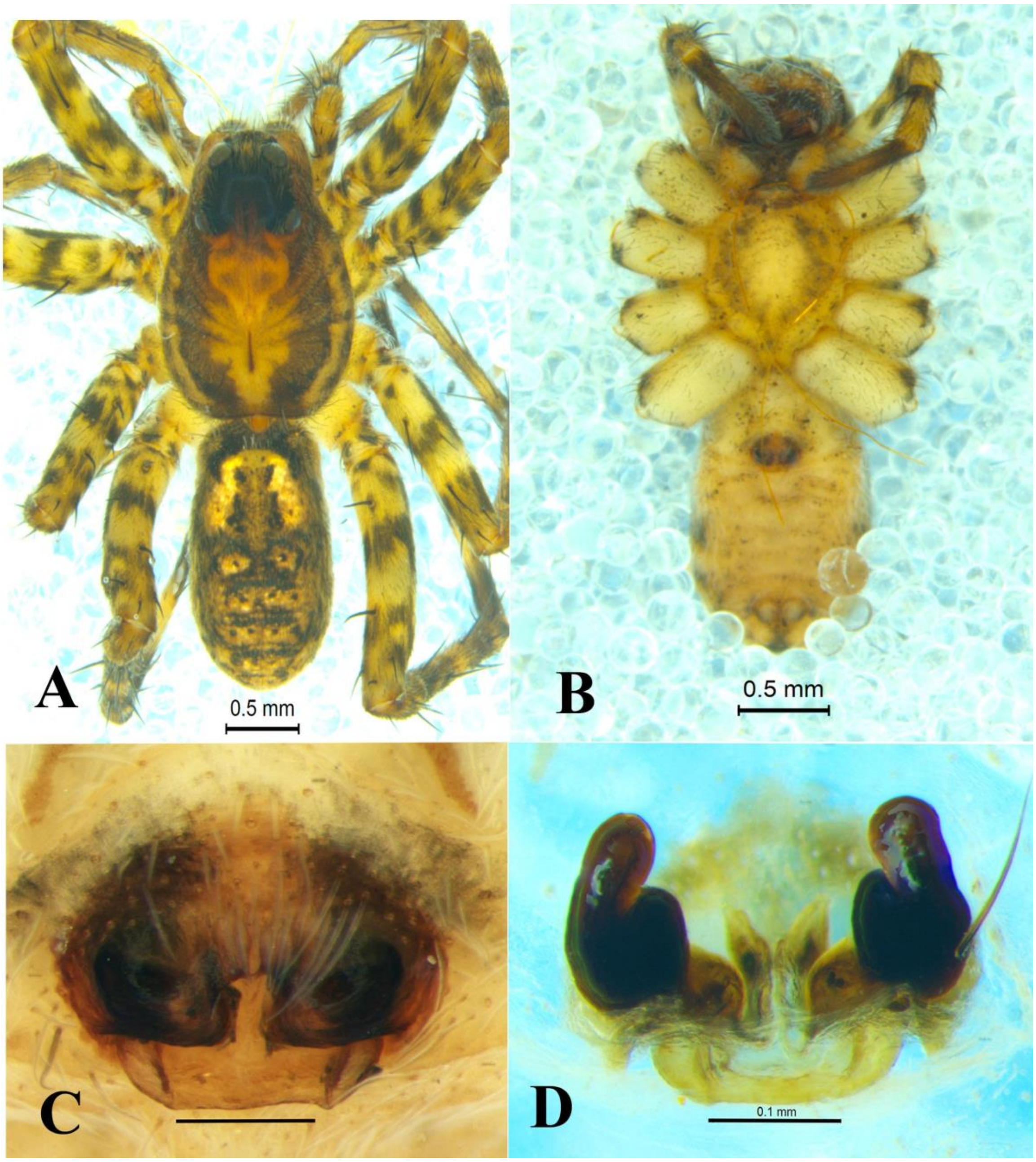


Fig. 2. *Draposa burasantiensis* (Tikader & Malhotra, 1976), female from Gavi, Pathanamthitta, Kerala. A-B. Female, habitus. A. dorsal view. B. ventral view. C-D. Epigyne. C. ventral view, *in situ*. D. dorsal view, cleared. (Scale bars: A-B. 0.5 mm, C-D. 0.1 mm).

Brief Natural history

Both species were collected from single continuous grassland. The collecting day had pleasant climate with a drizzle previous night. So the grassland is damp in some areas and dry in others. Insect population in the area is also found to be higher. Anthropogenic disturbances were also minimal. These situations were ideal for lycosids to flourish. Apart from two species mentioned, four other lycosid species were also collected from the same area. Most of the spiders were adults. Sub adults were found, but a few. Male individuals were also scarce. But, all the collected males were sexually matured. On their natural habitat males showed great vigour, faster and active than female counterparts and spotted with raised well developed, dark coloured palp. Even though, males of *D. burasantiensis* and *P. mukundi* are not obtained, considering same habitat, guild, behaviour, presence of sexually mature females, lack of egg cases and low proportion of males, it is clear that these species are also in their mating period. The wandering nature of mature males to nearby habitats for mating may be the reason for less spotting during collecting.

Remarks

P. mukundi is a rare lycosid reported only from North India and Bhutan. But, it was not reported from south Indian states. No males were yet reported from India. The description and illustration by Tikader & Malhotra (1980) are similar to our specimen. But, that lacks genital descriptions which is taxonomically important in the taxa. Buchar & Dolejš (2021) provided photographs of female type of the species, which is similar to our specimen. We provide detailed descriptions along with photographs for getting actual account of the species.

Draposa is a relatively new lycosid genus. It is morphologically very similar to genus *Pardosa*. Female genitalia figures of *Pardosa burasantiensis* (later transferred to *Draposa*) in Tikader & Malhotra (1980) and Yin *et al.* (2012) shows similarity with our specimen. Especially view of internal genitalia and the arrangement of SS with V-shaped hoods in Tikader & Malhotra (1980) resembles our specimens in question. Descriptions in the previous papers are mainly dealt with external morphology which also matches our specimens. To get a clear picture, the redescription of the female with genitalic characters and photographs is provided by us.

Acknowledgments

The authors express deepest gratitude to Principal, Christ College (Autonomous), Irinjalakuda, Kerala for providing laboratory facilities and the first author is specially thankful to Senior Research Fellowship [08/376(0013)EMR-1/2019] of Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology, Government of India, New Delhi for funding the research. We are expressing our gratitude to Kerala Forest and Wildlife department for granting field work permission [KFDHQ/1911/2021-CWW/WL10] in protected areas. We also acknowledge the funding rendered by DST-SERB Major Research Project EEQ/2021/000453, for the facilities used in the study.

References

Buchar, J. & Dolejš, P. 2021. Lycosidae from Bhutan 2: Lycosinae, Pardosinae, and Hippasinae (Arachnida: Araneae). *Arachnology*, 18(8): 935-953.

Dhali, D.C., Roy, T.K., Sen, S., Saha, S. & Raychaudhuri, D. 2012. Wolf spiders (Araneae: Lycosidae) of the reserve forests of Dooars, West Bengal, India. *Munis Entomology and Zoology*, 7(2): 1199-1213.

Dhali, D.C., Saha, S. & Raychaudhuri, D. 2017. Litter and ground dwelling spiders (Araneae: Arachnida) of reserve forests of Dooars, West Bengal. *World Scientific News*, 63: 1-242.

Jõgar, K., Metspalu, L., & Hiiesaar, K. 2004. Abundance and dynamics of wolf spiders (Lycosidae) in different plant communities. *Agronomy Research*, 2(2): 145-152.

Kronestedt, T. 2010. *Draposa*, a new wolf spider genus from South and Southeast Asia (Araneae: Lycosidae). *Zootaxa*, 2637: 31-54.

Marshall, S. D., & Rypstra, A. L. (1999). Patterns in the distribution of two wolf spiders (Araneae: Lycosidae) in two soybean agroecosytems. *Environmental Entomology*, *28*(6), 1052-1059.

Murphy, N.P., Framenau, V.W., Donnellan, S.C., Harvey, M.S., Park, Y-C. & Austin, A.D. 2006. Phylogenetic reconstruction of the wolf spiders (Araneae: Lycosidae) using sequences from the 12S rRNA, 28S rRNA, and NADH1 genes: implications for classification, biogeography, and the evolution of web building behavior. *Molecular Phylogenetics and Evolution*, 38(3): 583-602.

Sen, S., Dhali, D.C., Saha, S. & Raychaudhuri, D. 2015. Spiders (Araneae: Arachnida) of Reserve Forests of Dooars: Gorumara National Park, Chapramari Wildlife Sanctuary and Mahananda Wildlife Sanctuary. *World Scientific News*, 20: 1-339.

Song, D.X., Zhu, M.S. & Chen, J. 1999. *The spiders of China*. Hebei Science and Technology Publishing House, Shijiazhuang, 640 pp.

Tikader, B.K. & Biswas, B. 1981. Spider fauna of Calcutta and vicinity: Part-I. *Records of the Zoological Survey of India, Occasional Paper*, 30: 1-149.

Tikader, B.K. & Malhotra, M.S. 1976. Studies on some spiders of the genus *Pardosa* Koch from India (family: Lycosidae). *Proceedings of the Indian Academy of Science*, 83(3): 123-131.

Tikader, B.K. & Malhotra, M.S. 1980. Lycosidae (wolf-spiders). *Fauna India* (Araneae), 1: 248-447.

World Spider Catalog 2022. *World Spider Catalog*. Version 23.0. Natural History Museum Bern, online at http://wsc.nmbe.ch, accessed on 2 March 2022.

Yin, C.M., Peng, X.J., Xie, L.P., Bao, Y.H. & Wang, J.F. 1997. *Lycosids in China (Arachnida: Araneae)*. Hunan Normal University Press, 317 pp.

Yin, C.M., Peng, X.J., Yan, H.M., Bao, Y.H., Xu, X., Tang, G., Zhou, Q.S. & Liu, P. 2012. *Fauna Hunan: Araneae in Hunan, China*. Hunan Science and Technology Press, Changsha, 1590 pp.

Serket (2022) vol. 19(1): 79-84.

First record of *Pardosa parathompsoni* Wang & Zhang, 2014 (Araneae: Lycosidae) from biodiversity hotspot Western Ghats with additional information on cheliceral morphology

Raveendran Sudha Abhijith [1], Palissery Sheeba [2]
& Ambalaparambil Vasu Sudhikumar [1*]
[1] Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala-680125, India
[2] Department of Zoology, Vimala College (Autonomous), Kerala, India
[*] Corresponding author e-mail address: spidersudhi@gmail.com

Abstract

Taxonomic findings from biodiversity hotspots are always fascinating because of their vulnerability. In this paper we are reporting *Pardosa parathompsoni* Wang & Zhang, 2014 for the first time from Western Ghats region of India along with additional information on cheliceral morphology.

Keywords: Spider, Lycosidae, *Pardosa parathompsoni*, India.

Introduction

Western Ghats is one of the major biodiversity hotspots which serves as the paradise of biological wealth. New findings of fauna and flora from the region have great importance in the current climate change scenario. *Pardosa* C.L. Koch, 1847 is the largest genus in family Lycosidae (World Spider Catalog, 2022). *Pardosa parathompsoni* Wang & Zhang, 2014 belongs to *P. nebulosa* species-group, first reported from China and later reported from India (Wang & Zhang, 2014; Prasad *et al.*, 2022). This paper documents second report of the species from India and first from Western Ghats with additional information on cheliceral morphology.

Methodology

All specimens were collected by hand picking method and preserved in 70% ethanol and were studied, photographed and measured using a Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver.4.13). Epigynes were dissected and internal genitalia were cleared in 10% potassium hydroxide (KOH) solution. Male palp was separated and photographed. Ocular measurements were taken after placing the specimen dorsally. Leg measurements are shown as: total length (femur, patella + tibia, metatarsus, tarsus). All measurements are given in millimetres (mm).

Abbreviations used in the main text and figures are: ALE = anterior lateral eye, AME = anterior median eye, BS = base of septum, CD = copulatory duct, CO = copulatory opening, E = embolus, FD = fertilization duct, Ho = hood, MA= median apophysis, MOQ = median ocular quadrangle, Pa = palea, PLE = posterior lateral eye, PME = posterior median eye, Sp = spermatheca, SS = septal stem, St = subtegulum, TA= tegular apophysis, T = tegulum.

Systematics

Family Lycosidae Sundevall 1833
Genus *Pardosa* C.L. Koch 1847
Pardosa nebulosa-group
Pardosa parathompsoni Wang & Zhang 2014
(Figs. 1A-D, 2A-E)

Pardosa parathompsoni Wang & Zhang, 2014: 228, figs. 1A-E, 2A-J, (♂♀).
Pardosa parathompsoni Prasad *et al.*, 2022: 1591, figs. 1A-F (♂♀).

Material examined
INDIA, Kerala: 5♀♀ 1♂ from grassland in Gavi, Pathanamthitta district, Kerala, India (9°43.49'N, 77°16.01'E) 1035.9 m a.s.l., 8 October 2021, R.S. Abhijith.

Diagnosis
Habitus of both sexes morphologically very similar to other members of *Pardosa nebulosa*-group, the genitalia is close to *P. sumatrana* (Thorell, 1890), but can be distinguished by following set of characters: Epigynum with a short vase-shaped septum; SS broader in anterior and posterior ends with small hoods; Sp vertical with an inward angle; Male palp with a TA having a protrusion; Pa with a small sharp protrusion mid-retrolaterally towards the MA; MA comparatively stout with a slightly curved tip.

Description
Female from Gavi, Pathanamthitta (Figs. 1A-B): Total length 4.81-4.92. Prosoma 2.58 long, 1.60 wide. Opisthosoma 2.23 long, 1.45 wide. Carapace yellowish brown with a distinct longitudinal fovea. Fovea non-uniform in width, wider at both ends. Green spots along lateral edges of carapace. Median band greenish yellow, broader near ocular area and narrower in thoracic area. A small bifurcated extension of median band extended into the ocular area. Paramedian bands broad, dark greenish brown, uniform in width, continuous. Two comma-shaped patterns near ocular area. Paramedian bands joined near the pedicel. Ocular area black and hairy except bifurcated extension of median band. Head region flanked steep without any projections.
Eye sizes and inter-distances: AME 0.08, ALE 0.05, PME 0.18, PLE 0.13, AME-AME 0.06, AME-ALE 0.03, PME-PME 0.24, PME-PLE 0.26. MOQ wider posteriorly. Clypeus height 0.22. Labium dark grey, subequal in length and breadth. Chelicera with 3

promarginal and 3 retromarginal teeth. One of the promarginal teeth very small. Sternum heart-shaped, covered sparsely with black hairs. V-shaped dark band present away from the margin of sternum. Legs yellow with dark greenish yellow annuli. Leg measurements: I 4.43 (1.15, 1.60, 0.87, 0.81); II 4.16 (0.99, 1.50, 0.97, 0.70); III 4.01 (1.07, 1.31, 0.98, 0.65); IV 6.05 (1.52, 1.84, 1.71, 0.98). Leg formula: 4123. Palp 1.69 (0.56, 0.64, 0.49). Opisthosoma long oval. Dorsum dark yellowish brown with several lateral bands like patterns. Lanceolate pattern present medially. Venter yellow. Posterior spinnerets larger than anterior ones.

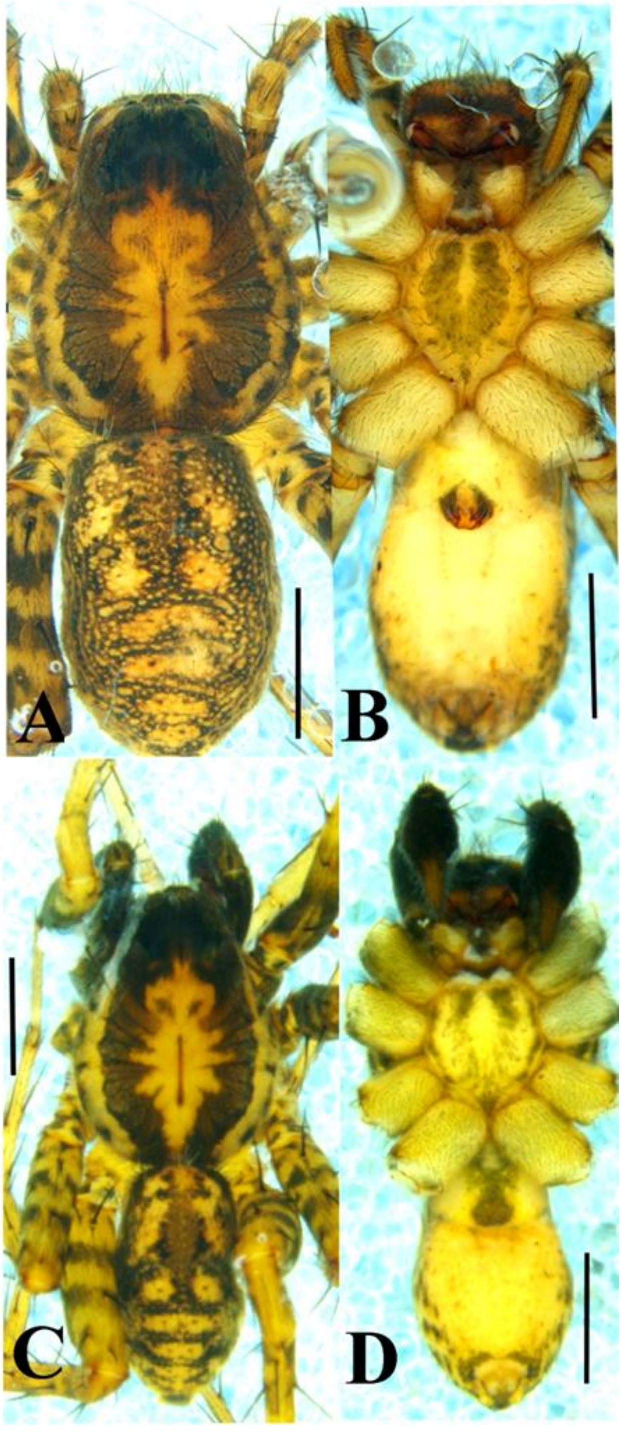


Fig. 1. *Pardosa parathompsoni* Wang & Zhang, 2014, Habitus. A-B. female. C-D. male. A, C. dorsal view. B, D. ventral view. (Scale bars: 1 mm).

The epigynum (Fig. 2A): short septum and non-prominent hood present. Internal genitalia (Fig. 2B): septum anchor shaped, SS wider near hood and BS, tapered medially; CD positioned laterally to SS with a slight upward angle; Sp longer than wide, positioned vertically at an inward angle to the SS, the proximal end angled away and bulged slightly beyond the epigyne area, tip angled towards septum, positioned higher than septal hood; FD small and close to base of CD.

Male from Gavi, Pathanamthitta (Figs. 1C-D): Morphologically similar to female, slightly smaller in size. Total length 3.91. Prosoma 2.01 long, 1.59 wide. Opisthosoma 1.90 long, 1.09 wide. Carapace yellowish brown with a distinct longitudinal fovea. Fovea almost uniform in width, only slightly wider posteriorly. Green spots along the margins of carapace, continuous than in female. Median band greenish yellow, broader near ocular area and narrower around the pedicel. A small bifurcated extension of median band trespassed into the dark ocular area. Paramedian bands broad, dark greenish brown, uniform in width, a few protrusions extended towards median band. Ocular area black and hairy except bifurcated extension of median band. Head region flanked steep without any projections.

Eye sizes and inter-distances: AME 0.06, ALE 0.05, PME 0.17, PLE 0.13, AME-AME 0.06, AME-ALE 0.04, PME-PME 0.24, PME-PLE 0.28. Anterior eye row slightly procurved. MOQ wider posteriorly. Clypeus height 0.20. Labium grey, subequal in length and width. Chelicera with 3 promarginal and 3 retromarginal teeth. One of the promarginal teeth very small (Fig. 2C). Sternum heart-shaped, clothed sparsely with black hairs. Dark band along the margin of sternum. Legs yellow with dark greenish yellow annuli. Leg measurements: I 5.01 (1.41, 1.80, 1.11, 0.69); II 4.93 (1.36, 1.76, 1.01, 0.80); III 4.63 (1.25, 1.55, 1.20, 0.63); IV 7.23 (1.75, 2.30, 2.17, 1.01). Leg formula: 4123. Opisthosoma long oval, slender than that of female. Dorsum dark yellowish brown with several lateral bands. Venter yellow with a dark brown pattern near pedicel. Posterior spinnerets larger than anterior ones.

Male Palp (Figs. 2D-E): dark, hairy; T large, TA small, tapered tip and directed downwards; St small, prolaterally positioned; Pa large, globular and positioned retrolaterally with a small sharp protrusion mid-retrolaterally towards the MA; MA with a slightly curved tip, horizontally extended retrolaterally, stout; embolus with a fine tapered end directed upwards, originated prolaterally, extended retrolaterally.

Distribution. China (Yunnan)(Wang & Zhang, 2014), India (Odisha)(Prasad *et al.*, 2022) new to Western Ghats region.

Remarks

Genital characters rather than other morphological characters have taxonomic importance in *Pardosa* genus. *Pardosa parathompsoni* was first described from China by Wang & Zhang (2014). The original description is extremely precise and mainly based on genitalic characters. Clear photographs and figures are also given. Description and photographs of copulatory organs are matching to our collected specimens. Body sizes of our specimens seem to be on a lower side than the Chinese specimens. Female body size is comparable, but size of male is smaller. This may be due to the difference in environmental conditions of two collection sites which are thousands of miles apart.

Notes on cheliceral morphology (Fig. 2C): Chelicera 0.6 mm, dark brown, fang sturdy, light brown. Chelicera with 3 promarginal and 3 retromarginal teeth. The number of promarginal teeth in chelicerae is different from the original description and description by Prasad *et al.* (2022), *i.e.* "two promarginal and three retromarginal teeth".

One of the teeth is comparatively very small and masked by a tuft of strong hairs. So, it is clear that this species shows variation in cheliceral teeth number.

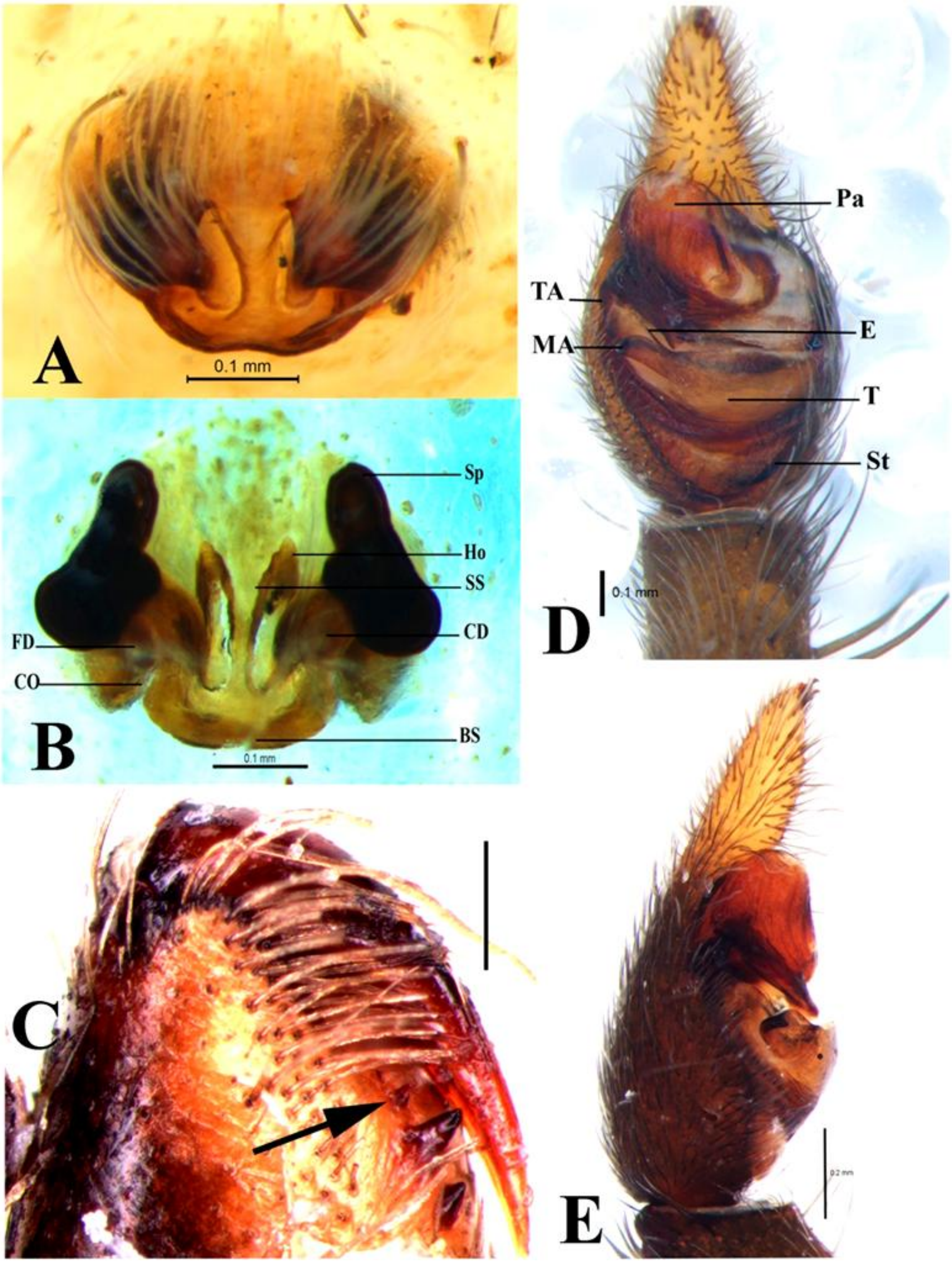


Fig. 2. *Pardosa parathompsoni* Wang & Zhang, 2014. A-B. Female epigyne. A. ventral view. B. dorsal view, cleared. C. male left chelicera; arrow indicates the small third pro-marginal teeth. D-E. Male palp. D. ventral view. E. retrolateral view. (Scale bars: 0.1 mm).

Natural history

The *P. parathompsoni* spiders were found in single continuous grassland. The grassland was adjacent to rocky region. The area contained discontinuous water logging marshy regions. The day was sunny with slightly drizzled previous night. The entire above mentioned habitat conditions are ideal for the flourishing of lycosids. The grass vegetation holds great population of prey insects, water logged areas and less anthropogenic disturbance might be the reason for abundant lycosid population. *Pardosa sumatrana* was the most abundant species which far exceeds other species. The time of collection was also ideal for observing spiders. Most of the spiders were sexually mature, but, few with egg cases or spiderlings. Sub-adults were found, but not many. Male individuals were also less in number, literally one in ten compared to females. But all the collected males were sexually matured with well-developed genitalia. On field, the observed males had great vigor, faster and active than female counterparts and spotted with raised well developed, dark coloured palp. This clearly indicates that time was mating period of these species. The low number of males might be because of the wandering nature of mature males in search of females for mating and reducing the sexual competition in the habitat. More studies are required to analyse the sexual selection of lycosids and whether the males travel to distant areas for avoiding competition.

Acknowledgments

Authors express deepest gratitude to Principal, Christ College (Autonomous), Irinjalakuda, Kerala for providing laboratory facilities and first author is especially thankful to Senior Research Fellowship [08/376(0013)EMR-1/2019] of Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology, Government of India, New Delhi and DST-SERB Major Research Project EEQ/2021/00453 for funding the research. We are expressing our gratitude to Kerala Forest and Wildlife department for granting field work permission [KFDHQ/1911/2021-CWW/WL10] in protected areas. We are grateful to all co-researchers in CATE lab for their moral support.

References

Prasad, P., Saha, G.K., Kumar, V. & Tyagi, K. 2022. First report of the wolf spider *Pardosa parathompsoni* (Araneidae: Lycosidae) from India. *Munis Entomology and Zoology*, 17(supplement): 1590-1595.

Wang, D. & Zhang, Z.S. 2014. Two new species and a new synonym in the *Pardosa nebulosa*-group (Lycosidae: *Pardosa*) from China. *Zootaxa*, 3856(2): 227-240.

World Spider Catalog 2022. *World Spider Catalog.* Version 23.5. Natural History Museum Bern, online at http://wsc.nmbe.ch, accessed on November 2022.

TAPROBANICA, ISSN 1800–427X. May, 2023. Vol. 12, No. 01: pp. 1–4, pl. 1–3.

http://www.taprobanica.org
https://doi.org/10.47605/tapro.v12i1.294

urn:lsid:zoobank.org:pub:734A2536-6401-45F5-ADD8-5BA628B0E74C

DESCRIPTION OF A NEW WOLF SPIDER SPECIES (ARACHNIDA: ARANEAE: LYCOSIDAE: *Draposa*) FROM WESTERN GHATS, INDIA

Section Editor: Francesco Ballarin *Submitted*: 10 June 2022, *Accepted*: 01 December 2022

Raveendran Sudha Abhijith[1,2] & Ambalaparambil Vasu Sudhikumar[1,3]

[1] *Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala 680125, India*
Corresponding authors. E-mail: [2]abhijithrsabhiramam@gmail.com, [3]spidersudhi@gmail.com

Abstract
Draposa is a relatively newly described wolf spider genus numbering 11 species, out of which eight have been reported from India**.** A new *Draposa* species from Kerala, Western Ghats, India, is described, photographed and illustrated. The male palp of the new species is similar to that of *D. lyrivulva* distributed in Pakistan, India and Sri Lanka, but it differs by having the following combination of characters: shorter tegular apophysis with a narrow and linear tip, prominent sub-apical protrusion, and embolus parallel to tegular apophysis.

***Keywords*:** Arachnida, distribution, Kerala, *Pardosa*, South Asia, taxonomy

Introduction

The taxonomy of Indian lycosid spider needs a thorough revision since several species lack a clear description, photographs or illustrations of genitalia and there is inadequate information of the type materials. *Draposa* Kronestedt, 2010 is a small recently described wolf spider genus with only 11 species distributed in India, China, Pakistan, Sri Lanka, Bhutan, Maldives, Indonesia, East Malaysia, Myanmar, Iran, Bhutan, Bangladesh and United Arab Emirates, out of which eight have been reported from India (WSC 2022). Indian *Draposa* species already described were initially attributed to *Pardosa* Koch, 1847 and later transferred to *Draposa* by Kronestedt (2010) and Dhali *et al*. (2012). Subfamily level revisions of lycosids were suggested by Kronestedt (2010) and Murphy *et al*. (2006). Therefore, Piacentini and Ramirez (2019) placed the genus *Draposa* along with the genera *Pardosa* and *Wadicosa* Zyuzin, 1985 in the sub-family Pardosinae.

Material and Methods

All specimens were collected by hand and preserved in 70% ethanol. The holotype and other voucher specimens of the new species are deposited at the Centre for Animal Taxonomy & Ecology (CATE), Department of Zoology, Christ College, Irinjalakuda, Kerala, India. Specimens were studied, photographed and measured using a Leica M205C stereo-microscope, a Leica DFC450 Camera, and LAS software (Ver.4.13). Epigynes were dissected and cleared in 10% potassium hydroxide (KOH) solution. Male palps were dissected before being photographed. The right palp is illustrated and described despite common taxonomic usage of left palp, for the comparison with descriptions of most *Draposa* species by Kronestedt (2010). Ocular measurements were taken after placing the specimen dorsally. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). All measurements are given in millimetres (mm). Part of the terms used in the description follows Sierwald (2000) and Kronestedt (2010) for e.g. epigynal cavity, bottom of epigynal cavity, sub-apical protrusion and sub-paleal sclerite.

Abbreviations: ALE, anterior lateral eye; AME, anterior median eye; ap, anterior process of sub-paleal sclerite; CD, copulatory duct; CO, copulatory opening; FD, fertilization duct; TA, tegular apophysis; MOQ, median ocular quadrangle; P, palea; PA, paleal apophysis; PLE, postero-lateral eye; PME, postero-median eye; pp, posterior process of sub-paleal sclerite; Se, septum; SAP, sub-apical protrusion; SS, septal stem; TA, tegular apophysis; Te, tegulum. All the measurements are in mm.

Results

Draposa Kronestedt, 2010

The males of the new species were identified as *Draposa* by the following combination of characters of palp: sub-paleal sclerite with two processes, transverse tegular apophysis with two projections, distal part with sub-apical protrusion and paleal apophysis. The females of the new species were identified as *Draposa* by the presence of a tongue-like septum (Se) in front of epigynal cavity.

Draposa sebastiani sp. nov.
[urn:lsid:zoobank.org:act: 52753126-81E9-4158-87FB-975BA8FBF38E]
(Figs.1–3)

Holotype. A male, CATE583911a, collected from Wayanad (11°47'52.8"N, 75°59'27.6"E; alt. 1,036 m a.s.l), Kerala, India, by R.S. Abhijith on 25 April 2021.

***Paratypes* (*n*=13).** 5 males (CATE583911b–f) and 8 females (CATE583911g–n). Other collection details same as for the holotype.

Diagnosis and comparison. The male palp of *D. sebastiani* sp. nov. is similar to that of *D. lyrivulva* (Bösenberg & Strand, 1906) known from Pakistan, India and Sri Lanka, but differs by having the following set of characters: shorter tegular apophysis (vs. comparatively longer); prominent sub-apical protrusion (vs. minute); narrow and linear tegular apophysis tip (vs. curved and hook-like); embolus parallel to tegular apophysis (vs. forming an upward angle). The male copulatory organs of the new species are comparable with those of *D. atropalpis* (Gravely, 1924) and *D.oakleyi* (Gravely, 1924), but differ by having a prominent sub-apical protrusion and a gap between tegular apophysis tip and paleal apophysis (vs. sub-apical protrusion is non-prominent and paleal apophysis is partially covered by tegular apophysis; see figures 8, 10, 33 in Kronestedt 2010).

The female copulatory organs of *D. sebastiani* sp. nov. are similar to those of *D. amkhasensis* (Tikader & Malhotra, 1976), but differ by having the following set of characters: shorter tongue-like median septum (vs. septum longer and close to the base of epigynal cavity), epigynal cavity wider medially (vs. cavity narrow and completely covered by septum), copulatory duct and spermatheca closer to epigynal cavity (vs. positioned further away), stalk and head of spermatheca wider (vs. narrower); epigyne of the new species is compared to *D. atropalpis* and *D. oakleyi*, but different with the spermatheca arrangement, shape of median septum and epigynal cavity (see figures 9, 11 in Kronestedt 2010 and figures 176, 178 in Tikader & Malhotra 1980).

Description of holotype. Total length 4.10. Carapace 2.16 long, 1.64 wide. Abdomen 1.94 long, 1.33 wide. Carapace greenish brown with yellow median band originating above fovea, wider anteriorly, narrowing approaching pedicel. A dark extension of median band posterior to ocular area. Fovea longitudinal, prominent. Marginal dark stripes, represented as broken line. Lateral bands yellow, wide, clothed with recumbent white pubescence. Clypeus yellow, flanked steep without any projections. Sternum light yellow with sparse dark hairs. Ocular area with dark pubescence. A few erect white hairs present. Eyes and inter-distances. AME 0.13, ALE 0.09, PME 0.26, PLE 0.23. AME-AME 0.05, AME-ALE 0.03, PME-PME 0.31, PME-PLE 0.29. Median ocular quadrangle narrower anteriorly. Chelicerae light brown dorsally, yellow ventrally; 3 retromarginal and 3 promarginal teeth, distal most promarginal tooth non-prominent; fangs light brown, sturdy. Labium wider than long, darker base. Legs yellow, without annulation. Femur I slightly

Plate 1

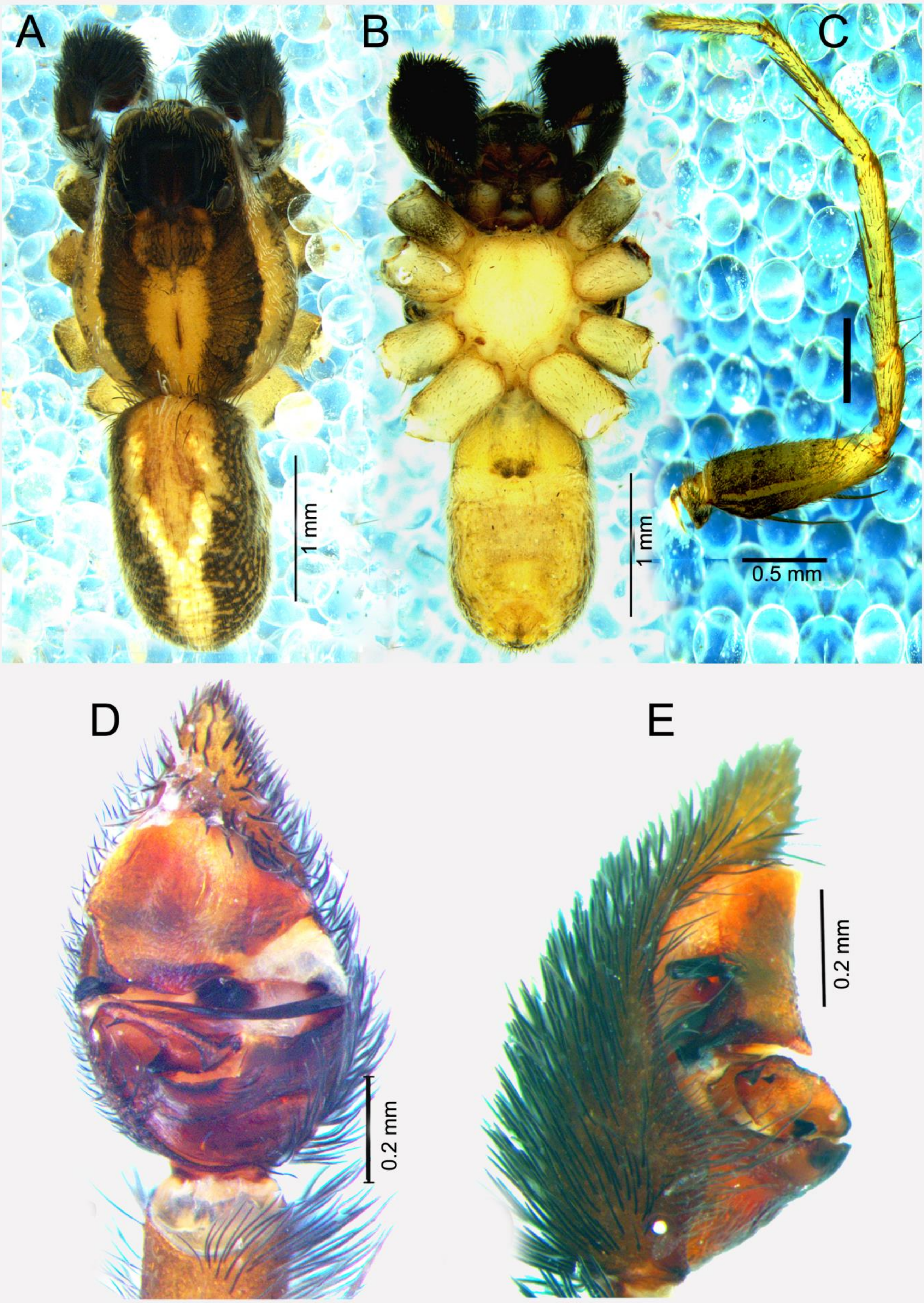


Figure 1. *Draposa sebastiani* sp. nov. holotype male: **(A)** dorsal and **(B)** ventral view of habitus, **(C)** leg, and **(D)** ventral and **(E)** retrolateral views of the palp

Plate 2

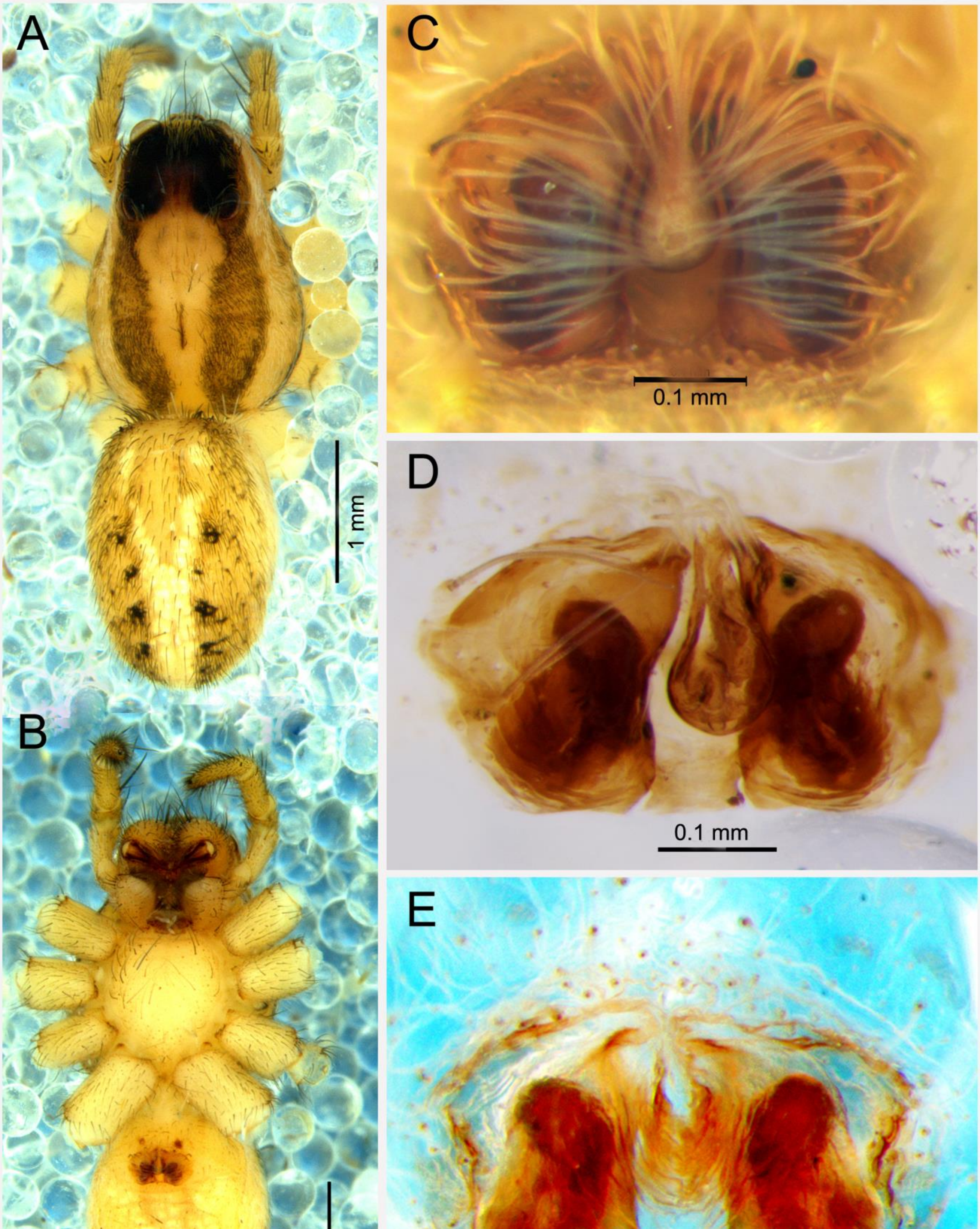


Figure 2. *Draposa sebastiani* sp. nov. paratype female: **(A)** dorsal and **(B)** ventral views of habitus; and **(C)** in-situ, **(D)** ventral, and **(E)** dorsal views of epigyne

Plate 3

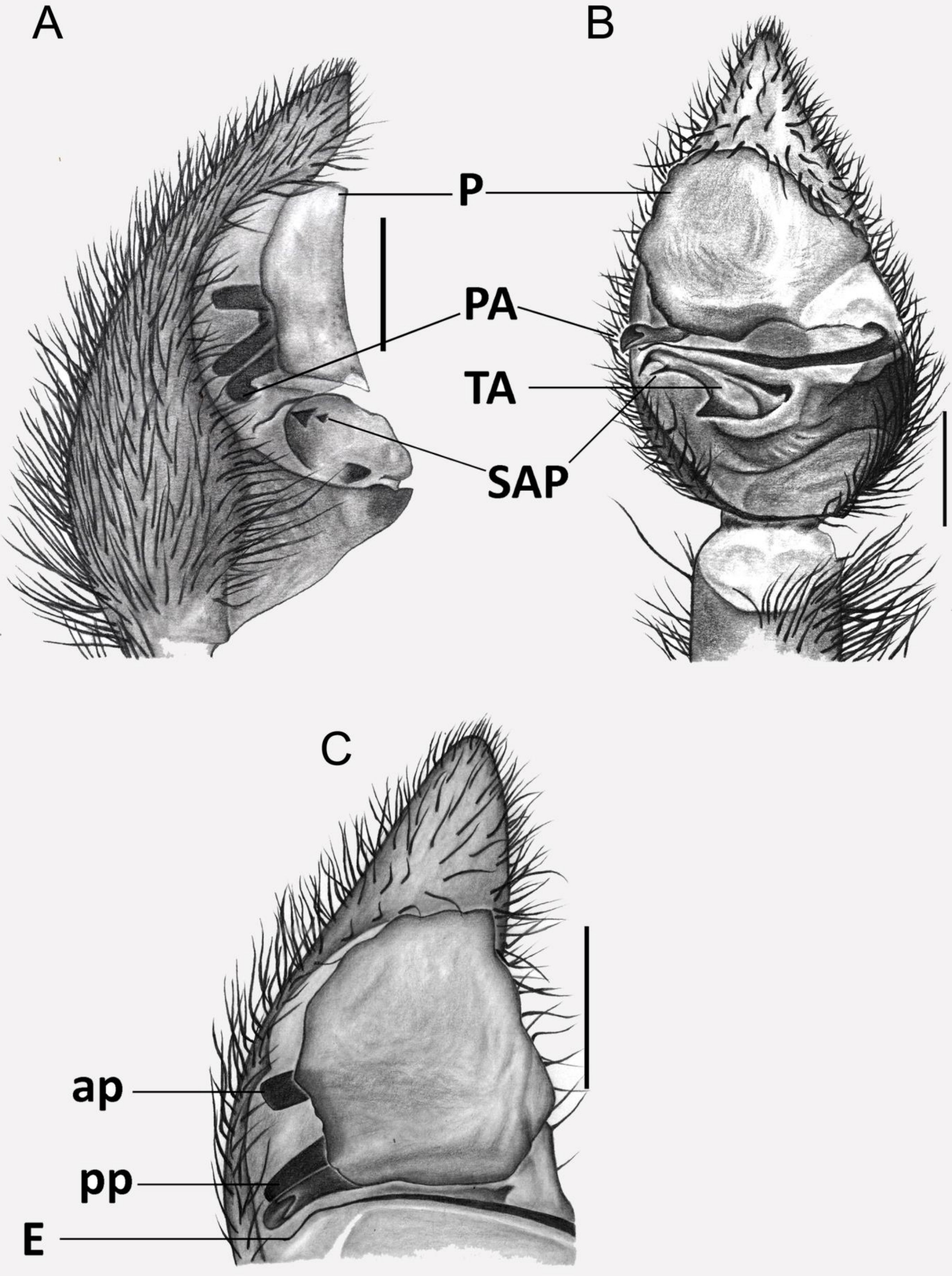


Figure 3. *Draposa sebastiani* sp. nov. holotype male: **(A)** retrolateral and **(B)** ventral views of the copulatory organ and **(C)** paleal division showing anterior and posterior process of sub-paleal sclerite; scale: 0.2 mm.

darker. Length of leg segments: I 5.16 (1.48, 0.57, 1.29, 0.97, 0.85); II 4.51 (1.56, 0.55, 0.67, 1.10, 0.63); III 4.04 (1.39, 0.41, 0.58, 1.07, 0.59); IV 7.61 (2.14, 0.70, 1.63, 2.23, 0.91). Leg formula 4123. Opisthosoma with dorsum greenish brown, distinct lanceolate spot in anterior half. Shining white guanine spots present postero-medially, recumbent and erect hairs present; ventrum light yellow. Palp. Tibia with oblique black setae patch prolaterally. Cymbium wide medially, dark with thick black hairs dorsally. Palea prominent, cone-shaped in retrolateral view. Subtegulum slightly wide positioned prolaterally. Tegular apophysis comparatively short with two well separated, downward projections medially, prominent sub-apical protrusions and tapering end. Sub-paleal sclerite with short anterior and long posterior processes. Paleal apophysis close to embolus apex. Starting of embolus wide apex filiform.

Description of paratype. Female (CATE583911g). Total length 4.47. Carapace 2.15 long, 1.54 wide. Abdomen 2.23 long, 1.52 wide. Carapace dorsum greenish brown with yellow median band widening anteriorly, behind dark ocular area. A dark extension of median band posterior to ocular area. Longitudinal fovea, shorter than in male. Marginal dark stripes non-prominent represented by discontinuous light spots. Lateral bands yellow, wider than in male. Sternum light yellow, comparatively blacker erect hairs than in males. Ocular area dark with sparse white pubescence. Eyes and inter-distances. AME 0.15, ALE 0.08, PME 0.31, PLE 0.27. AME-AME 0.04, AME-ALE 0.03, PME-PME 0.37, PME-PLE 0.31. Fangs brown. Length of leg segments: I 5.38 (1.53, 0.60, 1.35, 1.01, 0.89); II 4.61 (1.58, 0.56, 0.71, 1.11, 0.65); III 4.35 (1.48, 0.47, 0.68, 1.09, 0.63); IV 8.02 (2.25, 0.77, 1.68, 2.32, 1.00). Leg formula 4123. Opisthosoma wider, dorsum greenish brown, lighter than in male, narrower lanceolate pattern anteriorly, shining white guanocytes present. Guano pattern margined by paired dark spots. Erect dark hairs present anteriorly; ventrum light yellow, numerous white guanocytes visible posterior to epigynal plate. Posterior spinnerets larger than anterior ones. Epigyne with deep central cavity, wider medially, in front a globular 'uvula' shaped septum with short stalk extended up to middle of cavity. In ventral in-situ view spermatheca and copulatory duct appear bean-shaped. Internally spermatheca broader and positioned closer to central cavity. Bottom of epigynal central cavity extended laterally, covering entire spermatheca and copulatory duct. Copulatory duct originated near copulatory opening, turned inwards and connected to spermatheca. Fetilization duct tubular and swollen.

Etymology. The specific epithet is a noun in the singular genitive case, honouring one of the Indian arachnologists, Late Dr. Pothalil Antony Sebastian at Sacred Heart College, Kochi, India for his inestimable contributions to Indian spider taxonomy.

Distribution: Known only from the type locality (Fig. 4).

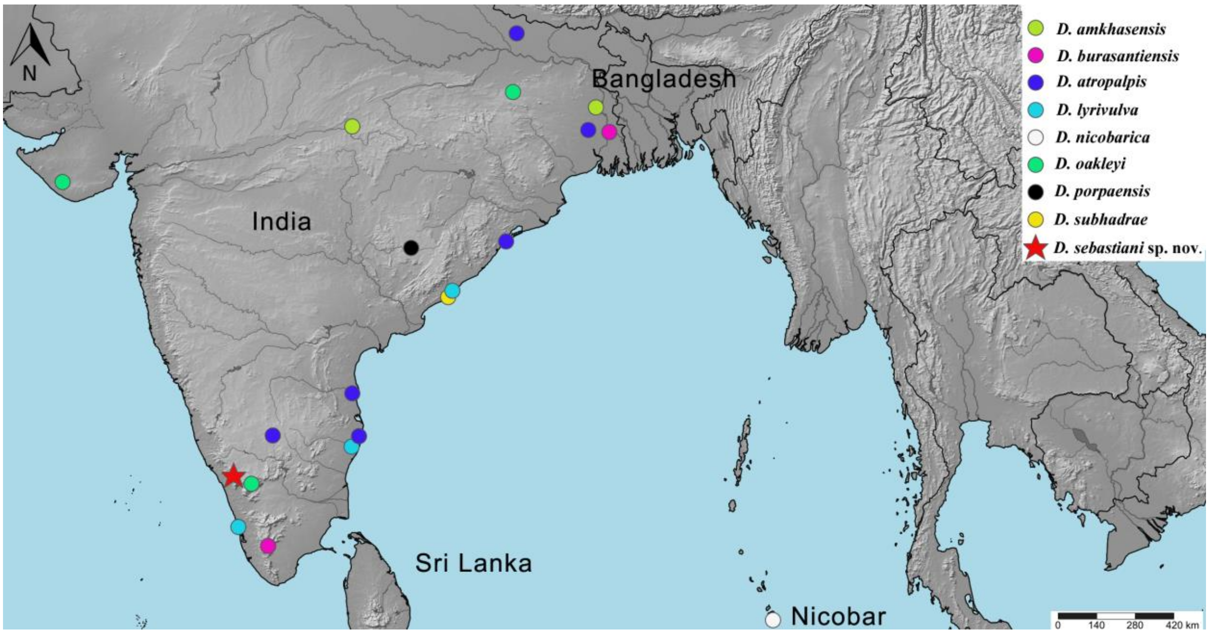


Figure 4. The current known distribution pattern of species of the genus *Draposa* in India

***Habitat and natural history*:** The mating pairs of spiders were found in grassland with a few coconut trees and patchy vegetable gardens. The grassland was adjacent to a busy road with forest on the other side. The habitat seemed to be a semi-disturbed one because of the presence of traffic and cattle grazing. The collection was done on a normal tropical summer day towards dusk.

Acknowledgements
We thank the Principal, Christ College (Autonomous), Irinjalakuda, Kerala for providing laboratory facilities and the Senior Research Fellowship [No. 08/376(0013) EMR-I/2019] of Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology, Government of India, New Delhi for funding; Souvik Sen (ZSI, Kolkata) for providing photographs of the type specimens; Kerala Forest and Wildlife department for granting research permits [No. KFDHQ/1911/2021-CWW/WL10]; DST-SERB Major Research Project EEQ/2021/000453 for the financial support; Asha T. Joy for productive discussions and supporting the illustration; and Alireza Zamani (University of Turku, Finland) for valuable comments.

Literature cited

Dhali, D.C., T.K. Roy, S. Sen *et al*. (2012). Wolf spiders (Araneae: Lycosidae) of the reserve forests of Dooars, West Bengal, India. *Munis Entomology and Zoology*, 7 (2): 1199–1213.

Koch, C. L. (1847). *Die Arachniden*, 15th Volume. J.L. Lotzbeck, Nurenberg: 136pp.

Kronestedt, T. (2010). *Draposa*, a new wolf spider genus from South and Southeast Asia (Araneae: Lycosidae). *Zootaxa*, 2637 (1): 31–54.

Murphy, N.P., V.W. Framenau, S.C. Donnellan *et al*. (2006). Phylogenetic reconstruction of the wolf spiders (Araneae: Lycosidae) using sequences from the 12S rRNA, 28S rRNA, and NADH1 genes: Implications for classification, biogeography, and the evolution of web building behavior. *Molecular Phylogenetics and Evolution*, 38 (3): 583–602.

Piacentini, L.N. and M.J. Ramírez (2019). Hunting the wolf: a molecular phylogeny of the wolf spiders (Araneae, Lycosidae). *Molecular Phylogenetics and Evolution*, 136 (1): 227–240.

Sierwald, P. (2000). Description of the male of *Sosippus placidus*, with notes on the subfamily Sosippinae (Araneae, Lycosidae). *Journal of Arachnology*, 28 (2): 133–140.

Tikader, B.K. and M.S. Malhotra (1980). Lycosidae (wolf-spiders). *Fauna India (Araneae)*, 1 (1): 248–447.

WSC (2022). World Spider Catalog, version 23.0 <http://wsc.nmbe.ch> Accessed on 12 May 2022.

Zyuzin, A.A. (1985). Generic and subfamilial criteria in the systematics of the spider family Lycosidae (Aranei), with the description of a new genus and two new subfamilies. *Trudy Zoologicheskogo Instituta Akademii Nauk SSSR, Leningrad*, 139 (1): 40–51.

Published date: 10 May 2023

TRAVAUX DU MUSÉUM NATIONAL D'HISTOIRE NATURELLE «GRIGORE ANTIPA»
THE JOURNAL OF "GRIGORE ANTIPA" NATIONAL MUSEUM OF NATURAL HISTORY

Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 67 (2): 173–181 (2024)
doi: 10.3897/travaux.67.e101496

RESEARCH ARTICLE

A new wolf spider species of *Wadicosa* (Araneae, Lycosidae) from Western Ghats of India

Raveendran Sudha Abhijith[1], Ambalaparambil Vasu Sudhikumar[1]

1 *Centre for Animal Taxonomy and Ecology (CATE), Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala, India-680125, Affiliated to University of Calicut, Kerala*

Corresponding author: *Ambalaparambil Vasu Sudhikumar* (spidersudhi@gmail.com)

Received 4 February 2023 | Accepted 20 March 2024 | Published 31 December 2024

Citation: Abhijith RS, Sudhikumar AV (2024) A new wolf spider species of *Wadicosa* (Araneae, Lycosidae) from Western Ghats of India. Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 67(2): 173–181. https://doi.org/10.3897/travaux.67.e101496

Abstract
The new wolf spider species *Wadicosa intermediata sp. n.* belongs *to W. quadrifera* species-group is described based on both sexes collected from Idukki district of Kerala, southern India.

Keywords
Kerala, Species group, Systematics, Taxonomy

Introduction

The lycosid subfamily Wadicosinae was erected by Zyuzin in 1985 with a monotypic member *Wadicosa* Zyuzin, 1985 as its only member (Zyuzin 1985). Later the subfamily found to be a junior synonym of subfamily Pardosinae (Piacentini & Ramirez 2019). The genus *Wadicosa* currently includes 17 species of which 4 have been reported from India (WSC 2023). Genus *Wadicosa* shows close resemblance to genus *Pardosa* C.L. Koch, 1847. Most of the current *Wadicosa* species were originally described in *Pardosa* (Ahmed et al. 2014). There may several species of *Wadicosa* still be misplaced in genus *Pardosa* (Kronestedt 2023). So far, three species-groups have been recognized in *Wadicosa*, viz. fidelis-group, manubriata-group and quadrifera-group (Kronestedt 2023). The new species is grouped under the *quadrifera*-species group (Kronestedt 2017) with two Indian species *W. quadrifera* (Gravely, 1924) and *W.*

ghatica Kronestedt, 2017. Male individuals of this species group are distinctive by cork-screw shaped embolus and the configuration of tegular apophysis and conductor (Kronestedt 2017). *W. intermediata sp.n.* described based on material of both sexes collected in southern India also possess the unique characters of *quadrifera*- group along with subtle differences that can be used to classify them as a new species. The specimens were found on rocky area with patched vegetation, where they were well camouflaged.

Materials and Methods

All specimens were collected by hand picking method and preserved in 70% ethanol and studied, photographed and measured using a Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver.4.13). The epigyne was dissected and cleared in 10% potassium hydroxide (KOH) solution. The Male palp was detached and photographed. Ocular measurements were taken from the dorsal side. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). All measurements are given in millimetres (mm). Type specimens are stored in Centre for Animal Taxonomy and Ecology, Department of Zoology, Christ College, Irinjalakuda, Thrissur, Kerala, India.

Abbreviations used in the main text are: **ALE** = anterior lateral eye, **AME** = anterior median eye, ***Cr*** = conductor, **CD** = copulatory duct, **CO** = copulatory opening, **E** = embolus, **MOQ** = median ocular quadrangle, **P** = palea, **PLE** = posterior lateral eye, **PME** = posterior median eye, **PMQ** = posterior median quadrangular depression, **S** = spermathecae, **SS** = septal stem, **TA** = tegular apophysis, **TR**= tegular retrolateral process.

Results & Discussion

Taxonomic Accounts
Lycosidae Sundevall, 1833
Wadicosa Zyuzin, 1985
Wadicosa quadrifera-species group

Wadicosa intermediata *sp. n.*
Figs 1 A–E, 2 A–D, 3 A–B, 4 A–B

Etymology***:*** The specific epithet refers to the intermediate condition of the epigyne, as it possesses features of both *W. ghatica* and *W. quadrifera.*

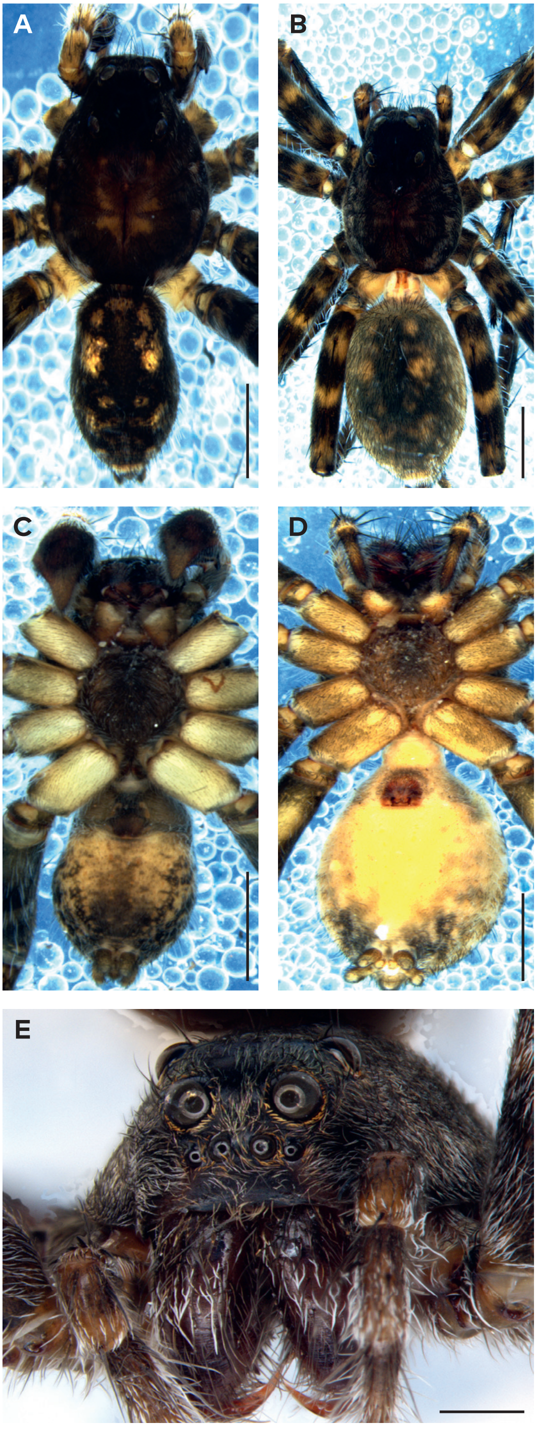


Figure 1. *Wadicosa intermediata sp. n.*, holotype male (**A**, **C**) and paratype female (**B**, **D**, **E**) habitus: **A**–**B** dorsal view **C**–**D** ventral view **E** frontal view. Scale bars: **A**–**D** = 1mm; **E** = 0.5mm.

Type Materials: INDIA• 2♂, 1♀; Kottappara, Idukki, Kerala;10˚1. 38' N, 76˚58. 11' E; 2194 m a.s.l; 15 October. 2021; R.S. Abhijith leg.; **Holotype**: • 1♂ CATE591225a, **Paratypes**: • 1♂ 1♀ CATE591225b.

Distribution**:** The species is only recorded from the type locality, Kottappara, Idukki, India (Fig. 5).

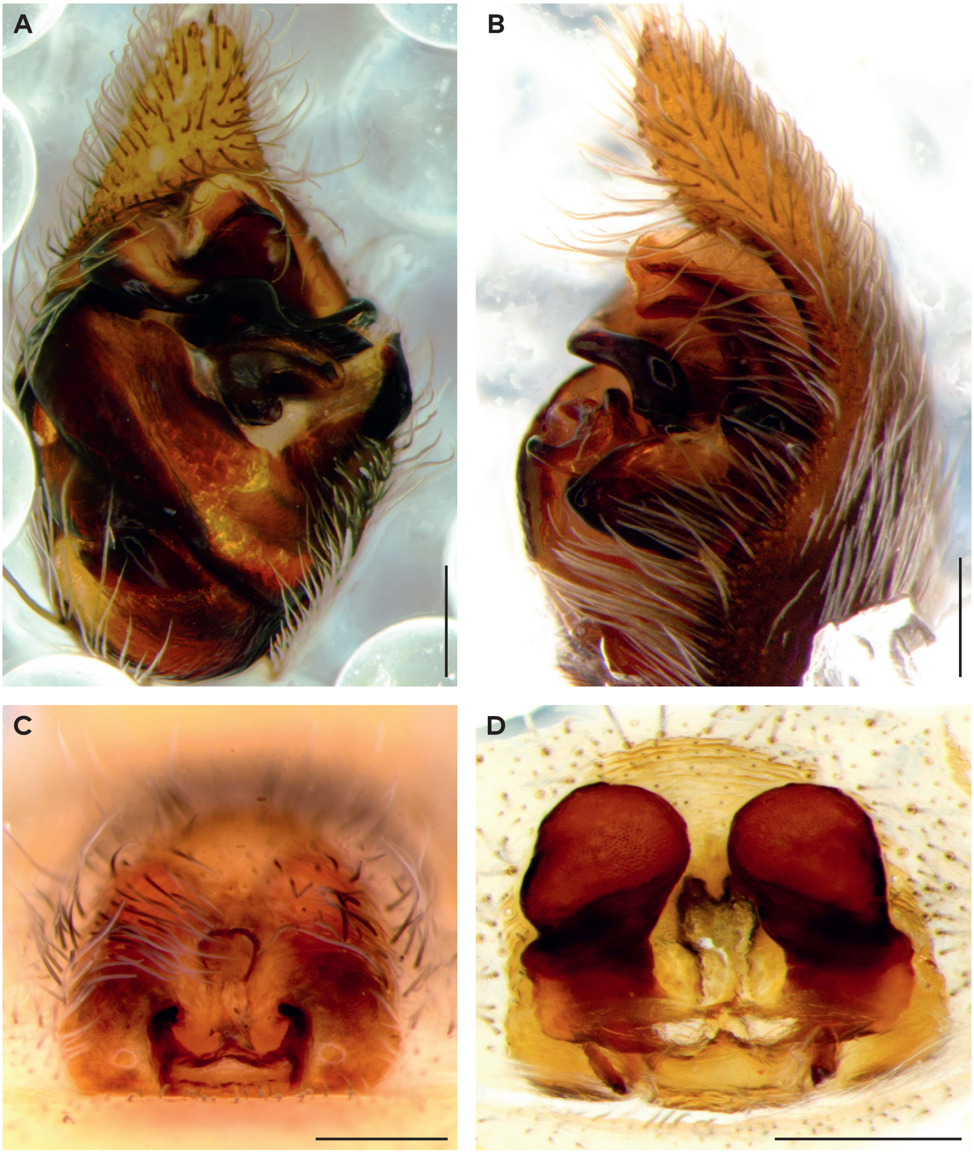


Figure 2. *Wadicosa intermediata sp. n.*, copulatory organs: **A** male palp ventral view **B** same reterolateral view **C** epigyne in-situ view **D** same cleared dorsal view. Scale bars = 0.1 mm.

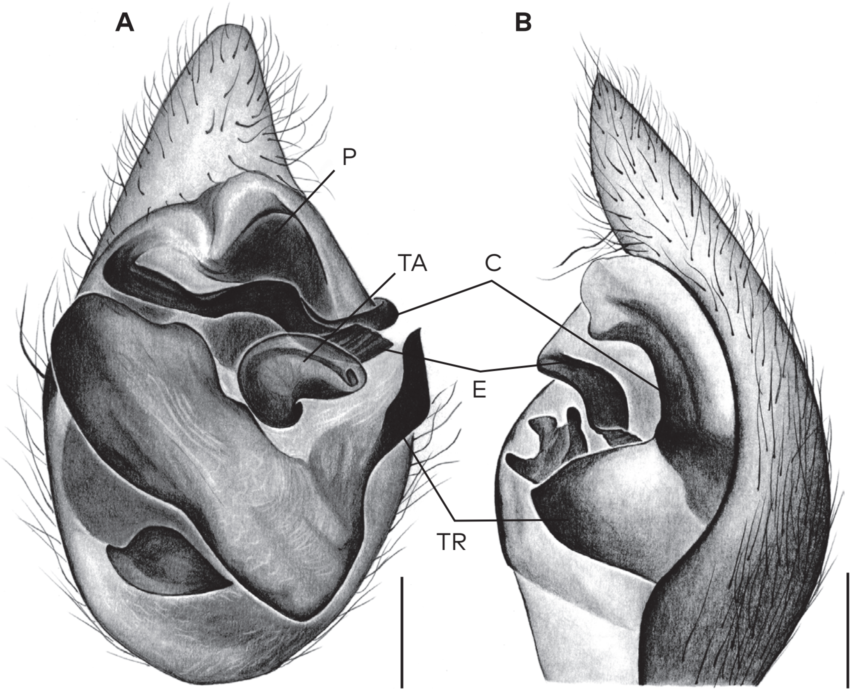


Figure 3. *Wadicosa intermediata sp. n.*, male palp: **A** ventral view **B** retrolateral view. Scale bars = 0.1mm.

Diagnosis*:* Males identified as members of genus *Wadicosa* by tegulum with anterior retrolateral process pointing ventrad; palea apical to conductor and embolus. Females identified as genus *Wadicosa* by epigyne with two less separated foveolae.

Male palp more similar to *W. ghatica*, but differs by following set of characters, embolus with conspicuous medial bulging and pointed tip (no such bulging and blunter tip in *W. ghatica*); noticable gap between embolus tip and tegular retrolateral process (no gap in *W. ghatica*); tegular reterolateral process blunter (more pointed in *W. ghatica*). The female epigyne more similar to *W. ghatica* but, differs by, posterior median quadrangular depression much broader than long (almost wide as long in *W. ghatica*) and sclerotized finger-like extension of copulatory duct (no such extension in *W. ghatica*).

Description

Male (Holotype). Habitus as in Fig. 1A, C: Total length 5.51. Carapace 3.12 long, 2.84 wide. Abdomen 2.31 long, 2.12 wide. Cephalothorax: Carapace brown with lighter area around fovea. Lateral bands discontinuous and indistinct. Lateral and posterior thoracic area with white recumbent hairs, rest of the carapace with numerous short dark hairs. Clypeus 0.35 long, black, without any projection. Labium wider

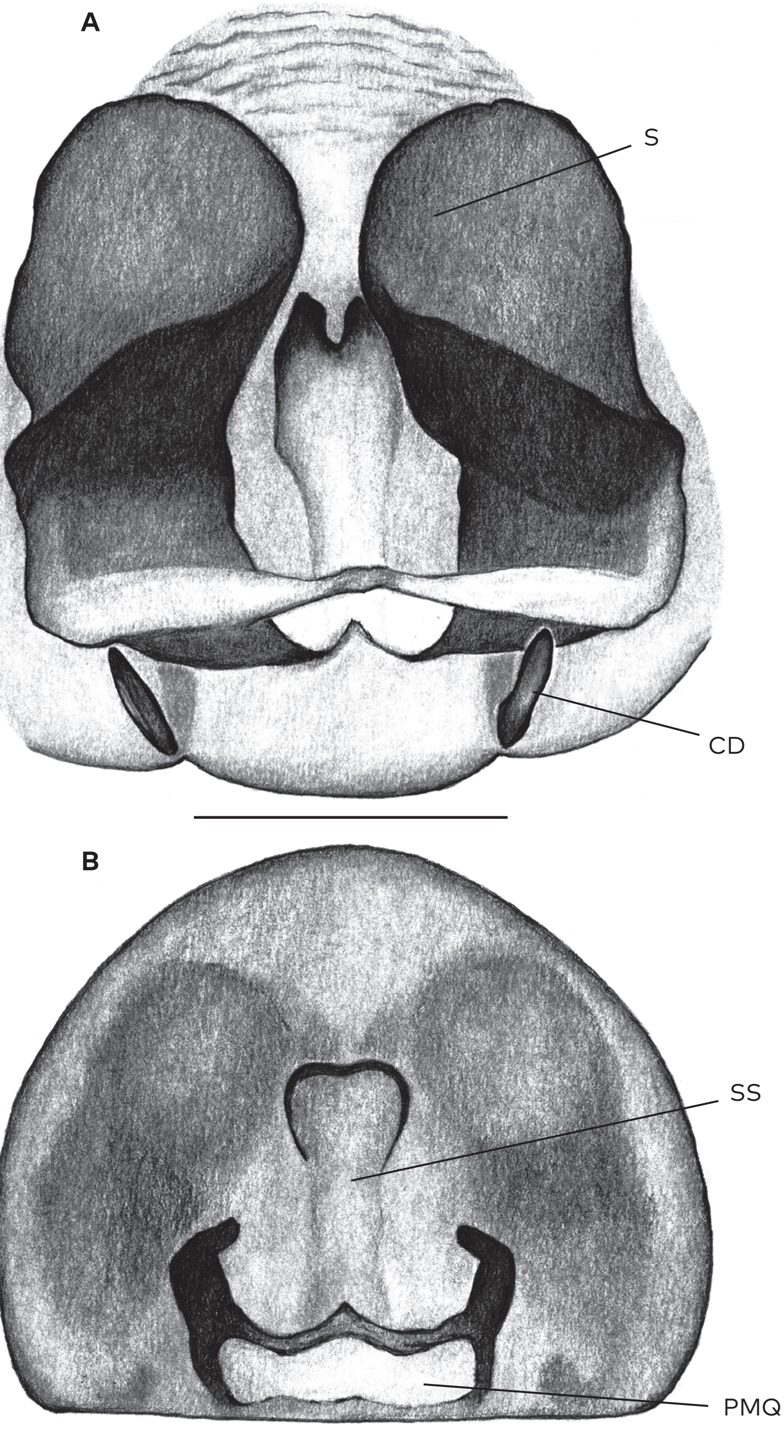


Figure 4. *Wadicosa intermediata sp. n.*, female epigyne: **A** ventral view **B** dorsal view. Scale bars = 0.1mm.

than long, darker posteriorly. Chelicera 1.25 long, brown with 3 retrolateral teeth. Sternum black with numerous hairs. Eye diameters and inter-distances: AME 0.18, ALE 0.11, PME 0.29, PLE 0.28. AME–AME 0.14, AME–ALE 0.08, PME–PME 0.36, PME–PLE 0.22, PME–AME 0.12. MOQ narrower anteriorly. Abdomen dorsum same colour as carapace. Lanceolate stripe obscure, dark brown. Shiny yellow dots and patches present. Short, black erect hairs present. Venter yellowish with a distinct black marking anteriorly. Legs are yellowish with wide, dark grey annulations. Coxae light yellow. Leg length: I 7.02 (2.33, 2.67, 1.41, 0.61); II 7.43 (2.27, 2.31, 1.66, 1.19); III 6.55 (2.17, 2.98, 0.71, 0.69); IV 10.72 (3.11, 3.13, 2.91, 1.57). Leg formula 4213. Palp as in figs. 2A–B, 3A–B: Cymbium darker than rest of the palp. White pubescent present. Tegular apophysis crescent-shaped with anteriorly pointed, ventrally curved, narrow upper process and wide, blunt basal process. Embolus cork screw- shaped, bearing a conspicuous bulging medially with pointed tip. Anterior part of tegulum with blunt ended, triangle shaped retrolateral process projecting ventrad. A gap present between embolus tip and retrolateral process. Conductor sclerotized and dorsally curved. Palea (partially membranous part of tegulum) partially sclerotized, positioned anterior to embolus and conductor. Subtegulum positioned prolaterally.

Female (Paratype). Figs. as in 1B, D: Total length 6.62. Carapace 3.11 long, 2.54 wide. Abdomen 3.13 long, 2.52 wide. Cephalothorax: Carapace same colour as in males, but lighter area around fovea indistinct. Lateral margin with white pubescent. Clypeus 0.38 long, black without any projection. Labium wider than longer, darker posteriorly. Chelicera 1.27 long, brown with 3 retrolateral teeth. Sternum light brown with dark pubescent. Eye diameters and inter-distances (Fig 1E): AME 0.20, ALE 0.14, PME 0.31, PLE 0.29. AME–AME 0.16, AME–ALE 0.09, PME–PME 0.39, PME–PLE 0.25,

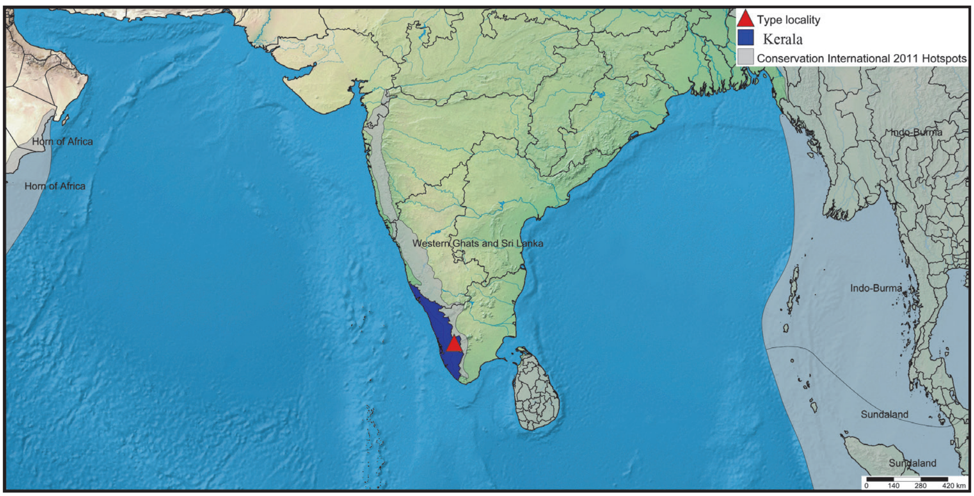


Figure 5. Type locality (Kottapara, Idukki, Kerala, India) of *W. intermediata sp. n.*

PME–AME 0.14. MOQ narrower anteriorly. Abdomen dorsum light brown with inconspicuous yellow spots. Dark and white erect hairs present. Venter yellow with black scattered markings. Legs: Colouration and annulation as in male. Leg length: I 7.68 (2.43, 2.88, 1.62, 0.75); II 8.33 (2.56, 2.56, 1.97, 1.24); III 7.23 (2.29, 3.15, 0.97, 0.82); IV 11.53 (3.22, 3.17, 3.42, 1.72). Leg formula 4213. Epigyne as in figs. 2C–D, 4A–B: Ventral view of epigyne with a PMQ depression which is much wider than long. Median septum with long septal stem, anteriorly with two close pockets (foveolae) forming almost continuous arch. Vulva with bulbous spermathecae. Copulatory duct with sclerotized finger-like projections near copulatory opening. Dorsally septal arch with two well separated lobes.

Discussion

The new species is the latest member of W. *quadrifera*- species group. Even though, this grouping has no taxon status currently, more findings in future may led to it. Males differ from other *Wadicosa* species except *W. quadrifera* and *W. ghatica* having a cork-screw shaped embolus. The female epigyne is characterized by features of both *W. ghatica* and *W. quadrifera*. The dorsal view of septal arch resembles that of *W. quadrifera*, but the shape of the septal pockets (foveolae) similar to that of *W. ghatica*. A connecting structure is present between spermathecae as in *W. ghatica*. Apart from these, the median quadrangular depression and finger like structures near CO are unique to this new species. The distribution of these three species is continuous and overlapping, suggesting that they are closely related taxa with recent evolutionary divergence. [compare figures, 1–8 of Kronestedt (2017)]

Acknowledgements

The authors express deepest gratitude to Principal, Christ College (Autonomous), Irinjalakuda, Kerala affiliated to University of Calicut for providing laboratory facilities and first author is especially thankful to Senior Research Fellowship [08/376(0013)EMR-1/2019] of Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology, Government of India, New Delhi for funding the research. We are expressing our gratitude to Kerala Forest and Wildlife department for granting field work permission [KFDHQ/1911/2021-CWW/WL10] in protected areas. Authors also acknowledge the funding rendered by DST-SERB Major Research Project EEQ/2021/000453, for the facilities used in the study. We are grateful to all co-researchers especially Ms. Asha T Joy in CATE lab for their moral support and illustration.

References

Ahmed M, Anam J, Saikia MK, Manthen SV, Saikia PK (2014) New records spider species under *Wadicosa* genus (Sub-order: Araneae; Family: Lycosidae) from agricultural field of Sonitpur District, Assam, India. Journal on New Biological Reports 3(1): 60–65.

Gravely FH (1924) Some Indian spiders of the family Lycosidae. Records of the Indian Museum, Calcutta 26(1): 587–613.

Kronestedt T (2017) Species of *Wadicosa* (Araneae, Lycosidae): a new species close to *W. quadrifera* (Gravely) from the Western Ghats, India. Zootaxa 4300(2): 295–300.

Kronestedt T (2023) Species of *Wadicosa* (Araneae, Lycosidae): transfer of four species from Africa currently placed in *Pardosa*. Zootaxa 5227(5): 531–548.

Piacentini LN, Ramírez MJ (2019) Hunting the wolf: a molecular phylogeny of the wolf spiders (Araneae, Lycosidae). Molecular Phylogenetics and Evolution 136. 227–240.

World Spider Catalog (2022) World Spider Catalog: Version 23.0: Natural History Museum Bern http://wsc.nmbe.ch/

Zyuzin AA (1985) Generic and subfamilial criteria in the systematics of the spider family Lycosidae (Aranei), with the description of a new genus and two new subfamilies. Trudy Zoologicheskogo Instituta Akademii Nauk SSSR, Leningrad 139: 40–51.

Proceedings of the International Seminar:

Biodiversity Conservation & Climate Change

03-04 January 2020

ISBN No. 979-8-5938-6048-4

PG & RESEARCH DEPARMENT OF ZOOLOGY,

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI,

CALICUT, KERALA, INDIA

Funded by Rashtriya Uchchatar Shiksha Abhiyan (RUSA), Govt. of India

MOLECULAR TAXONOMY OF WOLF SPIDERS (ARANEAE: LYCOSIDAE) - CURRENT STATUS

Abhijith R.S.* and Sudhikumar A.V.

Centre for Animal Taxonomy and Ecology, Department of Zoology, Christ College, Irinjalakuda, Kerala-680125

*abhijithrsabhiramam@gmail.com

ABSTRACT

Taxonomy the science of classification never loses its importance in the scientific research as it can be considered as the mother of all applied research happening in the field of biology. Morphological or classical taxonomy is a very well-established field, still it has some demerits which led to misidentification and associated anomalies. Morphological taxonomy of spiders has many challenges because of the presence of sexual dimorphism, polymorphism and lack of taxonomic keys for juveniles. This results in various wrong interpretations in the field which need to be rectified. It's not defaming classical morphological taxonomy, rather than that usage of novel technologies and additional helping tools will aid in resolving taxonomic ambiguities. The collaboration of morphological taxonomy and molecular biology already showed its charisma in the taxonomic field. Extensive usage of the same will soon result in a much clearer; mush easier taxonomic identification and thereby increasing the chance to find novel applications. Wolf spiders constitute the fourth largest spider family, with 2443 species described in 124 genera. They pursue an array of different prey capture strategies, from permanently vagrant hunters to permanently ` going.

Keywords: wolf spider, lycosidae, morphological taxonomy, sexual dimorphism, polymorphism

INTRODUCTION

Each organism in the biota is essential for the maintenance of the ecosystem. We humans may categorize them more and less beneficial according to anthropocentric perspective. Truly we cannot make such a distinction. As stated in the butterfly effect of Chaos theory, the extinctions caused by us in the environment may lead to massive destruction. Here comes the importance of taxonomy, the science of identification and classification of organisms. These studies are needed to make quantitative data for the organisms and make realize the human about the degree of destruction he makes.

Spiders can be seen as the main predators in most of the ecosystems. Spiders are one of the abundant insectivorous predators of terrestrial ecosystems (Nyffeler & Benz, 1987; Wise, 1993). They have been reported to occur in peak numbers of more than 1,000 individuals per m2 (Nyfeller & Birkhofer, 2017). Not only abundant, but they are one of the most diverse arthropod orders, with diverse species and exhibit a great variety of foraging strategies (Coddington & Levi, 1991; Foelix, 1996). The various foraging strategies can be attributed to better predatory control of insects and ecological importance. Because of their high abundance and insectivorous feeding habits, spiders are expected to play an important role in the balance of nature (Whitcomb, 1974; Gertsch, 1979; Young & Edwards, 1990; Wise, 1993; Nyffeler et al., 1994a, b). In agro-ecosystems also they play an immense role as natural predators of insect pests.

Lycosidae, wolf spiders constitute the fourth largest spider family, with 2443 species described in 124 genera (World Spider Catalog, 2020). Their adult body size ranges from 1 to 30 mm. They pursue an array of different prey capture strategies, from permanently vagrant hunters to permanently burrowing species, and some genera are known to build permanent sheet-webs (Murphy et al., 2006). Wolf spiders may also show very specific microhabitat preferences and may be susceptible to changes in habitat structure (Jogar et al., 2004; Marshall &

Rypstra, 1999). This ecological diversity may make them suitable for control of a wide variety of insect pests. They also manifest an immense role in the food web and maintain the decorum of the ecosystem. Climate change and global warming have influential effects on the behaviour and ecology of lycosids. It is found that some of the wolf spider species start to increase its foraging quantity to maintain body moisture during increasing ambient temperature. Another important aspect of spiders is spider silk and its immense applications. (Vendrely & Scheibel, 2007) Another promising field of research is spider venom therapeutics. Most spider venoms are dominated by disulfide-rich peptides that typically have high affinity and specificity for particular subtypes of ion channels and receptors (Saez et al., 2010). Researches on spider silk and venom along with ecological and phylogenetic studies will gain much importance in research scenario due to its direct application to mankind. These may make the spider more charismatic to the general public and led to the avoidance of unwanted killing and destruction of habitat. To make all these possible, initially taxonomy of the taxa should be done. Developments and lack of confusions in the taxonomic field will aid in the betterment of applied research.

Morphological taxonomy or classical taxonomy is a very well established field and never loses its importance in the field of biodiversity. Still sole reliability on the morphology can led to the misidentification, results in synonymy. Aid of molecular techniques can somewhat overcome the problem and help the classical taxonomy to reach a newer height of increased credibility. In India the use of molecular taxonomy is still coping up the pace. Initially DNA based taxonomy was much costlier than classical taxonomy. Now a lot of optimisations are happening so that costs will reduce, but, still it is costlier than traditional taxonomy. But the benefits of molecular taxonomy outweigh the cost. Molecular taxonomy utilizes various molecular markers for the creation of molecular barcodes. Cytochrome oxidase subunit 1 (COI) is considered to be the best and hence widely used molecular marker. Many other molecular markers are in use. As same as a normal barcode uniquely defines a product, a molecular barcode can represent a whole organism. This concept already positively altered the taxonomic viewpoint. Still, a lot of species are unknown. It is the duty of taxonomists to identify them and report them to the scientific world before them extinct from the biosphere.

Current status of molecular taxonomy of spiders especially lycosids in India is not appreciable. Compared to many other countries the entries from India is much lesser. Recently most of the taxonomists are showing interests in addition to molecular techniques along with classical approach. So it is evident that in the near future the contribution from India to BOLD systems will increase in alarming rate molecular techniques along with classical approach. So it is evident that in the near future the contribution from India to BOLD systems will increase in an alarming rate.

METHODOLOGY

The data about molecular taxonomy of lycosids are mined from Barcode of Life Database (BOLD Systems) http://www.boldsystems.org/. BOLD is a cloud-based data storage and analysis platform developed at the Centre for Biodiversity Genomics in Canada. It consists of four main modules, a data portal, an educational portal, a registry of BINs (putative species), and a data collection and analysis workbench. As BOLD Systems include molecular data from GenBank and other sources, it can act as a authenticate source of organisms' molecular barcodes.

RESULT

In Barcode of Life Database (BOLD) 10,153 molecular entries with Lycosidae species name are found which encompasses 375lycosid species. Molecular data of specimens from 53 countries deposited in 60 institutions are present. *Pardosa moesta* is the most represented lycosid in BOLD with 929 entries followed by *Alopecosa aculeate* with 499 entries, 375 unspecified and *Pardosa mackenziana* with 332 entries (Fig. 1). In the case of genera *Pardosa* is the most represented followed by *Alopecosa*, *Piratula* and *Trochosa*. Canada mostly contributed to the data contribution followed by United States, Germany and Pakistan (Fig. 2). In India, a

ISBN No. 979-8-5938-6048-4

mega biodiversity country only 10 published lycosid records with barcode are being submitted in the BOLD Systems which include six lycosid species. **Hippasa greenalliae, Hippasa madraspatana, Lycosa bistriata, Pardosa birmanica, Pardosa paludicola and Wadicosa fidelis are the lycosid species represented in the database.**

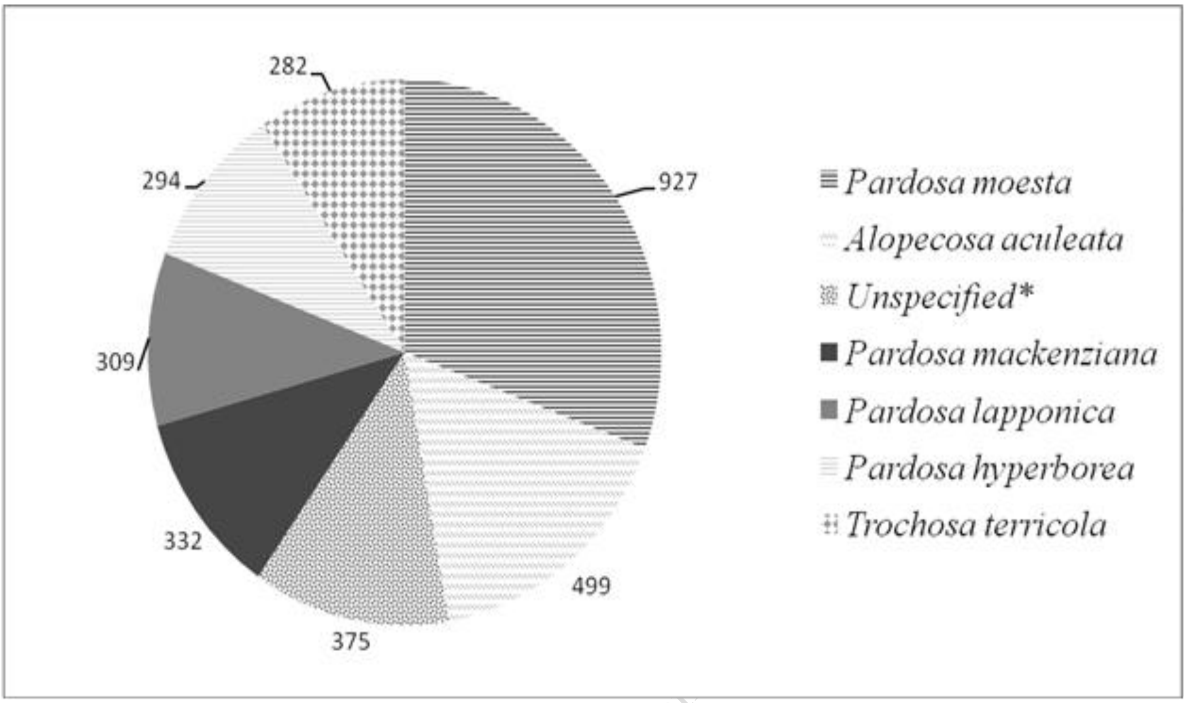


Figure 1. Pie diagram showing the most represented lycosids in BOLD systems

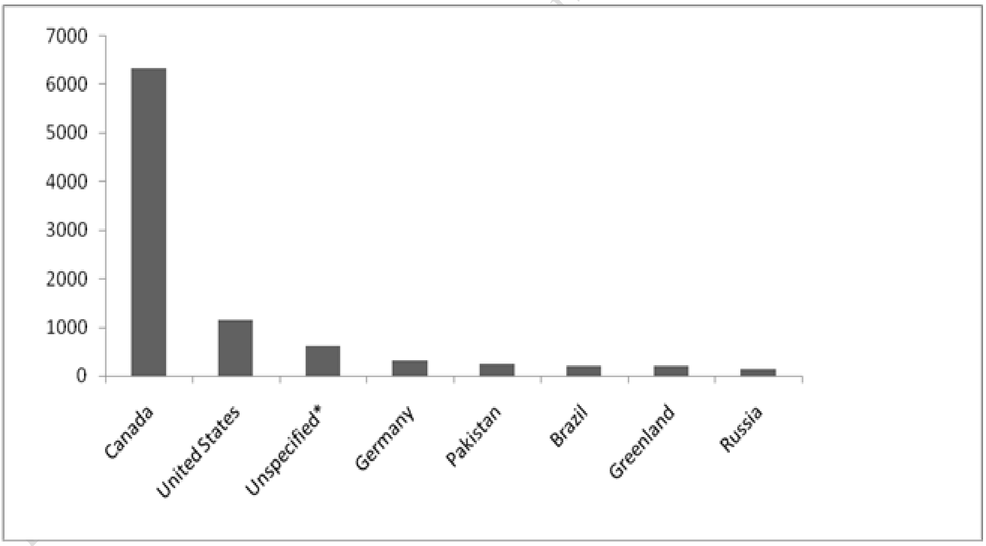


Figure 2. Bar diagram showing the contribution of various countries to lycosid molecular database in BOLD Systems

DISCUSSION

Various classical taxonomic works on lycosids can be traced from 18th century onwards. Works in lycosids using modern techniques can be traced back to 1982 when Elliot et al. examined allozymic variation in nine protein producing loci was examined in three species of *Pardosa* using starch gel electrophoresis.

ISBN No. 979-8-5938-6048-4

They published study as genetic variation among three species of *Pardosa*. The pioneering works of molecular taxonomy with phylogeny of lycosids were done by Zehethofer & Sturmbauer in 1998. They analysed mitochondrial 12 S rRNA of ribosomal small subunit of 27 lycosid species from Central European region. Monophyly of the lycosids was concluded during phylogenetic works using high bootstrap value. Through this study, they also concluded that tube builders are the most ancestral among lycosids.

The molecular phylogeny of lycosids in New Zealand and Australia were studied in the early 21st century. This study utilized data from nuclear gene NADH Dehydrogenase subunit 1 (ND1) and mitochondrial genes Cytochrome C oxidase subunit 1(CO1) and 12 S rRNA gene. These data were combined with molecular data of Asian, European and North American lycosids to perform phylogeny studies. Studied confirmed that Australasian species form distinct clade from other groups. The studies also revealed the utility of 12 rRNA gene data for examining closely related genera and its limitation to study deeper generic relationships. (Vink *et al.,* 2002)

Murphy et al. in 2006 studied lycosid molecular data from Africa, Asia and Neotropics using 28 rRNA, 12 S rRNA and ND1 as molecular markers. Along with Parsimony analysis, they also utilized Bayesian analysis for phylogenetic studies. They were skeptical about the usage of 28 rRNA as its results gave implausible results and omitted it from the final analysis. They also sequenced paralogous copies of the gene and suggested a cautionary approach for its further usage in lycosid phylogeny. Dimitrov *et al.* in 2017 reinstated the usage of this marker in studies of ecribillate spiders. But, as Murphy questioned the credibility of 28S marker specifically in lycosids, it will be better to use other markers in lycosids until further modifications in 28S rRNA analysis.

Systematics of the new Australian wolf spider genus *Tuberculosa* was done by Framenau & Yoo in 2006. Although the study was based on morphological data, phylogenetic analysis was performed on four *Tuberculosa* species based on 12 morphological characters. Various evolutionary data in the *Tuberculosa* genus were revealed.

The molecular phylogenetic relationships of *Wadicosa* in Chinese wolf spiders. Mitochondrial 16S rRNA gene sequence was utilized to analyze 26 species from 6 genera of Lycosidae. Bayesian and Maximum parsimony analyses were used for phylogenetic analysis. The results indicated that *Wadicosa* has the closest phylogenetic relationship with *Pardosa*. *Pardosa* and *Wadicosa* form a monophyletic group. They suggested the merging of *Pardosa* and *Wadicosa* to a subfamily (Yan and Yan, 2007).

In 2015 studied taxonomy and total evidence analysis of the phylogenetic relationships of Lycosoidea spiders. The study was so extensive, which include molecular and morphological data from 7 families in Lycosoidea superfamily. The morphological–behavioural matrix comprised 96 characters, and four gene fragments were used: 28S (~737 base pairs), actin (~371 base pairs), COI (~630 base pairs) and H3 (~354 base pairs). Monophyly of the Lycosidae family and evolution of grate shaped tapetum concluded in the study (Polotow *et al.*, 2015).

The molecular phylogenetic analyses to show that Trechaleidae and Lycosidaeare sister groups were done by Albo *et al.* in 2017. Based on morphological and behavioural studies contradictory findings on evolutionary relationships were obtained. So they have done the molecular phylogeny using five mitochondrial and three nuclear genes to conclude. This study shows the importance of molecular data in taxonomy and phylogeny.

The morphological and ecological phylogeny of halotolerant wolf spider genus *Tetralycosa* in Australia was also studied. A phylogenetic analysis of the genus identified a monophyletic clade of eight species that live permanently on the barren surface of salt lakes suggesting single radiation into this extremely inhospitable habitat. Many of the species in them are highly specialized to inhabit only a single salt lake which increases the importance of protecting the ecosystem also (Framenau & Hudson, 2017).

In 2018 Pavel and his co-workers studied molecular taxonomy and phylogeny of

Alopecosa genus from Central Europe to compare it with reproductive behaviour. They sequenced one mitochondrial (COI) and two nuclear genes (28S, H3) to reconstruct their phylogenetic relationships. The results of the phylogenetic analyses were largely incompatible with classical morphology based grouping. The monophyly of *Alopecosa* could not be recovered by the study. Both Bayesian inference and Maximum Likelihood were conducted. In both the genus showed to split into two different clades.

CONCLUSION

The molecular taxonomy of organisms are growing at a rapid pace. In almost all taxa molecular techniques are also being used along with morphological characteristics. In many countries taxonomic papers solely rely on molecular data are being published. But it is doubtful that whether the molecular technology is hundred percentage error proof to completely avoid morphological data. May be in near future itself molecular technologies will be efficient enough to do so. Many ambiguities in taxonomy, once taxonomists' nightmare are now fading away. In Barcode of Life Database (BOLD) 9982 molecular entries with Lycosidae species name are found which encompasses 374 lycosid species. Molecular data of specimens from 53 countries deposited in 60 institutions are present. Still contributions from many developing countries are very sparse. The real aim of taxonomy came into true only when data from entire world is collaborated together. Humans have a tendency they would not harm anything under two conditions. Either they have to study it or fear it. Earlier humans had fear towards nature, but now science and technology reduced that fear. So only way to make him protect the environment is make him study about its components and importance. Taxonomists all around the world are doing this work. Molecular techniques will make this process speedy and error proof.

ACKNOWLEDGEMENTS

The authors are extremely grateful to The Principal, Christ College, Irinjalakuda, Thrissur for support and Council for Scientific & Industrial Research, New Delhi for funding.

REFERENCES

Albo, M. J., Bidegaray-Batista, L., Bechsgaard, J., da Silva, E. L. C., Bilde, T., & Pérez-Miles, F. (2017). Molecular phylogenetic analyses show that Trechaleidae and Lycosidae are sister groups. *Arachnology*, *17*(4), 169-177.

Boldsystems.org. (2019). *Bold Systems v4*. [online] Available at: http: // www .boldsystems .org /index.php/Public_SearchTerms [Accessed on January 11, 2020].

Coddington, J. A. & Levi, H. W. (1991).Systematics and evolution of spiders (Araneae). A. Rev. Ecol. Syst. 22: 565-592.

Dimitrov, D., Benavides, L. R., Arnedo, M. A., Giribet, G., Griswold, C. E., Scharff, N., &Hormiga, G. (2017). Rounding up the usual suspects: a standard target gene approach for resolving the interfamilial phylogenetic relationships of ecribellate orb weaving spiders with a new family-rank classification (Araneae, Araneoidea). *Cladistics*, *33*(3), 221-250.

Ellenberg, H., &Schauermann, J. (Eds.). (1986). *Ökosystemforschung: Ergebnisse des Sollingprojekts 1966-1986*. Ulmer.

Foelix, R. F. (1996). Biology of spiders (2nd ed.). New York, Oxford University Press and Georg ThiemeVerlag.

Framenau, V. W., & Hudson, P. (2017). Taxonomy, systematics and biology of the Australian halotolerant wolf spider genus Tetralycosa (Araneae: Lycosidae: Artoriinae). *European Journal of Taxonomy*, 335.

Framenau, V. W., & Yoo, J. S. (2006). Systematics of the new Australian wolf spider genus Tuberculosa (Araneae: Lycosidae). *Invertebrate Systematics*, *20*(2), 185-202.

Gertsch, W. J. (1979). American spiders (2nd ed.). New York, Van Nostrand

Jogar, K., Metspalu, L., &Hiiesaar, K. (2004).Abundance and dynamics of wolf spiders (Lycosidae) in different plant communities. *Agron. Res*, *2*, 145-152.

Vendrely, C., & Scheibel, T. (2007). Biotechnological production of spider silk proteins enables new applications. *Macromolecular bioscience*, *7*(4), 401-409.

Marshall, S. D., & Rypstra, A. L. (1999). Patterns in the distribution of two wolf spiders (Araneae: Lycosidae) in two soybean agroecosytems. *Environmental Entomology*, *28*(6), 1052-1059.

Murphy, N. P., Framenau, V. W., Donnellan, S. C., Harvey, M. S., Park, Y. C., & Austin, A. D. (2006). Phylogenetic reconstruction of the wolf spiders (Araneae: Lycosidae) using sequences from the 12S rRNA, 28S rRNA, and NADH1 genes: implications for classification, biogeography, and the evolution of web building behavior. *Molecular Phylogenetics and Evolution*, *38*(3), 583-602.

Nyffeler, M., & Benz, G. (1987). Spiders in natural pest control: A review 1. *Journal of Applied Entomology*, *103*(15), 321-339.

Nyffeler, M., Sterling, W. L., & Dean, D. A. (1994). How spiders make a living. *Environmental entomology*, *23*(6), 1357-1367.

Nyffeler, M., Sterling, W. L., & Dean, D. A. (1994). Insectivorous activities of spiders in United States field crops. *Journal of Applied Entomology*, *118*(15), 113-128.

Nyffeler, M., &Birkhofer, K. (2017). An estimated 400–800 million tons of prey are annually killed by the global spider community. *The Science of Nature*, *104*(3-4), 30-35.

Polotow, D., Carmichael, A., & Griswold, C. E. (2015). Total evidence analysis of the phylogenetic relationships of Lycosoidea spiders (Araneae, Entelegynae). *Invertebrate Systematics*, *29*(2), 124-163.

Saez, N. J., Senff, S., Jensen, J. E., Er, S. Y., Herzig, V., Rash, L. D., & King, G. F. (2010). Spider-venom peptides as therapeutics. *Toxins*, *2*(12), 2851-2871.

Vink, C. J., Mitchell, A. D., & Paterson, A. M. (2002).A preliminary molecular analysis of phylogenetic relationships of Australasian wolf spider genera (Araneae, Lycosidae). *The Journal of Arachnology*, *30*(2), 227-238.

Whitcomb, W. H. (1974). Natural populations of entomophagous arthropods and their effect on the agroecosystem. *Proceedings of the Summer Institute of Biological Control of Plant, Insects and Diseases.Jackson, MI, University Press of Mississippi, pp. 150Á164*.

Wise, D. H. (1993). Spiders in ecological webs Cambridge University Press. *New York ISBN-13*, 978-0521.

World Spider Catalog.(2020). *World Spider Catalog.Version 20.0*. [online] Available at http://wsc.nmbe.ch.[Accessed on 11th January 2020]

Yan, Y. C., & Yan, H. M. (2007).Phylogenetic relationships of Wadicosa in Chinese wolf spiders (Lycosidae, Wadicosinae). *ActaZootaxonomicaSinica*, *32*, 996-999.

Young, O. P., & Edwards, G. B. (1990). Spiders in United States field crops and their potential effect on crop pests. *Journal of Arachnology*, 18 (1).1-27.

ISBN : 978-81-7255-134-6

MODERN TRENDS IN BIOLOGICAL RESEARCH

A Handbook in connection with the National Level Virtual Scientific Paper Presentation Competition organized by ZOOTOPIA - The Journal Club, PG Department of Zoology
Vimala College (Autonomous) , Thrissur – 680009
(NAAC Reaccredited (3rd cycle): A Grade-CGPA 3.5)
held on 9th January 2021

Current status of molecular taxonomy of spiders in India

Abhijith R. S*, Sheeba P, Sudhikumar A.V***

* Centre for Animal Taxonomy and Ecology, Department of Zoology, Christ College, Irinjalakuda, Kerala
** Department of Zoology, Vimala College, Thrissur, Kerala

Abstract

Morphological taxonomy is a very well-established field and never loses its importance in the field of biodiversity. Still the reliability solely on the morphology can led to the misidentification and synonymy. Aid of molecular techniques can somewhat overcome the problem and help the classical taxonomy to reach a newer height of increased credibility with less discrepancies. In India the use of molecular taxonomy is still coping up the pace. Total 247 published records of 139 species of spider DNA barcodes from India are there in Barcode of Life Data System. In India Araneidae is the most represented spider family in BOLD with 59 entries followed by Oxyopidae with 32, Salticidae and Theraphosidae with 30 entries. In 2019 Thyagi et al. conducted the first large scale DNA barcoding on Indian spiders which includes 101 morphospecies belongs to 72 genera. Caleb et al. in 2017 utilized the scope of molecular taxonomy in the discovery of two new species of jumping spiders (Salticidae) *Epocilla* and *Mogrus* from India. Kulkarni et al. in 2017 done the phylogenetic analysis of Theridiid genus *Meotipa* to understand placement of the genus. In 2017 Chatterjee et al. prepared the molecular barcode of *Menemerusnigli*during the first report of the species from India. Chatterjee et al. in 2018 utilized the sequence of mitochondrial cytochrome c oxidase subunit 1 in the first report of *Psechrus inflatus* and *Hyptiotesaffinis* from India. Collaboration of molecular techniques with classical taxonomy is need of the hour in this era of anthropological mass extinction.

Key Words: Spiders, Molecular taxonomy, Biodiversity, DNA barcode

Introduction

Spiders belong to the most abundant group of predators in most of the ecosystems, but have received much less attention than other insect predators (Whitehouse & Lawrence, 2001). Spiders are among the most abundant insectivorous predators of terrestrial ecosystems (Nyffeler & Benz, 1987; Wise, 1993). Not only abundant, but they are one of the most diverse arthropod orders, with diverse species and exhibit a great variety of foraging strategies (Coddington & Levi, 1991). The various foraging strategies can be attributed to better predatory control of insects and ecological importance. The diet of spider is made up primarily of insects from various taxa, and also of other spiders (Nyffeler, 1999). Eggs, larvae, and adults of many different insect pests are major diet of spiders (e.g. Whitcomb, 1974; Nyffeler et al., 1990; Young & Edwards, 1990). Another important aspect about spiders is spider silk and spider venom therapeutics.(Malik, 2018) (Saez et al., 2010). In order to make all these possible applications initially taxonomy of the taxa should be done. Developments and lack of confusions in taxonomic field will aid in the betterment of applied research.

Taxonomy, the classification of living organisms gains immense importance in current scenario where there is species loss in alarming scale due to anthropogenic activities. The database of every organism is necessary to estimate the loss as well as design various proactive and reactive strategies to prevent and cope up the species loss. The extent of undescribed species will be much higher for invertebrates than vertebrates. Using novel technologies of molecular biology in combination with classical taxonomy, the aim of quantification of biodiversity of our nature is very likely. Usage of molecular technologies in taxonomy will improve the credibility of description of particular species. The errors caused by pure morphological taxonomy can be overcome by the aid of molecular technologies. In India the use of molecular taxonomy is still coping up the pace. Use of molecular techniques with traditional taxonomy will make a paradigm shift in the taxonomic field in India. India is one of the mega diverse countries in the world. In order to quantify biological wealth of such a land mass molecular taxonomy should be considered as the optimal practice. Molecular taxonomy utilizes various molecular markers for the creation of molecular barcodes. Cytochrome oxidase Subunit 1 (COI) is considered to be the best and hence widely used molecular marker. Current status of molecular taxonomy of spiders in India is not appreciable. Compared to many other countries the entries from India is much lesser. The data about molecular taxonomy of spiders from India is mined from the website of Barcode of Life Database (BOLD Systems). Recently most of the taxonomists are showing interests in addition of molecular techniques along with classical approach. So it is evident that in the near future the contribution from India to BOLD systems will increase in alarming rate.

Results and Discussion

In India 287 published record of spider DNA barcode are there (Barcode of Life Data System). Barcode of 247 species of spiders, of which 139 are given full species name are found in BOLD. 40 unspecified species are also there. Araneidae is the most represented spider family in BOLD with 59 entries followed by Oxyopidae with 32 entries Salticidae and Theraphosidae with 30 entries each.(Fig – 1). Poecilotheria and Oxyopes are the most represented Genera with 25 entries each followed by 21 Unspecified and Neoscona with 16 entries.

Caleb et al. in 2017 utilized the scope of molecular taxonomy in the discovery of two new species of Jumping spider (Salticidae) *Epocilla* and *Mogrus* from India. After morphological assessment DNA extraction was performed by means of QIAamp® DNA Investigator Kit, following the instructions of manufacturer. Amplification of partial fragment (~650bp) of mitochondrial cytochrome C oxidase subunit I (mtCOI) gene were performed and sequencing was done by the means of the BigDye® Terminator Cycle Sequencing Kit (v3.1) on 3730 DNA Analyzer. The species were named *Epocilla sirohi* sp.n. and *Mogrus rajasthanensis* sp.n. The resulted sequence was submitted in GenBank, NCBI and BOLD.

Kulkarni et al. in 2017 done the phylogenetic analysis of Theridiid genus *Meotipa* to understand the placement of the genus. A previously published set of 242 morphological characters for Theridiidae phylogeny (Agnarsson 2004) with simple modifications were scored for these species. Parsimony and Bayesian analysis were done. The analysis revealed the monophyletic nature of the taxa.

In 2017 Chatterjee et al.prepared the molecular barcode of *Menemerus nigli* during the first report of the species from India. The species was described by Wesolowska & Freudenschuss, 2012 and the type locality was Pakistan. DNA barcode was utilized to confirm the identity of the specimen collected from West Bengal, India. Partial amplification of cytochrome C oxidase subunit I (mtCOI) was carried out for the purpose of barcoding. The sequencing was done at ZSI and sequence was uploaded to Barcode of life Data System (BOLD). The sequence developed in the study showed 100% similarity with sequences of *M. nigli* from Pakistan.Chatterjee et al. in 2018 utilized the sequence of mitochondrial Cytochrome c oxidase subunit 1 in the first report of *Psechrus inflatus* Bayer (Araneae: Psechridae) from India. The species previously known from China is recorded for the first time in India. Partial sequence data of mitochondrial cytochrome C oxidase (mtCOI) was generated and is submitted in BOLD. The barcode which is generated from 650 bp of mtCOI was used for a similarity search in NCBI and found to be 98% similar to the specimen from China.Chatterjee et al. in 2018 confirmed the identity of *Hyptiotes affinis* Bösenberg & Strand, 1906 by sequencing mt COI and results in the first report of the species from India. This species was previously known from China, Japan and Taiwan. During this study they found the species from Assam and utilized molecular techniques for the conformation.

Thyagi et al. in 2019 done the first large scale attempt on DNA barcoding of spiders from India with 101 morphospecies of 72 genera under 21 families. Cryptic species and species complex are also analyzed during the study. Data from these study showed that DNA barcoding is a valuable tool for species identification and species discovery.

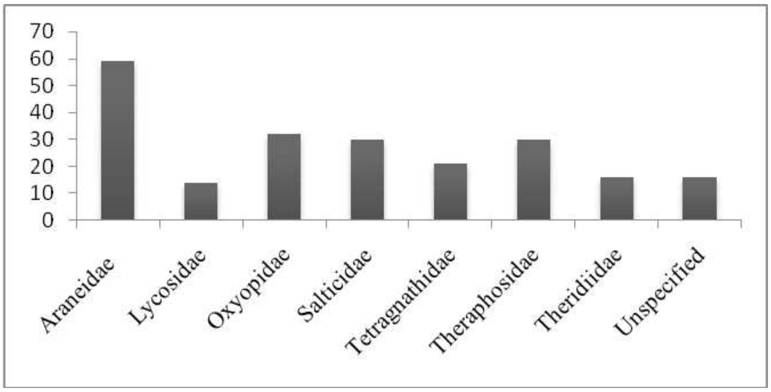


Figure1: Bar diagram showing different spider families entries from India deposited in BOLD Systems

Conclusion

Compared to other countries contribution from India to molecular taxonomy of spiders is only at initial stage. In India 287 published record of spider DNA barcode are there ((*Record List | Public Data Portal | BOLDSYSTEMS*, n.d.) . Barcode of 247 species of spiders, of which 139 are given full species name are found in BOLD. 40 unspecified species are also there. Araneidae is the most represented spider family in BOLD with 59 entries followed by Oxyopidae with 32 entries Salticidae and Theraphosidae with 30 entries each. In the case of genera Poecilotheria and Oxyopes are the most represented genera from India. The interesting part is that more than 75 percentages of entries of Indian spiders are done in foreign universities. This data showing that still molecular taxonomy is not common among Indian researchers. But as hope of light, many large scale molecular taxonomy works are being initiated in India which may jeopardize the anomalies in existing spider taxonomy along with better explanation of evolution.

Acknowledgments

I express my deepest gratitude to CSIR, New Delhi, India for providing funding and Principal, Christ College, Irinjalakuda for allowing me to use the facilities.

References

1. Agnarsson, I. (2004). Morphological phylogeny of cobweb spiders and their relatives (Araneae, Araneoidea, Theridiidae). *Zoological journal of the Linnean Society*, *141*(4), 447-626.
2. *Record List | Public Data Portal | BOLDSYSTEMS*. (n.d.). Retrieved December 31, 2020, from https://www.boldsystems.org/index.php/Public_SearchTerms
3. Bösenberg, W. & Strand, E. 1906. Japanische Spinnen. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft, 30: 93-422.
4. Caleb, J. T. D., Chatterjee, S., Tyagi, K., Kundu, S. & Kumar, V. (2017c). Two new jumping spiders of the genera *Epocilla* Thorell, 1887 and *Mogrus* Simon, 1882 from India (Araneae: Salticidae). *Arthropoda Selecta* 26(4): 329-334.
5. Chatterjee, S., Caleb, J. T. D., Tyagi, K., Kundu, S. & Kumar, V. (2017). First report of *Menemerus nigli* (Araneae: Salticidae) from India. *Halteres* 8: 109-111. doi:10.5281/zenodo.1133147
6. Chatterjee, S., Caleb, J. T. D., Tyagi, K., Kundu, S. & Kumar, V. (2018b). First report of *Psechrus Inflatus* Bayer (Araneae: Psechridae) from India. *Records of the Zoological Survey of India* 117(4, for 2017): 391-393. [publ. in April 2018] doi:10.26515/rzsi/v117/i4/2017/121294
7. Chatterjee, S., Caleb, J. T. D., Tyagi, K., Kundu, S. & Kumar, V. (2018a). First report of *Hyptiotes affinis* Bösenberg & Strand, 1906 (Araneae: Uloboridae) from India. *Munis Entomology and Zoology* 13(1): 211-213.
8. Coddington, J. A., & Levi, H. W. (1991). Systematics and evolution of spiders (Araneae). *Annual review of ecology and systematics*, 565-592.
9. Kulkarni, S., Vartak, A., Deshpande, V. & Halali, D. (2017). The spiny theridiid genus *Meotipa* Simon, 1895 in India, with description of a strange new species with translucent abdomen and a phylogenetic analysis about the genus placement (Araneae, Theridiidae). *Zootaxa* 4291(3): 504-520.

MODERN TRENDS IN BIOLOGICAL RESEARCH

A Handbook in connection with the National Level Virtual Scientific Paper Presentation Competition organized by ZOOTOPIA - The Journal Club, Department of Zoology, Vimala College (Autonomous), Thrissur – 680009 (NAAC Reaccredited (3rd cycle): A Grade-CGPA 3.5) held on 22 December 2021

Month and Year of Publication	:	July 2022
ISBN	:	978-81-7255-134-6
Printed at	:	The Union Press, Ph : 0487 2973213
Published and Distributed by	:	Sooryagatha (Publishers), Kochi - 682035

An Overview of Wolf Spiders (Araneae: Lycosidae) In Various Habitats of Gavi Eco-Tourism Region, Pathanamthitta, Kerala

Abhijith R.S.[1*], Sheeba P.[2]& Sudhikumar A.V.[1]
[1] Centre for Animal Taxonomy and Ecology, PG Department of Zoology, Christ College (Autonomous), Irinjalakuda, Kerala-680125
[2] PG Department of Zoology, Vimala College (Autonomous), Thrissur, Kerala
*abhijithrsabhiramam@gmail.com

Abstract

Lycosidae, wolf spiders are a group of ground dwelling spiders which are prominent in the predatory cluster of insects. They constitute the 6th largest spider family in the whole world. Many of the members in this family show morphological similarity and intra-specific variation, which makes their taxonomy difficult and make its field identification almost impossible. Gavi is an eco tourism location in Pathanamthitta district which is famous for its bird diversity and scenic beauty. The spider diversity especially lycosid diversity of the spot is sparsely studied. A single day expedition on location recorded around 200 individuals belonging to 16 species and 4 genus, among *Pardosa* being the most diverse and abundant genus. Considering the diversity of habitats in the location and low level of disturbances, we are expecting much more diversity which can be uncovered in a long and thorough expedition. Detailed reports of the findings along with notes on natural history are being given.

Key words: Wolf spiders, Kerala, Biodiversity, *Pardosa*

Introduction

Spiders are considered as main predators in most of the ecosystems, but not gained much attention compared to other insect predators (Whitehouse & Lawrence, 2001). In agro-ecosystems also they play an immense role as natural predators of insect pests. Wolf spiders, Lycosidae Sundevall, 1833, wolf spiders, are 6th largest spider family in the world with 2440 described species under 126 genera (World Spider Catalog, 2021).Their adult body size ranges from 1 to 30 mm. They have an array of different prey capture strategies, from permanent hunters to burrowing, and some genera are known to build sheet-webs (Murphy et al., 2006). Wolf spiders also exhibit specific microhabitat preferences and susceptible to changes in habitat structure (Jogar et al., 2004; Marshall & Rypstra, 1999). This ecological diversity may make them suitable for control of a wide variety of insect pests. They also manifest an immense role in food web and maintain the decorum of the ecosystem. In this group the species level identification can done only by genitalia analysis, making their taxonomy difficult.

The Western Ghats is one of the biodiversity hotspots of the world and the state of Kerala is a part of highly biodiversity rich regions of India and endowed with great diversity of climate, topography and soil. Studies on spiders especially wolf spiders are yet to be explored from Gavi, a part of Western Ghats and an eco-tourism spot in Pathanamthitta district of Kerala, which is famous for its bird diversity and scenic beauty.

Material and Methods

Study was done in October 2021 from various habitats in Gavi, Pathanamthitta district, Kerala, 9°43. 39N, 77°16.04E, alt. 3398.95ft. All specimens are collected by hand picking method and preserved in 70% ethanol and were studied, photographed and measured using a Leica M205C stereomicroscope, a Leica DFC450 Camera, and LAS software (Ver.4.13). Female epigynes are dissected and internal genitalia were cleared in 10% potassium hydroxide (KOH) solution and male palps are separated and photographed for identification. The graph is created by MS Excel 2007 software.

Results and Discussion

A total of 16 lycosid species belonging to 4 genera have been reported from the sample site (Table 1). *Pardosa* was the most diverse genus with 9 species followed by *Hippasa*, *Lycosa* and *Draposa*. Among species *Pardosa sumatrana* being the most abundant followed by *Hippasa ageneloides* (Figure 1).

Table 1: List of species collected from the sample site

Sl.No.	Name of Species	Number of females	Number of males
	Kingdom: Animalia **Phylum : Arthropoda** **Class: Arachnida** **Order: Araneae** **Family: Lycosidae Sundevall** **Genus:*Pardosa* C.L. Koch**		
1	*Pardosa mukundi*	*1*	*2*
2	*P. oriens*	*9*	*2*
3	*P. parathompsoni*	*4*	*2*
4	*P. pseudoannulata*	*1*	--
5	*P. pusiola*	*8*	*2*
6	*P.rhenockensis*	*2*	---

7	*P. shyamae*	*5*	---
8	*P. songosa*	*6*	*1*
9	*P. sumatrana*	55	*46*
	Genus: *Lycosa* Latreille, 1804		
10	*Lycosa bistriata*	*4*	---
11	*L. tista*	*2*	*1*
	Genus: *Draposa* Kronestedt, 2010		
12	*Draposa burasantiensis*	*5*	*3*
	Genus: *Hippasa* Simon, 1885		
15	*Hippasa agelenoides*	*14*	*6*
16	*H. holmerae*	*7*	*2*
14	*H. madraspatna*	---	*1*
13	*H. greenalliae*	*2*	*1*

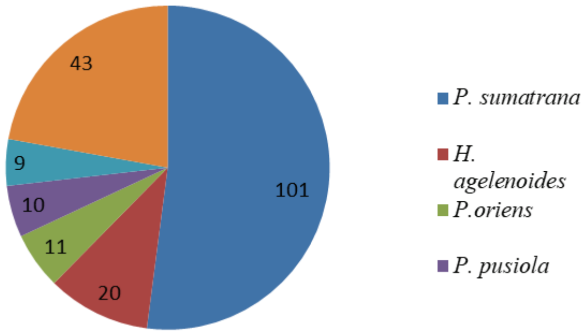


***Figure 1*:** Graphical representation of abundance of species.

Brief Natural history

All species were found in various habitats such as grasslands, rocky region, human settlements, riparian ecosystem, agricultural lands etc. The area where most species were found had a discontinuous water logged marshy region. The day was sunny with slightly drizzled previous night. The entire above mentioned habitat conditions are ideal for the flourishing of lycosids. The grass vegetation holds great population of prey insects, water logged areas and less anthropogenic disturbance might be the reason for abundant lycosid population. *P. sumatrana* outnumbered other species, showing its ability to survive well in all these habitats.

Till date, the studies of taxonomy and diversity of Wolf spiders in Kerala is very sparse. In most of the general faunistic study of spiders, diversity of wolf spiders mentioned in the form of checklists. Sebastian et al., (2005) explored the spider fauna of Mangalavanam, an eco-sensitive urban forest in Kochi and reported 2 species of lycosids belonging to 2 genera.Sudhikumar et al., (2005) studied the spider fauna of Mannavan Shola of Kerala, and reported 6 species of lycosids under 3 genera. Sudhikumar & Sebastian (2005) studied the spider fauna of Kuttanad paddy fields of Kerala, and reported 9 species of lycosids under 4 genera. Sunil et al., (2008) reported 12 species of lycosids under 5 genera from Parambikulam wildlife sanctuary of Kerala. Nafin et al., (2016) studied the spider fauna of Muriyadkol wetlands and reported 4 species of wolf spiders under 3 genera. Sudhin et al., (2015) reported 6 species of wolf spiders under 4 genera from the banks of Chaliyar River. Sudhin et al., (2018) reported 12 species of wolf spiders under 4 genera from Wayanad wildlife sanctuary. Sudhikumar et al., (2008) reported 20 species of lycosids under 6 genera from the Western Ghats region of India. Our study also agrees with the range of species mentioned in these studies. Almost all the species reported in the previous studies were able to record during the present study.

Conclusion

A total of 194 wolf spiders belong to 4 different genera were found in the study. *Pardosa* is found to be the most diverse genus with 9 species followed by *Hippasa* with 4, *Lycosa* with 2 and *Draposa* with single species. The common wolf spider *Pardosa sumatrana* is found to be the most abundant species. Number of female individual outnumbered the males. This is expected to be because of the wandering nature of males for mating. The study underlines the ecological importance of the area. Thorough and extensive studies are needed to document the real biological wealth of the area.

Acknowledgements

Authors express deepest gratitude to the Principal, Christ College (Autonomous), Irinjalakuda, Kerala for providing laboratory facilities. The first author is also grateful to the Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology, Government of India, New Delhi for providing Senior Research Fellowship [08/376(0013)EMR-1/2019] for the study.

References

1. Jogar, K., Metspalu, L., & Hiiesaar, K. (2004). Abundance and dynamics of wolf spiders (Lycosidae) in different plant communities. *Agron. Res*, *2*, 145-152.
2. Marshall, S. D., & Rypstra, A. L. (1999). Patterns in the distribution of two wolf spiders (Araneae: Lycosidae) in two soybean agroecosytems. *Environmental Entomology*, *28*(6), 1052-1059.

3. Murphy, N. P., Framenau, V. W., Donnellan, S. C., Harvey, M. S., Park, Y. C., & Austin, A. D. (2006). Phylogenetic reconstruction of the wolf spiders (Araneae: Lycosidae) using sequences from the 12S rRNA, 28S rRNA, and NADH1 genes: Implications for classification, biogeography, and the evolution of web building behavior. *Molecular Phylogenetics and Evolution*, *38*(3), 583-602.
4. Sebastian, P. A., & Peter, K. V. (Eds.). (2009). *Spiders of India*. Universities press.
5. Sudhikumar, A. V., & Sebastian, P. A. (2005). Diversity of spiders in Kuttanad rice agro-ecosystem, Kerala. *Journal of the Bombay Natural History Society*, *102*(1), 66-68.
6. Sudhikumar, A. V., Maelfait, J. P., & Lens, L. (2010). African and Southeast Asian elements in the spider fauna of the Western Ghats of India. *Arachnology 2008*, 165.
7. Sudhikumar, A. V., Mathew, M. J., Sunish, E., Murugesan, S., & Sebastian, P. A. (2005). Preliminary studies on the spider fauna in Mannavan shola forest, Kerala, India (Araneae). *European Arachnology Supplement*, *1*, 319â.
8. Sudhin, P.P., Nafin, K.S. & Sudhikumar, A.V. (2018). A preliminary checklist of spiders (Araneae) from Wayanad wildlife sanctuary, Kerala, India. India. *Faunal diversity and recent trends in animal taxonomy*. (Ed) Sudhikumar A.V., Christ College Publishers, Kerala. 107-111.
9. Sudhin P.P., Nafin K.S., Sobha T.R. & Sudhikumar A.V. (2015). A survey of spider fauna along the banks of Chaliyar River, Kerala, India. *Proceedings of National Seminar on Biodiversity conservation: Trends and prospects*. (Ed) Sudhikumar A. V., Christ College Publishers, Kerala.73-78.
10. Sunil, J. K., Sudhikumar, A., Davis, S., & Sebastian, P. (2008). Preliminary Studies On The Diversity Of Spider Fauna (Araneae: Arachnida) In Parambikulam Wildlife Sanctuary In Western Ghats, Kerala, India. *Journal of the Bombay Natural History Society*, *105*(3), 264-273.
11. Whitehouse, M. E. A., & Lawrence, L. (2001). Are spiders the perfect predator?. Aust. Cotton Grower 22, 30-33.
12. World Spider Catalog. 2021. World spider catalog, version 22.5. Natural History Museum Bern. Available at: http://wsc. nmbe.ch [Date accessed: 27 December 2021]

Presentations

1. “Revisiting ‘The Common Wolf Spider’ of Western Ghats Pardosa sumatrana (Thorell, 1890) in Light of Genitalic Polymorphism” at 33rd European Congress of Arachnology, Germany. (Online mode)
2. “Current status of molecular phylogeny of Wolf spiders” at International Seminar on Current status and Challenges for Conservation and Sustainable use of Biodiversity (ISCCSB), SN College, Kollam, Kerala.
3. “Current Status of Molecular Taxonomy of Spiders in India” at National Level Virtual Scientific Paper Presentation Competition, Vimala College, Thrissur, Kerala.