TAXONOMIC STUDIES ON THE WASP FAMILIES AMPULICIDAE AND SPHECIDAE (HYMENOPTERA: APOIDEA) OF SOUTHERN WESTERN GHATS AND ITS ADJACENT AREAS

Thesis submitted to the University of Calicut in partial fulfillment of the requirements for the award of the degree of

DOCTOR OF PHILOSOPHY IN ZOOLOGY

(Faculty of Science)

BY

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Under the guidance of

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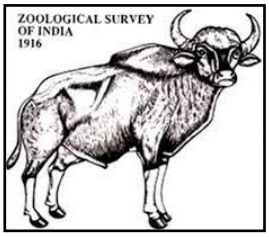

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This is to certify that this thesis entitled "**TAXONOMIC STUDIES ON THE WASP FAMILIES AMPULICIDAE AND SPHECIDAE (HYMENOPTERA: APOIDEA) OF SOUTHERN WESTERN GHATS AND ITS ADJACENT AREAS**" submitted to the University of Calicut for the award of the degree of Doctor of Philosophy in Zoology (Faculty of Science), is an authentic research work done by Ms. Anagha S in the Zoological Survey of India, Western Ghat Regional Centre, Kozhikode, under my direct supervision and guidance. This work has not been previously formed the basis for any other degree, diploma or similar titles.

It is further certified that the candidate has passed the Ph.D. qualifying examination of the University of Calicut held in July, 2019.

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DECLARATION

I do hereby declare that this thesis entitled "**TAXONOMIC STUDIES ON THE WASP FAMILIES AMPULICIDAE AND SPHECIDAE (HYMENOPTERA: APOIDEA) OF SOUTHERN WESTERN GHATS AND ITS ADJACENT AREAS**" submitted to the University of Calicut for the award of the degree of Doctor of Philosophy in Zoology (Faculty of Science), is the result of my own work carried under the supervision and guidance of **Dr. P. Girish Kumar**, Scientist D, Zoological Survey of India, Western Ghat Regional Centre, Kozhikode, and it has not been submitted to any other University or Institution for the award of any degree. I further declare that all the information submitted in the thesis is true to best of my knowledge.

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Dedicated to my Li'l one

CONTENTS

PAGE NO.

1. INTRODUCTION

1.1. Background …… 1

1.2. Taxonomy …… 1

1.3. Hymenoptera …… 2

1.4. Apoidea …… 3

1.5. Ampulicidae …… 3

1.6. Sphecidae …… 4

1.7. Scope and significance of the present study …… 5

1.8. Thesis objectives …… 6

2. REVIEW OF LITERATURE

2.1. Sphecid wasps: Historical Resume …… 7

2.2. World Ampulicidae & Sphecidae

2.2.1. Ampulicidae …… 8

2.2.2. Sphecidae …… 11

2.3. Indian Ampulicidae & Sphecidae

2.3.1. Ampulicidae …… 16

2.3.2. Sphecidae …… 17

3. MATERIALS AND METHODS

3.1. Study Area: southern Western Ghats and its adjacent areas …… 19

3.2. Collection Methods

3.2.1. Using Sweep nets …… 19

3.2.2. Rearing …… 20

3.2.3. Malaise trap …… 20

3.2.4. Pan trap …… 21

3.3. Collection Equipments …… 21

3.4. Preservation in Alcohol …… 21

3.5. Processing …… 22

3.6. Sorting …… 22

3.7. Relaxing …… 22

3.8. Mounting and Pinning …… 22

3.9. Labelling and Registering ……..…… 23
3.10. Identification ……..…… 23
3.11. Storing and Preservation ……...…… 24
3.12. Illustrations and Measurements ……...…….. 24
3.13. Catalog of Sphecidae ……..……. 25
3.14. Terminology and Abbreviations Used
3.14.1. Morphological terms ……..… 25
3.14.2. Abbreviations
3.14.2.1. Abbreviations used for Morphological terms ……..…… 27
3.14.2.2. Abbreviations used for the Museums ……..…… 28
3.15. Deposition of specimens (Vouchering specimens) …….…….. 29
3.16. Digital loan of Specimens ……..……...…… 29
3.17. Distribution Maps ……..…… 29
3.18. Collection sites ……..…… 30
PLATES ……. 32−34

4. RESULTS

4.1. Superfamily Apoidea ……...…… 35
4.2. Spheciformes ……...……..…….. 35

Chapter 1. FAMILY AMPULICIDAE

1.1. General Morphology ……..…… 36
1.2. Systematic Position ……..…... 37
1.2.1. Subfamily AMPULICINAE Shuckard, 1840
I. Genus *Ampulex* Jurine, 1807 ……...…… 38
i. *Ampulex ceylonica* Krombein, 1979 ……. 42
ii. *Ampulex compressa* (Fabricius, 1781) …….…….. 44
iii. *Ampulex dissector* (Thunberg, 1822) …… 45
iv. *Ampulex major* Kohl, 1893 ……..……. 46
v. *Ampulex ruficornis* (Cameron, 1889) ……. 48
vi. *Ampulex sadiyae* Anagha & Girish Kumar, 2019 ……..… 49
II. Genus *Trirogma* Westwood, 1841 ……...…….. 49
i. *Trirogma caerulea* Westwood, 1841 …… 51
ii. *Trirogma narendrani* Madhavikutty, 2004 …… 52

iii. *Trirogma regalis* Krombein, 1979 ……..……. 52
1.2.2. Subfamily DOLICHURINAE Dahlbom, 1842
A. Tribe Dolichurini Dahlbom, 1842
I. Genus *Dolichurus* Latreille, 1809 …….. 53
i. *Dolichurus albifacies* Krombein, 1979 ……..…… 56
ii. *Dolichurus amamiensis* Tsuneki and Iida, 1964 ……..….. 57
iii. *Dolichurus aridulus* Krombein, 1979 ……..…… 60
iv. *Dolichurus chareshi* Anagha & Girish Kumar, 2020 ….. 61
v. *Dolichurus gilberti* Turner, 1912 ……..… 62
vi. *Dolichurus sahyadriensis* Anagha & Girish Kumar, 2020 ……63
vii. *Dolichurus taprobanae* Smith, 1869 ……..…. 64
PLATES ……..…… 67–91

Chapter 2. FAMILY SPHECIDAE

2.1. General Morphology ……..…… 92
2.2. Systematic Position …….…… 93
2.2.1. Subfamily AMMOPHILINAE André, 1886
I. Genus *Ammophila* Kirby, 1798 ……..…… 96
i. *Ammophila clavus* (Fabricius, 1775) ……... 98
ii. *Ammophila laevigata* Smith, 1856 ……....…….. 101
2.2.2. Subfamily CHLORIONTINAE Fernald, 1905
I. Genus *Chlorion* Latrielle, 1802 …… 104
i. *Chlorion lobatum* (Fabricius, 1775) …….……. 105
ii. *Chlorion splendidum* Fabricius, 1804 ……..…… 107
2.2.3. Subfamily SCELIPHRINAE Ashmead, 1899
A. Tribe: Sceliphrini Ashmead, 1899
I. Genus *Chalybion* Dahlbom, 1843 ……..….. 108
i. *Chalybion bengalense* (Dahlbom, 1845) …….. 109
ii. *Chalybion gracile* Hensen, 1988 ……..…… 113
II. Genus *Sceliphron* Klug, 1801 …….……. 114
i. *Sceliphron coromandelicum* (Lepeletier, 1845) …..……. 118
ii. *Sceliphron javanum nalandicum* (Strand, 1915) ……. 119
iiia. *Sceliphron madraspatanum formosanum* van der Vecht, 1968 …….……... 121

iiib. *Sceliphron madraspatanum madraspatanum* (Fabricius, 1781) …….. 121

2.2.4. Subfamily SPHECINAE Latreille, 1802

A. Tribe Prionychini Bohart and Menke, 1963

I. Genus *Prionyx* Vander Linden, 1827 ……..…….. 125

i. *Prionyx viduatus* (Christ, 1791) ……... 127

B. Tribe Sphecini Latreille, 1802

I. Genus *Isodontia* Patton, 1880 ……...…… 129

i. *Isodontia aurifrons* (Smith, 1859) ……..……. 130

ii. *Isodontia edax* Bingham, 1897 ……...…… 131

iii. *Isodontia nigelloides* (Strand, 1915) ……..…… 132

II. Genus *Sphex* Linnaeus, 1758 ……..…… 134

i. *Sphex argentatus* Fabricius, 1787 ……...…….. 136

ii. *Sphex obscurus* (Fabricius, 1804) …… 138

iii. *Sphex sericeus* (Fabricius, 1793) ……..……. 139

iv. *Sphex subtruncatus* Dahlbom, 1843 ……..…….. 142

PLATES ……..…… 144−167

5. SUMMARY AND CONCLUSION

5.1. New species ……..…. 168

5.2. New country records

5.2.1. Ampulicidae …….…….. 169

5.2.2. Sphecidae ……...…… 169

5.3. New state records

5.3.1. Kerala

5.3.1.1. Ampulicidae ……...……. 169

5.3.1.2. Sphecidae …… 169

5.3.2. Tamil Nadu

5.3.2.1. Ampulicidae ……...……. 169

5.3.2.2. Sphecidae ……...……. 169

5.3.3. Karnataka

5.3.3.1. Ampulicidae ……...……. 170

5.4. Future Prospects ……..……...……... 170

LIST OF PLATES

1. Collection methods …….. 32
2. Morphological terms & abbreviations …… 33
3. Morphological terms & abbreviations …… 34
4. *Ampulex ceylonica* Krombein, 1979 (female) ……. 67
5. *Ampulex ceylonica* Krombein, 1979 (male) ..……. 68
6. *Ampulex compressa* (Fabicius, 1781) (female) ……..……. 69
7. *Ampulex compressa* (Fabicius, 1781) (male) ……..…… 70
8. *Ampulex dissector* (Thunberg, 1822) (female) ……...…… 71
9. *Ampulex major* Kohl, 1893 (female) …….……. 72
10. *Ampulex ruficornis* (Cameron, 1889) (female) …….…….. 73
11. *Ampulex ruficornis* (Cameron, 1889) (male) ……..…… 74
12. *Trirogma caerulea* Westwood, 1841 (female) ……...……. 75
13. *Trirogma caerulea* Westwood, 1841 (male) …….…….. 76
14. *Trirogma narendrani* Madhavikutty, 2004 (male) …….……. 77
15. *Trirogma regalis* Krombein, 1979 (female) ……...……. 78
16. *Trirogma regalis* Krombein, 1979 (male) ……..…. 79
17. *Dolichurus albifacies* Krombein, 1979 (female) ……..……... 80
18. *Dolichurus amamiensis* Tsuneki and Iida, 1964 (female) ……... 81
19. *Dolichurus amamiensis* Tsuneki and Iida, 1964 (male) …….. 82
20. *Dolichurus aridulus* Krombein, 1979 (male) ……...……...…… 83
21. *Dolichurus chareshi* Anagha & Girish Kumar, 2020 (male) ……...…….……. 84
22. *Dolichurus gilberti* Turner, 1912 (female) ……...……...…… 85
23. *Dolichurus sahyadriensis* Anagha & Girish Kumar, 2020 (female & male) ….. 86
24. *Dolichurus taprobanae* Smith, 1869 (female) …...……..……... 87
25. *Dolichurus taprobanae* Smith, 1869 (male) ……...……. 88
26. Distribution map of Genus *Ampulex* Jurine, 1807 from southern Western Ghats and its adjacent areas …….…..... 89
27. Distribution map of Genus *Trirogma* Westwood, 1841 from southern Western Ghats and its adjacent areas ……. 90
28. Distribution map of Genus *Dolichurus* Latreille, 1809 from southern Western Ghats and its adjacent areas …….……..…..…… 91
29. *Ammophila clavus* (Fabricius, 1775) (female & male) ……...…….……. 144

30. *Ammophila laevigata* Smith, 1856 (female & male) ……..……...…… 145
31. *Chlorion lobatum* (Fabricius, 1775) (female & male) ……...….. 146
32. *Chlorion splendidum* Fabricius, 1804 (female) ……...…….. 147
33. *Chalybion bengalense* (Dahlbom, 1845) (female & male) …..……..... 148
34. *Chalybion gracile* Hensen, 1988 (female) …….…….... 149
35. *Sceliphron coromandelicum* (Lepeletier, 1845) (female & male) ……. 150
36. *Sceliphron javanum nalandicum* (Strand, 1915) (female) & *Sceliphron madraspatanum formosanum* van der Vecht, 1968 (male) 151
37. *Sceliphron madraspatanum madraspatanum* (Fabricius, 1781) (female & male) … ……..…… 152
38. *Prionyx viduatus* (Christ, 1791) (male) ……..……...…… 153
39. *Isodontia aurifrons* (Smith, 1859) (female) ……...……..……. 154
40. *Isodontia edax* Bingham, 1897 (female & male) ……...… 155
41. *Isodontia nigelloides* (Strand, 1915) (female & male) ……...….. 156
42. *Sphex argentatus* Fabricius, 1787 (female & male) ……...….... 157
43. *Sphex obscurus* (Fabricius, 1804) (female & male) …..…… 158
44. *Sphex sericeus* (Fabricius, 1793) (female & male) ……...…… 159
45. *Sphex subtruncatus* Dahlbom, 1843 (female) ……...…...…. 160
46. Distribution map of Genus *Ammophila* Kirby, 1798 from southern Western Ghats and its adjacent areas ……..……. 161
47. Distribution map of Genus *Chlorion* Latrielle, 1802 from southern Western Ghats and its adjacent areas ……..……. 162
48. Distribution map of *Chalybion* Dahlbom, 1843 from southern Western Ghats and its adjacent areas ……..……...……...…..…. 163
49. Distribution map of Genus *Sceliphron* Klug, 1801 from southern Western Ghats and its adjacent areas ……..……...……. 164
50. Distribution map of *Prionyx* Vander Linden, 1827 from southern Western Ghats and its adjacent areas ……..……....……. 165
51. Distribution map of Genus *Isodontia* Patton, 1880 from southern Western Ghats and its adjacent areas ……....……...……. 166
52. Distribution map of Genus *Sphex* Linnaeus, 1758 from southern Western Ghats and its adjacent areas ……..……...……..……....……. 167

ABSTRACT

Ampulicidae and Sphecidae are highly significant groups of apoidean wasp families of order Hymenoptera that play an important role in regulating population dynamics of some of the arthropod pest species. These wasps follow a predatory life to feed their developing larva with paralysed prey. Ampulicids are found to attack vexatious cockroaches, while sphecids on spiders, caterpillars, grasshoppers, crickets, katydids, most of which are pests of important crops. Thus, these wasps have the potential to be used in biocontrol programs. However, it is also important to note that, certain spider-hunting sphecids can inflict notable harm to agricultural ecosystems as spiders play a crucial role in controlling various crop pests. This emphasizes the need for a delicate balance in utilising biocontrol agents effectively. Bingham's work (1897) happens to be the first basic study on Indian apoid wasps although changes in nomenclature have rendered it outdated. With few scattered reports and no valid revisionary work, the taxonomic studies of ampulicids and sphecids from India are still the least scanty. This void in research was the driving force behind the initiation of the present study, aiming to address and contribute to the understanding of these important insect groups.

The present investigation is attempted to understand the taxonomic diversity and vicariance to two families Ampulicidae and Sphecidae from one of the biodiversity's treasure troves of India *viz*., "southern Western Ghats, and its adjacent areas". The study uncovered a total of 16 species belonging to three genera in two subfamilies of family Ampulicidae and a total of 17 taxa (species and subspecies) belonging to seven genera in four subfamilies of family Sphecidae. Three ampulicid species new to science namely, *Ampulex sadiyae*, *Dolichurus chareshi*, and *Dolichurus sahyadriensis* were described and published. Two species *Dolichurus aridulus* Krombein (family Ampulicidae) and *Chalybion gracile* Hensen (family Sphecidae) and a subspecies *Sceliphron madraspatanum formosanum* van der Vecht (family Sphecidae) were recorded for first time from India. Type specimens from Natural History Museum, London, UK, Oxford University Museum of Natural History, UK, and Zoological Museum, Copenhagen, Denmark were studied and redescriptions are provided for taxa with poor descriptions. This study also provides dichotomous key of all the Indian ampulicids and sphecids genera illustrating all the species found from the southern Western Ghats. Distribution map to species of all genera collected in family Ampulicidae and Sphecidae were made using QGIS online software. The present study led to the publication of four international papers, two national papers, three book chapters, and two online publications.

സംക്ഷിപ്തം

ആർത്രോപോഡ (Arthropoda) വിഭാഗത്തിലെ ചില കീടങ്ങളെ നിയന്ത്രിക്കുന്നതിൽ പ്രധാന പങ്കു വഹിക്കുന്ന ഹൈമെനോപ്റ്റിറ (Hymenoptera) ഓർഡറിൽ വരുന്ന പ്രധാനപ്പെട്ട രണ്ട് അപ്പോയിഡിയൻ കടന്നൽ (Apoid wasps) കുടുംബങ്ങളാണ് ആംപുലിസിഡെയും (Ampulicidae) സ്ഫെസിഡെയും (Sphecidae). ഇരകളിൽ വിഷം കുത്തിവെച്ച് അബോധാവസ്ഥയിലാക്കി സ്വന്തം കുഞ്ഞുങ്ങൾക്ക് ഭക്ഷണം നൽകുന്ന ഇരപിടിയൻ ജീവിതരീതി പിന്തുടരുന്നവരാണിവർ. ആംപുലിസിഡുകൾ ഉപദ്രവകാരികളായ പാറ്റകളെയും (Cockroaches) സ്ഫെസിഡുകൾ ചില പ്രധാന വിളകളുടെ കീടങ്ങളായ പുഴുക്കൾ (Caterpillars), പുൽച്ചാടികൾ (Grasshoppers), ചീവീടുകൾ (Crickets) എന്നിവയെ കൂടാതെ ചിലന്തികളെയും (Spiders) ആക്രമിക്കുന്നതായി കാണപ്പെടുന്നു. അതിനാൽ ഇത്തരം കടന്നലുകളെ ജൈവകീട നിയന്ത്രണ പദ്ധതികളിൽ ഉപയോഗിക്കാനുള്ള സാധ്യത ഏറെയാണ്. എന്നിരുന്നാലും, വിവിധ വിള കീടങ്ങളെ നിയന്ത്രിക്കുന്നതിൽ ചിലന്തികൾ നിർണായക പങ്കു വഹിക്കുന്നതിനാൽ ചിലന്തിയെ വേട്ടയാടുന്ന സ്ഫെസിഡുകൾ കാർഷിക ആവാസവ്യവസ്ഥയ്ക്കു കാര്യമായ ദോഷം വരുത്തുമെന്നതും ശ്രദ്ധിക്കേണ്ടതാണ്. ബയോകൺട്രോൾ ഏജന്റുകളെ ഫലപ്രദമായി ഉപയോഗിക്കുന്നതിൽ കൃത്യമായ സന്തുലിതാവസ്ഥ നിലനിർത്തേണ്ടതിന്റെ പ്രാധാന്യം ഇത് എടുത്തു കാണിക്കുന്നു. ഭാരതത്തിലെ അപ്പോയിഡ് കടന്നലുകളെ കുറിച്ചുള്ള ആദ്യത്തെ അടിസ്ഥാന പഠനം ബിങ്ഹാമിന്റേതാണെങ്കിലും (1897), അന്നത്തെ ജനസുകളുടെയും (Genus) ഇനങ്ങളുടെയും (Species) നാമകരണം വളരെയധികം മാറിയിരിക്കുന്നതിനാൽ ആ പഠനം കാലഹരണപ്പെട്ടിരിക്കുന്നു. പരിമിതമായ റിപ്പോർട്ടുകൾക്കപ്പുറത്തേക്കു സാധുതയുള്ള പഠനങ്ങൾ ഇല്ലാത്തതിനാൽ ഭാരതത്തിൽ നിന്നുള്ള അപ്പോയിഡിയൻ കടന്നലുകളെ കുറിച്ചുള്ള വർഗ്ഗീകരണ ശാസ്ത്ര പഠനങ്ങൾ ഇപ്പോഴും വളരെ കുറവാണ്. ഭാരതത്തിലെ ആംപുലിസിഡെയുടെയും സ്ഫെസിഡെയുടെയും അവലോകനത്തിലെ ഈ അസമത്വമാണ് ഇത്തരമൊരു പഠനം നടത്തുന്നതിനുള്ള പ്രധാന പ്രേരണയായത്.

ഭാരതത്തിലെ ജൈവവൈവിധ്യത്തിന്റെ കലവറയായ തെക്കൻ പശ്ചിമഘട്ടവും അതിന്റെ സമീപ പ്രദേശങ്ങളിൽ നിന്നുമുള്ള ആംപുലിസിഡെ, സ്ഫെസിഡെ കുടുംബങ്ങളുടെ വൈവിധ്യം മനസ്സിലാക്കാനും വർഗ്ഗീകരണപരമായി തിരിച്ചറിയാനുമാണ് ഈ

പഠനം ശ്രമിക്കുന്നത്. ആംപുലിസിഡെ കുടുംബത്തിലെ രണ്ടു ഉപകുടുംബങ്ങളിലായി (Subfamilies) മൂന്നു ജനുസുകളിൽപ്പെടുന്ന 16 ഇനങ്ങളും സ്ഫെസിഡെ കുടുംബത്തിലെ അഞ്ച് ഉപകുടുംബങ്ങളിലായി ഏഴു ജനുസിൽപ്പെട്ട 17 ഇനങ്ങളും ഈ പഠനത്തിൽ കണ്ടെത്തിയിട്ടുണ്ട്. ഇവയിൽ മൂന്നു പുതിയ ആംപുലിസിഡെ ഇനങ്ങൾ ഉൾപ്പെടുന്നു. ആംപുലെക്സ് സാദിയെ (*Ampulex sadiyae*), ഡോളിക്യൂറസ് ചരേഷി (*Dolichurus chareshi*), ഡോളിക്യൂറസ് സഹ്യാദ്രിയൻസിസ് (*Dolichurus sahyadriensis*) എന്നിവയാണ് പുതിയ ഇനങ്ങൾ. ഇവ കൂടാതെ ഡോളിക്യൂറസ് അറിഡുലസ് (*Dolichurus aridulus*), ചാലിബിയോൺ ഗ്രാസയിൽ (*Chalybion gracile*) എന്നീ രണ്ടു ഇനങ്ങളും, സെലിഫ്രോൺ മദ്രാസ്പട്ടണം ഫോർമോസാനം (*Sceliphron madraspatanum formosanum)* എന്ന ഉപയിനവും (Subspecies) ഭാരതത്തിൽ നിന്നും ആദ്യമായി റിപ്പോർട്ട് ചെയ്യുന്നു. നാച്ചുറൽ ഹിസ്റ്ററി മ്യൂസിയം (ലണ്ടൻ, ഇംഗ്ലണ്ട്), ഓക്സ്ഫോർഡ് യൂണിവേഴ്സിറ്റി മ്യൂസിയം ഓഫ് നാച്ചുറൽ ഹിസ്റ്ററി (ഓക്സ്ഫോർഡ്, ഇംഗ്ലണ്ട്), കോപ്പൻഹേഗൻ സുവോളജിക്കൽ മ്യൂസിയം (ഡെൻമാർക്ക്) എന്നിവടങ്ങളിൽ നിന്നുള്ള ടൈപ് സ്പെസിമനുകൾ ഫോട്ടോഗ്രാഫുകൾ വഴി പഠിക്കുകയും, അധിക വിവരണങ്ങളില്ലാത്ത ഇനങ്ങൾക്ക് പുനർവിവരണം നൽകുകയും ചെയ്തു. ഈ പഠനത്തിൽ തെക്കൻ പശ്ചിമഘട്ടത്തിൽ നിന്നു കണ്ടെത്തിയിട്ടുള്ള 3 ജനുസിൽപ്പെട്ടിട്ടുള്ള എല്ലാ ഇന്ത്യൻ ആംപുലിസിഡെയുടെയും, 7 ജനുസിൽപ്പെട്ടിട്ടുള്ള എല്ലാ ഇന്ത്യൻ സ്ഫെസിഡെയുടെയും ഡൈകോട്ടമസ് കീ (Dichotomous key) നൽകിയിട്ടുണ്ട്. പശ്ചിമഘട്ടത്തിൽ നിന്നും ശേഖരിക്കപ്പെട്ട എല്ലാ ഇനങ്ങളുടെയും വ്യാപനം ക്യൂജിസ് ഓൺലൈൻ സോഫ്റ്റ്വെയറിൽ തയ്യാറാക്കിയിരിക്കുന്നു. ഈ പഠനത്തിൽ നിന്നും നാല് അന്തർദേശീയ പേപ്പറുകളും, രണ്ട് ദേശീയ പേപ്പറുകളും, മൂന്ന് പുസ്തക അദ്ധ്യായങ്ങളും, രണ്ട് ഓൺലൈൻ പ്രസിദ്ധീകരണങ്ങളും ഉരുതിരിഞ്ഞു വന്നിട്ടുണ്ട്.

INTRODUCTION

1. INTRODUCTION

1.1. Background

Science and technological advancements have radically transformed our world and the way humans live, but it's hard to argue that all those changes have been good. These developments singularly are not harmful but human's error in its application translates all these into a medium for the destruction of our environment (Ahuja, 2022). And, today we live in the middle of multiple irreversible disasters, the most serious of which is the unparalleled loss of biodiversity. Many biological communities that have evolved over millions of years all across the world are being destroyed. Experts estimate that the current rate of extinction is 1,000 to10,000 times greater than the natural extinction rate (Šijačić-Nikolić & Nonić, 2021) and in near future we may witness another extinction event in geological history, the centinelan extinction, where species become extinct before they are even identified (Liu *et al*., 2022). In wake of this possibly gruesome tomorrow, there is a growing recognition that biological diversity is an untapped resource of enormous value to both present and future generation and heightened public interest in safeguarding the world's biological treasure. The primary requisite towards this herculean task is to determine the rank and designation of an organisms before continuing with efforts to save it from extinction, because 'one cannot hope to protect the organisms that cannot be identified, and the efforts to investigate the impacts of environmental change and degradation are severely impeded if interacting components of natural ecosystems are not distinguished and explained' (Mace, 2004). Thus, here the crisis of biodiversity call for taxonomic urgency at the top priority list for biological science.

1.2. Taxonomy

Taxonomy simply can be defined as the discipline of biology, concerned with the identification, naming, and classification of organisms. In broad terms, it places all living creatures in formal classification units known as hierarchy of categories and name all of these categories using the international nomenclatural system of latin nomina, that serves as a common language among biologists (Dubois, 2003). Identifying species, doing cladistic studies, and retrieving information are all crucial aspects of taxonomy, but taxonomy encompasses much more. Taxonomic analysis of homologous characters, species, and clades provide a full, comprehensive account of the origin, diversity, and 3.8 billion-year history of life explained in a phylogenetic classification and related Linnaean names (Wheeler, 2014). Understanding range adjustments of non-invasive species in the context of climate change

and undertaking vulnerability assessments of prospective pest organisms early in their invasion are both made possible by taxonomic information. So, taxonomic understanding of any group of organisms is the cornerstone of all significant research, which opens the door to a massive repository of published knowledge on any taxa and has a great role in resolving the growing requirements of science and society.

The main goal of taxonomy is to record every species on earth but we are still a long way from achieving this objective as just a small percentage of our planet's species have been discovered and named. The time required to describe all these undiscovered taxa at the current rate would take several hundred years (Bouchet, 2006) and the taxonomists may find it impossible to fully define every unknown species. Aside from this, the resources needed to survey and estimate this diversity is limited and inadequate for present needs. Thus it become critical to prioritise groups of most value for research (LaSalle & Gauld, 1991). In today's world, majority of focus within the animal kingdom falls primarily on vertebrates, and when coming to invertebrates, the grey zones become more pronounced since relatively less number of taxonomists are working on these groups. Such lower groups, specifically most insects, are excellent markers of how biodiversity reacts to environmental perturbations (Parikh *et al*., 2020), and evaluation of their diversity in a region will help to develop successful conservation measures to protect not only them but also the whole biodiversity. Hymenopterans are among the insect groups that have shown promise as bioindicators in terrestrial ecosystems. Besides, they are most beneficial to humans as predators, parasitoids, and pollinators. Thus, the science and practice of classifying such organisms have grown in relevance in the modern period.

1.3. Hymenoptera

Hymenoptera is regarded as the most diverse insect orders after Coleoptera and Lepidoptera with more than 1, 50, 000 described species (Aguiar *et al*., 2013; Brock *et al*., 2021). This accounts for only 15 percent of its total population and a vast majority still awaits discovery. Conventionally, they are grouped into two suborders: Apocrita with ants, bees, and wasps which are distinguished by a considerably shortened or narrow connection between abdominal segments (commonly known as wasp waist) and Symphyta with saw flies, wood wasps and horntails, having broad connections between abdominal segments. Apocrita is further subdivided into Aculeata characterised by the use of the ovipositor for stinging prey or enemies rather than egg-laying, and Parasitica forming parasites of other insects with an ovipositor that maintains its basic egg laying function. Aculeata represent a highly significant

group of organisms with three superfamilies viz., Apoidea, Vespoidea, and Chrysidoidea (Brothers, 1975), among which Apoidea is the most speciose one.

1.4. Apoidea

Superfamily Apoidea includes about 30,000 known species of bees and apoid (= sphecoid) wasps having remarkable evolution of distinct life patterns and accompanying morphological adaptability (Sann *et al.*, 2018). Members of this superfamily are distinguished by characters, main of which are: an expanded propodeum; widely U-shaped pronotal postero-dorsal margin; and a prominent, yet small posterior pronotal lobe, well detached from and beneath the tegula (Finnamore & Michener, 1993). Contemporary Linnean classification always considered bees and these wasps under separate clades, based exclusively on their feeding habits. Valid evidence on their close association was proposed by Brothers (1975) in the phylogenetic studies of aculeatan Hymenoptera and placed them collectively within erstwhile superfamily Sphecoidea treating them as two informal series Apiformes and Spheciformes. Later on, the superfamily status was transferred to Apoidea based on the law of priority (Michner, 1986). The segregating morphological features between apoid wasps and bees are as listed: presence of simple unbranched setae (vs. branched setae in bees); hind basitarsus similar in size to remaining tarsal segments (vs. enlarged hind basitarsus modified as corbicula); and, last metasomal tergum not divided into lateral plates (vs. last metasomal tergum divided as lateral plates).

Unlike bees, most apoid wasps follow a predatory life to feed their developing larva with paralysed prey. This type of predation is known as provisioning predation, and cannot be considered as normal predation since wasps rarely feed for themselves. Although some species in few genera have social life histories (varying from eusociality to communal nesting), most apoid wasps are predominantly solitary in habit (Sann *et al.*, 2018). With over 10,000 described species, these wasps are divided in to four families viz., Ampulicidae, Sphecidae, Crabronidae and Heterogynaidae (Pulawski, 2023). Of these, three families, excluding Heterogynaidae, are distributed in the Oriental region including India.

1.5. Ampulicidae

Ampulicidae is a widespread small family of wasps, with over 205 species described worldwide. Most members are found in the tropics, with only few reported from temperate regions (Cassar *et al.*, 2020). *Ampulex* Jurine with 133 described species is the largest genus of the family followed by *Dolichurus* Latreille (53 species). Females of this wasps capture

cockroaches as food for their developing larva, hence commonly called as cockroach wasps. Wasps that are very small to carry the prey are reported to retropedalingly drag its prey into the nest (Bohart & Menke, 1976). These wasps nest in cavities as well as rotting wood near the ground and, generally their nests are with single larval chamber in which singular prey is provided (single provisioning). The species *Ampulex compressa* (Fabricius) commonly called as jewel wasp or emerald wasp, known for its attractive blue-green metallic coloration, large body size, prey stinging and nesting behaviour is one of the most popular representatives of this genus (Ohl *et al*., 2014). Being the commonest member, taxonomy, biology and other behavioural aspects of this species has been widely explored (Kohl, 1893; Bingham, 1897; Williams, 1942, Krombein, 1979; Kronaeur, 2004; Fox *et al*., 2006, 2009; Weiss *et al*., 2014; Arvidson *et al*., 2018). Various neurological and behavioural effect of wasp venom on cockroach host after being stung by *A. compressa* were studied by Piek *et al*. (1984), Fouad *et al*. (1996), Libersat *et al.* (1999), Weisel-Eichler *et al*. (1999), Libersat (2003), Haspel & Libersat (2004), Haspel *et al*. (2005), and Rosenberg *et al*. (2006). Most ampulicids move quickly showing characteristic running leaping behaviour, and are often ignored by collectors. As a result, ampulicid genera are still ill represented with monotypic genera like *Riekefella* Özdikmen.

1.6. Sphecidae

Like Ampulicidae, wasps of family Sphecidae are cosmopolitan in distribution occurring in all temperate and tropical areas with 808 described species worldwide (Pulawski, 2023). Genus *Ammophila* Kirby with 243 species has the greatest species diversity in the family followed by *Sphex* Linnaeus (146 species). Members of some sphecid genera are polychromatic and sometimes two sexes of same species are occasionally coloured differently (Bohart & Menke, 1976). Sphecids are known for their varied nesting habits, most of which are found subterraneous in the ground (digger wasps), some construct aerial nest from mud in and around human residency (mud dauber wasps) and very few establish their nest by remodelling pre-existing cavities (Coville, 1987). The typical life pattern of sphecid consist of a solitary female constructing nests composed of one or more cells (before or after prey capture) and subsequent provisioning these nests with captured prey (other insects and arachnids) for the immature to feed on. The nest is sealed after an egg is laid in each of several cells that have been stocked with prey items. When the egg hatches, larva begins to feed the provided prey till it complete its development (Weseloh & Hare, 2009). Sphecids are mostly mass provisioners stuffing their nest with two or more number of preys, while other

species are progressive provisioners, feeding food frequently or gradually as required by the larva in the cell until it completes its development. They restock the nest with more preys by reopening the cell, which is then resealed. The nest cells are sometimes left open until fully stocked.

Sphecids often restricts its prey to members of specific family or order (or at generic level with variable species) with prey preference at development stage of prey, prey size, or location of prey capture. The manner in which the prey is gripped by the wasp is the most crucial thing to consider when it comes to prey carrying. Generally, the primitive state is the wasp carrying the prey in its mandibles (mandibular mechanism), and in a more advanced stage, prey is carried well down under the body by the legs (mid legs or hind legs or both) (pedal mechanism) or by modified appendage at the end of metasoma (abdominal mechanism), letting the mandibles and fore legs free for other activities enabling faster nest provisioning, reducing predator and parasite threats during prey transport (Evans, 1962). Available data suggest that sphecids employ primitive prey carrying mechanisms that makes their prey susceptible to the attack of predators and parasites while they release the prey from mandibles to unblock or construct its nest. Sleeping aggregation, the clustering of species at night, is seen to be prevalent in sphecids (Jayakar & Mangipudi, 1965; Callan, 1984; Kurczewski, 1997; Pham, 2020) with social behaviour only marginally developed. The genus *Trigonopsis* exhibits a primitive or basic type of sociality where multiple females work together to construct a mud nest but no evidence of labour division is yet recorded (Eberhard, 1972). Another notable aspect of sphecids' lifestyle is kleptoparasitism, where one organism steals prey from another. Studies on interspecific kleptoparasitism among apoid wasps found Sphecidae to have the most instances of this behaviour (Polidori *et al*., 2006). Man's relationship with these insects are often hostile, owing to fear of their overstated stinging powers, while in fact, sphecids are mostly beneficial to humans and generally harmless.

1.7. Scope and significance of the present study

Ampulicidae and Sphecidae are considered ecologically important groups, because of their regulating effect on arthropod population in natural ecosystem. Restricting the arthropod population growth is an essential function since they reproduce rapidly, attaining population levels that can be harmful to plant and other invertebrate taxa (Gaston & Lawton, 1988). While ampulicids attack cockroaches, prey of sphecids include spiders, caterpillars, grasshoppers, crickets, katydids (Bohart & Menke, 1976), great majority of which are pests of important crops. Regardless of the size and typically limited host range, ampulicids are

proven to have significant impact on the population dynamics of troublesome cockroach species, hence regarded as effective bio control agent (Bridwell, 1920; Brock *et al*., 2021). Even though the potential of sphecids in biological control was recognised by previous workers (La Rivers,1945; Seyoum & Pulawski, 2001), the experimental investigatory base or foundation for their efficiency is limited. Thus, there is a great scope in exploiting sphecid species in biological control programmes but percentage of successful introduction of these species in a region is dependent on knowledge of their life histories and effective conservation strategies enabling each species to sustain its breeding. It's also imprtant to note that certain spider-hunting sphecids can unintentionally disrupt agricultural systems because spiders are crucial for controlling crop pests. This emphasizes the importance of maintaining a delicate balance when using biocontrol agents to prevent increased pest populations and subsequent crop damage. All of this is largely based on understanding of species identity, where the taxonomic knowledge become inevitable.

The taxonomic studies of Ampulicidae and Sphecidae from India are still scant represented by scattered publications and checklist reports. This is probably due to lack of sound revisionary studies based on substantial collections, a paucity of types for study, and a severe shortage of literature. A thorough review is required for the protection and long-term utilisation of this astonishing diversity. The dearth of knowledge on this specific group of wasps with huge promise in the field of biological control is reason enough for conducting the current investigation. Among the numerous compelling incentives for pursuing this research are the desire to provide more clarity and to solve some of the aforementioned taxonomic issues. Being home to vast array of species with unique assemblage of flora and fauna of Indian biodiversity in 0.6 percent of total subcontinent landmass, southern Western Ghats and its adjacent areas are selected as an area of interest for present taxonomic study.

1.8. Thesis Objectives

The present study envisages to address the following objectives:

- Surveying of Ampulicidae and Sphecidae species from southern Western Ghats and its adjacent areas.
- Identifying and describing new taxa encountered and redescribing little known taxa from freshly collected and deposited materials.
- Preparation of dichotomous key as an aid to generic and species level identification.
- To generate distribution maps for the species under study.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Up until recent past, most of the authors treated the members of present day Ampulicidae, Sphecidae, and Crabronidae within a single family, Sphecidae. Emergence of cladistics and integrated studies of the modern period, segregated the same into different families and is still actively updated. Here an attempt has been made to review the literature related to taxonomy of families Ampulicidae and Sphecidae relevant to the present work and are discussed under following headings:

2.1. Sphecid wasps: Historical Resume

Although **Dahlbom (1843-1845)** and **Lepeletier (1845)** attempted to classify *sphecid wasps,* the first modern categorisation of these wasps was published by **Kohl (1897)** in his work "*Die Gattungen der Sphegiden*", which treated all sphecoid wasps under singular family Sphegidae (= Sphecidae), and recognised 86 genera within Gattungs-gruppen (= subfamilies) and Untergruppen (= tribes). Though the classification was conventional based on general morphotaxonomy, Kohl's categorisation was mostly correct and major part of this classification is still being widely used all over the world. **Dalla Torre (1897)** catalogued World Hymenoptera and modified *Gattungs-gruppens* of Kohl by assigning them renewed subfamily stature. **Ashmead (1899)** compiled the sphecoid wasps in separate families under a single superfamily, Sphegoidea (= Sphecoidea) encompassing 12 families with 177 genera. Family Ampulicidae and Sphegidae (= Sphecidae) within this classification were represented by four genera in two subfamilies and 19 genera of four subfamilies respectively. This groupings were often assorted and was riddled with faults. **Pate (1937)** provided a comprehensive list of all generic name of sphecoid wasps (both valid and invalid) along with mention of their type species. **Murray (1951)** reverted back to Kohl's generic classification, although following Ashmead's system that downgraded subfamilies to tribes. **Brothers (1975)** recognised the close association of sphecoid wasps and bees treating them as two informal series Spheciformes and Apiformes respectively. **Bohart & Menke (1976)** published generic revision of sphecid wasps providing complete and comprehensive studies on diagnosis, biology, distributional data, generic catalog along with key to families, subfamilies, genera and subgenera of the group on global scale treating all sphecoid wasps within the single family Sphecidae. They divided the family into 11 subfamilies containing 33 tribes encompassing 226 genera. The authors claimed that, if sphecoid wasps were to be treated in separate families, the recognition of the

family Sphecidae with subfamilies Ampulicinae & Sphecinae, and another family Larridae comprising all the remaining subfamilies, seemed to be a sensible division. This was followed by **Lomholdt (1982)** in his classification of sphecid wasps and bees. **Day (1984)** described yet another old world subfamily Heterogyninae raising the total number of subfamilies of Sphecidae (*sensu* Bohart & Menke) to 12 but was again reduced to 11 when **Brothers & Carpenter (1993)** recognised Heterogynidae as a separate family in their cladistic phylogeny of Aculeata. **Gauld & Bolton (1988)**, **Borror *et al*. (1989)** and **Naumann (1991)** followed Bohart & Menke's classification of Sphecidae and classified genera and species within the single family.

Recent trends in phylogenetic studies on the erstwhile Sphecidae by **Alexander (1992)**, **Prentice (1998)**, **Brothers (1999)** & **Melo (1999)** showed that sphecid wasps are paraphyletic in relation to bees. Alexander's findings were rather equivocal however, Prentice Brothers, and Melo based on their phylogenetical and cladistic analysis of the group, collectively placed spheciformes wasps and apiformes bees under superfamily Apoidea and divided it into five monophyletic families: Ampulicidae, Sphecidae, Crabronidae, Heterogynidae and Apidae. Recently, **Branstetter *et al.* (2017)** and **Peters *et al*. (2017**) ventured cladistic analysis of Hymenoptera considering a restricted representation of Sphecidae validating the established classification. Later, a completely revised classification of Apoidea recognizing 10−12 families was put forward by **San *et al*. (2018, 2021)**, based solely on genetic characteristics, with no regard for morphotaxonomy and this might further be altered during subsequent cladistic analysis **(Pulawski, 2023)**.

2.2. World Ampulicidae & Sphecidae

2.2.1. Ampulicidae

Studies on ampulicids can be traced back to **1742**, when **Reamur** described the '*Guêpe ichneumon'* in his work "*Memoires pour servir a l'histoire des insects*". Later **Fabricius (1781)** reported this species under the name *Sphex compressus*, which was later revised to *Ampulex compressa* by **Jurine (1807)** while he described the genus *Ampulex*. **Latrielle (1809)** described another genus *Dolichurus* with *Pompilus corniculus* Spinola as the type species. **Shuckard (1840)** in his work "*On the history and natural arrangement of insects*" established family Ampulicidae providing its taxonomic characters. Two more genera *Aphelotoma* and *Trirogma* were added to family by **Westwood (1841a)** with *Aphelotoma*

tasmanica and *Trirogma caerulea* as type species respectively. **Westwood (1844)** established the genus *Rhinopsis* based on type species *Rhinopsis abbotti* which is now a synonym of *Ampulex canaliculata* Say.

Notable taxonomic treatment in various genera of family Ampulicidae were done by **Smith (1856, 1858a, 1860a, 1869, 1873a)** and **Cameron (1888a, 1889, 1903a, 1905, 1910).** A new species of *Ampulex* was described by **Kriechbaumer (1874)** under the name *Waagenia sikkimensis.* **Kohl (1893)** published the first global level comprehensive treatment of family Ampulicidae in which he copied or summarised the orginal descriptions of all ampulicid species known to him. 27 new species and a subspecies of *Ampulex* were described along with identification key to species of this genus. Further he transferred species *Waagenia sikkimensis* to genus *Ampulex.*

Taxonomy of ampulicid wasps progressed with work of **Turner (1910, 1914a & b, 1915, 1917a, 1919a & b, 1926)** adding more species, mainly of genus *Ampulex,* to the list of Ampulicidae. **Rohwer (1916)** recorded the first report of *Dolichurus* from Nearctic region with description of new species. **Arnold (1928a)** revised ampulicid wasps of South Africa and described four new species of *Dolichurus* and two subspecies of *Ampulex.* **Bradley (1934a)** described two new *Ampulex* species from Neotropical region followed by description of male of previously known species *viz*., *A. trigonopsis* Smith. In the same year **(1934b)**, he redefined genus *Rhinopsis* Westwood and described another new species of *Ampulex* from Texas. **Yasumatsu (1936)** revised ampulicid wasps of Japanese Empire with description of five new *Ampulex* species. **Leclerq (1954)** and **Gess (1984)** enhanced knowledge of *Ampulex* from South Africa. **Riek (1955)** studied systematics of Australian Ampulicidae and described genus *Austrotoma* with *Austrotoma atterima* (Turner) as type species. Key to species of *Aphelotoma* along with description of five new species of this genus were also provided**.**

William (1960) established the genus *Paradolichurus* as subgenus of *Dolichurus* with type species *Dolichurus californicus*. In **1962**, he added another species to this genus from southern Mexico under the name *Dolichurus* (*Paradolichurus*) *morelensis*. **Tsuneki & Iida (1964)**, **Kazenas (1976)**, **Barbier (1995)**, **Shorenko (2007)**, and **Kawano & Maeda (2012)**, contributed to the knowledge of Palearctic ampulicid fauna. **Tsuneki (1967a, 1973, 1977, 1982)** described good number of species belonging to various genera in Ampulicidae. **Tano & Tsuneki (1970)** synonymised *Dolichurus puliensis* Tsuneki with *Dolichurus amamiensis* Tsuneki & Iida. **Nagy (1971)** treated *Chlorampulex* de Saussure as a distinct genus and contributed significantly to ampulicid fauna by describing one new

species of this genus and four new species of *Dolichurus*. **Bohart & Menke (1976)** pointed out that *Chlorampulex* was isogenotypic with *Ampulex* and also relegated the status of *Rhinopsis* to species level. Furthermore they raised the status of subgenus *Paradolichurus* to genus level and included three species in it. **Krombein (1979)** undertook biosystematics studies of family Ampulicidae from Sri Lanka reporting 13 species of three genera, among which six species were new to Science. **Menke & Yusiz (1983)** documented the first occurance of *Ampulex compressa* in New World. **Wu & Chou (1985)** contributed immensely to Chinese ampulicids by describing five new species of genus *Ampulex* and two new species of *Trirogma* respectively.

Tsuneki (1992) listed all the known *Dolichurus* species from South & South East Asia and published a key to species of the region. **Kimsey (1993)** revised *Paradolichurus* with description of new species from Costa Rica. **Ohl (2002)** recognised three new species of *Dolichurus* from Australia providing keys, diagnosis, descriptions, distribution maps, and illustrations of major characteristics. **Ohl (2004)** further reported and described first fossil member of *Dolichurus viz., D. heevansi* with short notes on fossil Ampulicidae. This was followed by **Ohl *et al.* (2004)** describing another new species of *Dolichurus* from Foro Foro in Ivory coast of Afrotropical region.

Özdikmen (2005) proposed a substitute name *Riekefella* for genus *Austrotoma* Riek, as homonymy prevents it from being used as a valid name. **Kejval (2009)** reported the occurance of two ampulicid species from Czech Republic providing brief description on their binomy, taxonomy and distribution. **Chen & Li (2010)** described a new species of *Ampulex* from China. **Ohl & Spahn** in the same year performed cladistic analysis of the ampulicids based on their morphological characters and proposed revised classification of family Ampulicidae in light of their evolutionary findings. Later on, new species of *Dolichurus* was added to faunal list of Arabian Peninsula by **Ohl (2011)**. **Suda (2013)** provided an account on Southeast & East Asian Ampulicidae. **Ohl *et al.* (2014)** described a new species of *Ampulex* from Phetchaburi, Thailand. **Pires *et al.* (2014)** and **Hidalgo & Cazorla (2020)** added *Ampulex compressa* to the distribution records of Neotropical *Ampulex* by reporting the species from Amazone Biome and Caracas respectively. **Dollfuss (2017)** studied ampulicid wasp collection in Biologierzentrum, Austria, and recorded six species in three genera from various regions of the world.

Jahantigh *et al.* (2017) provided a checklist of Sphecidae *sensu lato* of Iran listing two ampulicids of genera *Ampulex* and *Trirogma* from the region. **Soliman *et al.* (2017)** reported the first occurrence of three species *viz., Ampulex assimilis* Kohl, *Dolichurus*

arabicus Ohl and *Trirogma caerulea* Westwood from Saudi Arabia. **Cassar *et al*. (2020)** revised ampulicid fauna of Maltese Island and reported two species of *Dolichurus*, one among which is documented for the first time from the Island. **Gadallah (2020a)** presented a checklist of ampulicids of Arabian Penninsula including its extra limital distribution. **Ghaderipour *et al*. (2020)** recorded the occurance of subfamily Dolichurinae from Iran and provided the first report of *Dolichurus* with two species. **Kim (2020)** reviewed Ampulicidae of Korea listing three species of *Ampulex*, of which one was species new to science. Key to Korean *Ampulex* species with taxonomic notes were also provided. **Can (2022)** studied ampulicid wasps of Turkey and reported *Trirogma* for the first time from the country. **Pulawski (2023)** maintains a frequently updated online world catalogue of apoid wasps.

2.2.2. Sphecidae

Studies on the World Sphecidae begins with work of **Linnaeus (1758)** who established the first sphecid genus '*Sphex*' in his work "Systema Naturae" with 25 species placed in it. **Fabricius (1775)** provided references to few Linnaean species and described 17 new *Sphex* species together with hundreds of hymenopterans from all over the world. At present, these species are allocated to genera belonging to various families of Hymenoptera including few in Sphecidae *sensu stricto*. The additions of numerous new species were continued by him **in the years (1781, 1793, 1798)**. His descriptions were often brief and incomplete, the species classification was sometimes inadequate, and often mistook species. **Kirby (1798***)* and **Klug (1801)** described genera *Ammophila* and *Sceliphron* with *Sphex sabulosa* Linnaeus and *Sphex spirifex* Linnaeus as type species respectively. **Latrielle (1802)** erected family Sphecidae (originally spelled Sphegimes) with *Sphex* Linnaeus as type species. Besides this, two more genera *Chlorion* and *Paleopus* were also established by him. *Chlorion* included *C. lobatum* (Fabricius) which is still now a valid species in the genus and *C. compressum* (Fabricius) the type of species to which Jurine in 1807 rightly gave an independent generic name *Ampulex*. **Fabricius (1804)** consolidated his hymenopteran knowledge and described genus *Podium* based on *Podium rufipes* as type species. Two new species to Palearctic records of sphecids were added by **Illiger (1807)**. Use of 'Spheg' as stem for family name by Latreille was followed by most of nineteenth century authors, which was gramatically incorrect and the correct usage 'Sphec' was done by **Leach (1815)** and clear explanation for the usage was provided

by **Tillyard (1926)**. **Van der Linden (1827)** dealt with burrowing wasp families and established the genus *Prionyx* with *Ammophila kirby* as type species.

Another genus *Trigonopsis* was described by **Perty (1833)** based on type species *Trigonopsis abdominalis*. **Dahlbom (1843−1845)** and **Lepeletier (1845)** attempted a comprehensive treatment of sphecoid wasps and erected genera *Chalybion* and *Dynatus* respectively. New species were added from around the world by **Smith (1851, 1856, 1858a & b, 1859, 1860b, 1863, 1868, 1873b−d), Cresson (1865a & b, 1869, 1873), de Saussure (1867, 1892)**, **Mocsáry (1883), Kohl (1884, 1885a, 1888a & b, 1889, 1890, 1895, 1898, 1901, 1906, 1918), Cameron (1888b, 1889, 1902a, 1910)**. **Taschenberg (1869)** described genus *Parapsammophila* with *Parapsammophila miles* as type species. Again in the years **1880**, **1882**, and **1890**, other genera *Isodontia*, *Eremochares*, *Palmodes* were described by **Patton**, **Gribodo**, and **Kohl** respectively.

Fernald (1903a & b, 1904, 1905, 1906, 1907, 1927, 1931a &b, 1934, 1943a−d), Murray (1938, 1940, 1945, 1951) and **Parker (1960)** contributed much to study of New World sphecid wasps. The discovery of new species continued and newer species were discovered and described by **Turner (1908, 1910, 1912a, 1919c, 1926, 1929)**, **Strand (1913 & 1915), Gussakovskij (1928, 1930, 1935, 1938)**, **de Beaumont (1956, 1968, 1970)**, and **Tsuneki (1957, 1971a−c, 1974)**. **Arnold (1920, 1928a & b, 1945, 1947, 1951)** significantly contributed to South African sphecid fauna. **Porter (1926)** synonymised *Paleopus* Latreille with *Sceliphron* Klug, as the type species designated for both genera were same. **Roth (1928)** revised Ammophilinae of North Africa with key to species of the region. **Bequaert (1929)** reported colour dimorphism in species *Podalonia violaceipennis* (Lepeletier). **Dow (1943)** dealt with male genitalia of *Isodontia* species with illustrations of left paramere apical half. **Dreisbach (1944)** & **Alayo Dalmau (1976)** published key to genera and species of Michigan & Cuban sphecids respectively. **Alfieri (1946 & 1961)** studied and enriched knowledge of Egyptian Ammophilinae. **Leclerq (1955)** published synonymical catalog of African sphecidae with geographical data at the end of synonymic list of each species.

Evans & Lin (1956) described sphecid larval characterstics from phylogenetic view points. Various subgenera, first proposed of generic value were revived to generic levels by works of **van der Vecht (1957a)**, **Bohart (1958)**, **Bohart & Menke (1961)**, **Menke (1961)** and **Bohart & Menke (1963)**. **van der Vecht (1957b, 1961, 1973)** provided notable taxonomic contribution to sphecid wasps of world. *Hoplammophila* and *Eremnophila* earlier described as subgenera under genus *Ammophila* by **de Beaumont**

(1960) & **Menke (1964a)**, were later elevated to generic status (**Menke (1966a)**. **Menke (1962)** further established the genus *Stangeella* (Type species: *Pelopaeus cyaniventris* Guérin) and in subsequent years **(1964b, 1966b, 1967, 1968, 1970, 1974a & b, 1996, 2004, 2007, 2020)**, contributed significantly to the study of sphecid fauna from the world. **Menke & Willink (1964)** surveyed *Chlorion* of Neotropical region and recognised five species providing key to species, illustations, synonymies and distributional data.

International Commission on Zoological Nomenclature (1968) upheld Fernald's taxonomic treatment of *Podalonia* in 1907 and designated *Ammophila violaceipennis* Lepeletier as type species of genus as per the case submitted to commission by **Menke *et al*. (1996)**. **Myartseva (1968)** explored and documented *Sceliphron* of Turkmenistan. **van der Vecht & van Breugel (1968)** revised the genus *Sceliphron* with description of three new subspecies and established *Prosceliphron* as subgenus of the genus. Extensive information on some hitherto missed characteristics, key to species and subspecies, maps, and distributional records of the genus were also provided by the authors. Two more genera *Chilosphex* and *Penepodium* were added to sphecid genus list when **Bohart & Menke (1976)** published their "Sphecid wasp of the World" and various ommissions and mistakes in this publication were corrected by **Menke & Bohart** in **1979. Pagliano (1984)** revised Sphecinae (=Sphecidae *sensu stricto*) of Italy providing key to tribes, genera and species of the region. **Krombein (1984)** dealt with biosystematics studies of Sphecidae from Sri Lanka and presented notes on its behaviour and life history.

Major taxonomic treatment in genera *Sceliphron*, *Chalybion*, and *Isodontia* were done by **Hensen (1987, 1988, 1991a & b)**. New species were added to Chinese list by **Li & Yang (1989, 1990, 1992, 1995a & b, 1996), Yang & Li (1989), Li (1995), Li *et al.* (1995), Li & Xue (1998), Li & He (2000), Yan & Li (2010), Yan *et al*. (2015), Wang *et al*. (2016, 2018),** and **Terayama & Tano (2018). Guichard (1988)** studied sphecid fauna of Arabian penninsula describing three new species among 48 species recorded from the region. Keys and distributional data of species were provided with confirmation of a synonymy. **Pagliano & Scaramozzino (1990)** proposed replacement name *Hensenia* for preoccupied name of subgenus *Prosceliphron.*

Chiappa *et al.* (1996) described morphology of larval, pupal, and cocoon stages of *Sphex latreillei* Lepeletier with emphasis on characters that facilitate comparison with other larvae of genus or subfamily. **Ohl (1996a & b)** discussed the phylogenetic relationships within the sphecid wasps. **Strumia (1996)** discussed the accidental introduction of *Sceliphron caementarium* (Drury) in province of Pisa, Italy. A checklist of

Taiwan sphecid wasps was prepared by **Porter *et al*. (1999). Genaro** in **Genaro & Juarrero (2000)** described a new species of *Sphex* from Cuba. **Menke & Pulawski (2000)** studied, diagnosed, and keyed *Sphex flavipennis* group from Mediterranean region with illustrations of male antennae. **Kazenas (2001)** added considerable knowledge on Kazakhstan sphecid fauna. **Moreira *et al*. (2003)** examined morphology and number of spermatazoa per cyst in *Sceliphron* and *Trypoxylon* species and suggested that the kind of data obtained in the study could enhance knowledge in taxonomic and phylogenetic studies.

New records were augmented from Palearctic and Neotropical regions by **Bogusch & Macek (2005), Genaro (2006), Barrera-Medina & Garcete-Barrett (2008), Compagnucci & Roig Alsina (2008), Bánk (2010), Baghirov (2011), Wiśniowski *et al*. (2013), Gülmez & Can (2015), Popelka (2015), Budrys & Orlovskytė (2016), Gradinarov (2017), Jahantigh *et al*. (2017), Notton (2017), Turrisi & Altadonna (2017), Can & Gülmez (2019), Zajac *et al*. (2019), Cassar & Misfud (2020), Turrisi (2020), Ceccolini (2021a & b, 2022), Cross *et al*. (2021), Demetriou *et al*. (2021, 2022), Ghaderipour *et al*. (2021), Kosibowicz (2021), Paulovic & Vas (2021), and Kaplan & Yildirim (2022). Engel (2005)** presented a classification framework of the Apoidea superfamily listing all names with synonymies. **O' Brien & Crave (2006)** recorded third report of *Isodontia* species from Michigan. **Lukas *et al*. (2006)** compiled all available distributional data of *Sceliphron destillatorium* (Illiger) in Czech Republic and Slovakia with brief discussion on its invasion to human settlements. **Castro (2007, 2010, 2020)** carried out the distributional study of *Sceliphron curvatum* (Smith) in Iiberian penninsula. **Roche (2007a & b)** improved the knowledge of Egyptian Sphecidae while **Dollfuss (2008, 2010a & b, 2013a & b, 2015a & b, 2016, 2019)** immensely contributed to the study of sphecid fauna from world. **Buys (2010)** reported distributional expansion of *Prionyx pumilio* (Taschenberg) to the state of Paraíba in northeast Brazil. Further, in **2011a**, he discussed the range expansions of six Neotropical apoid wasps including sphecids. Final instar larval morphology of *Sphecid* species were discussed by **Buys (2011b**, **2014**, **2020a & b)** and **Buys *et al*. (2004).**

Knowledge of sphecid fauna enhanced with the works of **Danilov (2011a & b, 2012a & b, 2013, 2016, 2017, 2018)**. **Ohl & Hohn (2011)** added a new *Chalybion* species to list of Indonesian sphecids. **Mei *et al*. (2012)** documented the first European record of *Chalybion bengalense* Dahlbom, providing evidence of its establishment in Italy. Iraq Sphecidae was extensively studied by **Augul *et al*. (2013, 2014, 2015)** & **Augul (2019)**.

Fernández & Castro-Huertas (2014) revised the genus *Sceliphron from* Colombia reporting three species along with key to Neotropical species of the genus. **Kim (2014)** catalogued spheciformes wasps of Korea and listed 216 species in total, of which 16 species belongs to Sphecidae. **Kim *et al.*** in the **same year** revised South Korean sphecids providing the first published key to species of the region. He recorded 17 species of 19 genera in three subfamilies with taxonomic data. **Schmidt-Egger (2014)** published key to *argentatus* species group of *Sphex* from Palearctic and Southwest Asia and further in **2019**, he revised *flavipennis* group of *Sphex* from Northwest Africa with description of two new species. **Dörfel & Ohl (2015, 2022)** extensively studied and revised *Sphex* from Australia and sub Saharan Africa with descriptions of 26 new species. **Danilov & Mokrousov (2016)** described and illustrated new species of *Podalonia* from West Kazakhstan.

Major contribution to Vietnam sphecid fauna were made by **Pham (2016a** & **b**, **2018**), **Pham & Dang (2017)**, and **Pham *et al*. (2019)**. **Kiran Vati & Bhasker Shenoy (2017)** investigated mandibular morphology of four wasp species including *Sceliphron caementarium* (Drury) and found that nesting and diet have significant effect in the evolution of mandible form. Then **Can & Gülmez (2018)** conducted the first study of abnormal wing vein defect in *Ammophila* species that were procured from several Turkish provinces and found six cases of defects in two species from 731 specimens of seven species. **Abenis & Lit (2020)** revised, keyed, and described two species of *Chalybion* from Philippines with a new report to the country. **Abenis *et al*.** in the same year, explored the extent of character disparity among Philippines *Sceliphron* species. Intraspecific genetic diversity within *Sceliphron madraspatanum conspicillatum* (Costa) were examined to determine whether yellow maculations represent various species population or solely phenotypic plasticity using DNA analysis.

Ben Khedher *et al*. (2020) published first checklist of Tunisian Sphecidae, recording 53 species and a subspecies of 10 genera in four subfamilies. Followed by this, he described hitherto unknown male of *Parapsammophila errabunda* (Kohl) in the same year from Tunisia with illustations and ecological notes of species. **Beutel *et al*. (2020)** characterised and documented distal structures of leg and discussed in terms of both functional and phylogenetic features. **Danilov & Byvaltev (2020**) reviewed Central Asian species of *Palmodes* describing a new species along with key to Palearctic species of the genus**.** New synonymies were proposed and a species was revived from synonymy. **Gadallah (2020b**) provided a checklist of Sphecidae in Arabian Peninsula reporting 70 species of 10 genera in four subfamilies. **Lewis (2020)** reported the first range extension of

Sphex ichneumoneus (Linnaeus) and *Sphex pensylvanicus* Linnaeus in Atlan Canada. **Olszewski & Danilov (2020)** described new species of *Ammophila* from Iran and reported new records of the genus from Palearctic regions. **Kolosova *et al.* (2022)** studied taxonomic richness of hymenopteran aggregation, linked with nest assemblage of *Sceliphron fuscum* Klug on Inner Seychelles in 2016. Local species displacement by alien taxa was found on comparing their result with collected historical data.

2.3. Indian Ampulicidae & Sphecidae

2.3.1. Ampulicidae

The earliest known ampulicid species reported from India date back to 1781, when **Fabricius** reported the species '*Sphex compressus*' (=*Ampulex compressa* (Fabricius)) from Kerala. Thereafter species new to science were added to Indian list by **Cameron (1889, 1891, 1899, 1891, 1900, 1902b & c, 1903b & c)** and **Kohl (1893)**. Taxonomy of Indian ampulicids greatly advanced with the work of Bingham (1897), who comprehensively revised hymenopterans from British India, recording 1,678 sphecoid wasps including ampulicids. **Rothney (1903)** studied aculeaten Hymenoptera from Barrackpore of West Bengal reporting three *Ampulex* species from the region. **Turner (1912b)** described two new species *viz*., *Ampulex approximata* & *Dolichurus gilberti* from 'Bombay presidency' and 'Assam' respectively. A catalogue of wasps and bees of Indian region was prepared by **Aiyar (1916, 1917)**.

New records were augmented from Uttarakhand, Meghalaya, Sikkim, Arunachal Pradesh, and Andaman & Nicobar by **Gupta (1995)**, **Jonathan *et al.* (2000), Jonathan & Kundu (2003)**, **Kundu *et al.* (2006)**, **Kundu *et a*l. (2012)**. **Madhavikutty (2004)** described a new species *viz*., *Trirogma narendrani* from Chembra hills of Wayanad in Kerala. **Job & Olakkengil (2014)** published a paper on sphecoid fauna in Thrissur district of Kerala and reported 10 species, among which two species belongs to Ampulicidae. **Girish Kumar & Sheela (2017)** revised, keyed and described a new species of the genus *Trirogma* from the Indian subcontinent along with a checklist of this genus from world. Again, in **2018**, **Girish Kumar & Sheikh** reviewed another genus *Dolichurus* from the Indian subcontinent, describing *Dolichurus venkataramani* from Himachal Pradesh while recording four species from India, of which two species were newly reported from the country. **Anagha & Girish Kumar (2019)** studied the genus *Ampulex* from India and recognised five species from India with the description of a new species *viz*., *Ampulex*

sadiyae. Key to Indian *Ampulex* species was also provided with new distributional records. A year after **(2020a)**, **Anagha & Girish Kumar** published an online catalogue of Indian Ampulicidae recording 35 species in three genera under two subfamilies. In the same year, **Anagha *et al.* (2020a)** listed 16 species of three genera in two subfamilies from the Western Ghats. Knowledge of Indian *Dolichurus* improved with the work of **Anagha *et al.* (2020b)** describing two new species *viz.*, *D. chareshi* and *D. sahyadriensis* from southern India with a key to *Dolichurus* species of Indian subcontinent.

2.3.2. Sphecidae

Linnaeus (1758) reported the earliest known sphecid *Sphex* (=*Prionyx*) *indus* from India. Later more species were added to the Indian list by Fabricius **(1775, 1787, 1793, 1798, 1804)**, **Lepeletier (1845)**, **Smith (1856)**, and **Cameron (1889, 1890, 1899)**. Significant contribution on Indian sphecid wasps was done by **Bingham (1897)**. **Rothney (1903**) reported several species belonging to four genera *viz*., *Ammophila*, *Chlorion*, *Sceliphron*, and *Sphex* from Barrackpore of West Bengal. Mention may be made to **Lefroy (1904)**, **Paiva (1907)**, **Maxwell-Lefroy (1909)**, **Dutt (1912)**, **Turner (1917b)**, and **Aiyar (1916−1917)** who contributed to refine the knowledge of Indian sphecids. **Chhotani & Ray (1975)** studied hymenopteran specimens of faunistic survey in Rajasthan reporting two sphecid species *Sphex aegyptius* Lepeletier (=*Prionyx crudelis* Smith) and *Sphex viduatus* (Christ) (=*Prionyx viduatus* Christ) from the state. **Hensen (1988)** revised *Chalybion* species and documented the presence of these species in some locations of northern India. **Sudheendrakumar & Narendran (1989)** listed sphecoid wasps of Kerala in which they listed 46 species including sphecids. **Kadirvelu (1990)** reported *Chalybion bengalense* (Dahlbom) from Coimbatore, recording the occurance of species for first time in South India. **Jha & Farooqui (1994)** studied and illustrated male genitalia of 20 Indian sphecid species of eight genera in four subfamilies. Sphecid fauna of Uttarakhand was explored by **Gupta** in his series of publication **(1995, 1997, 2004)**. Contribution of **Jha & Farooqui** continued in the the years **1995** and **1996** with description of six species in total from various regions of India.

Jonathan *et al.* (2000), Jonathan & Kundu (2003), **Kundu *et al.* (2006)**, and **Kundu *et al.* (2012)** studied and enriched knowledge of sphecid wasps from Meghalaya, Sikkim, Arunachal Pradesh and Andaman & Nicobar respectively. **Dollfuss (2008b, 2013a &b, 2015b)** dealt with Biologiezentrum Linz, collections of Austria, and reported sphecids from various regions of world including India. **Tiwari *et al.* (2004)** studied

aculeaten Hymenoptera of Desert National Park in Rajasthan and reported the only sphecid *Chlorion regale* Smith from the region. **Girish Kumar *et al.* (2014)** reviewed *Chlorion* from the Indian subcontinent and recorded three species with new Indian records. **Job & Olakkengil (2014)** reported eight sphecid species of four genera from Thrissur district of Kerala. Knowledge regarding sphecid diversity and distribution in Koradi region of Nagpur district in Maharashtra was provided by **Deshmukh (2015)**. **Sheikh *et al.* (2017)** reported four sphecid species of three genera with its diagnostic characters from Dumna Nature Park of Jabalpur district in Madhya Pradesh. First record of species *Chalybion bengalense* from various Indian states were discussed by **Mazumdar *et al.* (2018)**. **Anagha & Girish Kumar (2020b)** published an online catalogue of Indian Sphecidae and recorded 61 species of 10 genera in four subfamilies. In the same year, **Anagha *et al.* (2020c)** listed 24 species and four subspecies of nine genera in four subfamilies from the Western Ghats. **Gurule *et al.* (2020)** studied hymenopteran diversity of K.T.H.M. College, Maharashtra and reported three sphecid species viz., *Chalybion bengalense* (Dahlbom), *Sceliphron caementarium* (Drury), and *Ammophila sabulosa* (Linnaeus) from the area. **Anagha *et al.* (2021a)** revised *Sceliphron* from India recording the occurance of *Sceliphron destillatorium* (illiger) and *Sceliphron madraspatanum formosanum* van der Vecht for the first time from India. Another genus *Sphex* was studied from India by **Anagha *et al.* (2021b)** providing key to species of the region, illustrating male genitalia of the species and synonymising *Sphex zubaidiyacus* Augul with *Sphex obscurus* (Fabricius).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1. Study area: southern Western Ghats and its adjacent areas

Western Ghats also called Sahyadri, well known for its striking beauty, are chain of towering mountains, meandering rivers, open grass lands and dense forest that run along the western sides of India. Spread across five states- Kerala, Karnataka, Maharashtra, Goa and Tamil Nadu, it starts near border of Gujarat and Maharashtra south of Tapti river and ending at Kanyakumari at southern tip of India. Western Ghats, often called Great Escarpment of India (Kale, 2010) covers an area of 1,40,000 sq.km and has an average elevation of about 1200 m. With vast biological diversity and species endemism, it is added to list of UNESCO World heritage site and is recognised as hottest hot spot of biological diversity. Pleasant weather and presence of lush greenery makes Western Ghats an exciting treasure house of Biodiversity and is home to atleast 325 globally threatened (IUCN Red Data List) species.

The Western Ghat topographically is divided in to two distinct sub region- northern and southern Western Ghats lying in between the coordinates 8°–21°N and 74°–78°E interrupted only by the 30 km Palghat Gap at around 11°N and 76°E. Compared to Northern part, southern part is cooler, wetter and richer. The area under the present study is southern Western Ghats and its adjacent areas that run through states of Kerala, Karnataka, and Tamil Nadu. Collections were mainly taken from Western Ghats of Kerala and its adjoining area.

3.2. Collection Methods

Intensive collections of dead or alive ampulicids and sphecid wasps were preferred from as many ecosystem as possible and carried out as follows:

3.2.1. Using Sweep nets

Sweeping using sweep net is one of the most effective way to collect ampulicid and sphecid wasps. Early mornings and evenings were proved to be the right time to find a good collection in the absence of wind. Sweep net used in the present investigation had a detachable 75 cm net bag made of cloth having fine mesh, fitted in ring (diameter 30 cm) made of iron wire through 5 cm wide cloth rim, telescopic handle with fine rubber grip at end. Length of handle is adjustable from 55 cm to 180 cm. The Sweep net could be disassembled when not in use and could be reassembled back when in need. After spotting

wasp, net was swept back and forth and is flipped over with net bag hanging over the rim, trapping the wasp. Wasp trapped in net were collected and narcotized in killing jar with ethyl acetate.

3.2.2. Rearing

Rearing is found to be useful not only in insect collection but also to acquire information on its biology, host data and host association. Besides this, there are good chances of collecting both sexes at a time, that enable one to study sexual dimorphism exhibiting in particular taxa. In this method, nests containing egg, larvae, pupae were collected and placed in clear container that enable monitoring the emergence of adult wasps on a daily basis. The emerged wasp were collected and narcotized with ethyl acetate in killing jar.

3.2.3. Malaise trap

Malaise trap is also one of the most promising passive method for collection of ampulicid and sphecid wasps. Dr. Rene Edmond Malaise was the first to develop Malaise trap in 1934 in Burma (Malaise, 1937). Various modification of Malaise trap have been developed for over last few decades. Of these, smaller Townes designs and larger Gressitt designs are prominent (Achterberg, 2009). Modification of Townes trap was used in the present study, and it consist of tent made of fine mesh material, with a large opening at bottom for insects to fly in to, central wall, a roof that tapers at one end to form a slope, and a collecting jar filled with killing agent that is fitted at the top of the trap. The colour of trap is usually dark with light coloured roof. The principle of trap is that insect being positive phototropic, move upward and find themselves trapped in collecting jar filled with killing agent. The trap was carried at different study sites and factors like temperature, vegetation, wind, etc. were considered during placement of trap as all these have an influence on the efficiency of trap. When placing the trap, special attention was paid to pointing the collection head in the direction of maximum sunlight and towards the open area. The base on which the traps were placed was evenly leveled. In the shrub jungle, the plants were pruned from the surface to the optimum standard height so that the traps would stand upright without folding. Destruction of trap by animals and humans was major problem encountered during the setup of malaise traps. Special care was taken to ensure safety of trap through monitoring at all possible intervals. At regular intervals, killing jars with insects were collected.

3.2.4. Pan trap

Pan trapping is another passive method for collection of ground dwelling and low flying arthropods. The trap consist of small coloured pan of moderate sized plastic container having shallow depth and increased circumference, which is filled with water containing a little detergent. The principle of Pan trap is that insects are attracted to different colours. Yellow is the most commonly used colour as it attract wide variety of insects (Leong & Thorp, 1999). The detergent in the trap tends to reduce the surface tension of the water, and insects that land on the water will sink quickly. Saturated salt solution was used in trap when the collection were taken on 2-4 day basis, as salt solution keep the specimens intact till the collections were retrieved from the trap. Traps were placed randomly in open area in field under study. Proper care was taken to avoid interferences from animals, humans. Factors like temperature, wind, etc. were also considered during the placement of the trap. Pans were filled with sufficient amount of collection solution to avoid drying up on long run. At the end of the day or on 2-4 days basis, specimens are retrieved after straining water through a fine sieve.

3.3. Collection Equipments

Equipments used in the study include:

- Sweep net, malaise trap, yellow pans and plastic containers (for pit fall trap) to trap and collect wasps.
- Alcohol vials for dispatching collected wasps.
- Killing jar with ethyl acetate to kill the captured insects.
- Pen or pencils and field note book to record collection details.
- Forceps and hair brush to extricate specimens stuck on the sweep net's, as well as to manage specimens before transferring them in the preservative.

3.4. Preservation in Alcohol

All the collections obtained using various ways were moved to labelled alcohol vials from the fields, and their preservation was enhanced by freezing them until mounting for the study begins. Grades of Ethyl Alcohol are the most commonly utilised preservatives in the case of hymenopterans, with 70% chosen for short-term preservation and transit of specimens as wet collections. To avoid specimen deterioration, the alcohol should be replaced on a regular basis.

3.5. Processing

Processing of collected specimens involves; Sorting, Relaxing, Mounting, Pinning, Labelling, Registering, Storing and Preservation of specimens.

3.6. Sorting

For sorting, alcohol containing collected specimens from particular locality is poured in designed sorting trays and ampulicids and sphecids were separated out from it using a binocular stereozoom microscope with appropriate magnification. The remaining specimens were preserved in airtight vials filled with 70% ethanol and kept in the refrigerator.

3.7. Relaxing

Specimens killed using ethyl acetate tend to become dry and brittle which result in breakage of specimens while handling it. Relaxing was found to be suitable for such specimens with folded legs and wings. For this, specimens were held in acetic acid vapour for 6–8 hours to overnight treatments, depending on the condition of the specimen. The vapours of acetic acid were found to relax the specimen's different structures, which were subsequently managed using fine forceps as needed. Softened specimens then become appropriate for mounting and spreading.

Note.

- Before mounting, sorted and relaxed specimens were placed on high-absorbent blotting paper and was kept under table lamp for few minutes to dry out in fully stretched form.

3.8. Mounting and Pinning

Mounting and pinning are very important parts of taxonomic studies that need great care. Small specimens were mounted in such a way that either left or right half is completely visible along with all morphological characters used in identification. Drop of glue was applied on tip of triangular mounting card (made of ivory paper) pinned in entomological pin and specimen was transferred on to glue using hair brush moistened with alcohol. To enable easy remounting, cold water soluble glue was used for mounting.

Standard entomological pins were used for pinning medium to large specimens for easier study (some smaller specimens were also pinned using thinner pins). Specimens

were pinned on specialised pinning block to provide support for the limbs. The pin is driven through the thorax of insects. Care should be taken to avoid damage during pinning. The pin must be left enough, above and below the specimen, for handling (above) and labelling (below) and handling. Antennae, legs and wings were stretched properly while pinning and the specimens were again dried under table lamp for few hours.

3.9. Labelling and Registering

Specimen without data are useless in Taxonomic study. Proper labelling of each insect specimen help in this regard by upholding all the important information on the specimen. Temporary labels were provided in the field during collection and these labels were replaced by permanent rectangular labels (printed labels or labels written using Rotring 0-1 or 0.2 microtip pen) after mounting or pinning. The information included in the permanent labels include: location from where specimen was collected (country name in capital letter, name of state and locality in small letters), date (day, month and year) of its capture, and the name or initials of the collector. Month is mostly written in roman numerals between day and year to avoid confusion.

Specimens were registered and secondary labels such as determination label and label carrying register number (serial number to individual specimen) of specimen were provided after its identification. Register entries include all relevant information such as: collection number, scientific name, name of locality, date of collection, name of collector, name of determiner, date of determination, remarks.

Points to consider while providing labels to each specimen

* All the labels must be held on pin beneath the insect specimen and positioned in line with length of insect specimen.
* Most important labels are placed close to specimen.
* Pinning block is used to maintain height of labels.

3.10. Identification

The specimens were examined for recognisable morphological features under a stero zoom microscope (Leica M205A Stereozoom Microscope for smaller specimen and Leica M60 Stereozoom Microscope for larger specimen), and the specimens were identified using appropriate keys and published descriptions for the taxa.

- Keys provided by Bohart and Menke (1976) was modified (pers. comm. Pulawski) and used in the identification of subfamilies and genera of ampulicid and sphecid wasps.

Species level identification of few ampulicid species were done using different keys provided by:

- Tsuneki, 1992; Girish Kumar & Sheikh, 2018 – For genus *Dolichurus.*
- Krombein, 1979; Girish Kumar P & Sheela S, 2017 – For genus *Trirogma*.

Species level identification of few sphecid species were done using different keys provided by:

- Hensen, 1987 and van der Vecht & van Breugel, 1968 – For genus *Sceliphron*.
- Hensen, 1988 – For genus *Chalybion.*
- Hensen, 1991b and Dörfel & Ohl, 2015 – For genus *Sphex*.
- Dollfuss, 2013a – For genus *Ammophila.*

Note.

- Since workable key was not available for species under few genera, attempts were made to prepare it for the present study.
- Modified key of already published keys by different authors were also provided for species under few genera.

3.11. Storing and Preservation

All the labelled and registered specimens were stored in air tight insect cabinet boxes. To protect specimens from attack of insects, paradichlorobenzene were placed in boxes and periodic checking of specimens are done.

3.12. Illustrations and Measurements

The Photographs of specimens were captured with the camera model LEICA DFC 500 except few profile photos, that were captured with the camera Canon PowerShot SX 540 HS. Measurements were obtained using Leica LAS (Leica Application Suite V3.80) microsystems by Leica (Heerburg, Switzerland). Images at varying depth were stacked using Leica Automontage Software V3.80 and the final illustrations were post-processed for contrast and brightness using Adobe® Photoshop® CS5 (Version 6.1) software.

3.13. Catalog of Sphecidae

Cataloging or indexing species as they are discovered is a colossal task in today's fast-paced world. Wojciech J. Pulawski has been maintaining an updated online world catalog of apoid wasps of families Ampulicidae, Sphecidae, Crabronidae, and Heterogynaidae since 2003. This catalog was used extensively during the present study for literature references and distributional data of species and genera. Synonymic data used in the result section follows as in this catalog.

3.14. Terminology and Abbreviations Used

3.14.1. Morphological terms

Morphological terms followed here mostly follows those used by Bohart & Menke (1976), unless otherwise noted. Unlike Bohart & Menke, the term ‘mesosoma is used for definitive thorax since it contains first abdominal segment propodeum’ and metasoma is used for definitive abdominal segment (gaster plus petiole).

Head

Antennae: pair of movable segmented appendages on head between compound eyes.

Antennal socket: orifice on head in to which base of antennae is inserted.

Anterior ocellus: anterior oval or round simple median eye on vertex.

Carina: ridge or narrow raised line.

Clypeus: medial sclerite of head above the oral cavity and below the frons.

Flagellomeres: one of the division or a segment of flagellum (third antennal multisegmented structure).

Frons: middle section of face between the anterior margin of anterior ocellus and clypeus above.

Frontal platform: median U-shaped extension on the frons.

Frontoclypeal suture: cleavage line between frons and upper clypeus.

Galea: outer apical lobe of maxilla (paired structure, also called as side lip).

Hypostomal carina: U-shaped carina on back of head along oral cavity terminating at mandibular articulation posteriorly.

Mandible: strongly sclerotized paired lateral appendage of the mouthparts.

Pedicel: second antennal segment.

Placoid: elongate, flat, groove like or plate like sensory structures on male flagellomeres.

Posterior ocellus: two posterior oval or round simple lateral eyes on vertex.

Scape: first antennal segment.

Stipes: medial sclerite of maxilla.

Vertex: area on top of head behind frons.

Mesosoma

Areola: area enclosed by ridges or largely divided small uneven spaces.

Episternal sulcus: groove originating under the base of fore wing, and if complete, extend to antero-ventral margin of mesopleuron.

Mesopleuron: lateral part of mesothorax (part of thorax bearing middle pair of leg and fore wing).

Mesopleural suture: cleavage line on posterior margin of mesopleuron.

Mesoscutum: large dorsal plate or sclerite behind pronotum.

Metanotum: dorsal plate or sclerite behind scutellum.

Metapleuron: plate or sclerite in between mesopleuron and propodeum.

Metapleural sulcus: line or groove on posterior margin of metapleuron.

Metasternum: ventral surface or sternum of metathorax (division of thorax bearing hind legs and hind wings) between mid coxae and hind coxae.

Notauli: two longitudinal lines or grooves on mesoscutum.

Parapsidal furrows: two lateral longitudinal lines or grooves on mesoscutum.

Pronotal collar: raised or elavated posterior region of pronotum (first mesosomal segment).

Propodeum: dorsal plate or sclerite behind metanotum.

Propodeal enclosure: dorsal propodeal area delimited by carina.

Scutellum: dorsal plate or sclerite behind mesoscutum.

Sternaulus: horizontal groove near lower mesopleuron.

Spiracular groove: groove on propodeal side extending towards hind coxa.

Suture: a groove marking the line of fusion of two distinct plates.

Metasoma

Gaster: enlarged segmented part behind petiole.

Petiole: cylindrical stalk like structure that connect propodeum with gaster.

Petiole socket: orifice on posterior end of propodeum in which petiole is inserted.

Terga: one of division of tergum.

Tergum: dorsal gastral segments.

Sterna: one of division of sternum.

Sternum: ventral gastral segments.

Sessile metasoma: metasoma without petiole.

Wings

Cu-a: cubito-anal crossvein of fore wing, forming outer end of submedial cell.

Jugal lobe: area posteriod to anal lobe which is demarcated by a fold.

Fore wing media: longitudinal vein diverging at, before, or after Cu-a

Recurrent vein: medio-cubital cross vein of forewing, used in relation to their termination at the submarginal cell.

Submarginal cells: cells adjacent to stigma (darkly pigmented or strongly sclerotised area on leading edge of forewing towards the tip).

Tegula: small sclerite covering base of fore wing.

Legs

Apicoventral setae: setae arising on the apex of ventral surface of last tarsomere.

Arolium: sac like median lobe between tarsal claws.

Basitarsi: basal most tarsomere.

Coxa: first segment of leg.

Femur: third segment of leg.

Plantula: pad like organ projecting from ventral apex of tarsomeres.

Rake: linear series of setae on outer margin of foretarsus.

Tarsi: fifth segment of leg.

Tarsomere: one of division of tarsus.

Tibia: fourth segment of leg.

Tibial spur: spine like multicellular extension on distal end of tibia.

Trochanter: second segment of leg.

3.14.2. Abbreviations

3.14.2.1. Abbreviations used for Morphological terms

F1–F7 = Flagellomeres 1 to 7.

IOD = Inter ocular distance. Distance between the compound eyes medially.

LOL = Lateral ocellar length._Distance between the anterior ocellus and posterior ocellus medially.

Mm – Millimetre.

OOL = Ocellocular length._Distance between the compound eye and posterior ocellus medially.

POL = Posterior ocellar length._Distance between the posterior ocelli medially.

RV = Recurrent vein.

SMC = Submarginal cell.

T1-T6 = Metasomal terga 1 to 6.

3.14.2.2. Abbreviations used for the Museums

DEI: Deutsches Entomologisches Institut, Münchenberg, Germany.

EDZMU: Entomology Department, Zoological Museum, Uppsala University, P.O. Box 561, S-75122, Uppsala, Sweden.

MHNG: Musée d'Histoire Naturelle, Genève, Switzerland.

NHM: The Natural History Museum, London, England, formerly called 'British Museum (Natural History), London, Great Britain'.

NHMW: Naturhistorisches Museum, Wien, Austria.

NRS: Naturhistoriska Riksmuseet, Stockholm, Sweden.

NZC: Zoological Survey of India, Kolkata, India.

MHNG: Musée d'Histoire Naturelle, Genève, Switzerland.

MNHN: Muséum National d'Histoire Naturelle, Paris, France.

OXUM: Hope Department of Zoology, Oxford, England.

RMNH: Nationaal Naturhistorisch Museum (formerly Rijksmuseum van Natuurlijke Historie), Leiden, the Netherlands.

TMB: Természettudományi Múzeum, Budapest, Hungary.

USNM: National Museum of Natural History, Washington, D.C., U.S.A.

ZIN: Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia.

ZMUC: Zoological Museum, University of Copenhagen, Copenhagen, Denmark.

ZSIK: Western Ghat Regional Centre, Zoological Survey of India, Kozhikode, India.

3.15. Deposition of specimens (Vouchering specimens)

All those specimens (Holotypes and Paratypes) that were used for illustrations and descriptions have been labelled and deposited in to the 'National Collections of Zoological Survey of India, Western Ghat Regional Centre, Kozhikode (ZSIK) along with other wasps collected in the present study.

3.16. Digital loan of Specimens

Digital loan of Type specimens from Natural History Museum, London and Oxford University Museum of Natural History, UK were studied for confirming the identity of few collected species.

3.17. Distribution Maps

The co-ordinates for the collection sites of wasp specimens were noted using accurate GPS and map layers were digitised and compiled from forest maps and prepared using QGIS software.

3.18. Collection sites

States	Districts	Localities
Kerala	Thiruvananthapuram	Kallar, Kerala University campus, Neyyar Wildlife sanctuary, Paruthippara, Peppara wildlife sanctuary, Ponmudi hills.
	Kollam	Shasthamkotta, Shendurney Wildlife Sanctuary (Kattilapara).
	Kottayam	Cherupunkal.
	Idukki	Chinnar, Keerithodu, Kulamavu.
	Ernakulam	Thattekad Bird sanctuary, Vytilla.
	Palakkad	Lakkidi, Malampuzha, Parambikulam Wildlife Sanctuary, Nelliampathy, Paruthipara, Silent Valley National Park.
	Thrissur	Kattoor, Killimangalam, Porathissery, Puthenchira, Pullur, Chalakkudy, Kerala Agricultural University campus (Vellanikkara), Thumboor sacred groove, Vazhachal.
	Malappuram	Tenhipalam (Calicut University Campus) Nedumkayam, Nilambur, Parappanangadi.

	Kozhikode	Ashokapuram, Chaliyam, East Hill, Edakkara, Elathur, Jafer Khan colony (ZSI Campus), Janakikkadu, Kizhakkoth, Valiyaparamba, Kakkad, Kakkadampoyil, Kattangal, Kinalur, Kovoor, Kottooli Madappally, Malayamma, Mavoor paadam, Moorad, Nadakkavu, Nambikulam, Nanminda, Payanthong, Pathirapatta, Payyoli, Ponkunnumala, Kottakkal, Peruvannamuzhi, Purameri, Quilandy, Vallikkattukavu, Vengeri, Vilakottur, Vayalada.
	Kannur	Aralam Wildlife Sanctuary, Ayyoth, Kannapuram, Thalassery Mangrooves, Kuyyali, Thekkumbad dweep.
	Wayanad	Chandanathode, Chembra hills, Karlad, Kalloor, Machikudi, Mananthavadi, Mangavayal, Meenangadi, Meppadi, Muthanga Wildlife Sanctuary, Nadavayal, Panamaram, Ponkuzhi, Thirunelly.
	Kasaragod	Kottanjeri forest, Nileswaram, Ranipuram.
Tamil Nadu	Coimbatore	Anaikatty, Govanur, Kottur, Kurangumudi, Sadivayal, Siruvani, Valparai.
	Dindugal	Pannaikadu Shola forest.
	Nilgiris	Coonoor.
	Tenkasi	Courtallam.
	Theni	Vannathiparai, Bublimash stream.
	Tirunelveli	Ambasamudram range, Kuthiravetti, Gadana dam site, Gundaru dam site, Kalakkad Mundanthurai Tiger Reserve, Karaiyar dam site, Koonthankulam Bird Sanctuary, Kullanadimedu, Manimuthar dam site, Rosemiyapuram, Suruli Cumbam.
	Kanyakumari	Kanyakumari Wildlife Sanctuary (Alagiapandiapuram,

		Thuthukulivayal, Vellimalayi).
Karnataka	Coorg	Bettathur, Chiklihole reservoir site, Madikeri.
	Kodagu	Kodagu, Bettathur near Madikeri, Gonikoppal.
	Udupi	Various localities of Mookambika Wildlife Sanctuaries such as Areshiroor, Kollur, Heddarimane, Halkal junction, Mekke, Jadkal.
	Chikmagalur	Kabbinahalli Coffee Estate.
	Shimoga	Agumbe, Bhadra Wildlife Sanctuary, various localities of Mookambika Wildlife Sanctuaries such as Hosagadde near Kudajadri, Hulikal Guest House.

PLATE 1

Collection methods. 1. Sweeping; 2. Rearing; 3. Malaise traps; 4. Pan traps

PLATE 2

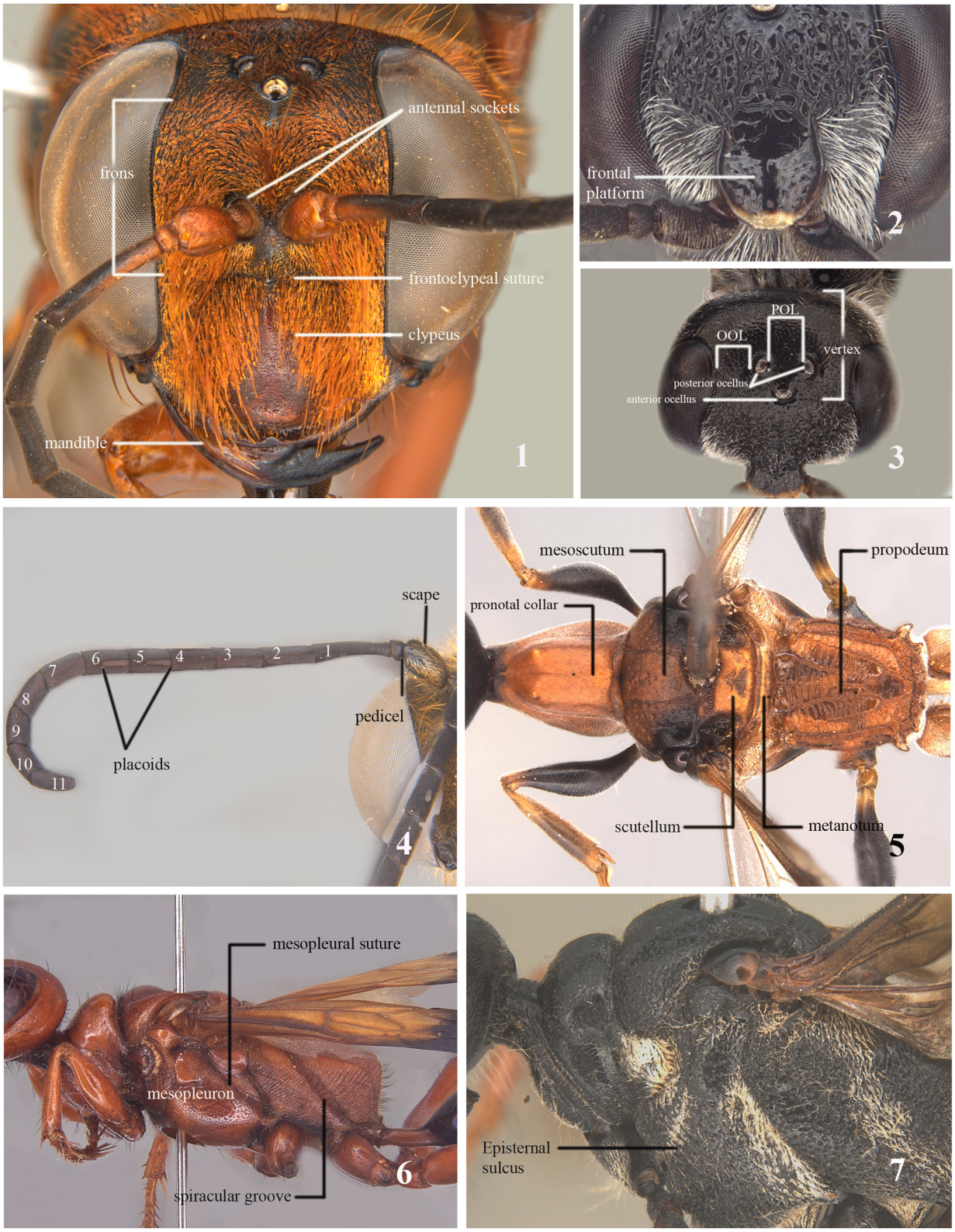


PLATE 2. MORPHOLOGICAL TERMS
1. *Sphex sericeus* (Fabricius): Head, frontal view; 2. *Dolichurus chareshi* Anagha & Girish Kumar: Frontal platform; 3. *Dolichurus aridulus* Krombein: Head, dorsal view; 4. *Sphex obscurus* (Fabricius): Antenna; 5. *Ampulex ceylonica* Krombein: Mesosoma, dorsal view; 6. *Chlorion splendidum* Fabricius: Mesosoma, lateral view; 7. *Ammophila laevigata* Smith: Episternal sulcus.

PLATE 3

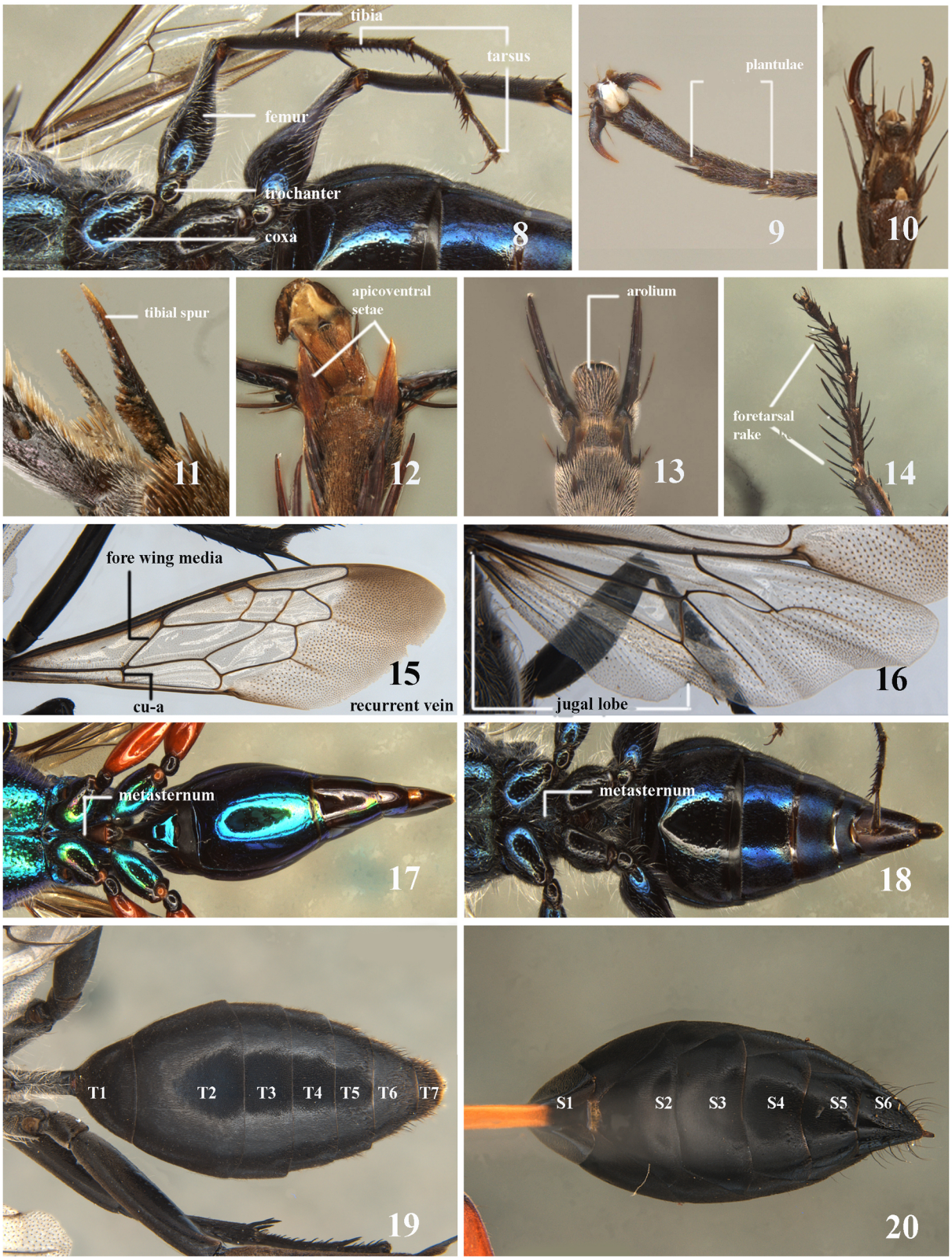
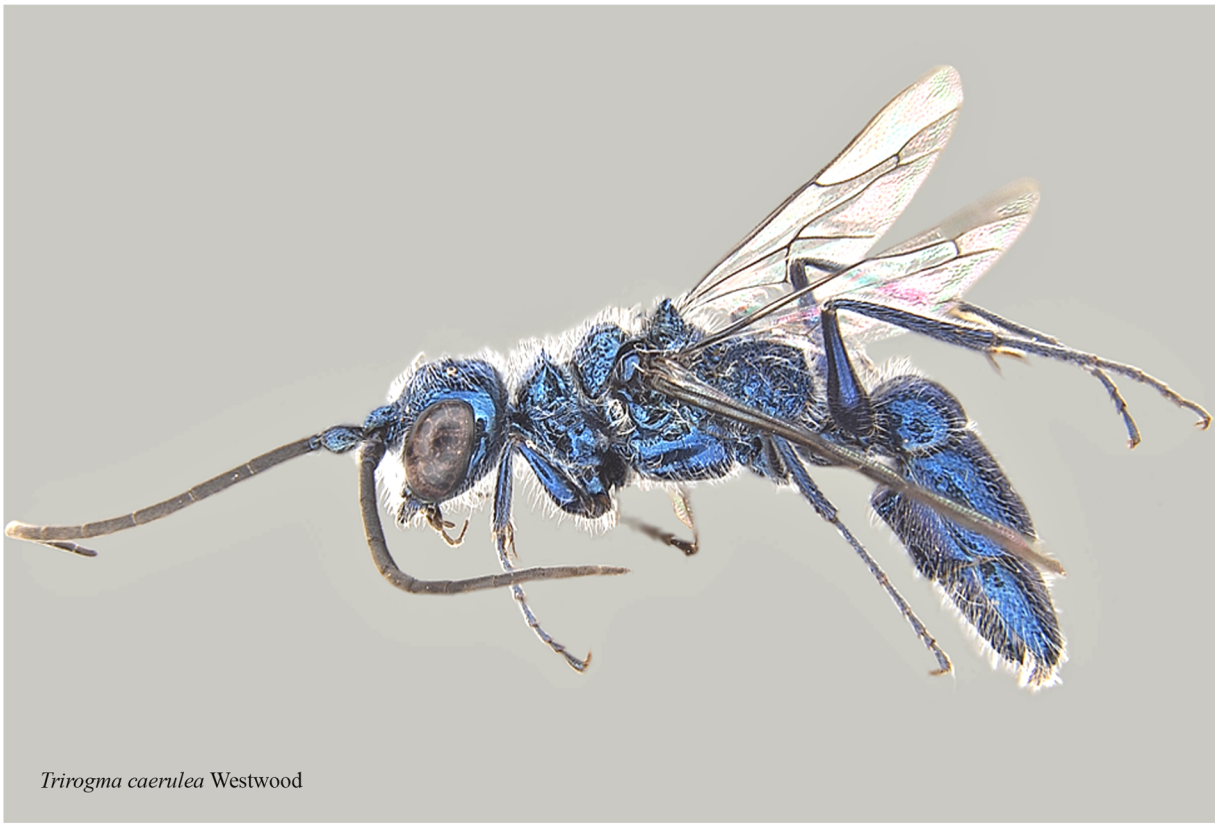


Plate 3. MORPHOLOGICAL TERMS

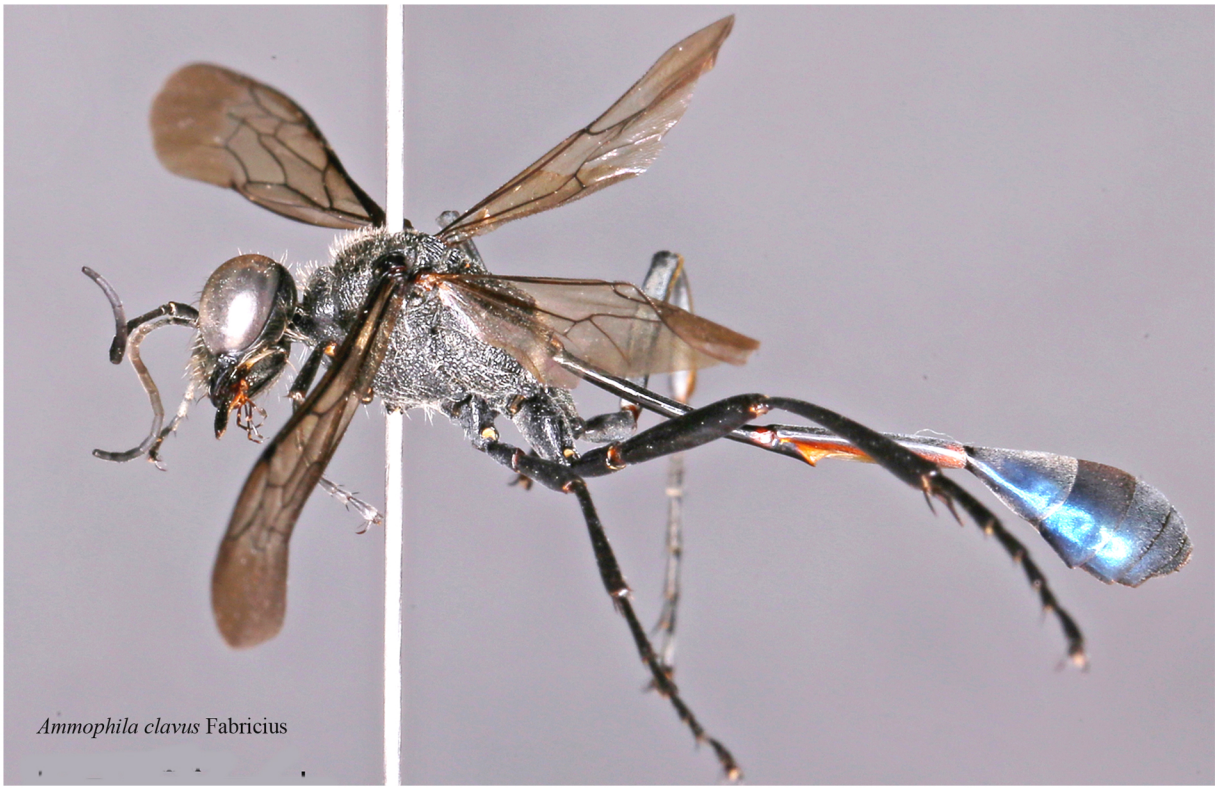
8. *Trirogma caerulea* Westwood: Mid leg; 9. *Chalybion gracile* Hensen: Plantulae; 10. *Chlorion splendidum* Fabricius: Tarsal claw; 11. *Prionyx viduatus* (Christ): Tibial spur; 12. *Sphex sericeus* (Fabricius): Apicoventral setae; 13. *Ammophila clavus* (Fabricius): Arolium; 14. *Chlorion lobatum* (Fabricius): foretarsal rake; 15. *Sphex argentatus* Fabricius: fore wing; 16. *Chalybion bengalense* (Dahlbom): Hind wing; 17. *Ampulex compressa* (Fabricius): metasternum; 18.*Trirogma caerulea* Westwood: metasternum; 19. *Sphex argentatus* Fabricius: metasomal terga; 20. *Sceliphron coromandelicum* (Lepeletier): metasomal sterna.

RESULTS



Trirogma caerulea Westwood

AMPULICIDAE



Ammophila clavus Fabricius

SPHECIDAE

4. RESULTS

4.1. Superfamily Apoidea

Superfamily Apoidea with Spheciformes (apoid wasps) and Apiformes (bees) are characterised chiefly by a combination of characters, such as concealed ovipositor which is modified as sting apparatus, enlarged propodeum, postero-lateral apex of pronotum that is set apart from tegula by discrete cuticular gap, its postero-lateral margin having convex lobe and with widely U shaped postero-dorsal margin. Well developed wing venation, slight to moderate sexual dimorphism are also the other characterstic features of Apoidea.

Key to series of Apoidea (adopted from Goulet & Hubert, 1993)

1. Body setae branched, often feather-like, at least a few such setae on dorsolateral area of propodeum; hind leg with tarsomere 1 wider than following tarsomeres. ..... **APIFORMES**

— Body setae simple, unbranched; hind leg with tarsomere 1 about as wide as following tarsomeres. ……..……..…… **SPHECIFORMES**

4.2. Spheciformes

Spheciformes are devoid of a single common name and comprises wasps such as sand wasps, mud dauber wasps, digger wasps, and thread waisted wasps that are grouped in to four families: Ampulicidae, Crabronidae, Sphecidae, and Heterogynaidae. They are very heterogenous group, and the majority of them are brightly coloured, fast moving, and conspicuous.

Note.Classification of Spheciformes and its families Ampulicidae and Sphecidae used here follows as in Pulawski (2023) catalog. The families and most subfamilies presented here mostly correspond to the subfamilies and tribes accepted in Bohart and Menke's (1976) revision of world genera.

Key to family Ampulicidae and Sphecidae (adopted from Bohart & Menke, 1976)

1. Gaster with or without petiole, if petiolate and composed of only sternum, then hind wing jugal lobe small. ……..… **AMPULICIDAE** SHUCKARD

— Gaster petiolate and petiole composed of only sternum, unless with two sections (as in *Ammophila* Kirby); hind wing jugal lobe large with anal vein. ..... **SPHECIDAE** LATREILLE

CHAPTER 1
AMPULICIDAE

1. FAMILY AMPULICIDAE

Ampulicidae is one of the smallest family within Apoidea with very less number of described species around the world. So far, family Ampulicidae is represented by 205 species and 85 subspecies under six genera in two subfamilies worldwide (Pulawski, 2023). Even with the perpetual tropical climatic conditions and rich diversity of Oriental region, distribution of these apoid wasps are far fewer explored. Ampulicidae with 87 species and two subspecies under three genera have been recorded from Oriental region till date (Pulawski, 2023).

During the present study, a total of 16 species belonging to three genera in two subfamilies of family Ampulicidae were studied. Distribution map to species of all genera collected and Illustrated dichotomous key to genera and species of this family are prepared. Since the family is represented by only few genera and species from India, Indian keys are attempted herein.

1.1. General Morphology

Ampulicids include small to large sized wasps with elongate body and slender appendages. Most species of this genus are identified by their blue green metallic colouration. Besides this, there are also species that are generally ant like in appearance with rufous and black or entirely black integument.

Antennae of these wasps are generally placed low on frons and their antennal sockets touching or slightly separated from fronto-clypeal suture. Inner margins of eyes are parallel or slightly converging above or below.

Pronotal collar is quite long, often with tubercles and not closely attached to mesoscutum, pronotal lobe almost touching the tegula. Mesoscutum is with centrally placed, long and distinct notauli. Propodeal dorsum generally with enclosure, which is often sculptured by carina. Episternal sulcus is absent but sometimes seen as traces between antero-ventral margin of mesopleuron and terminating end of omaulus. Legs are adapted for running with the femora generally spindle shaped at distal third. The tarsal claws are with one inner tooth and mid tibia with two apical spurs. Fore wing is with two or three SMC and two RV, SMC1 or SMC2 receives RV1 and SMC2 or SMC3 receives RV2. Jugal lobe of hind wing is absent or small and anal area is without an anal vein.

Gaster sessile, or petiolate having both tergum and sternum.

Sexual dimorphism ranges from slight to extreme. Mandible and clypeus in females are modified to perform different function such as for prey capturing and nest building. Antenna of male and female with twelve and thirteen segments respectively. Six gastral segments are visible in females while only three in males. Metasomal punctures generally fine, appears almost impunctatae in females and are coarser in males.

Note. Apart from the basic differences, most male and female ampulicids exhibit striking differences in certain characters depending on species, thus both male and female keys are provided for respective genera in the present study.

1.2. Systematic Position

CLASS: INSECTA
ORDER: HYMENOPTERA
SUPERFAMILY: APOIDEA
Family: Ampulicidae Shuckard, 1840
Subfamily: Ampulicinae Shuckard, 1840
- *Ampulex* Jurine, 1807
- *Trirogma* Westwood, 1841

Subfamily: Dolichurinae Dahlbom, 1842
Tribe: Aphelotomini Ohl and Spahn, 2009
- *Aphelotoma* Westwood, 1841
- *Riekefella* Özdikmen, 2005 (= *Austrotoma* Riek, 1955)

Tribe: Dolichurini Dahlbom, 1842
- *Dolichurus* Latreille, 1809
- *Paradolichurus* Williams, 1960

Key to Indian subfamilies and genera of Ampulicidae

1. Frontal platform not deeply grooved or completely divided medially (Plates 17−25, Figs. 84, 91, 97, 103, 109, 112, 117, 123, 131, & 137); tarsal plantulae present [DOLICHURINAE, DOLICHURINI]. ……..…….. ***Dolichurus*** Latreille

— Frontal platform deeply grooved or completely divided to form separate lobes covering each antennal base; tarsal plantulae absent [AMPULICINAE]. …….. 2

2. Each antennal sockets with a frontal lobe that overhangs (Plates 4−11, Figs. 2, 8, 13, 20, 25, 32, 38, & 45); metasternum Y shaped or forklike posteriorly (Plate 6, Fig. 17);

petiole placed between and on same plane as hind coxa (Plate 6, Fig. 17). ……..…..……. ***Ampulex*** Jurine

— Each antennal sockets covered by single platform like lobe medially (Plates 12−16, Figs. 50, 58, 65, 70, & 77) metasternum not Y shaped, but slightly emarginate posteriorly (Plate 12, Fig. 56); petiole placed above and to some degree after hind coxa (Plate 12, Fig. 56). ……..…….....……..… ***Trirogma*** Westwood

1.2.1. SUBFAMILY AMPULICINAE SHUCKARD, 1840

I. Genus *Ampulex* Jurine, 1807

Ampulex Jurine, 1807: 132. Type species: *Chlorion compressum* (Fabricius, 1804) (= *Sphex compressus* Fabricius, 1781) (designated by Audouin, 1822: 301).

Pronaeus Latreille, 1809: 56. Type species: *Dryinus aeneus* Fabricius, 1804 (designated by Latreille, 1810: 438) (synonymized with *Ampulex* Jurine by Pate, 1935: 247).

Lorrhoeum Shuckard, 1837: 18. Type species: *Chlorion compressum* (Fabricius, 1804) (= *Sphex compressus* Fabricius, 1781) by monotypy and original designation.

Rhinopsis Westwood, 1844: 68. Type species: *Rhinopsis abbotti* Westwood (= *Ampulex canaliculata* Say, 1823, by monotypy).

Waagenia Kriechbaumer, 1874: 55. Type species: *Waagenia sikkimensis* Kriechbaumer, 1874 by monotypy.

Chlorampulex de Saussure, 1892: 441. Type species: *Sphex compressus* Fabricius, 1781 (designated by Pate, 1937: 18).

Diagnosis. Antennal sockets generally set apart by diameter of a socket or a bit less, each covered by single frontal extension dorsally (Plates 4−11, Figs. 2, 8, 13, 20, 25, 32, 38, & 45); metasternum sharply divided to form Y shape apically (Plate 6, Fig. 17); hind wing without jugal lobe; clypeus mostly with a median carina, apical margin of female clypeus generally with three teeth (Plate 4, Fig. 2; Plate 6, Fig. 13; Plate 8, Fig 25; Plate 10, Fig. 38; Plate 11, Fig. 45); upper half of propodeal side with reticulations or areolate (Plate. 4−9; Figs. 4, 10, 16, 22, 27, & 34); gaster petiolate, petiole placed between and on same plane as hind coxa (Plate 6, Fig. 17); G2 much longer than other gastral segments; fore wing with two (Plate 4, Fig. 5; Plate 8, Fig. 28) or three SMC (Plate 6, Fig. 14; Plate 9, Fig. 35), media deviating at or before Cu–a; propodeal dorsal enclosure with medial longitudinal and few lateral carina that unites posteriorly, surface between these carina smooth with several

transverse carina (Plate 4−11, Figs. 3, 9, 15, 21, 26, 33, 40, & 46) (Bohart & Menke, 1976; Anagha & Girish Kumar, 2019).

Distribution. *Ampulex* is a widespread tropical genus distributed in Australasian, Afrotropical, Nearctic, Neotropical, Oriental and Palearctic Regions (Bohart & Menke, 1976; Anagha & Girish Kumar, 2019).

Keys: World Species: Schulz, 1904: 765 (key to *Ampulex* species from South America); Krombein, 1979: 4 (key to Ceylonese Ampulicidae), Gess, 1984: 20 (key to female *Ampulex* species (pronotal collar without conical tubercle) from southern Africa) (Pulawski, 2023).
Indian Species: Jonathan *et al*., 2000: 171 & 172 (key to *Ampulex* species from Meghalaya State of India); Anagha & Girish Kumar, 2019: 4 (key to *Ampulex* species from India) (Pulawski, 2023).

Note. Genus is represented by 134 species and four subspecies worldwide. So far, 53 species and a subspecies are recorded from the Oriental region, of which 26 species and the subspecies are from India.

Biology. The species of this genus are known to attack cockroaches belonging to family Blattidae and Ectobiidae (Bohart & Menke, 1976). The wasps on finding cockroach, attacks and disable its escape movement. After the roach is paralysed, wasp cut off antenna of host at specific location and drink out some oozing haemolymph (Piek *et al*., 1984). The stung cockroach is then dragged by wasp into its burrow or any pre-existing cavity by grasping its truncated antenna (Veltman & Wilhelm, 1991). Once inside the burrow, wasp lay an egg on the mid coxa of cockroach, comes out and close the entrance of burrow with various debris to keep other predators out. Later, egg hatches and larva will bore its way in to cockroach body and consume its internal organ in the order most likely to keep it alive as long as possible. Finally, last instar larva kills the host, undergo pupation and new wasp emerge out, ready to begin the process again.

Key to Indian species of *Ampulex* Jurine (except *Ampulex sodalicia* Kohl due to lack of details in the descriptions) (adopted from Anagha & Girish Kumar, 2019)

1. Female. 2
— Male. 24
2. Body brilliant metallic green, bluish green, blue or purple (Plate (6, Fig. 12, Plate 8, Fig. 24, & Plate 9, Fig. 30). 3

— Body either rufous and black (Plate 4, Fig. 1; Plate 10, Fig. 37; Plate 11, Fig. 44) or entirely black. ……..……..…… 19

3. Mesoscutum with well defined punctures (Plate 6, Fig. 15, Plate 8, Fig. 26, & Plate 9, Fig. 33). ……...…. 4

— Mesoscutum without punctures, nearly smooth or aciculate. ……...…. 17

4. Pronotal collar with striations, transverse rugulae (Plate 6, Fig. 15 & Plate 8, Fig. 26), or few obscure transverse wrinkles. ……..…… 5

— Pronotal collar without striations, transverse rugulae, or few obscure transverse wrinkles. ……...…. 8

5. Temple behind eye with a projecting tubercle. …...…. ***A. sikkimensis*** (Kriechbaumer)

— Temple behind eye without any such projecting tubercle……...…… 6

6. Mid and hind femora rufous (Plate 6, Fig. 12 & Plate 7, Fig. 17). …….. 7

— Only hind femur rufous (Plate 8, Fig. 24). ...……..…..…. ***A. dissector*** (Thunberg)

7. Mesoscutum with distinct parapsidal furrows (Plate 6; Fig. 15); T2 with scattered fine punctures (Plate 6, Fig. 18)…...……..…… ***A. compressa*** (Fabricius)

— Mesoscutum with poorly defined parapsidal furrows; T2 much more strongly punctate. ……..…..…. ***A. carinifrons*** Cameron

8. Wings smoky violaceous or smoky fuscous or fuscoviolaceous. ……...…… 9

— Wings fuscohyaline or hyaline with slight infumation. ……..…… 15

9. Hind femur entirely or partly red or rufous……..……..……...…. 10

— Hind femur either blue or black. ……..……...….. ***A. difficilis*** Strand

10. Length of third and fourth joints of antenna equal. …… 11

— Length of third and fourth joints of antenna variable. ……...……..……12

11. Clypeal carina diverging near apex. ……...…..…....…. ***A. latifrons*** Kohl

— Clypeal carina not diverging near apex. ……...…..……. ***A. interstitialis*** Cameron

12. Head entirely or partly purple. ……..……..……...…. 13

— Head not purple, either green or blue. ……..…….. 14

13. Legs black, hind femur and tibia purple apically. ……... ***A. khasiana*** Cameron

— Legs blue, hind femur and tibia purple apically. ……..…… ***A. longicollis*** Cameron

14. Mid and hind femora rufous. ……..……. ***A. montana*** Cameron

— Only hind femur rufous (Plate 9, Fig. 30). …….. ***A. major*** Kohl

15. Vertex and pronotal collar nearly impunctate. …… ***A. aborensis*** Nurse

—Vertex and pronotal collar punctate. ……..…….. 16

16. Head bluish green. ……... ***A. hospes cognata*** Kohl

— Head purple variegated with dark green. ……..…… ***A. himalayensis*** Cameron

17. Pronotal collar and mesoscutum aciculate. …… ***A. pilosa*** Cameron

— Pronotal collar and mesoscutum not aciculate, bare. ……..……. 18

18. Frons with punctures. ……..… ***A. crudelis*** Bingham

— Frons without punctures. …… ***A. ruficoxis*** Cameron

19. Body entirely black. ……..……...… ***A. approximata*** Turner

— Body not entirely black. ……..…… 20

20. Mesosoma and legs entirely black. …… ***A. nigricans*** Cameron

— Mesosoma and legs not entirely black. ……..……..…… 21

21. Mesosoma mostly rufous or medium brown (Plate 4, Fig. 3, Plate 10, Fig. 40, & Plate 11, Fig. 44). ……...……....… 22

— Mesosoma black with some violet patches. ……..…… ***A. rothneyi*** Cameron

22. Propodeal dorsum with long curved tooth postero-laterally (Plate 4, Fig. 3). ……...…... ***A. ceylonica*** Krombein

— Propodeal dorsum with blunt tooth postero-laterally (Plate 10, Fig. 40 & Plate 11, Fig. 44). ……..…… 23

23. Mandibles angulate at basal third of outer border (Plate 10, Fig. 39); petiole rufous (Plate 10, Figs. 37 & 43)……..… ***A. ruficornis*** (Cameron)

— Mandibles with evenly rounded outer margin (Plate 11, Fig. 45); petiole white (Plate 11, Figs. 44 & 48). ..... ***A. sadiyae*** Anagha & Girish Kumar

24. Body metallic green, blue, bluish green, bluish or purple (Plate 7, Fig. 19) …..…... 25

—Body not metallic, either rufous or rufous and black (Plate 5, Fig. 7 & Plate 10, Fig. 41). ……..…… 30

25. Mesosoma with dense long black setae. ……..…… ***A. pilosa*** Cameron

— Mesosoma with sparse long black setae or without any setae. ……..……...…. 26

26. Pronotal collar with striations, transverse rugulae (Plate 7, Fig. 21), or wrinkles. … 27

— Pronotum without transverse rugulae, striations or wrinkles. …… 28

27. Mid and hind femora rufous (Plate 7, Fig. 19). ……..….. ***A. compressa*** (Fabricius)

— Only hind femur rufous. ……..…....…… ***A. dissector*** (Thunberg)

28. Hind femur more or less blue violet shimmering. …… ***A. difficilis*** Strand

— Hind femur red. ……..…….....…… 29

29. Length of third and fourth joints of antenna equal. ……...…… ***A. latifrons*** Kohl

— Length of third and fourth joints of antenna not equal, third joint slightly but distinctly longer than fourth. ……..... ***A. assamensis*** Cameron

30. Body entirely black. ……..…….……...… ***A. approximata*** Turner
— Body not entirely black. …….…….……..... 31
31. Mesosoma and legs entirely black. ……..….. ***A. nigricans*** Cameron
— Mesosoma and legs not entirely black. …….…….…. 32
32. Mesosoma mostly rufous or medium brown (Plate 5, Fig. 9). ……...… 33
— Mesosoma black with some violet patches. ……..… ***A. rothneyi*** Cameron
33. T1 with sides diverging towards apex. ……...…… 34
— T1 with sides not diverging towards apex, nodose (Plate 10, Fig. 43). ……..… ***A. ruficornis*** (Cameron)
34. Mesoscutum closely punctate (Plate 5, Fig. 9). ……....…….. ***A. ceylonica*** Krombein
— Mesoscutum microsculptured. ……..….. ***A. constanceae*** (Cameron)

Note. Female unknown for *A. assamensis* Cameron & *A. constanceae* (Cameron).
Male unknown for *A. aborensis* Nurse, *A. carinifrons* Cameron, *A. crudelis* Bingham, *A. hospes cognata* Kohl, *A. interstitialis* Cameron, *A. khasiana* Cameron, *A. longicollis* Cameron, *A. major* Kohl, *A. ruficoxis* Cameron, *A. sadiyae* Anagha & Girish Kumar, & *A. sikkimensis* (Kriechbaumer).

Species from southern Western Ghats and its adjacent areas

i. *Ampulex ceylonica* Krombein, 1979
(Plates 4 & 5; Figs. 1–11)

Ampulex ceylonica Krombein, 1979: 9. (USNM) Holotype: ♀, Sri Lanka, Kandy District, Udawattakele Sanctuary.

Material examined. Kerala: 1 ♀, Kozhikode district, Kottooli wetland, Coll. P. Girish Kumar, 20.vi.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13151; 1 ♂, Thiruvananthapuram district, Peppara Wildlife Sanctuary, Pattankulichapara, Coll. P. Girish Kumar & Party, 20.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13153; 1 ♀, Thiruvananthapuram district, Neyyar Widlife Sanctuary, Kottur, Coll. Md. Jafer Palot & Party, 17.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13161; 1 ♀, Kozhikode district, Purameri, Coll. K.P. Hanima Raveendran, 6.vii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13162; 1 ♀, Thiruvananthapuram district, Methottam, Coll. S. Anagha & Party, 17.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13163; 4 ♂, Kozhikode district, Madappally, Coll. K. Anju, 13.xi.2019, 7.xii.2019 & 6.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13434, 13505 & 18480–18481; 2 ♂, Kozhikode district, Madappally, Coll. S. Anagha, 16.xi.2019 &

7.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18478–18479; 1 ♂, Kozhikode district, Vilangad, Coll. K. Anju, 2.i.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18482; 1 ♀, Kozhikode district, Moorad, Coll. J.B. Terine, 16.i.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18831; 1 ♀, Thiruvananthapuram district, Peppara Wildlife Sanctuary, Pattankulichapara, Coll. P. Girish Kumar & Party, 5.xii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19572. Tamil Nadu: 1 ♂, Coimbatore district, Anaikatti, Coll. P. Girish Kumar & Party, 4.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13152.

Diagnosis. **Female (Plate 4, Figs 1−6)**. Body size: 12–13 mm. Head black, frons and vertex microsculptured with sparse moderately large punctures (indistinct on frons of some specimens) (Plate 4; Fig. 2); antenna and mandible rufous, apex of mandible ferruginous; clypeus produced medially, apical margin with well developed median tooth and well separated antero-laterally directed lateral tooth (Plate 4; Fig. 2); pronotal collar microsculptured with moderately large punctures, weak median furrow and pair of small acute tubercles anteriorly (Plate 4; Fig. 3); mesosoma mostly rufous, sides of mesoscutum and scutellum black; mesoscutum, scutellum, and metanotum with moderately large punctures, punctures relatively distinct and more on mesoscutum; postero-lateral propodeal dorsum with long curved silvery white spines (Plate 4; Fig. 3); mesopleuron almost similarly punctate as in mesoscutum, sternaulus distinct and crenulate (Plate 4; Fig. 4); tegula black; gaster black with fine punctures, apical third of T1 with sides diverging towards T2 (Plate 4, Fig. 6); petiole silvery white (Plate 4; Fig. 1); hind coxa, base of tibiae, all trochanters and tarsi, rufous; fore wing with two SMC, subhyaline with dark infumation on radial, submarginal, discoidal and submedial cell (Plate 4, Fig. 5).

Male (Plate 5, Figs. 7–11). Body size: 9–11 mm. Colouration almost similar to female (Fig. 7); frons and vertex pitted with longitudinal rugulae (Plate 5, Fig. 8); clypeus with produced median part, lateral tooth absent (Plate 5; Fig. 8); mesoscutum, scutellum and mesopleurae closely pitted; sculpturing of propodeum as in female (Plate 5, Fig. 9); notauli and sternaulus not distinct as in female; petiole black; fore wing infumation lighter.

Distribution. India: Kerala, Tamil Nadu, Meghalaya. *Elsewhere*: Indonesia; Laos; Sri Lanka (Anagha & Girish Kumar, 2019; Anagha & Girish Kumar, 2020a; Pulawski, 2023).

Remarks. Anagha & Girish Kumar (2019) reported this species from Kerala and Tamil Nadu for the first time.

ii. *Ampulex compressa* (Fabricius, 1781)

(Plates 6 & 7, Figs. 12–23)

Sphex compressus Fabricius, 1781: 445. (NHM) Holotype or syntypes: India, Kerala, Malabar.

Ampulex compressa; Jurine, 1807: 134.

Ampulex sinensis de Saussure, 1867: 43. (NHMW) Holotype or syntypes: ♂, China, Hong Kong (synonymized with *Ampulex compressa* by Gerstaecker, 1871: 852).

Chlorampulex striolata de Saussure, 1892: 446. (MHNG) Holotype or syntypes: ♀, Tanzania, Zanzibar (no specific locality) (synonymized with *Ampulex compressa* by Schulz, 1911: 152).

Material examined. Kerala: 1 ♀, Kozhikode district, Jafer Khan Colony, Coll. P. Girish Kumar, 24.ix.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10205; 1 ♀, Wayanad district, Thirunelli, Coll. P. Girish Kumar, 16.ii.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10479; 1 ♀, Kollam district, T.K.M Arts and Science College, Coll. A.K. Aseeb. A.K, 1.i.2018-31.iii.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12324; 1 ♂, Idukki, Keerithodu, Coll. P.M. Sureshan & Party, 20.xi.1999, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13093; 2 ♀, Kozhikode district, ZSI Campus, Coll. GSDP Students, 11.x.2018 & 19.xi.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13098 & 13150; 1 ♀, Kasaragod district, Ranipuram, Coll. Rajan, 10.xii.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13150; 1 ♀, Kozhikode district, Balussery, Coll. P. Girish Kumar, 8.xii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13847; 4 ♀, Kozhikode district, Kottooli wetland, Coll. Veneesa Rose, Feb–Nov 2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15429-15432; 1 ♀, Kozhikode district, Purameri, Coll. K.P. Hanima Raveendran, 21.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18832; 1 ♀, Kozhikode district, Madappally, Coll. S. Anagha, 22.iii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19406.

Diagnosis. **Female (Plate 6, Figs. 12–18)**. Body size: 15–24 mm. Body brilliant metallic green or blue (Plate 6; Fig. 12); frons punctate with distinct carina from antennal tubercle extending upward, becoming evanescent above (Plate 6, Fig. 13); antenna black, scape metallic blue dorsally; mandible black, apex rufous; clypeus with produced median part, apical margin rounded medially, lateral tooth distinct (Plate 6, Fig. 13); vertex with a short median groove; pronotal collar with median furrow, postero-medial tubercles and few transverse rugulae on anterior two third (Plate 6, Fig. 15); vertex, mesoscutum, scutellum,

metanotum and mesopleuron, with distinct punctures, punctures less and more scattered on scutellum and metanotum; postero-lateral propodeal dorsum with blunt tooth (Fig. 16); gaster with fine punctures (Plate 6, Fig. 18); mid and hind femora rufous, apex black; fore wing subhyaline with three SMC (Fig. 14).

Male (Plate 7, Figs. 19–23). Body size: 13–16 mm. Resembles female in most aspects; punctations on frons, vertex, mesosoma, mesopleurae and metasoma coarser, closer than in female; frons with carina from antennal tubercle extending upward where it passes behind anterior ocellus (Plate 7; Fig. 20); clypeus with produced median part, apical margin with indistinct emargination medially (Plate 7; Fig. 20), vertex with evanescent medial groove.

Distribution. India: Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Himachal Pradesh, Karnataka, Kerala, Lakshadweep, Maharashtra, Meghalaya, Odisha, Sikkim, Tripura, Uttarakhand, West Bengal. *Elsewhere*: Australia; Bangladesh; Brazil; Chagos Archipelago; China; Cook Islands; Ethiopia; France; Hawaii island; Indonesia; Iran; Island of Bourbon; Island of Reunion; Island of St. Helena; Kenya; Laos; Mauritius; Myanmar; Nepal; New Caledonia; Philippines; Seychelles; Saudi Arabia; Singapore; Sri Lanka; Tanzania; United Arab Emirates; Venezuela; Vietnam; Zanzibar (Anagha & Girish Kumar, 2019; Anagha & Girish Kumar, 2020a; Pulawski, 2023).

iii. *Ampulex dissector* (Thunberg, 1822)

(Plate 8, Figs. 24–29)

Ichneumon dissector Thunberg, 1822: 272. (EDZMU) Holotype or syntypes: Japan (no specific locality).

Ampulex amoena Stål, 1857: 63. (NRS) Holotype or syntypes: China (no specific locality) (synonymized with *Ampulex dissector* by Kohl, 1893: 489).

Ampulex novarae de Saussure, 1867: 44. (NHMW) Holotype or syntypes: ♂, Hong Kong (synonymized with *Ampulex dissector* by Roman, 1912: 251).

Ampulex consimilis Kohl, 1893: 468. (NHMW) Holotype or syntypes: ♀, China, Hong Kong (synonymized with *Ampulex amoena* by Schulz, 1912: 96).

Ampulex japonica Kohl, 1893: 467. (TMB) Holotype or syntypes: ♀, Japan (no specific locality) (synonymized with *Ampulex dissector* by Roman, 1912: 251).

Ampulex dissector; Roman, 1912: 251.

Material examined. Kerala: 1 ♀, Kannur district, Kannapuram. Coll. C. Charesh, 2.ii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13103.

Diagnosis. **Female (Plate 8, Figs. 24–29)**. Body size: 14–20 mm. Body brilliant metallic green or blue; frons and vertex with well defined distinct punctures (Plate 8, Fig. 25); antenna and mandible black, apex rufous; clypeus produced medially, apical margin with median tooth and lateral tooth of equal size separated by narrow emargination (Plate 8, Fig. 25); pronotal collar with transverse rugulae interrupted by shallow median groove, postero-medial tubercles absent; mesoscutum, scutellum, and metanotum with scattered punctures; postero-lateral propodeal dorsum with blunt tooth (Plate 8, Fig. 26); mesopleuron also with distinct punctures, sternaulus distinct and crenulate (Plate 8, Fig. 27); gaster with fine punctures (Plate 8, Fig. 29); hind femur rufous, apex black; fore wing hyaline with two SMC (Plate 8, Fig. 28).

Male. Body size: 9–12 mm. Frons with close longitudinal rugulae; much of vertex with large subcontiguous punctures; sculpturing of pronotal collar as in female but ruge comparitively coarser; mesopleuron as in female (Krombein, 1979).

Distribution. India: Kerala, Uttarakhand. *Elsewhere*: China; Japan; Korea; Laos; Sri Lanka; Taiwan; Thailand (Anagha & Girish Kumar, 2019; Anagha & Girish Kumar, 2020a; Pulawski, 2023).

Remarks. Anagha & Girish Kumar (2019) reported this species from Kerala for the first time.

iv. *Ampulex major* Kohl, 1893

(Plate 9; Figs. 30–36)

Ampulex major Kohl, 1893: 467. (TMB) Holotype or syntypes: ♀, Indonesia, Moluccas (no specific locality).

Material examined. Kerala: 1 ♀, Kasaragod district, Kottanjeri forest, Coll. K. Rajmohana & Party, 5.iii.2006, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12267; 1 ♀, Kozhikode district, Kakkayam, Coll. Tessy Rajan, 10.i.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 16682; 2 ♀, Wayanad district, Chandanthodu, Coll. K.A. Subramanian & Party, 14.ii.2021 & 15.ii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17127 & 18477; 1 ♀, Kannur district, Aralam, Chavachi, Coll. K.A. Subramanian & Party, 24.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17337.

Redescription. Female (Plate 9, Figs. 30–36). Body size: 24–29 mm.

Colour. Body metallic blue, sometimes marked with greenish tints, gaster with purplish blue tint (Plate 9, Fig. 36); antenna except scape and mandibles black; hind femur rufous, apex black; fore wing fuscous (Plate 9, Fig. 35).

Vestiture. Pubescence on head, thorax and gaster silvery white; clypeal margin with long brown setae.

Head. Head rounded in frontal view; vertex slightly arched above eyes; inner eye margin converging above and below; mandibles with evenly rounded outer margin; clypeus strongly carinate, medially produced, apical margin with median tooth and well developed lateral tooth separated by narrow emargination (Plate 9, Fig. 32); head 1.92× as wide as IOD at anterior ocellus; POL 0.63× LOL and 0.29× OOL; frons distinctly punctate with striations; vertex with median groove and distinct moderately large punctures; F1 0.84× combined length of F2 and F3.

Mesosoma. Pronotal collar broader than long with distinct punctations, antero-median area depressed with a weak medial line, postero-medial tubercles absent; mesoscutum 1.4× broader than long with scattered moderately large deep punctures and small punctures, punctures more on sides and anterio-median area of mesoscutum; scutellum also with scattered punctures, anterior margin with coalesced punctures arranged linearly; metanotum with a curved row of moderately large punctures medially; propodeal dorsal enclosure with medial longitudinal and four lateral longitudinal carina that unite posteriorly, surface between these carina smooth with several transverse carina, postero-lateral propodeal dorsum with blunt tooth (Plate 9, Fig. 33); upper part of propleura strongly punctate, lower half smooth, faintly aciculate; mesopleuron with distinct scattered punctures; upper half of propodeal side areolate, lower half smooth (Plate 9, Fig. 34); fore wing fuscous with three SMC (Plate 9, Fig. 35).

Metasoma. Smooth and shining with fine punctures (Plate 9, Fig. 36); length of T2 0.8× width.

Male. Unknown.

Distribution. India: Kerala. ***Elsewhere***: Indonesia; Laos; Malaysia (Anagha & Girish Kumar, 2020a; Pulawski, 2023).

v. *Ampulex ruficornis* (Cameron, 1889)

(Plate 10, Figs. 37–43)

Rhinopsis ruficornis Cameron, 1889: 115. (OXUM) Holotype: ♀, India, Barrackpore.

Ampulex constanceae; Bingham, 1897: 255 (in revision of aculeates of British India), corrected to *Ampulex ruficornis* by Krombein, 1979: 11.

Ampulex ruficornis; Kohl, 1893: 500.

Material examined. Karnataka: 1 ♂, Mookambika Wildlife Sanctuary, Udupi district, Kollur, Coll. V.D. Hegde & Party, 4.ix.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19352; Kerala: 1 ♀, Kozhikode district, ZSI Campus, Coll. J.B. Terine, 25.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18309.

Diagnosis. **Female (Plate 10; Figs. 37–40)**. Body size: 9 mm. Head black, frons microsculptured, appears almost granulate (Plate 10, Fig. 38); vertex with distinct small punctures; antenna and mandible rufous; mandible abruptly angulate at basal third of outer margin; clypeus produced medially, apical margin with well developed median tooth and antero-laterally directed lateral tooth (Plate 10, Fig. 38 & 39); mesosoma largely rufous; pronotal collar microsculptured with punctures and median furrow, postero-medial tubercles absent (Plate 10, Fig. 40); mesoscutum, scutellum, and mesopleuron microsculptured with sparse small punctures; postero-lateral propodeal dorsum with blunt tooth (Plate 10, Fig. 40); tegula black; gaster black with fine punctures, T1 apically nodose; petiole rufous; fore tibia and all tarsi rufous; fore wing subhyaline with two SMC, infumation in SMC 2, at apex of SMC 1 and submedial cell.

Male (Plate 10, Figs. 41–43). Resembles female in most aspects except: colour more rufous than female (Plate 10, Fig. 41); propleura black; mandible normal with rather evenly rounded outer margin; clypeus with produced median part, apical margin without lateral tooth (Plate 10, Fig. 42).

Distribution. India: Karnataka, Kerala, West Bengal. *Elsewhere*: Laos; Sri Lanka; Thailand (Anagha & Girish Kumar, 2020a; Anagha *et al*., 2023a (2021), Pulawski, 2023).

Remarks. Anagha *et al*. (2023a) (2021) reported this species from Karnataka and Kerala and for the first time.

vi. *Ampulex sadiyae* Anagha & Girish Kumar, 2019

(Plate 11, Figs. 44–48)

Ampulex sadiyae Anagha & Girish Kumar, 2019: 5. (ZSIK) Holotype: ♀, India, Kerala, Kovoor.

Material examined. Kerala: 1 ♀, Kozhikode district, Kovoor, Coll. Sadiya Thasneem, 26.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13237.

Diagnosis. **Female (Plate 11, Figs. 44–48)**. Body size. 11 mm. Head black, frons with longitudinal striations (Plate 11, Fig. 45); antenna and mandible rufous; clypeus with produced median part, apical margin with blunt median tooth and distinct antero-laterally directed lateral tooth separated by narrow emargination (Plate 11, Fig. 45); mesosoma largely rufous; pronotal collar microsculptured with median furrow, postero-medial tubercles absent; vertex, mesoscutum, scutellum, and mesopleuron microsculptured with sparse small punctures; postero-lateral propodeal dorsum with blunt tooth (Plate 11, Fig. 46); tegula black; gaster black with fine punctures (Plate 11, Fig. 48); petiole silvery white; fore tibia and all tarsi rufous; fore wing subhyaline with yellowish tinge and dark markings in marginal cells.

Male. Unknown.

Distribution. India: Kerala (Anagha & Girish Kumar, 2019; Anagha & Girish Kumar, 2020a; Pulawski, 2023).

Remarks. Anagha & Girish Kumar (2019) described and published this species.

II. Genus *Trirogma* Westwood, 1841

Trirogma Westwood, 1841a: 152. Type species: *Trirogma caerulea* Westwood.
Trirogma Westwood, 1841b: 16. Objective synonym of *Trirogma* Westwood, 1841a.

Diagnosis. Both antennal sockets covered by single deeply grooved frontal platform medially (Plates 12−16, Figs. 50, 58, 65, 70, & 77); apical margin of male clypeus short (Plate 13, Fig. 58, Plate 14, Fig. 65, & Plate 16, Fig. 77); female clypeus slightly convex with eight macrosetae in curved transverse row; gaster with short petiole, petiole placed above and to some degree behind hind coxa (Plate 12, Fig. 56); fore wing with three SMC, SMC3 trapezoidal (Plates 13−16, Figs. 59, 67, 71, & 78), media deviating before or at Cu–a; hind wing jugal lobe small (Plate 12, Fig. 51); propodeal enclosure widely U shaped with large

areolae (Plates 12−16; Figs. 52, 60, 66, 72, & 79); metasternum slightly emarginate posteriorly (Fig, 56) (Bohart & Menke, 1976).

Distribution. They are not widely distributed genus and are restricted to Oriental and Palearctic regions (Girish Kumar & Sheela, 2017; Pulawski, 2023).

Keys. World species: Krombein, 1979: 5 (key to Ceylonese Ampulicidae).
Indian species: Girish Kumar & Sheela, 2017: 111 (key to *Trirogma* species from Indian subcontinent).

Note. Genus is represented by eight species worldwide. So far, six species are recorded from Oriental region, of which four species are from India (Pulawski, 2023).

Biology. Much less is known about the biology of *Trirogma* species. Tsuneki (1972) identifed *T. caerulea* species transporting a nymph of *Periplaneta australacia* (Fabricius).

Key to *Trirogma* Westwood of Indian subcontinent (adopted from Girish Kumar & Sheela 2017)

1. Female. ……...…… 2
— Male. ……..……...…… 3
2. Groove on upper mesopleuron not crenulate (Plate 15, Fig. 73); S2 anteriorly with semicircular foveate groove running beyond tubercle (Plate 15, Fig. 74); frons pitted; sides of frontal platform with few shallow fine grooves (Plate 15, Fig. 70); clypeus with wide median lobe (Plate 15, Fig. 70). ……..... ***T. regalis*** Krombein
— Groove on upper mesopleuron crenulate (Plate 12, Fig. 53); S2 anteriorly with foveate groove ending at tubercle (Plate 12, Fig. 54); frons with moderately large shallow and sparse small, punctures; sides of frontal platform with single, deep, broad groove (Fig. 50); clypeus with narrow median lobe (Plate 12, Fig. 50). ….. ***T. caerulea*** Westwood
3. Groove on upper mesopleuron crenulate (Plate 13, Fig. 61); notauli deeply crenulate (Plate 13, Fig. 60); sternaulus present, crenulate (Plate 13, Fig. 61); S2 anteriorly with foveate groove interrupted on median tubercle (Plate 13, Fig. 62). ……..... 4
— Groove on upper mesopleuron not crenulate (Plate 16, Fig. 80); notauli weakly or not crenulate (Plate 16, Fig. 79); sternaulus absent (Plate 16, Fig. 80); S2 anteriorly with very short, curved lateral groove (Plate 16, Fig. 81). ……..……..… 5
4. Frons immediately above platform with pair of oblique pits; postero-lateral tubercle of pronotal collar not sharply angled, rounded. …….. ***T. kohima*** Girish Kumar & Sheela

— Frons immediately above platform without pair of oblique pits; postero-lateral tubercle of pronotal collar sharply angled (Plate 13, Fig. 61). .. ***T. caerulea*** Westwood

5. Mandible silvery white on basal half, black at apex (Plate 16, Fig. 77). ……..... ***T. regalis*** Krombein

— Mandible entirely black (Plate 14, Fig. 65). ……..……. ***T. narendrani*** Madhavikutty

Note. Female unknown for *T. narendrani* Madhavikutty.

Species from southern Western Ghats and its adjacent areas

i. *Trirogma caerulea* Westwood, 1841

(Plates 12 & 13, Figs. 49–63)

Trirogma caerulea Westwood, 1841a: 152. (depository?) Holotype or syntypes: ♂, northern India (no specific locality).

Trirogma caerulea Westwood, 1841b: 16. Objective synonym of *Trirogma caerulea* Westwood, 1841a.

Trirhogma [sic] *caerulea* Westwood, 1842: 225. Objective synonym of *Trirogma caerulea* Westwood, 1841a.

Material examined. Kerala: 1 ♀, Kozhikode district, ZSI Campus, Coll. S. Anagha, 5.xii.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13251; 1 ♀, Kozhikode district, Elathur, Coll. C. Binoy, 22.xi.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18475; 1 ♀, Kozhikode district, Madappally, Coll. S. Anagha, 14.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18476.

Diagnosis. **Female (Plate 12, Figs. 49–56)**. Body size: 16.5–25 mm. Body metallic blue, gaster sometimes purplish (Plate 12; Fig. 49); frons with shallow punctures, separated by less than a puncture diameter; frontal platform more deeply furrowed, lateral margin thick with deep groove; antenna and mandible black; clypeus somewhat produced, apical margin of lobe subtruncate (Plate 12; Fig. 50); vertex, pronotal collar, mesoscutum, scutellum, metanotum, and mesopleuron with distinct scattered punctures; upper mesopleural groove crenulate (Plate 12; Fig. 53); S2 with foveate groove on anterior third beginning at antero-lateral angle and crossing basal tubercle (Plate 12; Fig. 54); fore wing hyaline with three SMC.

Male (Plate 13, Figs. 57–63). Body size: 8–13 mm. Colouration as in female; frons closely pitted; frontal platform more deeply furrowed, lateral margin thick with deep groove; clypeus short with apex broadly concave and slightly emarginate (Plate 13, Fig. 58); vertex, pronotal

collar, mesoscutum, scutellum, metanotum, and mesopleuron with distinct moderately large punctures; upper mesopleural groove crenulate (Plate 13; Fig. 61); S2 with a foveate groove interrupted only on median tubercle (Plate 13; Fig. 62); fore wing hyaline with three SMC (Plate13; Fig. 59).

Distribution. India: Chhattisgarh, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Sikkim, Uttarakhand, West Bengal. *Elsewhere*: China; Indonesia; Iran; Iraq; Myanmar; Saudi Arabia; Singapore; Sri Lanka; Taiwan; United Arab Emirates (Anagha & Girish Kumar, 2020a; Pulawski, 2023).

ii. *Trirogma narendrani* Madhavikutty, 2004

(Plate 14, Figs. 64–68)

Trirogma narendrani Madhavikutty, 2004: 594. (ZSIK) Holotype: ♀, India, Kerala, Chembra Hills, Wayanad.

Material examined. Kerala: 1 ♂, Wayanad district, Chembra Hills, Coll. T. Jobiraj, 10.iii.2001, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 1924.

Diagnosis. **Male (Plate 14; Figs. 64–68)**. Body size: 10mm. Frons pitted; frontal platform deeply furrowed, lateral margin with several fine, shallow grooves; frons immediately above platform with pair of deep bisinuate groove (Plate 14; Fig. 65); vertex glossy with few shallow punctures; mandibles black; clypeus short with apex broadly concave and slightly emarginate; pronotal collar, mesoscutum, scutellum, and metanotum with scattered punctures; upper mesopleural groove not crenulate; S2 with only a short, curved lateral groove; legs blue; fore wing hyaline with three SMC (Plate 14; Fig. 67).

Female. Unknown.

Distribution. India: Kerala (Madhavikutty, 2004; Pulawski, 2023).

iii. *Trirogma regalis* Krombein, 1979

(Plates 15 & 16; Figs. 69–82)

Trirogma regalis Krombein, 1979: 12. (USNM) Holotype: ♂, Sri Lanka, Kandy district, Udawattakele Sanctuary.

Material examined. Tamil Nadu: 1 ♂, Tirunelveli district, Karaiyar dam site, Coll. P. Girish Kumar & Party, 29.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13160; 1 ♀, Tirunelveli

district, Kalakad Mundanthurai Tiger Reserve *(*KMTR), Nambikovil, Coll. P. Girish Kumar & Party, 26.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19571.

Diagnosis. **Female (Figs. 69–75)**. Body size: 15 mm. Frons closely pitted; frontal platform shallowly depressed, lateral margin with several fine, shallow grooves; frons immediately above platform with pair of small oblique pits (Plate 15, Fig. 70); mandible black; clypeus somewhat produced, apical margin of lobe round (Plate 15; Fig. 70); vertex, pronotal collar, mesoscutum, scutellum, and metanotum with moderately large scattered punctures; upper mesopleural groove simple, not crenulate (Plate 15, Fig. 73); S2 with semicircular groove passing behind basal tubercle (Plate 15, Fig. 74); legs blue; fore wing hyaline with three SMC (Plate 15, Fig. 71).

Male (Plate 16, Figs. 76–82). Body size: 14 mm. Metallic blue; frons coarsely pitted; frontal platform deeply furrowed, lateral margin with several fine, shallow grooves; frons immediately above platform with pair of deep bisinuate groove (Plate 16, Fig. 77); mandible silvery white at basal half; clypeus short with apex broadly concave and slightly emarginate (Plate 16, Fig. 77); vertex, pronotal collar, mesoscutum, scutellum, and metanotum with distinct moderately large punctures; upper mesopleural groove simple, not crenulate (Plate 16, Fig. 80); S2 with only a short, curved lateral groove (Plate 16, Fig. 81); fore wing hyaline with three SMC (Plate 16, Fig. 78).

Distribution. India: Tamil Nadu. *Elsewhere*: Sri Lanka (Girish Kumar & Sheela, 2017; Anagha & Girish Kumar, 2020a; Pulawski, 2023).

1.2.2. Subfamily DOLICHURINAE Dahlbom, 1842

A. Tribe Dolichurini Dahlbom, 1842

I. Genus *Dolichurus* Latreille, 1809

Dolichurus Latreille, 1809: 387. Type species: *Pompilus corniculus* Spinola, 1808 (designated by Latreille, 1810: 438).

Thyreosphex Ashmead, 1904: 282. Type species: *Thyreosphex stantoni* Ashmead, 1904, by monotypy.

Diagnosis. Both antennal sockets covered by single frontal platform medially (Plates (17−25), Figs. 84, 91, 97, 103, 109, 112, 117, 123, 131, & 137); metasoma almost sessile; tegula brown, base silvery white; fore wing with three SMC, SMC3 almost triangular in

shape, media deviating after Cu–a (Plates (17−20), Figs. 88, 94, 100, 104; Plate 22, Fig. 120; Plate 24, Fig. 134; Plate 25, Fig. 140); hind wing jugal lobe small; propodeal dorsal enclosure with median longitudinal and certain lateral carina, surface between these carina smooth with several transverse or few oblique carina or rugulae, lateral edge of enclosure irregular (Bohart & Menke, 1976; Girish Kumar & Sheikh, 2018; Anagha *et al*., 2020b).

Distribution. They are cosmopolitan genus distributed in Australasian, Afrotropical, Nearctic, Neotropical, Oriental and Palearctic Regions (Bohart & Menke, 1976; Anagha *et al*., 2020b).

Keys. World species. Tsuneki, 1992: 42 (key to *Dolichurus* species from southeastern Asia); Tsuneki *et al*., 1992: 7 (key to *Dolichurus* species from Philippines); Krombein, 1979: 5 (key to Ceylonese Ampulicidae) (Pulawski, 2023).
Indian species. Jonathan *et al*., 2000: 169 (key to *Dolichurus* species from Meghalaya State of India); Anagha *et al*., 2020b: 124 (key to *Dolichurus* species from the Indian subcontinent).

Note. Genus is represented by 53 species and 2 subspecies species worldwide. So far, 28 species and a subspecies is recorded from Oriental region, of which 8 species are from India (Pulawski, 2023).

Biology. The species of this genus are known to attack cockroaches belonging to family Ectobiidae (Bohart & Menke 1976). Upon finding the cockroach, the wasp grasp it with leg or cercus and stings to paralyse it. Like *Ampulex*, *Dolichurus* also cut of antenna of host and the cockroach is dragged into appropriate nesting place which is often a pre-existing cavity (Bohart & Menke, 1976; Lomholdt, 1975-1976; Ghaderipour *et al*., 2020).

Key to species of *Dolichurus* Latreille from India (except male of *D. gilberti* Turner due to lack of details in the descriptions) (adopted from Anagha *et al*., 2020b)

1. Female. ……..…….. 2
— Male. ……. 8
2. G4–G6 entirely black; clypeus with or without median carina. ……..... 3
— G4–G6 rufous or orange (Plate 22, Fig. 121); clypeus medially with longitudinal carina on basal half (Plate 22, Fig. 117). ……..... ***D. gilberti*** Turner
3. Clypeus with median longitudinal carina almost reaching apical margin (Plate 24, Fig. 132). ……..... ***D. taprobanae*** Smith

— Clypeus without any such carina, if present, then poorly defined and restricted to basal half. . . . . ……...……... 4

4. Mesopleuron with distinct sternaulus (Plate 17, Fig. 84). ……..……...… 5

— Mesopleuron without or with indistinct sternaulus. ……. 7

5. Clypeus, frons, pronotal collar, and scutellum with long macrosetae; clypeus entirely black, without any white markings. . . …….....…… 6

— Clypeus, frons, pronotal collar, and scutellum without such macrosetae; clypeus with white markings (Plate 17; Fig. 85). ……...…….. ***D. albifacies*** Krombein

6. Pronotal collar with well defined anterior bordering transverse carina (Plate 23, Fig. 128). …….....…… ***D. sahyadriensis*** Anagha & Girish Kumar

— Pronotal collar without any well defined anterior bordering carina. ……..….... ***D. silvicola*** Krombein

7. Pronotal collar with well defined anterior bordering transverse carina (Plate 18, Fig. 92). …….…..... ***D. amamiensis*** Tsuneki & Iida

— Pronotal collar without any well defined anterior bordering carina. ……..... ***D. aridulus*** Krombein

8. Clypeus entirely black without any white markings, T1 and T2 with or without impunctate area. ……..... 9

— Clypeus with white markings; T1 and T2 with large impunctate areas. ……..……..... ***D. albifacies*** Krombein

9. T1 and T2 entirely punctured. ……..……. 10

— T1 and T2 without any coarse punctures on posterior third. ……..……... 14

10. Mesopleuron with rugulose reticulations (Plates 19, Fig. 99; Plate 20, 106). .....…. 11

— Mesopleuron differently sculptured. ……...……...…... 12

11. Pronotal collar with well defined anterior bordering transverse carina (Plate 19, Fig. 98). . ……...…….. ***D. amamiensis*** Tsuneki & Iida

— Pronotal collar without any well defined anterior bordering transverse carina (Plate 20, Fig. 105). ……..... ***D. aridulus*** Krombein

12. Mesopleuron with distinct coarse setaceous punctures, punctures medially with widened interspaces (Plate 21, Fig. 114); frontal platform as broad as long. …….. ……..……. ***D. chareshi*** Anagha & Girish Kumar

— Mesopleuron with fine scattered setaceous punctures; frontal platform broader than long. ...……. 13

13. T1 with punctures mostly separated by average diameter of a puncture (Plate 25, Fig. 141). . ……..... ***D. taprobanae*** Smith

— T1 with punctures mostly separated by 2 to 3× the average diameter of a puncture. ….……... ***D. venkataramani*** Girish Kumar & Sheikh

14. Pronotal collar without any well defined anterior bordering transverse carina; T1–T3 with punctures separated by less than the average puncture diameter. ……..…... ***D. silvicola*** Krombein

— Pronotal collar with well defined anterior bordering transverse carina (Plate 23, Fig. 124); T1–T3 with punctures separated by more than average puncture diameter (Plate 23, Fig. 126). ……..…….. ….... ***D. sahyadriensis*** Anagha & Girish Kumar

Note. Female unknown for *D. chareshi* Anagha & Girish Kumar & *D. venkataramani* Girish Kumar & Sheikh**)**

Species from southern Western Ghats and its adjacent areas

i. *Dolichurus albifacies* Krombein, 1979
(Plate 17, Figs. 83–89)

Dolichurus albifacies Krombein, 1979: 18. (USNM) Holotype: ♀, Sri Lanka, Kandy District, Udawattakele Sanctuary.

Material examined. Karnataka: 1 ♀, Kodagu district, Kodagu, Coll. K.A. Subramanian & Party, 16.x.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 11498. Kerala: 1 ♀, Kannur district, Kottiyoor, Coll. K.A. Subramanian & Party, 23.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18194; 1 ♀, Wayanad district, Muthanga, Coll. K.A. Subramanian & Party, 21.ii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18511; 1 ♀, Wayanad district, Machikudi, Coll. K.A. Subramanian & Party, 18.ii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18512. Tamil Nadu: 1 ♀, Tirunelveli district, Kalakkad Mundanthurai Tiger Reserve (KMTR), Kuthiravetti, Coll. B.H.C.K. Murthy & Party, 24.viii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13504.

Diagnosis. **Female (Plate 17, Figs. 83–89)**. Body size: 6.2–6.4 mm. Frons with small punctures separated by less than a puncture diameter; frontal platform finely punctate, twice as broad as long, lateral and apical margin silvery white (Plate 17, Fig. 84); antenna dark brown, scape black; mandible silvery white except base and apex; clypeus somewhat produced medially with silvery white markings and without carina, apical margin of lobe

subtruncate (Plate 17, Fig. 85); anterior pronotal collar with few close transverse rugulae (Plate 17, Fig. 87); vertex, posterior pronotal collar, scutum, scutellum, metanotum, and mesopleuron with distinct small punctures; propodeal dorsal enclosure subrectangular, postero-lateral propodeal dorsum with moderate blunt tooth (Plate 17, Fig. 87); sternaulus present (Plate 17, Fig. 86); metasoma smooth and shiny, T1 without apical row of fine punctures (Plate 17, Fig. 89); inner surface of fore tibia and lower surface of fore tarsi light brown, rest of tarsi brownish, mid and hind tibial spurs silvery white; black macrosetae absent on clypeus, frons and mesoscutum; fore wing hyaline (Plate 17, Fig. 88).

Male. 5 mm. Sculpturing of frons, frontal platform, propodeum as in female; dorsal pronotal collar except narrow median strip white; clypeus slightly emarginate apically; pronotal collar shorter; thorax sparsely punctate than in female; postero-lateral propodeal dorsum with weak tooth (Krombein,1979).

Distribution. India: Karnataka, Kerala (new state record), Tamil Nadu. ***Elsewhere***: Sri Lanka (Anagha & Girish Kumar, 2020a; Anagha *et al*., 2020b; Pulawski, 2023).

Remarks. Anagha *et al*. (2020b) reported this species from Tamil Nadu for the first time.

ii. *Dolichurus amamiensis* Tsuneki and Iida, 1964
(Plates 18 & 19, Figs. 90–101)

Dolichurus amamiensis Tsuneki & Iida, 1964: 41. (originally Tsuneki collection, now USNM) Holotype: ♀, Japan, Amami Oshima Island, Koniya.

Dolichurus puliensis Tsuneki, 1967a: 10. (originally K. Tsuneki collection, now USNM) Holotype: ♂, Taiwan, Puli (synonymized with *Dolichurus amamiensis* by Tano & Tsuneki, 1970: 40).

Material examined. Karnataka: 1 ♀ & 1 ♂, Chikmagalur district, Bygoor, Kabbinahalli, Coffee Estate, Coll. P. Girish Kumar & Party, 26.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13574–13575; 1 ♀, Udupi district, Mookambika Wildlife Sanctuary, Areshiroor, Coll. V.D Hegde & Party, 2.ix.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18818; 1 ♂, Udupi district, Mookambika Wildlife Sanctuary, Heddarimane, Hulikal, Junction, Coll. V.D Hegde & Party, 1.ix.2021, ZSIK ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18819; 3 ♀ and 5 ♂, Udupi district, Mookambika Wildlife Sanctuary, Areshiroor, Coll. V.D. Hegde & Party, 17.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21299−21306. Kerala: 1 ♀, Kasaragod district, Panathady, Coll. P.M. Rajan, 29.xi.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 11499; 2 ♂, Kozhikode district, Kakkadampoyil, Coll. George

Mathew, 21.i.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 11502–11503; 1 ♀ & 6 ♂, Thiruvananthapuram district, Neyyar Wildlife Sanctuary, dam site, Coll. P. Girish Kumar & Party, 5.i.2019, 16.i.2019 & 17.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12584–12586, 12656 & 13550–13552; 1 ♂, Kollam district, Shendurney Wildlife Sanctuary, Coll. Md. Jafer Palot & Party, 23.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12587; 3 ♂, Kozhikode district, Madappally, Coll. K. Anju, 25.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12584–12586; 1 ♀ & 1 ♂, Kozhikode district, Janakikaadu, Coll. K. Anju, 1.xi.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12590–12591; 1 ♂, Kottayam district, Cherupunkal, Coll. Tessy Rajan, 17.xi.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12595; 3 ♀ & 5 ♂, Kozhikode district, Payanthong, Coll. K.P. Hanima Raveendran, 1.xi.2019 & 26.vi.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12596–12597 & 13557–13562; 5 ♂, Kozhikode district, Moorad, Coll. S. Anagha, 18.iv..2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12598–12602; 5 ♂, Kannur district, Kannapuram, Coll. C. Charesh, 5.v.2019 & 18.v.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12604–12607 & 12610; 2 ♂, Kozhikode district, Edakkara, Coll. P.M. Sureshan & Party, 17.v.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12608–12609; 1 ♀, Malappuram district, Nilambur, Balankulam, Coll. C. Charesh, 3.x.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12654; 1 ♀ & 2 ♂, Kozhikode district, Peruvannamuzhi, Coll. K. Anju, 20.v.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13553–13555; 1 ♂, Kannur district, Thekkumbad dweep, Coll. C. Charesh, 19.v.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13556; 1 ♀, Thrissur, Kerala Agricultural University, Coll. C. Binoy, 1–14.v.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13576; 1 ♀, Kozhikode district, Valayam, Coll. K.P. Hanima Raveendran, 13.vi.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13577; 3 ♂, Malappuram district, Calicut University Botanical Garden, Coll. S. Anagha & Party, 20.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13578–13580; 3 ♂, Kozhikode district, Moorad, Coll. J.B Terine, 16.i.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13631– 13633; 5 ♀ & 4 ♂, Kozhikode district, Madappally, Coll. S. Anagha, 16.v.2019 & 21.ii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13814–13821 & 18367; 1 ♀, Wayanad district, Kuruva Island, Coll. K.A. Subramanian & Party, 20.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18192; 1 ♂, Kozhikode district, Planetarium, Coll. S. Anagha, October 2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18343; 1 ♂, Kozhikode district, Janakikaadu, Coll. S. Anagha, 1.iv.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18351; 2 ♂, Kozhikode district, Elathur, Coll. C. Binoy, 31.vii.2019 & 13.i.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18489–18490; 1 ♀, Kasaragod district, Nileswaram, Coll. K. Anju, 21.i.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18357; 2 ♂,

Wayanad district, Muthanga, Ponkuzhi, Coll. K.A. Subramanian & Party, 20.iii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18364–18365; 1 ♂, Kozhikode district, Kunnamangalam, Coll. C. Binoy, 12.v.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18483; 3 ♂, Palakkad district, Lakkidi, Ramakrishnappadi, Coll. K.S. Surya, 20.iii.2019–25.iv.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18485–18487; 2 ♂, Kozhikode district, Chaliyam Timber Depot, Coll. A.P. Kamila, 11.ii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18491–18492; 1 ♂, Wayanad district, Karlad, Coll. K. Anju, 29.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18493; 2 ♂, Wayanad district, Nadavayal, Coll. Kuriakose, 11.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18505–18506; 2 ♂, Wayanad district, Meenangad, Coll. Kuriakose, 12.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18507–18508; 2 ♂, Wayanad district, Panamaram, Coll. Kuriakose, 13.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18509–18510; 2 ♂, Kollam district, Shendurney Wildlife Sanctuary, Kattilapara, Coll. P. Girish Kumar & Party, 2.xii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 19635–19636; 1 ♂, Kozhikode district, Kakkodi, Coll. T.K. Viswanath, 23.i.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 20685. Tamil Nadu: 3 ♂, Coimbatore district, Kottur, Coll. P. Girish Kumar & Party, 2.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12581–12582 & 18484; 1 ♀ & 1 ♂, Tirunelveli district, Kalakad Mundanthurai Tiger Reserve (KMTR), Kuthiravetti, Coll. B.H.C.K. Murthy & Party, 24.viii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13566–13567; 1 ♂, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Zero Point, Kulashekaram range, Coll. Souvik Sen & Party, 18.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18356; 1 ♂, Tirunelveli district, Shenkotai, Kannupulimettu, Coll. B.H.C.K. Murthy & Party, 24.viii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18488; 1 ♂, Kanyakumari district, Kalikesham, ARS Quarters, Coll. Souvik Sen & Party, 18.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18494; 1 ♂, Theni district, Bublimash Stream, Amaravathi beat, Gudalur range, Coll. R. Babu & Party, 1.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 20684.

Diagnosis. **Female (Plate 18, Figs. 90–95)**. Body size: 5.4–8.8 mm. Frons and frontal platform with few sparse punctures and irregular rugulae (Plate 18, Fig. 91), apex of frontal platform 2× upper width; antenna black, scape black or brown; apex of mandible rufous to light brown; clypeus somewhat produced with weak median carina on basal half, apical margin of lobe round to subtruncate (Plate 18, Fig. 91); pronotal collar with well defined carina on anterior border (Plate 18, Fig. 92); vertex, posterior pronotal collar, scutum, and scutellum with distinct small punctures; metanotum with longitudinal rugulae; propodeal

dorsal enclosure U shaped, postero-lateral propodeal dorsum with moderate blunt tooth (Plate 18, Fig. 92); mesopleuron rugulose reticulate, sternaulus indistinct (Plate 18, Fig. 93); metasoma smooth and shiny, T1 without apical row of fine punctures (Plate 18, Fig. 95); legs black or brown, mid and hind tibial spurs light brown; black macrosetae present on clypeus, frons and mesoscutum; fore wing subhyaline (Plate 18, Fig. 94).

Male (Plate 19, Figs. 96–101). Body size: 3.8–4 mm. Frons rugulose-reticulate; frontal platform slightly longer than broad with fine sparse puncture, apical and lateral margin silvery white; antenna black; apex of mandible rufous; clypeus strongly carinate, apical margin of lobe with median tooth, lobe emarginate on either side ending in weak rounded angle (Plate 19, Fig. 97); pronotal collar with well defined carina on anterior border as in female (Plate 19, Fig. 98); vertex, posterior pronotal collar, mesoscutum, and scutellum with small sparse punctures; propodeal dorsal enclosure U shaped, posterolateral propodeal dorsum without any tooth (Plate 19, Fig. 98); mesopleuron rugulose-reticulate, sternaulus absent (Plate 19, Fig. 99); metasoma with well defined distinct punctures (Plate 19, Fig. 101); tibiae and tarsi brown, mid and hind tibial spurs white; fore wing subhyaline (Plate 19, Fig. 100).

Distribution. India: Daman, Goa, Karnataka, Kerala, Tamil Nadu, Uttarakhand. *Elsewhere*: China; Japan; Malaysia; Philippines; Sri Lanka; Taiwan; Thailand; Vietnam (Anagha & Girish Kumar, 2020a; Anagha *et al*., 2020b; Pulawski, 2023).

Remarks. Anagha *et al*. (2020b) reported this species from Karnataka and Tamil Nadu for the first time.

iii. *Dolichurus aridulus* Krombein, 1979

(Plate 20, Figs. 102–110)

Dolichurus aridulus Krombein, 1979: 21. (USNM) Holotype: ♀, Sri Lanka, Trincomalee District, Trincomalee, China Bay Ridge Bungalow.

Material examined. Karnataka: 1 ♂, Udupi district, Mookambika Wildlife Sanctuary, Areshiroor, Coll. V.D. Hegde & Party, 17.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21307. Kerala: 1 ♂, Kozhikode district, Madappally, Coll. K. Anju, 16.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12657; 1 ♂, Kannur district, Kannapuram, Coll. C. Charesh, 25.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12659. Tamil Nadu: 1 ♂, Tenkasi district, Old courtallam, Coll. P. Girish Kumar & Party, 3.x.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12653.

Diagnosis. **Female (Plate 20, Figs. 102–107)**. Body size: 7.7 mm. Frons with well defined distinct punctures, region above frontal platform with longitudinal row of punctures and impunctate area on either side, frontal platform with sparse small punctures on lower half and curved close rugulae on upper half (Plate 20, Fig. 109), apex 1.5× upper width; scape ventrally and mandible except utmost apex, light red; clypeus produced medially without carina, apical margin of lobe round to subtruncate (Plate 20, Fig. 109); anterior pronotal collar with few close transverse rugulae; vertex, posterior pronotal collar, scutum, scutellum, metanotum, and mesopleuron with distinct small punctures; metanotum with close longitudinal carina; propodeal dorsal enclosure subrectangular, postero-lateral propodeal dorsum with strong acute tooth; mesopleuron rugulose reticulate, sternaulus absent; metasoma smooth and shiny, T1 without apical row of fine punctures; fore tibia above, mid and hind tibiae, and all tarsi, brown; mid and hind tibial spurs white; black macrosetae present on clypeus, frons and mesoscutum; fore wing hyaline (Krombein 1979).

Male (Figs. 108–110). Body size: 4.5–4.8 mm. Frons rugulose-reticulate; frontal platform longer than broad with sparse punctures, apical and lateral margin yellowish brown (Plate 20, Fig. 103); vertex with small close punctures; scape beneath and mandibles except extreme tip yellowish brown; clypeus strongly carinate, apical margin of lobe with small tooth, lobe emarginate on either side (Plate 20, Fig. 103); anterior pronotal collar with few close transverse rugulae (Plate 20, Fig. 105); posterior pronotal collar, mesoscutum, and scutellum with small punctures; metanotum with longitudinal rugulae; propodeal dorsal enclosure subrectangular, postero-lateral propodeal dorsum without any tooth (Plate 20, Fig. 105); mesopleuron rugulose- reticulate, sternaulus absent (Plate 20, Fig. 106); metasoma with well defined distinct punctures (Plate 20, Fig. 107); tibiae and tarsi yellowish brown, hind basitarsi much paler than remaining tarsal segments, mid and hind tibial spurs white; fore wing subhyaline (Plate 20, Fig. 104).

Distribution. India: Karnataka, Kerala, Tamil Nadu. *Elsewhere*: Sri Lanka (Anagha & Girish Kumar, 2020a; Anagha *et al*., 2020b; Pulawski, 2023).

Remarks. Anagha *et al*. (2020b) reported this species from India for the first time.

iv. *Dolichurus chareshi* Anagha & Girish Kumar, 2020
(Plate 21, Figs. 111–115)

Dolichurus chareshi Anagha & Girish Kumar in Anagha *et al*., 2020b: 123. (ZSIK) Holotype: ♂, India, Tamil Nadu, Coonoor.

Material examined. Tamil Nadu: 3 ♂, Nilgiri district, Coonoor, Coll. C. Charesh & Party, 7.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13587–13589.

Diagnosis. **Male (Figs. 111–115)**. Body size: 5.3 mm. Frons rugulose-reticulate; frontal platform broad as long with sparse small punctures, apical margin of frontal platform pale yellow (Plate 21, Fig. 112); antenna dark brown, scape black; apex and base of mandibles rufous; clypeus without carina, apical margin of lobe emarginate on either side ending in weak rounded angle (Plate 21, Fig. 112); anterior pronotal collar with few close transverse rugulae (Plate 21, Fig. 113); vertex, posterior pronotal collar, mesoscutum and scutellum, distinctly punctate; propodeal dorsal enclosure subrectangular, postero-lateral propodeal dorsum with blunt tooth (Plate 21, Fig. 113); mesopleuron with distinct coarse punctures and the punctures in median region with widened interspaces, sternaulus absent (Plate 21, Fig. 114); metasoma with well defined distinct punctures (Plate 21, Fig. 115); legs brown, mid and hind tibial spurs light brown to silvery white; fore wing subhyaline.

Female.Unknown.

Distribution. India: Tamil Nadu, Rajasthan (Anagha & Girish Kumar, 2020a; Anagha *et al*., 2020b; Pulawski, 2023).

Remarks. Anagha *et al*. (2020b) described and published this species.

v. *Dolichurus gilberti* Turner, 1912
(Plate 22, Figs. 116–121)

Dolichurus gilberti Turner, 1912b: 365. (NHM) Holotype: ♀, India: 'Assam', now Meghalaya, Shillong.

Material examined. Tamil Nadu: 1 ♀, Nilgiri district, Coonoor, Coll. C. Charesh & Party, 7.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12782.

Diagnosis. **Female (Plate 22, Figs. 116–121)**. Body size: 9.5 mm. Frons longitudinally ruguloso–striate and punctate (Plate 22, Fig. 117); frontal platform longer than broad with with few sparse punctures on lower surface and irregular rugulae on upper half; antenna black; apex of mandible rufous; clypeus somewhat produced with median carina not reaching apex, apical margin of lobe round to subtruncate (Plate 22, Fig. 117); anterior pronotal collar with few close transverse rugulae (Plate 22, Fig. 118); vertex, posterior pronotal collar, mesoscutum, and scutellum distinctly punctate; metanotum with close longitudinal carina and

punctutres; propodeal dorsal enclosure subrectangular, postero-lateral propodeal dorsum with blunt tooth (Plate 22, Fig. 118); mesopleuron rugulose-reticulate, sternaulus distinct (Plate 22, Fig. 119); metasoma smooth and shiny, G4–G6 rufous (Plate 22, Fig. 121); legs black, mid and hind tibial spurs light brown; fore wing hyaline (Plate 22, Fig. 120).

Male. Body size: 6 mm. Frons punctate; carina on clypeus reaching apex (Turner 1912b).

Distribution. India: Arunachal Pradesh, Karnataka, Meghalaya, Rajasthan, Tamil Nadu, Uttarakhand (Anagha & Girish Kumar, 2020a; Anagha *et al*., 2020b; Pulawski, 2023).

Remarks. Anagha *et al*. (2020b) reported this species from Tamil Nadu for the first time.

vi. *Dolichurus sahyadriensis* Anagha & Girish Kumar, 2020
(Plate 23, Figs. 122–129)

Dolichurus sahyadriensis Anagha & Girish Kumar in Anagha *et al*., 2020b: 125. (ZSIK) Holotype: ♂, India, Kerala, Peppara Wildlife Sanctuary: Pattankulichappara.

Material examined. Kerala: 2 ♂ & 1 ♀, Thiruvananthapuram district, Peppara Wildlife sanctuary, dam site, Pattankulichappara, Coll. P. Girish Kumar & Party, 20.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13584–13586; 1 ♀, Wayanad district, Muthanga, Manchal, Coll. K.A. Subramanian & Party, 21.ii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18368; 2 ♂, Wayanad district, Kalloor, Manchal, Coll. Kuriakose, 10.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18369–18370. Tamil Nadu: 2 ♂, Theni district, Suruli Cumbam, Coll. R. Venkitesan & Party, 2.viii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 20679-20680; 1 ♂, Theni district, Suruli Cumbam, Coll. R. Babu & Party, 27.ii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 20679-20683.

Diagnosis. **Female (Plate 23, Figs. 122–126)**. Body size: 6.2 mm. Frons with sparse small punctures; frontal platform longer than broad with irregular weak wrinkles and punctures; antenna black; apex of mandibles rufous; clypeus somewhat produced with weak median carina on basal half, apical margin of lobe simple, broadly round to subtruncate; pronotal collar with well defined carina on anterior border (Plate 23, Fig. 128); vertex, pronotal collar, mesoscutum, and scutellum with distinct small punctures; metanotum with longitudinal rugulae; propodeal dorsal enclosure U shaped, postero-lateral propodeal dorsum with moderate sharp tooth; mesopleuron areolate rugulose postero-dorsally with antero-ventrally smooth and bare area, sternaulus distinctly foveolate (Plate 23, Fig. 129); metasoma smooth and shiny, T2–T5 latero–apically and T2 and T3 basally with row of close fine punctures; all

tibiae and tarsi brown, mid and hind tibial spurs brown; black macrosetae present on clypeus, frons and mesoscutum; fore wing subhyaline.

Male (Figs. 127–129). Body size: 5–5.5 mm. Frons rugulose-reticulate; frontal platform longer than broad with sparse small punctures, apical and lateral margin silvery white (Plate 23, Fig. 123); antenna brown, scape black; apex of mandible rufous; clypeus strongly carinate, apical margin of lobe emarginate on either side ending in weak rounded angle (Plate 23, Fig. 123); pronotal collar with well defined carina on anterior border as in female (Plate 23, Fig. 124); vertex, pronotal collar, mesoscutum, scutellum, and metanotum with scattered small punctures; propodeal dorsal enclosure U shaped, postero-lateral propodeal dorsum without tooth; posterior ventral portion of mesopleuron along mesopleural suture with punctures coalescent in short rows, elsewhere smooth with sparse small punctures; sternaulus distinct (Plate 23, Fig. 125); metasoma shiny, apical third of T1 and T2 without coarse punctation (Plate 23, Fig. 126), punctures on T3 closer than T1 and T2; tibiae and tarsi brown, mid and hind tibial spurs light brown to white; fore wing subhyaline.

Distribution. India: Kerala (Anagha & Girish Kumar, 2020a; Anagha *et al*., 2020b; Pulawski, 2023).

Remarks. Anagha *et al*. (2020b) described and published this species.

vii. *Dolichurus taprobanae* Smith, 1869
(Plates 24 & 25, Figs. 130–141)

Dolichurus taprobanae Smith, 1869: 304. (NHM) Holotype: ♀, Sri Lanka, no specific locality (synonymized with *Dolichurus taprobanae* by Krombein, 1979:14).

Dolichurus bipunctatus Bingham, 1896: 438. (NHM) Holotype: ♂, Burma, Pegu Hills.

Dolichusus [sic] *clavipes* Cameron, 1897: 18. (OXUM) Holotype: ♂, India, Bengal, Barrackpore (synonymized with *Dolichurus taprobanae* by Krombein, 1979: 14).

Dolichurus reticulatus Cameron, 1899: 56. (OXUM) Holotype or syntypes: ♂, India, Assam, Khasia Hills (synonymized with *Dolichurus bipunctatus* by Turner, 1912b: 364).

Material examined. Karnataka**:** 1 ♀, Kodagu district, Bettathur near Madikeri, Coll. P. Girish Kumar & Party, 24.xii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13573; 1 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Hosagadde near Kudajadri, Coll. P. Girish Kumar & Party, 29.xii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13635. Kerala: 1 ♀ & 2 ♂, Kozhikode district, Purameri, Coll. K.P. Hanima Raveendran, 15.xii.2018 &

15.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13169 & 13823–13824; 1 ♀, Kozhikode district, Madappally, Coll. S. Anagha, 5.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13170; 1 ♀, Thiruvananthapuram district, Neyyar Wildlife sanctuary, dam site, Coll. P. Girish Kumar & Party, 16.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13172; 1 ♀, Kasaragod district, Ranipuram, Coll. S. Anagha, 21.i.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13634; 1 ♀, Malappuram district, Nilambur, Kerala Forest Research Institute *(*KFRI*)*, Coll. K.P. Hanima Ravdendran & Party, 29.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18340; 1 ♀, Palakkad district, Silent Valley, Coll. S. Anagha & Party, 11–12.ii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18342; 1 ♀, Kozhikode district, Kakkodi, Coll. T.K. Viswanath, 23.i.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 20682. Tamil Nadu: 2 ♀, Coimbatore district, Govanur, Coll. P. Girish Kumar & Party, 6.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13825–13826; 1 ♂, Theni district, Suruli Cumbam, Coll. R. Venkitesan & Party, 2.viii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 20681.

Diagnosis. **Female (Plate 24, Figs. 130–135)**. Body size: 7.1–10.5 mm. Frons smooth with sparse punctures; frontal platform as long as broad with few sparse punctures (Plate 24, Fig. 131); antenna black; apex of mandible rufous; clypeus somewhat produced with median carina reaching apical margin, apical margin of lobe simple, broadly round (Plate 24, Fig. 131); anterior pronotal collar with few close transverse rugulae (Plate 24, Fig. 132); vertex, posterior pronotal collar, mesoscutum, scutellum, and metanotum distinctly punctate; propodeal dorsal enclosure subrectangular, postero-lateral propodeal dorsum with sharp tooth (Plate 24, Fig. 132); mesopleuron with subcontiguous punctures in oblique rows, sternaulus distinct (Plate 24, Fig. 133); metasoma smooth and shiny,T2–T4 with two or three rowsof close fine punctures at apical margin (Plate 24, Fig. 135); tarsi, mid and hind tibiae, mid and hind tibial spurs, brown; fore wing hyaline (Plate 24, Fig. 134).

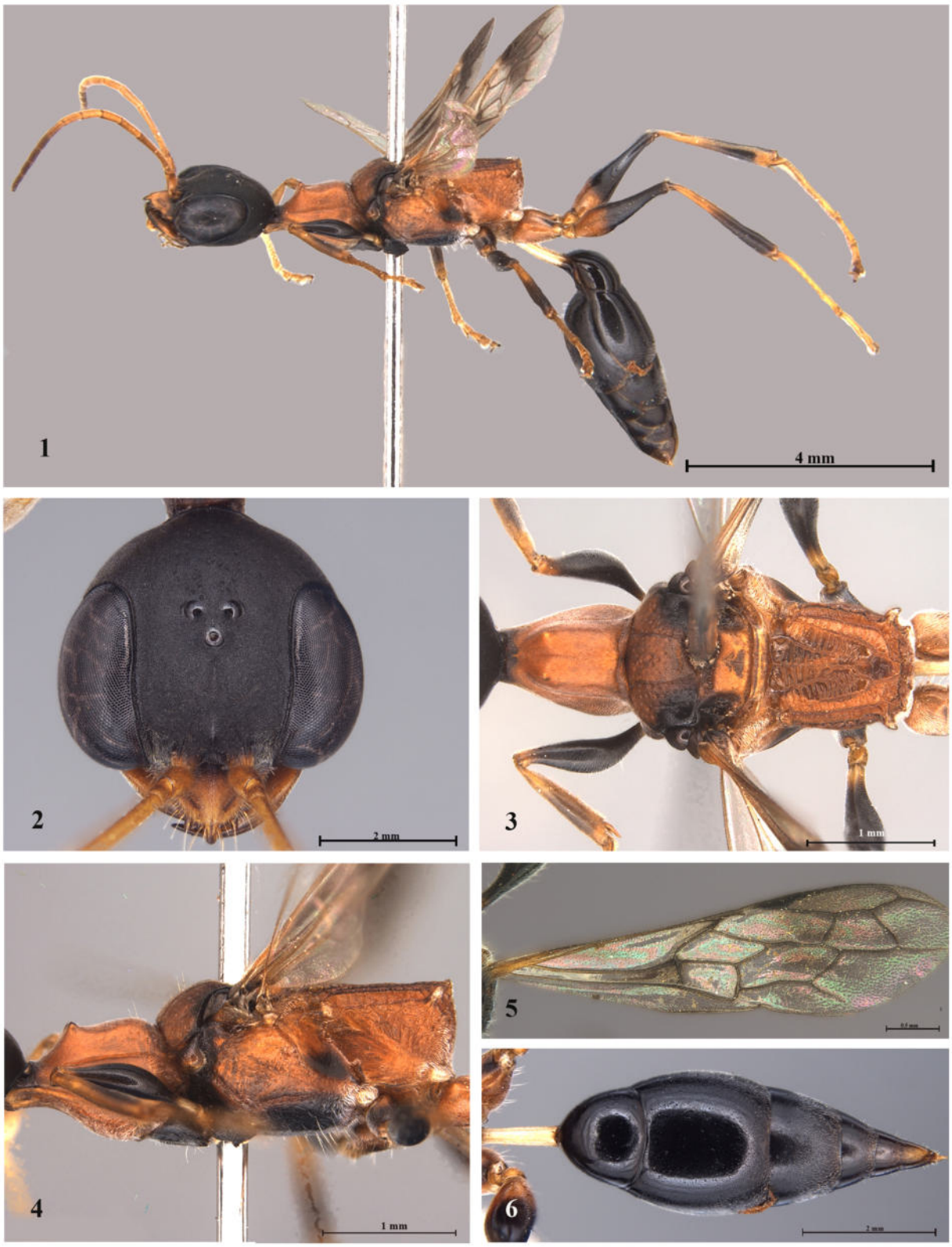
Male (Plate 25, Figs. 136–141). Body size: 5–5.2 mm. Frons rugulose reticulate (Plate 25, Fig. 137); frontal platform smooth, longer than broad, apical and lateral margin of frontal platform silvery white; antenna black; apex of mandibles rufous; clypeus strongly carinate, apical margin of lobe with weak median tooth, lobe emarginate on either side ending in weak tooth (Plate 25, Fig. 137); anterior pronotal collar with few close transverse rugulae (Plate 25, Fig. 138); vertex, posterior pronotal collar, mesoscutum, scutellum, metanotum, and mesopleuron with scattered small punctures; propodeal dorsal enclosure U shaped, postero-lateral propodeal dorsum with blunt tooth (Plate 25, Fig. 138); sternalus absent (Plate 25, Fig. 139); metasoma with well defined distinct punctures (Plate 25, Fig. 141); tibiae and tarsi

black or brown, mid and hind tibial spurs light brown to silvery white; fore wing subhyaline (Plate 25, Fig. 140).

Distribution. India: Assam, Bihar, Himachal Pradesh, Karnataka, Kerala, Meghalaya, Nicobar Islands, Sikkim, Tamil Nadu, Uttarakhand, West Bengal. *Elsewhere*: China; Indonesia; Laos; Malaysia; Myanmar; Sri Lanka; Thailand; Vietnam (Anagha & Girish Kumar, 2020a; Anagha *et al*., 2020b; Pulawski, 2023).

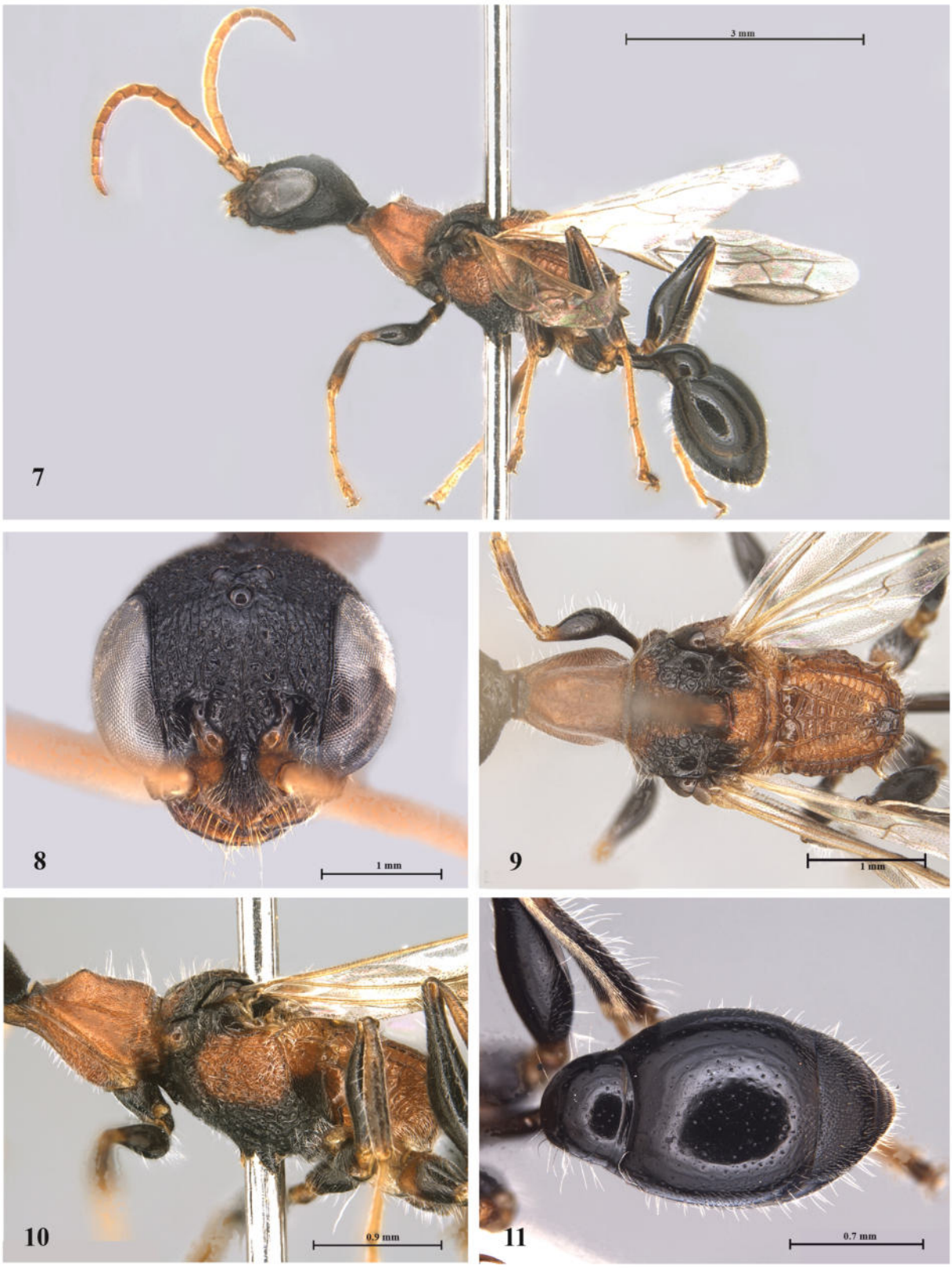
Remarks. Anagha *et al*. (2020b) reported this species from Karnataka, Kerala, Tamil Nadu for the first time.

PLATE 4



***Ampulex ceylonica* Krombein, 1979**
Figures. **1–6**. **Female**, Habitus, lateral view; 2. Head, frontal view; 3.Mesosoma, dorsal view; 4.Mesosoma, lateral view; 5. Fore wing; 6. Metasoma, dorsal view.

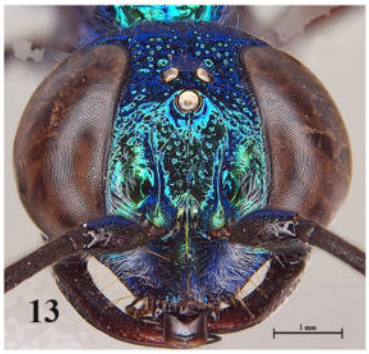
PLATE 5

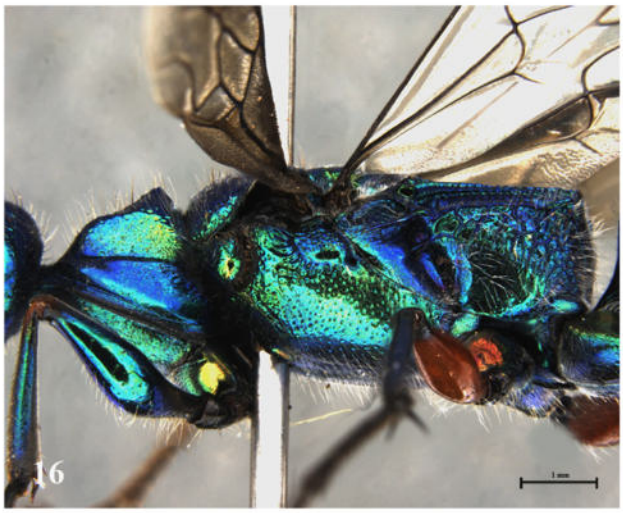


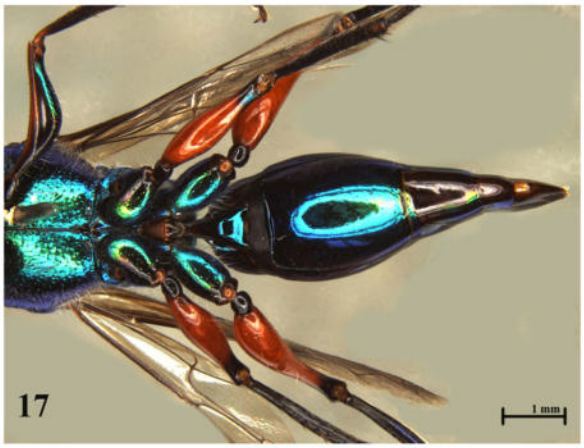
Ampulex ceylonica **Krombein, 1979**

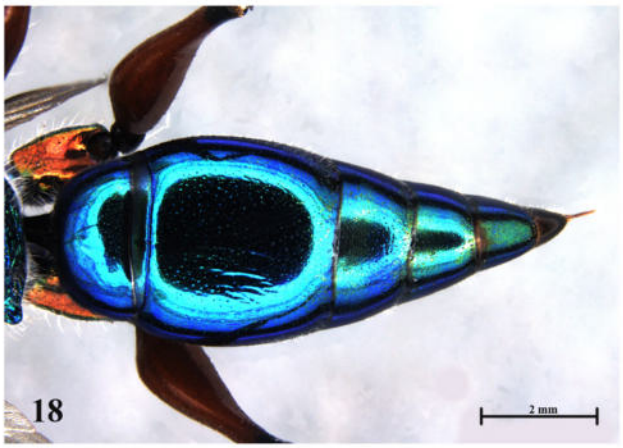
Figures. **7–11**. **Male**, 7. Habitus, lateral view; 8. Head, frontal view; 9. Mesosoma, dorsal view; 10. Mesosoma, lateral view; 11. Metasoma dorsal view.

PLATE 6



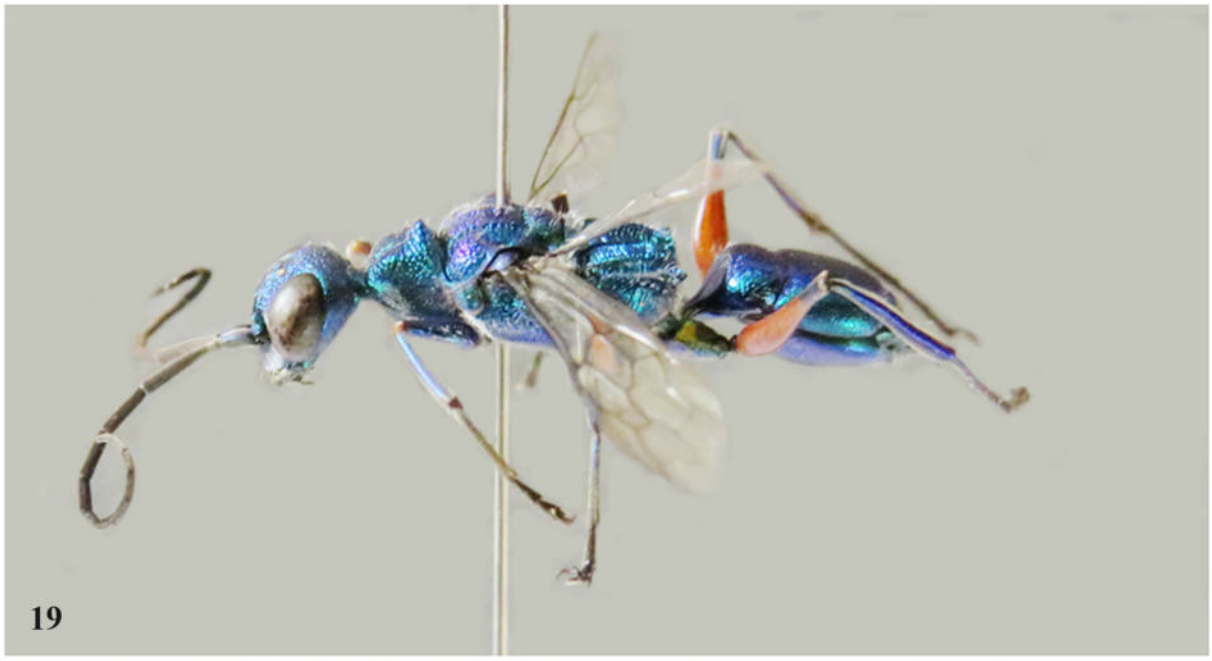


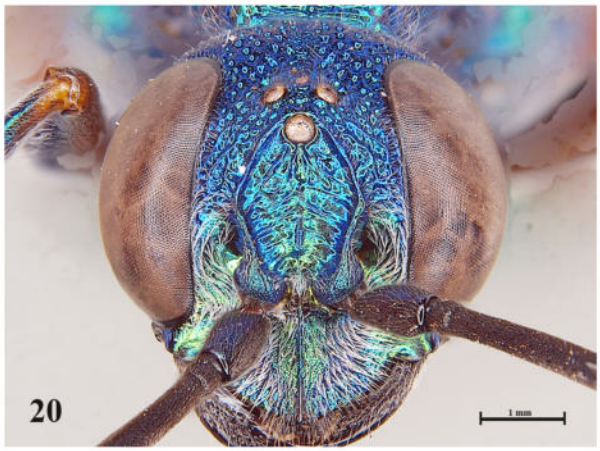


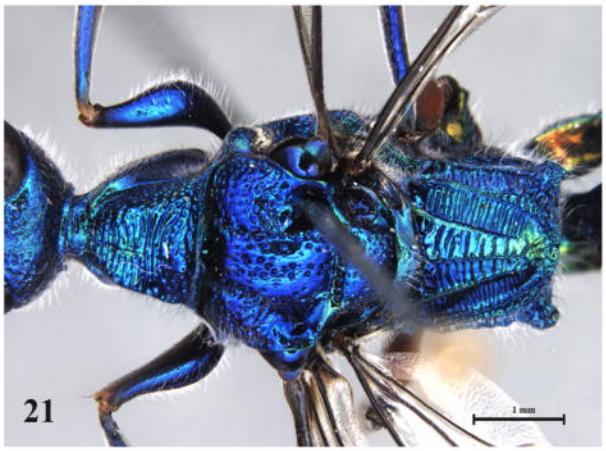


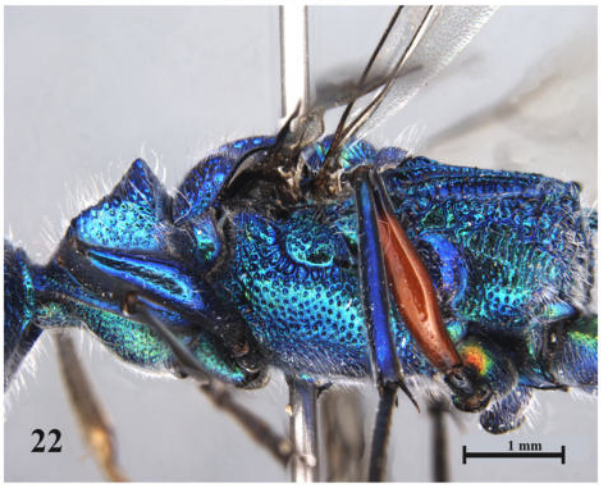
***Ampulex compressa* (Fabricius, 1781)**
Figures. **12–18**. **Female**, 12. Habitus, lateral view; 13. Head, frontal view; 14. Fore wing; 15. Mesosoma, dorsal view; 16. Mesosoma, lateral view; 17. Metasternum, ventral view; 18. Metasoma, dorsal view.

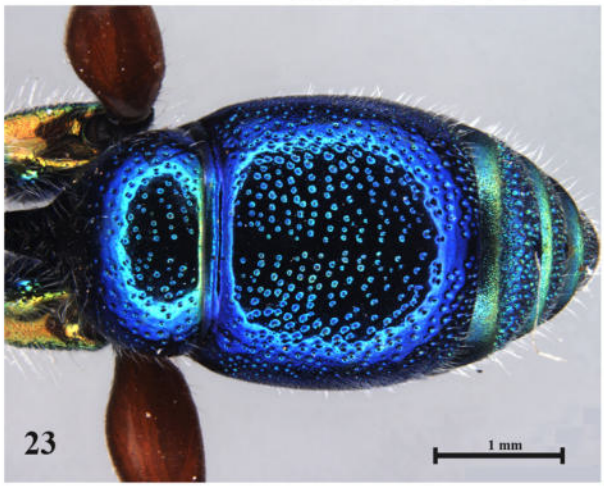
PLATE 7





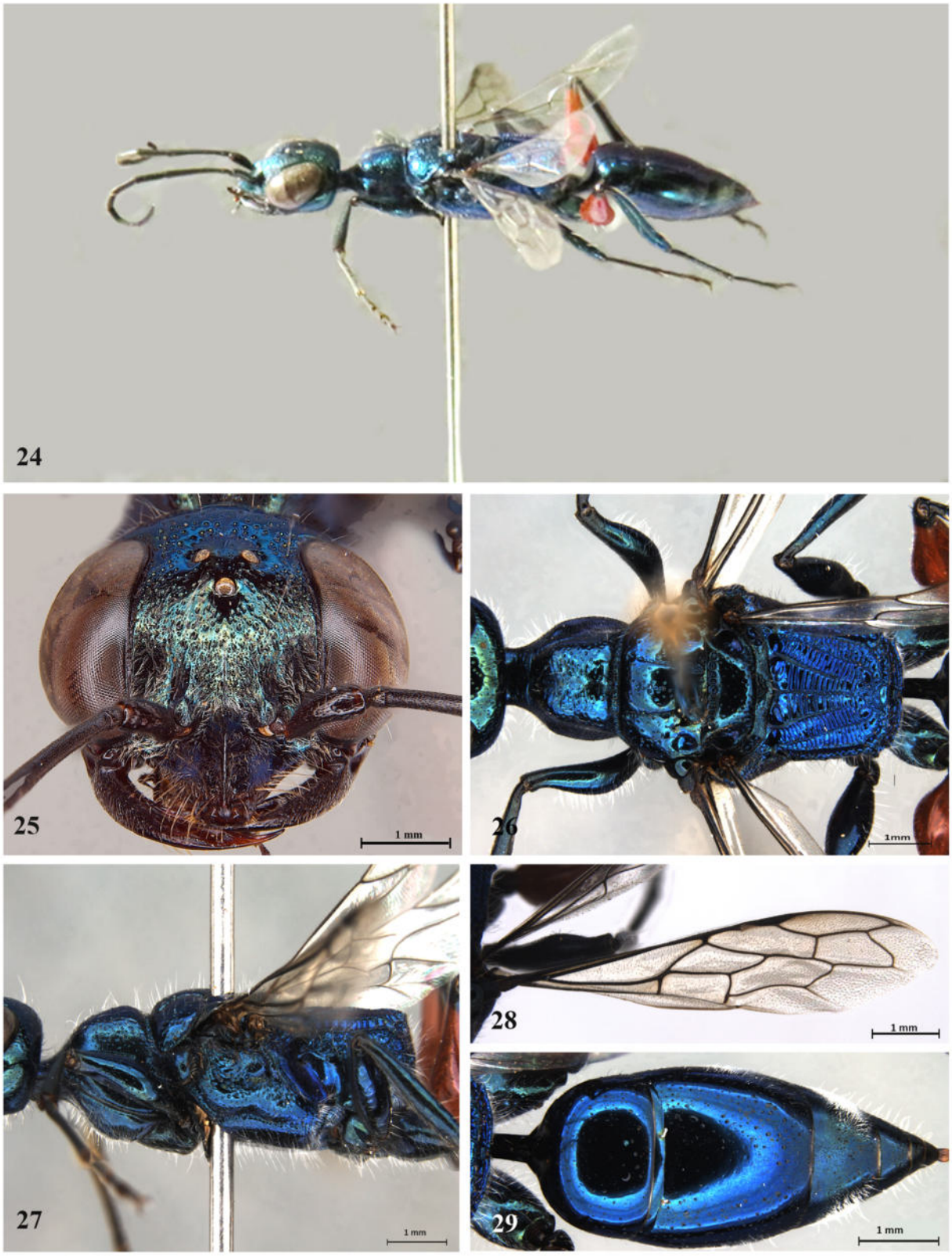






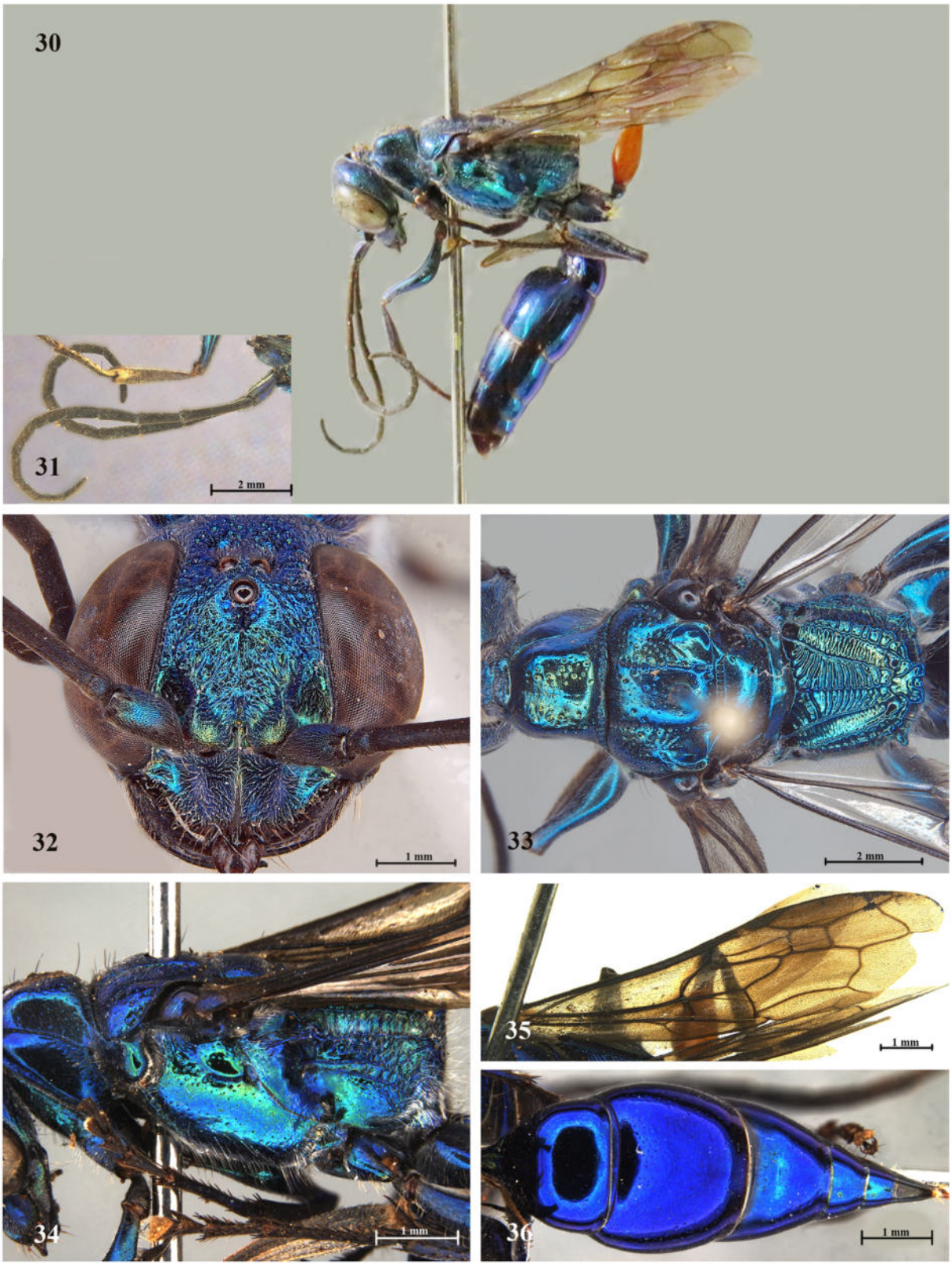
***Ampulex compressa* (Fabricius, 1781)**
Figures 19–22. **Male**, 9. Habitus, lateral view; 20. Head, frontal view; 21. Mesosoma, dorsal view; 22. Mesosoma, lateral view; 23. Metasoma, dorsal view.

PLATE 8



***Ampulex dissector* (Thunberg, 1822)**
Figures. **24–29**. **Female**, 24. Habitus, lateral view; 25. Head, frontal view; 26. Mesosoma, dorsal view; 27. Mesosoma, lateral view; 28. Fore wing; 29. Metasoma, dorsal view.

PLATE 9



***Ampulex major* Kohl, 1893**

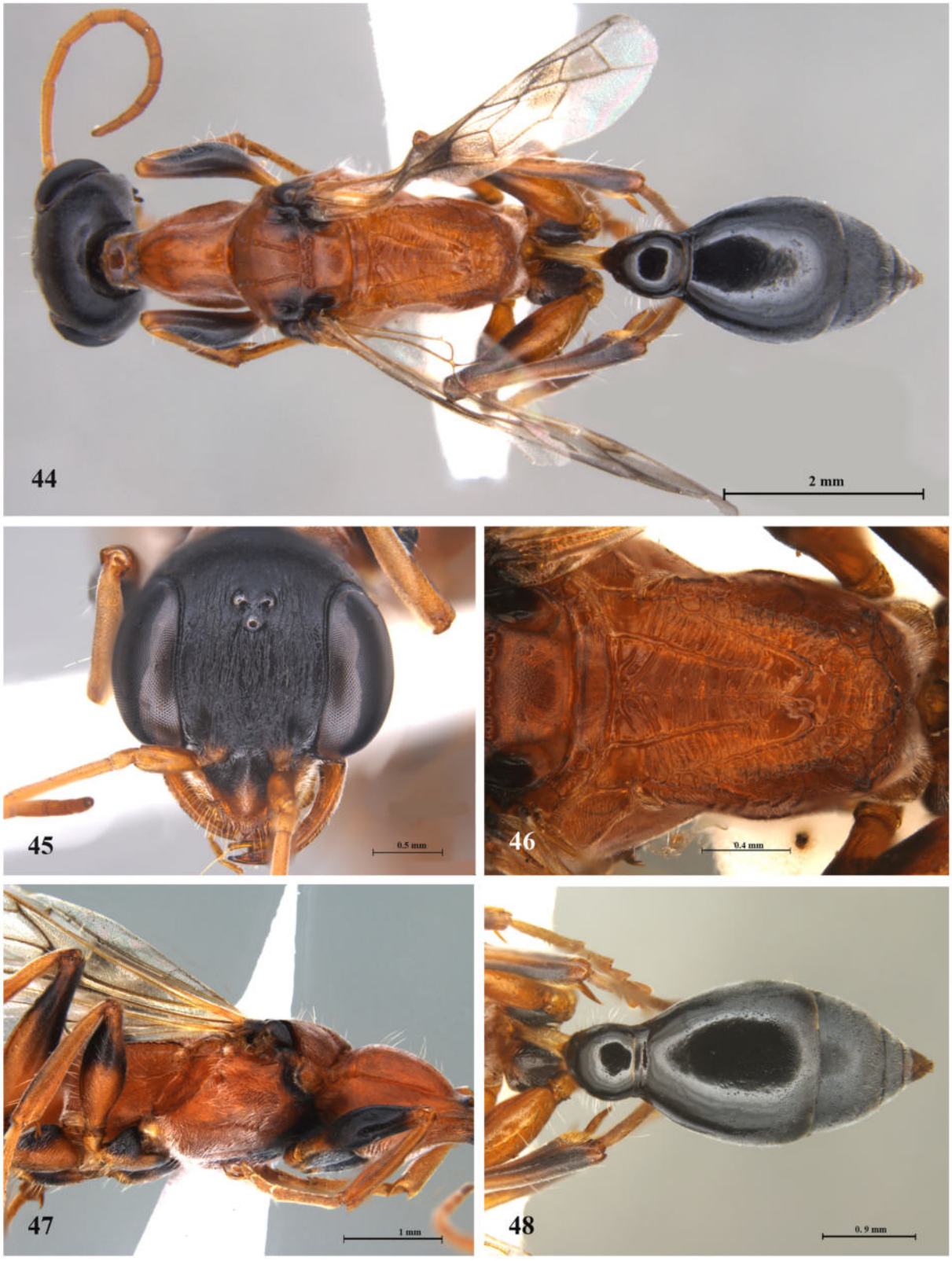
Figures. **30–36**. **Female**, 30. Habitus, lateral view; 31. Antenna; 32. Head, frontal view; 33. Mesosoma, dorsal view; 34.Mesosoma, lateral view; 35. Fore wing; 36. Metasoma, dorsal view.

PLATE 10

***Ampulex ruficornis* (Cameron, 1889)**

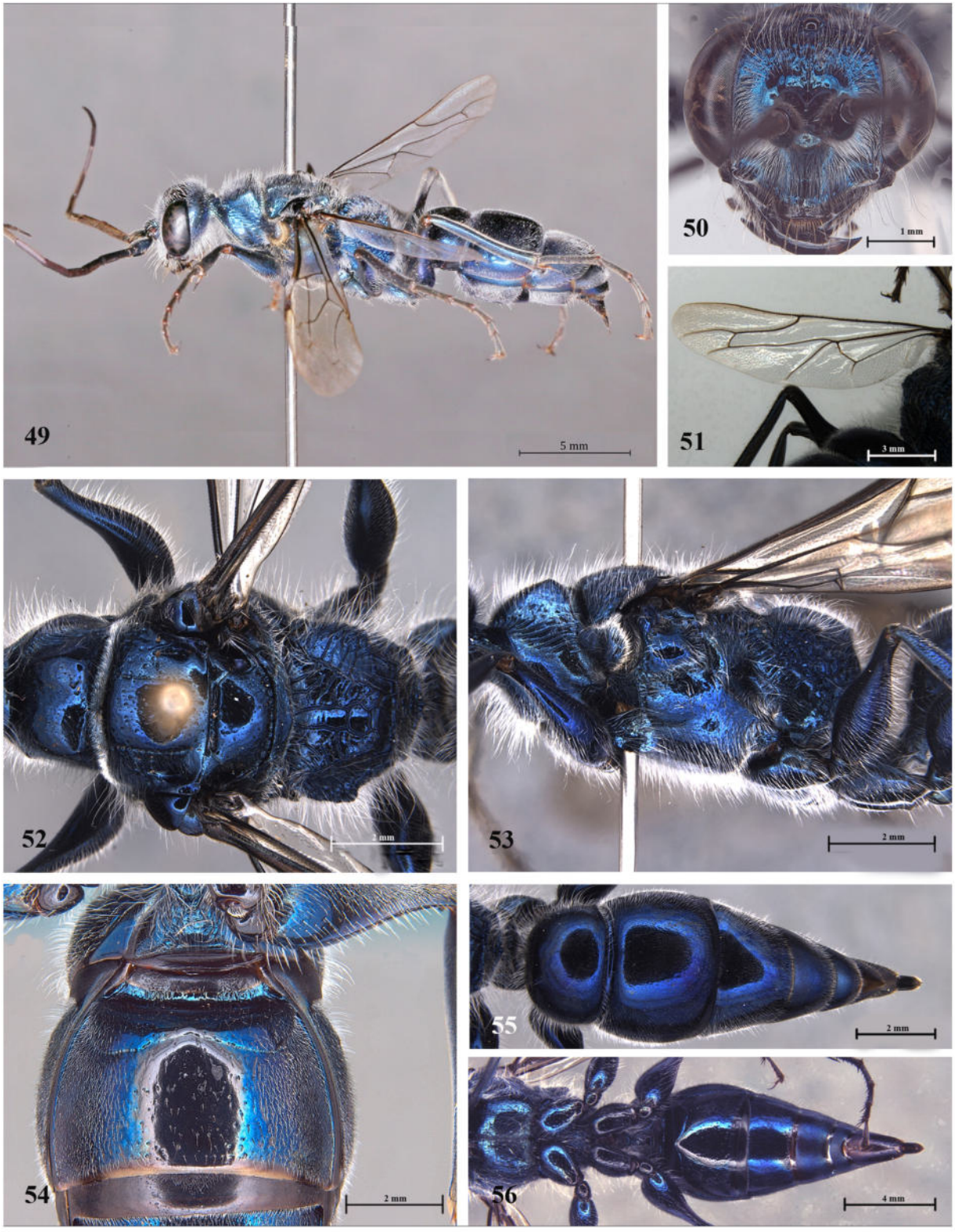
Figs. 37–40. **Female**, 37. Habitus, lateral view; 38. Head, frontal view; 39. Lower half of head, frontal view; 40. Mesosoma, dorsal view. **Figs. 41–43**. **Male**, 41. Habitus, lateral view; 42. Head, frontal view; 43. Metasoma, dorsal view.

PLATE 11



***Ampulex sadiyae* Anagha & Girish Kumar, 2019 (Female)**
44. Habitus, lateral view; 45. Head, frontal view; 46. Mesosoma, dorsal view; 47. Mesosoma, lateral view; 48. Metasoma, dorsal view.

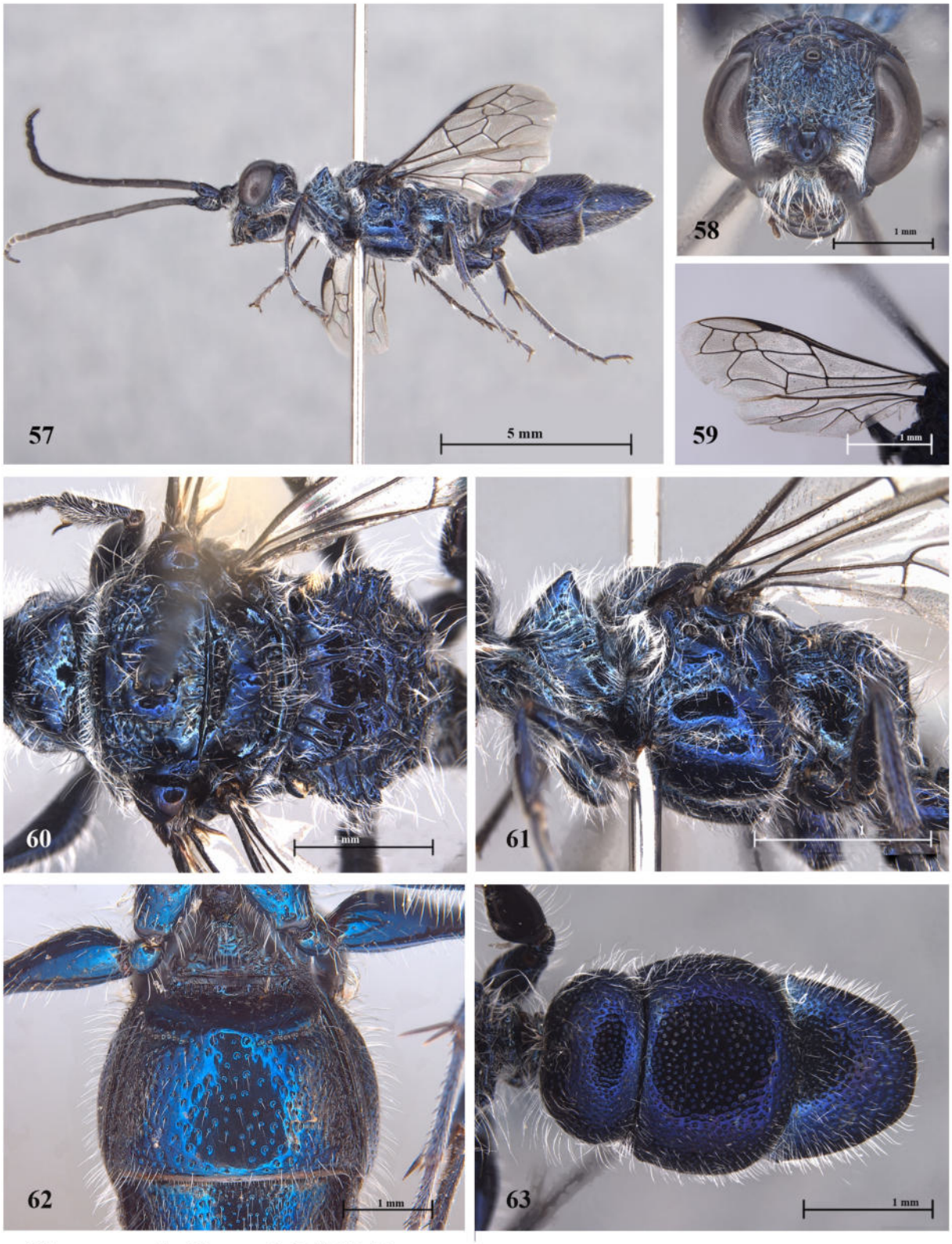
PLATE 12



***Trirogma caerulea* Westwood, 1841 (Female)**

49. Habitus, lateral view; 50. Head, frontal view; 51. Hind wing; 52. Mesosoma, dorsal view; 53. Mesosoma, lateral view; 54. Metasomal sternum 2 (S2), ventral view; 55. Metasoma, dorsal view.; 56. Metasternum, ventral view.

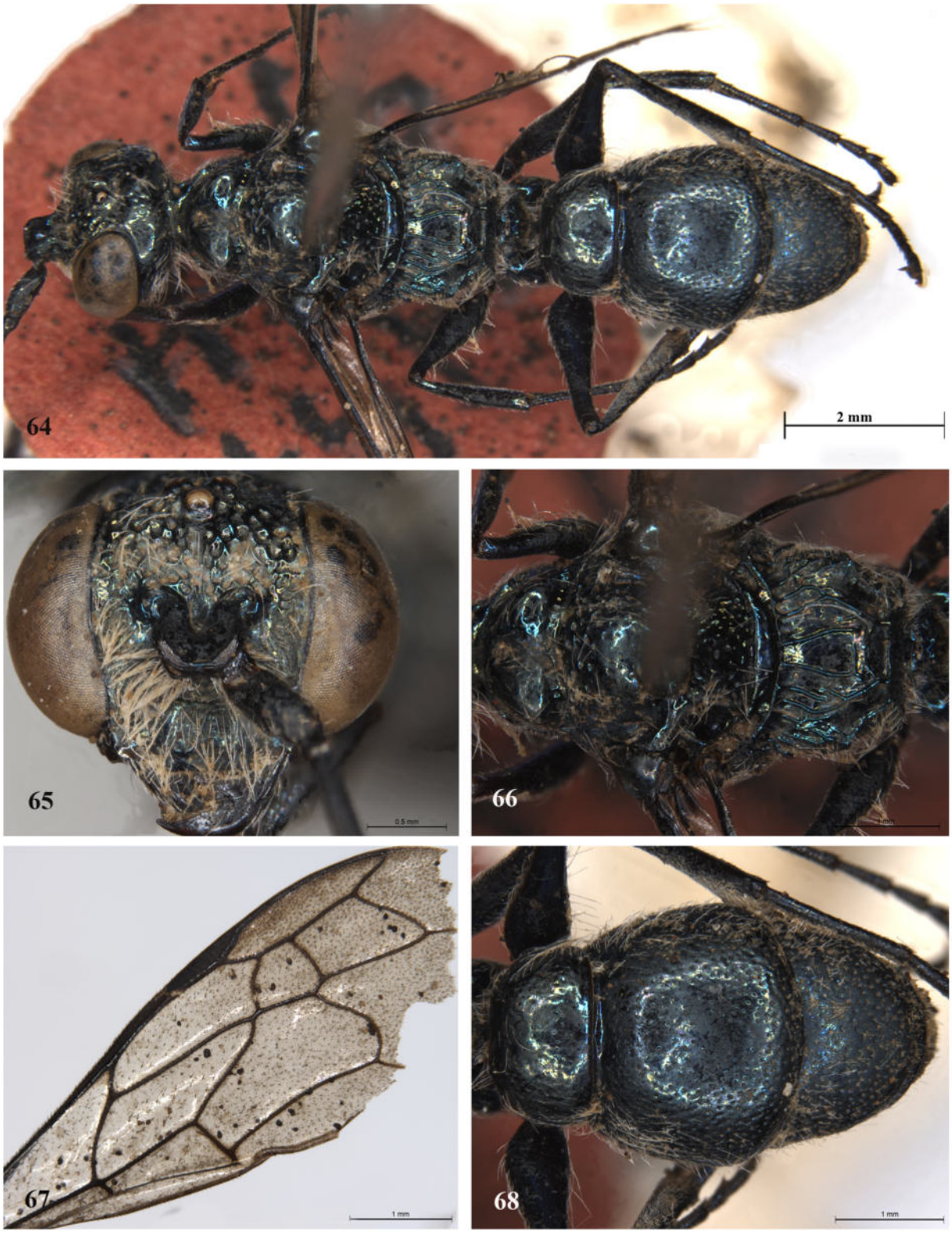
PLATE 13



***Trirogma caerulea* Westwood, 1841 (Male)**

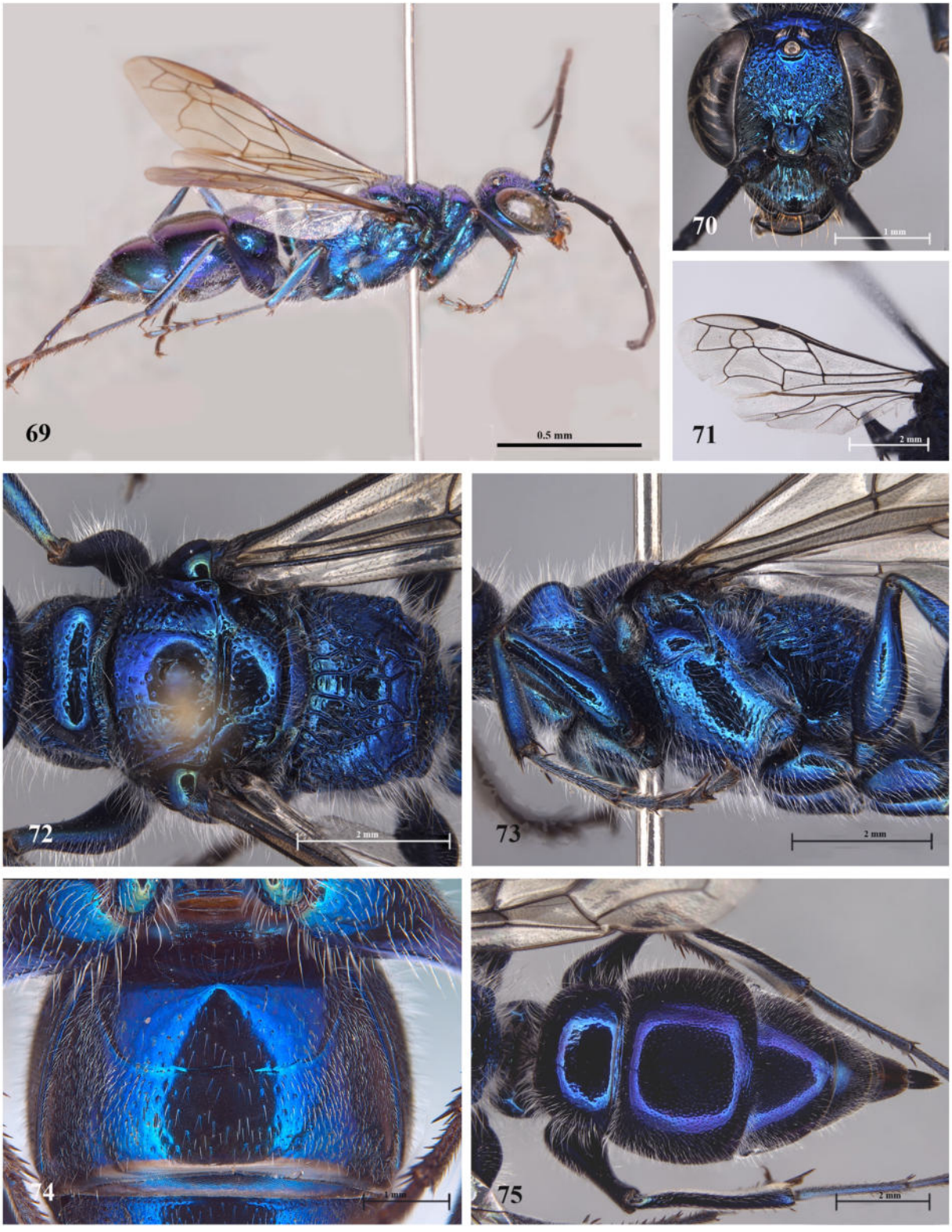
57. Habitus, lateral view; 58. Head, frontal view; 59. Fore wing; 60. Mesosoma, dorsal view; 61. Mesosoma, lateral view; 62. Metasomal sternum 2 (S2), ventral view; 63. Metasoma, dorsal view.

PLATE 14



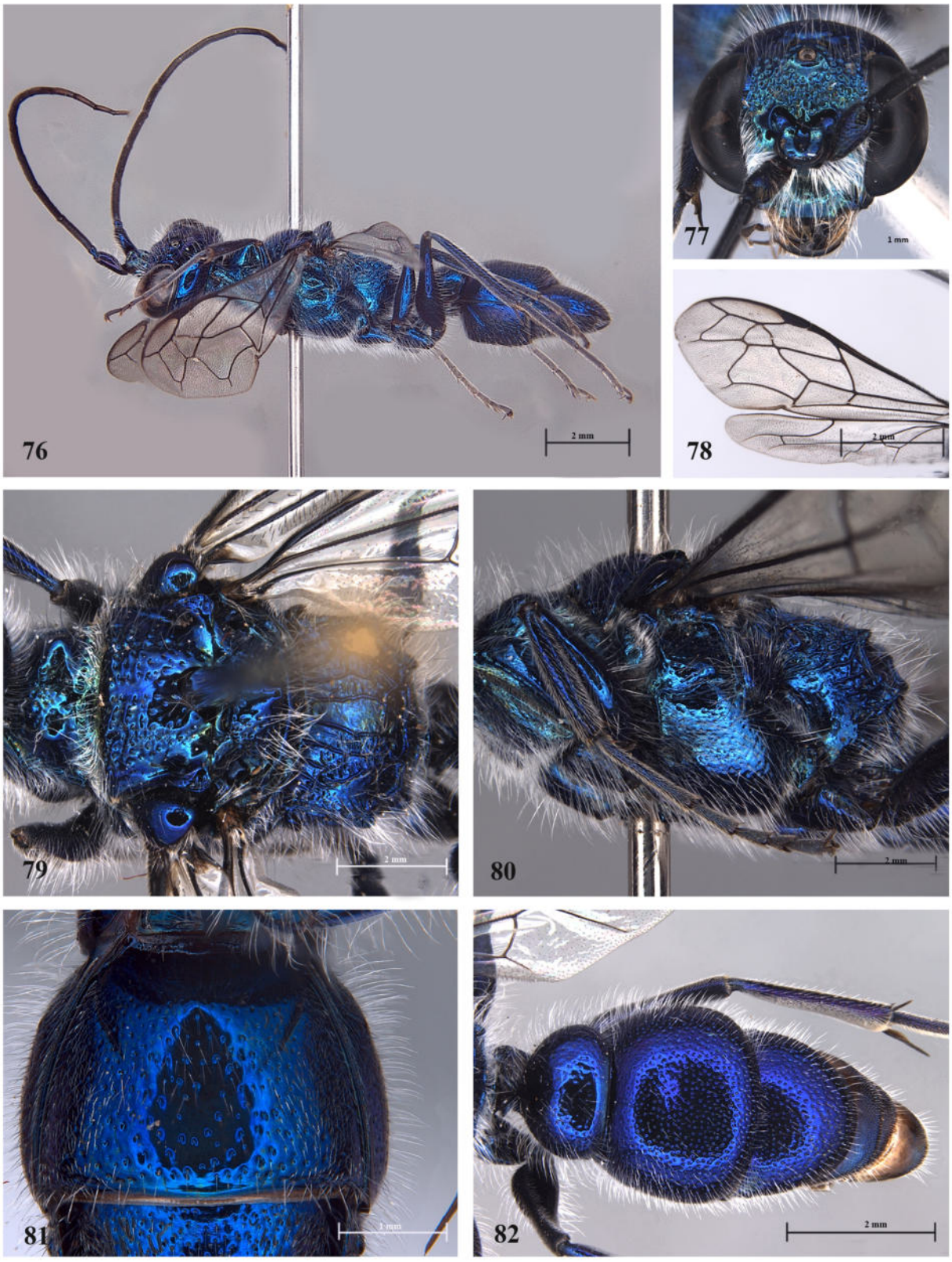
***Trirogma narendrani* Madhavikutty, 2004 (Male)**
64. Habitus, lateral view; 65. Head, frontal view; 66. Mesosoma, dorsal view; 67. Fore wing; 68. Metasoma, dorsal view.

PLATE 15



***Trirogma regalis* Krombein, 1979 (Female)**
69. Habitus, lateral view; 70. Head, frontal view; 71. Fore wing; 72. Mesosoma, dorsal view; 73. Mesosoma, lateral view; 74. Metasomal sternum 2 (S2); 75. Metasoma, dorsal view.

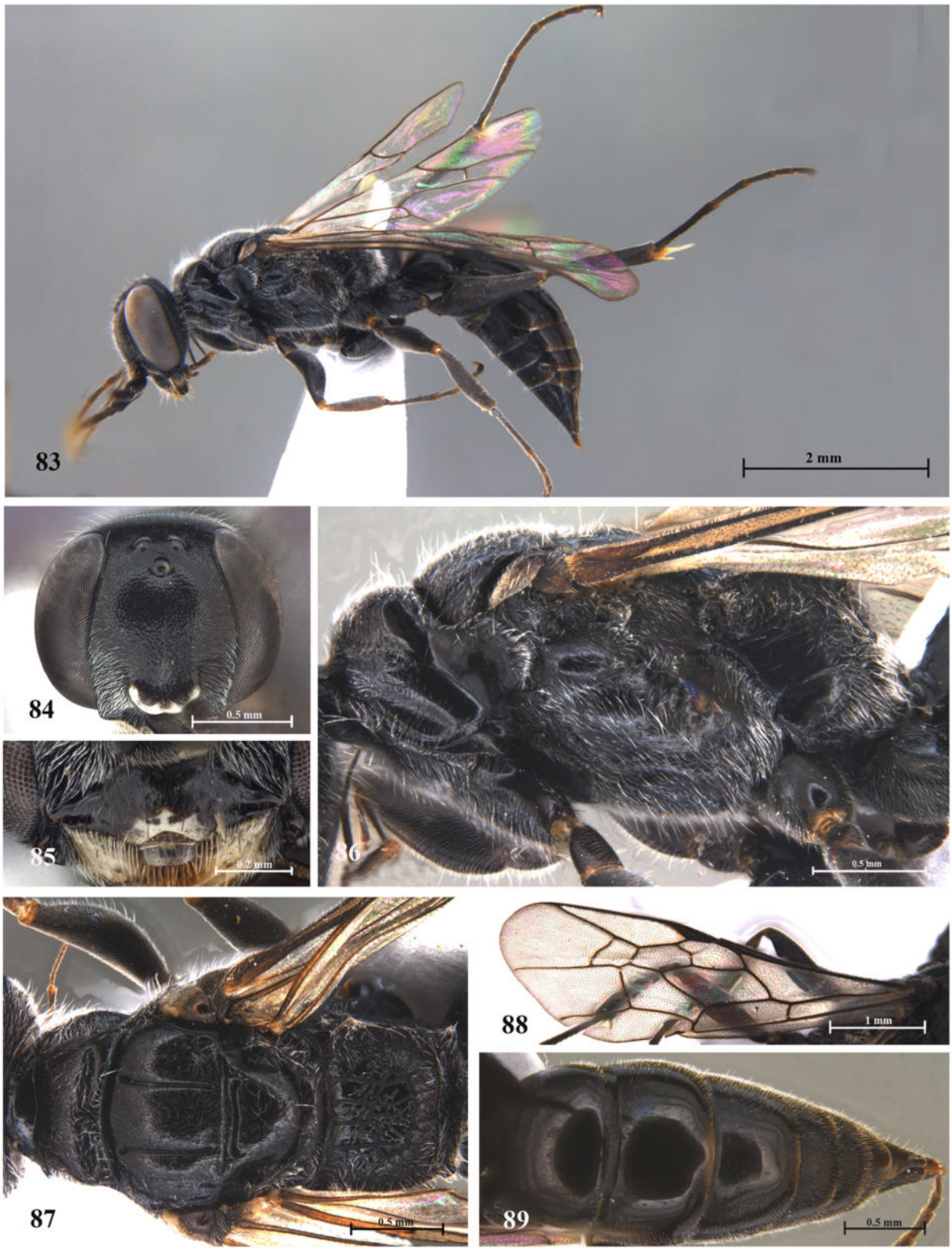
PLATE 16



***Trirogma regalis* Krombein, 1979 (Male)**

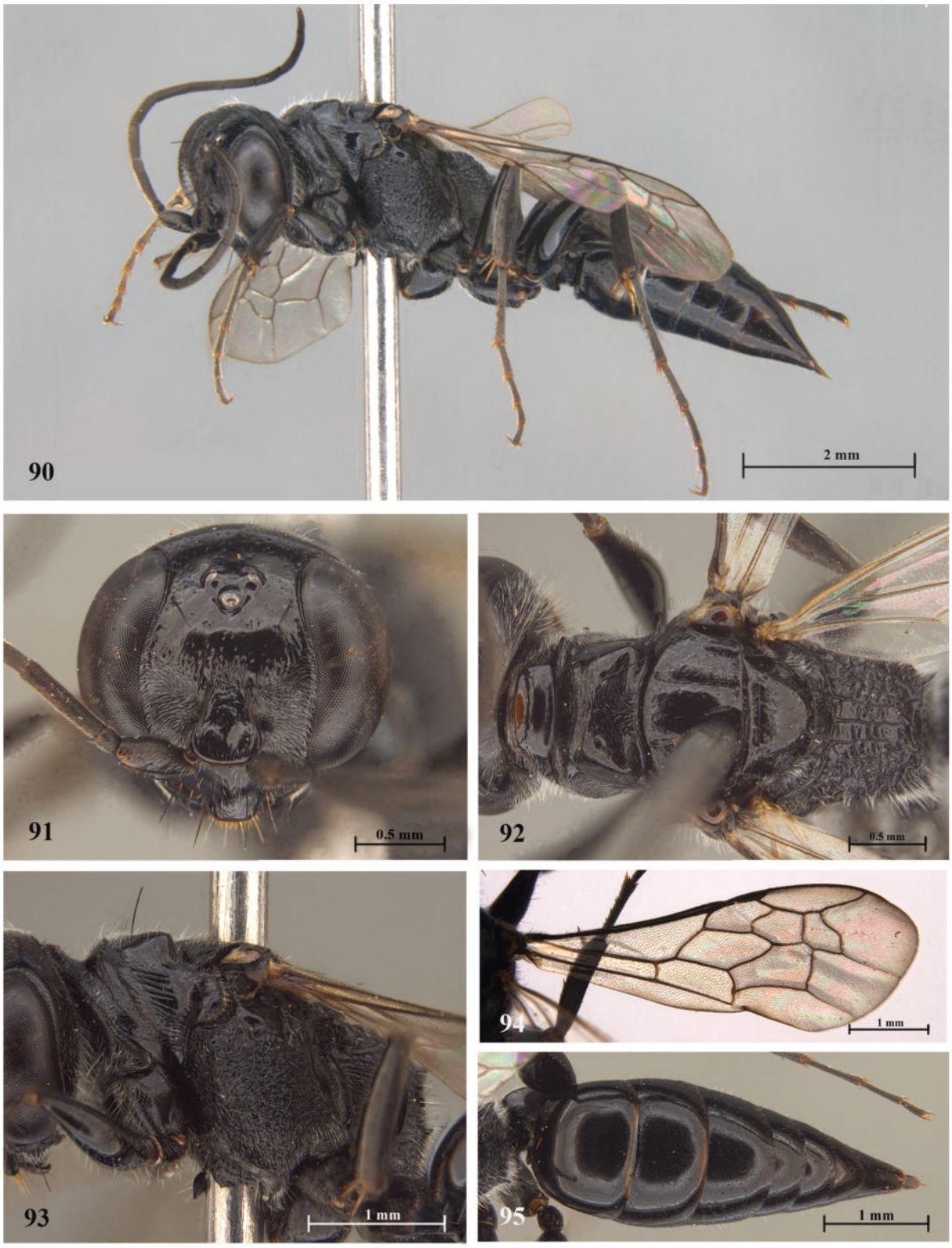
76. Habitus, lateral view; 77. Head, frontal view; 78. Fore wing; 79.Mesosoma, dorsal view; 80. Mesosoma, lateral view; 81. Metasomal sternum 2 (S2), ventral view; 82. Metasoma, dorsal view.

PLATE 17



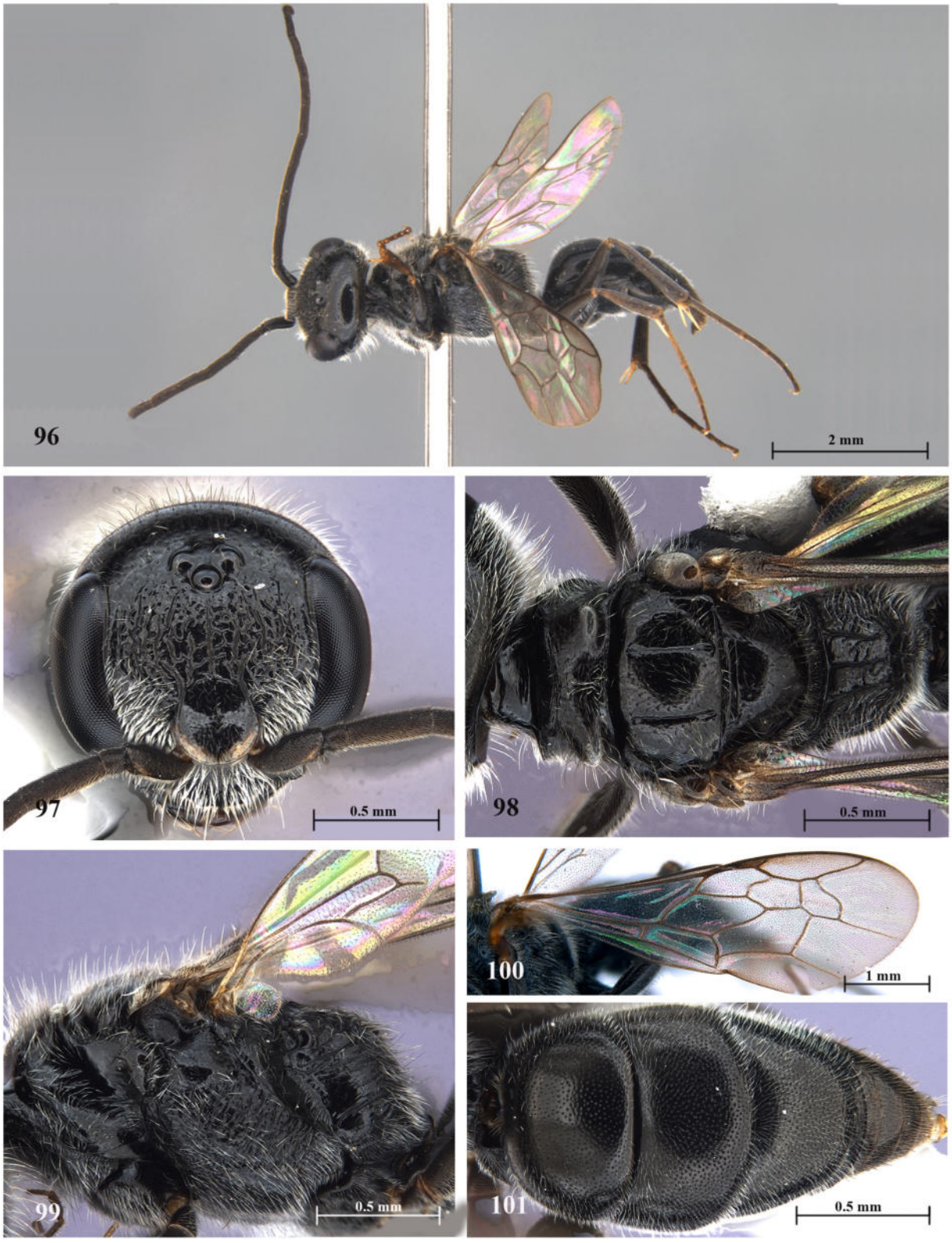
***Dolichurus albifacies* Krombein, 1979 (Female)**
83. Habitus, lateral view; 84. Head, frontal view; 85. Lower half of head, frontal view; 86. Mesosoma, lateral view; 87. Mesosoma, dorsal view; 88. Fore wing; 89. Metasoma, dorsal view.

PLATE 18



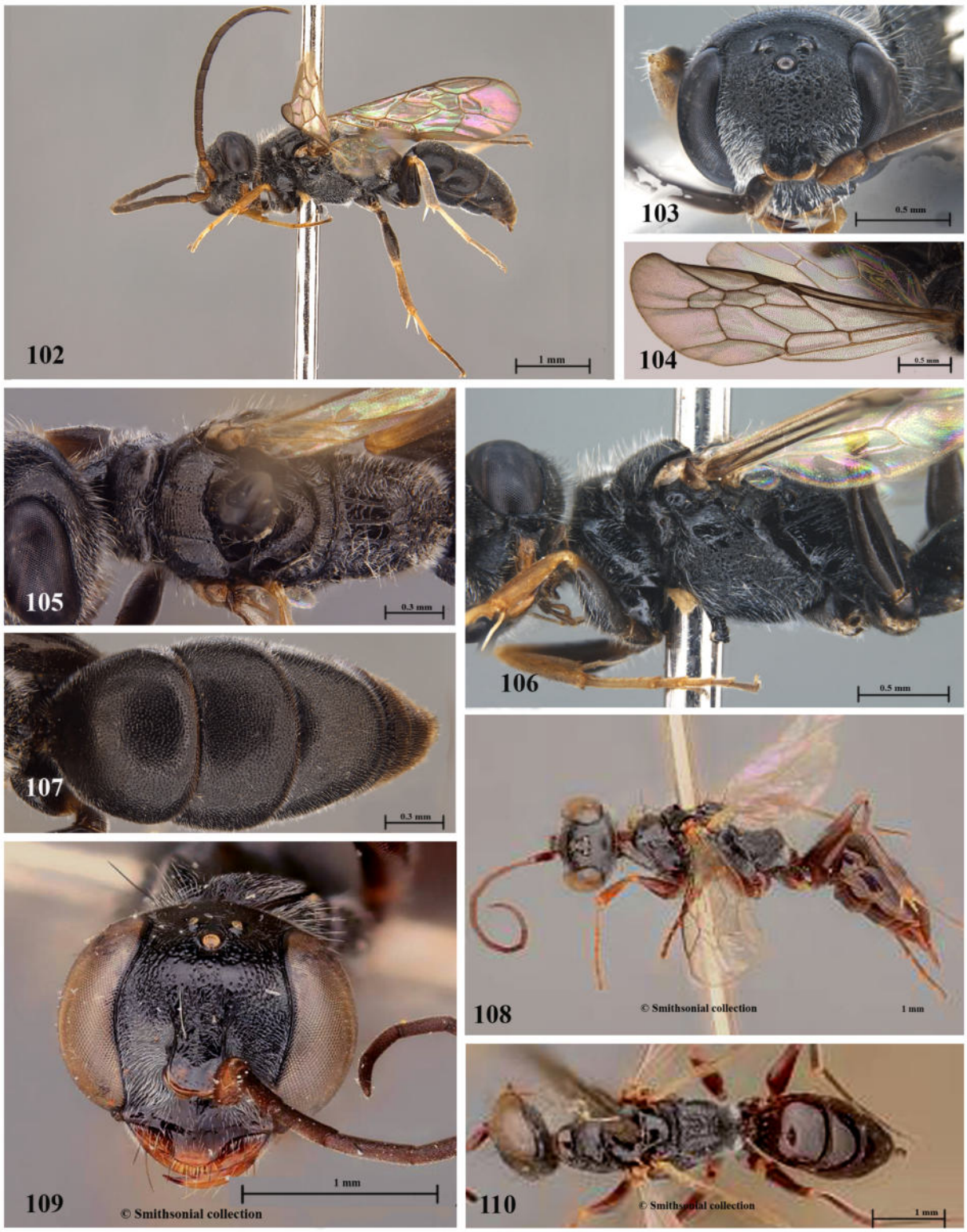
***Dolichurus amamiensis* Tsuneki and Iida, 1964**
90. Habitus, lateral view; 91. Head, frontal view; 92. Mesosoma, dorsal view; 93. Mesosoma, lateral view; 94. Fore wing; 95. Metasoma, dorsal view.

PLATE 19



***Dolichurus amamiensis* Tsuneki and Iida, 1964 (Male)**
96. Habitus, lateral view; 97. Head, frontal view; 98. Mesosoma, dorsal view; 99. Mesosoma, lateral view; 100. Fore wing; 101. Metasoma, dorsal view.

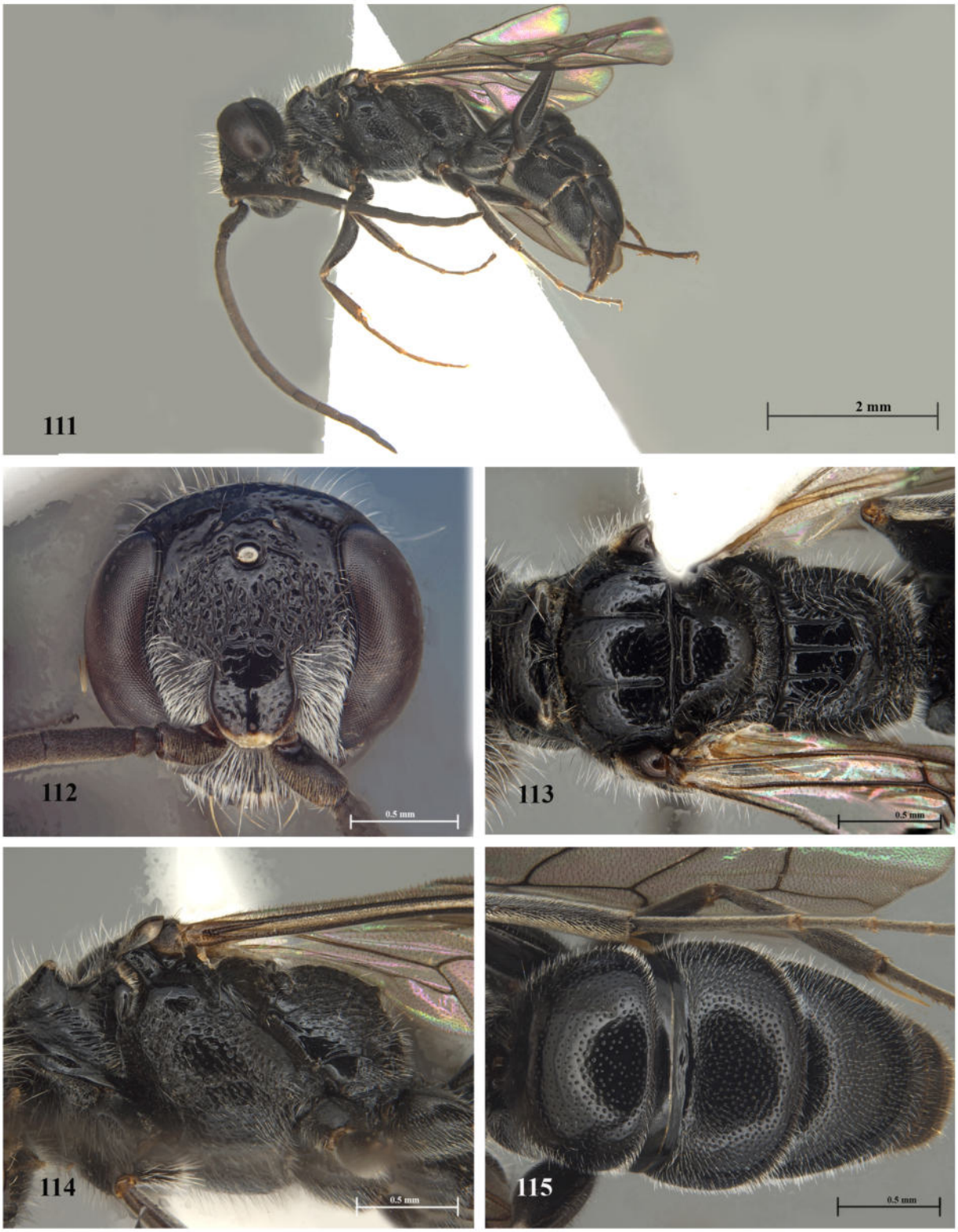
PLATE 20



***Dolichurus aridulus* Krombein, 1979**

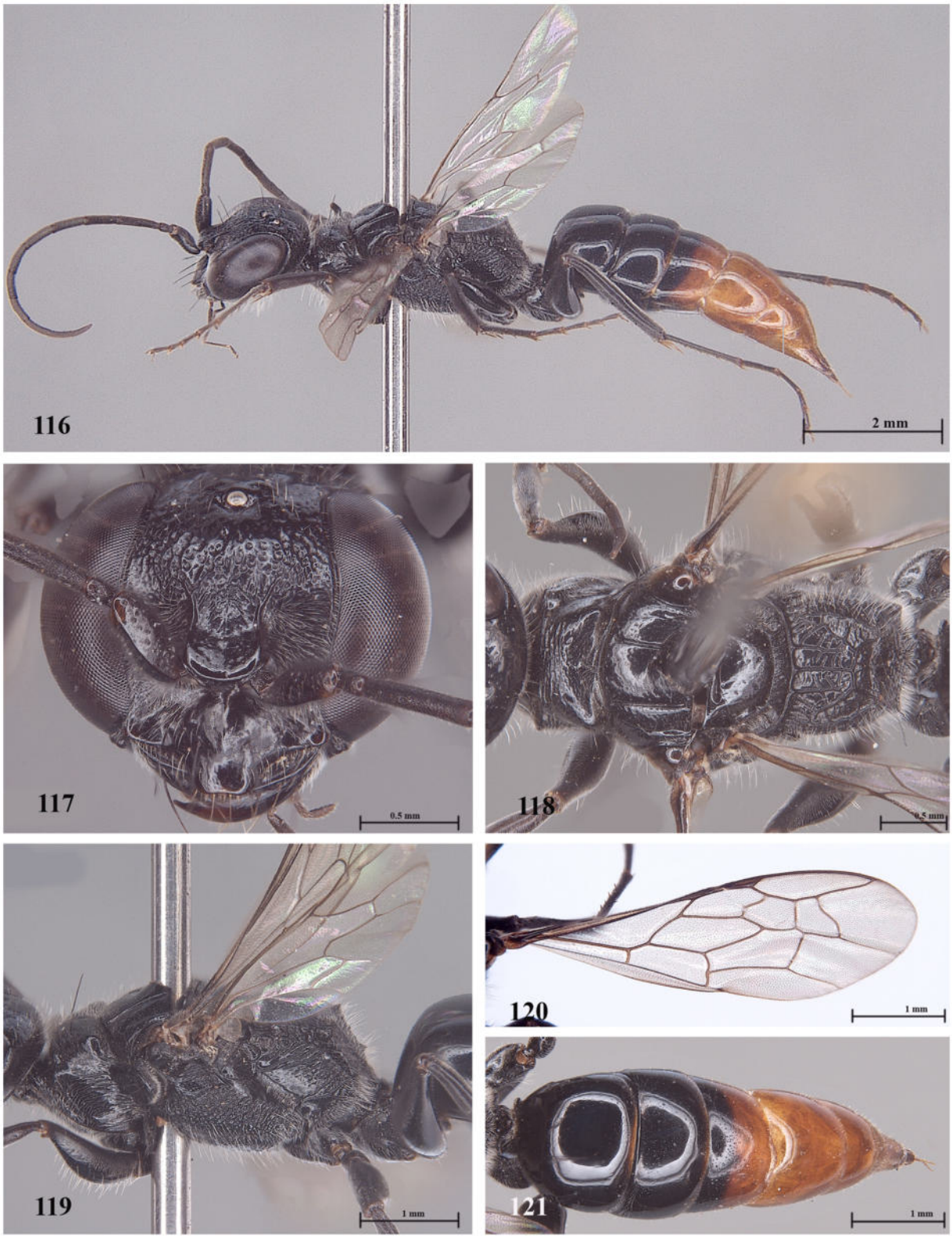
Figs. 102–107. Male, 102. Habitus, lateral view; 103. Head, frontal view; 104. Fore wing; 105. Mesosoma, dorsal view; 106. Mesosoma, lateral view; 107. Metasoma, dorsal view. Figs. 108–110. Female, 108. Habitus, lateral view; 109. Head, frontal view; 110. Habitus, dorsal view

PLATE 21



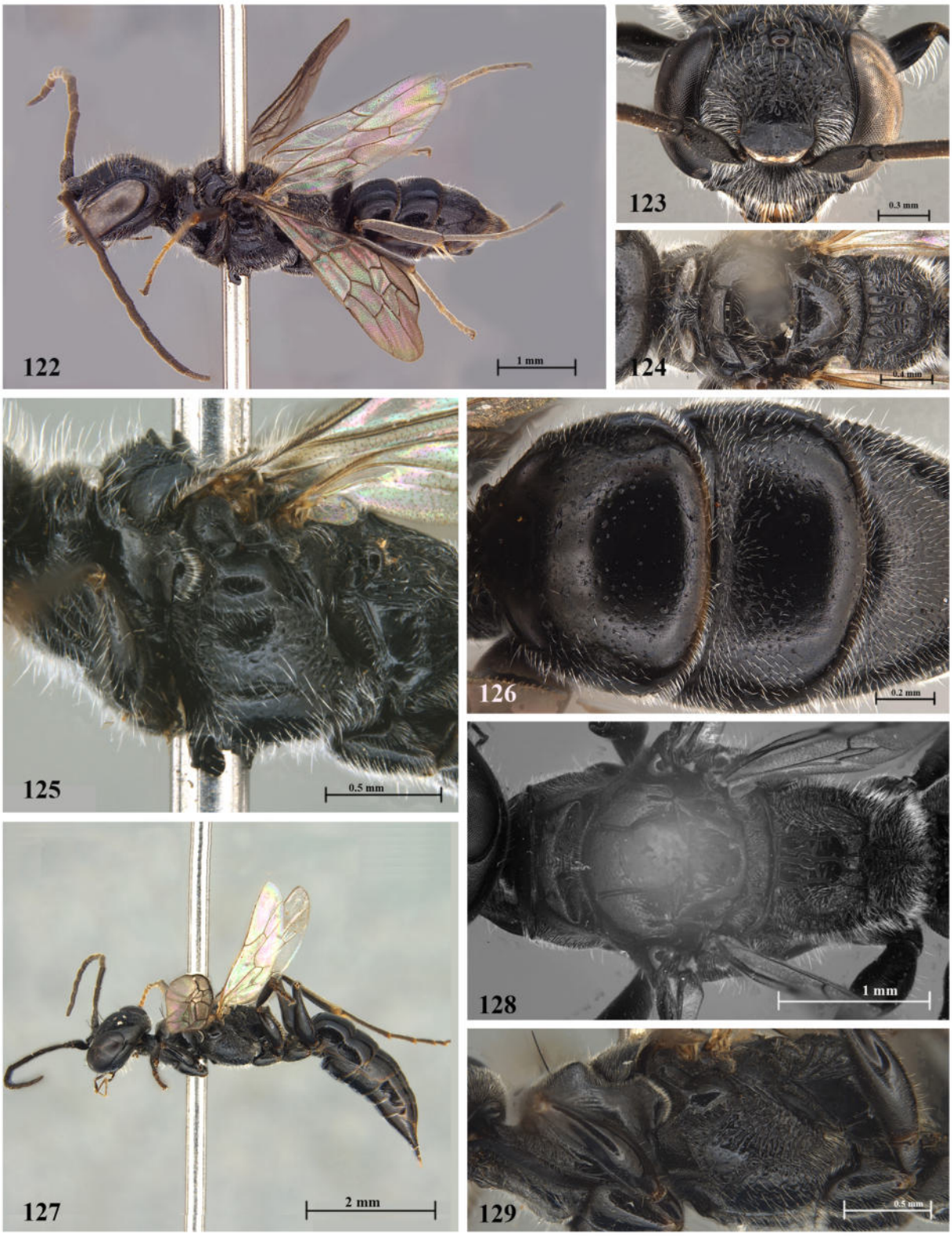
***Dolichurus chareshi* Anagha & Girish Kumar, 2020 (Male)**
111. Habitus, lateral view; 112. Head, frontal view; 113. Mesosoma, dorsal view; 114. Mesosoma, lateral view; 115. Metasoma, dorsal view.

PLATE 22



***Dolichurus gilberti* R. Turner, 1912**
116. Habitus, lateral view; 117. Head, frontal view; 118. Mesosoma, dorsal view; 119.Mesosoma, lateral view; 120. Fore wing; 121. Metasoma, dorsal view.

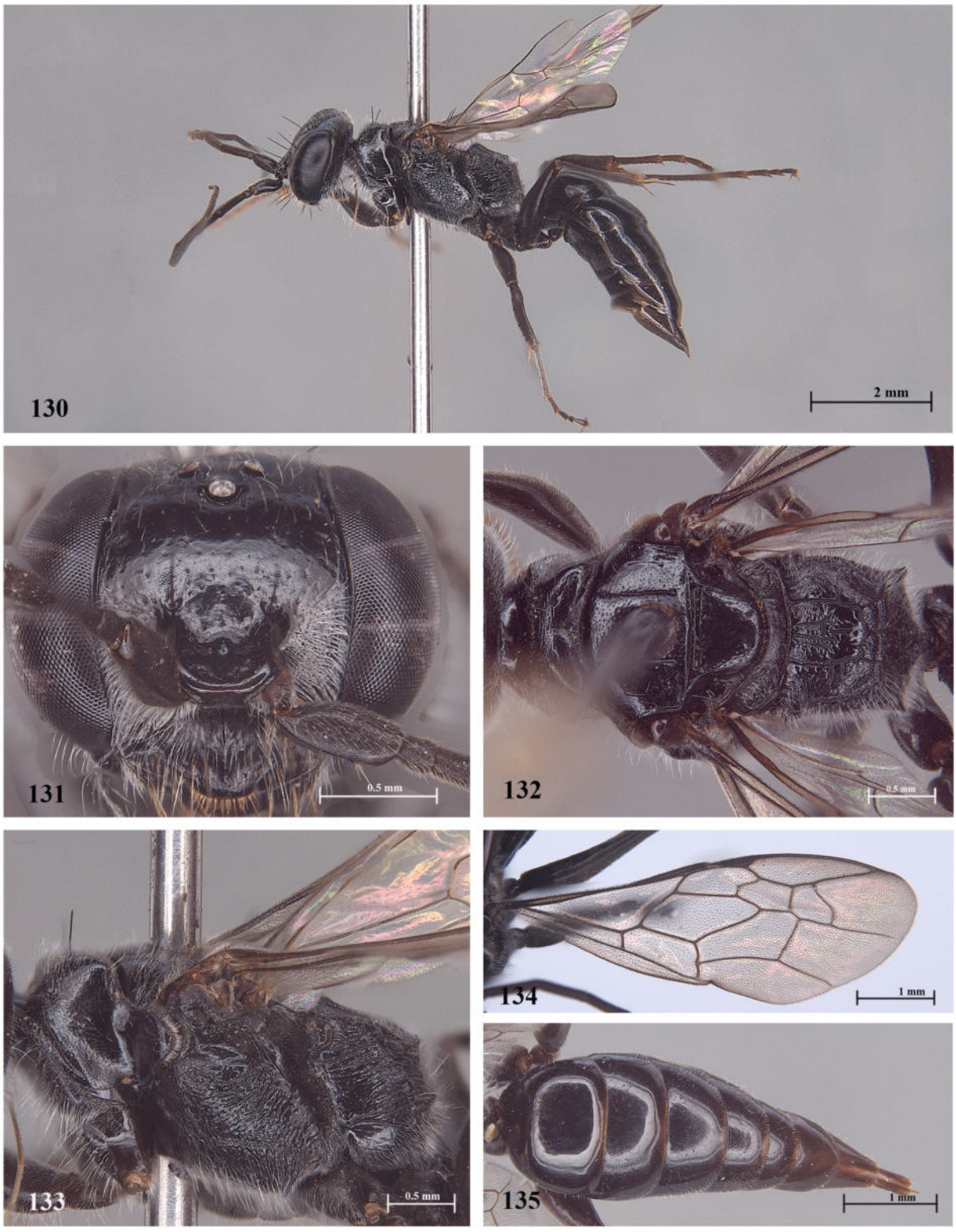
PLATE 23



***Dolichurus sahyadriensis* Anagha & Girish Kumar, 2020**

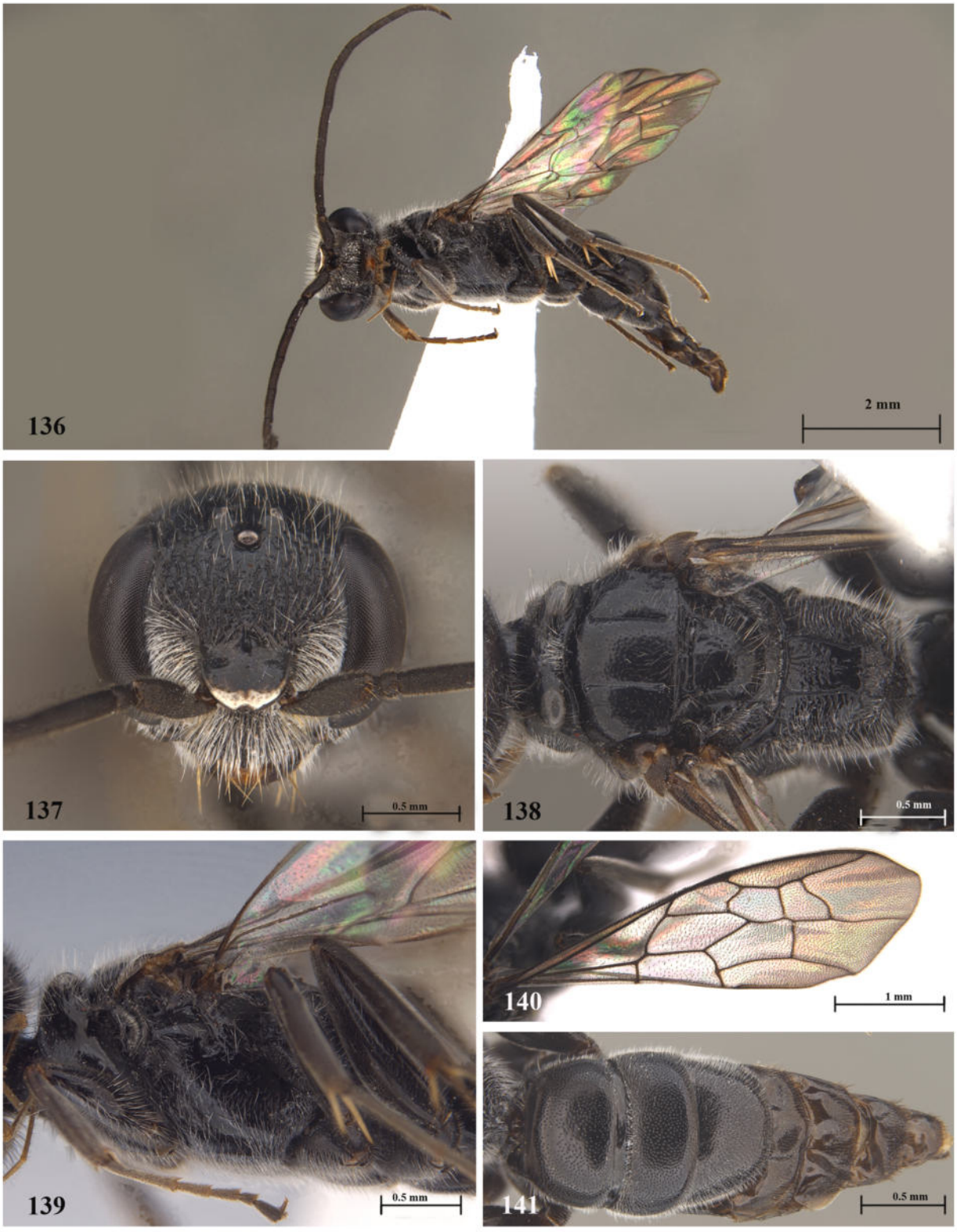
Figs. 122-126. Male, 122. Habitus, lateral view; 123. Head, frontal view; 124. Mesosoma, dorsal view; 125. Mesosoma, lateral view; 126. Metasomal Terga 1 & 2 (T1 & T2). **Figs. 127-129**. **Female**, 127. Habitus, lateral view; 128. Mesosoma, dorsal view; 129. Mesosoma, lateral view.

PLATE 24



***Dolichurus taprobanae* Smith, 1869 (female)**
130. Habitus, lateral view; 131. Head, frontal view; 132. Mesosoma, dorsal view; 133. Mesosoma, lateral view; 134. Fore wing; 135. Metasoma, dorsal view.

PLATE 25



***Dolichurus taprobanae* Smith, 1869 (Male)**
136. Habitus, lateral view; 137. Head, frontal view; 138. Mesosoma, dorsal view; 139. Mesosoma, lateral view; 140. Fore wing; 141. Metasoma, dorsal view.

PLATE 26

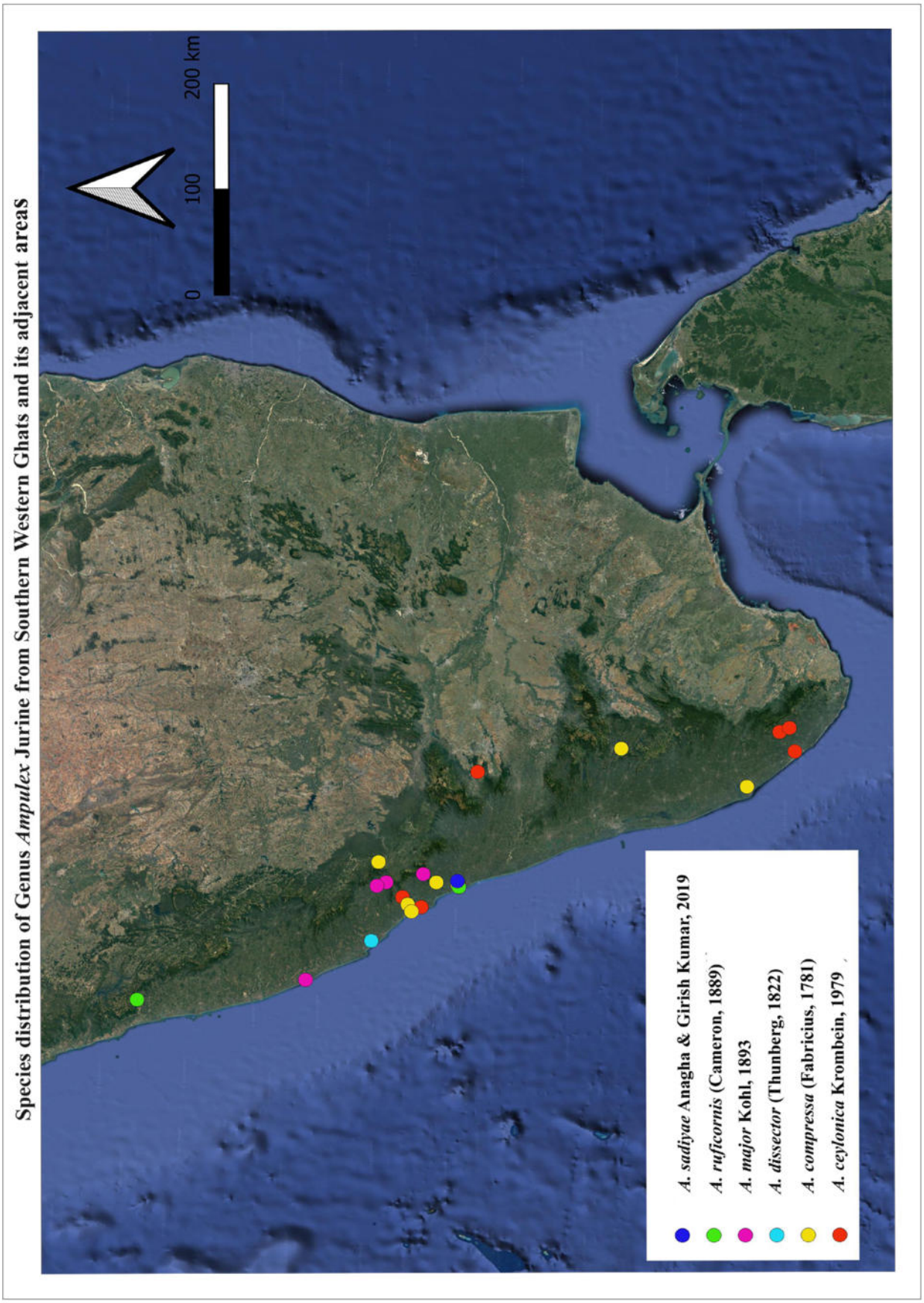

Species distribution of Genus *Ampulex* Jurine from Southern Western Ghats and its adjacent areaS
0
100
200 km
A. sadiyae Anagha & Girish Kumar, 2019
A. ruficornis (Cameron, 1889)
A. major Kohl, 1893
A. dissector (Thunberg, 1822)
A. compressa (Fabricius, 1781)
A. ceylonica Krombein, 1979

PLATE 27

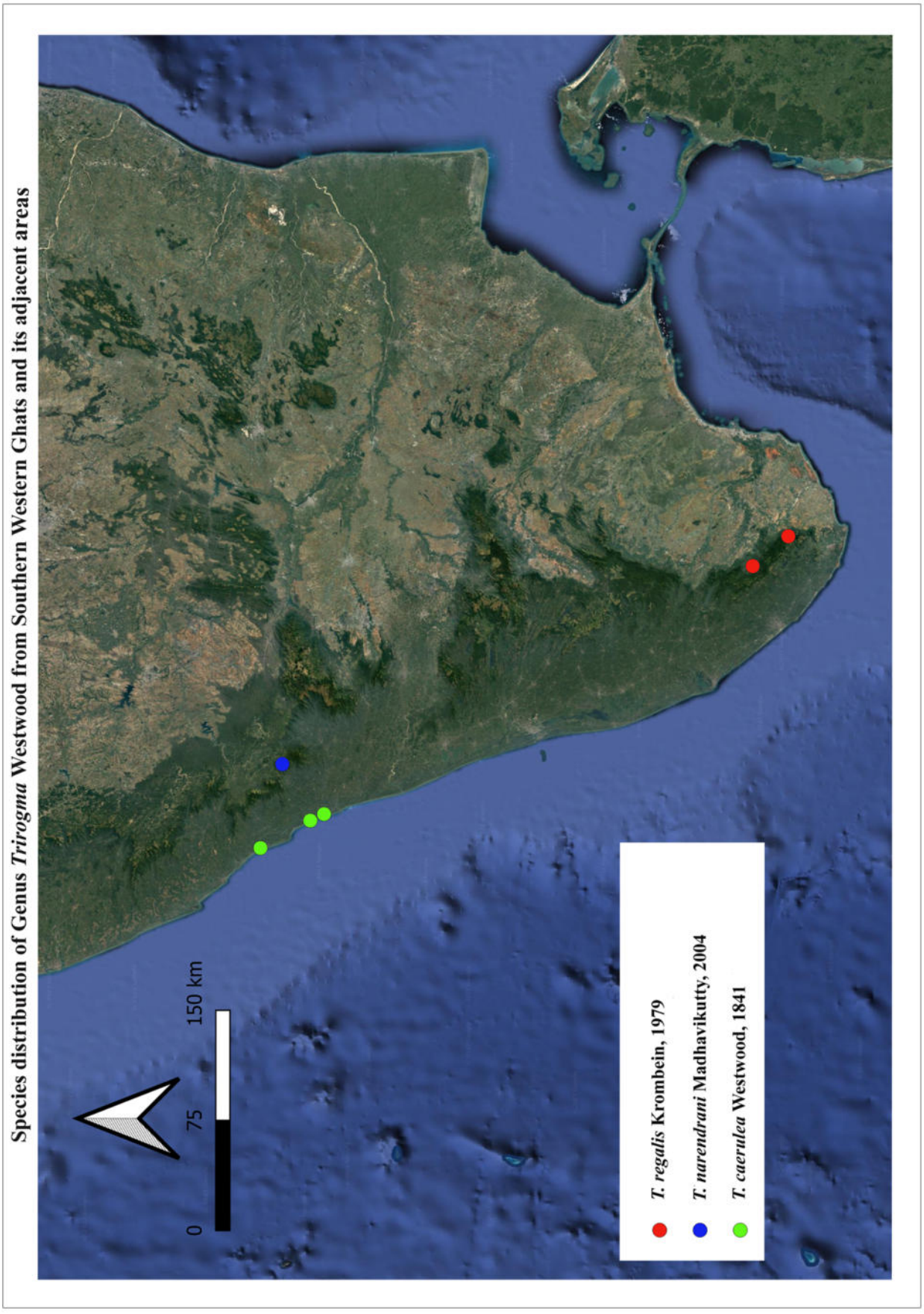
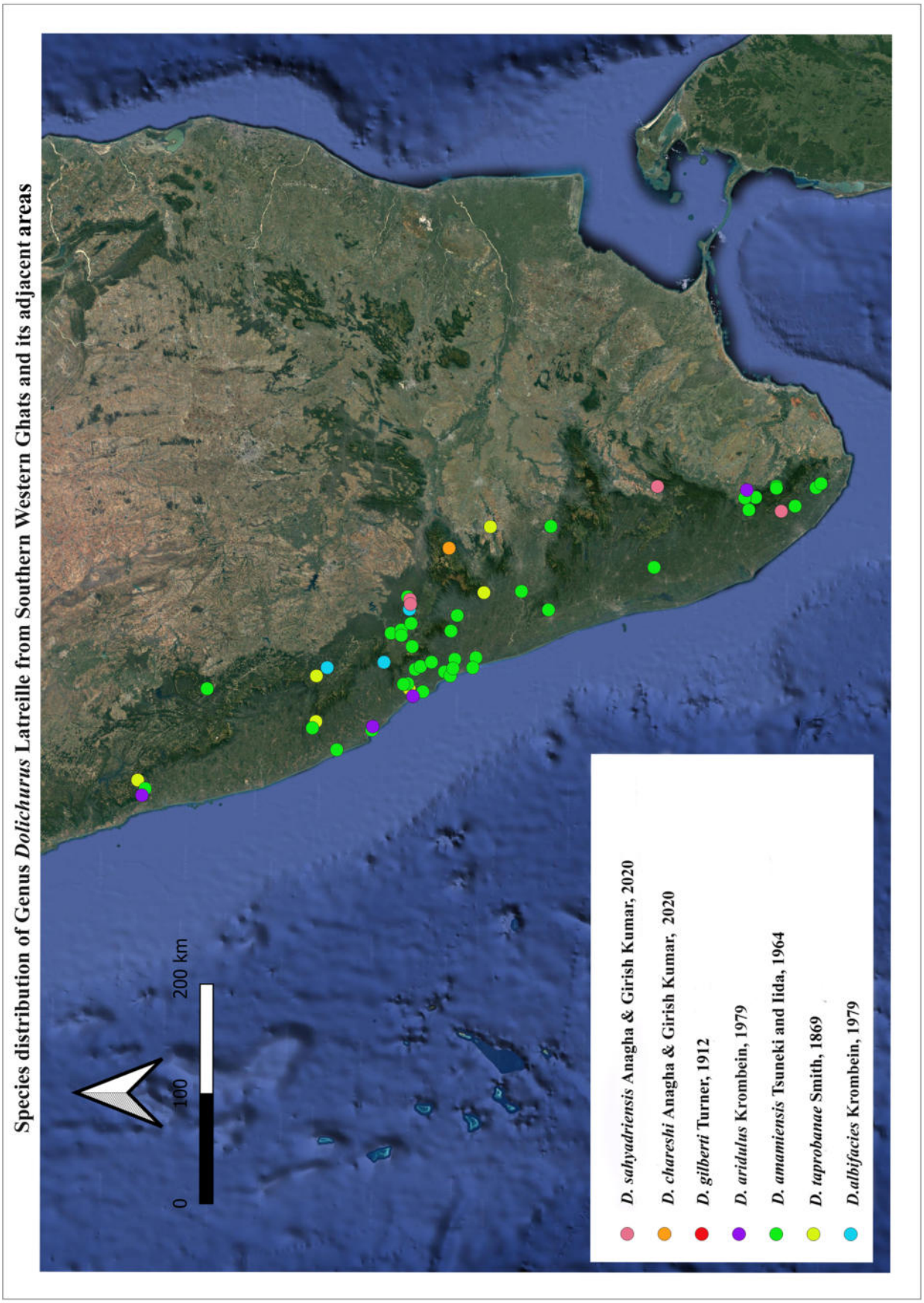

Species distribution of Genus *Trirogma* Westwood from Southern Western Ghats and its adjacent areas
0
75
150 km
T. regalis Krombein, 1979
T. narendrani Madhavikutty, 2004
T. caerulea Westwood, 1841

PLATE 28


Species distribution of Genus *Dolichurus* Latreille from Southern Western Ghats and its adjacent areas
0
100
200 km
D. sahyadriensis Anagha & Girish Kumar, 2020
D. chareshi Anagha & Girish Kumar, 2020
D. gilberti Turner, 1912
D. aridulus Krombein, 1979
D. amamiensis Tsuneki and Iida, 1964
D. taprobanae Smith, 1869
D.albifacies Krombein, 1979

CHAPTER 2
SPHECIDAE

2. FAMILY SPHECIDAE

Sphecidae is a diverse group of medium to large solitary wasps. At present, the family Sphecidae is represented by 808 species under 19 genera in five subfamilies all over the world (Pulawski, 2023). The distribution of sphecid wasps in Oriental region are far fewer explored. Till date, 127 species and 28 subspecies under 12 genera have been recorded from Oriental region (Pulawski, 2023).

During the present study, a total of 17 taxa (species and subspecies) belonging to seven genera in four subfamilies of Sphecidae were studied. Distribution map to species of all genera collected and Illustrated dichotomous key to genera and species of this family are prepared. Since the family is represented by only few genera and species from India, Indian keys are attempted herein also.

2.1. General Morphology

Sphecids are medium to large wasps with long and petiolate abdomen giving the body appearance of thread waist. They show great diversity in shape and colour, their body may all be black or dark brown, yellow and black, or black and red (sometimes orange or rufous).

Antennae generally placed near middle of frons in almost all sphecid wasps and their antennal sockets touching or broadly separated from fronto-clypeal suture.

Pronotal collar high, short or elongate and rarely tuberculate, pronotal lobe widely set apart from tegula. Mesoscutum is with or without centrally placed short and indistinct notauli. Propodeal dorsum is with or without enclosure. Episternal sulcus generally present and extends to antero-ventral region of mesopleuron. Inner margin of tarsal claws are simple or with one to five teeth and mid tibia with two apical spurs. Fore wing is with three SMC but some exceptions are seen in genera *Ammophila* Kirby and *Prionyx* Vander Linden. Jugal lobe of hind wing is large covering most of anal area with a third anal vein.

Gaster petiolate, and petiole consist of only sternum if it is without two sections as in *Ammophila*.

Like ampulicids, sphecids also exhibit significant sexual dimorphism in number of antennal segments (twelve in females and thirteen in males), number of gastral segments (six in females and seven in males) and shape of clypeus. Males of sphecids generally have narrow head compared to female. Sometimes, colour of sexes differs significantly and males are normally less coloured and have pale coloured wings than female.

Note. Unlike ampulicids, most sphecids show negligible sexual differences other than the aforementioned basic differences, so here, a unified key is provided for each genus

2.2. Systematic Position

CLASS: INSECTA

ORDER: HYMENOPTERA

SUPERFAMILY: APOIDEA

Family: Sphecidae Latreille, 1802

Subfamily: Ammophilinae André, 1886

- Genus *Ammophila* Kirby, 1798
- Genus *Eremnophila* Menke, 1964
- Genus *Eremochares* Gribodo, 1883
- Genus *Hoplammophila* de Beaumont, 1960
- Genus *Parapsammophila* Taschenberg, 1869
- Genus *Podalonia* Spinola, 1927

Subfamily: Chloriontinae Fernald, 1905

- Genus *Chlorion* Latreille, 1802

Subfamily: Sceliphrinae Ashmead, 1899

Tribe: Podinii de Saussure, 1892

- Genus *Dynatus* Lepeletier de Saint Fargeau, 1845
- *Genus Penepodium Menke* in Bohart & Menke, 1976
- Genus *Podium* Fabricius, 1804
- Genus *Trigonopsis* Perty, 1833

Tribe: Sceliphrini Ashmead, 1899

- Genus *Chalybion* Dahlbom, 1843
- Genus *Sceliphron* Klug, 1801

Subfamily: Sphecinae Latreille, 1802

Tribe: Prionychini Bohart and Menke, 1963

- Genus *Chilosphex* Menke in Bohart & Menke, 1976
- Genus *Palmodes* Kohl, 1890
- Genus *Prionyx* Vander Linden, 1827

Tribe: Sphecini Latreille

- Genus *Isodontia* Patton, 1880

- *Genus Sphex* Linnaeus, 1758

Subfamily: Stangeellinae Bohart and Menke, 1976

- Genus *Stangeella* Menke, 1962

Note. Except Stangeellinae, all other subfamilies are found in India.

Key to Indian subfamilies and genera of Sphecidae

1. Inner margin of tarsal claw with one or more basal teeth (Plate 38, Fig. 69) or without tooth; tarsi without plantulae. ……..…..…..….. 2

— Inner margin of tarsal claws of some legs with one tooth medially (Plate 33, Fig. 36); tarsi with or without plantulae ……..…….. 9

2. Tarsal claws with two or more teeth (Plate 38, Fig. 69); RV2 generally received by SMC3 (Plates 38−41, Figs. 71, 79, 83, 91, & Plate 44, Fig. 110), if not then tarsal claw with not less than three teeth or apicoventral setae of last tarsomere generally set apart at base by not more than one and half setal breadth; tarsi with plantulae [SPHECINAE]. ……..…….. 3

— Tarsal claws generally simple or with one tooth, if with two teeth, then apicoventral setae of last tarsomere generally set apart at base by three or more setal breadth; RV2 generally received by SMC2 (Plate 29, Fig. 3; Plate 30, Fig. 13); tarsi sometimes with plantulae [AMMOPHILINAE]. ……..……. 6

3. Anterior veinlet length of SMC2 equal to or greater than basal veinlet (Plates 39−41, Figs. 79, 83, 91; Plate 44, Fig. 110); inner margins of eye straight below but converging towards ocelli above (Plates 39−44, Figs. 76, 82, 90, 99, 102, 104, 107, & 116); pectens of inner hind tibial spurs fine and almost closely arranged (Plate 44, Fig. 113); spiracular groove present or absent [SPHECINI]. ……..... 4

— Anterior veinlet length of SMC2 shorter than basal veinlet (Plate 38, Fig. 71); inner margins of eye straight or diverging away from ocelli above (Plate 38, Fig. 67); pectens of inner hind tibial spurs generally coarse and well separated at least medially (Plate 38, Fig. 70); spiracular groove absent [PRIONYCHINI]. ……..…… 5

4. Sides of propodeum with complete spiracular groove (Plate 44, Fig. 114); dorsal petiole length much less than combined length of hind tarsomeres two to four. …….. ***Sphex*** Linnaeus

— Sides of propodeum with or without spiracular groove, if present, groove not complete, length not more than half way from hind coxa to spiracle (Plate 39, Fig. 78); petiole length variable. ……..…… ***Isodontia*** Patton

5. Inner margin of hind tarsal claw with two to five teeth (Plate 38, Fig. 69); male flagellomeres with or without placoids; apical margin of female clypeus complete or with a notch medially. …….. ***Prionyx*** Vander Linden

— Inner margin of hind tarsal claw with two teeth; male flagellomeres generally without placoids; apical margin of female clypeus with truncate or slightly depressed lobe medially and defined laterally by notch. …..……. ***Palmodes*** Kohl

6. Mouthparts long, galea reaches base of stipes on folding; tarsal claws generally simple (inner margin with single basal tooth in some species). ……...…… 7

— Mouthparts short, galea never reaches beyond middle of stipes on folding; tarsal claws with one or two basal teeth. …….. 8

7. Petiole extending to and overlapping base of S2; spiracle of T1 found before apex of petiole; petiole bent upward to level of T1 base. ……..…… ***Podalonia*** Fernald

— Petiole not extending to base of S2 (Plate 29, Fig. 6); spiracle of T1 found at or beyond apex of petiole (Plate 29, Fig. 6); petiole bent downward (Plate 29, Fig. 6) or straight to level of T1 base. ……...… ***Ammophila*** Kirby

8. Propodeal tergum nearly completely encircles socket of petiole; inner margin of female eye strongly converging below. ……...…….. ***Eremochares*** Gribodo

— Propodeal sternum (T shaped) ventrally bordering socket of petiole; inner margin of female eye parallel or weakly converging or diverging below. …… ***Parapsammophila*** Taschenberg

9. RV2 received by SMC3 (Plate 31, Fig. 19; Plate 32, Fig. 30); spiracular groove present on sides of propodeum (Plate 32, Fig. 29); females with fore tarsal rake (Plate 31, Fig. 20) [CHLORIONTINAE]. ……..……...… ***Chlorion*** Latreille

— RV1 and RV2 received by SMC2 (Plates 33−35, Figs. 33, 41, 46; Plate 37, Fig. 62); spiracular groove absent on sides of propodeum; females without fore tarsal rake [SCELIPHRINAE, SCELIPHRINI]. ……..… 10

10. Propodeal dorsum with U shaped enclosure (Plates 35−37, Figs. 45, 53, 56, & 60) marked atleast posteriorly by broad semicircular furrow or sulcus; body generally with yellow markings (Plate 36, Fig. 55; Plate 37, Fig. 58). …… ***Sceliphron*** Klug

— Propodeal dorsum without enclosure and utmost with a longitudinal furrow or sulcus medially or with postero-median pit; body generally metallic blue (Plate 33, Fig. 32; Plate 34, Fig. 39) or green without yellow markings. ……... ***Chalybion*** Dahlbom

2.2.1. Subfamily AMMOPHILINAE André, 1886

I. Genus *Ammophila* Kirby, 1798

Ammophila Kirby, 1798: 199. Type species: *Sphex sabulosus* Linnaeus, 1758 (designated by International Commission on Zoological Nomenclature, 1946: 571 (Opinion 180)).

Ammophylus Latreille, 1802: 332. Lapsus or emendation of *Ammophila* Kirby, 1798.

Miscus Jurine, 1807: 130, no included species. Type species: *Miscus campestris* (Latreille, 1809) (= *Ammophila campestris* Latreille, 1809) (designataed by Shuckard, 1837: 79).

Argyrammophila Gussakovskij, 1928: 7. Type species: *Ammophila induta* Kohl, 1901.

Apycnemia Leclercq, 1961: 211. Type species: *Ammophila fallax* Kohl, 1884 (= *Ammophila hungarica* Mocsáry, 1883).

Diagnosis. Petiole generally slides to base of T1 or straight, and very rarely bent upwards to base of T1, without extending to base of S2 (Plate 29, Fig. 6); spiracle of T1 found at or beyond apex of petiole (Plate 29, Fig. 6); SMC3 sometime absent or petiolate (Plate 29, Fig. 3; Plate 30, Fig. 11); episternal sulcus generally present, running vertically from subalar fossa to anteroventral margin of mesopleuron without continuing through scrobe (Plate 29, Fig. 5, Plate 30, Fig. 13); tarsal claw simple in most species but with sharp single basal tooth on the inner margin in some species; females with fore tarsal rake consisting of short, rigid spines or long, delicate spines; small to large arolium present (Plate 29, Fig. 7) (Bohart & Menke, 1976; Olszewski & Danilov, 2020).

Distribution. They are cosmopolitan genus distributed in Australasian, Afrotropical, Nearctic, Neotropical, Oriental and Palearctic Regions (Pulawski, 2023).

Keys. World species. Tsuneki, 1967b: 9 (key to *Ammophila* species from East Asia); Myartseva, 1971: 76 (key to *Ammophila* species from Turkmenistan); Alayo Dalmau, 1976: 11 (key to *Ammophila* species from Cuba); Guichard, 1988: 126 (key to *Ammophila* species from Arabian Peninsula); Menke, 2004: 772 (provisional key to describe red legged South American *Ammophila*); Augul *et al*., 2013: 13 (key to *Ammophila* species from Iraq); Dollfuss, 2013a: 386 (key to *Ammophila* species from Palaearctic and Indian region); Danilov, 2014: 519 (key to *Ammophila* species from Siberia) (Pulawski, 2023).

Note. Genus is represented by 243 species and 15 subspecies around the world. 19 species and six subspecies are recorded from Oriental region, of which 11 species are known to occur in India (Anagha & Girish Kumar, 2020b; Pulawski, 2023).

Biology. *Ammophila* species are known to attack lepidopterous caterpillars and occasionally larva of Symphyta to feed their larvae. Weevil larvae has also been reported to be used as prey by some species like *A. azteca* Cameron (Evans, 1965). Nest are dug before prey capture in most species (except in few species like *A. wrightii* (Cresson)). Nests generally are single celled short burrows. Female *Ammophila* on finding the prey, paralyses it, stinging several times. The wasp carries the caterpillar upside down (head forward) with its mandible assisted by fore legs and is flown to the nest or dragged over the ground, depending on the size of prey. Egg is laid on the first pey brought in to nest near its head. Although mass provisioning is the rule, progressive provisioning is reported for some species (Bohart & Menke, 1976).

Key to Indian species of *Ammophila* Kirby (adopted from Dollfuss, 2013a)

1. Dorsal pronotal collar and mesoscutum transversely striate. ……..…… 2
— Dorsal pronotal collar not transversely striate, mesoscutum transversely striate or punctate. …… …..... 3
2. Pronotal collar elongate; mesothoracic venter produced anteriorly, incurvate for reception of fore coxa, depression bordered by carina that in some specimens forms one projection on each side. .....……..... ***A. gracillima*** Taschenberg
— Pronotal collar not elongate (Plate 29, Figs. 4; Plate 30, Fig. 12); mesothoracic venter not produced anteriorly. ……...…… ***A. clavus*** Fabricius
3. Legs entirely or partly orange (Plate 30, Figs. 9 & 15). ... ……...… 4
— Legs entirely black. ……..…… 7
4. Pronotal collar elongate; head and thorax with uniformly distributed dense appressed silvery white setae; wings hyaline. ……..… ***A. gracillima*** Taschenberg
— Pronotal collar not elongate; pronotal lobe and mesopleural suture with band or patch of appressed silvery white setae or with uniformly distributed silvery white setae; wings yellowish or hyaline. …….....……. 5
5. Mesoscutum transversely striate. ……..…… ***A. heydeni*** Dahlbom
— Mesoscutum punctate, at most with limited striae. ……..…… 6
6. Pronotal lobe, mesopleural suture, metapleural sulcus and propodeum posterolaterally with band or patch of appressed silvery white setae (Plate 30, Fig. 13). …….. ***A. laevigata*** Smith
— Prontal lobe and mesopleuron with uniformly distributed appressed silvery white setae. ……..…. ***A. smithii*** Smith
7. Gastral apex with metallic shine. ……..…… 8

— Gastral apex black, without metallic shine. ……..…… 10

8. Supra antennal lamellate projection absent or poorly developed. .....…. ***A. sabulosa*** (Linnaeus)

— Supra antennal lamellate well developed. …….. 9

9. Frons, clypeus and mesopleuron with appressed silvery white setae. ……..…….……... ***A. formosensis*** Tsuneki

— Frons, clypeus, and mesopleuron (in most specimens) without appressed silvery white setae. ……..……..... ***A. vagabunda*** Smith

10. Petiole entirely black. …….…….... ***A. punctata*** Smith

— Petiole partly or entirely orange ……..……..…… ***A. brevipennis*** Bingham

Species from southern Western Ghats and its adjacent areas

i. ***Ammophila clavus* (Fabricius, 1775)**

(Plate 29, Figs. 1−8)

Sphex clavus Fabricius, 1775: 348. (NHM: Banks collection) Holotype or syntypes: ♀, Nova Hollandia, now Australia (no specific locality).

Ammophila clavus; Audouin, 1822: 242.

Ammophila atripes Smith, 1852: 46. (NHM) Holotype or syntypes: ♀, India, Maharashtra, Khandaly (synonymized with *Ammophila clavus* by Dollfuss, 2013a: 419).

Ammophila basalis Smith, 1856: 214. (NHM) Syntypes: ♀, India or Pakistan, Punjab (no specific locality) (synonymized with *Ammophila clavus* by Dollfuss, 2013a).

Ammophila nigripes Smith, 1856: 215. (NHM) Holotype or syntypes: ♂, India, Tamil Nadu, Madras.

Ammophila dimidiata Smith, 1856: 216. (NHM) Syntypes: ♀, India: Bombay, Madras, north Bengal (synonymized tentatively with *Ammophila atripes* by Bohart & Menke, 1976: 151, synonymy validated by Dollfuss, 2013a: 418).

Ammophila simillima Smith, 1856: 217. (NHM) Holotype or syntypes: ♀, China, Hong-Kong (synonymized with *Ammophila atripes* by Bingham, 1897: 229).

Ammophila pulchella Smith, 1856, 28. (NHM) Syntypes: China, Hong Kong and Shanghai (synonymized with *Ammophila atripes* by Bingham, 1897: 229).

Ammophila longiventris de Saussure, 1867, 24. (MHNG) Lectotype: ♂, Sri Lanka, Trincomalee (MHNG) (synonymized with *Ammophila atripes* by Bingham, 1897: 229).

Ammophila humbertiana de Saussure, 1867: 25. (MHNG) Lectotype: ♀, Sri Lanka, Trincomalee (synonymized with *Ammophila atripes* by Schulz, 1911: 161).

Ammophila spinosa Smith, 1873a: 259. (NHM) Holotype or syntypes: ♀, China, Hong Kong (synonymized with *Ammophila atripes* by Bingham, 1897: 229).

Ammophila orientalis Cameron, 1889: 9. (OXUM) Syntypes: origin not indicated, but probably India (synonymized with *Ammophila atripes* by Bingham, 1897: 229).

Ammophila buddha Cameron, 1889: 94. (OXUM) Syntypes: India: Uttar Pradesh, Allahabad; West Bengal, Barrackpore (synonymized with *Ammophila atripes* by Bingham, 1897: 229).

Material examined. Karnataka: 2 ♀, Kodagu district, Bettathur, Coll. P. Girish Kumar & Party, 23.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15330 & 15584; 1 ♀, Chikmagalur district, Kabbinahalli Coffee Estate, Coll. P. Girish Kumar & Party, 26.xii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV.15331; 1 ♀, Shimoga district, Kabali, Coll. V.D. Hegde & Party, 18.xii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 20666; 1 ♀, Udupi district, Mookambika Wildlife Sanctuary, Chittoor site, Coll. V.D. Hegde & Party, 16.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21279; 1 ♀, Udupi district, Mookambika Wildlife Sanctuary, Gollihole, Coll. V.D. Hegde & Party, 16.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21280; 1 ♀ and 3 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Niduguppe, Coll. V.D. Hegde & Party, 22.vi.2022, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 21291−21294; 1 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Dooduru, Coll. V.D. Hegde & Party, 22.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21291−21294. Kerala: 3 ♂, Ernakulam district, Thattekkad, Butterfly Garden, Coll. P. Girish Kumar & Party, 23.ix.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 7656, 7658 & 7659; 4 ♀ & 1 ♂, Kozhikode district, Kottooli wet land, Coll. P. Girish Kumar & Party, 7.v.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 8959−8963; 1 ♀, Kasaragod district, Nileswaram, Coll. Manoj, 5.vii.2014, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 9335; 1 ♀, Kannur district, Madayippara, Coll. C. Charesh, 5.viii.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12481; 1 ♂, Kozhikode district, Madappally, Coll. S. Anagha, 22.ix.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15585; 2 ♂, Thiruvananthapuram district, Peppara Wildlife Sanctuary, dam site, Coll. S. Anagha & P. Girish Kumar, 28.ix.2019 & 4.xii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 16677 & 19647. Tamil Nadu: 1 ♂, Tirunelveli district, Gundaru dam site, Coll. P. Girish Kumar & Party, 27.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15315; 2 ♂, Coimbatore district, Kullanadimedu, Coll. P.

Girish Kumar & Party, 6.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15316−15317; 1 ♂, Coimbatore district, Anaikatti, Coll. P. Girish Kumar & Party, 4.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15318; 3 ♂, Coimbatore district, Govanur, Coll. P. Girish Kumar & Party, 6.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15319−15321; 1 ♀, Tirunelveli district, Kalakkad Mundanthurai Tiger Reserve (KMTR), Kuthiravetti, Ambasamudram, Coll. B.H.C.K Murthy & Party, 27.viii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15329; 2 ♂, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Vellimalayi range, Puravilai, Coll. Souvik Sen & Party, 17.ii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16678−16679; 1 ♂, Coimbatore district, Anaikatti, Coll. P. Girish Kumar & Party, 4.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17246.

Diagnosis. **Female (Plate 29, Figs. 1−6)**. Body size: 19−22 mm. Body black, following orange: scape, petiole, legs except coxae, trochanters, and apical tarsi; head broad; frons and vertex aciculate with thin silvery white pubescence and long erect black setae (Plate 29, Fig. 2); mandible obscurely ferruginous medially; clypeus sparsely punctate, apical margin arcuate, slightly emarginate medially (Plate 29, Fig. 2); pronotal collar and mesoscutum with distinct transverse striations, striae widely separated; scutellum and metanotum with longitudinal striations; propodeal enclosure finely reticulate medially and covered with appressed silvery white setae, laterally obliquely striate without setae (Plate 29, Fig. 4); mesopleuron and sides of propodeum rugosely reticulate with punctures (Plate 29, Fig. 5); patch of dense silvery white pubesence on pronotal lobe (Plate 29, Fig. 4), postero-lateral propodeum, along mesopleural and metapleural sulcus; tegula dark brown, ferruginous posteriorly; gaster black with blue metallic shine (Plate 29, Fig. 6); fore wing with three SMC, subhyaline with yellowish brown tinge (Plate 29, Fig. 3).

Male (Figs. 7−8). Body size: 24−28 mm. Sculpturing as in female; scape, petiole and legs entirely black (Plate 29, Fig. 7); clypeus slightly elongate (Plate 29, Fig. 8).

Distribution. India: Arunachal Pradesh, Assam, Bihar, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal. *Elsewhere*: Australia; Bangladesh; China; Indonesia; Japan; Korea; Laos; Malaysia; Myanmar; Nepal; Pakistan; Philippines; Singapore; Sri Lanka; Taiwan; Thailand; Vietnam (Anagha & Girish Kumar, 2020b; Pulawski, 2023).

ii. *Ammophila laevigata* Smith, 1856

(Plate 30, Figs. 9−16)

Ammophila laevigata Smith, 1856: 215. (NHM) Syntypes: India. Tamil Nadu, Madras; Gujarat (no specific locality).

Ammophila laevigata ab. *bicellularis* Strand, 1915: 97. (DEI) Holotype: ♂, Sri Lanka, Vurelia (synonymized with *Ammophila laevigata* by Bohart & Menke, 1976: 152).

Material examined. Karnataka: 3 ♀, Kodagu district, Kodagu, Coll. P. Girish Kumar & Party, 22.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15560−15562; 2 ♀ & 4 ♂, Kodagu district, Betathur, Coll. P. Girish Kumar & Party, 23.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15563−15568; 6 ♀ & 4 ♂, Kodagu district, Gonikoppa, Coll. P. Girish Kumar & Party, 25.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15569−15578; 1 ♀, Kodagu district, Bettathur near Madikeri, Coll. P. Girish Kumar & Party, 24.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15607; 1 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Hosagadde, Coll. P. Girish Kumar & Party, 29.xii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 16684; 1 ♂, Shimoga district, Bhadra Wildlife Sanctuary, Coll. Md. Jafer Palot & Party, 20.xii.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 16686; 2 ♀, Udupi district, Mookambika Wildlife Sanctuary, Mekke, Jadkal, Coll. V.D. Hegde & Party, 1.ix.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18797−18798; 4 ♀ & 2 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Hulikal Guest House, Coll. V.D. Hegde & Party, 5.ix.2021 & 16.xii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18799−18803 & 20657; 3 ♀ & 1 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Melina Ammanagude, Coll. V.D. Hegde & Party, 16.xii.2021 & 17.xii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 20658-20661; 1 ♀ & 2 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Kabali, Coll. V.D. Hegde & Party, 18.xii.2021 & 17.xii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 20662-20664; 1 ♀, Shimoga district, Mookambika Wildlife Sanctuary, Balamane, Hulikal, Coll. V.D. Hegde & Party, 18.xii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 20665; 5 ♀ and 2 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Hulikal FRH, Coll. V.D. Hegde & Party, 19.vi.2022, 20.vi.2022, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 21282−21288; 1 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Melsunka, Coll. V.D. Hegde & Party, 21.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21289; 1 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Niduguppe, Coll. V.D. Hegde & Party, 22.vi.2022, ZSIK Regd. No. ZSI/WGRC/IR/INV/ 21290. Kerala: 3 ♀ & 1 ♂, Ernakulam district, Thattekkad, Koottampara, Coll. P. Girish Kumar & Party, 28.x.2015, 29.x.2015 & 6.ii.2017, ZSIK Regd.

Nos. ZSI/WGRC/I.R.–INV. 7660, 7661, 8694 & 8695; 1 ♀, Wayanad district, Mangavayal, Coll. P. Girish Kumar & Party, 19.x.2015, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8061; 1 ♂, Kasaragod district, Nileswaram, Coll. Manoj, 5.vii.2014, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 9334; 1 ♀ & 3 ♂, Kozhikode district, Kottooli wet land, Coll. P. Girish Kumar & Party, 28.x.2015, 29.x.2015 & 6.ii.2017, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 9987−9990; 1 ♀, Thrissur district, Malakkapara, Vaazhachal, Coll. P. Girish Kumar & Party, 1.ii.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10481; 1 ♀ & 1 ♂, Kozhikode district, Kakkadampoyil, Coll. P. Girish Kumar & Party, 13.i.2017, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15287−15288; 1 ♂, Kozhikode district, Vilakottur, Coll. K.P. Hanima Raveendran, 21.x.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15291; 1 ♀, Kozhikode district, Vayalada, Coll. S. Anagha, 10.v.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15304; 2 ♀ & 2 ♂, Kozhikode district, Kakkadampoyil, Coll. P.M. Sureshan & Party, 25.v.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15305−15307 & 18740; 2 ♂, Kozhikode district, Madappally, Coll. S. Anagha, 22.ix.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15309 & 18744; 1 ♂, Thiruvananthapuram district, Peppara Wildlife Sanctuary, dam site, Coll. S. Anagha, 28.ix.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15310; 3 ♀ & 5 ♂, Malappuram district, Calicut University Campus, Coll. S. Anagha, 20.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15552−15559; 1 ♀ & 1 ♂, Kozhikode district, Purameri, Coll. K.P. Hanima Raveendran, 21.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15580 & 15609; 1 ♀, Malappuram district, Nedumkayam, Coll. K.S. Surya & Party, 29.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15610; 1 ♀, Kozhikode district, Vayalada, Coll. S. Anagha, 10.v.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 16683; 1 ♂, Kasaragod district, Ranipuram, Coll. S. Anagha & Party, 22.i.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 16688; 1 ♂ & 1 ♀, Kozhikode district, Ponkunnumala, Coll. S. Anagha & Party, 16.ix.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18338 & 18743; 1 ♀ & 1 ♂, Palakkad Wildlife Sanctuary district, Parambikulam, Coll. K.C. Gopi, 21.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18728−18729; 1 ♂, Kasaragod district, Ranipuram, Coll. Rajan, 17.xii.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18736; 1 ♂, Idukki district, Chinnar, Coll. K.P. Hanima Raveendran & Party, 28.xi.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18736; 1 ♀, Wayanad district, Chandanthodu, Coll. K.A. Subramanian & Party, 14.ii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18745; 1 ♂, Kannur district, Aralam, Chavachi, Coll. K.A. Subramanian & Party, 24.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18746; 1 ♂, Wayanad district, Coll. K.S. Surya & Party, 24.xii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18759. Tamil Nadu: 1 ♂, Tirunelveli district, Koonthankulam Bird Sanctuary, Coll. P.

Girish Kumar & Party, 27.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15290; 2 ♀ & 2 ♂, Coimbatore district, Kottur, Coll. P. Girish Kumar & Party, 2.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15292−15295; 1 ♀, Coimbatore district, Kullanadimedu, Coll. P. Girish Kumar & Party, 2.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15296; 2 ♂, Coimbatore district, Sethumadai, Coll. P. Girish Kumar & Party, 3.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15297 & 16685; 1 ♀ & 2 ♂, Coimbatore district, Anaikatti, Coll. P. Girish Kumar & Party, 4.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15298−15300; 1 ♀ & 2 ♂, Coimbatore district, Govanur, Coll. P. Girish Kumar & Party, 6.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15301−15303 & 18739; 1 ♀, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Kalikesam, Alambarai, Coll. Souvik Sen & Party, 15.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15579; 1 ♀, Coimbatore district, Sadivayal, Coll. P. Girish Kumar & Party, 5.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15581; 1 ♀, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Azhakiyapandipuram range, Thuthukulivayal, Coll. Souvik Sen & Party, 16.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15608; 1 ♀, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Kulashekaram range, Zero point, Coll. Souvik Sen & Party, 19.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15611; 1 ♀ & 3 ♂, Coimbatore district, Govanur near Palamalai range, Coll. P. Girish Kumar & Party, 6.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15301−15303 & 16687; 1 ♂, Coimbatore district, Tholampalayam, Coll. P. Girish Kumar & Party, 4.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18738.

Diagnosis. **Female (Plate 30, Figs. 9–14)**. Body size: 20−22 mm. Body black, following orange; G1 (with black stripe dorsally), basal third of G2 (entirely black in some specimens), femora (except dorso- basally), anterior and intermediate tibiae, and petiole (with black stripe dorsally); frons with appressed silvery white pubescence and punctures (Plate 30, Fig. 10); apex of mandibles ferruginous; clypeus vertex, pronotal collar, mesoscutum, scutellum, and metanotum with scatterd punctures; apical margin of clypeus nearly flat; propodeal enclosure coarsely reticulate medially and covered with appressed erect silvery white setae, laterally obliquely striate without setae (Plate 30, Fig. 12); mesopleuron and sides of propodeum strongly punctate; patch of dense silvery white pubesence on pronotal lobe, postero-lateral propodeum, along mesopleural and metapleural sulcus (Plate 30, Fig. 13); tegula dark brown, orange posteriorly; T5 and T6 with dense fine setae (Plate 30, Fig. 14); fore wing with three SMC, subhyaline with brownish tinge (Plate 30, Fig. 11).

Male (Figs. 15–16). Body size: 19−20 mm. Resembles female in most aspects except clypeus elongate (Plate 30, Fig. 16).

Note. Colour of legs vary among specimens (more or less orange).

Distribution. India: Arunachal Pradesh, Bihar, Gujarat, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh,West Bengal. *Elsewhere*: China; Laos; Madagascar; Nepal; Sri Lanka; Thailand; Vietnam (Anagha & Girish Kumar, 2020b; Pulawski, 2023).

2.2.2. Subfamily CHLORIONTINAE Fernald, 1905

I. Genus *Chlorion* Latrielle, 1802

Chlorion Latreille, 1802: 333. Type species: *Sphex lobatus* Fabricius, 1775, by monotypy.
Chlorium Billberg, 1820: 105. Emendation of *Chlorion* Latreille, 1802.
Chlorium Schulz, 1906: 193. Emendation of *Chlorion* Latreille, 1802.

Diagnosis. SMC2 and SMC3 receives RV1 and RV2 respectively, SMC2 longer than broad, length of anterior veinlet shorter than basal veinlet (Plate 31, Fig. 19; Plate 32, Fig. 30); claw tooth generally medial; male flagellomeres with placoid like areas; S4 and S5 of male utmost sparsely setose; propodeal dorsal enclosure U shaped, generally with fine to coarse striations (Plate 31, Fig. 22; Plate 32, Fig. 27); propodeal side with complete spiracular groove (Plate 31, Fig. 21; Plate 32, Fig. 28); females with fore tarsal rake consisting of long spines (Fig. 20); female clypeus short, broader than long with five teeth (Plate 31, Fig. 18; Plate 32, Fig. 26) (rarely with two or four teeth) on apical margin; male clypeus 2 × as wide as long (Bohart & Menke, 1976).

Distribution. *Chlorion* species are found all over the world except Australia and Europe (Bohart & Menke, 1976; Girish Kumar *et al*., 2014).

Keys. World species. de Beaumont, 1962: 29 (key to *Chlorion* species from Palearctic region), Menke, 1961: 669 (key to *Chlorion* species from Neartic region); Menke & Willink, 1964: 549 (key to *Chlorion* species from Neotropical region); Kohl, 1890: 133 (key to Oriental and East Asian species) (Pulawski, 2023).

Note. Genus is represented by 20 species and three subspecies worldwide. So far, only three species and a subspecies is recorded from Oriental region and India (Pulawski, 2023).

Biology. Available data for only three species of *Chlorion*: *C. maxillosum* (Poiret), *C. lobatum* Fabricius and *C. aerarium* Patton, suggest that these wasps use Gryllidae to feed their larvae. After immobilising the prey with their sting, wasp lays an egg on host. The wasp larva grows by consuming the host, eventually kills it, pupates and finally adult emerges out. The species *C. maxillosum* digs down to its host's burrow and stings the cricket either in the latter's burrow or on the soil surface if the cricket attempts to flee. Until the stage of egg deposition, *C. lobatum* behaves similar to *C. maxillosum*. *C. aerarium* excavate nest prior to hunting of prey and the captured prey is flown or carried on the ground to nest (Bohart & Menke, 1976).

Key to Indian species of *Chlorion* Latreille

1. Body brilliant bluish green (metasoma sometimes purplish blue) (Plate 31, Figs. 17 & 24) ..... ***C. lobatum*** (Fabricius)
— Body differently coloured. ……... 2
2. Fore wing dark brown with violet reflections; propodeum blackish brown with violet reflection …..…….....…..……... ***C. regale*** Smith
— Fore wing subhyaline with yellowish tinge (Plate 32, Fig. 30); propodeum rufous (Plate 32, Fig. 27). ……..……..… ***C. splendidum*** Fabricius

Species from southern Western Ghats and its adjacent areas

i. *Chlorion lobatum* (Fabricius, 1775)

(Plate 31, Figs. 17−25)

Sphex lobatus Fabricius, 1775: 348. (NHM) Lectotype: ♀, Africa, actually India or China (no specific locality) (designated by van der Vecht, 1961: 37).

Sphex semiauratus viridis Barbut, 1781: 255. (destroyed?) Holotype or syntypes: unknown origin, not British (synonymized tentatively with *Sphex lobatus* by Kohl, 1890: 177).

Sphex chrysis Christ, 1791: 308. (lost) Holotype or syntypes: West Indies (no specific locality).

Sphex chrysis nitidus Christ, 1791: 310. Holotype or syntypes: origin unknown.

Chlorion azureum Lepeletier & Audinet-Serville, 1828: 451. (Spinola collection, Torino) Lectotype: ♂, unknown origin (designated by Menke in Bohart & Menke, 1976: 90) (synonymized with *Sphex lobatus* by Kohl, 1890: 177).

Chlorion lobatum; Fabricius, 1804: 217.

Material examined. Kerala: 1 ♀, Idukki district, Chinnar, Churulipatti, Coll. K. Rajmohana & Party, 4.iv.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10196; 1 ♀, Wayanad district, Meppadi, Coll. K.N. Nair & Party, 18.iv.1984, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10197; 1 ♀, Palakkad district, Malampuzha, Coll. P.M. Sureshan & Party, 17.viii.1999, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10198; 4 ♀ & 1 ♂, Kozhikode district, Madappally, Coll. S. Anagha, 17.viii.2019, 12.iii.2020 & 11.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 13252, 18314–18315 & 18316–18317; 1 ♂, Kannur district, Thekkumbad dweep, Coll. C. Charesh, 18.v.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13254; 2 ♀, Kozhikode district, Kottakkal, Coll. Unknown, 16.iv.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18314–18315; 1 ♀, Kozhikode district, Purameri, Coll. K.P. Hanima Raveendran, 21.iii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18321; 1 ♀, Kozhikode district, Elathur, Coll.C. Binoy, 5.vi.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18322. Tamil Nadu: 1 ♀, Dindugal district, Pannaikadu Shola forest, Coll. R. Aengels & Party, 25.vii.2013, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13253.

Diagnosis. **Female (Plate 31, Figs. 17−23)**. Body size: 33−35mm. Frons and vertex with fine shallow punctures (Plate 31, Fig. 18); antenna and mandible black; clypeus transverse, broader than high, convex in the middle, apical margin wavy and emarginate with five teeth (Plate 31, Fig. 18); pronotal collar, mesoscutum, scutellum, metanotum, and mesopleuron with sparse fine punctures; propodeal dorsal enclosure with fine transverse striations, posteriorly not much slopped (Plate 31, Fig. 22); side of propodeum with distinct striations (Plate 31, Fig. 21); metasoma smooth and shining with fine punctures (Plate 31, Fig. 23); tibia and tarsi black; fore wing yellowish hyaline, apex fuscous (Plate 31, Fig. 19).

Male (Figs. 24−25). Body size: 28−30 mm. Resembles female in most aspects except: smaller and slender compared to female; clypeus not transverse, apicomedially shallowly emarginate with triangular like apical lobes (Plate 31, Fig. 25).

Distribution. India: Arunachal Pradesh, Assam, Chhattisgarh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Odisha, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal. *Elsewhere*: Bangladesh; China; Indonesia; Laos; Madagascar; Malaysia; Myanmar; Nepal; Philippines; Singapore; Sri Lanka; Thailand; Turkmenistan; Vietnam; West Indies (Girish Kumar *et al*., 2014; Anagha & Girish Kumar, 2020b; Pulawski, 2023).

ii. *Chlorion splendidum* Fabricius, 1804

(Plate 32, Figs. 26–31)

Chlorion splendidum Fabricius, 1804: 218. (ZMUC) Holotype: ♂, India (no specific locality) (synonymized with *Sphex splendidus* by Smith, 1851: 32).

Pronoeus campbelli Saunders, 1841: 58. (depository not known) Holotype: ♀, India (no specific locality) (synonymized with *Sphex splendidus* by Smith, 1851: 32).

Sphex pulcher Lepeletier, 1845: 335. (Spinola collection, Torino) Holotype: ♂, unknown origin (synonymized with *Sphex splendidus* by Smith, 1856: 238).

Chlorion melanosoma Smith, 1856: 238. (NHM) Holotype or syntypes: ♀, India, Pondicherry (synonymized with *Sphex splendidus* by Kohl, 1890: 18).

Chlorion forficula de Saussure, 1891: 259. (MHNG) Holotype or syntypes: ♀, Madagascar (no specific locality) (synonymized with *Sphex splendidus* by Kohl, 1895: 45).

Sphex forficula de Saussure, 1892: 259. Objective synonym of *Sphex forficula* de Saussure, 1891.

Material examined. Tamil Nadu: 1 ♀, Tirunelveli district, Gadanam dam site, Coll. P. Girish Kumar & Party, 30.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13255; 1 ♀, Tirunelveli district, Ramanadi dam site, Coll. P. Girish Kumar & Party, 2.x.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13256.

Diagnosis. **Female (Figs. 26–31).** Body size: 32–34 mm. Head, mesosoma, petiole, and legs rufous; gaster puplish blue; frons and vertex with shallow punctures, separated by more than a puncture diameter (Plate 32, Fig. 27); antenna and mandibles rufous, apex of mandibles black; clypeus transverse, broader than high, convex in the middle, its anterior margin with five teeth (Plate 32, Fig. 27); pronotal collar, mesoscutum, scutellum, metanotum, and mesopleuron with scattered fine punctures; pronotal collar deeply notched in the middle; propodeal dorsal enclosure with wavy striations above, becoming transverse posteriorly (Plate 32, Fig. 28); side of propodeum with distinct striations (Plate 32, Fig. 29); metasoma with fine punctures (Plate 32, Fig. 31); fore wing yellowish hyaline, apex fuscous (Plate 32, Fig. 30).

Male. Resembles female in most aspects except: small and slender; clypeus triangular with three strong teeth at apex (Girish Kumar *et al*., 2014).

Distribution. India: Chhattisgarh, Karnataka, Maharashtra, Pondicherry, Tamil Nadu (new state record). *Elsewhere*: Egypt; Eritrea or Ethiopia; Hungary; Iran; Madagascar; Myanmar;

Philippines; Saudi Arabia; Somalia; Sudan; Turkmenistan (Girish Kumar *et al*., 2014; Anagha & Girish Kumar, 2020b; Pulawski, 2023).

2.2.3. Subfamily SCELIPHRINAE Ashmead, 1899

A. Tribe: Sceliphrini Ashmead, 1899

I. Genus *Chalybion* Dahlbom, 1843

Chalybion Dahlbom, 1843: 21. Type species: *Chalybion caeruleum* (Linnaeus, 1763) (= *Pelopeus californicus* de Saussure, 1867) (designated by Patton, 1880: 378).
Chalybium Agassiz, 1846: 77. Emendation of *Chalybion* Dahlbom, 1843.
Chalybium Schulz, 1906: 192. Emendation of *Chalybion* Dahlbom, 1843.
Hemichalybion Kohl, 1918: 79. Type species: *Pelopoeus eckloni* Dahlbom, 1845.

Diagnosis. SMC2 receives both RV1 and RV2, length of anterior veinlet of SMC2 shorter than basal veinlet (Plate 33, Fig. 34 ; Plate 34, Fig. 41); episternal sulcus ending to antero-ventral margin of mesopleuron; male flagellomeres mostly with irregular or poorly defined placoids; propodeum without dorsal enclosure; apical margin of female clypeus generally with three (Plate 34, Fig. 40) or five teeth or lobes (Plate 33, Fig. 33) and male with three teeth or lobes (Plate 33, Fig. 38); tarsi mostly without plantulae (Bohart & Menke, 1976).

Distribution. They are cosmopolitan genus distributed in Australasian, Afrotropical, Nearctic, Neotropical, Oriental and Palearctic Regions (Pham, 2019; Fateryga *et al*., 2020).

Keys: World species. Ohl & Höhn, 2011: 341 (key to females of *Chalybion* fabricator groups from Sulawesi); Mei *et al*., 2012: 39 (key to *Chalybion* species from Europe); Danilov, 2014: 512 (key to *Chalybion* species from Siberia); Pham *et al*., 2019: 203 (key to *Chalybion* species from North Western Vietnam); Abenis & Lit, 2020: 98 (key to *Chalybion* species from Philippines) (Pulawski, 2023).
Indian species. Anagha *et al*., 2023b (key to *Chalybion* species from India).

Note. Genus is represented by 51 species and seven subspecies worldwide. So far, 17 species are recorded from Oriental region, of which three species are known to occur in India (Pulawski, 2023).

Biology. The species of this genus are known to nests in pre-existing cavities, very often vacated nests of other mud-dauber wasps and bees, and hunts spiders with the preference to the families Araneidae, Tetragnathidae, and Theridiidae to feed their larvae (Barthélémy,

2011; Mei *et al*., 2012; Fateryga *et al*., 2020). *Chalybion* species use mud to daub their nest, however instead of collecting mud from wet areas they bring water to a source of dry clay soil near their nests and use it to wet and plaster the soil (Bohart & Menke, 1976). Nests are multicellular, tubule shaped, and the wasp puts up to 10 spiders in each cell, to one of which an egg is attached on abdomen, after which the wasp seal off the nest. Some species, inaddition to mud employ a white substance composed of either lime from whitewashed walls or uric acid from bird or reptile droppings to seal their nest (Jayakar & Spurway, 1963; Barthélémy, 2011; Pham, 2019; Fateryga *et al*., 2020).

Remarks. Though genus *Chalybion* was divided into two subgenera – *Chalybion* Dahlbom, 1843 and *Hemichalybion* Kohl, 1918 by Bohart & Menke (1976), the present study does not recognise sub-generic status.

Key to Indian species of genus *Chalybion* Dahlbom (adopted from Anagha *et al*., 2023b)

1. Apical margin of clypeus with widely projecting median lobe (feebly emarginate medially in female or bi or trilobate in male); legs and petiole partly with yellow markings (colour pattern resembles to most *Sceliphron*); tarsi without plantulae. …….. ***C. spinolae*** (Lepeletier)

— Apical margin of clypeus with three or five teeth or lobes; legs and petiole without yellow markings; tarsi with or without pantulae. ……..…….. 2

2. Tarsi with plantulae; metapleuron with carina running along outerside of mid coxa. . ……. ***C. gracile*** Hensen

— Tarsi without plantulae; metapleuron without any such carina. ……..… 3

3. Clypeus with five teeth, median three closely held, lateral teeth sharp; S6 of female wide and flat, truncate apically……..…… ***C. malignum*** (Kohl)

— Clypeus with three or five teeth, lateral teeth nearly blunt in latter (Plate 33, Fig. 33); S6 of female not strikingly wide, rounded apically. ..…..… ***C. bengalense*** (Dahlbom)

i. *Chalybion bengalense* (Dahlbom, 1845)

(Plate 33, Figs. 32−38)

Sphex violaceus Fabricius, 1775: 346. (ZMUC) Lectotype: ♀, South Africa, Cape of Good Hope (designated by van der Vecht, 1961: 4).

Pelopoeus bengalensis Dahlbom, 1845: 433. Holotype or Syntypes: India, Bengal (no specific locality (Lund)) (synonymized with *Pelopaeus violaceus* by Bingham, 1896: 438).

Pelopoeus convexus Smith, 1876: 449. (NHM) Syntypes: ♂, Mascarenes, Island of Rodriguez (NHM) (synonymized with *Chalybion bengalense* by Hensen, 1988: 51).

Chalybion bengalense; Smith, 1871: 360.

Material examined. Karnataka: 1 ♀ & 3 ♂, Kodagu district, Bettathur near Madikeri, Coll. P. Girish Kumar & Party, 24.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18050–18053; 1 ♀ & 1 ♂, Udupi district, Mookambika Wildlife Sanctuary, Heddarimane, Halkal junction, Coll. V.D. Hegde & Party, 2.ix.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18775–18776; 1 ♀ & 6 ♂, Udupi district, Mookambika Wildlife Sanctuary, Areshiroor, Coll. V.D. Hegde & Party, 31.viii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18777–18783; 2 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Hulikal Guest House, Coll. V.D. Hegde & Party, 7.ix.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18784–18785; 1 ♀, Shimoga district, Mookambika Wildlife Sanctuary, Agumbe, Coll. V.D. Hegde & Party, 27.xii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18890; 1 ♀ & 1 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Balamane, Coll. V.D. Hegde & Party, 18.xii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 20674. Kerala: 2 ♀, Kozhikode district, Kottooli wetland, Coll. P. Girish Kumar, 20.vi.2017, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 10004–10005; 1 ♀, Kannur district, Madayipara, Coll. Sandra, 2.xii.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12842; 5 ♀ & 4 ♂, Thiruvananthapuram district, Neyyar Wildlife Sanctuary, Coll. P. Girish Kumar & Party, 16.i.2019 & 17.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16881–16888 & 16897; 1 ♂, Idukki district, Chinnar, Koottaram, Coll. S. Anagha & Party, 28.xi.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17112; 1 ♀, Kozhikode district, Vilakottur, Coll. K. P. Hanima Raveendran, 12.x.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17257; 1 ♂, Kozhikode district, Madappally, Coll. K. Anju, 11.xi.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV.18063; 2 ♂, Malappuram district, Calicut University Campus, Coll. S. Anagha, 20.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18064 & 18545; 1 ♂, Kozhikode district, Pathirapatta, Coll. K. Anju, 20.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18062; 2 ♂, Kozhikode district, Purameri, Coll. K.P. Hanima Raveendran, 2.ii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17271–17272; 2 ♂, Kozhikode district, Ashokapuram, Coll. S. Anagha & K. P. Hanima Raveendran, 11.i.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17273–17274; 1 ♀ & 1 ♂, Kozhikode district,

Madappally, Coll. S. Anagha, 5.i.2019 & 15.i.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18521 & 18522; 1 ♀ & 3 ♂, Thiruvananthapuram district, Neyyar Wildlife Sanctuary, Kottur, Coll. Md. Jafer Palot & Party, 17.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18523–18526; 1 ♀, Kollam district, Shendurney Wildlife Sanctuary, Coll. P. Girish Kumar & Party, 22.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18527; 1 ♀ & 1 ♂, Thiruvananthapuram district, Kallar, Coll. Md. Jafer Palot & Party, 23.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18528–18529; 1 ♀ & 1 ♂, Wayanad district, Chandanathodu, Coll. K.A. Subramanian & Party, 14.ii.2021 & 15.ii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18356 & 18357; 1 ♀, Kozhikode district, Vallikattukavu, Coll. P. M. Sureshan & Party, 30.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18532; 1 ♀, Kannur district, Madayippara, Coll. C. Charesh, 6.iii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18533; 1 ♀, Palakkad district, Lakkidi, Ramakrishnappadi, Coll. K. S. Surya, 25.iv.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18538; 1 ♀, Idukki district, Kulamavu, Coll. Tessy Rajan, 26.xii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18546; 1 ♀ & 1 ♂, Wayanad district, Kalloor, Coll. Kuriakose, 10.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18551–18552; 1 ♀, Kannur district, Thekkumbad dweep, Coll. I.V. Ashiga, 30.v.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18559; 1 ♂, Palakkad district, Parambikulam Wildlife Sanctuary, Coll. P. Girish Kumar & Party, 27.xi.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18577; 2 ♀ & 3 ♂, Palakkad district, Silent Valley, Coll. S. Anagha & Party, 12.iii.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18592–18596; 1 ♀, Kannur district, Aralam Wildlife Sanctuary, Chavachi, Coll. K.A. Subramanian & Party, 24.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18597; 1 ♀, Thiruvananthapuram district, Peppara Wildlife Sanctuary, dam site, Coll. P. Girish Kumar & Party, 5.xii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19647; 1 ♂, Kozhikode district, Kottooli wetland, Coll.V.D Hegde & Party, 5.vii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18891. Tamil Nadu: 6 ♂, Tirunelveli district, Rosemiyapuram, Coll. P. Girish Kumar & Party, 25.ix.2018 & 27.ix.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16855–16857 & 16858–16860; 1 ♀ & 1 ♂, Tirunelveli district, Koonthankulam Bird Sanctuary, Coll. P. Girish Kumar & Party, 27.ix.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16861–16862; 2 ♂, Tirunelveli district, Gadana dam site, Coll. P. Girish Kumar & Party, 30.ix.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16863–16864; 4 ♀ & 6 ♂, Tirunelveli district, Manimuthar dam site, Coll. P. Girish Kumar & Party, 1.x.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16865–16874; 1 ♀ & 1 ♂, Tirunelveli district, Ramnadi dam site, Coll. P. Girish Kumar & Party, 2.x.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16875–16876; 4 ♂, Kanyakumari district,

Kanyakumari Wildlife Sanctuary, Alagiyapandipuram range, Kalikesham, Coll. Souvik Sen & party, 16.ii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16889–16892; 2 ♀, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Kulashekaram range, Coll. Souvik Sen & party, 19.ii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16893–16894; 1 ♂, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Peechipara dam site, Coll. Souvik Sen & party, 20.ii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16895; 1 ♂, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Vellimalayi range, Coll. Souvik Sen & party, 17.ii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16896; 1 ♀ & 7 ♂, Coimbatore district, Sethumadai, Coll. P. Girish Kumar & Party, 3.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17259–17266; 2 ♂, Coimbatore district, Anamalai Tiger Reserve, Kullanadimedu, Coll. P. Girish Kumar & Party, 2.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17267 & 18513; 2 ♀, Coimbatore district, Tholampalayam, Coll. P. Girish Kumar & Party, 4.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17268–17269; 1 ♀ & 4 ♂, Coimbatore district, Sadivayal, Siruvani, Coll. P. Girish Kumar & Party, 5.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17270 & 18514–18517; 1 ♀ & 3 ♂, Coimbatore district, Govanur, Coll. P. Girish Kumar & Party, 6.i.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17270 & 18518–18520; 1 ♀, Tirunelveli district, Stephan Junction, on the way to Manchola, Ambasamudram, Kalakkad Mundanthurai Tiger Reserve (KMTR), Coll. B.H.C.K Murthy & Party, 25.viii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18887; 1 ♀ & 1 ♂, Theni district, Vannathiparai, Madathupuliyamaram, Coll. R. Babu & Party, 1.iii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 20675-20676; 1 ♀, Theni district, Bublimash Stream, Amaravathi beat, Gudalur range, Coll. R. Babu & Party, 1.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 20677; 1 ♀, Tirunelveli district, Bublimash Stream, Nathal odai, Coll. R. Babu & Party, 1.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 20678.

Diagnosis. **Female (Plate 33; Figs. 32−36)**. Body size: 13−30 mm. Body blue to greenish blue; frons densely coarsely punctate to rugose punctate; frontal platform absent; antenna and mandibles black; clypeus broadly projecting medially, apical margin with five teeth (Plate 33, Fig. 33); vertex, pronotal collar, mesoscutum, scutellum, and metanotum finely to coarsely punctate; propodeal enclosure absent, propodeal dorsum transversely striate with shallow punctures (see Fig. 13 of Anagha *et al*. (2023b: 63)); mesopleuron and sides of propodeum coarsely punctate to rugose-punctate; side of propodeum with smooth interspace medio-ventrally; metapleuron without carina (Plate 33, Fig. 35); metasomal terga with silvery white

pubescence; T1 slender; legs blue, tarsi without plantulae; fore wing subhyaline with brownish tinge, apica margin infuscated (Plate 33, Fig. 34).

Male (Plate 33, Figs. 37−38). Body size: 12−26 mm. Resemble female in most aspects except: smaller in size (generally) compared to female; clypeus with three teeth (Plate 33, Fig. 38).

Distribution. India: Andaman and Nicobar Island, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal. *Elsewhere*: Algeria; Australia; Bangladesh; Chagos Archipelago; China; Egypt; Eritrea; Ethiopia; France; French Polynesia; Gilbert Island; Greece; Guam Island; Hawaiian island; Indonesia; Iraq; Italy; Japan; Kenya; Laos; Madagascar; Malaysia; Maldives; Mascarenes; Mauritius; Micronesia; Mozambique; Myanmar; Nepal; New Caledonia; Philippines; Phoenix island; Seychelles islands; Singapore; South Africa; Sri Lanka; Taiwan; Tanzania; Thailand; Vietnam; Yemen (Anagha & Girish Kumar, 2020b; Pulawski, 2023).

ii. *Chalybion gracile* Hensen, 1988

(Plate 34, Figs. 39−43)

Chalybion gracile Hensen, 1988: 28. (USNM) Holotype: ♀, Sri Lanka, Ratnapura District, Sinharaja Forest.

Material examined. Material examined: Karnataka, 1 ♀, Udupi district, Mookambika Wildlife Sanctuary, Valur, Coll. V.D. Hegde & Party, 19.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21313. Kerala, 1 ♀, Idukki district, Kulamavu, Coll. Tessy Rajan, November 2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18066; 1 ♀, Wayanad district, Ponkuzhi, Coll. K. A. Subramanian & party, 7.ii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18067; 1 ♀, Palakkad district, Silent Valley, Coll. S. Anagha, 12.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18175.

Diagnosis. **Female (Plate 34, Figs. 39−43)**. Body size: 11−13.5 mm. Body metallic blue; frons areolate-rugulose; frontal platform present; antenna and mandible black; clypeus with three teeth (Plate 34, Fig. 40); vertex, pronotal collar, scutellum, and metanotum distinctly punctate; mesoscutum and propodeal dorsum transversely striate with shallow punctures between striae (see Fig. 4 of Anagha *et al*. (2023b: 61)); mesopleuron coarsely punctate; sides of propodeum with irregular incomplete striae and punctures, medio-ventrally with smooth

interspace (see Fig. 5 of Anagha *et al*. (2023b: 61); metapleuron with carina, passing along outer side of midcoxa and posteriorly bending outwards, that end above base of hind coxa (Plate 34, Fig. 42); metasomal terga with silvery white pubescence, T1 slender; legs blue, tarsi without plantulae; fore wing clearly hyaline (Plate 34, Fig. 41).

Male. Unknown.

Distribution. India. Kerala Karnataka. ***Elsewhere***. Sri Lanka; Vietnam (Anagha & Girish Kumar, 2020b; Anagha *et al*., 2023b; Pulawski, 2023).

Remarks. Anagha *et al*. (2023b) reported this species for the first time from India.

II. Genus *Sceliphron* Klug, 1801

Sceliphron Klug, 1801: 561. Type species: *Sphex spirifex* Linnaeus, 1758 (designated by Bingham, 1897: 235).

Pelopoeus Latreille, 1802: 334. Type species: *Pelopoeus spirifex* Fabricius (1804) (= *Sphex spirifex* Linnaeus, 1758) (designated by Latreille, 1810: 438).

Pelopaeus Latreille, 1804: 180. Lapsus or emendation of *Pelopoeus*.

Sceliphrum Schulz, 1906: 192. Emendation of *Sceliphron* Klug, 1801.

Prosceliphron van der Vecht in van der Vecht & van Breugel, 1968: 192. Type species: *Sceliphron coromandelicum* (Lepeletier, 1845) (= *Pelopoeus coromandelicus* Lepeletier, 1845].

Hensenia Pagliano & Scaramozzino, 1990: 5. Substitute name for *Prosceliphron* van der Vecht, 1968.

Diagnosis. SMC2 receives both RV (Plate 35, Fig. 46; Plate 37, Fig. 62); male flagellomeres without placoids; tarsi with plantulae; propodeum with U shaped dorsal enclosure (Plate 35−37, Figs. 45, 53, 56, & 60); apical margin of female clypeus incised medially, with or without lateral incisions (deep or shallow), followed by sublateral lobes (Plate 35, Fig. 47; Plate 37, Fig. 59); apical margin of male clypeus emarginate (Plate 35, Fig. 49), with or without blunt lobes laterally; antennal sockets separated from fronto-clypeal suture by atleast 0.5 diameter of a socket (Bohart & Menke, 1976; Anagha *et al*., 2021a).

Distribution. They are cosmopolitan genus distributed in Australasian, Afrotropic, Nearctic, Neotropical, Oriental and Palearctic Regions (Pulawski, 2023).

Keys: World species. Leclercq & Claparède, 1978: 251 (key to *Sceliphron* from South Western Europe); Hensen, 1987: 222–224 (key to species of subgenus *Prosceliphron*); Schmid-Egger, 2005: 9–11 (key to *Sceliphron* from European & Mediterranean region); Bitsch & Barbier, 2006: 234–235 (key to French Sceliphrini); Augul *et al*., 2014: 665 (key to *Sceliphron* from Iraq); Fernández & Castro-Huertas, 2014: 383–385 (key to *Sceliphron* from Neotropical region); Danilov, 2014: 519 (key to *Sceliphron* species from Siberia) (Pulawski, 2023).

Indian species. Anagha *et al*., 2021a: 62 & 63 (key to *Sceliphron* from India) (Pulawski, 2023).

Note. Genus is represented by 35 species and 30 subspecies around the world. 18 species and 20 subspecies are recorded from Oriental region, of which 12 species and seven subspecies are known to occur in India (Anagha *et al*., 2021a; Pulawski, 2023).

Biology. *Sceliphron* species are known to attack spiders belonging to the families Anyphaenidae, Araneidae, Argiopidae, Clubionidae, Heteropodidae, Loxoscelidae, Mimetidae, Miturgidae, Oxyopidae, Philodromidae, Pholcidae, Salticidae, Selenopidae, Scytodidae, Theridiidae and Thomisidae (Anagha *et al*., 2021a) for feeding their larvae. Female wasps actively search for prey, and upon finding, stings it causing paralysis. The wasp then carries the prey to nest made of mud. Nests are composed of several cells and each cell is tubule shaped, mostly build in and around human habitations attached to various surfaces. After the completion of first cell construction, wasp mass provision the nest with spiders, and well positioned egg is laid on the prey, after which nest cell is sealed off and another cell construction begins (Grandi, 1961; Mitchell & Hunt, 1985; Anagha *et al*., 2021a). Eventually, egg hatches out in to larva, grow by consuming the prey, pupates and at final stage adult emerge out.

Remarks. Though genus *Sceliphron* was divided into two subgenera – *Prosceliphron* (now *Hensenia*) and *Sceliphron* by van der Vecht & van Breugel (1968), the present study does not recognise subgeneric status and all species are place under single genus *Sceliphron*

Key to Indian species and subspecies of *Sceliphron* Klug (Indian species *S. neobilineatum* Jha & Farooqi, *S. paraintrudens* Jha & Farooqui, and *S. isaaci* Jha & Farooqi are excluded from key due to lack of details in the descriptions) (adopted from Anagha *et al*., 2021a)

1. S6 of female with longitudinal carina that measures about half length of former (Plate 35, Fig. 48); inner eye margin almost straight on lower half (see Fig. 2 of Anagha *et*

al. (2021a: 65)); T7 of male with pygostyle (see Fig. 9 of Anagha *et al*. (2021a: 65)); anterior veinlet of SMC2 greater than third (Fig. 46); mandibles without inner tooth. …….. 2

— S6 of female rarely with short longitudinal carina on apical third (Plate 37, Fig. 64); inner eye margin distinctly curving towards clypeus on lower half (Plate 37, Fig. 59); T7 of male without pygostyle (see Fig. 50 of Anagha *et al*. (2021a: 79)); anterior veinlet of SMC2 not greater than third, if greater, then female mandible with distinct inner tooth. ……..…... 8

2. Petiole almost straight in lateral view, generally longer than hind tibia. ……. ***S. rectum*** Kohl. ……. 3

— Petiole distinctly curved in lateral view, generally shorter than hind tibia. ……. 4

3. Metanotum with yellow streak or band; propodeal dorsum with extensive yellow markings; G1 generally with yellow band; hind tibia black. …….. ***S. rectum pulchellam*** Gussakovskij

— Metanotum, propodeum, and G1 black; hind tibia yellow on outer side. ……... ***S. rectum rectum*** Kohl

4. Mesoscutum rugulosostriate, dull. 5

— Mesoscutum striate regularly, relatively shiny. ……. 6

5. Length of F1 distinctly shorter than interocular distance at vertex. …… ***S. curvatum*** (Smith)

— Length of F1 longer than interocular distance at vertex. ……..... ***S. formosum formosum*** (Smith)

6. Gaster black, petiole yellow to yellowish brown (Plate 35, Fig. 44); mesosoma generally entirely black (except on prontal collar) (Plate 35, Fig. 45). ……... ***S. coromandelicum*** (Lepeletier)

— Gaster colour variable, petiole mostly or entirely black; mesosoma generally with large yellow areas. ……... ***S. deforme*** (Smith. …… 7

7. G1 and G2 with complete yellow bands; post antennal tubercle with yellow spot. ……..…….. ***S. deforme deforme*** (Smith)

— G1 and G2 mostly rufous to deep brown, paler on the posterior margin of remaining terga (see Fig. 19 of Anagha *et al*. (2021a: 68)); post antennal tubercle black. …….. ***S. deforme tibiale*** Cameron

8. Hind coxa rounded dorso-basally (Plate 37, Fig. 61); mandibles with more or less distinct inner tooth; sides of propodeum relatively less sharply and coarsely striate (Plate 36, Fig. 5; Plate 37, Fig. 63). ….. ***S. madraspatanum*** species group. ……..... 9

— Hind coxa angulate dorso-basally (Plate 36, Fig. 52); mandibles simple (except in *S. arabs*); sides of propodeum in most species more sharply and coarsely striate (Plate 36, Fig. 54). ...…….. ***S. spirifex*** species group. …….……..... 14

9. Mesopleuron distinctly rugose with punctures and yellow mark below tegulae, dull, less shining than sides of propodeum. …….. ***S. caementarium*** (Drury)

— Mesopleuron more or less coarsely punctate (some species with fine punctation in interspaces), shining, and generally more so than sides of propodeum. 10

10. Tegula black or brown. ……. ***S. intrudens*** (Smith)

— Tegula with yellow markings. ……..……..…….. 11

11. Scutellum and propodeal enclosure typically without yellow markings (Plate 37, Fig. 60); mesopleuron with or without yellow mark below tegulae, if present, more or less reduced (Plate 37, Fig. 63). …….……... 12

— Scutellum and propodeum with or without yellow markings (Plate 36, Fig. 56); mesopleuron with distinct yellow mark below tegulae (Plate 36, Fig. 57). . ...…….. 13

12. Pronotal collar and metanotum with yellow band, band narrowly interrupted on former and bit wide on latter (Plate 37, Fig. 60). ……..... ……..... ***S. madraspatanum madraspatanum*** (Fabricius)

— Pronotal collar and metanotum black without yellow band (see fig. 34 of Anagha *et al*. (2021a: 75)). ……..…..... ***S. madraspatanum andamanicum*** Kohl

13. Propodeal dorsum generally with yellow markings (see Fig. 53 of Anagha *et al*. (2021a: 80)). ……...……..... ***S. madraspatanum pictum*** (Smith)

— Propodeal dorsum entirely black (Plate 36, Fig. 56) . …… ***S. madraspatanum formosanum*** van der Vecht

14. Tegula and generally metanotum with yellow or yellowish brown markings (see Fig. 22 of Anagha *et al*. (2021a: 71)); petiole relatively short, about 0.8× length of hind tibia. …… ***S. destillatorium*** (Illiger)

— Tegula and metanotum entirely black (Plate 36, Fig. 53); petiole as long as hind tibia or little longer. …….. ***S. javanum*** (Lepeletier). 15

15. Hind tibia yellow (Plate 36, Fig. 51). ..... ***S. javanum nalandicum*** Strand

— Hind tibia black. 16

16. Hind femur yellow generally with indistinct dark mark dorso-apically; if dark mark present all around, then dark part converges angularly on inner side of femur, and hardly extend more than apical third on outer side. ……..…..... ***S. javanum javanum*** (Lepeletier)

— Hind femur yellow with at least apical third black, dark part clearly separated from basal yellow part. ……... ***S. javanum petiolare*** Kohl

Species from southern Western Ghats and its adjacent areas

i. *Sceliphron coromandelicum* (Lepeletier, 1845)

(Plate 35, Figs. 44−50)

Pelopaeus coromandelicus Lepeletier, 1845: 306, ♀. (M. Spinola collection, Torino) Holotype or syntypes: ♀, India, Coromandel Coast (no specific locality).

Sceliphron coromandelicum; Bingham, 1897: 238.

Material examined. Karnataka: 1♂, Shimoga district, Mookambika Wildlife Sanctuary, Agumbe, Coll. P. Girish Kumar, 27.xii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14047. Kerala: 2 ♀, Kozhikode district, Kizhakkoth Valiyaparamba, Coll. T.P. Dijila, 6.iii.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 7223 & 7224; 2 ♀, Thrissur district, Kattoor, Coll. Graie Maria, 18–29.xii.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 8496 & 8497; 1 ♀, Ernakulam district, Thattekad Bird Sanctuary, Kolumba, Coll. P. Girish Kumar, 5.ii.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8693; 2 ♀, Kozhikode district, Nambikulam, Coll. Sandra, Aug. 2018–May 2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12454 & 12456; 1 ♀, Kozhikode district, Vilakottur, Coll. K.P. Hanima Raveendran, 12.v.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14033; 1 ♀, Thiruvananthapuram district, Paruthippara, Coll. N.V. Ayisha Mawadda, 18.xi.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14034; 1 ♂, Kannur district, Aralam Wildlife Sanctuary, Coll. P. Girish Kumar, 16.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14035; 1 ♀ & 2 ♂, Thiruvananthapuram district, Kerala University Campus, Coll. S. Anagha, 27.ix.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 14036-14038; 1 ♀, Malappuram district, Calicut University Botanical garden, Coll. S. Anagha, 20.xii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14044; 1 ♀, Kozhikode district, ZSI Campus, Coll. P. Girish Kumar, 28.viii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14045; 1 ♀, Kozhikode district, Purameri, Coll. K.P. Hanima Raveendran, 21.iii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14889; 1 ♀, Kozhikode district, Elathur, Coll. C. Binoy, 5.vi.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14890; 1 ♀, Thrissur district, Thumboor

sacred groove, Coll. K.R. Renanath, 10.i.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14891; 2 ♀, Kozhikode district, ZSI Campus, Coll. P. Girish Kumar, 7.viii.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18770–18771; 1 ♀, Kozhikode district, Kattangal, Coll. Unknown, 18–19.iii.2014, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18773; 1 ♀, Kozhikode district, Madappally, Coll. S. Anagha, 28.xi.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18774; 1 ♀, Kozhikode district, Moorad, Coll. S. Anagha, 2.iii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19321; 1 ♂, Kozhikode district, Pilassery, Coll. Abitha, 24.vi.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19322.

Diagnosis. **Female (Plate 35, Figs. 44−48)**. Body size: 18–21 mm. Frons and clypeus with appressed silvery white pubescence and long erect brown setae, pubescence completely concealing the sculpture; scape and basal joints of F1−F4 yellowish brown, rest of antenna black; mandible black, apex dark ferruginous; clypeus apico-medially incised forming two lobes; upper clypeal margin with yellowish brown macula (Plate 35, Fig. 47); vertex punctate with upright dark brown setae; mesosoma black with apressed silvery white pubescence and erect dark brown setae; dorsal pronotal collar weakly punctate with yellowish brown band and mesal notch; mesoscutum and scutellum with distinct striations, striae strong and transverse on former and longitudinally oblong on latter, metanotum with weak transverse striations (Plate 35, Fig. 45); propodeum distinctly stiate, striae running transversely across dorsal surface and obliquely along sides, yellowish brown spot may be seen sometimes on posterior side of propodeum (Plate 35, Fig. 45); mespisternum with fine striations as in sides of propodeum; upper region of mesopleuron below tegula often with yellowish brown spot (see Fig. 5 of Anagha *et al*. (2021a: 65)); tegula yellowish brown; gaster black with fine setae; petiole yellow or yellowish brown; apex of femora, tibiae and tarsi of four anterior legs, and whole of the femora, tibia and tarsi of posterior pair, yellowish brown; fore wing subhyaline with yellowish brown tinge (Plate 35, Fig. 46).

Male (Figs. 49−50). Body size: 16–20 mm. Resembles female in most aspects except: petiole little longer; clypeus medially shallowly emarginate (Plate 35, Fig. 49).

Distribution. India: Andaman Islands, Assam, Bihar, Delhi, Goa, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Meghalaya, Odisha, Pondicherry, Punjab, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. *Elsewhere*: Bangladesh; Cambodia; Laos; Malaysia; Myanmar; Sri Lanka; Thailand (Anagha *et al*., 2021a; Pulawski, 2023).

ii. *Sceliphron javanum nalandicum* (Strand, 1915)

(Plate 36, Figs. 51–54)

Pelopoeus spinolae; Smith, 1856: 231 (Bombay, Sri Lanka).

Sceliphron javanum var. *nalandicum* Strand, 1915: 93. (DEI) Syntypes: ♀, Sri Lanka, Nalanda & Kandy.

Sceliphron javanum nalandicum; van der Vecht & van Breugel, 1968: 244.

Material examined. Kerala: 1 ♀, Thrissur district, Porathissery, Coll. V. Mable, 28.xii.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8495; 1 ♀, Kannur district, Kannapuram, Coll. C. Charesh, 3.ix.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 9921; 1 ♀, Kozhikode district, Kottooli wetland, Coll. Anisha and Party, 8.v–20.vi.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10006; 2 ♀, Idukki district, Chinnar, Coll. K. Rajmohana, 4.iv.2016, Regd. Nos. ZSI/WGRC/I.R.–INV. 10199 & 14956; 1 ♂, Kannur district, Kannapuram mangrooves, Coll. C. Charesh, 13-14.v.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 11436; 1 ♀, Kozhikode district, Quilandy, Coll. C. Charesh, 3.ix.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19323.

Diagnosis. **Female**. Body size: 28–30 mm. Frons and clypeus with appressed silvery white pubescence and long erect black setae, pubescence completely concealing the sculpture (see Fig. 26 of Anagha *et al*. (2021a: 73)); antenna black, ventral side of scape yellowish brown; mandible dark ferruginous; clypeus apico-medially incised, with lateral incisions, followed by sublateral lobes (see Fig. 26 of Anagha *et al*. (2021a: 73)); vertex punctate with upright black setae; mesosoma black with erect black setae; dorsal pronotal collar black with fine punctations and medial notch; mesoscutum finely striate, striae almost transverse anteriorly and becoming oblique posteriorly; scutellum and metanotum longitudinally striate; propodeal enclosure medially depressed with wavy striation (Plate 36, Fig. 53); mesopleuron smooth and shiny with fine punctation; sides of propodeum with oblique striations and punctures in interstices (Plate 36, Fig. 54); tegula black; gaster black with fine setae, petiole yellow; apex of femora, tibiae, and basal two or three joints of tarsi of anterior and intermediate legs reddish yellow; the trochanters, femur, tibia, basal two or three joints of tarsi of posterior legs, yellow; fore wing subhyaline with yellowish brown tinge.

Male. Body size: 27 mm. Resembles female im most aspects except: clypeus medially emarginate with small triangular apical lobes (Anagha *et al*., 2021a).

Distribution. India: Kerala, Maharashtra, Meghalaya, Odisha, Pondicherry, Sikkim, Tamil Nadu, West Bengal. *Elsewhere*: Bangladesh; Indonesia; Sri Lanka (Anagha *et al*., 2021a; Pulawski, 2023).

iiia. *Sceliphron madraspatanum formosanum* van der Vecht, 1968
(Plate 36, Figs 55–57)

Sceliphron madraspatanum; Rohwer, 1911: 482 (Taiwan).

Sceliphron madraspatanum formosanum van der Vecht 1968 *in* van der Vecht & van Breugel, 204. (RMNH) Holotype: ♀, Taiwan, Chiai Prefecture, Kagi, now Chiayi.

Material examined. Kerala: 1 ♂, Kollam district, Sasthamkotta, Coll. P. Girish Kumar, 26.ix.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10147.

Diagnosis. **Female**. Body size: 20–22mm. Frons and clypeus with appressed silvery white pubescence and long erect yellow setae, pubescence completely concealing the sculpture antenna black, ventral side of scape yellow; mandibles black, apex dark ferruginous; clypeus apico-medially incised, with lateral incisions, followed by sublateral lobes; vertex punctate with upright yellow setae; mesosoma black with erect yellow setae, dorsal pronotal collar medially depressed with two yellow linear spots on each side of depression; mesoscutum strongly striate, striae almost transverse anteriorly and becoming oblique posteriorly; scutellum with longitudinally oblong striations and large yellow spots; metanotum with broad yellow band; propodeal enclosure medially depressed with wavy striation; mespisternum smooth and shiny with fine punctuations; sides of propodeum with oblique striations and punctures in interstices; yellow streak below the tegula on upper mesopleuron; tegula yellow; gaster black with fine setae, petiole yellow; tibiae and apical half of femora of anterior and intermediate legs, trochanters, base of femora and tibia, and basal joint of tarsi of posterior legs, yellow; fore wing subhyaline with yellowish tinge (Anagha *et al*., 2021a).

Male. Body size: 15 mm. Resembles female in most aspects except clypeus medially emarginate with small triangular apical lobes (see Fig. 38 of Anagha *et al*. (2021a: 76)).

Distribution. India: Bihar, Chhattisgarh, Jharkhand, Kerala, Maharashtra, Odisha, Uttar Pradesh. *Elsewhere*: China; Japan; Taiwan (Anagha *et al*., 2021a; Pulawski, 2023).

Remarks. Anagha *et al*. (2021a) reported this species for first time from India.

iiib. *Sceliphron madraspatanum madraspatanum* (Fabricius, 1781)

(Plate 37, Figs 58–65)

Sphex madraspatanus Fabricius, 1781: 445. (NHM) Lectotype: ♂, India, Kerala, former Malabar District (NHM) (designated by van der Vecht, 1961: 43).

Pelopoeus interruptus Palisot de Beauvois, 1806: 51. (destroyed?) Holotype or syntypes: origin unknown, probably Asia (synonymized with *Sceliphron madraspatanum* by Schulz, 1906: 192).

Pelopaeus bilineatus Smith, 1852: 47. (NHM) Holotype or syntypes: ♀, India: Maharashtra: Bombay, now Mumbai (synonymized with *Sceliphron madraspatanum* by Turner, 1917b: 176).

Pelopoeus separatus Smith, 1852: 47. (NHM) Holotype or syntypes: ♀, India, Maharashtra, Bombay, now Mumbay (synonymized with *Sceliphron madraspatanum* by Bingham, 1897: 237).

Sceliphron madraspatanum; Mocsáry, 1892: 127.

Material examined. Karnataka: 1 ♀ & 1 ♂, Kodagu district, Chiklihole dam site, Coll. P. Girish Kumar & Party, 22.xii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18878 & 18879; 1 ♀ & 2 ♂, Udupi district, Mookambika Wildlife Sanctuary, Heddarimane, Halkal Junction, Coll. V.D Hegde & Party, 31.viii.2021, ZSIK Regd. Nos. ZSI/WGRC/IR/INV/ 18811–18813; 1 ♀, Udupi district, Mookambika Wildlife Sanctuary, Beedikeri, Coll. V.D Hegde & Party, 2.ix.2021, ZSIK Regd. No. ZSI/WGRC/IR/INV/ 18815; 1 ♂, Shimoga district, Mookambika Wildlife Sanctuary, Kudajadri Hills, Coll. V.D Hegde & Party, 3.ix.2021, ZSIK Regd. No. ZSI/WGRC/IR/INV/ 18816; 1 ♂, Udupi district, Mookambika Wildlife Sanctuary, Kollur, Mookambika Check dam, Coll. V.D. Hegde & Party, 4.ix.2021, ZSIK Regd. No. ZSI/WGRC/IR/INV/ 18817; 1 ♀, Udupi district, Mookambika Wildlife Sanctuary, Gollihole, Coll. V.D. Hegde & Party, 17.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21316. Kerala: 2 ♂, Kannur district, Thalassery Mangrooves, Kuyyali, Coll. K. Sruthi, 11.vi.2016 & 15.viii.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 6976 & 7264; 1 ♀, Kozhikode district, Kizhakkoth Valiyaparamba, Coll. T.P. Dijila, 15.ii.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 7225; 1 ♀, Kollam district, Sasthamkotta lake environs, Punnakkad, Coll. P. Girish Kumar, 26.viii.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 7608; 2 ♀, Ernakulam district, Thattekkad Bird Sanctuary, Kolumba, Coll. P. Girish Kumar, 20.ix.2016 & 23.ix.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 7865 & 7866; 2 ♀ & 1 ♂, Kozhikode district, Mavvor paadam, Coll. P. Girish Kumar, 4.x.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 8066-

8068; 1 ♂, Kozhikode district, Malayamma, Coll. P. Girish Kumar, 4.x.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8069; 2 ♂, Kozhikode district, Vallikkattukavu, Coll. P. Girish Kumar, 5.x.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 8070 & 8074; 1 ♂, Malappuram district, Kadakkattupara, Coll. P. Girish Kumar, 20.x.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8075; 4 ♀ & 6 ♂, Kollam district, Sasthamkotta lake environs, Padinharekara & Muthupilakkad, Coll. Md. Jafer Palot and Party, 21.xii.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 8220–8229; 1 ♀, Thrissur distric, Puthenchira, Coll. V.M. Mariat, 17.xii.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8491; 1 ♀, Thrissur district, Pullur, Coll. Rosmi Reji, 24.i.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8494; 3 ♂ & 2 ♀, Kozhikode district, Kottooli wetland, Coll. P. Girish Kumar, 7.v.2016 & 20.vi.2017, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 8956–8958 & 10009–10010; 1 ♀, Kasaragod district, Nileswaram, Coll. Sangeetha Varma, 10.vii.2014, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 9336; 1 ♀, Kozhikode district, Payyoli, Kottakkal, Coll. K. Anurag, 4.iv.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 9817; 1 ♂, Kollam district, Sasthamkotta, Vettolikadavu, Coll. P. Girish Kumar, 26.ix.2017, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 10146; 1 ♂, Kollam district, Sasthamkotta, East side of D.B. College, Coll. P. Girish Kumar, 27.ix.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10148; 1 ♀, Kannur district, Ayyoth, Coll. C. Charesh, 26.x.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10429; 1 ♀, Kozhikode district, Nanminda, Coll. P. Girish Kumar, 3.xii.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10431; 1 ♂, Kannur district, Kannapuram paddy, Coll. C. Charesh, 9.xii.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10432; 1 ♀, Palakkad district, Nelliampathy, Ayyappanthitta, Coll. P. Girish Kumar, 28.ii.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10480; 3 ♀, Kannur district, Kannapuram Mangroves, Coll. C. Charesh, 29–30.iv.2018 & 13-14.v.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 11363–11364 & 11468; 1 ♀, Kannur district, Madayipara, Coll. C. Charesh, 1.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12843; 2 ♂, Kozhikode district, Vengeri, Coll. K.P. Hanima Raveendran, 20.ix.2018 & 27.x.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 14859 & 14860; 1 ♂, Kozhikode district, Purameri, Coll. K.P. Hanima Raveendran, 29.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14861; 1 ♀, Palakkad district, Paruthipra, Coll. N.V. Ayisha Mawadda, 18.xi.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14862; 1 ♂, Thrissur district, Killimangalam, Coll. N.V. Ayisha Mawadda, 20.xi.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14863; 1 ♂, Ernakulam district, Vyttila, Coll. S. Anagha, 16.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14865; 1 ♀, Kozhikode district, Jafer Khan Colony Road, Coll. K.P. Hanima Raveendran, 16.v.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14869; 2 ♀ & 1 ♂, Thiruvananthapuram district,

Karyavattom, Kerala University Campus, Coll. S. Anagha, 27.ix.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 14870–14872; 1 ♀ & 1 ♂, Kannur district, Aralam, Coll. C. Bijoy, 10.i.2013, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 14952–14953; 2 ♂, Malappuram district, Parappanangadi, Coll. P. Girish Kumar, 7.xii.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18323–18324; 2 ♀, Palakkad district, Malampuzha, Coll. P. Girish Kumar, 2.iii.2017, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18325–18326; 1 ♂, Thiruvananthapuram district, Peppara Wildlife Sanctuary, dam site, Coll. S. Anagha & Party, 28.ix.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18877. Tamil Nadu: 2 ♀, Tirunelveli district, Manimuthar dam site, Coll. P. Girish Kumar & Party, 1.x.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 14873–14874; 1 ♂, Tirunelveli district, Gundaru dam site, Coll. P. Girish Kumar, 3.x.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14875; 1 ♀, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Vellimalai range, Puravilai, Coll. Souvik Sen & Party, 17.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14888.

Diagnosis. **Female (Plate 37, Figs. 58−64)**. Body size: 18–23 mm. Frons and clypeus with appressed sivery white pubescence and long erect yellow setae, pubescence completely concealing the sculpture (Plate 37, Fig. 59); antenna black, ventral side of scape yellow; mandible dark ferruginous; clypeus apico-medially incised, with lateral incisions, followed by sublateral lobes (Plate 37, Fig. 59); vertex punctate with upright yellow setae; mesosoma black with erect yellow setae, dorsal pronotal collar medially depressed with two yellow linear spots on each side of depression; mesoscutum strongly striate, striae almost transverse anteriorly and becoming oblique posteriorly; scutellum with longitudinally oblong striations; metanotum with broad yellow band; propodeal enclosure medially depressed with wavy striation (Plate 37, Fig. 60); mespisternum smooth and shiny with fine punctuations; sides of propodeum with oblique striations and punctures in interstices (Plate 37, Fig. 63); tegula yellow; gaster black with fine setae, petiole yellow; tibiae and apical half of femora of anterior and intermediate legs, trochanters, base of femur and tibia, and basal joint of tarsi of posterior legs, yellow; fore wing subhyaline with yellowish tinge (Plate 37, Fig. 62).

Male (Fig. 65). Body size: 15–21 mm. Resemble female in most aspects except; petiole little longer; clypeus medially emarginate with small triangular apical lobes (see Fig. 49 of Anagha *et al*. (2021a: 79)).

Distribution. India: Andaman and Nicobar Islands, Assam, Andhra Pradesh, Arunachal Pradesh, Bihar, Chhattisgarh, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya

Pradesh, Maharastra, Manipur, Meghalaya, Odisha, Pondichery, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand, West Bengal. *Elsewhere:* Afghanistan; Arabia; Bangladesh; Bulgaria; Cambodia*;* China; Croatia; Democratic Republic of Congo; France; Greece; Indonesia; Iran; Iraq; Italy; Japan; Kazakhstan; Kyrgyzstan; Laos; Madagascar; Malaysia; Maldives; Montenegro*;* Myanmar; Nepal; Oman; Pakistan; Philippines; Russia; Spain; Sri Lanka; Syria; Taiwan; Tajikistan*;* Thiland; Turkey; Turkmenistan; United Arab Emirates; Ukraine; Uzbekistan; Vietnam (Anagha *et al*., 2021a; Pulawski 2023).

2.2.4. Subfamily SPHECINAE Latreille, 1802

A. Tribe Prionychini Bohart and Menke, 1963

I. Genus *Prionyx* Vander Linden, 1827

Prionyx Vander Linden, 1827: 362. Type species: *Ammophila kirbii* Vander Linden, 1827.

*Prionony*x Dahlbom, 1843: 28. Type species: *Pepsis thomae* (Fabricius, 1804) (= *Sphex thomae* Fabricius, 1775).

Enodia Dahlbom, 1843: 28. Type species: *Sphex albisectus* Lepeletier, 1828 (= *Ammophila kirbii* Vander Linden, 1827) (designated by Kohl, 1885a: 164) (synonymized with *Prionyx* Vander Linden by Pate, 1935: 250).

Harpactopus Smith, 1856: 264. Type species: *Harpactopus crudelis* F. Smith (designated by Patton, 1880: 384).

Parasphex Smith, 1856: 267. Type species: *Sphex albisectus* Lepeletier & Audinet-Serville, 1828 (= *Ammophila kirbii* Vander Linden, 1827) (designated by Kohl, 1885a: 164) (synonymized with *Prionyx* Vander Linden by Pate, 1935: 250).

Pseudosphex Taschenberg, 1869: 420. Type species: *Pseudosphex pumilio* Taschenberg, 1869.

Calosphex Kohl, 1890: 113. Type species: *Sphex niveatus* Dufour, 1853 (designated by Pate, 1937: 15).

Neosphex Reed, 1894: 627. Type species: *Neosphex albospiniferus* Reed, 1894 (= *Pseudosphex pumilio* Taschenberg, 1869).

Diagnosis. Length of anterior veinlet of SMC2 shorter than basal veinlet (Plate 38, Fig. 71); inner margin of hind tarsal claw generally with two teeth but up to five teeth in some species

(Plate 38, Fig. 69); inner eye margin bending away from ocelli above (Plate 38, Fig. 67); sides of propodeum without spiracular groove; legs with moderate to thick spines; female with fore tarsal rake consisting of long setae; apical margin of female clypeus entire or with a notch medially; male flagellomeres most often with flat placoids on F3−F5 or F6 (hardly on F2−F7 or F3−F4) but without placoids in some Old World species (Bohart & Menke, 1976).

Distribution. They are cosmopolitan genus distributed in Australasian, Afrotropical, Nearctic, Neotropical, Oriental and Palearctic Regions (Bohart & Menke, 1976).

Keys. World Species. Parker, 1960: 206 (key to *Prionyx* species from North America); Mingo & Gayubo, 1983: 152 (key to *Prionyx* species from Spain); Pagliano, 1984: 366 (key to *Prionyx* species from Italy); Guichard, 1988: 119 (key to *Prionyx* species from Arabian Peninsula); Danilov, 2012a: 162 (key to *Prionyx* species from Russia and adjacent countries); Danilov, 2012b: 61 (key to *Prionyx* species from Russia & Central Asia); Can & Gülmez, 2019: 348 (key to *Prionyx* species from Turkey); Danilov, 2014: 514 (key to *Prionyx* species from Siberia).

Note. Genus is represented by 57 species and 12 subspecies worldwide. So far, seven species and a subspecies is recorded from Oriental region, of which six species are known to occur in India (Pulawski 2023).

Biology. The species of this genus are known to attack grass hoppers of family Acrididae to feed their larvae. Female wasps actively search for prey and upon finding, stings it causing paralysis. Nests are dug before or after prey capture**.** *Prionyx* drag the prey over the ground by its antenna, place it in the nest with head turned bottom to cell and lay an egg with one end at base of hind coxa (Evans, 1958**).** Typically, the nest is short, single celled and provisioned with only one grasshopper (Bohart & Menke, 1976). Only one species *P. spinolae* is known to carry its prey in flight and to make a multicellular nest, each provisioned with 5–10 grasshoppers (Grissel, 1981).

Key to species of *Prionyx* Vander Linden from the India (except *P. indus* (Linnaeus) due to lack of details in descriptions)

1. Tarsal claws with two inner tooth near base. …….. 2
— Tarsal claws with three or four inner tooth near base (Plate 38, Fig. 69). ... ***P. viduatus*** (Christ)
2. Gaster partly red or testaceous……. 3

— Gaster black. ……..……4

3. Wings flavohyaline, infumate apically; nervures darker in colour ….....…. ***P. binghami*** Jha and Farooqi

— Wings hyaline, nervures testaceous. ……..… ***P. fragilis*** (Nurse)

4. Body size large (female: 23-35 mm; male: 17-24 mm); propodeal dorsum with almost decumbent long setae; metanotum with more or less pointed tubercle; F3-F5 of male with palcoids. ……...……... ***P. crudelis*** (Smith)

— Body size small (female: 13-22 mm; male: 10-18 mm); propodeal dorsum with erect pubescence; metanotum with short tubercle; F3-F6 of male with placoids. ……..…… ***P. subfuscatus*** (Dahlbom)

Species from southern Western Ghats and its adjacent areas

i. *Prionyx viduatus* (Christ, 1791)

(Plate 38, Figs. 66–74)

Sphex viduatus Christ, 1791: 305. Holotype or syntypes: France, Provence Region (no specific locality) (lost).

Sphex pubescens Fabricius, 1793: 205. (ZMUC) Lectotype: ♂, Guinea (no specific locality) (designated by van der Vecht, 1961: 33) (synonymized tentatively with *Prionyx viduatus* by Kohl, 1890: 332 and synonymy validated by van der Vecht, 1961: 33).

Enodia canescens Dahlbom, 1843: 28. Syntypes: Senegal & Guinea (no specific localities) (Lund) (synonymized with *Enodia fervens* by Dahlbom, 1845: 439).

Sphex micans Eversmann, 1849: 368. (ZIN) Syntypes: Russia, lower Volga area (synonymized with *Enodia lividocincta* by Radoszkowski, 1887: 91, tentatively with *Sphex lividocincta* by Kohl, 1885a: 190, 1889: 24, and with *Sphex viduatus* by Kohl, 1890: 332).

Sphex leuconotus Morawitz, 1890: 579. (ZIN) Lectotype: ♀, Turkmenistan, Ashkhabad (designated by Danilov, 2012b: 68) (synonymized with *Prionyx viduatus* by Danilov, 2012b: 68).

Sphex granti Kirby, 1900: 23. (NHM) Syntypes: Yemen, Abd-el-Kuri islands (no specific locality) (synonymized with *Sphex pollens* by Kohl, 1906: 198).

Sphex platynotus Matsumura, 1912: 177, 178. Holotype or syntypes: ♀, Japan, Okinawa (no specific locality) (depository?) (synonymized with *Sphex viduatus* by Yasumatsu, 1935: 36).

Sphex perezi Berland, 1926: 170. (MNHN) Lectotype: ♀, Senegal (no specific locality) (designated by Menke in Bohart & Menke, 1976: 134) (synonymized with *Prionyx viduatus* by Guichard, 1988: 121).

Prionyx viduatus; Iwata, 1964: 355.

Material examined. Tamil Nadu: 1 ♂, Tirunelveli district, Koonthankulam Bird Sanctuary, Coll. P. Girish Kumar & Party, 27.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18821.

Redescription. **Male**. Body size: 16.5 mm.

Colour. Black, gaster testaceous (Fig. 66), tegulae dark ferruginous; fore wing hyaline with brownish tinge.

Vestiture. Body with silvery white pubescence; dense and appressed on frons, erect on vertex and thorax with patch of pubescence on mesopleuron, propodeal side and posterior propodeum; decumbent and relatively dense on T1; moderately dense on posterior terga. T2 and T3 with trace of microscopic pubescence (Plate 38, Fig. 74).

Head. Head broader than long, frons and vertex punctate, pubescence on frons nearly concealing sculpture (Plate 38, Fig. 67); mandible with single subapical inner tooth; clypeus convex, apical margin emarginate medially (Plate 38, Fig. 68); head 2.69× as wide as IOD at anterior ocellus; POL 2.3× LOL and 1.01× OOL; F1 0.65× combined length of F2 and F3.

Mesosoma. Pronotal collar finely punctate; mesoscutum, scutellum and metanotum with moderately large distinct punctures, mostly separated by less than diameter of a puncture; mesoscutum 1.14× broader than long; propodeal dorsum with transverse striations, enclosure hardly set off (Plate 38, Fig. 72); mesopleuron strongly punctate, pubescence nearly concealing sculptures as on frons; sides of propodeum also densely pubescent with striations and punctures (Plate 38, Fig. 73).

Metasoma. Smooth and shiny (Plate 38, Fig. 74); T2 1.42× broader than long; petiole distinctly curved (Plate 38, Fig. 66).

Female. Resemble male in most aspects except petiole little shorter (Bingham, 1897).

Distribution. India: Tamil Nadu (new state record), Rajasthan. *Elsewhere*: Afghanistan; Algeria; Angola; Botswana; Cameroon; Canary Islands; China; Cyprus; Democratic Republic of the Congo; Egypt; Ethiopia; France; Greece; Guinea; Iran; Iraq; Israel; Italy; Japan; Jordan; Kazakhstan; Kenya; Libya; Malawi; Malaysia; Malta; Mauritania; Morocco; Mozambique; Namibia; Niger; Oman; Portugal; Qatar; Russia; Saudi Arabia; Senegal; Sierra-

Leone; Somalia; South Africa; Spain; Sri Lanka; Syria; Taiwan; Tajikistan; Tanzania; Thailand; Tunisia; Turkey; Turkmenistan; Ukraine; United Arab Emirates; Uzbekistan; Vietnam; Western Sahara; Yemen (Anagha & Girish Kumar, 2020b; Pulawski, 2023).

B. Tribe Sphecini Latreille, 1802

I. Genus *Isodontia* Patton, 1880

Isodontia Patton, 1880: 380. Type species: *Isodontia philadelphica* (Lepeletier de Saint Fargeau, 1845), (= *Sphex philadelphicus* Lepeletier, 1845), by original designation.

Leontosphex Arnold, 1945: 90. Type species: *Sphex leoninus* de Saussure, 1890.

Murrayella Bohart & Menke, 1963: 137. Type species: *Sphex elegans* Smith, 1856.

Diagnosis. Tarsal claws generally long, claw teeth slanting towards inner margin (Plate 41, Fig. 94); sides of propodeum without spiracular groove, if present, then seen only near hind coxa (Plate 39, Fig. 78); petiole curved in lateral view and length when measured dorsally, greater than combined length of hind tarsi two to four (hardly slightly less in some species); male flagellomeres with placoids (number and arrangement varies among species); female generally without fore tarsal rake, if present, then rake spines short (Bohart & Menke, 1976).

Distribution. Though they are distributed in Australasian, Afrotropical, Nearctic, Neotropical, Oriental and Palearctic Regions, most species are being reported from Neotropical and Oriental regions (Bohart & Manke, 1976).

Keys: World Species. Fernald, 1903a: 269 (key to *Isodontia* species from North America); Bohart & Menke, 1963: 133 (key to *Isodontia* species from America north of Mexico); Pagliano, 1984: 366 (key to *Isodontia* species from Italy); Scaramozzino & Pagliano, 1987: 155 (key to *Isodontia* species from Italy).

Note. Genus is represented by 62 species and one subspecies worldwide. So far, 27 species are recorded from Oriental region of which nine species are known to occur in India.

Biology. The species of this genus are known to attack orthopterans, normally Gryillidae and Tettigonidae to feed their larvae, but Blattidae has also been reported to be used as prey by some species of *Isodontia (*Iwata, 1939; Barthélémy, 2010; Ito *et al*., 2015). The wasps mainly nest in natural existing holes or preexisting cavities and use grass or other plant materials to make partitions and seal off these nests, which make them different from other

cavity nesting wasps. Hunting begins soon after the nest making and paralysed prey is brought in on the wing upside down to the nest. Mass provisioning is the rule and ocassionally mixed preys are provisioned by wasps. They construct both multicellular and brood chamber nest. Egg is laid on thoracic venter of first provision and in brood chamber nest, eggs are laid in the order on following few preys carried to the nest. As long as sufficient food is stored by female wasps, larvae show no cannibalism. A single brood chamber consisting of only males and females was the other interesting findings observed among *Isodontia* (Tsuneki, 1963; Krombein, 1967).

Key to Indian species of *Isodontia* Patton (except *I. apicata* (Bingham) & *I. nigella* (Smith), due to lack of details in descriptions)

1. Metasoma partly or largely red or testaceous brown (Plate 40, Figs. 81 & 86). …… 2
— Metasoma entirely black (Plate 39, Fig. 75, Plate 41, Figs. 89 & 96). …… 6
2. Dense pubescence on frons golden yellow. ……...…… ***I. aurifrons*** (Smith)
— Dense pubescence on frons grey, or silvery white (Plate 40, Figs. 82 & 88). …… 3
3. Cellular fore wing area hyaline ……...……..…….…….. 4
— Cellular fore wing area not hyaline, rusty yellow or fuscous with violet effulgence. . ……...…….…….. 5
4. F2 as long as F1 & F3; clypeus truncate. ……...… ***I. splendidula*** (Costa)
— F2 shorter than F1 & F3; clypeus wavy. …….....……...… ***I. diodon*** (Kohl)
5. Mandible bidentate; fore wing fuscous with violet effulgence (Fig. 83). ……..... ***I. edax*** (Bingham)
— Mandible tridentate; fore wing rusty yellow. …… ***I. formosicola*** (Strand)
6. Dense pubescence on frons golden yellow (Plate 39, Fig. 76). …. ***I. aurifrons*** (Smith)
— Dense pubescence on frons grey, or silvery white (Plate 41, Figs. 90 & 97). …… 7
7. Cellular fore wing area subhyaline (Plate 41, Fig. 91). ……..…. ***I. nigelloides*** Strand
— Cellular fore wing area rusty yellow. ..... ***I. ochroptera*** (Kohl)

i. *Isodontia aurifrons* (Smith, 1859)

(Plate 39, Figs. 75–80)

Sphex aurifrons Smith, 1859: 157. (OXUM) Lectotype: ♀, Indonesia, Maluku, Island of Aru (designated by Hensen, 1991a: 13).

Sphex morosus Smith, 1860b: 122. (OXUM) Holotype or syntypes: ♂, Indonesia, Moluccas, Batjan Islands (now Bacan) (no specific locality) (synonymized with *Isodontia aurifrons* by Hensen, 1991a: 13).

Sphex volatilis Smith, 1860b: 122. (OXUM) Holotype: ♂, Indonesia, Moluccas, Batjan Islands (now Bacan) (no specific locality) (synonymized with *Isodontia morosa* by van der Vecht in Bohart & Menke, 1976: 123).

Sphex triodon Kohl, 1890: 377. (NHMW) Lectotype: ♂, Indonesia, Java (no specific locality) (synonymized with *Isodontia aurifrons* by Hensen, 1991a: 13).

Sphex abditus Kohl, 1895: 51, ♀. (NHMW) Holotype: ♀, Sikkim? (synonymized with *Isodontia aurifrons* by Hensen, 1991a: 13).

Sphex abditus st. *nugenti* Turner, 1910: 345. (NHM) Holotype or syntypes: ♀, Australia, Queensland, Cairns (synonymized with *Isodontia aurifrons* by Hensen, 1991a: 13).

Isodontia aurifrons; Bohart & Menke, 1976: 123.

Material examined. Tamil Nadu: 1 ♀, Tirunelveli district, Karaiyar dam site, Coll. P. Girish Kumar & Party, 29.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19308.

Diagnosis. Female (Pate 39, Figs. 75–80). Body size: 23 mm. Body black, tegula and legs rufous; frons and clypeus with appressed golden yellow pubescence and long erect setae of same colour, pubescence nearly concealing the sculpture; apical margin of clypeus wavy or curved, elevated medially with a notch in the middle; mandible with three apical teeth (Fig. 76); vertex, mesoscutum, and scutellum, with distinct punctures; propodeal dorsum finely rugulose with crowded punctures (Fig. 77); mesopleuron and sides of propodeum also with crowded punctures (Fig. 78); pubescence on thorax golden yellow; gaster with fine setae; fore wing dark brown with coppery reflections. (Fig. 79)

Male. Body black, femora, tibiae and tarsi except apex of claw dark ferruginous; clypeus with sivery white or golden yellow pubescence and long black erect setae; thorax slightly shining with black pubescence; fore wing dark brown with coppery reflections (Smith, 1860b).

Distribution. India: Maharashtra, Tamil Nadu (new state record).

ii. *Isodontia edax* Bingham, 1897

(Plate 40, Figs. 81 –88)

Sphex edax Bingham, 1897: 251. (NHM) Syntypes: ♀, India, Sikkim; Burma, Tenasserim; Sri Lanka (no specific locality).

Isodontia edax; Bohart and Menke, 1976: 123.

Material examined. Kerala: 1 ♀ & 4 ♂, Kannur district, Madayippara, Coll. C. Charesh, 1.ix.2018, 10.viii.2017, 29.vii.2018, & 5.viii.2018, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 19309−19313.

Redescription. Female (Plate 40, Figs. 81 –86). Body size: 32 mm.

Colour. Black, apex of G1 and following segments rufous, apex of mandible ferruginous; fore wing fuscous with violet effulgence.

Vestiture. Head and thorax with silvery white pubescence, dense and appressed on frons, erect on vertex and thorax with patch of dense pubescence on pronotal collar, pronotal lobes, sides of mesoscutum, basal sides of propodeal dorsum, upper mesopleural region below tegulae, along lower mesopleural suture and posterior propodeal sides.

Head. Head 2.2× as wide as IOD at anterior ocellus; POL 1.15× LOL and 0.29× OOL; frons smooth and shining with scattered moderately large punctures; vertex slightly arched above eyes; mandible stout, arcuate and bidentate, basally with tuft of long yellow setae; apical margin of clypeus wavy with three teeth, median tooth sharp and widely separated from lateral teeth (Plate 40, Fig. 82); F1 0.69× combined length of F2 and F3.

Mesosoma. Pronotal collar, mesoscutum, scutellum, metanotum, propodeal dorsum, with scattered small punctures (Plate 40, Fig. 85), punctures coarse and relatively close on propodeal dorsum, mesopleuron and sides of propodeum; mesoscutum 1.2× broader than long; scutellum and metanotum convex, latter more convex than former; distinct deep grove separates scutellum and metanotum as well as metanotum and propodeum (Plate 40, Fig. 85).

Metasoma. Metasoma smooth and shiny with fine punctures; T1 1.3× broader than long; petiole distinctly curved.

Male. Body size: 30−33 mm. Resembles female in most aspects except: apical margin of clypeus with four teeth, two teeth medially with widely separated lateral teeth (Plate 40, Fig. 88).

Distribution. India: Kerala (new state record), Sikkim. *Elsewhere*: China; Myanmar; Sri Lanka; Vietnam (Pulawski, 2023).

iii. *Isodontia nigelloides* (Strand, 1915)

(Plate 41, Figs. 89−97)

Sphex nigelloides Strand, 1915: 88. (DEI) Holotype: Sri Lanka: Pankulam.
Isodontia nigelloides; Hensen, 1991a :14.

Material examined. Karnataka: 1 ♀, Udupi district, Mookambika Wildlife Sanctuary, Valur, Coll. V.D. Hegde & Party, 16.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21297; 1 ♂, Udupi district, Mookambika Wildlife Sanctuary, Gollihole, Coll. V.D. Hegde & Party, 17.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21315. Kerala: 10 ♀, Ernakulam district, Thattekkad Bird Sanctuary, Kolumba, Coll. P. Girish Kumar, 20.ix.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 7868−7877; 1 ♀, Palakkad district, Nelliampathy, Kaikatty, Coll. P. Girish Kumar, 27.ii.2017, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 10482; 1 ♀, Thiruvananthapuram district, Ponmudi, Coll. B.H.C.K. Murthy & Party, 18.i.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19305; 1 ♀, Palakkad district, Silent valley, Coll. S. Anagha & Party, 12.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19306; 1 ♀, Kannur district, Aralam Wildlife Sanctuary, Chavachi, Coll. K.A. Subramanian & Party, 24.iii.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19307. Tamil Nadu: 1 ♂, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Thuthukulivayal, Coll. S. Sen & Party, 16.ii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19303; 1 ♂, Tirunelveli district, Shenbega devi temple, Coll. B.H.C.K. Murthy & Party, 26.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19304.

Redescription. Female (Plate 41, Figs. 89−95). Body size: 16−18 mm.

Colour. Entirely black, tegula ferruginous; fore wing almost hyaline, apex fuscous.

Vestiture. Body with silvery white pubescence, appressed on frons, erect on head and thorax, almost decumbent on gaster.

Head. Head 2.2× as wide as IOD at anterior ocellus; POL 1.15× LOL and 0.29× OOL; frons with rugose punctures; vertex arched above eyes; mandible long and slender, bidentate, but outer tooth bifid with small tooth like structure, basally with tuft of long yellow setae (Plate 41, Fig. 90); apical margin of clypeus emarginate or weakly curved in middle (Plate 41, Fig. 90); F1 0.69× combined length of F2 and F3.

Thorax. Pronotal collar, mesoscutum, scutellum, metanotum, propodeal dorsum, mesopleuron, and sides of propodeum with distinct punctures, punctures dense and crowded on propodeal dorsum (Plate 41, Fig. 92), mesopleuron and sides of propodeum (Plate 41, Fig.

93); mesoscutum 1.2× broader than long with conspicuous parapsidal lines and admedian groove extending one third of mesoscutum (Plate 41, Fig. 92); scutellum and metanotum convex, latter more convex than former; distinct deep grove separates scutellum and metanotum as well as metanotum and propodeum.

Metasoma. Metasoma smooth and shiny with fine setae (Plate 41, Fig. 95), petiole distinctly curved.

Male (Figs. 96−97). Body size: 30 mm. Resembles female in most aspects except: mandible bidentate, outer tooth not bifid (Plate 41, Fig. 97).

Distribution. India: Karnataka, Kerala, Tamil Nadu. *Elsewhere*: Sri Lanka (Anagha & Girish Kumar, 2020b; Pulawski, 2023).

II. Genus *Sphex* Linnaeus, 1758

Sphex Linnaeus, 1758: 569. Type species: *Sphex flavipennis* Fabricius, 1793 (designated by International Commission on Zoological Nomenclature, 1946: 571 (Opinion 180)).

Sphaex Scopoli, 1772: 122. Lapsus or emendation of *Sphex* Linnaeus, 1758.

Ammobia Billberg, 1820: 105. Type species: *Pepsis argentata* (Fabricius, 1804) (= *Sphex argentatus* Fabricius, 1787) (designated by Rohwer, 1911: 153).

Proterosphex Fernald, 1905: 163. Type species: *Sphex maxillosus* Fabricius, 1793.

Fernaldina Bohart & Menke, 1963: 130. Type species: *Sphex lucae* de Saussure, 1867.

Diagnosis. Petiole generally short, length less than combined length of hind tarsi two to four when measured dorsally; sides of propodeum with complete spiracular groove (Plate 44, Fig. 114); inner margin of hind tarsal claw generally with two teeth; male flagellomeres most often with flat placoids on F4−F6 (Plate 44, Fig. 117); females with a fore tarsal rake (Bohart & Menke, 1976; Anagha *et al*., 2021b).

Distribution. They are cosmopolitan genus distributed in Australasian, Afrotropical, Nearctic, Neotropical, Oriental and Palearctic Regions (Dörfel & Ohl, 2015; Anagha *et al*., 2021b; Pulawski, 2023).

Keys. World species. Turner, 1910: 343 (key to *Sphex* species from Australia); Arnold, 1928b: 341 (key to *Sphex* species from South Africa); Leclercq, 1961: 324 (key to African *Sphex* species of haemorrhoidalis group); Diniz, 1964: 99 (key to *Sphex* species from Angola, includes all Sphecini); Alayo Dalmau, 1976: 10 (key to *Sphex* species from Cuba); Pagliano,

1984: 367 (key to *Sphex* species from Italy); Guichard, 1988: 118 (key to *Sphex* species from Arabia); Danilov, 2014: 513 (key to *Sphex* species from Siberia) (Pulawski, 2023).
Indian species. Anagha *et al*., 2021b.

Note. Genus is represented by 131 species and 13 subspecies species worldwide. So far, 19 species are recorded from Oriental region, of which 9 species are known to occur in India (Pulawski, 2023).

Biology. The species of this genus are known to attack Orthoptera of the families Tettigoniidae, a few on Gryllacrididae and some on Gryllidae to feed their larvae (Bohart & Menke, 1976; Evans *et al*., 1982; Dörfel & Ohl, 2015; Anagha *et al*., 2021b). Female wasp upon finding prey, attack and stings it causing paralysis. The wasp grasp prey by its antenna which are held by the mandibles and prey is flown dorsum up to the nest. The wasp may take short, hopping flight or even walk to nest, if the prey is too large. Majority of *Sphex* species are gregarious, and nests in large groups of multiple individuals. Nests are digged before or after prey capture (Hanson & Menke, 2006). Some species close the nest while hunting for prey, while others leave it open. Typically the nest is multicellular and contain 3-10 separate cells which are built in side branches of the main tunnel. Though mass provisioning is the rule, progressive provisioning is also found in some species and number of prey items in each compartment ranges from three to seven. The egg is laid on the thoracic venter of the first provision (Bohart & Menke, 1976; Dörfel & Ohl, 2015).

Key to Indian species of *Sphex* (except *S. deplanatus* Kohl, 1895 due to lack of detail;s in descriptions) (adopted from Anagha *et al*., 2021b)

1. Metanotum with medially elevated tubercles (Plate 44, Fig. 111). 2
— Metanotum without tubercles (Plate 43, Fig. 105, Plate 45, Fig. 120) (weakly defined tubercles in *S. pruinosus* Germar). 5
2. Propodeal enclosure with wide transverse ridges (Plate 44, Fig.111). …… ***S. sericeus*** (Fabricius)
— Propodeal enclosure without wide transverse ridges (Plate 42, Fig. 100). ……..... 3
3. Fore wing mostly hyaline without yellow tinge. …… ***S. argentatus*** Fabricius
— Fore wing mostly hyaline with yellow tinge. 4
4. Propodeal enclosure with pubescence concealing sculpture. ..... ***S. diabolicus*** Smith
— Propodeal enclosure with pubescence not concealing sculpture. ..... ***S. neoumbrosus*** Jha & Farooqi

5. Propodeal enclosure with wide transverse ridges. ..... ***S. pruinosus*** Germar

— Propodeal enclosure without wide transverse ridges. 6

6. Legs entirely or partly rufous (Plate 45, Fig. 118). ..... ***S. subtruncatus*** Dahlbom

— Legs entirely black (Plate 43, Fig. 103). **7**

5. Propodeal enclosure with silvery white or golden yellow pubescence (Plate 43, Figs. 105 & 106). ..... ***S. obscurus*** (Fabricius)

— Propodeal enclosure with light brown or black pubescence. .... ***S. praedator*** Smith

i. ***Sphex argentatus*** **Fabricius, 1787**

(Plate 42, Figs. 98−102)

Sphex argentatus Fabricius, 1787: 274. (ZMUC) Lectotype: ♀, southeastern India, Coromandel coast (no specific locality) (ZMUC) (designated by van der Vecht, 1961: 28).

Sphex unicolor Fabricius, 1787: 275. (depository unknown, possibly under *Sphex argentatus* in ZMUC) Holotype or syntypes: Spain (no specific locality) (synonymized with *Sphex argentatus* by Fabricius, 1804: 209).

Sphex umbrosus Christ, 1791: 293. Holotype or syntypes: origin not stated (destroyed) (synonymized with *Sphex argentatus* by van der Vecht, 1961: 28 & 1973: 345).

Sphex argentifrons Lepeletier, 1845: 337. (M. Spinola collection, Torino) Lectotype: ♀, Indonesia, Java (no specific locality) (synonymized with *Sphex argentatus* by Smith, 1856: 252).

Sphex plumifer Costa, 1864: 112. Holotype: Philippines, Luzon (no specific locality) (Napoli) (synonymized with *Sphex umbrosus* by Kohl, 1890: 407).

Sphex umbrosus var. *nanulus* Strand, 1913: 83. (DEI) Holotype: ♀, Taiwan, Waihorin.

Material examined. Karnataka: 2 ♀ & 3 ♂, Udupi district, Mookambika Wildlife Sanctuary, Heddarimane, Halkal junction, Coll. V.D. Hegde & Part, 1.ix.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18788−18792; 1 ♀ & 3 ♂, Udupi district, Mookambika Wildlife Sanctuary, Mekke, Jadkal, Coll. V.D Hegde & Party, 1.ix.2021, ZSIK Regd. Nos. ZSI/WGRC/IR/INV/ 18793–18796; 1 ♀, Udupi district, Mookambika Wildlife Sanctuary, Chittoor site, Coll. V.D. Hegde & Party, 16.vi.2022,mZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21295. Kerala: 3 ♀, Ernakulam district, Thattekkad Bird Sanctuary, Coll. P. Girish Kumar, 22.ix.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 7860−7862; 1 ♂, Kollam district,

Sasthamkotta, Muthupilakkadu, Coll. Md. Jafer Palot & Party, 22.xii.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8230; 1 ♀, Kozhikode district, Kottooli wet land, Coll. P. Girish Kumar & Party, 7.v.2016, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8964; 1 ♀, Thiruvananthapuram district, Ponmudi Shola, Coll. P.M. Sureshan & Party, 24.ii.2017, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10483; 1 ♂, Kannur district, Madayipara, Coll. C. Charesh, 1.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12844; 2 ♀, Thrissur district, Agriculture University Campus, Coll. P. Girish Kumar & Party, 5-16.x.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 15352−15353; 2 ♀ & 4 ♂, Kozhikode district, Madappally, Coll. S. Anagha, 11.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17338−17343; 1 ♀, Kozhikode district, Ashokapuram, Coll. S. Anagha & K.P. Hanima Raveendran, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17868; 1 ♀ & 2 ♂, Kozhikode district, Chaliyam, Coll. P. Manju, 7.x.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17880−17882; 1 ♀, Kozhikode district, Edakkara, Coll. Santhosh, 3.i.2021, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17884; 1 ♂, Kozhikode district, Ponkunnu Hills, Coll. P. Girish Kumar & Party, 25.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18837. Tamil Nadu: 1 ♀, Tirunelveli district, Rosemiyapuram, Coll. P. Girish Kumar & Party, 25.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17860; 1 ♀, Tirunelveli district, Kalakad Mundanthurai Tiger Reserve (KMTR), Coll. P. Girish Kumar & Party, 28.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17861; 1 ♀, Tirunelveli district, Kodumudiyar dam site, Coll. P. Girish Kumar & Party, 28.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17862; 1 ♀, Tirunelveli district, Ramanadi dam site, Coll. P. Girish Kumar & Party, 2.x.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17869.

Diagnosis. **Female (Plate 42, Figs. 98−100)**. Body size: 28–34 mm. Body black; frons and clypeus densely pubescent, pubescence appressed and silvery white in colour, completely conceals sculpture; antenna and mandible black; apical margin of clypeus arcuate with small protrusion medially (Plate 42, Fig. 99); pronotal collar, mesoscutum, scutellum, mesopleuron, and sides of propodeum with fine punctures; pubescence on pronotal collar and scutum silvery white, on scutum slightly denser laterally than medially; scutellum convex with shallow medial impression; metanotum with distinct pair of tubercles; propodeal dorsum finely transversely striate with thin erect silvery setae (Plate 42, Fig. 100); gaster with fine setae; petiole thinly pubescent; legs black; fore wing hyaline.

Male (Figs. 101−102). Body size: 21–28 mm. Resemble female in most aspects except: smaller in size (generally) compared to female; apical margin of clypeus broadly, shallowly emarginate with small protrusion medially (Plate 42, Fig. 102).

Distribution. India: Arunachal Pradesh, Assam, Bihar, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. *Elsewhere*: Angola; Australia; Benin; Botswana; Cambodia; China; Democratic Republic of the Congo; Dableeh Island; Djibouti; Egypt; Ethiopia; Gambia; Greece; Indonesia; Israel; Ivory Coast; Japan; Kazakhstan; Kenya; Korea; Kuwait; Laos; Malawi; Malaysia; Myanmar; Mozambique; Namibia; New Guinea; Pakistan; Philippines; Senegal; Seychelles Islands; Sierra Leone; South Africa; Spain; Sri Lanka; Sudan; Taiwan; Tanzania; Thailand; Uganda; Vietnam; Yemen; Zambia; Zimbabwe (Anagha *et al*., 2021b; Pulawski, 2023).

ii. ***Sphex obscurus*** **(Fabricius, 1804)**

(Plate 43, Figs. 103−107)

Pepsis obscura Fabricius, 1804: 213. (ZMUC) Lectotype: ♂, India (no specific locality) (designated by van der Vecht, 1961: 31).

Sphex cinerascens Dahlbom, 1843: 25. Holotype: ♂, "E. Guinea" (no specific locality) (Lund) (synonymized with *Sphex obscurus* by van der Vecht, 1961: 31).

Sphex xanthopterus Cameron, 1889: 113. (OXUM) Syntypes: India, Barrackpore, Mussoorie (synonymized with *Sphex cinerascens* by Kohl, 1895: 52).

Sphex zubaidiyacus Augul in Augul in Augul *et al.*, 2013: 476. (Iraq Natural History Research Center & Museum, University of Baghdad) Holotype: ♂, Iraq, Wasit Province, center of Al-Zubaidiya region (synonymized with *Sphex obscurus* by Anagha *et al*., 2021b: 453).

Sphex obscurus: Dalla Torre, 1897: 419 (new combination, in catalog of world Hymenoptera).

Material examined. Kerala: 1 ♀ & 3 ♂, Kozhikode district, Madappally, Coll. S. Anagha, 11.iii.2020, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17871−17874; 1 ♂, Kannur district, Kannapuram, Coll. C. Charesh, 17.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17875; 1 ♂, Kozhikode district, Peruvannamuzhi, Coll. K. Anju, 20.v.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17876; 1 ♂, Kannur district, Koothuparamb, Coll. Sr. Jeen Lisb, 30.ix.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18836.

Diagnosis. **Female (Plate 43, Figs. 103 –105)**. Body size: 18.5 mm. Body black; frons and clypeus densely pubescent, pubescence appressed and silvery white in colour, completely

concealing sculpture; antenna and mandible black; apical margin of clypeus with small median lobe which may be notched (Plate 43, Fig. 104); pronotal collar, mesoscutum, scutellum, mesopleuron, and sides of propodeum with fine punctures; pubescence on pronotal collar and scutum silvery white, on scutum slightly denser laterally than medially; metanotum without tubercles; propodeal dorsum with dense long erect setae and appressed pubescence, pubescence concealing sculpture as in frons (Plate 43, Fig. 105); gaster with fine setae; petiole densely pubescent; legs black; fore wing subhyaline with yellowish tinge, faint fuscous band at apex.

Male (Figs. 106 –107). Body size: 17–19 mm. Resembles female in most aspects except: apical margin of clypeus broadly, shallowly emarginate with median lobe (Plate 43, Fig. 107); pubescence on head and thorax golden yellow (Plate 43, Fig. 106).

Distribution. India: Kerala, Uttarakhand, West Bengal. *Elsewhere*: Ghana; Guinea; Iran; Mali; Sri Lanka; Thailand; Turkmenistan; United Arab Emirates (Anagha *et al*., 2021b; Pulawski, 2023).

iii. *Sphex sericeus* (Fabricius, 1793)

(Plate 44, Figs. 108 –117)

Sphex aurulentus Fabricius, 1793: 201. (depository unknown) Holotype or syntypes: India, Tranquebar.

Pepsis sericeus Fabricius, 1804: 211. (ZMUC) Lectotype: ♀, "in maris pacifici Insulis" (designated by van der Vecht, 1961: 30) (synonymized with *Sphex aurulentus* Fabricius, 1793 by Kohl, 1890: 392).

Sphex fabricii Dahlbom, 1843: 27. (depository unknown:) Syntypes: ♀, India, Tamil Nadu, Tranquebar (synonymized with *Sphex sericeus* by Kohl, 1885a: 194 & 1885b: 164).

Sphex lineolus Lepeletier, 1845: 353. (M. Spinola collection, Torino) Holotype or syntypes: ♂, Indonesia, Java (no specific locality, origin probably erroneous (Hensen, 1991b: 22) (synonymized with *Sphex sericeus* by Kohl, 1885a: 195 & 1885b: 165).

Sphex ferrugineus Lepeletier, 1845: 345. (originally Serville coll., now?) Holotype or syntypes: ♀, "sans patrie mais exotique" (synonymized with *Sphex sericeus* by Kohl, 1885a: 194 & 1885b: 164).

Sphex lepeletierii de Saussure, 1867: 40. (NHMW) Holotype or syntypes: ♀, Indonesia, Java, Batavia, now Djakarta, origin likely imprecise (Hensen, 1991b: 22) (synonymized with *Sphex sericeus* by Kohl, 1885a: 195 & 1885b: 165)

Sphex godeffroyi de Saussure, 1869: 57. (Mus. Hamburg, destroyed in World War II) Holotype or syntypes: ♀, Australia, Queensland, Cape York (no specific locality) (synonymized with *Sphex sericeus* by Kohl, 1885a: 195, & 1885b: 165).

Sphex aurulentus var. *pallidehirtus* Kohl, 1890: 393. (NHMW) Syntypes: Papua New Guinea, Port Moresby & Indonesia, Island of Ambon (synonymized with *Sphex sericeus* by Hensen, 1991b: 22).

Sphex rugosus Matsumura, 1912: 176. (depository?) Holotype or syntypes: Taiwan, Horisha, Koshun (depository?) (synonymized with *Isodontia auripygata* by Sonan, 1931: 7, and with *Sphex sericeus* by Hensen, 1991b: 22).

Sphex lineolus wegneri van der Vecht & Krombein, 1955: 39. (RMNH) Holotype: ♂, Indonesia, Muara Kaman (synonymized with *Sphex sericeus* by Hensen, 1991b: 22).

Sphex sericeus nigrescens van der Vecht & Krombein, 1955: 39. (USNM) Holotype: ♀, Philippines, Los Baños (synonymized with *Sphex sericeus* by Hensen, 1991b: 22).

Sphex sericeus ferocior van der Vecht & Krombein, 1955: 40. Substitute name for *Sphex ferox* Smith (synonymized with *Sphex sericeus* by Hensen, 1991b: 22).

Sphex stueberi van der Vecht & Krombein, 1955: 42. (RMNH) Holotype: ♀, Indonesia, Papua (= Indonesian New Guinea): Hollandia, now Jayapura (synonymized with *Sphex sericeus* by Hensen, 1991b: 22).

Sphex sericeus; Dahlbom; 1843: 26 (new combination, in revision of Sphecidae and Pompilidae), 437 (in key to world Sphecini).

Material examined. Karnataka: 2 ♀, Udupi district, Mookambika Wildlife Sanctuary, Jadkal, Coll. V.D. Hegde & Part, 1.ix.2021, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18786−18787; 1 ♀, Shimoga district, Mookambika Wildlife Sanctuary, Melsunka, Coll. V.D. Hegde & Party, 21.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21296; 1 ♂, Udupi district, Mookambika Wildlife Sanctuary, Gollihole, Coll. V.D. Hegde & Party, 17.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21314. Kerala: 1 ♂, Thiruvananthapuram district, Peppara Wildlife Sanctuary, dam site, Coll. S. Anagha, 28.ix.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17895; 1 ♂, Kozhikode district, Madappally, Coll. S. Anagha, 11.iii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17896; 2 ♂, Kannur district, Munderiukadavu, Coll. K.M. Rajesh, 10.iii.2016, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17899–17900; 1 ♂, Kozhikode district, East Hill, Coll. P. Girish Kumar, 10.x.2015, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 19838; 1 ♂, Kozhikode district, Purameri, Coll. K.P. Hanima Raveendran, 21.iii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18839. Tamil

Nadu: 1 ♀, Tirunelveli district, Kalakad Mundanthurai Tiger Reserve (KMTR), Nambikovil, Coll. P. Girish Kumar & Party, 26.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17886; 1 ♀, Tirunelveli district, Kalakad Mundanthurai Tiger Reserve (KMTR), Kadayam, Coll. P. Girish Kumar & Party, 30.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17887; 1 ♀, Tirunelveli district, Shenbega devi Temple, Coll. B.H.C.K Murthy & Party, 26.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17889; 1 ♀, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Kulashekaram range, Zero point, Coll. Souvik Sen & Party, 19.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17890; 1 ♀, Kanyakumari district, Kanyakumari Wildlife Sanctuary, Thuthukulivayal, Alagiyapandipuram range, Coll. Souvik Sen & Party, 16.iii.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17891; 1 ♂, Tirunelveli district, Rosemiyapuram, Coll. P. Girish Kumar & Party, 25.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17893; 1 ♂, Tirunelveli district, Koonthankulam Bird Sanctuary, Coll. P. Girish Kumar & Party, 27.ix.2018, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17894.

Diagnosis. **Female (Plate 44, Figs. 108 –114)**. Body size: 20–24.5 mm. Body black, following rufous: basal half of mandible, clypeus, scape, pedicel, base of flagellomere I, scutellum, metanotum, G1, anterior two third of G2, and legs excluding claw; frons and clypeus densely pubescent, pubescence appressed and golden yellow in colour, completely concealing sculpture; clypeus with medial glabrous stipe, apical margin medially notched (Plate 44, Fig. 109); pronotal collar, mesoscutum, scutellum, mesopleuron, and sides of propodeum with fine punctures; pubescence on pronotal collar and scutum golden yellow, on scutum slightly denser laterally than medially; scutellum convex with shallow medial impression; metanotum with distinct pair of tubercles; propodeal dorsum with three to four broad transverse ridges (Plate 44, Fig. 111); gaster with fine setae; petiole thinly pubescent; fore wing fuscous with slight blue iridescence and faint dark band at apex (Plate 44, Fig. 110)

Male (Figs. 115 –117). Body size: 16–19 mm. Sculpturing as in female. Body black except metasoma (variegated with rufous and black) (Plate 44, Fig. 115); head and thorax with silvery white pubescence; apical margin of clypeus broadly shallowly emarginate (Plate 44, Fig. 116).

Distribution. India: Assam, Karnataka, Kerala, Maharashtra, Meghalaya, Odisha, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. *Elsewhere*: Australia; Cambodia; Chagos Archipelago; China; Indonesia; Japan; Korea; Laos; Malaysia; Madagascar;

Myanmar; New Guinea; Pakistan; Philippines; Sri Lanka; Taiwan; Thailand; Vietnam; Western Sahara; Yemen (Anagha *et al*., 2021b; Pulawski, 2023).

Variations

All the female specimens examined here have petiole black and wings fuscous with blue iridescence, but according to previous workers like Bingham (1897), Dörfel & Ohl (2015), females species have red or orange coloured petiole and yellow tinged subhyaline wings.

iv. *Sphex subtruncatus* Dahlbom, 1843
(Plate 45, Figs. 118−122)

Sphex subtruncatus Dahlbom, 1843: 25. Lectotype: ♀, "Africa" (no specific locality but Oriental region according to Schulz, 1912: 94 (Lund)) (designated by van der Vecht, 1973: 350).

Sphex nigripes Smith, 1856: 254.

Sphex siamensis Taschenberg, 1869: 413. Holotype or syntypes: ♀, "Siam" (no specific locality, likely Philippines) (synonymized with *Sphex subtruncatus* by Hensen, 1991b: 28).

Sphex erythropoda Cameron, 1889: 110. (Calcutta Museum) Syntypes: India (no specific locality) (synonymized with *Sphex nigripes* by Kohl, 1890: 421.).

Sphex sulciscutus Gribodo, 1894: 2. (MSNG) Holotype or syntypes: ♀, Philippines, Mindoro (no specific locality).

Sphex nigripes var. *tsingtauensis* Strand, 1916: 108. (DEI) Holotype: ♂, China, Tsingtau, now Qingdao.

Sphex subtruncatus xuthus van der Vecht, 1957b: 364. (MHNB) Holotype: ♂, Indonesia, Sumba, Bondo Kodi (synonymized with *Sphex subtruncatus* by Hensen, 1991b: 28).

Sphex subtruncatus coraxus van der Vecht, 1957b: 365, ♀. Holotype: ♀, Indonesia, Sumba: Pogobina (MHNB) (synonymized with *Sphex subtruncatus* by Hensen, 1991b: 28).

Sphex subtruncatus orius van der Vecht, 1957b: 366. (MHNB) Holotype: ♂, Indonesia, Flores, Rana Mese (synonymized with *Sphex subtruncatus* by Hensen, 1991b: 28).

Sphex subtruncatus krombeini van der Vecht in Krombein, 1984: 28. (USNM) Holotype: ♀, Sri Lanka, Galle District, Kanneliya Jungle (synonymized with *Sphex subtruncatus* by Hensen, 1991b: 28).

Sphex cyanescens; Gribodo, 1884: 301 (Ethiopia: kingdom of Scioa), rectified to *Sphex nigripes* var. *muticus* by Schulz, 1911: 168.

Sphex nigripes; Bingham, 1896: (Sri Lanka: Pundaluoya), rectified to *Sphex subtruncatus krombeini* by van der Vecht in Krombein, 1984: 28.

Sphex nigripes var. *siamensis*; Strand, 1915: 89 (Sri Lanka), rectified to *Sphex subtruncatus krombeini* by van der Vecht in Krombein, 1984: 28.

Sphex nigripes var. *erythropoda*; Berland, 1928: 329 (Sri Lanka), rectified to *Sphex subtruncatus krombeini* by van der Vecht in Krombein, 1984: 28.

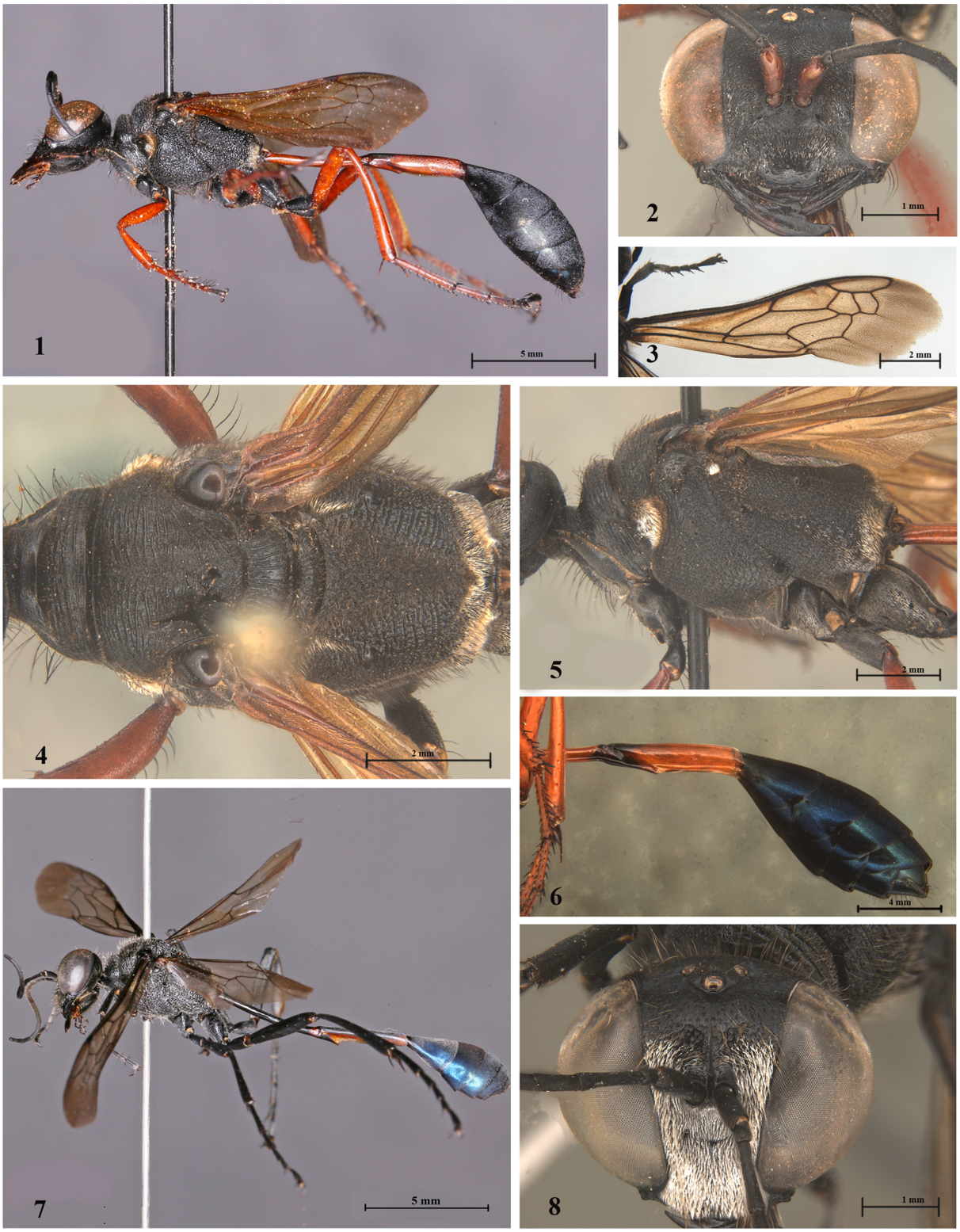
Material examined. Karnataka: 1 ♀, Udupi district, Mookambika Wildlife Sanctuary, Idurkunhady, Coll. V.D. Hegde & Party, 19.vi.2022, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21281. Kerala: 1 ♂, Kozhikode district, Nadakkavu, Coll. J.B. Terine, 6.viii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17908; 1 ♀, Kozhikode district, Madappally, Coll. S. Anagha, 6.viii.2020, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17909; 1 ♀, Kozhikode district, Jaferkhan Colony, ZSI Campus, Coll. K.P. Hanima Raveendran, 3.ix.2019, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17910.

Diagnosis. **Female (Plate 45, Figs. 118−123)**. Body size: 30–30.2 mm. Body black; frons punctate with appressed silvery white pubescence and black long erect setae; antenna and mandible black; apical margin of clypeus with median notch (Plate 45, Fig. 119); pronotal collar, mesoscutum, scutellum, mesopleuron, and sides of propodeum with fine punctures; pubescence on pronotal collar and scutum black, metanotum without tubercles; propodeal dorsum transversely ruguloso striate with long erect setae and appressed black pubescence (Plate 45, Fig. 120); gaster with fine setae (Plate 45, Fig. 122); petiole thinly pubescent; femora and tibiae rufous; fore wing subhyaline with yellowish tinge, faint fuscous band at apex.

Male. Resemble female in most aspects except: clypeus nearly truncate with slightly arched anterior margin; darker wings (Bingham, 1897; Anagha *et al*., 2021b).

Distribution. Arunachal Pradesh, Himachal Pradesh, Karnataka, Kerala, Meghalaya, Sikkim, Tripura, Uttarakhand, Uttar Pradesh, West Bengal. *Elsewhere*: Bhutan; China; Ethiopia; Indonesia; Japan; Korea; Laos; Malawi; Myanmar; Nepal; Philippines; Singapore; Sri Lanka; South Africa; Taiwan; Thailand; Vietnam (Anagha & Girish Kumar, 2020b; Anagha *et al*., 2021b; Pulawski, 2023).

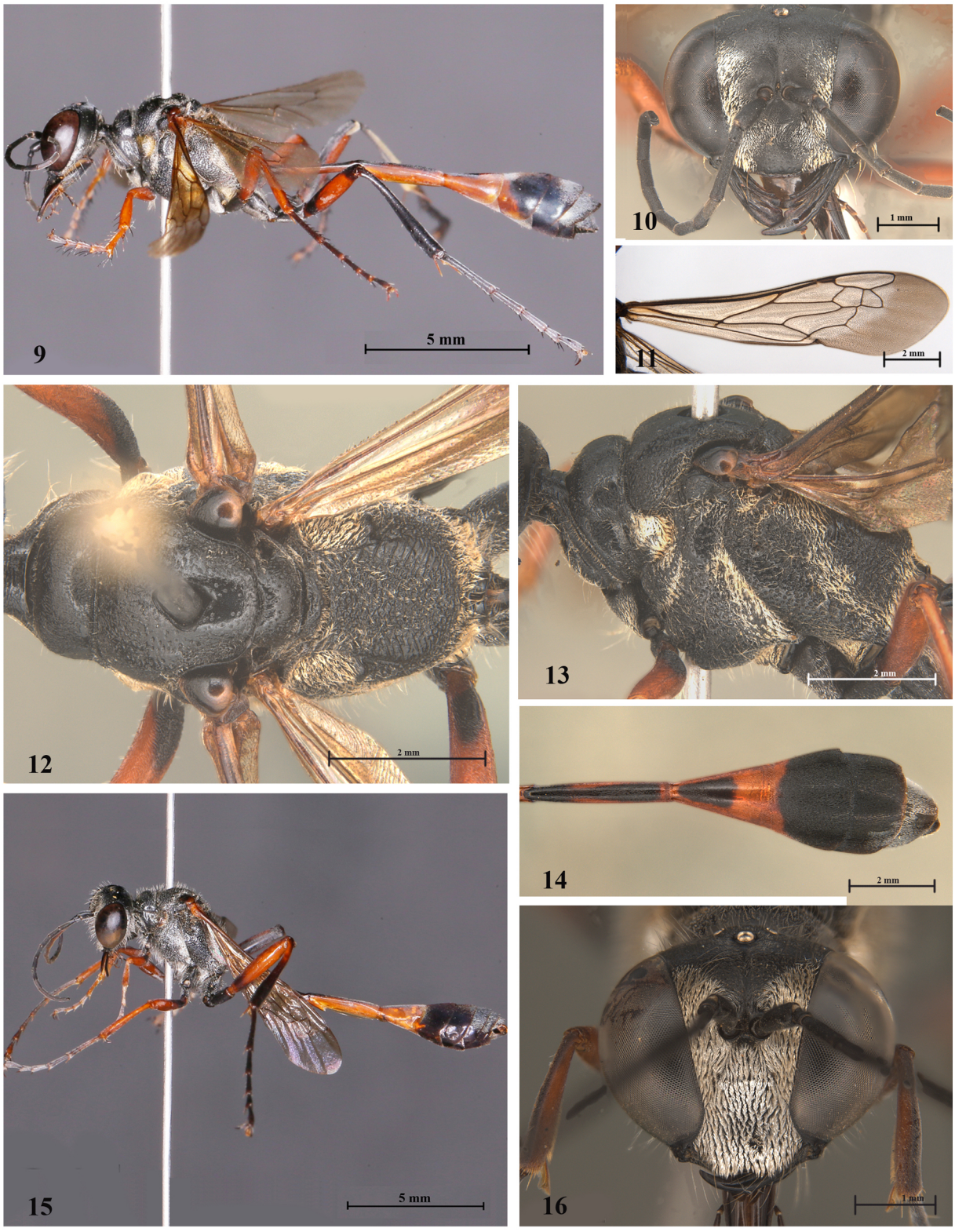
PLATE 29



***Ammophila clavus* (Fabricius, 1775)**

Figs. 1–6. Female, 1. Habitus, lateral view; 2. Head, frontal view; 3. Fore wing; 4. Mesosoma, dorsal view; 5. Mesosoma, lateral view; 6. Metasoma, lateral view. **Fig 7–8**. **Male**. 7. Habitus, lateral view; 8. Head, frontal view.

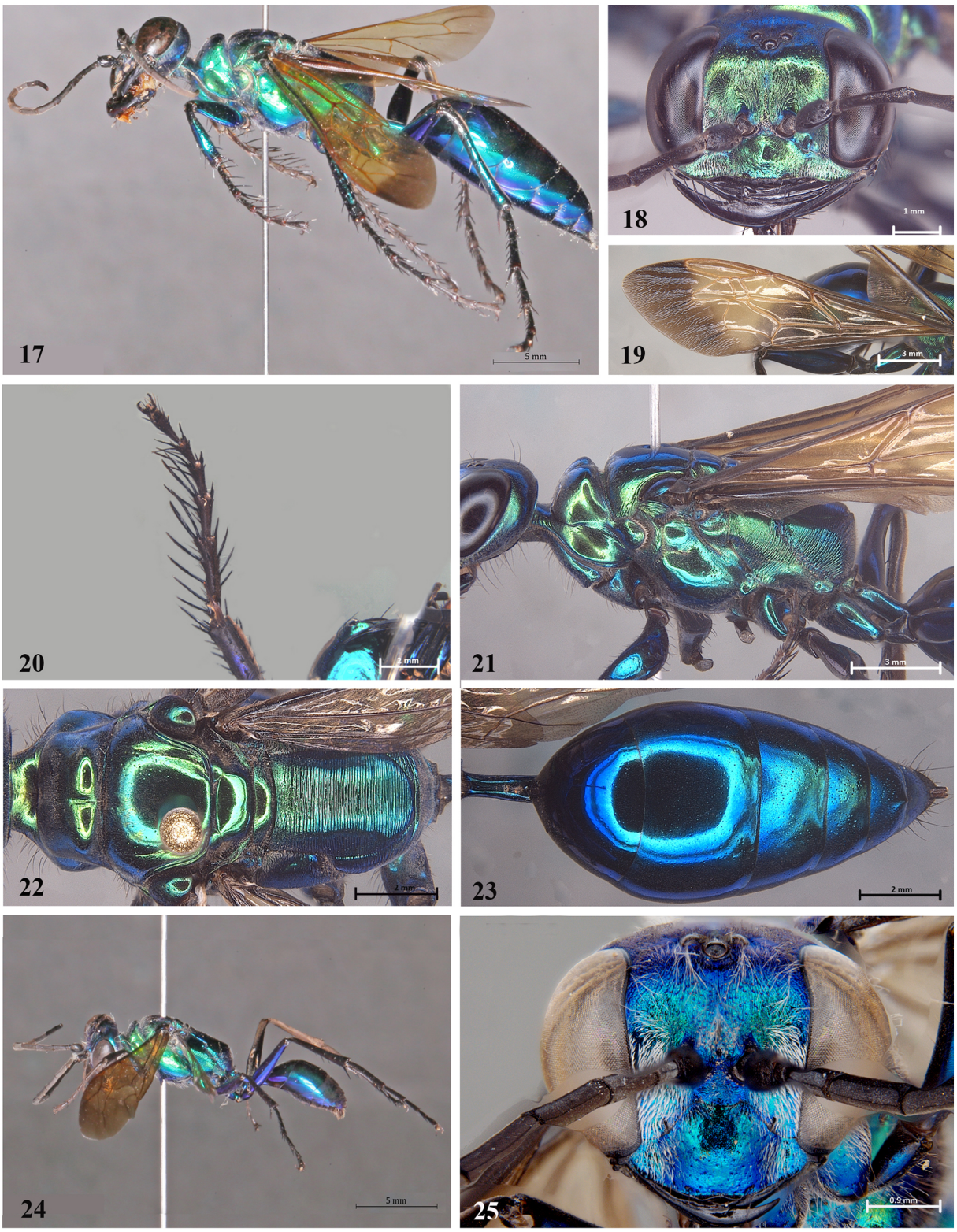
PLATE 30



***Ammophila laevigata* Smith, 1856**

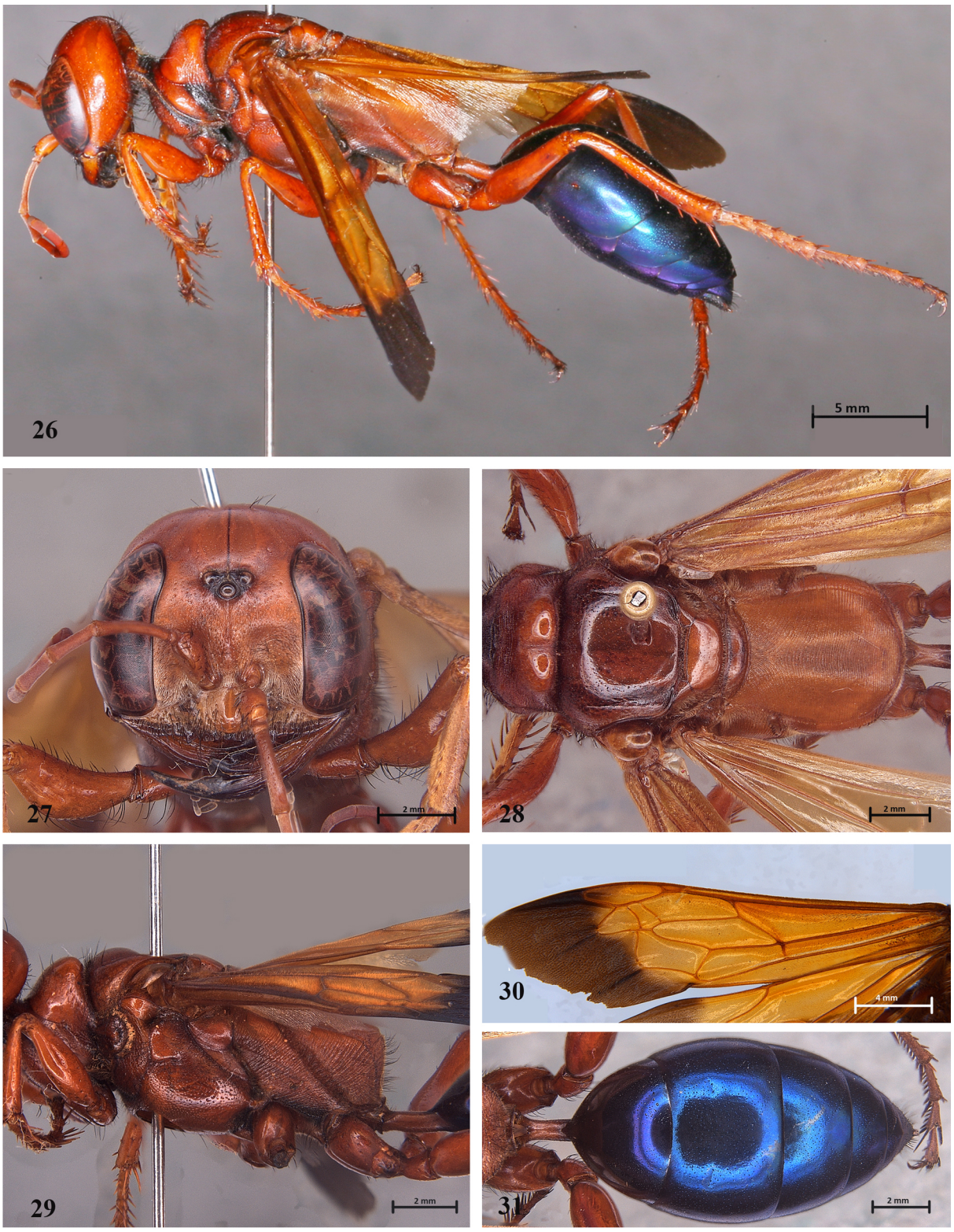
Figs. 9–14. Female, 9. Habitus, lateral view; 10. Head, frontal view; 11. Fore wing; 12. Mesosoma, dorsal view; 13. Mesosoma, lateral view; 14. Metasoma, dorsal view. Figs 15–16. Male, 15. Habitus, lateral view; 16. Head, frontal view.

PLATE 31



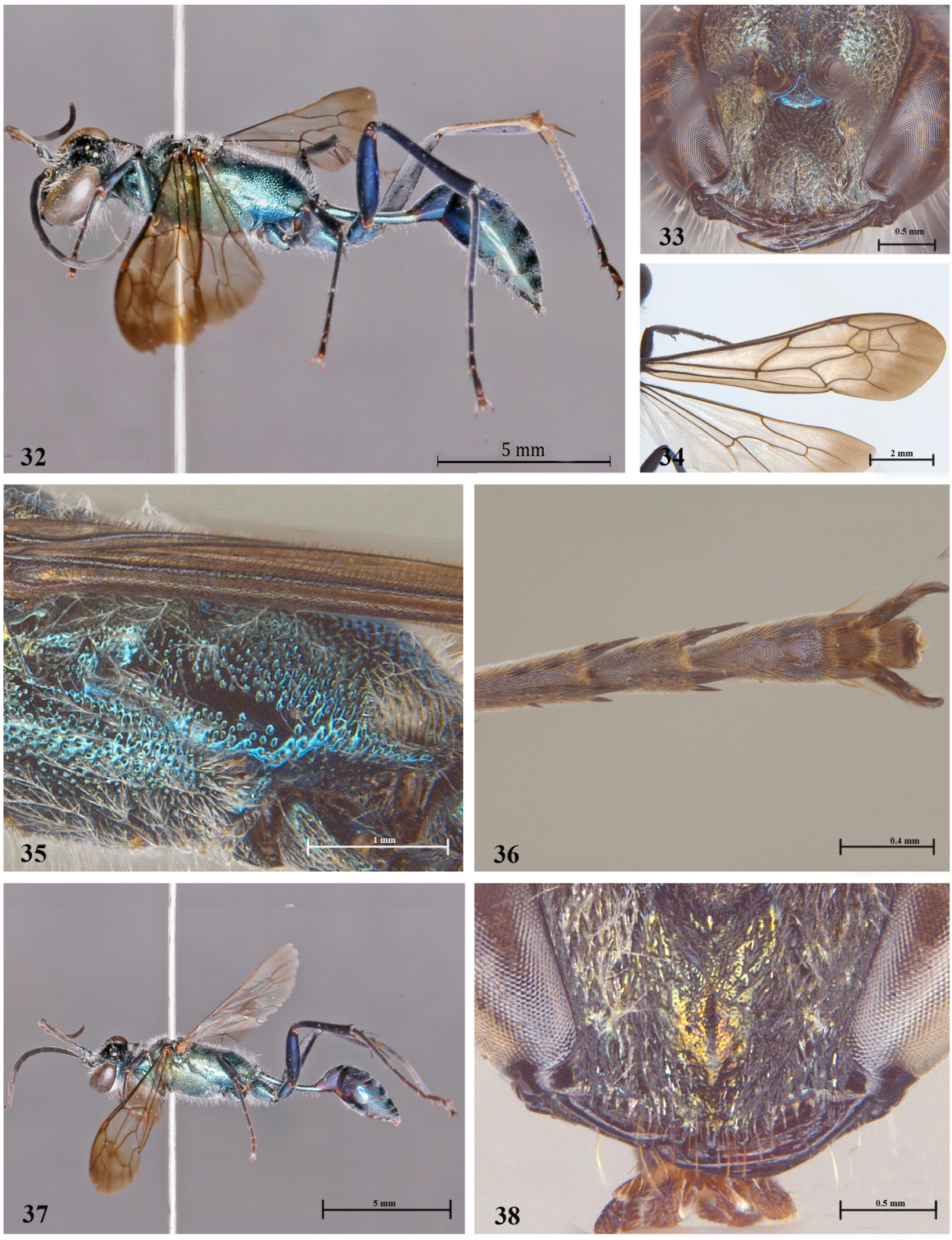
***Chlorion lobatum* (Fabricius, 1775)**
Figs. 17–22. **Female**, 17. Habitus, lateral view; 18. Head, frontal view; 19. Fore wing; 20. Fore tarsal rake; 21. Mesosoma, lateral view; 22. Mesosoma, dorsal view; 23. Metasoma, dorsal view. **Figs. 24–25**. **Male**, 24. Habitus, lateral view; 25. Head, frontal view.

PLATE 32



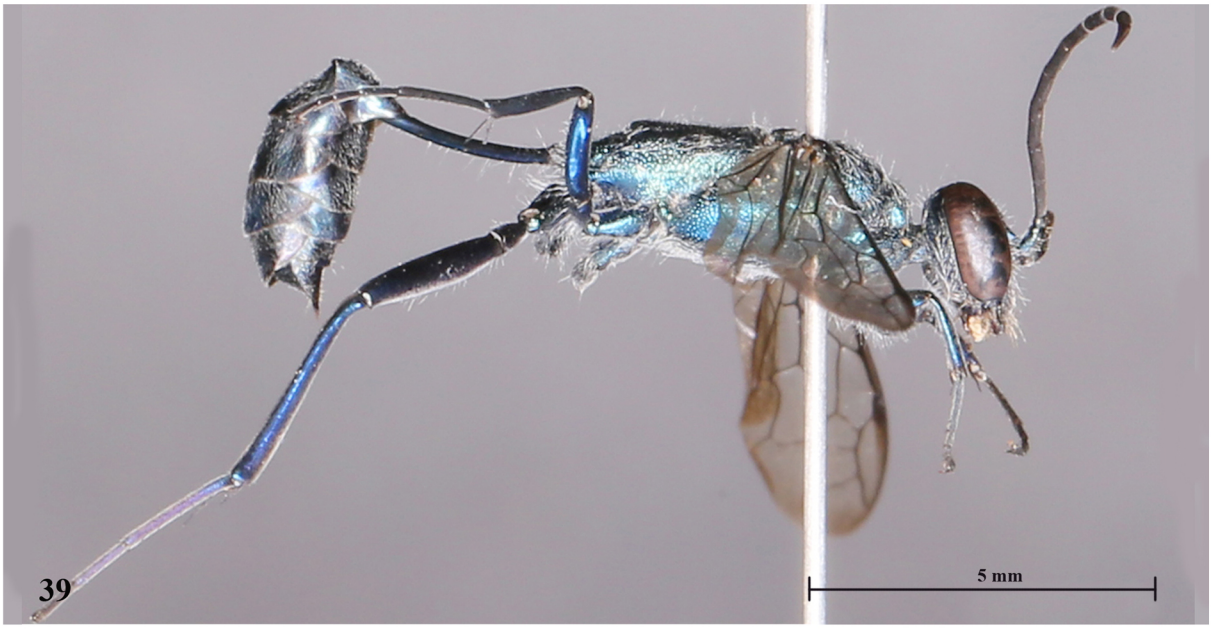
***Chlorion splendidum* Fabricius, 1804 (Female)**
26. Habitus, lateral view; 27. Head, frontal view; 28. Mesosoma, dorsal view; 29. Mesosoma, lateral view; 30. Fore wing; 31. Metasoma, dorsal view.

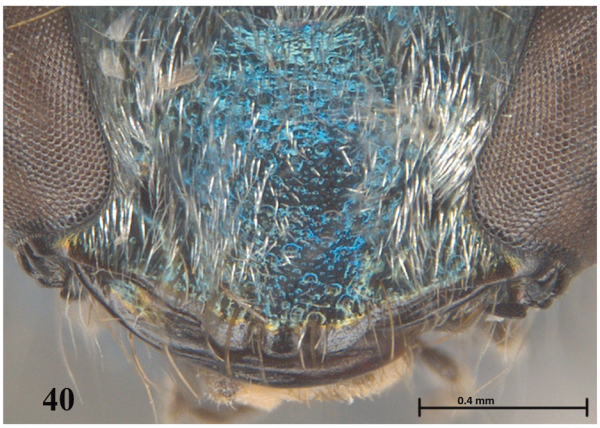
PLATE 33

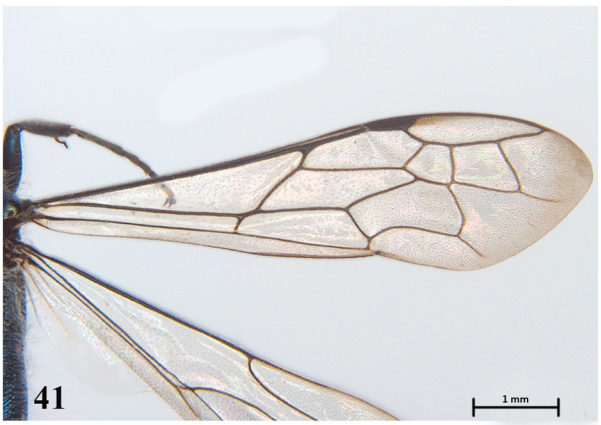


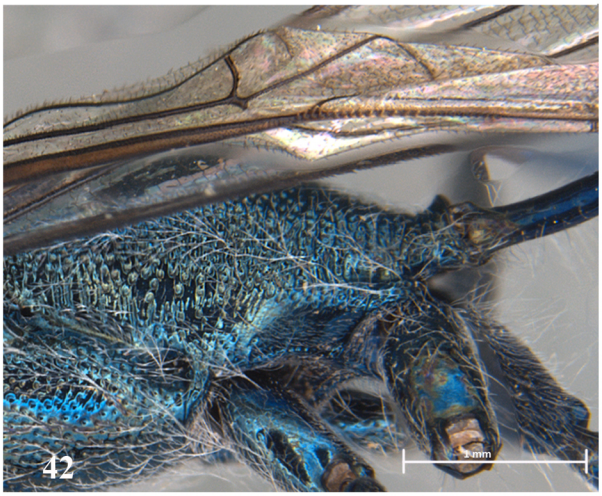
***Chalybion bengalense* (Dahlbom, 1845)**
Figs. 32–36. **Female**, 32. Habitus, lateral view; 33. Head, frontal view; 34. Fore wing; 35. Metapleuron; 36. Hind tarsi. **Figs. 37–38**. **Male**, 37. Habitus, lateral view; 38. Lower half of head, frontal view.

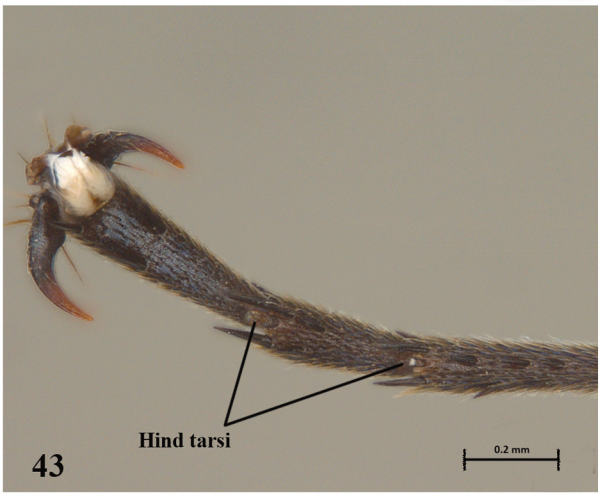
PLATE 34





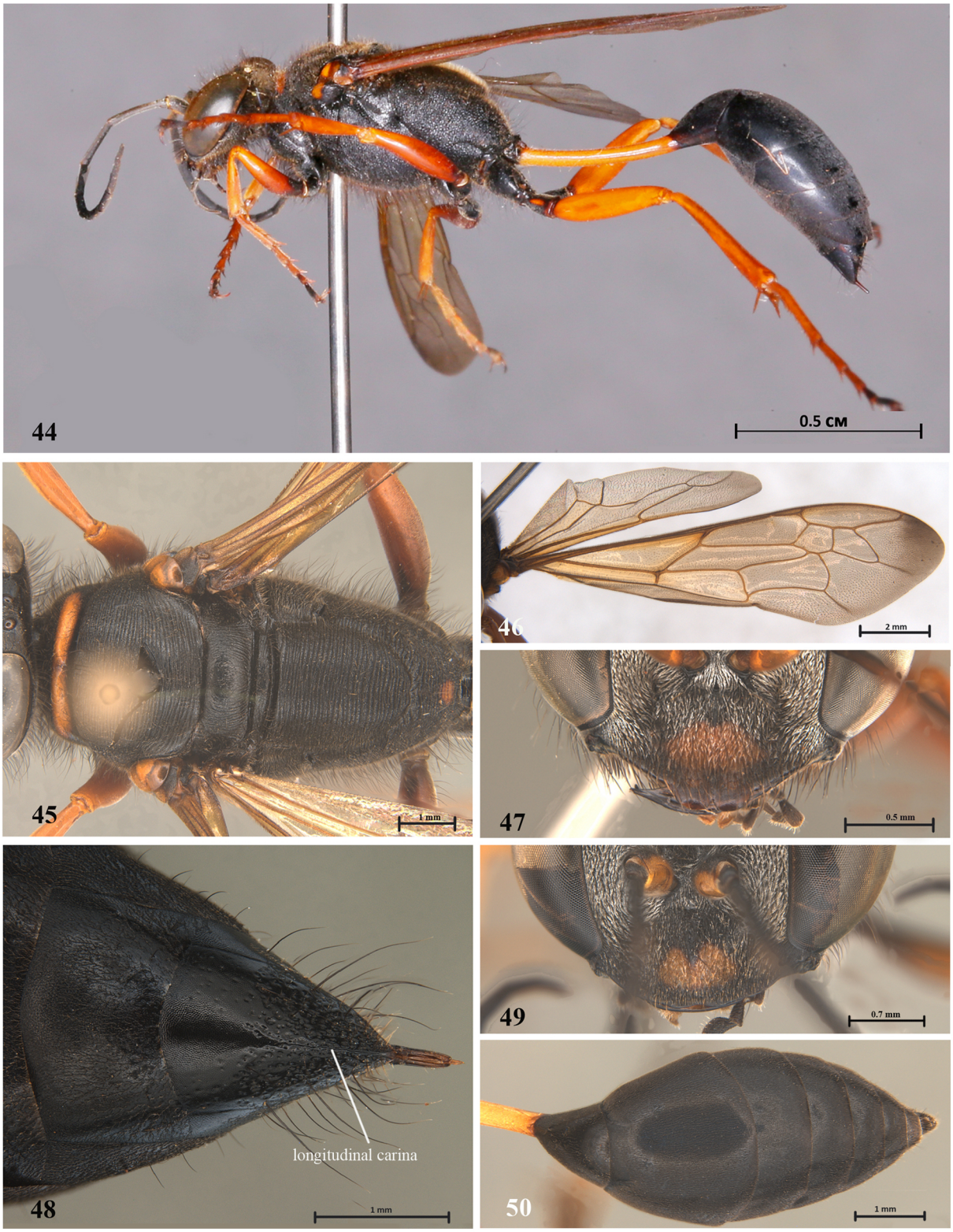






***Chalybion gracile* Hensen, 1988 (Female)**
39. Habitus, lateral view; 40. Lower half of head, frontal view; 41. Fore wing; 42. Metapleuron; 43. Hind tarsi.

PLATE 35



***Sceliphron coromandelicum* (Lepeletier, 1845)**

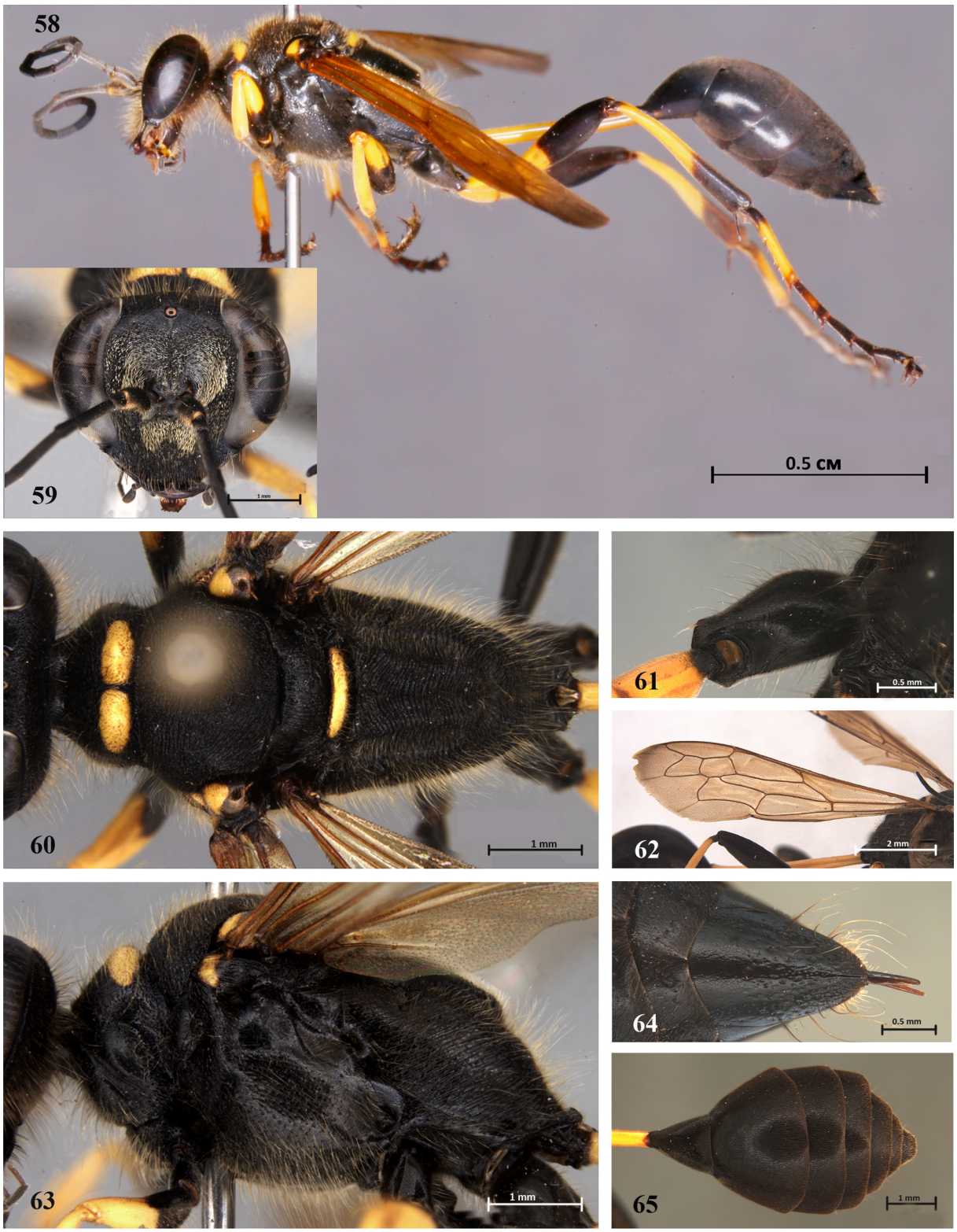
Figs. 44–48. Female, 44. Habitus, lateral view; 45. Mesosoma, dorsal view; 46. Fore wing; 47. Lower half of head, frontal view; 48. Metasomal sterna; **Figs. 49–50. Male**, 49. Lower half of head, frontal view; 50. Metasoma, dorsal view.

PLATE 36

***Sceliphron javanum nalandicum* (Strand, 1915) (Female)**
51. Habitus, lateral view; 52. Hind coxa; 53. Mesosoma, dorsal view; 54.Mesosoma, lateral view.

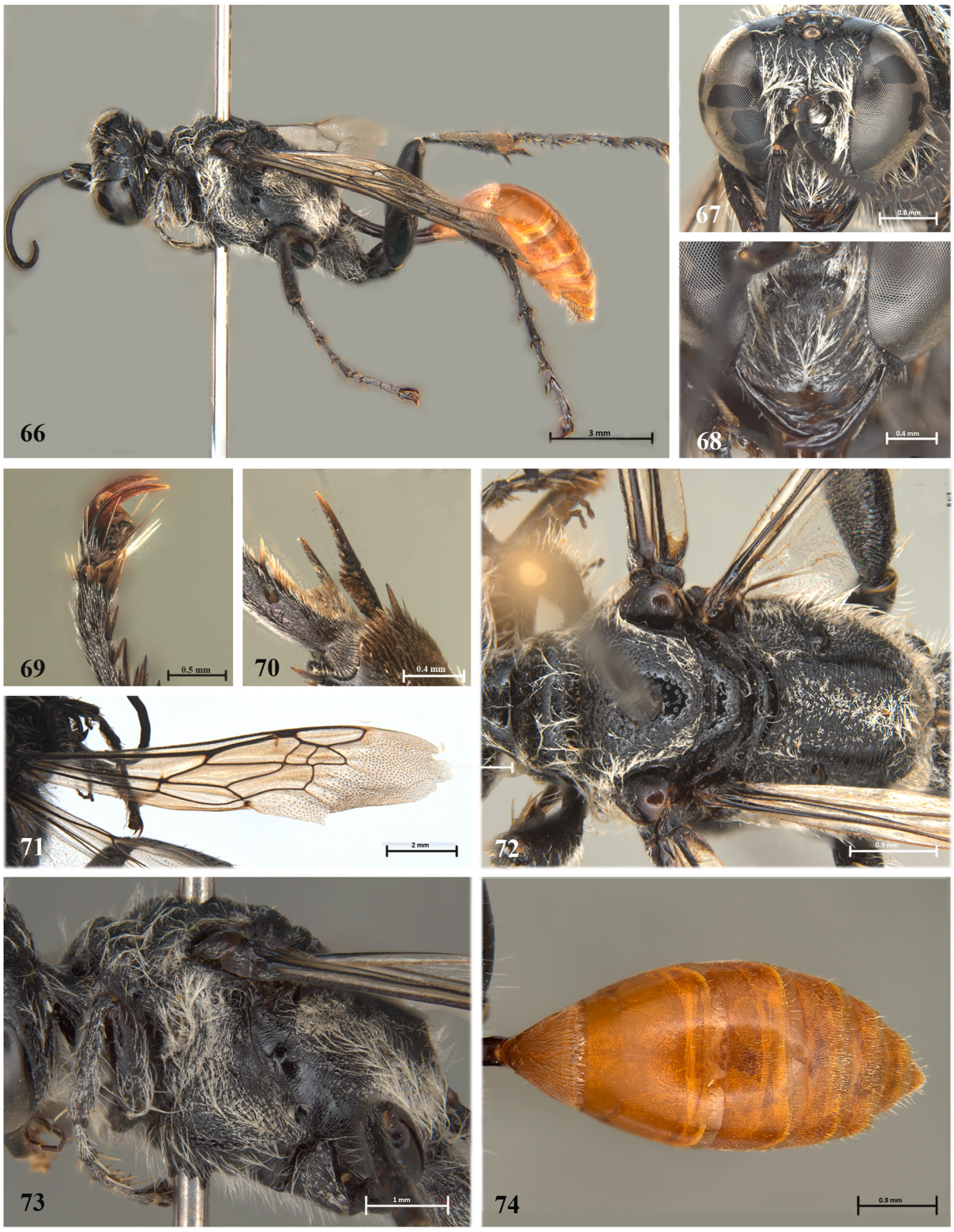
***Sceliphron madraspatanum formosanum* van der Vecht, 1968 (Male)**
55. Habitus, lateral view; 56. Mesosoma, dorsal view; 57. Mesosoma, lateral view.

PLATE 37



***Sceliphron madraspatanum madraspatanum* (Fabricius, 1781)**
Figs. 58–64. Female, 58. Habitus, lateral view; 59. Head, frontal view; 60. Mesosoma, dorsal view; 61. Hind coxa; 62. Fore wing; 63. Mesosoma, lateral view; 64. Metasomal sterna. Fig. 65. Male, Metasoma dorsal view.

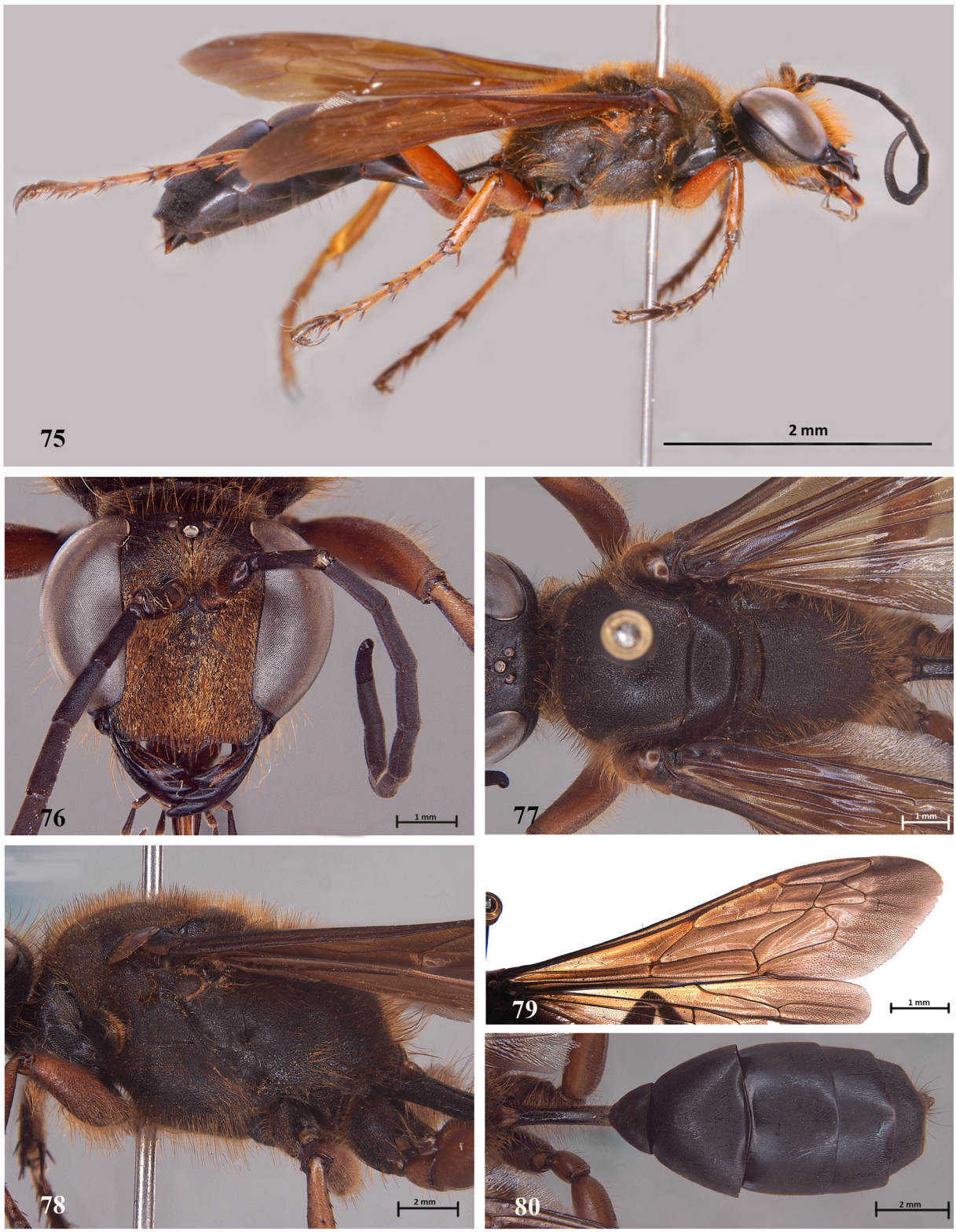
PLATE 38



***Prionyx viduatus* (Christ, 1791)**

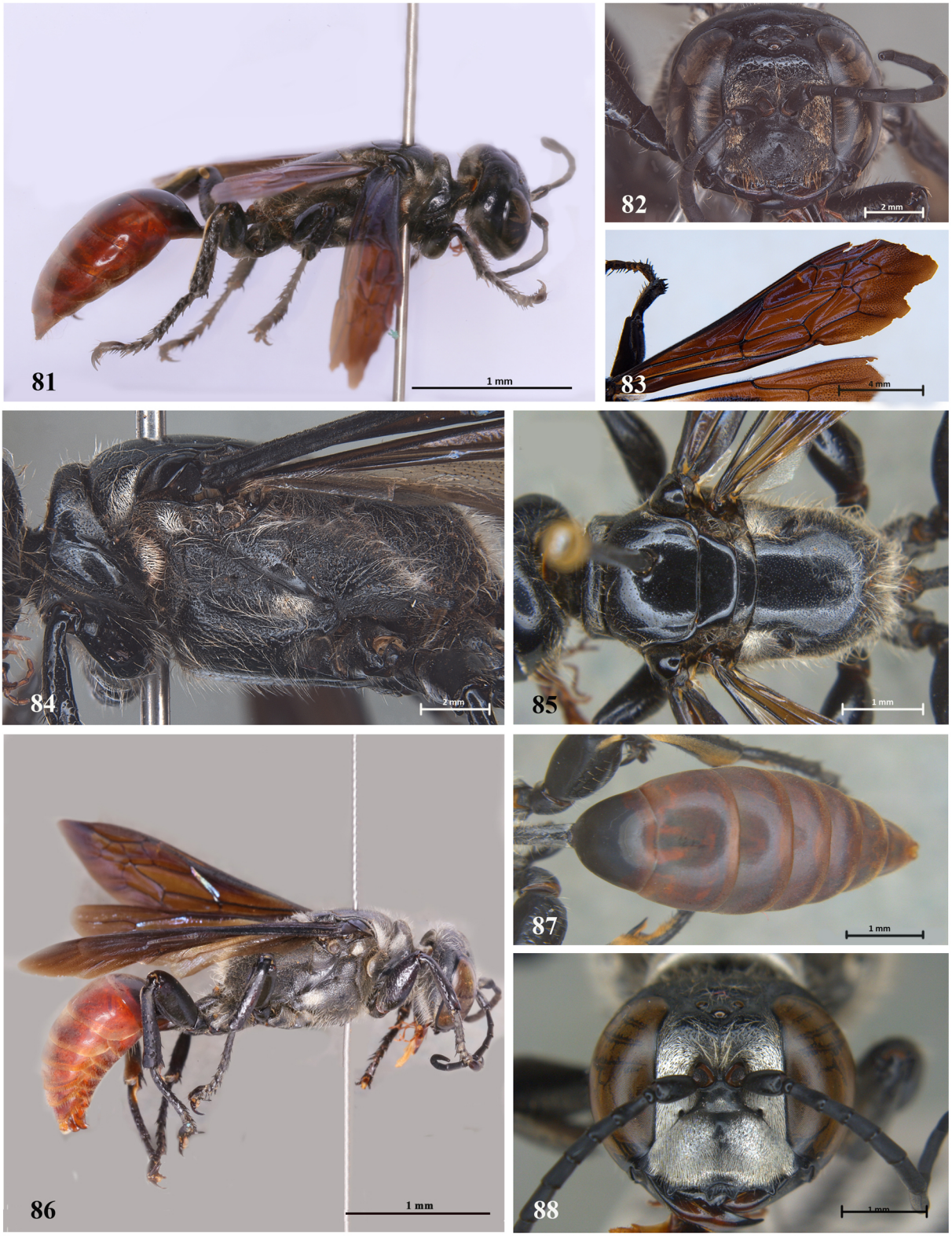
66. Habitus, lateral view; 67. Head, frontal view; 68. Lower half of head, frontal view; 69. Hind tarsal claw; 70. Hind tibial spur; 71. Fore wing; 72. Mesosoma, dorsal view; 73. Mesosoma, lateral view; 74. Metasoma, dorsal view.

PLATE 39



***Isodontia aurifrons* (F. Smith, 1859) (Female)**
75. Habitus, lateral view; 76. Head, frontal view; 77. Mesosoma, dorsal view; 78. Mesosoma, lateral view; 79. Fore wing; 80. Metasoma, dorsal view

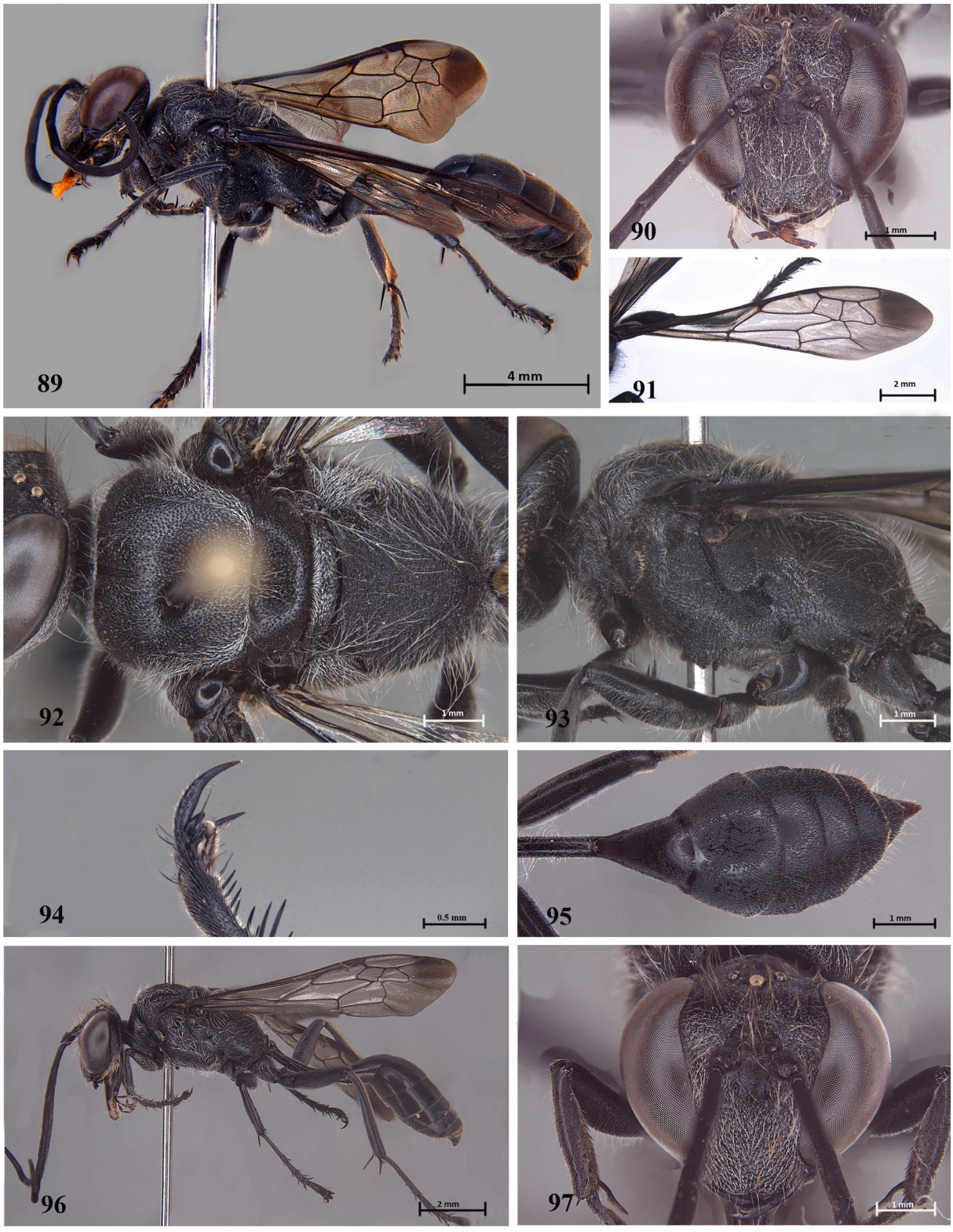
PLATE 40



***Isodontia edax* Bingham, 1897**

Figs. 81–85. Female, 81. Habitus, lateral view; 82. Head, frontal view; 83. Fore wing; 84. Mesosoma, lateral view; 85. Mesosoma, dorsal view. **Figs. 86–88. Male**, 86. Habitus, lateral view; 87. Metasoma, dorsal view; 88. Head, frontal view.

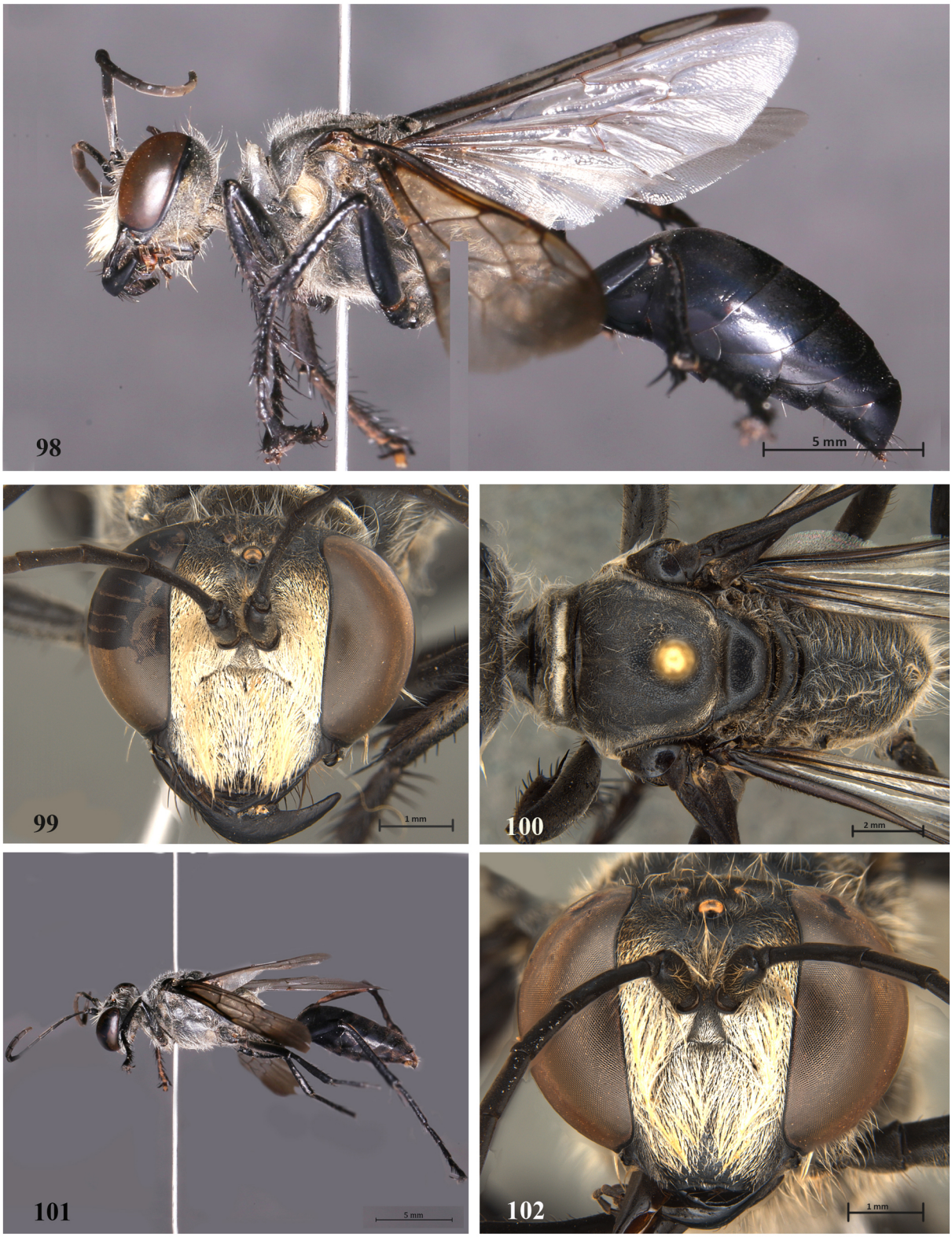
PLATE 41



***Isodontia nigelloides* (Strand, 1915)**

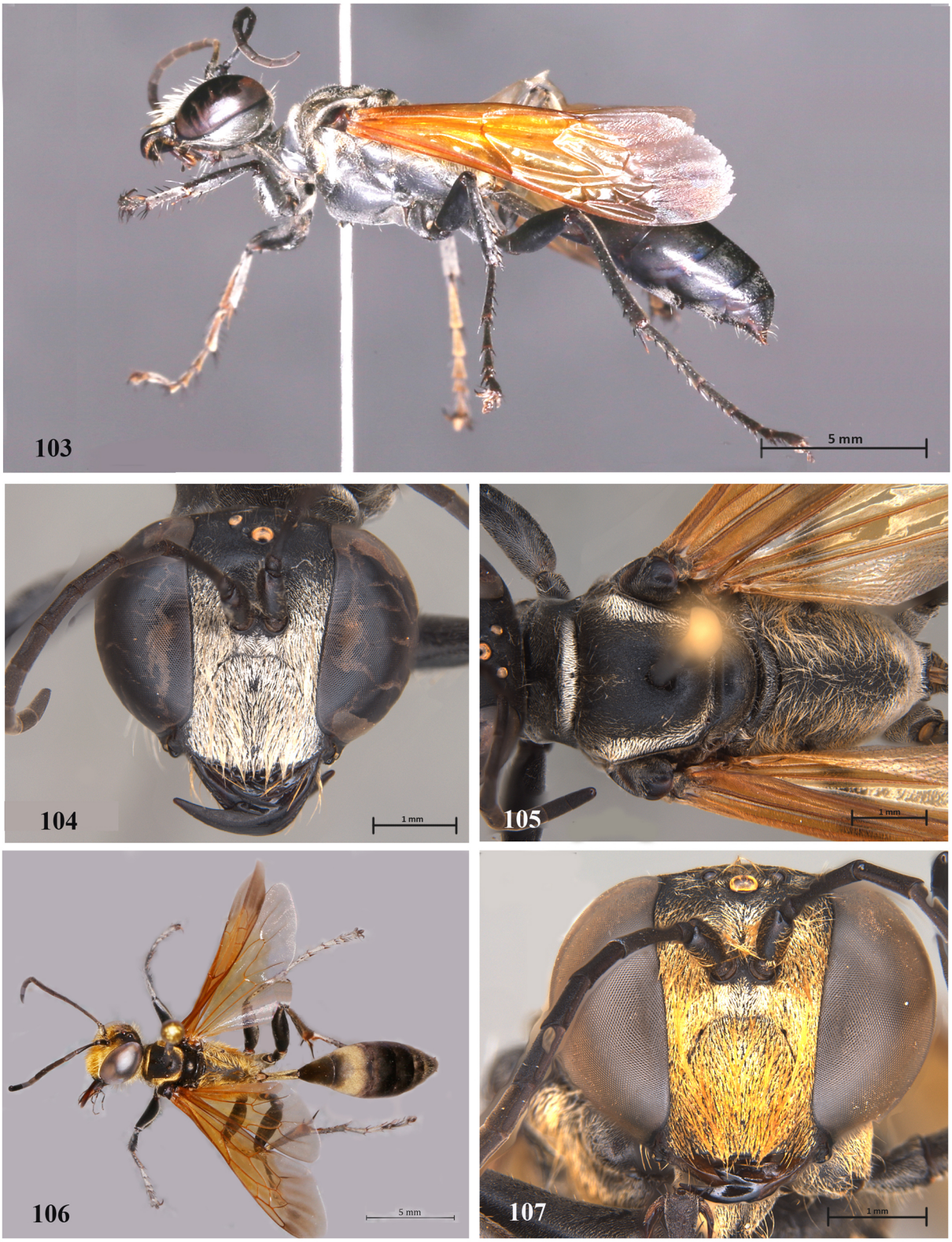
Figs. 89–95. Female, 89. Habitus, lateral view; 90. Head, frontal view; 91. Fore wing; 92. Mesosoma, dorsal view; 93. Mesosoma, lateral view; 94. Tarsal claw; 95. Metasoma, dorsal view**. Figs. 96–97. Male,** 96. Habitus, lateral view; 97. Head, frontal view.

PLATE 42



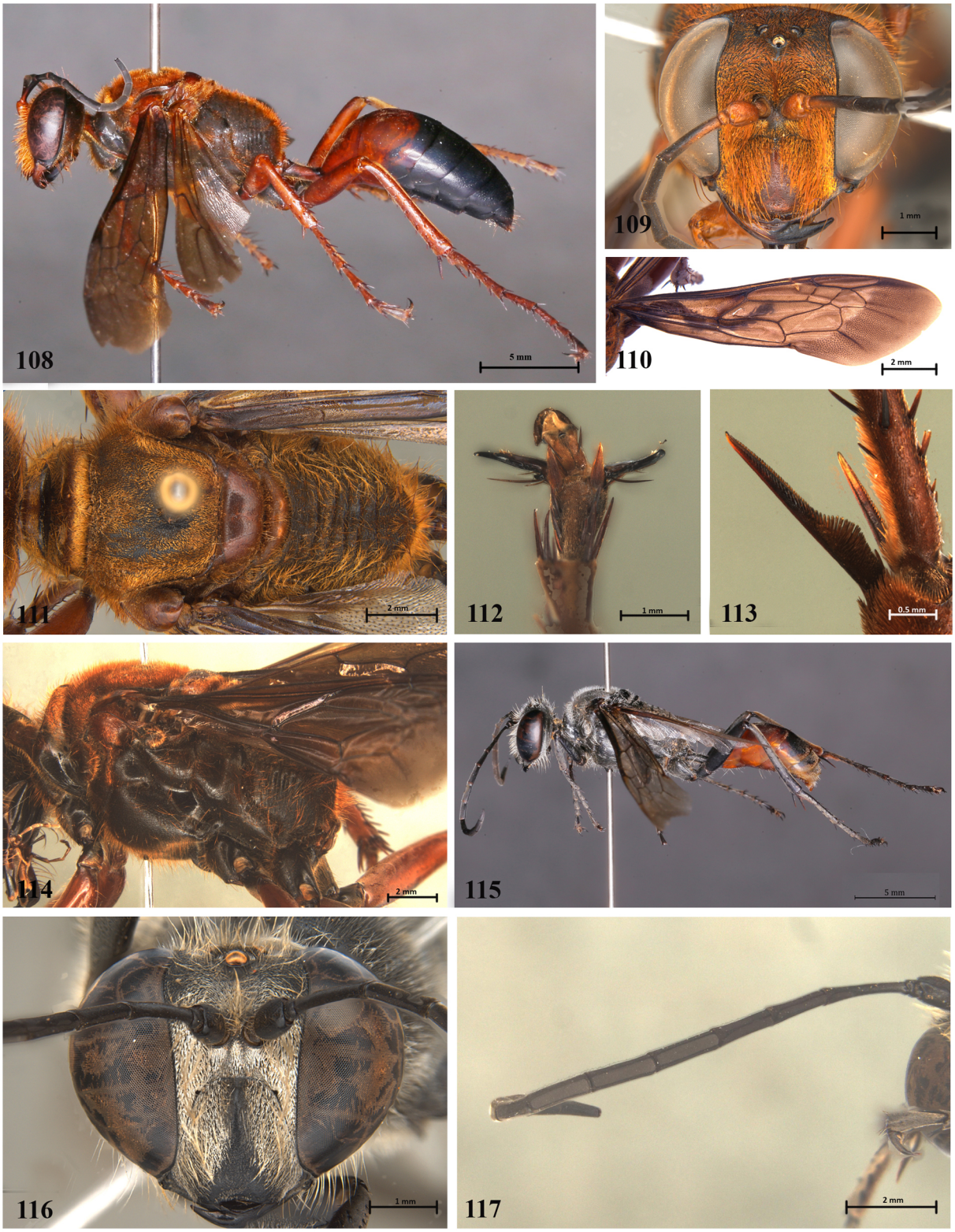
***Sphex argentatus* Fabricius, 1787**
Figs. 98–100. Female, 98. Habitus, lateral view; 99. Head, frontal view; 100. Mesosoma, dorsal view;
Figs. 101–102. Male, 101. Habitus, lateral view; 102. . Head, frontal view.

PLATE 43



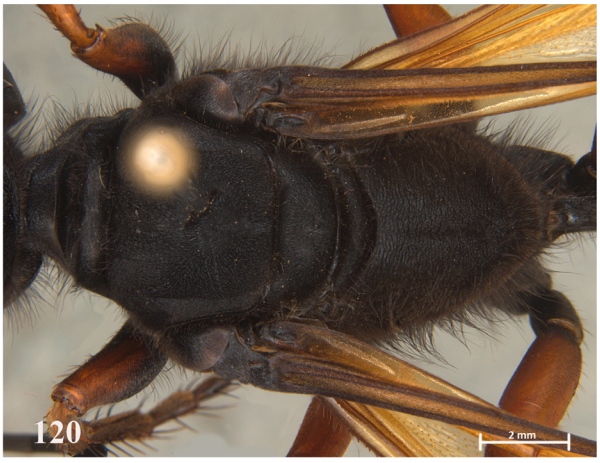
***Sphex obscurus* (Fabricius, 1804)**
Figs. 103–105. Female, 103. Habitus, lateral view; 104. Head, frontal view; 105. Mesosoma, dorsal view.
Figs. 106–107. Male, 106. Habitus, lateral view; 107. Head, frontal view.

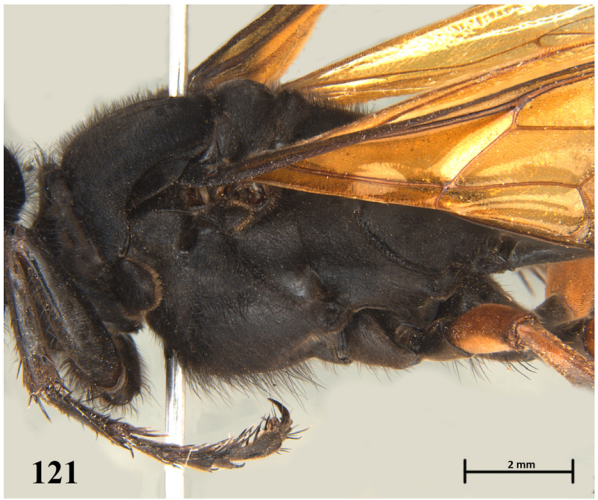
PLATE 44

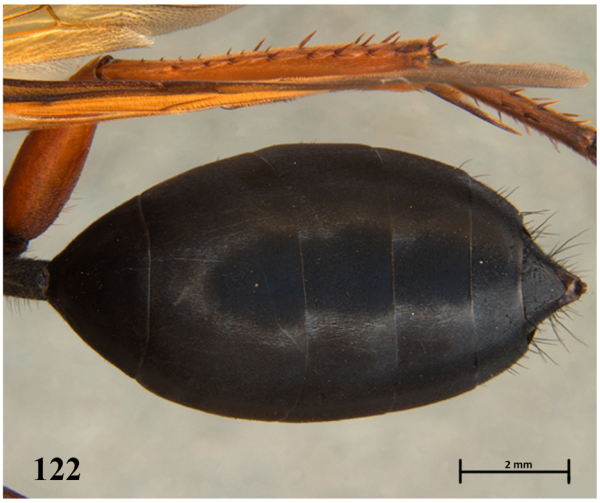


***Sphex sericeus* (Fabricius, 1793)**
Figs. 108–114. **Female**, 108. Habitus, lateral view; 109. Head, frontal view; 110. Fore wing; 111. Mesosoma, dorsal view; 112. Apicoventral setae; 113. Tibial spur; 114. Mesosoma, lateral view. **Figs. 115–117**. **Male**, 115. Habitus, lateral view; 116. Head, frontal view, 117. Flagellomeres with Placoids.

PLATE 45







***Sphex subtruncatus* Dahlbom, 1843 (Female)**
118. Habitus, lateral view; 119. Head, frontal view; 120. Mesosoma, dorsal view; 121. Mesosoma, lateral view; 122. Metasoma, dorsal view.

PLATE 46

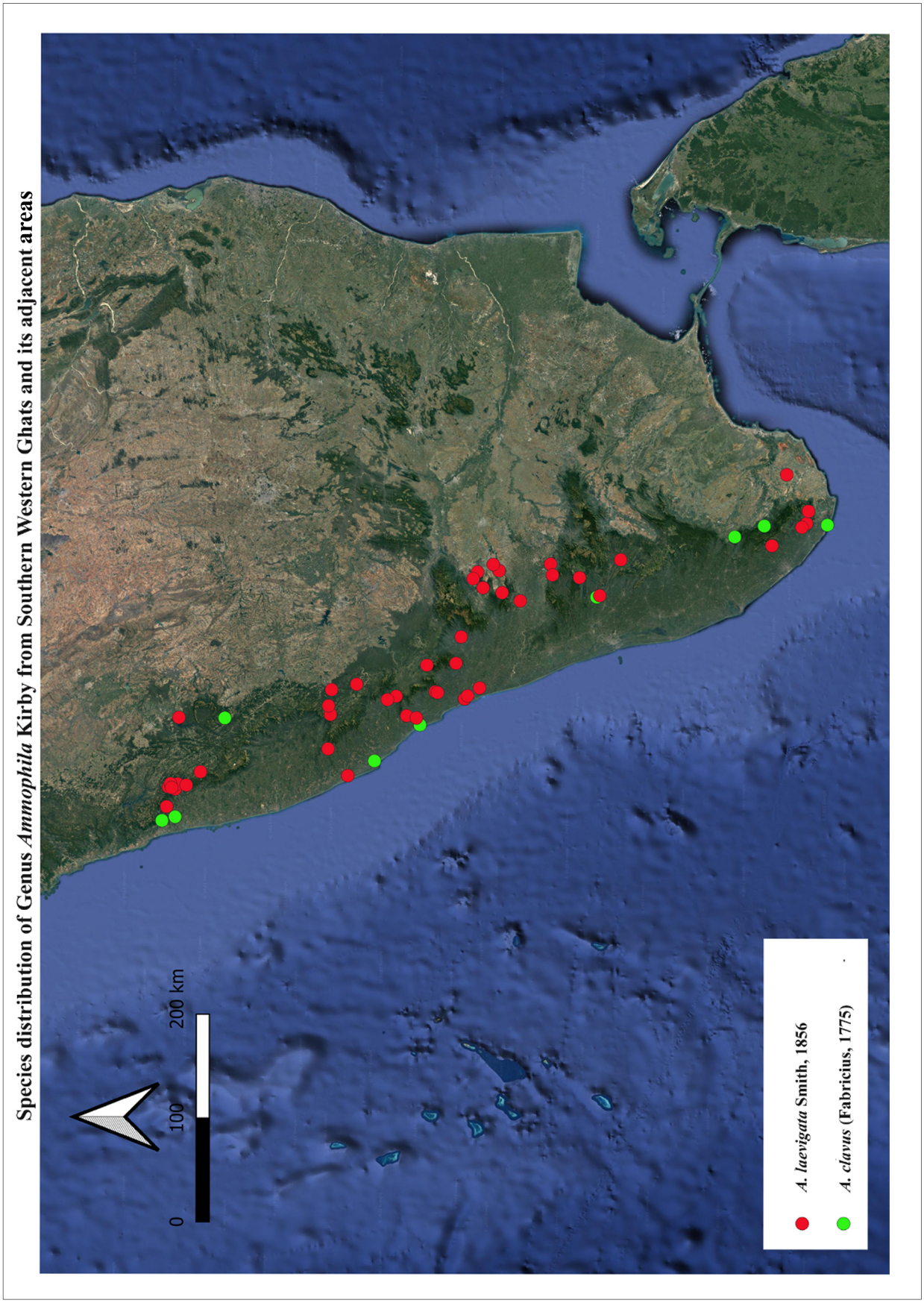

Species distribution of Genus *Ammophila* Kirby from Southern Western Ghats and its adjacent areas
0
100
200 km
A. laevigata Smith, 1856
A. clavus (Fabricius, 1775)

PLATE 47

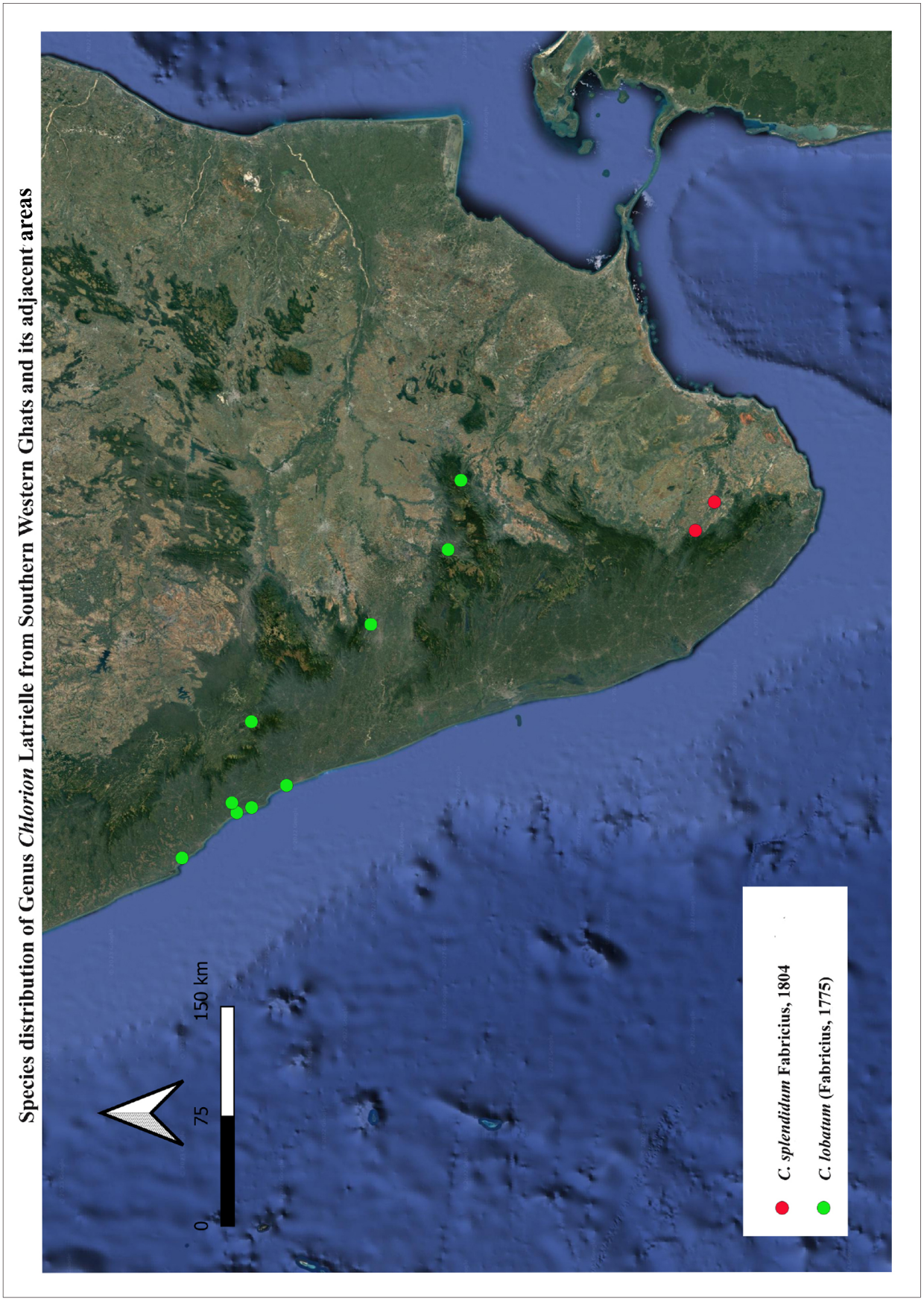

Species distribution of Genus *Chlorion* Latrielle from Southern Western Ghats and its adjacent areas
0
75
150 km
C. splendidum Fabricius, 1804
C. lobatum (Fabricius, 1775)

PLATE 48

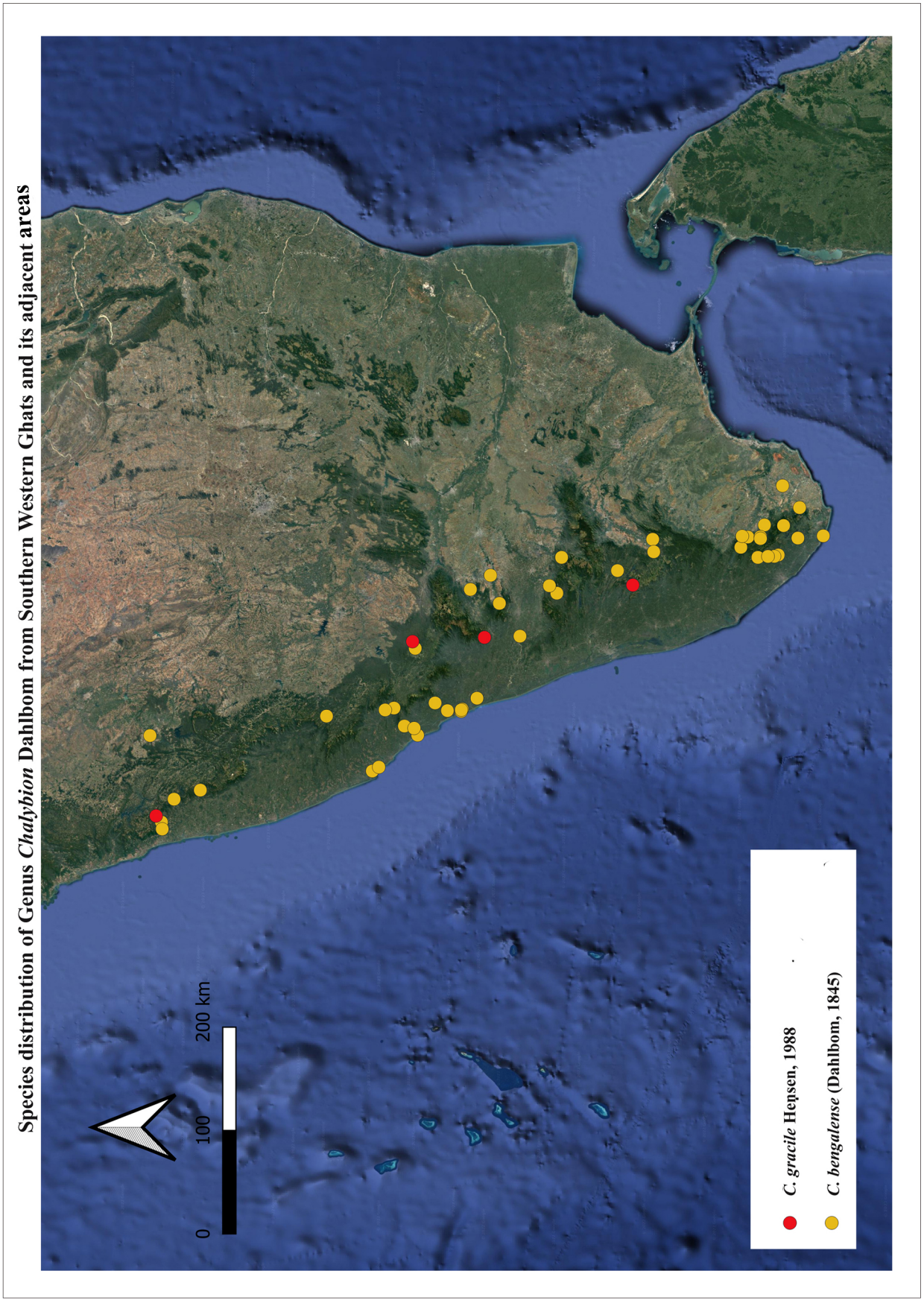

Species distribution of Genus *Chalybion* Dahlbom from Southern Western Ghats and its adjacent areas
0
100
200 km
C. gracile Hepsen, 1988
C. bengalense (Dahlbom, 1845)

PLATE 49

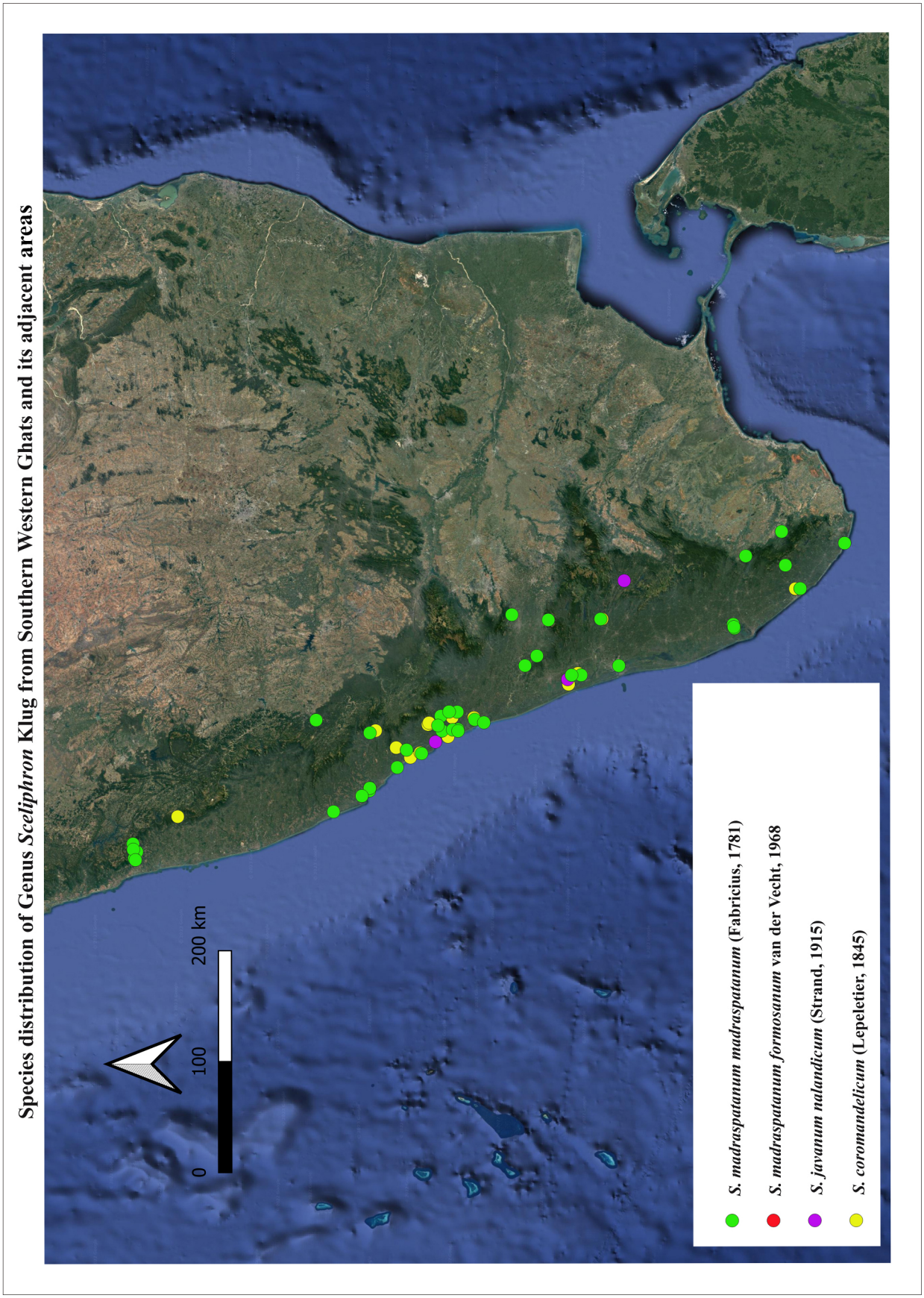

Species distribution of Genus *Sceliphron* Klug from Southern Western Ghats and its adjacent areas
0
100
200 km
S. madraspatanum madraspatanum (Fabricius, 1781)
S. madraspatanum formosanum van der Vecht, 1968
S. javanum nalandicum (Strand, 1915)
S. coromandelicum (Lepeletier, 1845)

PLATE 50

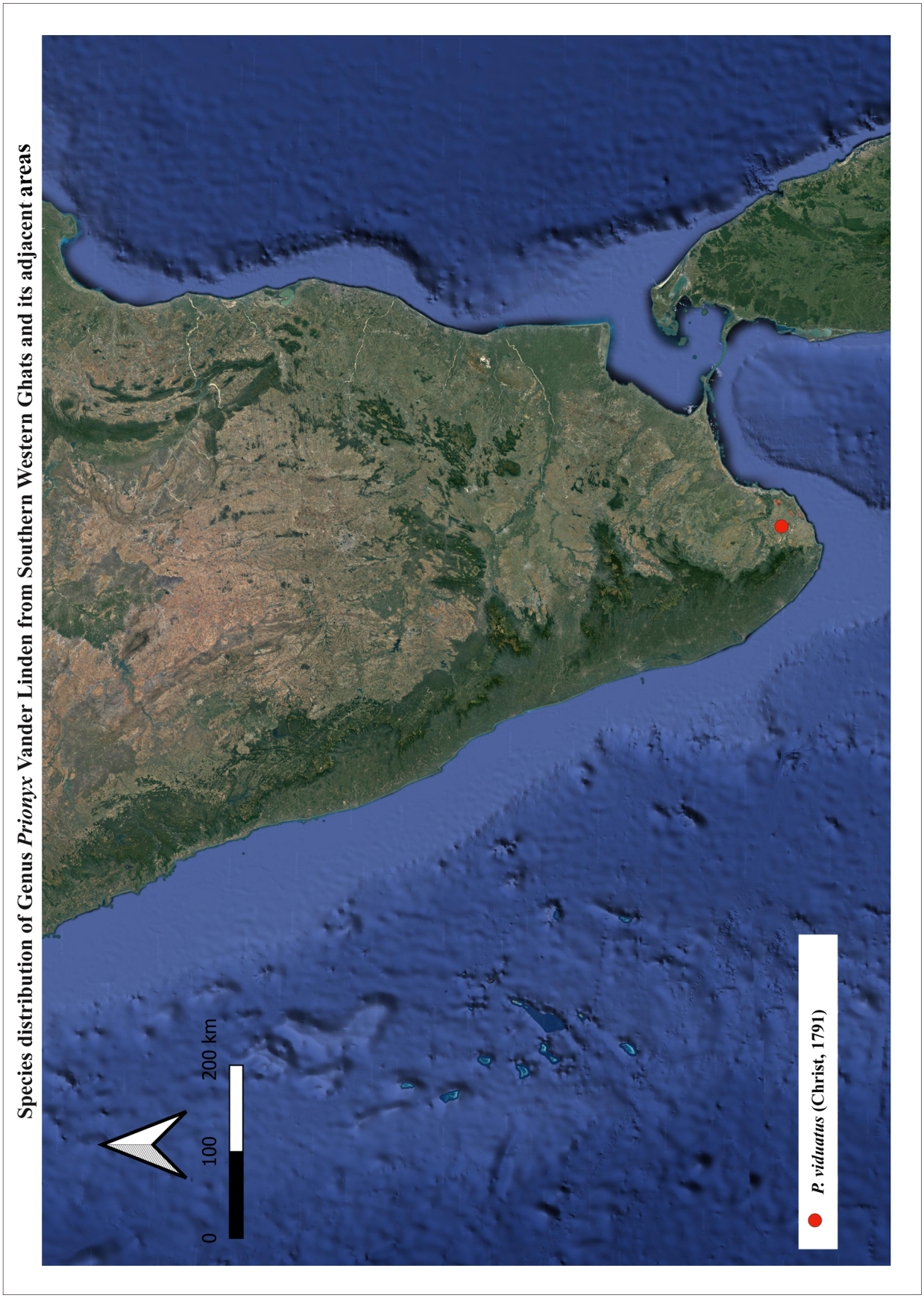

Species distribution of Genus *Prionyx* Vander Linden from Southern Western Ghats and its adjacent areas
0
100
200 km
P. viduatus (Christ, 1791)

PLATE 51

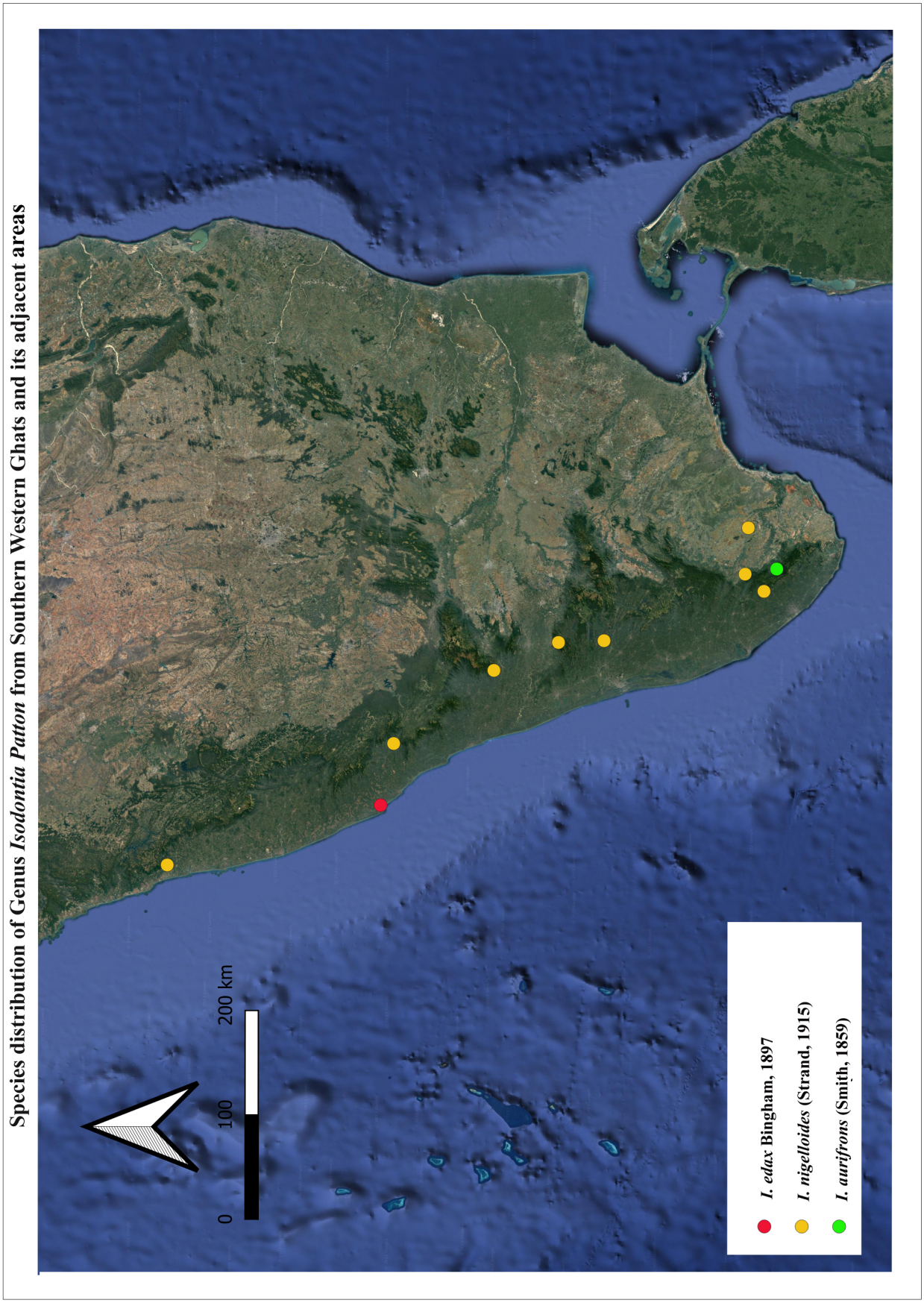
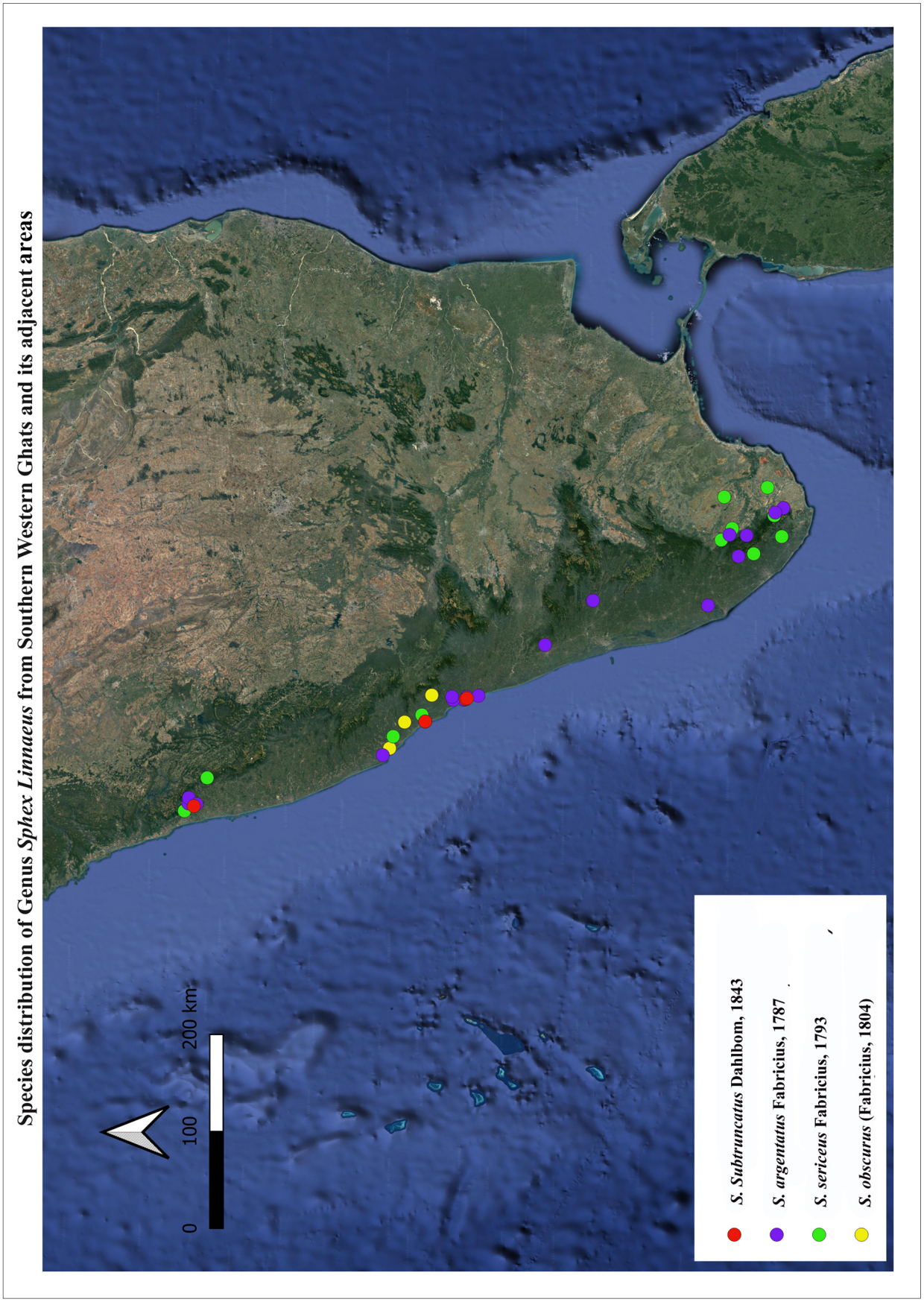

Species distribution of Genus *Isodontia Patton* from Southern Western Ghats and its adjacent areas
0
100
200 km
I. edax Bingham, 1897
I. nigelloides (Strand, 1915)
I. aurifrons (Smith, 1859)

PLATE 52


Species distribution of Genus *Sphex Linnaeus* from Southern Western Ghats and its adjacent areas
0
100
200 km
S. Subtruncatus Dahlbom, 1843
S. argentatus Fabricius, 1787
S. sericeus Fabricius, 1793
S. obscurus (Fabricius, 1804)

SUMMARY AND CONCLUSION

5. SUMMARY AND CONCLUSION

As previously stated, knowledge of ampulicid and sphecid fauna in the southern Western Ghats is far from complete. To address this gap in knowledge, a three-year taxonomic study of the Ampulicidae and Sphecidae families from the southern Western Ghats and surrounding areas was done by me.

The findings are summarised below:

- A total of 16 species belonging to three genera in two subfamilies of family Ampulicidae and a total of 17 taxa (species and subspecies) belonging to seven genera in four subfamilies of family Sphecidae were documented from the study area.
- Three new species of family Ampulicidae were described and published (Anagha & Girish Kumar, 2019; Anagha *et al*., 2020b).
- Two species, each belonging to family Ampulicidae and Sphecidae and a subspecies of family Sphecidae were recorded for first time from India (Anagha & Girish Kumar, 2019; Anagha *et al*., 2021a; Anagha *et al*., 2023b) .
- Eight ampulicid species and five sphecids were new state records.
- Species ***Shex zubaidiyacus*** Augul, 2013 was synonymised with ***Sphex obscurus*** (Fabricius, 1804) (Anagha *et al*., 2021b).
- Key to the Indian genera of each subfamilies, diagnosis of identified species with distributional records, and redescription of four little known species, were provided. Plates to all the examined species were prepared and provided at the end of the corresponding chapter (Family).
- Co-ordinates using accurate GPS were noted for the collection site of ampulicid and sphecid specimens and distribution maps were prepared using QGIS software.
- Type specimens from **Natural History Museum, London, Oxford University Museum of Natural History, UK, and Zoological Museum, Copenhagen,** were studied inorder to validate the identity of few collected species.

5.1. New species

* *Ampulex sadiyae* Anagha & Girish Kumar, 2019
* *Dolichurus chareshi* Anagha & Girish Kumar, 2020
* *Dolichurus sahyadriensis* Anagha & Girish Kumar, 2020

5.2. New country records

5.2.1. Ampulicidae

* *Dolichurus aridulus* Krombein, 1979

5.2.2. Sphecidae

* *Chalybion gracile* Hensen, 1988
* *Sceliphron madraspatanum formosanum* van der Vecht, 1968

5.3. New state records

5.3.1. Kerala

5.3.1.1. Ampulicidae

* *Ampulex ceylonica* Krombein, 1979
* *Ampulex dissector* (Thunberg, 1822)
* *Ampulex ruficornis* (Cameron, 1889)
* *Dolichurus albifacies* Krombein, 1979
* *Dolichurus taprobanae* Smith, 1869

5.3.1.2. Sphecidae

* *Sphex obscurus* (Fabricius, 1804)
* *Isodontia edax* (Bingham, 1897)

5.3.2. Tamil Nadu

5.3.2.1. Ampulicidae

* *Ampulex ceylonica* Krombein, 1979
* *Dolichurus albifacies* Krombein, 1979
* *Dolichurus amamiensis* Tsuneki and Iida, 1964
* *Dolichurus gilberti* Turner, 1912
* *Dolichurus taprobanae* Smith, 1869

5.3.2.2. Sphecidae

* *Chlorion splendidum* Fabricius, 1804
* *Prionyx viduatus* (Christ, 1791)

* *Isodontia aurifrons* (Smith, 1859)

5.3.3. Karnataka

5.3.3.1. Ampulicidae

* *Ampulex ruficornis* (Cameron, 1889)
* *Dolichurus amamiensis* Tsuneki and Iida, 1964
* *Dolichurus taprobanae* Smith, 1869

5.4. Future Prospects

Less number of new taxa and newly recorded species from the study area may indicate that southern Western Ghats is not so rich in terms of ampulicid and sphecid fauna. Here, the present study will form an initial reference work for ampulicid and sphecid fauna of southern Western Ghats as it provide a baseline information on the distribution of these wasps and is expected that future research work will give more insights into diversity and other biological aspects of these ecologically significant group in southern Western Ghats. The insufficient data on the variant yellow patterns in *Sceliphron* species, which may indicate different species or variance within the same populations, or simply phenotypic plasticity, necessitates molecular and phylogenetic studies to determine the interrelationship or divergence of the subspecies. Variation in the morphology of various species are also a promising aspect that has yet to be explored by their evolutionary history and molecular studies.

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A taxonomic study of the genus *Ampulex* Jurine (Hymenoptera: Ampulicidae) from India with the description of one new species from Kerala

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Key words: *Ampulex,* India, species, new record, key.

Abstract

The genus *Ampulex* Jurine (Hymenoptera: Ampulicidae) is studied from India with the description of one new species, *Ampulex sadiyae* Anagha and Girish Kumar sp. nov., from Kerala. The reported distributions of *A. ceylonica* Krombein, *A. compressa* (Fabricius), and *A. dissector* (Thunberg) within various states of India are augmented here. A key and an updated checklist to the Indian species of *Ampulex* Jurine are provided.

1. Introduction

The genus *Ampulex* Jurine is the largest genus within the family Ampulicidae and the members are commonly known as cockroach wasps. It is a widespread tropical genus distributed in Australia, Ethiopian, Nearctic, Neotropical, Oriental and Palearctic Regions. One hundred and thirty two species are recorded in this genus worldwide, of which twenty five species are recorded from India (Pulawski, 2019). This paper deals with the species belonging to the genus *Ampulex* from India with the description of one new species, *Ampulex sadiyae* Anagha and Girish Kumar sp. nov., from Kerala. New distributional records from various Indian states for *A. ceylonica* Krombein, *A. compressa* (Fabricius), and *A. dissector* (Thunberg) are reported. A key and an updated checklist to the Indian species of *Ampulex* Jurine are also provided.

2. Materials and Methods

The present study is based on the specimens present in the Western Ghat Regional Centre, Zoological Survey of India, Kozhikode, and also the fresh specimens collected from various localities of India. The specimens were studied under a stereoscopic binocular microscope of model LEICA M205 and the images were captured with the camera model LEICA DFC 500 except few profile photos (Figs. 11–14) were captured with the camera Canon Power Shot SX 540 HS. Measurements were obtained using Leica LAS (Leica Application Suite V3.80) microsystems by Leica (Heerburg, Switzerland). Images at varying depth were stacked using Leica Automontage Software V3.80 and the final illustrations were post-processed for contrast and brightness using Adobe® Photoshop® CS5 (Version 6.1) software. All the specimens were properly preserved,

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duly labelled and added to the 'National Zoological Collections' of the Western Ghat Regional Centre, Zoological Survey of India, Kozhikode (ZSIK).

Abbreviations used for the Museums: EDZMU — Entomology Department, Zoological Museum, Uppsala University, P.O. Box 561, S-75122, Uppsala, Sweden; NHM — The Natural History Museum, London, England; MHNG — Musée d' Histoire Naturelle, Genève, Switzerland; NHMW — Naturhistorisches Museum, Wien, Austria; NRS — Naturhistoriska Riksmuseet, Stockholm, Sweden; OXUM — Hope Department of Zoology, Oxford, England; TMB — Természettudományi Múzeum, Budapest, Hungary; USNM — National Museum of Natural History, Washington, D.C., U.S.A.; ZSIK — Western Ghat Regional Centre, Zoological Survey of India, Kozhikode, India.

Abbreviations used for the terms: F = Flagellar segment; IOD = Inter Ocular Distance; LOL = Lateral Ocellar Length; OOL = Ocellocular Length; POL = Posterior Ocellar Length; T = Metasomal tergum.

3. Results & Discussion

Genus *Ampulex* Jurine, 1807

Ampulex Jurine, 1807: 132. Type species: *Chlorion compressum* of Latreille and of Fabricius [= *Chlorion compressum* (Fabricius, 1804) = *Sphex compressus* Fabricius, 1781, designated by Audouin, 1822: 301.

Diagnosis: Antennal sockets each with an overhanging frontal lobe; metasternum Y- shaped with arms directed posteriorly; petiole inserted between and on same level as hind coxae.

Distribution: Australia, Ethiopian, Nearctic, Neotropical, Oriental, and Palearctic regions.

Key to Indian species of *Ampulex* Jurine (except *Ampulex sodalicia* Kohl due to want of enough details)

1. Female. 2

— Male. ……..... 24

2. Integument of body brilliant metallic green, blue, bluish green, bluish or purple. ……..... 3

— Integument of body not metallic, either red and black or black. …….. 19

3. Mesoscutum with distinct punctures. ……..... 4

— Mesoscutum without punctures, almost smooth or aciculate. …….. 17

4. Pronotum with transverse rugulae, striations or few obscure transverse wrinkles. ……..... 5

— Pronotum without transverse rugulae, striations or obscure transverse wrinkles. ……..... 8

5. Temple behind eye with a prominent tubercle. ...……..…… ***sikkimensis*** **(Kriechbaumer**)

— Temple behind eye without prominent tubercle. ……..... 6

6. Mid and hind femora red...…….. 7

— Only hind femora red. ……..…… ***dissector*** **(Thunberg)**

7. Parapsidal furrows of mesoscutum distinct; most of disc of second metasomal segment with scattered small punctures, dense fine punctures only on narrow lateral strip. …..…… ***compressa*** **(Fabricius)**

— Parapsidal furrows of mesoscutum not clearly defined; second metasomal segment much more strongly punctured. ……..…..…… ***carinifrons*** **Cameron**

8. Wings fuscoviolaceous or smoky violaceous or smoky fuscous. ……. 9

— Wings fuscohyaline or hyaline with slight infumation. ……..... 15

9. Hind femora partly or completely red. ……..... 10

— Hind femora not red, either blue or black. ……..... ***difficilis*** **Strand**

10. Third and fourth joints of antennae equal in length. ……..... 11

— Third and fourth joints of antennae not equal in length. ……..... 12

11. Clypeal carina bifurcating close to apex. …… ***latifrons*** **Kohl**

— Clypeal carina not bifurcating close to apex. …….. ***interstitialis*** **Cameron**

12. Head partly or completely purple. ……..... 13

— Head not purple, either blue or green. ……..... 14

13. Legs black, apex of hind femora and tibiae purple. …..…… ***khasiana*** **Cameron**

— Legs blue, apex of hind femora and tibiae purple. …… ***longicollis*** **Cameron**

14. Only hind femora red..... ……..... ***major*** **Kohl**

— Mid and hind femora red. ……..... ***montana*** **Cameron**

15. Vertex and pronotum punctate. ……..... 16

— Vertex and pronotum almost impunctate. .....……. ***aborensis*** **Nurse**

16. Head bluish green. …..... ***hospes cognata*** **Kohl**

— Head purple mixed with dark green. .....…….. ***himalayensis*** **Cameron**

17. Pronotum and mesoscutum aciculated. .....…..…… ***pilosa*** **Cameron**

— Pronotum and mesoscutum not aciculated, bare. ……..... 18

18. Front with punctures. ……..…..... ***crudelis*** **Bingham**

— Front without punctures. ……..…..... ***ruficoxis*** **Cameron**

19. Integument entirely black. ……..... ***approximata*** **Turner**

— Integument not entirely black. ……..... 20

20. Mesosoma and legs entirely black. ……..…..... ***nigricans*** **Cameron**

— Mesosoma and legs not entirely black. ……..……..... 21

21. Greater part of mesosoma rufous or medium brown. ……..……..... 22

— Mesosoma black with some violet patches. ……..…..... ***rothneyi*** **Cameron**

22. First metasomal segment with sides diverging towards apex. ……..... 23

— First metasomal segment with sides not diverging towards apex, nodose. ……..... ***ruficornis*** **(Cameron)**

23. Mesoscutum microsculptured with irregularly interspersed macropunctures. …… ***ceylonica*** **Krombein**

— Mesoscutum microsculptured without irregularly interspersed macropunctures (Fig. 5). ……. ***sadiyae*** **Anagha and Girish Kumar sp. nov.**

24. Integument of body brilliant metallic green, blue, bluish green, bluish or purple. .....…… 25

— Integument of body not metallic, either red and black or black. ……... 30

25. Mesosoma thickly covered with long black hairs. …… ***pilosa*** **Cameron**

— Mesosoma sparsely or not covered with long black hairs. ……..... 26

26. Pronotum with transverse rugulae, striations or wrinkles. ……..... 27

— Pronotum without transverse rugulae, striations or wrinkles. ……..... 28

27. Mid and hind femora red. ……..... ***compressa*** **(Fabricius)**

— Only hind femora red. ……..... ***dissector*** **(Thunberg)**

28. Hind femora with more or less blue violet shimmering. ..…… ***difficilis*** **Strand**

— Hind femora not with blue violet shimmering, red. ……..... 29

29. Third and fourth joint of antennae equal in length. …… ***latifrons*** **Kohl**

— Third and fourth joint of antennae not equal in length, third joint slightly but distinctly longer than fourth. ……..... ***assamensis*** **Cameron**

30. Integument entirely black. ……..… ***approximata*** **Turner**

— Integument not entirely black. ……..……..... 31

31. Mesosoma and legs entirely black. ……..…… ***nigricans*** **Cameron**

— Mesosoma and legs not entirely black. ……..……..... 32

32. Greater part of mesosoma rufous or medium brown. ……..…..... 33

— Mesosoma black with some violet patches. ……..…..... ***rothneyi*** **Cameron**

33. First metasomal segment with sides diverging towards apex. ……..... 34

— First metasomal segment with sides not diverging towards apex, nodose. ……..... ***ruficornis*** **(Cameron)**

34. Mesoscutum closely punctured. ……..... ***ceylonica*** **Krombein**

— Mesoscutum microsculptured without irregularly interspersed macropunctures. ……..… ***constanceae*** **(Cameron)**

1. ***Ampulex sadiyae*** **Anagha and Girish Kumar sp. nov.**

(Figs. 1-8)

Diagnosis: The species is characterized by having frons with irregular longitudinal striations (Fig. 2); vertex and occiput with minute setigerous punctures; mesopleurae rough with small decumbent and erect large hairs (Fig. 6); pronotum and mesoscutum microsculptured (Fig. 5); anterior margin of scutellum with linear depression of coalesced punctures (Fig. 5); propodeal spine blunt (Fig. 5); mesoscutum anteromedially with V-shaped ridge.

Description: Holotype ♀. Head. Head rounded behind eyes; clypeus conical shaped with a median carina, apical end and lateral side toothed (Fig. 3); head 1.9 × as wide as IOD at anterior ocellus; ocelli forming low triangle; POL 1.16 × LOL and 0.32 × OOL; frons with irregular longitudinal striations; eyes surrounded by carina; F1 0.79 × combined length of F2 and F3.

Mesosoma: Pronotum longer than broad, base narrowed than apex, microsculptured with a sharp median furrow in the middle, pair of acute tubercles absent anterolaterally (Fig. 5); mesoscutum microsculptured, almost impunctate, mesoscutum anteromedially with V shaped ridge, parapsidal furrows and notauli distinct (Fig. 5); scutellum and metanotum microsculptured with very few scattered punctures (Fig. 5); anterior margin of scutellum with linear depression of coalesced punctures; propodeal dorsum coarsely areolate with a median and four lateral longitudinal ridges connected by several transverse carina with truncate median process at posterior margin, propodeal spines blunt (Fig. 5); mesopleuron with small decumbent and erect large hairs (Fig. 6); fore wing with submarginal cell bent away from wing margin for most of its length, pointed distally, first inter submarginal veinlet lacking, so that submarginal cells I and II fused to form markedly long cell (Fig. 7); legs long and slender.

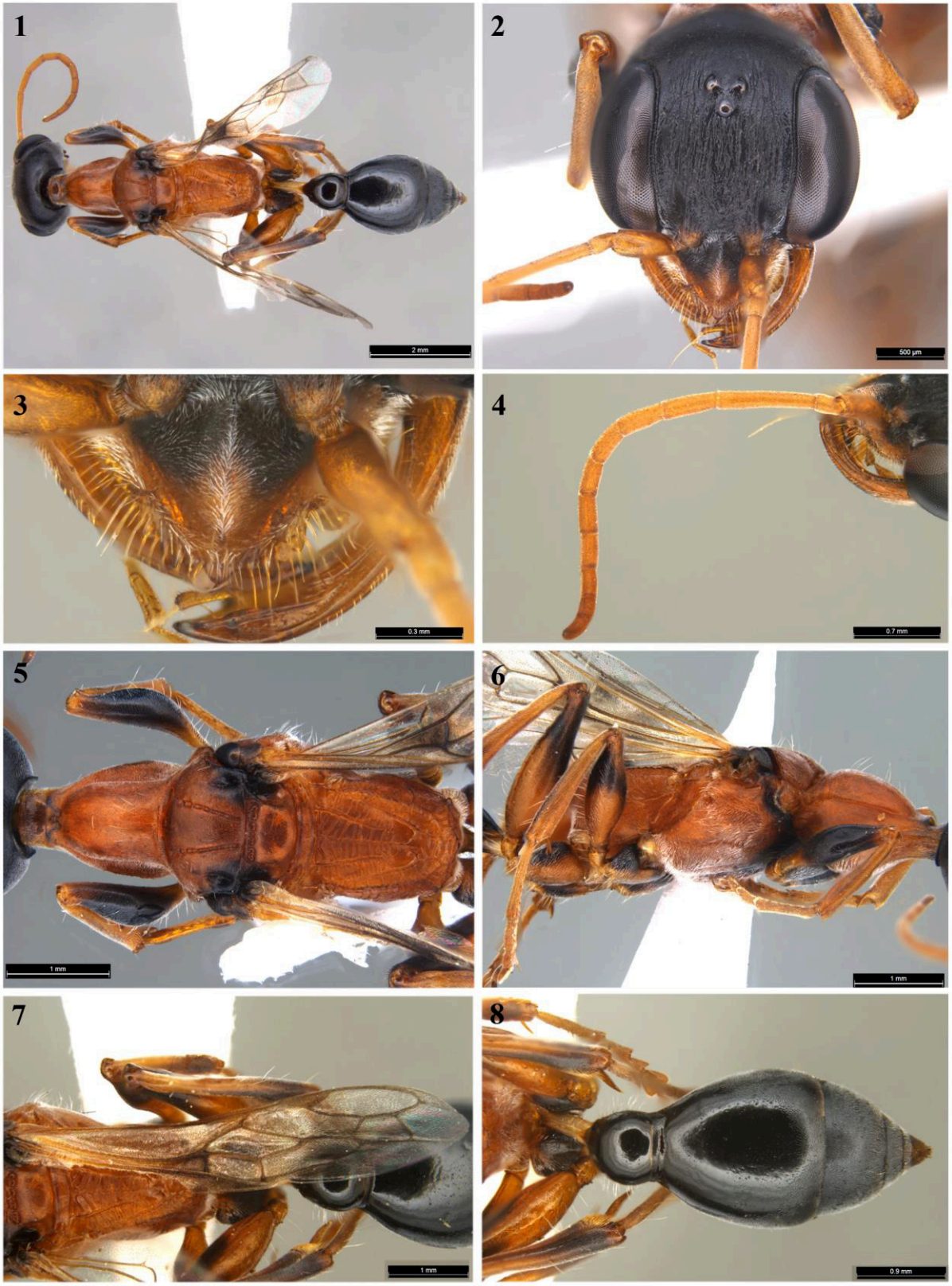
Metasoma: Petiole almost evenly tubular; T1 small and shining (Fig. 8); T2 exceptionally large and broader than T1, 2 × longer than T1 and 2.25 × wider than T1; posterolateral corner of T2 and remaining metasomal tergites with finer setigerous punctures (Fig. 8).

Colour: The following Black: Head, tegulae, most of femora, coxa, and metasoma. The following light red: mandibles, most of clypeus, prothorax, most of mesoscutum, mesopleuron, and all tarsus. Propodeal spines brownish; petiole whitish; fore wing slightly yellowish with dark markings in marginal cells, hind wing hyaline.

Length: 11 mm.

Male: Unknown.

Materials examined: Holotype ♀, INDIA: Kerala, Kozhikode district, Kovoor (11°16' 14.16''N, 75°49'52.32''E, 19m), 26.iii.2019, Coll. Sadiya Thasneem, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13237.



FIGURES 1–8. *Ampulex sadiyae* Anagha and Girish Kumar sp. nov. Holotype Female. 1. Habitus, dorsal view; 2. Head, frontal view; 3. Clypeus, frontal view; 4. Antennae; 5. Mesosoma, dorsal view; 6. Mesosoma, lateral view; 7. Fore wing; 8. Metasoma, dorsal view.

Distribution: India: Kerala.

Etymology: The species epithet is derived from the name of the collector of holotype.

Discussion: This new species comes close to the other non-metallic and small-sized *Ampulex* species such as *A. ceylonica* and *A. ruficornis*, but distinctly differs from both. The female of this new species differs from female of *A. ceylonica* in having: (1) Frons with irregular longitudinal striations (in *A. ceylonica*, frons dull, granulate from fine close punctuation with larger moderately scattered punctures); (2) Absence of pair of acute tubercles on pronotum anterolaterally (in *A. ceylonica*, a pair of acute tubercles on pronotum present); (3) Mesoscutum microsculptured, almost impunctate, mesopleurae rough with small decumbent and erect large hairs (in *A. ceylonica*, mesoscutum with dense fine punctures and interspersed mostly subcontiguous larger punctures, mesopleuron similarly punctate); and (4) Propodeal spines being short, blunt and brownish (in *A. ceylonica*, propodeal spines long, curved and whitish at tip).

The female of this new species differs from female of *A. ruficornis* in having: (1) Frons with irregular longitudinal striations (in *A. ruficornis*, frons with dense fine punctures); (2) Absence of pair of acute tubercles on pronotum antereolaterally *(in A. ruficornis*, a pair of acute tubercles on pronotum present); (3) Mesoscutum microsculptured, almost impunctate, mesopleurae rough with small decumbent and erect large hairs (in *A. ruficornis*, mesoscutum and mesopleuron with delicate close punctuation and scattered small punctures); and (4) First metasomal segment with sides diverging towards apex (in *A. ruficornis*, first metasomal segment with sides not diverging towards apex).

Ampulex constanceae is the other non-metallic and small-sized *Ampulex* species from India which is known by male only. The holotype female of the present new species differs from male of *A. constanceae* in having frons with irregular longitudinal striations (in *A. constanceae* head finely rugosely punctured) (based on the male description of Cameron (1891)).

2. *Ampulex ceylonica* Krombein, 1979

(Figs. 9, 10, 15 & 16)

Ampulex ceylonica Krombein, 1979: 9, ♀, ♂. Holotype: ♀, Sri Lanka: Kandy District: Kandy, Udawattakele Sanctuary (USNM).

Diagnosis: Female. Front dull and granulate with fine close punctation and with evanescent carinae touching anterior ocellus along midline (Fig. 15); pronotal disk with delicate close punctation, scattered larger punctures on posterior half, a weak median furrow and pair of small acute tubercles anteriorly; mesoscutum with dense fine punctures and interspersed, mostly subcontiguous larger punctures; mesopleuron similarly punctate, sternaulus crenulate; propodeal dorsum with a slender, curved elongate tooth; petiole white in colour; apical third of T1 with sides diverging towards T2, not nodose. Length: 13 mm.

Male. Front and vertex with large close punctures (Fig. 16); occiput with deep median pit; pronotal disc with subcontiguous larger punctures; mesoscutum and mesopleuron with large close pits; propodeal dorsum with a slender, curved elongate tooth; petiole almost black; apical third of T1 with sides diverging towards T2, not nodose. Length: 9 mm.

Material examined: INDIA: **Kerala**, Kozhikode district, Kottooli wetland, 1 ♂, 20.vi.2019, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13151; Thiruvananthapuram district, Agasthyamalai Biosphere Reserve, Peppara Wildlife Sanctuary, Pattankulichapara, 1 ♂, 20.i.2019, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13153; Kozhikode district, Madappally, 5 ♂, 13.xi.2019, Coll. K. Anju, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13434; Thiruvananthapuram district, Neyyar Wildlife Sanctuary, Kottur, 1 ♀, Coll. M. Jafer Palot, ZSIK Regd. No. ZSI/WGRC/I.R–INV. 13161; Kozhikode district, Purameri, 1 ♀, Coll. K.P. Hanima Raveendran, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13162; Thiruvananthapuram district, Methottam, 1 ♀, Coll. S. Anagha, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13163. **Tamil Nadu**, Coimbatore district, Anaikatty, 1 ♂, 4.i.2019, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13152.

Distribution: India: Kerala (**new record**), Tamil Nadu (**new record**), Meghalaya. *Elsewhere*: Indonesia; Laos; Sri Lanka. (Pulawski, 2019).

3. *Ampulex compressa* (Fabricius, 1781)

(Figs. 11, 12, 17 & 18)

Ampulex compressa (Fabricius), 1781: 445, sex not indicated (as *compressa*, incorrect original termination). Holotype or syntypes: India: Kerala: Malabar (NHM, Banks coll.).

Ampulex sinensis de Saussure, 1867: 43, ♂. Holotype or syntypes: ♂, China: Hong Kong (NHMW). Synonymized with *Ampulex compressa* by Gerstaecker, 1871: 852, synonymy confirmed by Kohl, 1893: 492.

Chlorampulex striolata de Saussure, 1892: 446, ♀. Holotype or syntypes: ♀, Tanzania: Zanzibar: no specific locality (MHNG). Synonymized with *Ampulex compressa* by Schulz, 1911: 152.

Diagnosis: Female. Face with narrow median area delimited below by strong carina from antennal tubercle extending upward, becoming evanescent above where it passes behind fore ocellus (Fig. 17); frontal punctures moderately large, more separated on median area than laterally (Fig. 17); vertex with moderately large, subcontiguous punctures and a short median groove; occiput with fine close punctuation; pronotal disc with a median furrow, some delicate transvers rugulae on anterior two third; mesopleuron without sternaulus; forewing with three submarginal cells; mid and hind femora red. Length: 15-24 mm.

Male. Frons with enclosed area broader, delimiting carinae stronger; punctation of frons and vertex closer and coarser than in ♀ (Fig. 18); vertex

with evanescent median groove; occiput with fine close punctures; pronotal disc with a median furrow, some stronger transvers rugulae covering most of surface; mesopleuron without sternaulus; forewing with three submarginal cells; mid and hind femora red. Length: 13-16 mm.

Materials examined: INDIA: **Arunachal Pradesh**, Lower Dibang Valley district, Roing, 1 ♀, 13.ix.1997, Coll. A.R. Lahiri and party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13092. **Himachal Pradesh**, Solan district, Solan, 1 ♂, 30.vi.1968, Coll. O.B. Chhotani, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13088. **Chhattisgarh**, Kabirdham district, Balasamund, 1 ♀, 1.ix.2011, Coll. Sunil K. Gupta, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13095. **Kerala**, Kozhikode district, Jaferkhan Colony, 1 ♀, 24.ix.2016, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10205; Wayanad district, Thirunelli, 1 ♀, 16.ii.2016, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10479; Kollam district, Karicode TKMCAS campus, 1 ♂, 1.i.2018–31.iii.2018, Coll. A.K. Aseeb, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12324; Idukki district, Keerithodu, 20.xi.1999, 1 ♂, Coll. P. M. Sureshan and party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13093; Kozhikode district, ZSI Campus Kozhikode, 2 ♀, 11.x.2018 & 19.xi.2018, Coll. C. Charesh, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13098 & 13150; Kasaragod district, Ranipuram, 1 ♀, 10.xii.2017, Coll. Rajan, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13099. **Lakshadweep**, Amini Island, 1 ♂, 26.iii.2018, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13100. **Maharashtra**, Ratnagiri district, Ratnagiri, 1 ♂, 7.vii.1981, Coll. P. Paruiand P.H. Roy, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13091. **Tripura**, South Tripura district, Abhoya, 3 ♂, 16.v.1978, Coll. J.K. Jonathan and Party, ZSIK Regd. No. ZSI/ WGRC/I.R.–INV. 13089. **Uttarakhand**, Dehradun district, Kalsi, 1 ♀, 18.vii.2019, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13101. **West Bengal**, Kolkata district, V.K. Road side, 1 ♀, 6.x.1979, Coll. S.C. Roy Chowdhary, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13090; Kolkata district, Southern Avenue, 1 ♀, 2.ix.2011, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13094; Kolkata district, Southern Avenue, 2 ♀ & 1 ♂, 21.v.2012, 16.xii.2012 & 1.xii.2012, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13096, 13097 & 13102.

Distribution: India: Andaman and Nicobar Islands, Arunachal Pradesh (**new record**), Assam, Chhattisgarh (**new record**), Himachal Pradesh (**new record**), Karnataka, Kerala, Lakshadweep (**new record**), Maharashtra, Meghalaya, Tripura (**new record**), Uttarakhand, West Bengal. *Elsewhere*: Africa; Australia; Bangladesh; Borneo; Brazil; China; France; Indonesia; Iran; Island of Bourbon; Island of Reunion; Island of St. Helena; New Caledonia; Hawaii island; Laos; Kenya; Madagascar; Mauritius; Nepal; Philippines; Seychelles; Saudi Arabia; Singapore; Sri Lanka; Tanzania; United Arab Emirates; Venezuela; Vietnam; Zanzibar. (Pulawski, 2019).

4. ***Ampulex dissector*** **(Thunberg, 1822**)

(Figs. 13 & 19)

Ampulex dissector (Thunberg), 1822: 272, sex not indicated. Holotype or syntypes (Thunberg, 1824: 341): Japan: no specific locality (EDZMU).

Ampulex amoena Stål, 1857: 63, sex not indicated. Holotype or syntypes: China: no specific locality (NRS). Synonymized with *Ampulex dissector* by ... – Kohl, 1893: 489 (original description copied).

Ampulex novarae de Saussure, 1867: 44, ♂. Holotype or syntypes: ♂, Hong Kong (NHMW). Synonymized with *Ampulex dissector* by Roman, 1912: 251.

Ampulex consimilis Kohl, 1893: 468, ♀. Holotype or syntypes: ♀, China: Hong Kong (NHMW). Synonymized with *Ampulex amoena* by Schulz, 1912: 96.

Ampulex japonica Kohl, 1893: 467, ♀. Holotype or syntypes: ♀, Japan: no specific locality (TMB). Synonymized with *Ampulex dissector* by Roman, 1912: 251.

Diagnosis: Female. Forewing with 2 submarginal cells; only hind femora red; front not keeled, surface with small subcontiguous punctures and more scattered larger ones (Fig. 19); vertex with closer larger punctures; pronotal disc with transverse rugulae interrupted by a shallow median groove; mesopleuron with sternaulus; hind femora red. Length: 13-15 mm.

Materials examined: INDIA: **Kerala**, Kannur district, Kannapuram, 1 ♀, 2.ii.2019, Coll. C. Charesh, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13103. **Uttarakhand**, Dehradun district, Kalsi, 1 ♀, 18.vii.2019, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13104, Haridwar district, Haridwar, 1 ♀, 13.x.1995, Coll. Arun Kumar and party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 13154.

Distribution: India: Kerala (**new record**), Uttarakhand. *Elsewhere*: China; Japan; Korea; Laos; Sri Lanka; Ryukyu archipelago; Taiwan; Thailand. (Pulawski, 2019).

5. ***Ampulex major*** **Kohl 1893**

(Figs. 14 & 20)

Ampulex major Kohl, 1893: 467, ♀. Holotype or syntypes: ♀: Indonesia: Moluccas: no specific locality (TMB).

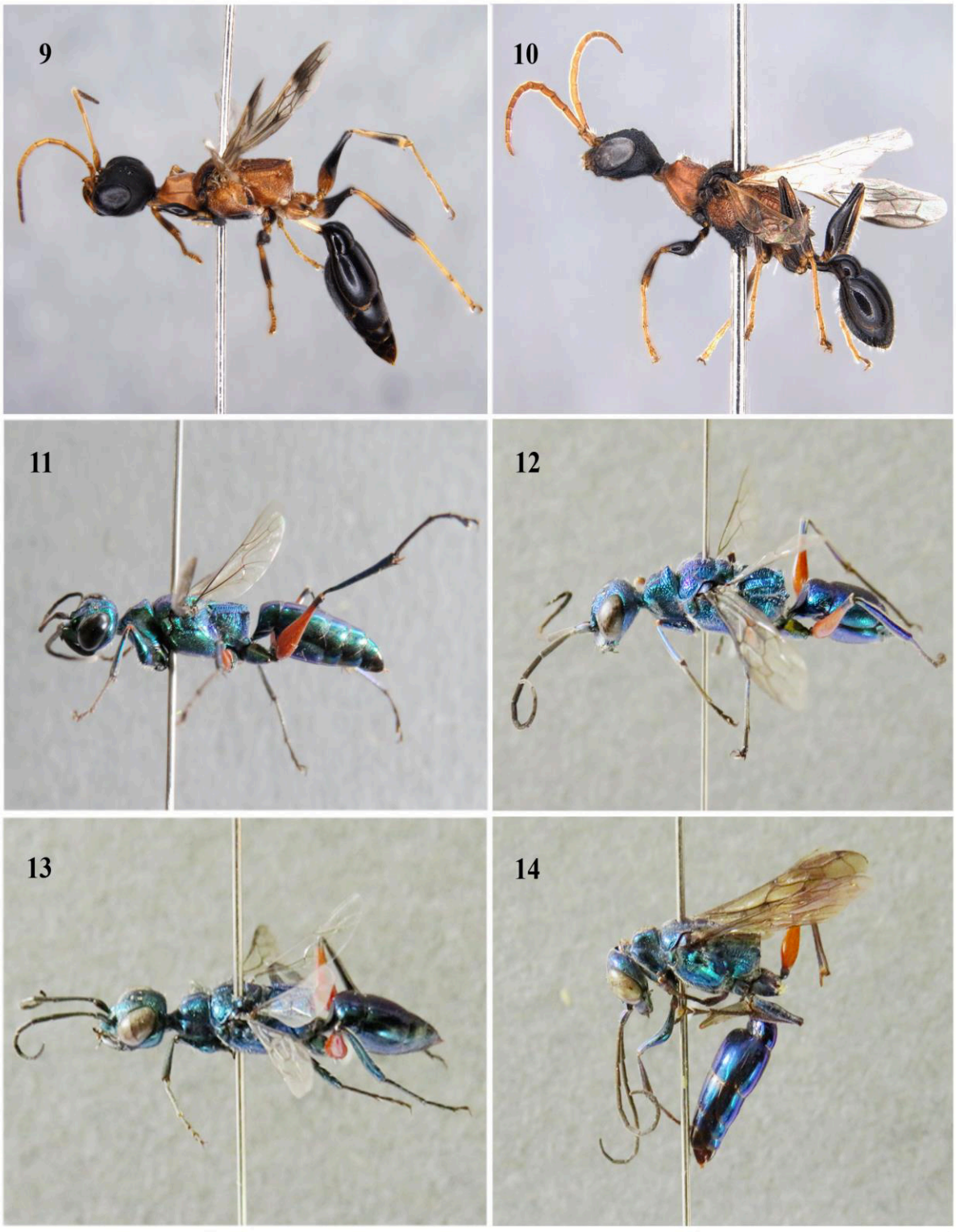
Diagnosis: Female. Forewing with three submarginal cells, one being incomplete; clypeus with a median carina and its apex with three teeth; dorsal surface of pronotum not flat, anteromedian area depressed, without a median longitudinal deeply impressed line, but only with a weak median line in the middle only; hind femora red. Length: 20 mm.

Materials examined: INDIA: Kerala, Kasaragod district, Kottanjeri forest, 1 ♀, 5.iii.2006, Coll. K. Rajmohana, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12267.

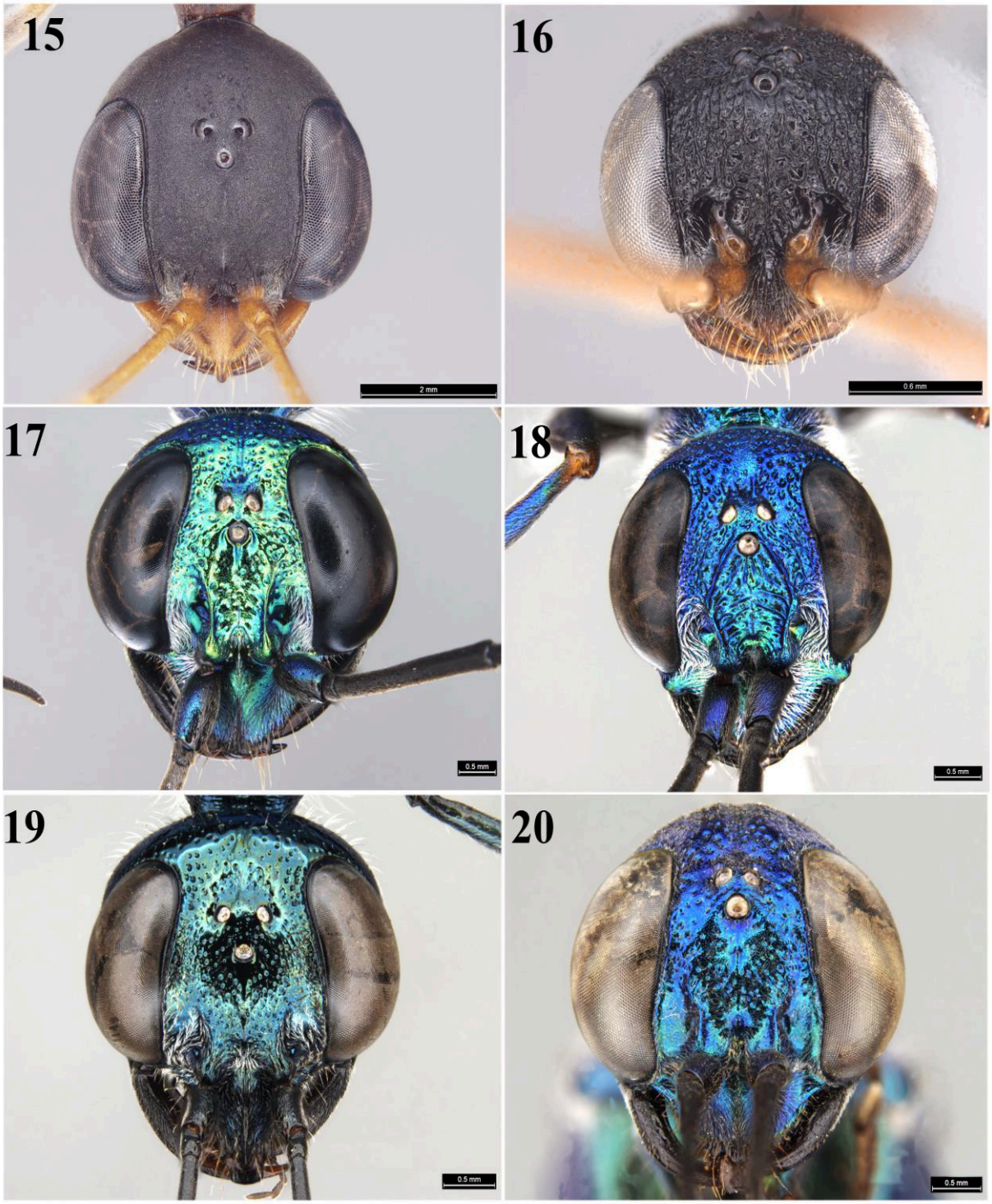
Distribution: India: Kerala. *Elsewhere*: Indonesia; Laos; Malaysia. (Pulawski, 2019).

6. ***Ampulex sodalicia*** **Kohl, 1893**

Ampulex sodalicia Kohl, 1893: 470, ♀. Holotype or syntypes: ♀, Indonesia: Moluccas: no specific locality (TMB).



FIGURES 9–14. Habitus. 9–10 *Ampulex ceylonica* Krombein, 9 Female; 10 Male. 11–12 *A. compressa* (Fabricius), 11 Female; 12 Male. 13 *A. dissector* (Thunberg), Female. 14 *A. major* Kohl, Female.



FIGURES 15–20. Head, frontal view. 15–16 *Ampulex ceylonica* Krombein, 15 Female; 16 Male. 17–18 *A. compressa* (Fabricius), 17 Female; 18 Male. 19 *A. dissector* (Thunberg), Female. 20 *A. major* Kohl, Female.

Ampulex striatifrons Cameron, 1902: 95, ♂. Holotype or syntypes: ♂, East Malaysia: Sarawak: Kuching (NHM). Synonymized with *Ampulex sodalicia* by Turner, 1912: 368.

Ampulex tricarinata Cameron, 1902: 245, ♀ (as tri-carinata, incorrect original hyphenation). Syntypes: ♀, Borneo: no specific locality (OXUM). Synonymized with *Ampulex sodalicia* by Turner, 1912: 368.

Since no specimen of this species was available for the present study, the following diagnostic characters were taken from the original description by the designating author. Also the sculpturing of mesosoma of the species was not clearly given in the original description (which is taken as a strong character in the present key to the Indian species of *Ampulex*), the species is thus excluded from the present key.

Diagnosis: Female. The female of this species is distinguished by its metallic green, largely mixed with blue colour; wings hyaline with slight infumation; head above antennae blue, smooth and shining, below them green thickly covered with silvery pubescence; prothorax smooth and shining; mesoscutum smooth and shining with two wide and deep furrows and with stout transverse keel throughout; mesopleurae distinctly punctured on the basal half above, below with curved furrow which reaching beyond middle; metasoma about twice longer than wide and not much narrowed at base.

Male. The male of this species is distinguished by its dark green largely tinged with blue colour; wings hyaline with slight infumation; head blue, ocellar region largely tinged with purple; the three stout keels in front reach to base of mandibles, the part between them, from near their top bears stout oblique striae, the part on their outerside at the top bears some large punctures; prothorax, elongate base distinctly narrowed, sparsely punctured; central part of mesonotum strongly and deeply punctured, sides are more sparsely punctured; abdomen, strongly punctured, apical half distinctly depressed and closely but not so strongly punctured.

Distribution: India: Sikkim. *Elsewhere*: Borneo; Indonesia; Malaysia. (Pulawski, 2019).

Checklist of Indian species of *Ampulex* (Adopted from Pulawski, 2019)

1. *A. aborensis* Nurse, 1914 – India: Assam, Meghalaya.
2. *A. approximata* Turner, 1912 – India: Gujarat, Maharashtra. *Elsewhere*: Sri Lanka; Thailand.
3. *A. assamensis* Cameron, 1903 – India: Meghalaya.
4. *A. carinifrons* Cameron, 1903 – India: Meghalaya.
5. *A. ceylonica* Krombein, 1979 – India: Kerala (**new record**), Tamil Nadu (**new record**), Meghalaya. *Elsewhere*: Indonesia; Laos; Sri Lanka.
6. *A. compressa* (Fabricius, 1781) – India: Andaman and Nicobar Islands, Arunachal Pradesh (**new record**), Assam, Chhattisgarh (**new record**), Himachal Pradesh (**new record**), Karnataka, Kerala,

Lakshadweep (**new record**), Maharashtra, Meghalaya, Tripura (**new record**), Uttarakhand, West Bengal. *Elsewhere*: Africa; Australia; Bangladesh; Borneo; Brazil; China; France; Indonesia; Iran; Island of Bourbon; Island of Reunion; Island of St. Helena; New Caledonia; Hawaii island; Laos; Kenya; Madagascar; Mauritius; Nepal; Philippines; Seychelles; Saudi Arabia; Singapore; Sri Lanka; Tanzania; United Arab Emirates; Venezuela; Vietnam; Zanzibar.

7. *A. constanceae* (Cameron, 1891) — India: Maharashtra.
8. *A. crudelis* Bingham, 1897 — India: Meghalaya, Sikkim.
9. *A. difficilis* Strand, 1913 — India: Meghalaya. *Elsewhere*: China; Laos; Taiwan; Vietnam.
10. *A. dissector* (Thunberg, 1822) — India: Kerala (**new record**), Uttarakhand. *Elsewhere*: China; Japan; Korea; Laos; Sri Lanka; Ryukyu archipelago; Taiwan; Thailand.
11. *A. himalayensis* Cameron, 1903 — India: Meghalaya.
12. *A. hospes cognata* Kohl, 1893 — India: Meghalaya. *Elsewhere*: Indonesia.
13. *A. interstitialis* Cameron, 1903 — India: Meghalaya.
14. *A. khasiana* Cameron, 1903 — India: Meghalaya.
15. *A. latifrons* Kohl, 1893 — India: Meghalaya, Sikkim. *Elsewhere*: China.
16. *A. longicollis* Cameron, 1902 — India: Meghalaya.
17. *A. major* Kohl, 1893 — India: Kerala. *Elsewhere*: Indonesia; Laos; Malaysia.
18. *A. montana* Cameron, 1903 — India: Meghalaya.
19. *A. nigricans* Cameron, 1899 — India: Meghalaya.
20. *A. pilosa* Cameron, 1900 — India: Meghalaya. *Elsewhere*: Malaysia.
21. *A. rothneyi* Cameron, 1902 — India: Meghalaya.
22. *A. ruficornis* Cameron, 1889 — India: West Bengal. *Elsewhere*: Sri Lanka; Thailand.
23. *A. ruficoxis* Cameron, 1902 — India: Meghalaya.
24. *A. sadiyae* Anagha and Girish Kumar **sp. nov.** — India: Kerala.
25. *A. sikkimensis* Kriechbaumer, 1874 — India: Sikkim. *Elsewhere*: China.
26. *A. sodalicia* Kohl, 1893 — India: Sikkim. *Elsewhere*: Borneo; Indonesia; Malaysia.

4. Conclusion

The genus *Ampulex* Jurine is studied from India with the description of one new species, *Ampulex sadiyae* Anagha and Girish Kumar sp. nov., from Kerala. The species *A. ceylonica* Krombein is newly recorded from Kerala and Tamil Nadu. The species *A. compressa* (Fabricius) is newly recorded from Arunachal Pradesh, Chhattisgarh, Himachal Pradesh, Lakshadweep, and Tripura. The species *A. dissector* (Thunberg) is newly recorded from Kerala. A key and an updated checklist to the Indian species of *Ampulex* Jurine are also provided.

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Additions to the knowledge of the genus *Dolichurus* Latreille (Hymenoptera: Ampulicidae) from India with the description of two new species

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Abstract

The genus *Dolichurus* Latreille is studied from India and two new species are described: *Dolichurus sahyadriensis* Anagha and Girish Kumar **sp. nov**., and *D. chareshi* Anagha and Girish Kumar **sp. nov**.. *D. aridulus* Krombein 1979 is recorded from India for the first time. Records of four other *Dolichurus* species from various states of India are presented here. A key to the species of *Dolichurus* from the Indian subcontinent is provided.

Key words: Taxonomy, cockroach wasps, Indian subcontinent, new record, key

Introduction

The wasps of the genus *Dolichurus* Latreille 1809 are among the smallest sphecoid wasps, commonly called 'cockroach wasps'. These wasps use cockroaches as prey for their larvae and are generally seen on leaf litter, dead stumps, and on tree trunks (Bohart & Menke 1976). *Dolichurus* are distributed in the Nearctic (1 sp.), the Neotropical (2 spp.), the Palearctic (6 spp.), the Ethiopian (10 spp.), the Oriental (28 spp.), and the Australian (4 spp.) regions; altogether 51 species are described, with only eight from the Indian subcontinent. Of these, five, namely, *Dolichurus amamiensis* Tsuneki and Iida 1964, *D. albifacies* Krombein 1979, *D. gilberti* Turner 1912, *D. taprobanae* Smith 1869, and *D. venkataramani* Girish Kumar and Sheikh 2018 are known from India (Girish Kumar & Sheikh 2018; Pulawski 2020). In this paper, two new species, *D. sahyadriensis* Anagha and Girish Kumar **sp. nov.**, and *D. chareshi* Anagha and Girish Kumar **sp. nov.**, from India are described. *D. aridulus* Krombein, 1979 is recorded from India for the first time. New reports from various states for other species are also presented.

Materials and methods

This study is based on specimens present in the Western Ghat Regional Centre, Zoological Survey of India, Kozhikode, and also on fresh specimens collected from various localities of India. The specimens were studied under a LEICA M205 stereo microscope and the images were captured using a LEICA DFC 500 camera. Measurements were obtained using software Leica LAS (Leica Application Suite V3.80). Images at varying focus depth were stacked using Leica Automontage Software V3.80 and were post-processed using Adobe® Photoshop® CS5 (Version 6.1) software. Photographs of *Dolichurus taprobanae* (NHMUK010576385, a female), *D. reticulatus*, and *D. clavipes* (= *taprobanae*) (both males), were borrowed from NHMUK and OXUM and compared with collected specimens. All specimens including types studied here were preserved, labelled and added to the 'National Zoological Collections' at Western Ghat Regional Centre, Zoological Survey of India, Kozhikode (ZSIK).

Terminology: The morphological terminology used in this paper follows Bohart & Menke (1976) and the nomenclature for cuticular sculpturing follows Harris (1979), unless otherwise noted. The following terms and abbreviations used in the text are redefined here and are as follows:

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BL: Body length as measured from head to apex of metasoma.
F: Flagellomere. One unit or article of the flagellum.
Frontal platform: Lamella of Tsuneki (1992). A median, U shaped platform like extension on the frons overhanging the antennal bases (Ohl 2002).
IOD: Inter ocular distance. Distance between the compound eyes medially.
LOL: Lateral ocellar length. Distance between the anterior ocellus and posterior ocellus medially.
OOL: Ocellocular length. Distance between the compound eye and posterior ocellus medially.
POL: Posterior ocellar length. Distance between the posterior ocelli medially.
Rugae: Series of folds or wrinkles.
T: Tergum. Metasomal tergites.

The following abbreviations are used for the Museums in the text.

NHMUK: The Natural History Museum, London, England.
OXUM: Hope Department of Entomology, Oxford, Great Britain.
USNM: National Museum of Natural History, Washington, D.C., U.S.A.
ZSIK: Western Ghat Regional Centre, Zoological Survey of India, Kozhikode, India.

Results

Genus *Dolichurus* Latreille 1809

Dolichurus Latreille 1809: 387. Type species: *Pompilus corniculus* Spinola 1808, designated by Latreille 1810: 438.
Thyreosphex Ashmead 1904: 282. Type species: *Thyreosphex stantoni* Ashmead 1904, by monotypy.

Diagnosis. Both antennal sockets covered by a single median platform like lobe; metasternum somewhat emarginated posteriorly; metasoma inserted above and somewhat behind hind coxae; fore wing media diverging after Cu–a; hind wing media diverging before Cu–a; hind wing jugal lobe present; notauli well developed, complete to posterior scutal margin or nearly so; propodeal outline rather sharply bent in profile (Bohart & Menke 1976).

Distribution. Oriental; Ethiopian; Australian; Palearctic; Nearctic and Neotropical region.

Key to species of *Dolichurus* Latreille from the Indian subcontinent

(Modified from Tsuneki 1992; Girish Kumar and Sheikh 2018; females unknown in *D. chareshi* **sp. nov.**, *D. gilberti* and *D. venkataramani*)

1.	Female	2
-	Male	9
2.	T4–T6 black; clypeus with or without median carina	3
-	T4–T6 reddish brown (Fig. 30); clypeus with median longitudinal carina on basal half.	***D. gilberti*** Turner
3.	Clypeus with median longitudinal carina nearly reaching apical margin	***D. taprobanae*** Smith
-	Clypeus without any such median carina, if present, then weak and restricted to basal half.	4
4.	Sternaulus on mesopleuron distinct	5
-	Sternaulus on mesopleuron indistinct or lacking	7
5.	Clypeus, frons, pronotum and scutellum with long macrosetae; clypeus black, without white markings.	6
-	Clypeus, frons, pronotum and scutellum without such macrosetae; clypeus with white markings (Fig. 32)	***D. albifacies*** Krombein
6.	Distinct anterior bordering transverse carina present on pronotal collar (Fig.19)	***D. sahyadriensis*** Anagha and Girish Kumar **sp. nov**.
-	Anterior bordering transverse carina absent on pronotal collar	***D. silvicola*** Krombein
7.	Anterior bordering transverse carina absent on pronotal collar	8
-	Distinct anterior bordering transverse carina present on pronotal collar (Fig. 31)	***D. amamiensis*** Tsuneki and Iida
8.	Vertex flat; frons coarsely sculptured with large subcontiguous punctures (Fig. 34); mandible, except apex, and fore tibia dark.	***D. lankensis*** Krombein
-	Vertex arched; frons moderately sculptured with larger punctures confluent in longitudinal rows along inner eye margin, tiny punctures adjacent to frontal platform and a small impunctate areas halfway between anterior ocellus and frontal platform (Fig.	

33); mandible and fore tibia beneath light red . . . . . ***D. aridulus*** Krombein

9. Clypeus black without white markings, T1 and T2 with or without impunctate area 10
- Clypeus with white markings; T1 and T2 with large impunctate areas . . . . . ***D. albifacies*** Krombein
10. T1 and T2 entirely punctured 11
- Coarse punctures absent on posterior third of T1 and T2. 16
11. Mesopleuron rugulose reticulate (Fig. 36) 12
- Mesopleuron differently sculptured 14
12. Distinct anterior bordering transverse carina present on pronotal collar . . . . . ***D. amamiensis*** Tsuneki and Iida
- Anterior bordering transverse carina absent on pronotal collar 13
13. Clypeus with median carina reaching apical margin; hind basitarsus paler than the remaining tarsal segments . . . . . ***D. aridulus*** Krombein
- Clypeus without median carina; hind basitarsus not conspicuously paler than the remaining tarsal segments. . . . . ***D. lankensis*** Krombein
14. Mesopleuron shiny with scattered tiny setaceous punctures (Fig. 35); frontal platform broader than long 15
- Mesopleuron shiny with distinct coarse setaceous punctures, punctures in median region with widened interspaces (Fig. 5); frontal platform as broad as long . . . . . ***D. chareshi*** Anagha and Girish Kumar **sp. nov**.
15. Punctures of T1–T3 mostly separated by the average puncture diameter . . . . . ***D. taprobanae*** Smith
- Punctures of T1–T3, especially on T1, scattered and, in the median region, separated by 2 to 3× the average puncture diameter. . . . . ***D. venkataramani*** Girish Kumar and Sheikh
16. Anterior bordering transverse carina absent on pronotal collar; T1–T3 with punctures separated by less than the average puncture diameter. . . . . ***D. silvicola*** Krombein
- Distinct anterior bordering transverse carina present on pronotal collar (Fig. 12); T1–T3 with punctures separated by more than the average puncture diameter (Fig. 15). . . . . ***D. sahyadriensis*** Anagha and Girish Kumar **sp. nov.**

Dolichurus chareshi Anagha and Girish Kumar sp. nov.

(Figs. 1–7)

urn:lsid:zoobank.org:act:D4DB6237-5EA5-41D6-AC37-66A6F16D1DE5

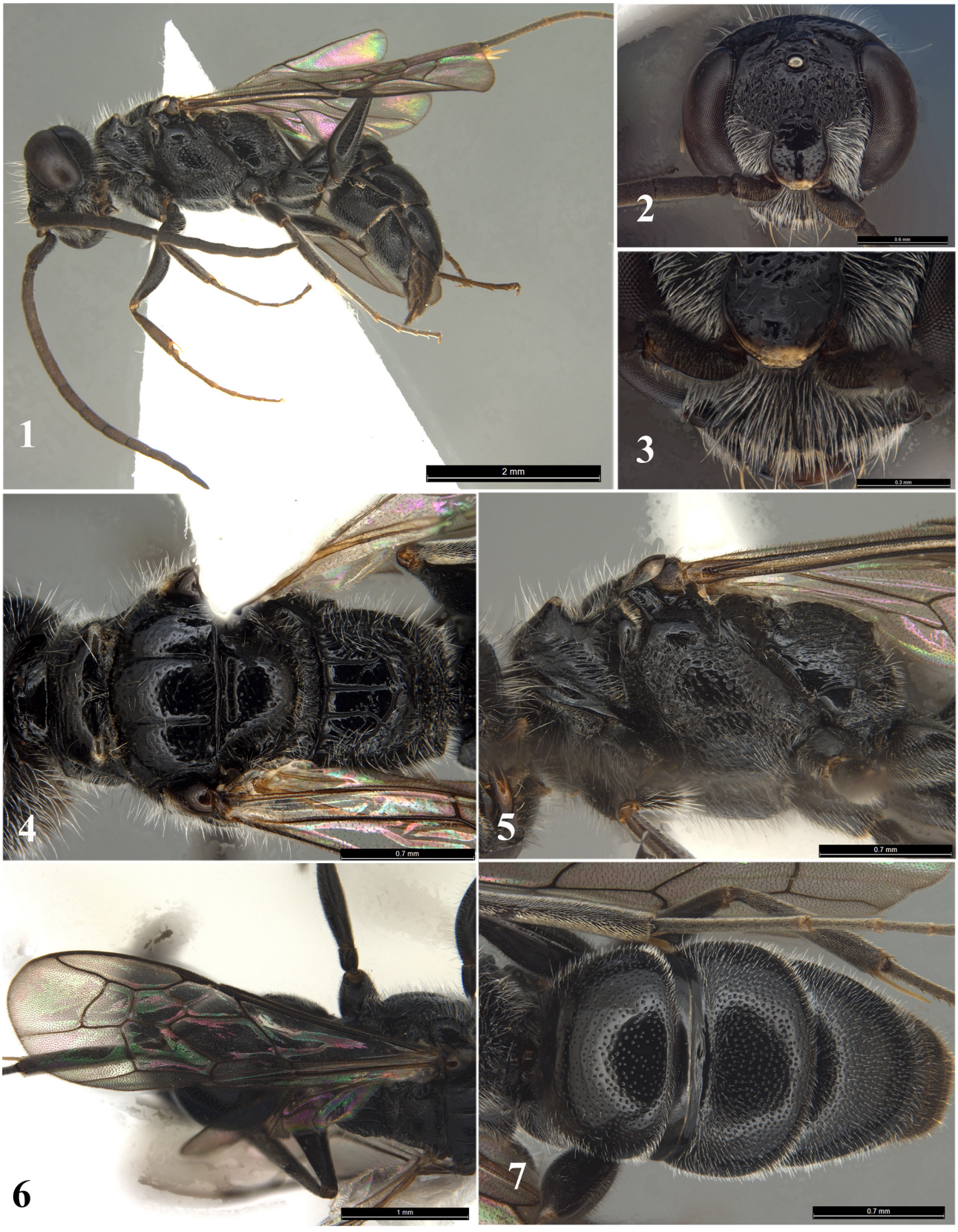
Diagnosis. The new species *D. chareshi* runs close to *D. taprobanae* and *D. venkataramani* in the key, but differs from these species as follows: the mesopleuron is shiny with distinct coarse setaceous punctures and the punctures in the median region have widened interspaces (Fig. 5) (in *D. taprobanae* and *D. venkataramani*, mesopleuron shiny with scattered tiny setaceous punctures); frontal platform as broad as long (Fig. 2) (in *D. taprobanae* and *D. venkataramani*, frontal platform broader than long); lateral pronotal surface with scattered fine punctures and with rugae posteriorly (Fig. 5) (in *D. taprobanae* and *D. venkataramani,* lateral pronotal surface with scattered fine punctures, but without rugae posteriorly). Additionally, *D. chareshi* have dense coarse punctures on T1-T3, especially on T1, punctures separated by less than twice puncture diameter (Fig. 7), while in *D. venkataramani,* the punctures of T1-T3, especially on T1 are scattered and, at the median region, they are separated by more than 2–3× the average puncture diameter.

Description. MALE (Fig. 1). *Head*. rounded in frontal view, vertex slightly arched above eyes; clypeus hairy, clypeal lobe convex with median carina, lobe emarginated on either side of median tooth ending in a weak rounded angle (Fig. 3); head 1.96× as wide as IOD at anterior ocellus; ocelli forming low triangle; POL 1.45× LOL and 0.83× OOL; frontal platform broad as long, with apical margin rounded, sides slightly converging towards top, surface concave and smooth with few scattered punctures near margin; frons with rugulose reticulations (Fig. 2), eyes converging below; vertex with scattered punctures; F1 0.6× combined length of F2 and F3.

Mesosoma. Pronotal collar margined anteriorly with few transverse rugulae (Fig. 4), dorsally with scattered setaceous punctures, dorso-lateral tubercle raised, median pronotal groove shallow or virtually lacking, pronotum smooth laterally with scattered fine setaceous punctures and rugae on posterior half; scutum and scutellum with scattered setaceous punctures; mesopleuron shiny with distinct coarse setaceous punctures and the punctures in median region is with widened interspaces (Fig. 5), sternaulus present as shallow pitted groove; metanotum coarsely longitudinally to obliquely carinate; dorsal surface of propodeal enclosure subrectangular, areolate with certain longitudinal and few oblique carina or rugulae, surface between the carina smooth; posterior surface irregularly rugose, propodeal sides with irregular rugulae and punctures that partly diminishes anteriorly.

Metasoma. Coarse punctures densely on three exposed terga, mainly on T1, separated by less than twice the diameter of punctures (Fig. 7).

Color. Black; apex and base of mandible reddish brown, tegula brownish, flagellomeres dark brown, tibial spurs light brown to ivory; following white to ivory: apical margin of frontal platform and dorso-lateral tubercles on pronotal collar; forewings evenly and slightly infumated.



FIGURES 1–7. *Dolichurus chareshi* Anagha and Girish Kumar **sp. nov.** Holotype ♂. 1. Habitus, lateral view; 2. Head, frontal view; 3. Lower half of head, frontal view; 4. Mesosoma, dorsal view; 5. Mesosoma, lateral view; 6. Fore wing; 7. Metasoma, dorsal view.

Vestiture. Whitish vestiture mostly decumbent on clypeus, between antennal sockets and posterior internal margins of eyes, erect on head and mesosoma, short and decumbent on metasomal tergum.

BL. 5.3 mm.

Female. Unknown.

Type material. Holotype ♂, INDIA: Tamil Nadu, Nilgiris district, Coonoor, (11°21'10.8''N, 76°47'45.24''E), 7.i.2019, Coll. C. Charesh, ZSI/WGRC/I.R–INV.13585. Paratypes: 2 ♂, same as holotype, ZSI/WGRC/I.R.–INV.13586 and 13587. Other individuals: 1 ♂, Rajasthan, Sirohi district, Mount Abu, (24°35'33.36''N, 72°42'56.16''E), 28.iii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.13588.

Distribution. India: Tamil Nadu, Rajasthan.

Etymology. The species name is named after C. Charesh (Laboratory Assistant at Western Ghat Regional Centre, Zoological Survey of India, Kozhikode), who collected the type specimens.

Dolichurus sahyadriensis Anagha and Girish Kumar sp. nov.

(Figs. 8–22)

urn:lsid:zoobank.org:act:F61EA21A-4F21-40C5-B5F3-F876CABB32CC

Diagnosis. *Dolichurus sahyadriensis* is closely related to *D. silvicola* and females of *D. sahyadriensis* and *D. silvicola* are difficult to distinguish. Male and female *D. sahyadriensis* are characterised by having a distinct anterior bordering transverse carina on pronotal collar (Figs. 12 and 19) (in *D. silvicola*, distinct anterior bordering transverse carina absent). Male *D. sahyadriensis* have anterior half of T1 and T2 with punctures mostly separated by more than the diameter of a puncture (Fig. 15) (in *D. silvicola*, anterior half of T1 and T2 with punctures mostly separated by less than the diameter of a puncture). Both sexes of *D. sahyadriensis* also resemble *D. albifacies* but can be distinguished by following characteristics: both sexes of *D. sahyadriensis* have anterior bordering transverse carina on pronotal collar (in *D. albifacies*, anterior bordering transverse carina absent); clypeus black, without white markings (in *D. albifacies*, clypeus black, with white markings). The female *D. sahyadriensis* has black long macrosetae present on clypeus, frons, pronotum and scutellum (in *D. albifacies*, black long macrosetae absent on clypeus, frons, pronotum and scutellum); mesopleuron areolate rugulose postero-dorsally (Fig. 20) (in *D. albifacies*, mesopleuron with scattered fine punctures).

Description. MALE (Figs. 8–15). *Head*. rounded in frontal view, vertex slightly arched above eyes; clypeus hairy, clypeal lobe convex, with median carina, lobe emarginated on either side ending in a weak rounded angle; head 1.97× as wide as IOD at anterior ocellus; ocelli forming low triangle; POL 2.33× LOL and 0.66× OOL; frontal platform broader than long with apical margin sinuous, sides parallel, surface smooth with scattered punctures; most of frons with rugulose reticulations, usually with a frontal line forming carina (Fig. 9); vertex shiny with scattered punctures; F1 0.54× combined length of F2 and F3.

Mesosoma. Pronotal collar with distinct anterior bordering transverse carina (Fig. 12), dorso–lateral tubercle raised, median pronotal groove shallow, lateral pronotal surface anteriorly with a carina, rest of surface smooth with scattered fine setaceous punctures; scutum with scattered small setaceous punctures; notauli deeply impressed; scutellum with similar sculptures as on mesoscutum; metanotum with setaceous punctures; mesopleuron smooth with scattered small setaceous punctures except on ventral posterior portion along mesopleural suture, where several punctures are confluent in short rows (Fig. 13); sternaulus present; propodeum areolate, with certain number of longitudinal or oblique and varying number of transverse carina or rugulae, posterior surface irregularly rugose, propodeal sides with irregular rugulae that partly diminishes antero–medially.

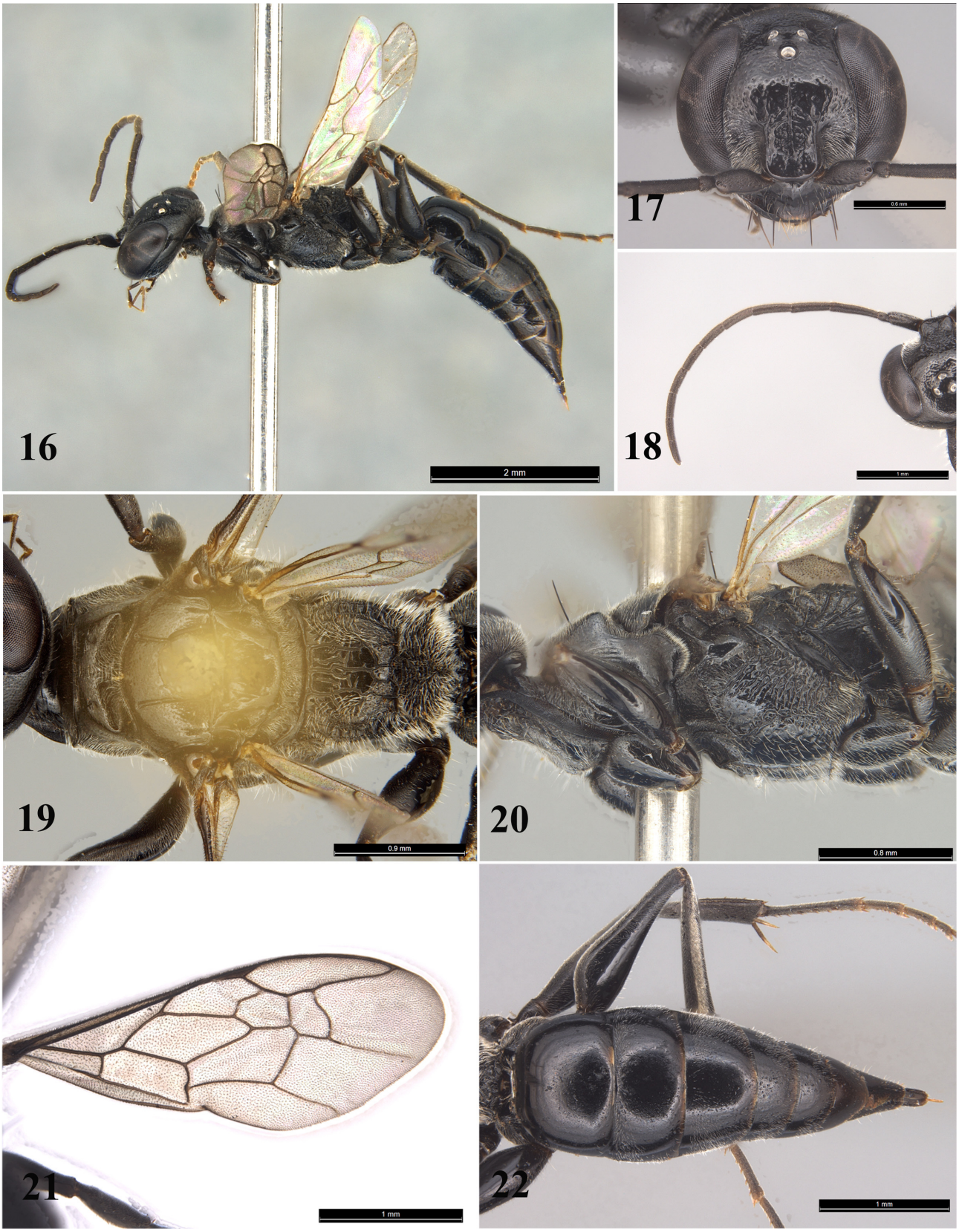
Metasoma. Apical third of T1 and T2 without coarse punctation, punctures on T3 closer than T1 and T2 (Fig. 15).

Color. Body black; apical half of mandible, and tegula brownish, tibial apical spurs white to light brown, flagellomeres dark brown, dorso-lateral elevation of pronotal collar and apical margin of fontal platform white, a spot anteriorly on tegula translucent, fore wings evenly and slightly infumated.

Vestiture. Whitish vestiture mostly decumbent on clypeus, between antennal sockets and posterior internal margins of eyes, erect on frons, vertex and mesosoma, short and decumbent on anterior half of T1 and T2, and all of T3.

BL. 5.5 mm.

FIGURES 8–15. *Dolichurus sahyadriensis* Anagha and Girish Kumar **sp. nov.** Holotype ♂. 8. Habitus, lateral view; 9. Head, frontal view; 10. Antenna; 11. Clypeus; 12. Mesosoma, dorsal view; 13. Mesosoma, lateral view; 14. Fore wing; 15. Metasoma, dorsal view.



FIGURES 16–22. *Dolichurus sahyadriensis* Anagha and Girish Kumar **sp. nov.** Paratype ♀. 16. Habitus, lateral view; 17. Head, frontal view; 18. Antenna; 19. Mesosoma, dorsal view; 20. Mesosoma, lateral view; 21. Fore wing; 22. Metasoma, dorsal view.

FEMALE (Figs. 16–22). *Head*. rounded in frontal view, vertex slightly arched above eyes; clypeus convex with weak median carina on its basal third; head 2.57× as wide as IOD at anterior ocellus; ocelli forming low triangle; POL 1.02× LOL and 0.36× OOL; frontal platform longer than broad, apical margin sinuous, sides parallel, surface with irregular weak wrinkles and punctures; eyes converging above; frons with scattered punctures and frontal line forming carina (Fig. 17); vertex glossy with scattered fine pits; F1 0.61× combined length of F2 and F3.

Mesosoma. Pronotal collar with distinct anterior bordering transverse carina (Fig. 19), dorsally with close small setaceous punctures, dorso-lateral tubercles low and rounded, median pronotal groove shallow; scutum with slightly larger setaceous punctures separated by about diameter of a puncture, scutellum with sparse small punctures; mesopleuron (Fig. 20) areolate rugulose postero-dorsally with antero-ventrally smooth and bare area, ventrally with scattered setaceous punctures; sternaulus distinctly foveolate on mesopleuron; dorsal surface of propodeum with U-shaped enclosure bearing complete or several incomplete longitudinal and few oblique carina or rugulae, propodeal sides with a extensively area smooth, few rugulae above and posteriorly.

Metasoma. T2–T5 latero–apically and T2 and T3 basally with row of close tiny setaceous punctures (Fig. 22).

Color. Mostly black; mandible brownish subapically and black apically with sub basal ivory spot (on tegument); tegula, tibial apical spurs and tarsi brownish, fore wing evenly and slightly infumated.

Vestiture. Black macrosetae on mandible, clypeus, frons, pronotum, scutum and scutellum. Whitish vestiture mostly decumbent between posterior internal margins of eyes, and clypeus, suberect on vertex, almost reclined on mesosoma, short and decumbent on sides and apex of T2–T5 and base of T2 and T3.

BL. 6.2 mm.

Type material. Holotype ♂, INDIA: Kerala, Thiruvananthapuram district, Agasthyamalai Biosphere Reserve, Peppara Wildlife Sanctuary, Pattankulichappara (8°37’24.24’’N, 77°8’8.52’’E), 20.i.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.13582. Paratypes: 1 ♂ and 1♀, same as holotype, ZSI/WGRC/I.R.– INV.13583 and 13584.

Distribution. India: Kerala.

Etymology. The species name is derived from ‘Sahyadri’ the vernacular name for Western Ghats where the types were collected.

Dolichurus albifacies Krombein 1979
(Fig. 24)

Dolichurus albifacies Krombein, 1979: 18, ♀, ♂. Holotype: ♀, Sri Lanka: Kandy district, Kandy, Udawattakele Sanctuary (USNM).

Diagnosis. FEMALE. BL 6.4 mm; frons with small punctures separated by less than the diameter of a puncture, clypeus with white markings and without median carina (Fig. 32); absence of macrosetae at normal positions of clypeus, frons, pronotum, and scutellum; frontal platform broad, twice as broad as long; pronotal collar with a few close transverse rugulae on anterior half; mesopleuron with scattered tiny punctures, distinct sternaulus present on mesopleuron.

Material examined. INDIA: Tamil Nadu, Thirunelveli district, Kalakkad Mundanthurai Tiger Reserve, Kuthiraivetti, 1 ♀, 24.viii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.13504.

Distribution. India: Karnataka, Tamil Nadu (new state record). *Elsewhere*: Sri Lanka (Krombein 1979; Girish Kumar & Sheikh 2018).

Dolichurus amamiensis Tsuneki and Iida, 1964
(Figs. 25–26)

Dolichurus amamiensis Tsuneki and Iida 1964: 41, ♀. Holotype: ♀, Japan: Amami Oshima Island: Koniya (USNM).
Dolichurus puliensis Tsuneki 1967: 10, ♂. Holotype: ♂, Taiwan: Nantou Prefecture: Puli (USNM). Synonymized with *Dolichurus amamiensis* by Tano and Tsuneki 1970: 40.

Diagnosis. FEMALE. BL 8 mm; frons with delicate longitudinal rugulae, upper frons and vertex with sparse punctation; clypeus with weak median carina on basal half; black macrosetae at normal positions of clypeus, frons, pro-

notum, and scutellum; frontal platform with apex having greatest width twice the upper width; pronotal collar with distinct transverse anterior bordering carina (Fig. 31); mesopleuron rugulose reticulate with indistinct sternaulus.

MALE. BL 3.8 mm; most of frons delicately rugulose reticulate; vertex with scattered small punctures; clypeus with a distinct median carina ending in a small apical tooth; frontal platform slightly longer than broad; pronotal collar with transverse anterior bordering carina; mesopleuron rugulose reticulate with indistinct sternaulus.

Material examined. INDIA: Daman & Diu, Daman district, Nani, 2 ♀, 21.i.2018, Coll. K. Rajmohana and Party, ZSI/WGRC/I.R.–INV.13168 and 13822. Karnataka, Chickmagalur district, Bygoor, Kabbinahalli Coffee estate, 1 ♂ and 1 ♀, 26.xii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.13574-13575; Kerala, Kozhikode district, Purameri, 2 ♂, 22.ix.2018 and 5.i.2019, Coll. K.P. Hanima Raveendran, ZSI/WGRC/I.R.–INV.12578 and 12583; Thrissur district, Elanad, 1 ♂, 24.xii.2018, Coll. N.V. Ayisha Mawadda, ZSI/WGRC/I.R.–INV.12579; Kozhikode district, Kovoor, 1 ♂, 19.xii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.12580; Thiruvananthapuram district, Agasthyamalai Biosphere Reserve, Neyyar Wildlife Sanctuary, Neyyar dam site, 4 ♂ and 1 ♀, 16.i.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.12584, 12656 and 13550–13552; Thiruvananthapuram district, Agasthyamalai Biosphere Reserve, Neyyar Wildlife Sanctuary, Kottur, 2 ♂, 16.i.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.12585 and 12586; Kollam district, Shendurney Wildlife Sanctuary, 1 ♂, 23.i.2019, Coll. Md. Jafer Palot and Party, ZSI/WGRC/I.R.–INV.12587; Kozhikode district, Madappally, 2 ♂, 25.i.2019, Coll. K. Anju, ZSI/WGRC/I.R.–INV.12588 and 12589; Kozhikode district, Janakikadu, 1 ♂ and 1 ♀, 1.ii.2019, Coll. K. Anju, ZSI/WGRC/I.R.–INV.12590 and 12591; Kozhikode district, Chengottukavu, 2 ♂, 1.ii.2019, Coll. C. Binoy, ZSI/WGRC/I.R.–INV.12592 and 12593; Kottayam district, Cherupunkal, 1 ♂, 1.ii.2019, Coll. Tessy Rajan, ZSI/WGRC/I.R.–INV.12595, Kozhikode district, Payanthong, 5 ♂ and 3 ♀, 22.iv.2019 and 26.vi.2019, Coll. K.P. Hanima Raveendran, ZSI/WGRC/I.R.–INV.12596, 12597 and 13557–13562; Kozhikode district, Moorad, 5 ♂ and 3 ♂, 18.iv.2019, Coll. S. Anagha, ZSI/WGRC/I.R.–INV.12598–12602 and 13631–13633; Kannur district, Kannapuram, 5 ♂, 5.v.2019 and 18.v.2019, Coll. C. Charesh, ZSI/WGRC/I.R.–INV.12604–12607 and 12610; Kozhikode district, Edakkara, 2 ♂, 7.v.2019, Coll. P.M. Sureshan and Party, ZSI/WGRC/I.R.–INV.12608 and 12609; Kozhikode district, Edakkara, 2 ♂, 17.v.2019, Coll. K.P. Hanima Raveendran, ZSI/WGRC/I.R.–INV.12611 and 12616; Malappuram district, Nilambur, Balankulam, 1 ♀, 8.xii.2018, Coll. C. Charesh, ZSI/WGRC/I.R.–INV. 12654; Kozhikode district, Jaferkhan Colony, 1 ♂, 16.iv.2019, Coll. Tessy Rajan, ZSI/WGRC/I.R.–INV.12658; Kozhikode district, Madappally, 4 ♂ and 5 ♀, 16.v.2019, Coll. S. Anagha, ZSI/WGRC/I.R.–INV.12660 and13814-13821; Kozhikode district, Peruvannamuzhi, 3 ♂ and 1 ♀, 20.v.2019, Coll. K. Anju, ZSI/WGRC/I.R.–INV.13553–13555; Kannur district, Thekkumbad dweep, 1 ♂, 19.v.2019, Coll. C. Charesh, ZSI/WGRC/I.R.–INV.13556; Kozhikode district, Calicut University Botanical garden, 3 ♂, 20.xii.2019, Coll. S. Anagha, ZSI/WGRC/I.R.–INV.13578–13580. Tamil Nadu, Coimbatore district, Sadivayal, Siruvani, 1 ♀, 5.i.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.12655; Coimbatore district, Kottur, 2 ♂, 2.i.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.12581 and 12582; Chennai district, Velachery, 2 ♂, 16.ii.2019 and 29.iv.2019, Coll. S. Anagha, ZSI/WGRC/I.R.–INV.12594 and 12603; Thirunelveli district, Kalakkad Mundanthurai Tiger Reserve, Kuthiravetti, 1 ♂ and 1 ♀, 24.viii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.13566 and 13567. Uttarakhand, Dehradun district, ZSI Campus, 2 ♀, 15-18.vii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV. 13563 and 13564.

Distribution. India: Daman (new union territory record), Goa, Karnataka (new state record), Kerala, Tamil Nadu (new state record), Uttarakhand (new state record). *Elsewhere*: China; Japan; Malaysia; Philippines; Sri Lanka; Taiwan; Thailand; Vietnam (Girish Kumar & Sheikh 2018).

Dolichurus aridulus Krombein, 1979
(Fig 23)

Dolichurus aridulus Krombein 1979: 21, ♀, ♂. Holotype: ♀, Sri Lanka: Trincomalee district: Trincomalee, China Bay Ridge Bungalow (USNM).

Diagnosis. MALE. BL 4.5mm; frons rugulose reticulate; vertex with small close punctures separated by about half the diameter of puncture; clypeus with a median carina till apical margin; pronotal collar with a few close transverse rugulae on anterior half; hind basitarsus much paler than remaining tarsal segments; mesopleuron rugulose reticulate without sternaulus (Fig. 36).

Material examined. INDIA: Kerala, Kozhikode district, Madappally, 1 ♂, 25.i.2019, Coll. K. Anju, ZSI/

WGRC/I.R.–INV.12657; Kannur district, Kannapuram, 1 ♂, 16.v.2019, Coll. C. Charesh. ZSI/WGRC/I.R.–INV.12659. Tamil Nadu, Thirunelveli district, Old Courtallam, 1 ♂, 3.x.2018, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.12653.

Distribution. India (new country record): Kerala, Tamil Nadu. *Elsewhere*: China; Sri Lanka (Krombein 1979; Hua 2006).

FIGURES 23. *Dolichurus aridulus* Krombein, ♂ Habitus lateral view.

Dolichurus gilberti Turner 1912
(Fig. 27)

Dolichurus gilberti Turner 1912: 365, ♀, ♂. Holotype: ♀, India: Meghalaya ["Assam"], Shillong (NHMUK).

Diagnosis. FEMALE. BL 9.5 mm; frons longitudinally rugoso–striate; vertex with sparse punctures; clypeus with median carina not reaching apex; frontal platform longer than broad; pronotal collar with a few close transverse rugulae on anterior half; mesopleuron rugulose; T4-T6 reddish brown (Fig. 30).

Material examined. INDIA: Rajasthan, Sirohi district, Mount Abu, 6 ♀, 28.iii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.12572–12577. Uttarakhand, Dehradun district, Kalsi, 1 ♀, 18.vii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.12781. Tamil Nadu, Nilgiri district, Coonoor, 1 ♀, 7.i.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.12782.

Distribution. India: Arunachal Pradesh, Karnataka, Meghalaya, Rajasthan (new state Record), Tamil Nadu (new state record), Uttarakhand (new state record) (Girish Kumar & Sheikh 2018).

Dolichurus taprobanae Smith 1869
(Figs 28–29)

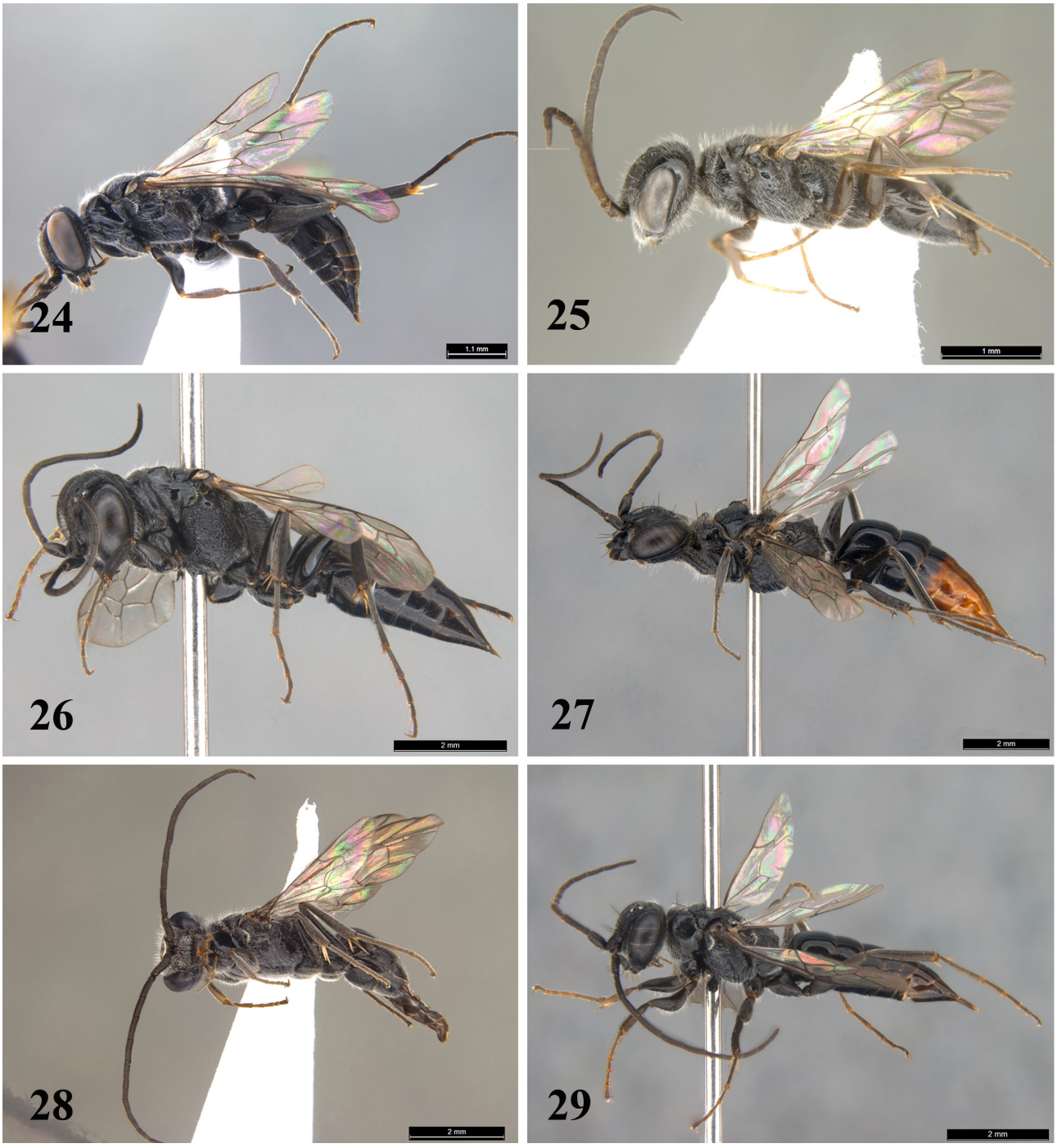
Dolichurus taprobanae Smith 1869: 304, ♂, actually ♀ (Turner 1912: 365). Holotype: ♀, Sri Lanka: no specific locality (NHMUK).

Dolichurus bipunctatus Bingham 1896: 438, ♂. Holotype: ♂. Burma: Pegu Hills (NHMUK). Synonymized with *Dolichurus taprobanae* by Krombein 1979: 14.

Dolichusus clavipes Cameron 1897: 18, ♂, junior primary homonym of *Dolichurus clavipes* Dahlbom 1829. Holotype: ♂, India: Bengal: Barrackpore 20 km N Calcutta (OXUM). Synonymized with *Dolichurus taprobanae* by Krombein 1979: 14.

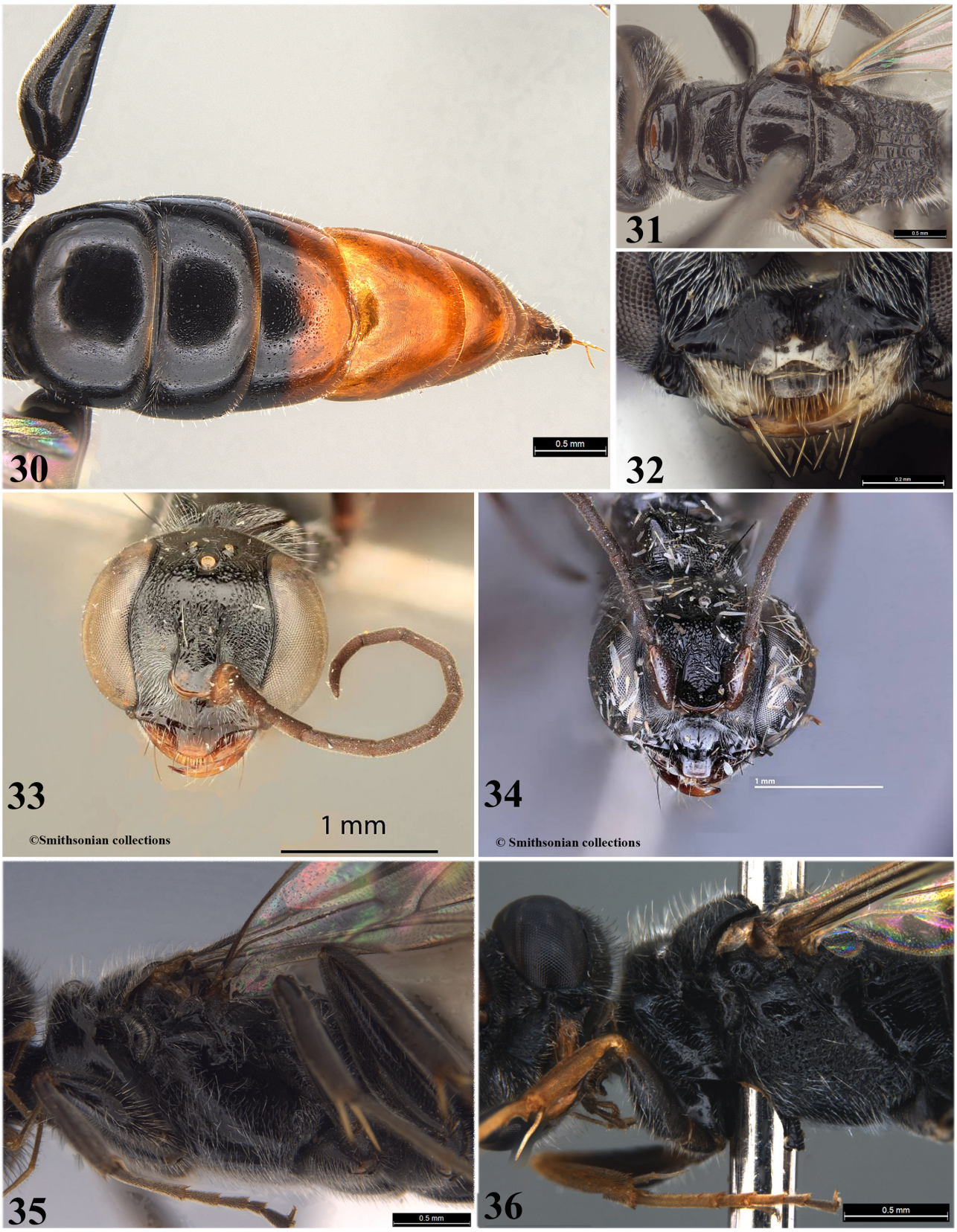
Dolichurus reticulatus Cameron 1899: 56, ♂. Holotype or syntypes: ♂, India: Assam: Khasia Hills (OXUM). Synonymized with *Dolichurus bipunctatus* by Turner 1912: 364.

Diagnosis. FEMALE. BL 7.1 mm; frons smooth with scattered punctures; clypeus with median longitudinal carina reaching apical margin; black macrosetae at normal positions of clypeus, frons, pronotum, and scutellum; pronotal collar with a few close transverse rugulae on anterior half; mesopleuron with subcontiguous punctures tending to coalesce in oblique rows.



FIGURES 24–29. **24**. *Dolichurus albifacies* Krombein, ♀ Habitus, lateral view; **25**. *Dolichurus amamiensis* Tsuneki and Iida**,** ♂ Habitus, lateral view; **26**. *Dolichurus amamiensis* Tsuneki and Iida, ♀ Habitus, lateral view; **27**. *Dolichurus gilberti* Turner, ♀ Habitus, lateral view; **28**. *Dolichurus taprobanae* Smith, ♂ Habitus lateral view; **29**. *Dolichurus taprobanae* Smith, ♀ Habitus lateral view.

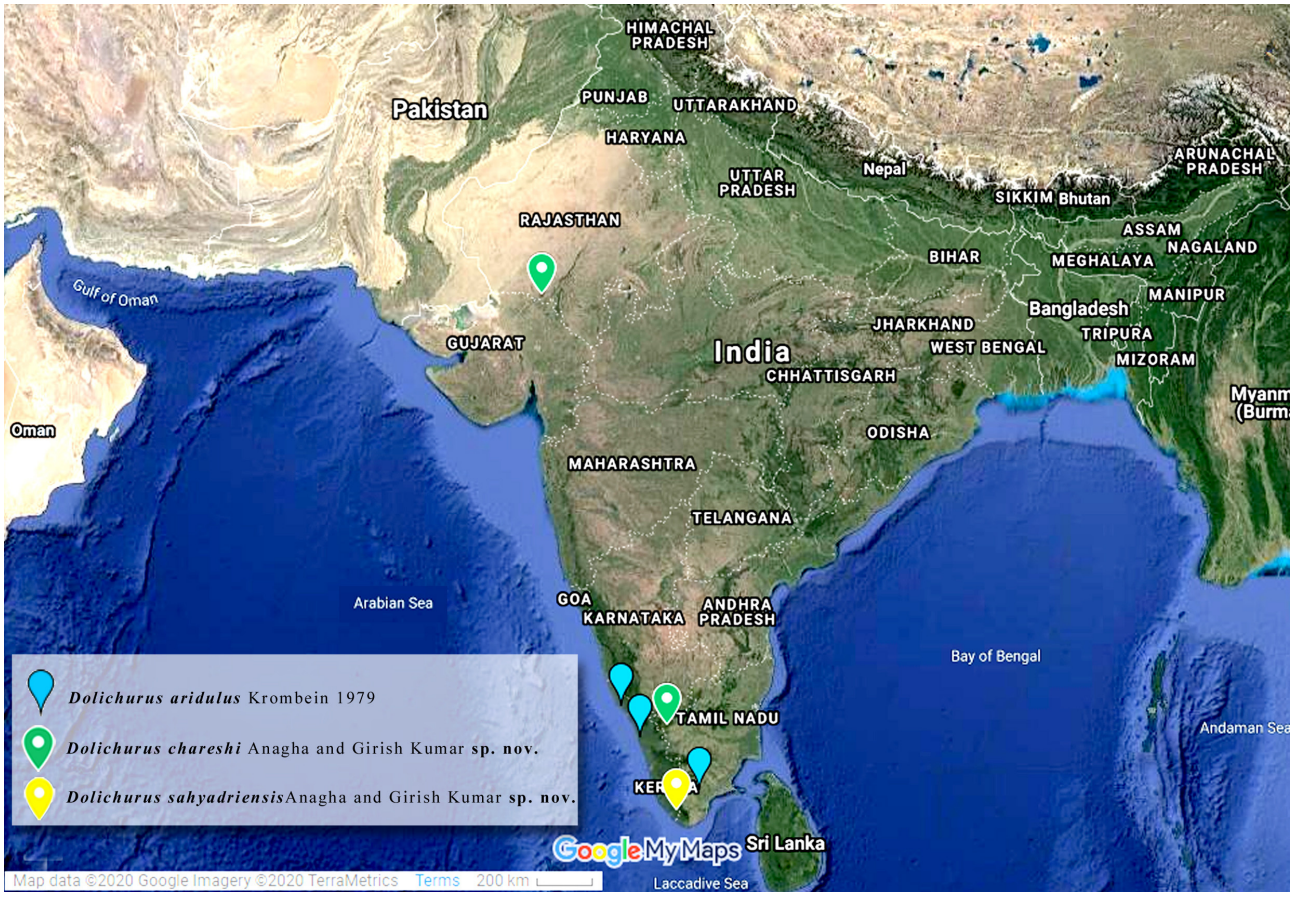
MALE. BL 5.2 mm; frons with rugulose reticulations; vertex with scattered tiny punctures; clypeus with median carina reaching apical margin; fontal platform broader than long; pronotal collar with a few close transverse rugulae on anterior half; mesopleuron with scattered tiny punctures (Fig. 31).



FIGURES 30–36. **30**. *Dolichurus gilberti* Turner**,** ♀ Metasoma; **31**. *Dolichurus amamiensis* Tsuneki and Iida, ♀ Mesosoma; **32**. *Dolichurus albifacies* Krombein, ♀ Clypeus; **33**. *Dolichurus aridulus* Krombein, ♀ Head, frontal view; **34**. *Dolichurus lankensis* Krombein, ♀ Head, frontal view; **35**. *Dolichurus taprobanae* Smith, ♂ Mesopleuron; **36**. *Dolichurus aridulus* Krombein, ♂, Mesopleuron.

Material examined. INDIA: Karnataka, Kodagu district, Betathur near Madikeri, 1 ♀, 24.xii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.13573; Shimoga district, Hosagadde, 1 ♀, 29.xii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.13635. Kerala, Kozhikode district, Purameri, 2 ♂ and 1 ♀, 15.xii.2019, Coll. K.P. Hanima Raveendran, ZSI/WGRC/I.R.–INV.13169 and 13823-13824; Kozhikode district, Madapally, 1 ♀, 5.1.2019, Coll. S. Anagha, ZSI/WGRC/I.R.–INV. 13170; Kozhikode district, Madapally, 1♂, 13.xi.2019, Coll. K. Anju, ZSI/WGRC/I.R.–INV.13435; Kasargod district; Ranipuram, 1 ♀, 21.i.2020, Coll. S. Anagha, ZSI/WGRC/I.R.–INV.13634. Tamil Nadu, Coimbatore district, Govanur, 1 ♂ and 2 ♀, 6.i.2019. Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV. 13171 and 13825-13826. Uttarakhand, Dehradun district, ZSI Campus, 1 ♀, 3.iii.2009, Coll. Rashmi and Aparna, ZSI/WGRC/I.R.–INV.12779; Dehradun district, ZSI Campus, 1 ♂, 18.vii.2019, Coll. P. Girish Kumar, ZSI/WGRC/I.R.–INV.13565.

Distribution. India: Assam, Bihar, Himachal Pradesh, Karnataka (new state record), Kerala (new state record), Meghalaya, Nicobar Islands, Sikkim, Tamil Nadu (new state record), Uttarakhand, West Bengal. *Elsewhere*: China; Indonesia; Laos; Malaysia; Myanmar; Sri Lanka; Thailand; Vietnam (Girish Kumar & Sheikh 2018).



MAP. Distribution map of new species and new record of *Dolichurus* from India

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(= *taprobanae,* male). The authors thankfully acknowledges C. Binoy, Research Scholar, University of Calicut for suggestions and support. The first author thankfully acknowledges UGC for the financial support by means of UGC-JRF.

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A review of the mud-dauber wasps of genus *Sceliphron* Klug (Hymenoptera: Sphecidae) from India

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Abstract

The mud-dauber wasp genus *Sceliphron* Klug (Hymenoptera: Sphecidae) is reviewed, with six species and six subspecies reported from various parts of India. The Palaerctic species, *S. destillatorium* (Illiger), is recorded for the first time from the Indian subcontinent. The subspecies *S. madraspatanum formosanum* van der Vecht is also recorded for first time from the Indian subcontinent. The distribution records of species and subspecies within various states of India are augmented. A modified key to the species of *Sceliphron* occurring in India is provided. Intraspecific variation within nominal species is discussed.

Key words: *Sceliphron*, India, new records, taxonomy, key

Introduction

Mud-dauber wasps of the genus *Sceliphron* Klug (Sphecidae: Sceliphrini) are known for their architectural dexterity in making nests from mud. They are represented by 35 species (including one fossil) and an additional 40 subspecies worldwide, of which 12 species and 11 subspecies are known from India (Pulawski 2021). The present study adds *S. destillatorium* (Illiger) and *S. madraspatanum formosanum* van der Vecht to the list of Indian *Sceliphron*.

Members of the genus are medium sized wasps (12–32 mm) having a temperate and tropical distribution (Bohart & Menke 1976; Pulawski 2021) and are proficient spider hunters. They track, hunt and paralyse spiders to provision their nest as food for developing larvae (Camillo 2002; Fateryga & Kovblyuk 2014). Each nest is composed of more than one cell and after constructing a single cell, the female stocks it with prey and lays a well-positioned egg on the spider before sealing the cell. A cell is completed and sealed off before constructing a subsequent one (Grandi 1961; Mitchell & Hunt 1986).

The genus *Sceliphron* Klug, 1801 (Type species: *Sphex* (=*Sceliphron*) *spirifex* Linnaeus) was divided into two subgenera *viz*., *Prosceliphron* and *Sceliphron* (van der Vecht & van Breugel 1968). *Prosceliphron*, being a preoccupied name, was replaced with *Hensenia* by Pagliano and Scaramozzino (1990).

Kohl (1918) revised the genus for the first time. Later van der Vecht & van Breugel (1968) revised the subgenus *Sceliphron* and Hensen (1987) revised the subgenus *Prosceliphron*. However, sub-generic status is not recognized in the present study and all species are placed under the genus *Sceliphron*.

Although common in collections, no comprehensive work has been done on the taxonomy of *Sceliphron* of India since Bingham (1897) and others adding species to the list. Since then, the generic and specific nomenclature has extensively changed and Bingham's work is scarcely useable in present times. Here, we provide the results of our taxonomic and distributional studies on the genus in India, with notes on intraspecific variation of the genus.

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Materials and methods

The *Sceliphron* specimens studied here belong to the Hymenoptera Section of the Zoological Survey of India, Kolkata (NZC), and Western Ghat Regional Centre, Zoological Survey of India, Kozhikode (ZSIK) along with fresh specimens collected from various localities in India. The specimens mounted on entomological pins were studied under LEICA M205 stereoscopic binocular microscope and images were captured using attached LEICA DFC 500 camera. Habitus images of the species were captured with digital camera (Canon Power Shot SX540 HS). Measurements were obtained using Leica LAS (Leica Application Suite V3.80) microsystems by Leica (Heerburg, Switzerland). Images at varying depth were stacked using Leica Automontage Software V3.80 and the final illustrations were processed for contrast and brightness using Adobe® Photoshop® CS5 (Version 6.1) software. Freshly collected specimens after curation are added to the 'National Zoological Collections' of ZSIK.

The morphological terminology used in this paper mostly follows Bohart & Menke (1976). Pulawski (2021) may be referred to for the taxonomic history of species with long lists of subsequent citations.

Museum abbreviations: **BMNH**: The Natural History Museum, formerly British Museum (Natural History), London, England; **DEI**: Deutsches Entomologisches Institute, Münchenberg, Germany; **NHMW**: Naturhistorisches Museum, Wien, Austria; **NZC**: National Zoological Collections, Zoological Survey of India, Kolkata, India; **MCZ**: Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA; **MRSN**: Museo Regionale di Scienze Naturali di Torino (Turin Museum of Natural History, Turin, Italy); **OXUM**: Hope Department of Zoology, Oxford, England; **RMNH**: Nationaal Naturhistorisch Museum, formerly Rijksmuseum van Natuurlijke Historie, Leiden, the Netherlands; **USNM**: National Museum of Natural History, Washington, D.C., U.S.A; **ZIN**: Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia; **ZMA**: Zoological Museum, Amsterdam, the Netherlands; **ZMHU**: Zoologisches Museum der Humboldt Universität, currently Museum für Naturkunde der Humboldt Universität zu Berlin, Berlin, Germany; **ZSIK**: National Zoological Collections, Western Ghat Regional Centre, Zoological Survey of India, Kozhikode, India.

Results

Genus *Sceliphron* Klug, 1801

Sceliphron Klug 1801: 561. Type species: *Sphex* (= *Sceliphron*) *spirifex* Linnaeus, 1758, designated by Bingham 1897: 235. Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. Propodeum with U-shaped dorsal enclosure; both recurrent veins of fore wing received by second submarginal cell; spiracular groove absent; female without fore tarsal rake; tarsi with plantulae; body usually with yellow markings (Bohart & Menke 1976); clypeus of female apico-medially incised, with or without deep/shallow lateral incisions, followed by sublateral lobes (Figs 2, 11, 16, 21, 26, 33, 43, 52); clypeus of male apico-medially emarginate, with or without blunt lobes laterally (Figs 8, 31, 38, 49).

Distribution. Widely distributed in temperate and tropical regions throughout the world (Pulawski 2021).

Prey. Spiders belonging to the families Anyphaenidae, Araneidae, Argiopidae, Clubionidae, Heteropodidae, Loxoscelidae, Mimetidae, Miturgidae, Oxyopidae, Philodromidae, Pholcidae, Salticidae, Selenopidae, Scytodidae, Theridiidae and Thomisidae (Camillo 2002; Fateryga & Kovblyuk 2014).

Key to Indian species and subspecies of *Sceliphron* Klug

(Adopted from van der Vecht & van Breugel (1968) and Hensen (1987))

(Indian species *S. neobilineatum* Jha & Farooqi, *S. paraintrudens* Jha & Farooqui, and *S. isaaci* Jha & Farooqi are excluded due to lack of details in the descriptions; our efforts to locate the type material proved unsuccessful)

1. Last metasomal sternum of female with longitudinal carina as long as half length of sternum (Fig. 7); lower half of inner eye margin sub-parallel (Fig. 2); last metasomal tergum of male with pygostyle (Fig. 9); second submarginal cell of fore wing wider than third anteriorly (Fig. 3); mandibles without tooth on inner side 2

- Last metasomal sternum of female slightly convex, rarely with short longitudinal carina on apical third (Fig. 48); lower half of inner eye margin distinctly converging towards clypeus (Fig. 43); last metasomal tergum of male without pygostyle (Fig. 50);

second submarginal cell of fore wing not wider than third anteriorly, if wider than third, then female mandible with distinct tooth on inner side 8
2. Petiole in lateral view nearly straight, yellow, usually longer than hind tibia . . . . . ***S. rectum*** Kohl ... 3
- Petiole in lateral view distinctly curved (Figs 1, 15), usually shorter than hind tibia 4
3. Metanotum with yellow band; propodeum with extensive yellow markings; first tergum usually with yellow band; hind tibia black . . . . . ***S. rectum pulchellam*** Gussakovskij
- Metanotum, propodeum and first tergum black; hind tibia yellow on outer side . . . . . ***S. rectum rectum*** Kohl
4. Mesoscutum dull, ruguloso-striate (Fig. 12) 5
- Mesoscutum comparatively shiny, regularly striate (Figs 4 & 17) 6
5. Interocular distance at vertex distinctly longer than first flagellomere . . . . . ***S. curvatum*** (F. Smith)
- Interocular distance shorter . . . . . ***S. formosum formosum*** (F. Smith)
6. Petiole yellow to yellowish brown, rest of metasoma black; mesosoma usually entirely black (except on frontal collar) (Fig. 4) . . . . . ***S. coromandelicum*** (Lepeletier)
- Petiole entirely or mostly black; mesosoma usually with extensive yellow areas . . . . . ***S. deforme*** (F. Smith) ... 7
7. Yellow bands on first and second terga complete; post antennal tubercle with yellow spot . . . . ***S. deforme deforme*** (F. Smith)
- First and second terga mostly reddish brown to deep brown, paler on the posterior margin of remaining terga (Fig. 19); post antennal tubercle black . . . . . ***S. deforme tibiale*** Cameron
8. Hind coxa normal or somewhat swollen, rounded on outer side (Fig. 44); inner side of mandible with more or less distinct tooth; propodeal side less sharply and coarsely striate . . . . . ***S. madraspatanum*** species group ... 9
- Hind coxa swollen on outer side, dorso-basally angulate (Fig. 27); mandible simple (except in *S. arabs*); propodeal side in most species more sharply and coarsely striate . . . . . ***S. spirifex*** species group ... 14
9. Mesepisternum distinctly rugose between punctures, dull, not shinier than propodeal side; with yellow mark below tegula . . . . . ***S. caementarium*** (Drury)
- Mesepisternum more or less coarsely punctate (interstices in some species with microscopically fine punctation, but not distinctly rugose), as a rule shiny and usually more so than striate propodeal side; with or without yellow mark below tegula 10
10. Tegula brown or black . . . . . ***S. intrudens*** (F. Smith)
- Tegula marked with yellow 11
11. Mesepisternum black, sometimes with more or less reduced yellow mark below tegula; scutellum and propodeum typically without yellow markings 12
- Mesepisternum with distinct yellow mark below tegula; scutellum and propodeum with or without yellow markings 13
12. Pronotum with narrowly interrupted yellow band; metanotum with yellow band (Fig. 45) . . . . . ***S. madraspatanum madraspatanum*** (Fabricius)
- Pronotum and metanotum black (Fig. 34) . . . . . ***S. madraspatanum andamanicum*** Kohl
13. Propodeum typically with yellow markings (Fig. 53) . . . . . ***S. madraspatanum pictum*** (F. Smith)
- Propodeum black (Fig. 39) . . . . . ***S. madraspatanum formosanum*** van der Vecht
14. Tegula and usually metanotum marked with yellow or yellowish brown (Fig. 22); metasomal petiole relatively short, about 0.8× length of hind tibia . . . . . ***S. destillatorium*** (Illiger)
- Tegula and metanotum black; metasomal petiole as long as hind tibia or little longer . . . . . ***S. javanum*** (Lepeletier) ... 15
15. Hind tibia yellow (Fig. 25) . . . . . ***S. javanum nalandicum*** Strand
- Hind tibia black 16
16. Hind femur yellow with usually ill-defined fuscous mark dorso-apically; if entirely fuscous to black, then dark part angularly produced on inner side of femur, and rarely covers more than apical third on outer side . . . ***S. javanum javanum*** (Lepeletier)
- Hind femur with at least apical third black, dark part rather sharply separated from basal yellow part . . . . . ***S. javanum petiolare*** Kohl

1. *Sceliphron caementarium* (Drury, 1773)

Sphex caementarius Drury, 1773: index to First Volume, ♀ (as *caementaria*, incorrect original termination). Syntypes: "Antigua and several other places in the West-Indies" (lost: van der Vecht & van Breugel 1968: 222).
Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. Frons distinctly pilose; pronotal collar dorsally with yellow band, pronotum side black; scutellum, metanotum and posterior surface of propodeum with yellow markings; mesepisternum dull, distinctly rugose between punctures, yellow mark below tegula; first tergum mostly yellow, and rest of metasomal segments and petiole black; fore and mid legs yellow: coxae, trochanter, base of femora black; hind leg black: tibiae with broad yellow ring at base, hind tarsi partly yellow.

Note. As no specimens were seen during the present study, the above diagnosis has been based on published descriptions (F. Smith 1856; Bingham 1897; van der Vecht & van Breugel 1968; Schmidt–Egger 2005).

Distribution. India (no specific locality). ***Elsewhere***: Australia; Austria; Bangladesh; Belgium; Belize;

Bermuda; Bulgaria; Canada; Canary island; Chile; Cook Island; Costa Rica; Croatia; Cuba; Czech Republic; Eritrea; France; French Polynesia; Fiji; Germany; Hungary; Iran; Italy; Jamaica; Japan; Korea; Luxembourg; Mariana Island; Marshall Island; Mexico; Netherland; New Caledonia; Nicaragua; Portugal; Puerto Rico; Samoa; Slovakia; Switzerland; Ukraine; United States of America; West Indies (Pulawski 2021).

2. *Sceliphron coromandelicum* (Lepeletier, 1845)

(Figs 1–9)

Pelopaeus coromandelicus Lepeletier, 1845: 306, ♀ (as *Coromandelicus*, incorrect original capitalization). Holotype or syntypes: ♀, India: Coromandel Coast: no specific locality (M. Spinola collection (MRSN)).

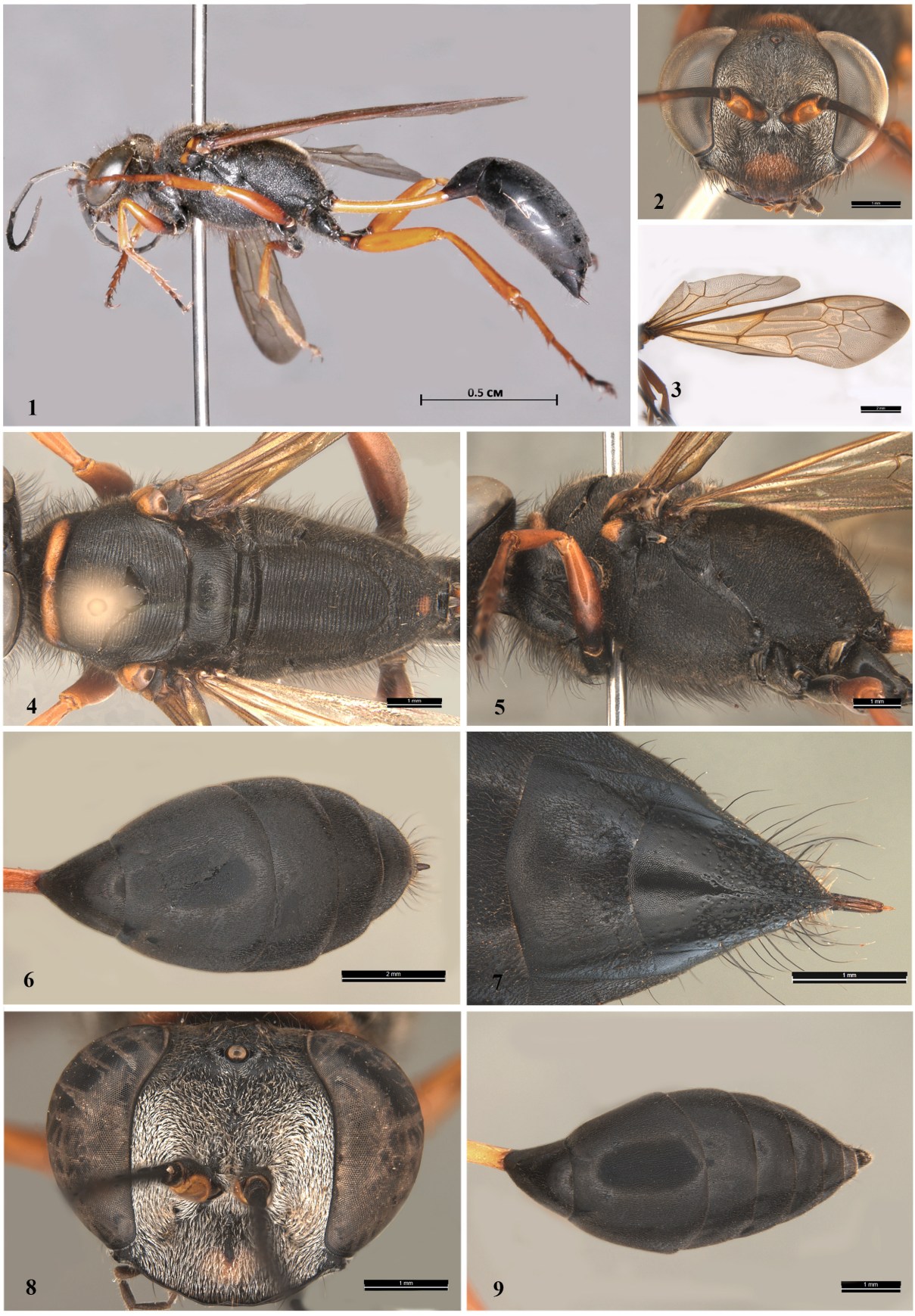
Diagnosis. **Female**. Frons distinctly pilose, sculpture not visible due to pilosity; clypeus incised apico-medially, forming two lobes, yellowish brown macula on upper clypeal margin (Fig. 2); pronotal collar dorsally with yellowish brown band, medially notched; mesoscutum distinctly transversely striate; scutellum with longitudinal oblong striation; metanotum with faint transverse striation; propodeal enclosure transversely striate with shallow longitudinal depression medially, posterior surface of propodeum sometimes with small yellowish brown spot (Fig. 4); mesepisternum and propodeum side with fine striation, yellowish brown spot below tegula on upper mesopleuron (Fig. 5); metasoma black with fine setae (Fig. 6); petiole yellow or yellowish brown.

Male. Similar to female.

Variability. The specimens examined here differ in colour compared to the description of Hensen (1987). Maculae on upper clypeal margin; ventral surface of scape; and band on pronotum are yellowish brown rather than yellow as mentioned by Hensen.

Material examined. India: Andaman Islands: South Andaman Dist., Port Blair. 1♀, 4.iii.2020, Coll. A.K Dubey, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 15285. Bihar: Purnia Dist., 1♀, Date of collection unknown, Coll. Unknown, NZC Regd. No. 14890/H3. Delhi: North Delhi Dist., Delhi University Campus, 1♀, 15.viii.1977, Coll. Anita, NZC Regd. No. 14891/H3. Goa: North Goa Dist., Salim Ali BS, 1♀, 14.v.2018, Coll. P. Girish Kumar and Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14046. Himachal Pradesh: Kangra Dist., Kangra Valley, 1♀, March1899, Coll. Dudgeon, NZC Regd. No. 14892/H3. Karnataka: Banglore Dist., G.K.V.K Dok, 1♀, Date of collection. unknown, Coll. N.K.K. Kumab, NZC Regd. No. 14893/H3; Shimoga Dist., Agumbe, 1♂, 27.xii.2019, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14047. Kerala: Ernakulam Dist., Thattekad BS, 1♀, 05.ii.2017, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 8693; Kozhikode Dist., Nambikulam, 3♀, Aug. 2018–May 2019, Coll. Sandra Lishikumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 12454–12456; Thiruvananthapuram Dist., Paruthippara, 1♀, 18.xi.2018, Coll. N.V. Ayisha Mawadda, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14034; Kannur Dist., Aralam, 1♂, 16.iii.2019, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14035. Maharashtra: Satara Dist., Panchgani, 1♀ and 1♂, Date of collection unknown, Coll. E. Flatter and J. Fernandez, NZC Regd. Nos. 14894/H3 and 14895/H3. Odisha: Mayurbhanj Dist., Burrapani, 1♀, 06.iv.1923, R.P. Mullins, NZC Regd. No. 14896/H3; Keonjhar Dist., Jajpur Road Temple, 1♀, 19.viii.1972, S.K. Mitra and Party, NZC Regd. No. 14897/H3. Punjab: Jalandhar Dist., 2♀, 05.iv.1905, Coll. Unknown, NZC Regd. Nos. 14898/H3 and 14899/H3. Sikkim: 1♀, August1897, Coll. Dudgeon, NZC Regd. No. 14900/H3. Tamil Nadu: Cuddalore Dist., Pichavaram Mangrove Island, 1♀, 29.i.1981, Coll. M. Srinivas and Party, NZC Regd. No.14901/H3. Uttarakhand: Dehradun Dist., Sahastra Dhara Hills, 1♀, 24.6.1964, Coll. R.K. Bhatnagar, NZC Regd. No. 14902/H3; Dehradun Dist., Mussorie, 1♀, 29.v.1965, Coll. T.D. Soota, NZC Regd. No. 15626/H3; Dehradun Dist., Kalsi, 5♂, Coll. P. Girish Kumar; 18.vii.2019, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 14039–14043. Uttar Pradesh: Bareilly Dist., 1♀, 01.ix.1905, Coll. Brunetti, NZC Regd. No. 14903/H3. West Bengal: Kolkata, Southern Avenue, 1♀ and 7♂, 26.vii.2011 and 04.iv.2012, Coll. P. Girish Kumar, NZC Regd. Nos. 14904/H3–14908/H3 and 14910/H3–14912/H3; Nadia Dist., Chakdah, 1♀, 10.x.2012, C.R. Satpati and Party, NZC Regd. No. 14909/H3.

Distribution. India: Andaman Islands (new union territory record), Assam, Bihar, Delhi (new state record), Goa (new state record), Himachal Pradesh (new state record), Karnataka, Kerala, Maharashtra, Meghalaya, Odisha, Pondicherry, Punjab (new state record), Sikkim (new state record), Tamil Nadu, Uttarakhand (new state record), Uttar Pradesh (new state record), West Bengal. ***Elsewhere***: Bangladesh; Cambodia; Laos; Malaysia; Myanmar; Sri Lanka; Thailand (Hensen 1987; Dollfuss 2016; Pulawski 2021).



FIGURES 1–9. *Sceliphron coromandelicum* (Lepeletier), 1–7 ♀. 1. Habitus, lateral view; 2. Head, frontal view; 3. Fore wing; 4. Mesosoma, dorsal view; 5. Mesosoma, lateral view; 6. Metasoma, dorsal view; 7. Apical metasomal sterna; 8–9 ♂. 8. Head, frontal view; 9. Metasoma, dorsal view.

3. *Sceliphron curvatum* (F. Smith, 1870)

(Figs 10–14)

Pelopaeus curvatus F. Smith, 1870: 187, Lectotype: ♂, India: North-West Provinces, now Uttar Pradesh: Mainpuri (BMNH), designated by Hensen 1987: 230.

Sceliphron deforme Basil-Edwardes, 1921: 293 (nesting habits), identification corrected to *S. curvatum* by Hensen, 1987: 220.

Diagnosis. **Female**. Frons distictly pilose, upper frons rugulose to inconspicuously striate punctate, sculpture on remaining frons not visible due to pilosity; clypeus apico-medially produced with median incision forming two lobes, yellow macula on upper clypeal margin (Fig. 11); pronotal collar dorsally with yellow band, medially notched; mesoscutum with irregular rugulose striae; scutellum with longitudinal oblong striae and distinct punctures, broad yellow patch antero–medially; metanotum irregularly rugulose; propodeal enclosure ruguloso-striate with shallow depression in middle, large yellow spot on posterior region of propodeum (Fig 12); mesepisternum finely striate to alveolate, coarsely punctate towards posterior region, yellow mark below tegula; propodeum side with rugulose striae (Fig. 13); metasoma with yellowish brown band on terga (Fig. 14); petiole black.

Male. Not seen in the present study. Similar to female except for petiole little longer (Hensen 1987).

Variability. Band on pronotum; patch on antero–median scutellum; large spot on posterior surface of propodeum are reddish brown in some female specimens examined here.

Material examined. India: Himachal Pradesh: Chamba Dist., Khajjiar, 1♀, 26.vi.2012, Coll. D. Banerjee and Party, NZC Regd. No. 15580/H3; Kangra Dist., Kangra Valley, 6♀, May1899, Coll. Dudgeon, NZC Regd. Nos. 15610/H3–15616/H3; Shimla Dist., 1♀, viii.1925, Coll. B.C. Chopra, NZC Regd. No. 15617/H3; Chamba Dist., Khajjiar, 1♀, 29.vi.1965, Coll. D. Ram, NZC Regd. No. 15618/H3. Jammu and Kashmir: N-W Himalayas, 1♀, 1915, H.T. Pease, NZC Regd. No. 15619/H3; Srinagar Dist., Pari Mahal, 1♀, 10.x.2020, Coll. A. H. Sheikh, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17126. Uttarakhand: Nainital Dist., Nainital, 2♀, 1908, Coll. R.E. Lloyd, NZC Regd. Nos. 15579/H3 and 15620/H3; Dehradun Dist., Mussorie, 3♀, 20.v.1905 and 20.vi.1906, Coll. Brunetti, NZC Regd. Nos. 15621/H3–15623/H3.

Distribution. India: Himachal Pradesh, Jammu and Kashmir, Nagaland, Punjab, Uttarakhand, Uttar Pradesh. ***Elsewhere***: Afghanistan; Argentina; Austria; Belarus; Belgium; Bulgaria; Chile; Croatia; Czech Republic; France; French Polynesia; Georgia; Germany; Greece; Hungary; Iraq; Italy; Kazakhstan; Kyrgyzstan; Lithuania; Montenegro; Nepal; Netherland; Pakistan; Poland; Portugal; Russia; Serbia; Slovakia; Slovenia; Spain; Switzerland; Tajikistan; Turkey; Ukraine; Uzbekistan (Pulawski 2021).

4. a. *Sceliphron deforme deforme* (F. Smith, 1856)

Pelopoeus deformis F. Smith, 1856: 231, ♀. Lectotype: ♀, North China: no specific locality (BMNH), designated by Hensen, 1987: 238.

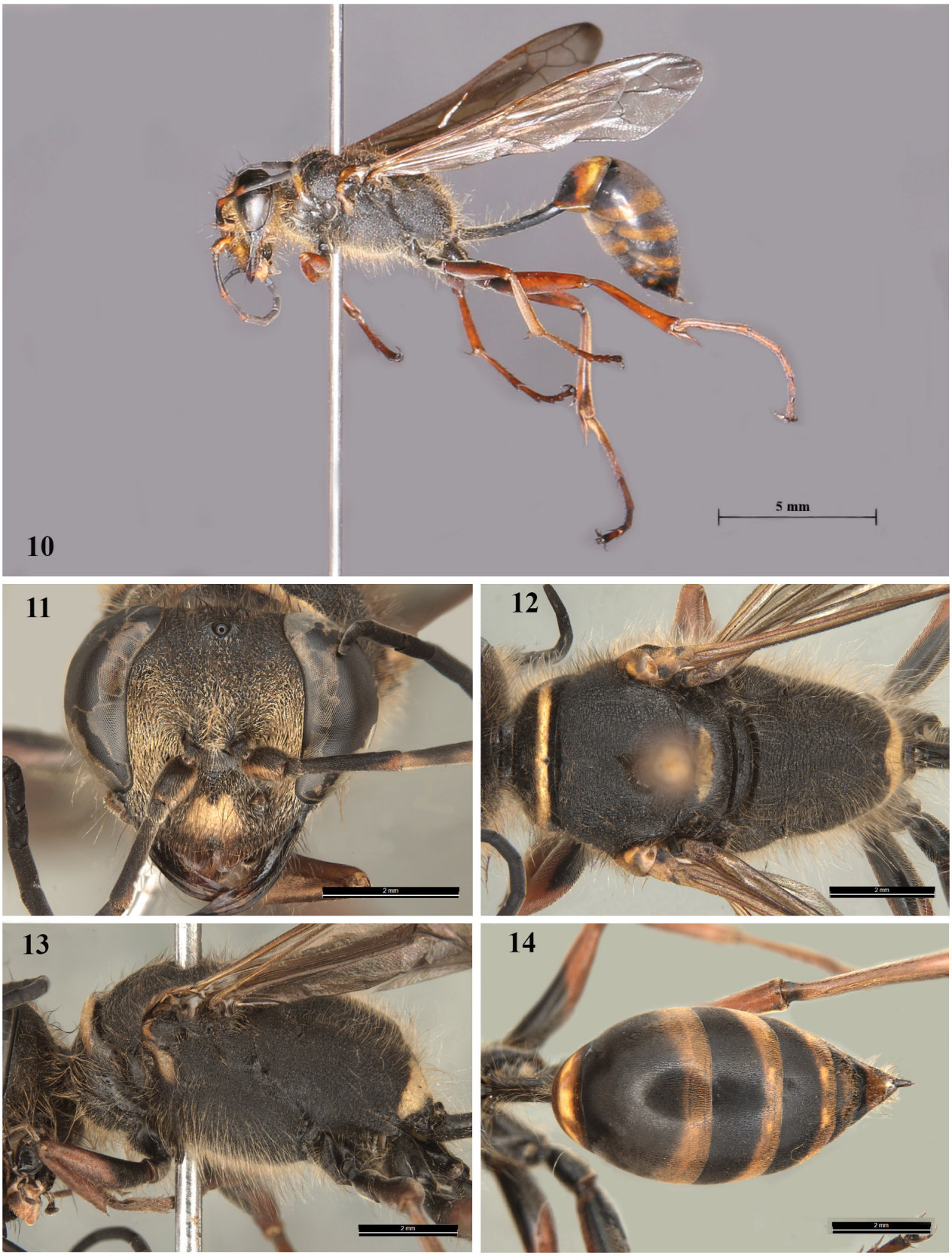
Sceliphron deforme taiwanum Tsuneki, 1971: 6, ♀, ♂. Holotype: ♀, Taiwan: Taitung Prefecture: Chulu (originally K. Tsuneki coll., now USNM). Synonymized with *Sceliphron deforme deforme* by Hensen, 1987: 238.

Diagnosis. **Female.** Frons distinctly pilose; clypeus apico-medially incised without lateral incisions (*c.f.* Figs 33 & 34 of Hensen (1987: 229)); pronotal collar and scutellum with yellow markings; mesoscutum and propodeum transversely striate; propodeum with large basal spots and sometimes with pair of spot at apex of dorsal enclosure; metasoma with reddish yellow band on all terga.

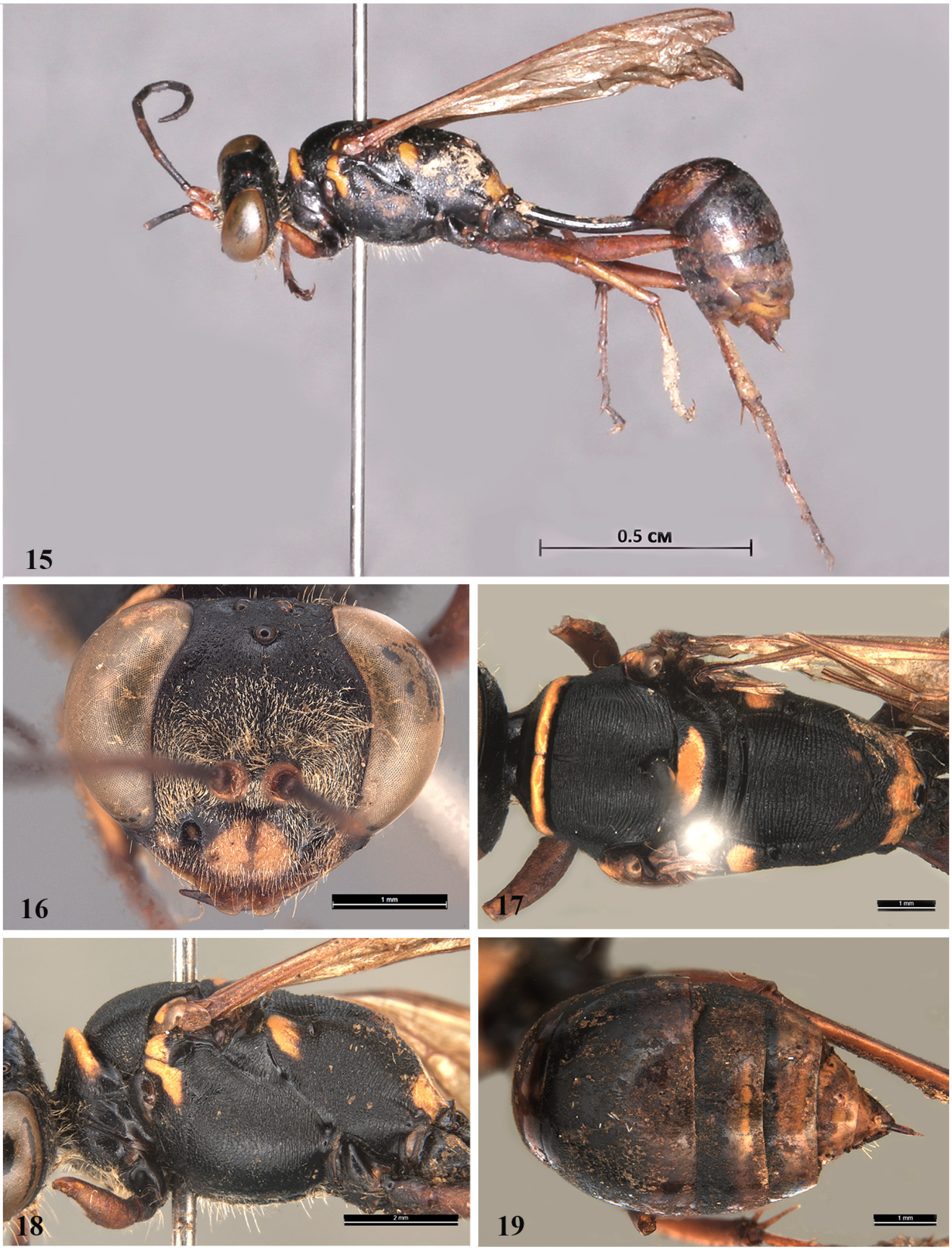
Male. Darker than the female, yellow markings less developed: clypeus often with pair of small spots; basal propodeal spots and bands on terga usually reduced, sometimes nearly absent.

Note. As no specimens were seen during the present study, the above diagnosis has been based on the published descriptions of the species (F. Smith 1856; Tsuneki 1971; Hensen 1987).

Distribution. India: Assam. ***Elsewhere***: China (including Hong Kong); France; Japan; Kazakhstan; Korea; Laos; Mongolia; Montenegro; Myanmar; Philippines; Russia; Tajikistan; Taiwan; Thailand; Vietnam (Barthélémy 2014; Dollfuss 2016; Pulawski 2021).



FIGURES 10–14. *Sceliphron curvatum* (F. Smith), ♀. 10. Habitus, lateral view; 11. Head, frontal view; 12. Mesosoma, dorsal view; 13. Mesosoma, lateral view; 14. Metasoma, dorsal view.



FIGURES 15–19. *Sceliphron deforme tibiale* Cameron, ♀. 15. Habitus, lateral view; 16. Head, frontal view; 17. Mesosoma, dorsal view; 18. Mesosoma, lateral view; 19. Metasoma, dorsal view.

b. *Sceliphron deforme tibiale* Cameron, 1899

(Figs 15–19)

Sceliphron formosum Bingham, 1897: 239 (in revision of wasps and bees of British India), identification corrected to *S. deforme tibiale* by Hensen 1987: 234.

Sceliphron tibiale Cameron, 1899: 53, sex not indicated. Lectotype: ♀, India: Assam [now Meghalaya]: Khasia Hills (OXUM), designated by Hensen 1987: 236. As *Sceliphron deforme tibiale*: Bohart and Menke, 1976: 106 (new status).

Sceliphron lineatipes Cameron, 1900: 36, ♂. Lectotype: ♂, India: Assam [now Meghalaya]: Khasia (OXUM) designated by Hensen 1987: 236. Synonymized with *Sceliphron deforme* by Hensen, 1987: 236.

Diagnosis. **Female**. Frons distictly pilose, upper frons rugulose to weakly striate, sculpture on remaining frons not visible due to pilosity; clypeus apico-medially produced with median incision forming two lobes; pale yellowish brown macula on upper clypeal margin (Fig. 16); pronotal collar dorsally with broad pale yellowish brown band, medially notched; mesoscutum transversely striate; scutellum with longitudinal oblong striations and punctures, broad pale yellowish patch antero–medially; metanotum faintly and transversely striate; propodeal enclosure transversely striate, with shallow depression in middle, basal propodeal spots (on each side), pair of small spots at apex of dorsal enclosure and large mark at posterior surface of propodeum pale yellowish brown (Fig. 17); mesepisternum and propodeum side with fine striation, pale yellowish brown mark below tegula (Fig. 18); metasoma with first and second tergum mostly reddish brown to deep brown, paler on posterior margin of remaining terga (Fig. 19); petiole black.

Male. Not seen during the present study. Colouration similar to female or at most reduced: clypeus with pair of small yellow spots or completely black; yellow spots at base of propodeum small or absent; metasoma with narrow yellow bands on fourth to sixth tergum, those on second and third reduced or absent (Hensen 1987).

Variability. The female specimens examined here differ in colour from the description of Bingham (1897). Macula on upper clypeal margin; band on pronotum; antero–median patch on scutellum; pair of spots at apex of dorsal enclosure and large mark on posterior surface of propodeum are pale yellowish brown in the specimens examined, while yellow according to Bingham.

Material Examined. India: Arunachal Pradesh: Papumpare Dist., Itanagar, Shanke Valley, 2♀, 08.vii.2002, Coll. P.T. Bhutia and Party, NZC Regd. Nos. 15555/H3–15556/H3; Papumpare Dist., Tipi, 1♀, 03.v.1966, Coll. A.N.T. Joseph, NZC Regd. No. 15557/H3. Assam: Kamrup Dist., Manas, Kahitama, 1♀, 24.iv.1986, S.S. Saha and Party, NZC Regd. No. 15558/H3. Meghalaya: East Garo Hills Dist., Songsok, 5♀, 05.v.1979, Coll. J.K. Jonathan and Party, NZC Regd. Nos. 15559/H3–15563/H3; East Garo Hills Dist., Dainadubi, 1♀, 08.v.1979, Coll. J.K. Jonathan and Party, NZC Regd. No. 15564/H3; East Garo Hills Dist., Williamnagar, 1♀, 27.v.1990, Coll. M.S. Shisodia and Party, NZC Regd. No. 15567/H3; West Garo Hills Dist., Bhaitbari, 1♀, 06.iv.1973, Coll. S. Biswas and Party, NZC Regd. No. 15568/H3; West Garo Hills Dist., Anugiri, 1♀, 20.iv.1991, Coll. B.C Das and Party, NZC Regd. No.15569/H3. Manipur: Thoubal Dist., Thoubal, 1♀, 21.viii.1922, Coll. Unknown, NZC Regd. No.15569/H3. Tripura: Unakoti Dist., Kailashahar, 1♀, 28.v.1978, Coll. J.K. Jonathan and Party, NZC Regd. No. 15571/H3. West Bengal: Darjeeling Dist., Siliguri, 2♀, 06.iv.1973, Coll. N.S. Sharma and Party, NZC Regd. Nos. 15572/H3 and 15573/H3; Darjeeling Dist., Singla, 2♀, Date of Collection. unknown, Coll. Lord Carmichael, NZC Regd. Nos. 15574/H3 and 15575/H3.

Distribution. India: Arunachal Pradesh (new state record), Assam (new state record), Manipur (new state record), Meghalaya, Sikkim, Tripura (new state record), Uttarakhand, West Bengal. ***Elsewhere***: Australia; Bangladesh; Myanmar; Tanzania (Bingham 1897; Pulawski 2021).

5. *Sceliphron destillatorium* (Illiger, 1807)

(Figs 20–24)

Pepsis destillatoria Illiger, 1807: 94, sex not indicated. Holotype or syntypes: Europe: no specific locality (destroyed). Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. Female. Frons pilose, distinctly punctate; clypeus apico–medially produced with median incision forming two lobes, these lobes followed by lateral incisions forming blunt lobes sublaterally (Fig. 21); pronotal collar finely punctate with notch in middle; mesoscutum with more or less distinct, fine close striation, anteriorly

almost transversely striate, becoming oblique posteriorly; scutellum and metanotum with longitudinal oblong striation; metanotum with broad yellowish brown band (Fig. 22); propodeal enclosure with wavy striation, medially with shallow depression; mesepisternum shiny, with close and coarse fine punctures; propodeum side with distinct striation and punctures in interstices (Fig. 23); metasoma black (Fig. 24); tegula and petiole yellowish brown.

Male. Not seen during the present study. Similar to female in most aspects (Kohl 1918).

Variability. The female specimens examined here differ in colour compared to the description of Schmid–Egger (2005). Tegula, band on metanotum, petiole, parts of legs are yellowish brown in the specimens examined, while lemon yellow according to Schmid–Egger.

Material Examined. India: Himachal Pradesh: Shimla Dist., 1♀, May 1971, Coll. Unknown, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14897.

Distribution. India (new country record): Himachal Pradesh. ***Elsewhere***: Afghanistan; Albania; Algeria; Austria; Bulgaria; China; Croatia; Czech Republic; France; Germany; Greece; Hungary; Iran; Iraq; Israel; Italy; Jordan; Kazakhstan; Kyrgyzstan; Macedonia; Montenegro; Morrocco; Poland; Portugal; Romania; Russia; Serbia; Slovakia; Slovenia; Spain; Switzerland; Syria; Tajikistan; Tunisia; Turkey; Turkmenistan; Ukraine; Uzbekistan (Pulawski 2021).

6. *Sceliphron formosum formosum* (F. Smith, 1856)

Pelopaeus formosus F. Smith 1856: 230, ♀. Lectotype: ♀, Australia: Northern Territory: Port Essington (BMNH), designated by Hensen 1987: 258.

Sceliphron papuanum Cameron 1906: 221, ♀. Holotype or syntypes: ♀, Indonesia: Papua: Merauke (ZMA). Synonymized with *Sceliphron formosum* by van der Vecht *in* R. Bohart and Menke, 1976:106.

Diagnosis. **Female**. Frons distinctly pilose; clypeus apico-medially incised with lateral incisions (see Fig. 103 of Hensen (1987: 250)); pronotal collar with yellow band; mesoscutum and propodeum transversely striate; scutellum with yellow patch; basal spot on each side of propodum, large one posteriorly and two oblong large spots in middle, yellow; metasoma with first, fourth (more or less), fifth, and sixth terga and petiole yellow (see Fig. 86 of Hensen (1987: 245)).

Male. Second tergum black, or with strongly reduced band; sterna usually black; petiole and antennal scape yellow; petiole a little longer than in female.

Note. No specimens were seen during the present study, so the above diagnosis has been based on the published descriptions (F. Smith 1856; Kohl 1918; Hensen 1987).

Distribution. India: Arunachal Pradesh, Himachal Pradesh, Meghalaya, Sikkim, Uttar Pradesh. ***Elsewhere***: Australia; China; Indonesia; Japan; Myanmar; New Guinea (Kundu *et al*. 2006; Pulawski 2021).

7. *Sceliphron intrudens* (F. Smith, 1858)

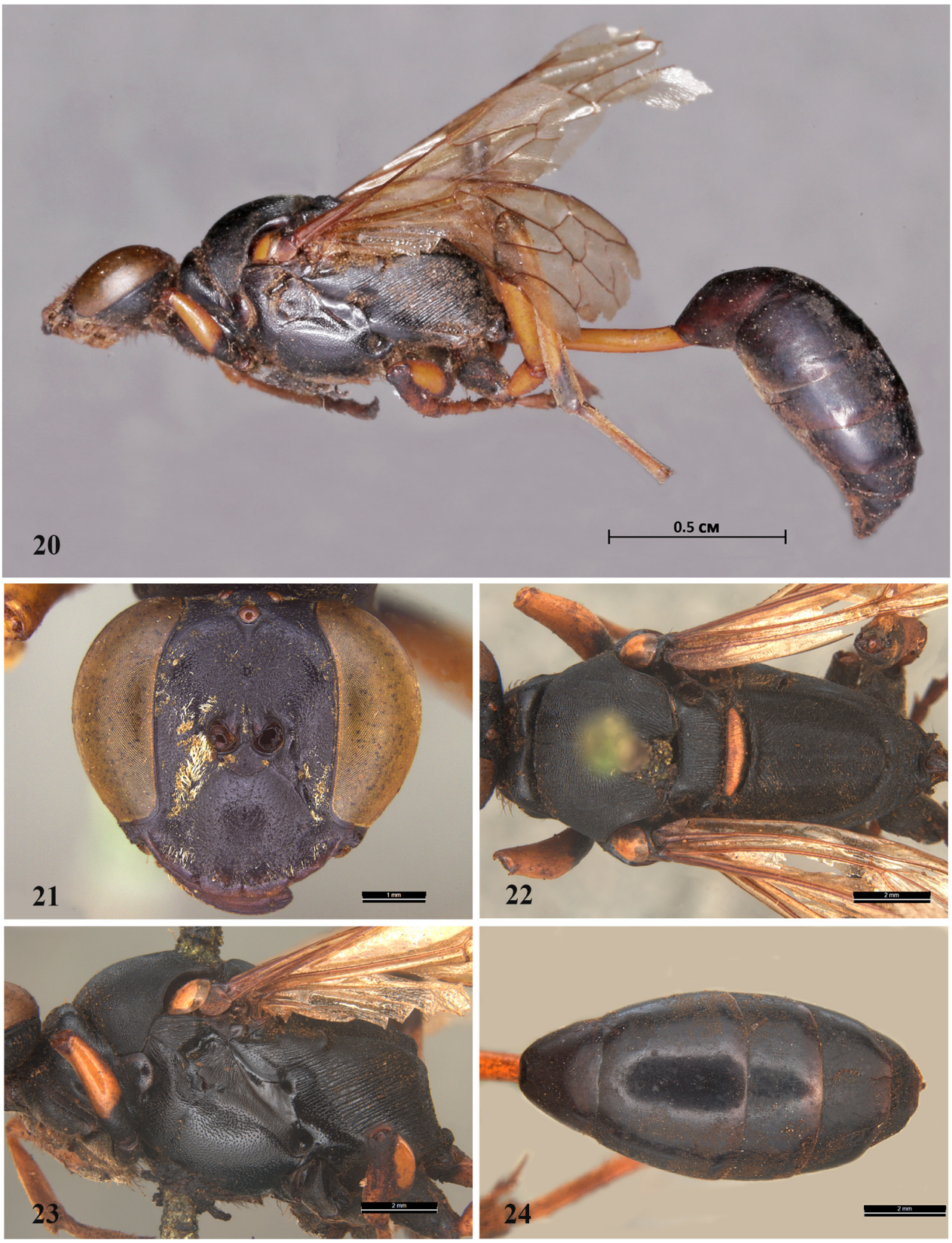
Pelopeus intrudens F. Smith, 1858: 15, ♀, ♂. Lectotype: ♀, Indonesia: Sulawesi: no specific locality (BMNH), designated by van der Vecht & van Breugel 1968: 212.

Diagnosis. Female. Frons distinctly pilose; clypeus incised medially; mesoscutum and propodeum transversely striate; scutellum and metanotum longitudinally striate; mesepisternum more or less coarsely punctate; metasoma smooth and shining; petiole pale yellow.

Male. Similar to female except smaller in size (F. Smith 1858; van der Vecht & van Breugel 1968).

Note. No specimens were seen during the present study, hence the above diagnosis has been based on the published descriptions (F. Smith 1858; Bingham 1897; van der Vecht & van Breugel 1968).

Distribution. India: Sikkim, Meghalaya. ***Elsewhere***: Indonesia; Malaysia; Maldives; Myanmar; Sri Lanka; Thailand; Vietnam (Jonathan & Kundu 2003; Pulawski 2021).



FIGURES 20–24. *Sceliphron destillatorium* (Illiger), ♀. 20. Habitus, lateral view; 21. Head, frontal view; 22. Mesosoma, dorsal view; 23. Mesosoma, lateral view; 24. Metasoma, dorsal view.

8. a. *Sceliphron javanum javanum* (Lepeletier, 1845)

Pelopaeus javanus Lepeletier 1845: 309, ♀ (as *Javanus*, incorrect original capitalization). Holotype: ♀, Indonesia: Java: no specific locality (originally Audinet-Serville coll., now M. Spinola collection (MRSN)).

Diagnosis. **Female**. Mesoscutum more or less distinctly striate, but striae not sharply defined; scutellum longitudinally striate; propodeum transversely striate with shallow depression medially; second submarginal cell anteriorly narrower than third; petiole equal to length of hind tibia; hind tibia black; hind femur yellow with usually ill defined fuscous mark at apex above; fore and mid femora black, brownish at apex; fore and mid tibiae orange yellow to pale brown.

Male. Similar to female except for petiole little longer (Bingham, 1897).

Note. No specimens were seen during the present study, so the above diagnosis has been based on the published descriptions (Bingham 1897; van der Vecht & van Breugel 1968).

Distribution. India: Arunachal Pradesh, Kerala, Sikkim, West Bengal. ***Elsewhere***: Cambodia; China; Indonesia; Japan; Laos; Malaysia; Myanmar; Nepal; Sri Lanka; Thailand; Vietnam (Barthélémy 2014; Dollfuss 2016; Kundu *et al*. 2006; Pulawski 2021).

b. *Sceliphron javanum nalandicum* (Strand, 1915)

(Figs 25–31)

As *Pelopoeus spinolae* F. Smith, 1856: 231 (Bombay, Sri Lanka), 1871: 359 (in catalog of Oriental Aculeata).
Sceliphron javanum var. *nalandicum* Strand, 1915: 93, ♀. Syntypes: ♀, Sri Lanka: Nalanda and Kandy (DEI).

Diagnosis. Female. Frons distinctly pilose, sculpture not clearly visible due to pilosity; clypeus apico–medially produced with median incision forming two lobes, these two lobes followed by lateral incisions forming blunt lobes sublaterally (Fig. 26); pronotal collar finely punctate with mesal notch; mesoscutum with more or less distinct fine close striation, anteriorly almost transversely striate, striae becoming oblique posteriorly; scutellum and metanotum with longitudinal oblong striation; propodeal enclosure with wavy striation, medially with shallow depression (Fig. 28); mesepisternum shiny with fine punctation; propodeum side with distinct striation and punctures in interstices (Fig. 29); metasoma black with fine setae (Fig. 30); tegula black; petiole yellow.

Male. Similar to female.

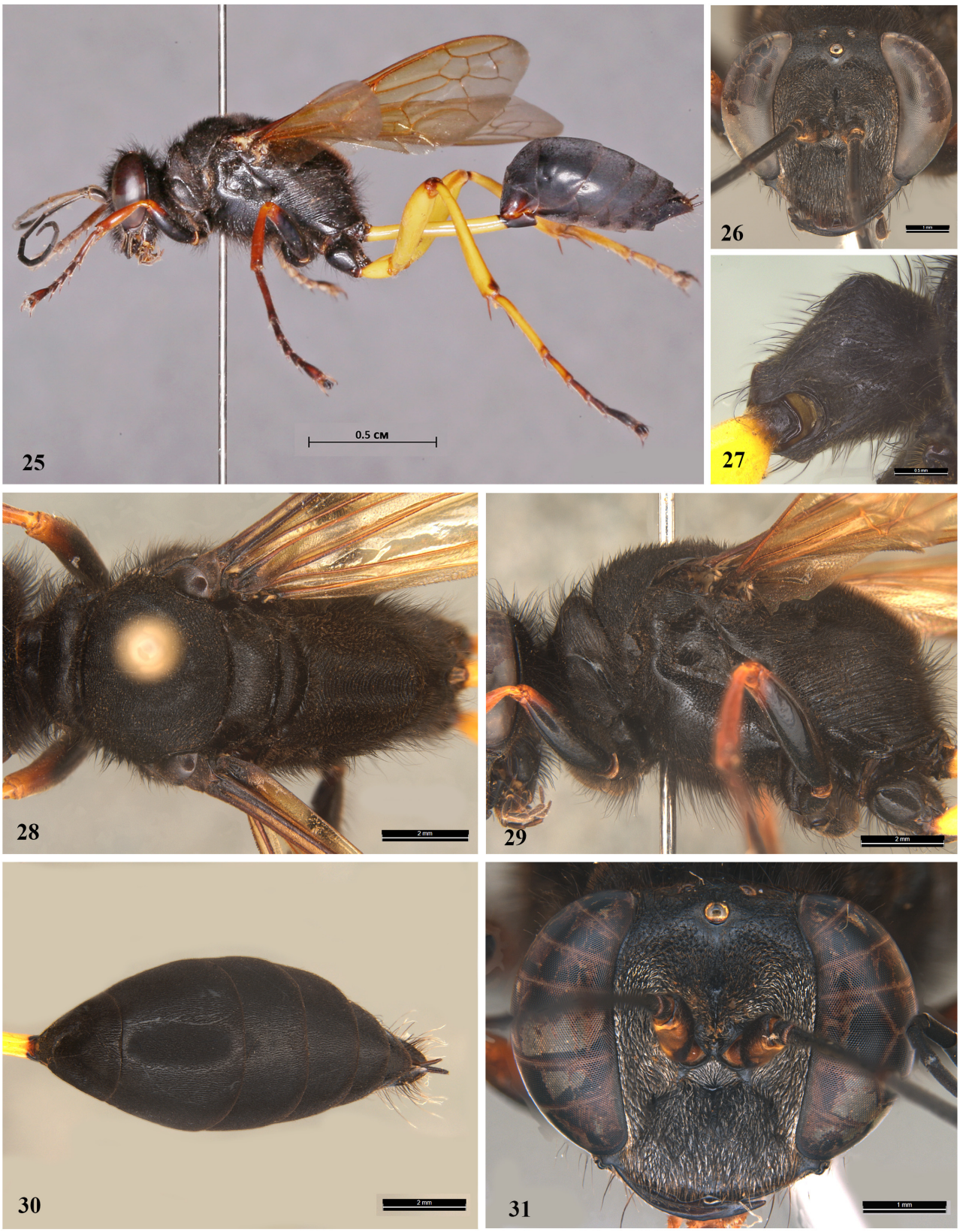
Material Examined. India: Meghalaya: West Garo hills Dist., Tura, 1♀, 15.vi.1915, Coll. S.K. Kemp, NZC Regd. No. 15658/H3. Odisha: Mayurbhanj Dist., Magshani, 1♀, 19.iii.1973, Coll. S.K. Gupta and Party, NZC Regd. No. 15653/H3; Mayurbhanj Dist., Astic, Baripada, 1♀, 21.iii.1973, Coll. S.K. Gupta and Party, NZC Regd. No. 15654/H3; Mayurbhanj Dist., Burrapani, 2♀, 06.iv.1923, Coll. R.P. Mullins, NZC Regd. Nos. 15655/H3 and 15656/H3. Kerala: Idukki Dist., Periyar, 1♀, 01.iii.1981, Coll. R.S. Pillai and Party, NZC Regd. No. 15657/H3; Kozhikode Dist., Kottooli wetland, 1♀, 08.v–20.vi.2017, Coll. Anisha and Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10006; Kannur Dist., Kannapuram mangrooves, 13-14.v.2018, 1♂, Coll. C. Charesh, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 11436.

Distribution. India: Kerala, Maharashtra, Meghalaya (new state record), Odisha (new state record), Pondicherry, Sikkim, Tamil Nadu, West Bengal. ***Elsewhere***: Bangladesh; Indonesia; Sri Lanka (van der Vecht & van Breugel 1968; Bohart & Menke 1976; Pulawski 2021).

c. *Sceliphron javanum petiolare* Kohl, 1918

Sceliphron petiolare Kohl, 1918: 95, ♀. Holotype: ♀, Indonesia: Sumatra: Deli (ZMHU).

Diagnosis. Mesoscutum more or less distinctly striate, but striae not sharply defined; scutellum longitudinally striate; second submarginal cell anteriorly as a rule narrower than third; petiole distinctly longer than hind tibia; at least apical third of hind femur black, dark area rather sharply separated from basal yellow part.



FIGURES 25–31. *Sceliphron javanum nalandicum* Strand, 25–30 ♀. 25. Habitus, lateral view; 26. Head, frontal view; 27. Hind coxa, dorsal view; 28. Mesosoma, dorsal view; 29. Mesosoma, lateral view; 30. Metasoma, dorsal view; 31 ♂. Head, frontal view.

According to Kohl (1918), *S. javanum petiolare* Kohl is similar to *S. javanum javanum* (Lepeletier) in general sculpture.

Note. No specimens were seen during the present study, so the above diagnosis has been based on the published descriptions (Kohl 1918; van der Vecht & van Breugel 1968).

Distribution. India (no specific locality). ***Elsewhere:*** Indonesia; Malaysia; Myanmar; Thailand; Vietnam (van der Vecht & van Breugel 1968; Pulawski 2021).

9. a. *Sceliphron madraspatanum andamanicum* Kohl, 1918
(Figs 32–36)

Sceliphron madraspatanum var. *andamanicum* Kohl, 1918: 109, sex not indicated. Syntypes: Andaman Islands (NHMW).

Diagnosis. **Female**. Similar to *S. madraspatanum madraspatanum* (Fabricius) in general morphology and colouration except pronotum and metanotum entirely black (Fig. 34).

Male. Similar to female.

Material Examined. India: Andaman and Nicobor Island, 1♀ and 1♂, Date of Collection unknown, Coll. Unknown, NZC Regd. Nos. 15504/H3 and 15505/H3; South Andaman Dist., Aberdeen, 1♀ and 1♂, 19.vi.1935, Coll. H.S. Rao, NZC Regd. No. 15502/H3 and 15506/H3; Nicobar Dist., Swarup Nullah, 1♀ and 1♂, 21.vii.1984, Coll. S.S. Saha and Party, NZC Regd. Nos. 15503/H3 and 15507/H3; South Andaman Dist., Viper Island, 1♀, 28.viii.1928, Coll. R.B.S. Sewell, NZC Regd. No. 15508/H3; Nicobar Dist., Campbell, 1♀, 07.xii.2010, Coll. E.E. Jehamalar, NZC Regd. Nos. 15509/H3–15511/H3; South Andaman Dist., Port Blair, 1♀, 15.ii.1915, Coll. Kewp, NZC Regd. No. 15512/H3. Arunachal Pradesh: West Siang Dist., Basar, 1♀, 31.x.1966, Coll. S.K.T and G.S.A, NZC Regd. No. 15530/H3. Odisha: Koraput Dist., Jagannath Sagar, Jaypore, 2♂, 16.ii.1972, Coll. K.V.S. Rao and Party, NZC Regd. No. 15513/H3 and 15514/H3.

Distribution. India: Andaman and Nicobar Islands, Arunachal Pradesh (new state record), Odisha (new state record) (Pulawski 2021).

b. *Sceliphron madraspatanum formosanum* van der Vecht, 1968
(Figs 37–41)

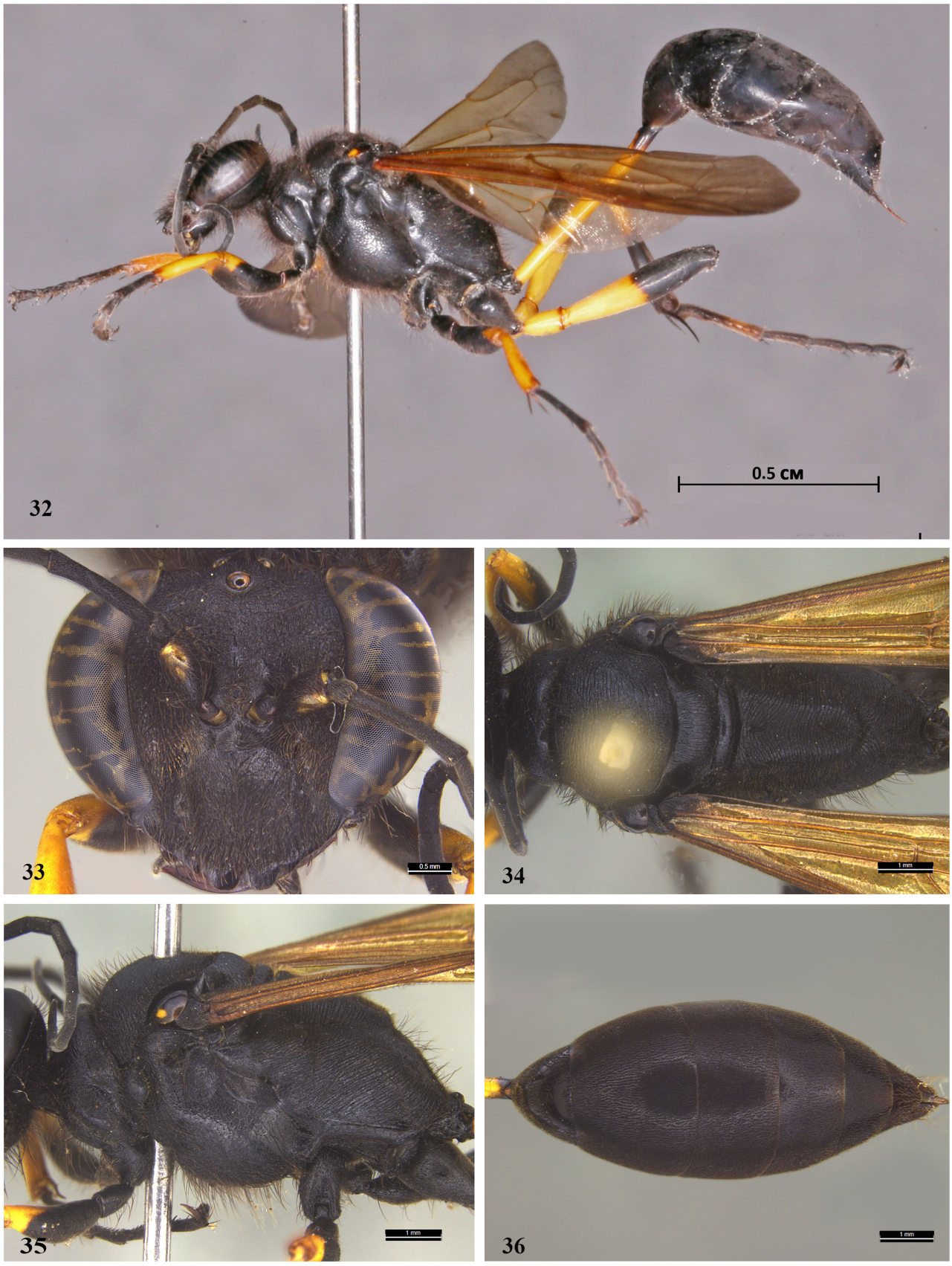
Sceliphron madraspatanum Rohwer, 1911: 482 (Taiwan).
Sceliphron madraspatanum formosanum van der Vecht *in* van der Vecht & van Breugel, 1968: 204, ♀, ♂. Holotype: ♀, Taiwan: Chiai Prefecture: Kagi, now Chiayi (RMNH).

Diagnosis. **Female**. Similar to *S. madraspatanum madraspatanum* (Fabricius) in general morphology and colouration except distinct yellow mark below tegula (Fig. 40); scutellum with large yellow spot (Fig. 39).

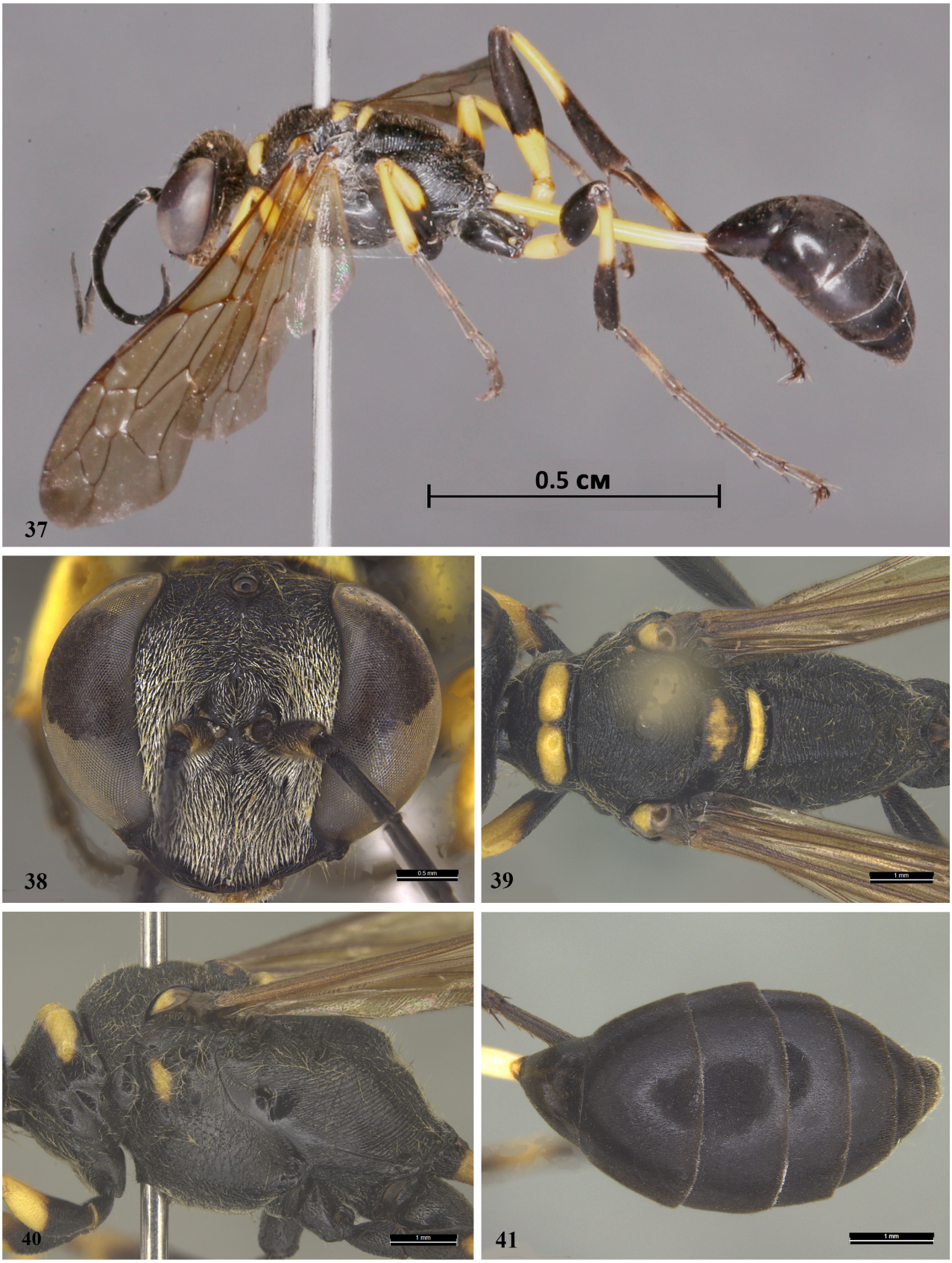
Male. Similar to female.

Material Examined. India: Bihar: Bhojpur Dist., Arrha, 1♀, 10.xii.2012, Coll. B.K. Singh, NZC Regd. No. 15538/H3. Chhattishgarh: Kabirdham Dist., Chilpi, 1♂, 09.vi.2012, NZC Regd. No. 15539/H3. Jharkhand: Singbhum Dist., Chotonagpur, Manoharpur, 1♀ and 3♂, 26.ii.1954 and 24.ii.1954, Coll. A.P. Kapur, NZC Regd. Nos. 15533/H3–15534/H3, 15535/H3 and 15536/H3; Manoharpur, 1♀, 27.ii.1954, Coll. A.P. Kapur, NZC Regd. No.15537/H3. Maharashtra: Thanae Dist., Kalyan East, 23.iii.2019, 1♂, Coll. C. Charesh, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14881. Odisha: Ganjam Dist., Chilka Lake, 1♀, Date of Collection. unknown, Coll. Annandale, NZC Regd. No. 15540/H3. Kerala: Kollam Dist., Sasthamkotta, 1♂, 26.ix.2017 Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 10147. Uttar Pradesh: Sitapur Dist., Laharpur, 1♂, 24.ix.2006, Coll. M. Sil and Party, NZC Regd. No. 15531/H3; Sitapur Dist., Gangaganj, 1♂, 22.ix.2006, Coll. M. Sil and Party, NZC Regd. No. 15532/H3.

Distribution. India (new country record): Bihar, Chhattishgarh, Jharkhand, Kerala, Maharashtra, Odisha, Uttar Pradesh. ***Elsewhere***: China; Japan; Taiwan (Pulawski 2021).



FIGURES 32–36. *Sceliphron madraspatanum andamanicum* Kohl, ♀. 32. Habitus, lateral view; 33. Head, frontal view; 34. Mesosoma, drsal view; 35. Mesosoma, lateral view; 36. Metasoma, dorsal view.



FIGURES 37–41. *Sceliphron madraspatanum formosanum* van der Vecht, ♂. 37. Habitus, lateral view; 38. Head, frontal view; 39. Mesosoma, dorsal view; 40. Mesosoma, lateral view; 41. Metasoma, dorsal view.

c. *Sceliphron madraspatanum madraspatanum* (Fabricius, 1781)

(Figs 42–50)

Sphex madraspatanus Fabricius, 1781: 445, sex not indicated (as *madraspatana*, incorrect original gender). Lectotype: ♂, India: Kerala: former Malabar District (BMNH, coll. Banks), designated by van der Vecht 1961: 43 (use of the word "type"). Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. Female. Frons distinctly pilose, sculpture not visible due to pilosity; clypeus apico-medially with median incision separating two lobes, these two lobes followed by lateral incisions forming blunt lobes sublaterally (Fig. 43); pronotal collar dorsally with broad yellow band, medially deeply notched; mesonotum almost transversely striate, striae becoming oblique posteriorly, striation bold and more distinct than in *S. javanum nalandicum*; scutellum with longitudinal oblong striation; metanotum with broad yellow band and fine punctures; propodeal enclosure with wavy striation and shallow depression in middle (Fig. 45); mesepisternum shiny with fine punctures; propodeum side with striation and punctures in interstices (Fig. 46); metasoma black with fine setae (Fig. 47); petiole yellow.

Male. Similar to female.

Material examined. India: Assam: Cachar Dist., Dehangi; 1♀, 23.v.1979, Coll. S.B. Roy and Party, NZC Regd. No.15047/H3; Dhubri Dist., 1♀ and 2♂, 30.v.1966, Coll. A.N.T. Joseph, NZC Regd. Nos. 15048/H3 and 15052/H3–15043/H3. Andhra Pradesh: 1♂, 15.x.1998, Coll. S.K. Mandal and party, NZC Regd. No. 15056/H3. Arunachal Pradesh: East Siang Dist., Ruehin, 1♂, 25.ix.2002, Coll. M. Sil and Party, NZC Regd. No. 15057/H3; West Siang Dist., Kambang, 1♀, 14.x.1966, Coll. S.K.T and G.S.A, NZC Regd. No. 15067/H3. Bihar: Purnia Dist., 2♀, Date of Collection unknown, Coll. Unknown, NZC Regd. Nos. 15081/H3 and 15082/H3; Saran Dist., Siripur, 1♀, 26.ix.1910, Coll. Unknown, NZC Regd. No. 15472/H3. Chhatisgarh: Bastar Dist., Sonpur, 1♀ and 1♂, 01.i.1981, Coll. S.S. Saha and Party, NZC Regd. Nos.15084/H3 and 15085/H3; Jashpur Dist., Badalkhol, 4♀, 25.v.2012, Coll. A. Raha and Party, NZC Regd. Nos. 15316/H3–15319/H3. Jharkhand: West Singbhum Dist., Chotanagpur, Manoharpur, 12♀ and 6♂, 24.ii.1954, 26.ii.1954, 27.ii.1954, Coll. A.P. Kapur, NZC Regd. Nos. 15326/H3–15332/H3, 15333/H3–15341/H3 and 15342/H3–15343/H3; Hazaribagh Dist., 1♀, 13.vi.1994, Coll. A.K. Sanyal and Party, NZC Regd. No. 15344/H3. Himachal Pradesh: Shimla Dist., Tatta Pani, 1♂, 18.ix.1969, Coll. O.B. Chhotany and Party, NZC Regd. No. 15351/H3; Kangra Dist., Kangra Valley, 1♀, Date of Collection unknown, Coll. Dudgeon, NZC Regd. No. 15352/H3. Karnataka: Bangalore Dist., Bangalore, 1♂, Date of Collection unknown, Coll. Unknown, NZC Regd. No. 15353/H3; Chikmagalore Dist., Mudigere, 1♂, 30.xii.1980, Coll. S.K. Gupta and Party, NZC Regd. No. 15366/H3. Kerala: Kozhikode Dist., Kizhakkoth, Valiyaparamba, 1♀, 15.ii.2016, Coll. T.P. Dijila, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 7225; Ernakulam Dist., Thattekkad BS, Kolumba, 1♀, 20.ix.2016, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 7865; Thiruvananthapuram Dist., Karyavattom, Kerala University Campus, 2♀ and 1♂, 27.ix.2019, Coll. S. Anagha, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 14870–14872. Maharashtra: Kohlapur Dist., Rankala, 1♀ and 1♂ , 06.iv.2005, Coll. R. Babu and Party, NZC Regd. Nos. 15370/H3 and 15371/H3; Amrabati Dist., Melghat, 1♂, 22.ix.2007, Coll. P. Girish Kumar, NZC Regd. No. 15372/H3; Pune Dist., Khandala, Western Ghat, 1♂, 24.i.1966, Coll. M.S. Mani, NZC Regd. No. 15373/H3. Madhya Pradesh: Mandsaur Dist., 1♂, 11.v.1975, Coll. S.K. Gupta and Party, NZC Regd. No. 15377/H3. Manipur: Bishnupur Dist., Lamjo, 1♂, 22.v.1993, Coll. B. Mitra and Party, NZC Regd. No. 15377/H3; 16 Mile north of Imphal on Dimapur road, 1♀, 20.ix.1945, Coll. M.L. Roonwal, NZC Regd. No. 15381/H3. Meghalaya: East Garo Hills Dist., Sonsak 1♀, 22.xi.1975, Coll. N. Muraleedharan and Party, NZC Regd. No. 15382/H3; East Garo Hills Dist., Dainadubi, 1♀ and 2♂, 08.v.1979, Coll. S.B. Roy and Party, NZC Regd. Nos. 15383/H3–15385/H3. Odisha: Mayurbhanj Dist., Bahadurpur, 1♂, 13.ix.1972, Coll. K. Rai and Party, NZC Regd. No. 15388/H3; Cuttack Dist., Biological Park, 1♀, 22.iii.1974, R.K. Kakkar and Party, NZC Regd. No. 15389/H3. Sikkim: South Sikkim Dist., Jorethang, 2♀ and 3♂, 11.iv.1994, Coll. P.H. Roy and Party, NZC Regd. Nos. 15392/H3–15395/H3, 15401/H3. Uttarakhand: Pithoragarh Dist., Pacholi, 1♀, 22.ix.2004, Coll. B. Mitra and Party, NZC Regd. No.15406/H3; Nainital Dist., Kota, 1♀, 05.v.1908, Coll. R.H., NZC Regd. No.15407/H3. Uttar Pradesh: Azamgarh Dist., Jamalpur, 7♀ and 3♂, 02.v.1981, Coll. T.R. Mitra and Party, NZC Regd. Nos. 15409/H3–15418/H3; Junpur Dist., Gujartal, 1♂, 25.xi.2000, Coll. M. Prasad and Party, NZC Regd. No.15424/H3. Tamil Nadu: Tirunelveli Dist., Manimuthar dam site, 2♀, 01.x.2018, Coll. P. Girish Kumar and Party, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 14873 and 14874; Tenkasi Dist., Ukkonam, 1♂, 27.vii.2019, Coll. B.H.C.K. Murthy and Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14876. Telengana: Ranga Reddy Dist., Rajendra Nagar, 1♂, 24–25.x.2016, Coll. P. Girish Kumar and Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14877. Tripura: North Tripura Dist., Dharamnagar, 1♀ and 7♂ 01.vi.1978 and 24.v.1978, Coll. J.K. Jonathan and Party, NZC Regd. Nos.

15434/H–15439/H3 and 15440/H3–15441/H3. West Bengal: Kolkata Dist., 2♀, 26.vii.1907, Coll. Unknown, NZC Regd. Nos. 15442/H3 and 15448/H3; Kolkata Dist., 1♀, Date of Collection unknown, Coll. Unknown, NZC Regd. No. 15445/H3; South 24 Parganas Dist., Herobhanga, 1♀ and 1♂ and, 19.iv.1986, Coll. B.N. Das and Party, NZC Regd. Nos. 15452/H3 and 15467/H3.

Distribution. India: Andaman and Nicobar Islands, Assam, Andhra Pradesh, Arunachal Pradesh, Bihar, Chhattisgarh, Himachal Pradesh, Jharkhand (new state record), Karnataka, Kerala, Madhya Pradesh, Maharastra, Manipur (new state record), Meghalaya, Odisha, Pondichery, Sikkim, Tamil Nadu, Tripura (new state record), Uttar Pradesh, Uttarakhand, West Bengal. ***Elsewhere****:* Afganisthan; Arabia; Bangladesh; Bulgaria; *Cambodia;* China; Croatia; Democratic Republic of Congo; France; Greece; Indonesia; Iran; Iraq; Italy; Japan; Kazakhstan; Kyrgyzstan; Laos; Madagascar; Malaysia; Maldives; *Montenegro;* Myanmar; Nepal; Oman; Pakistan; Philippines; Russia; Spain; Sri Lanka; Syria; Taiwan; *Tajikistan;* Thiland; Turkey; Turkmenistan; United Arab Emirates; Ukraine; Uzbekistan; Vietnam (van der Vecht & van Breugel 1968; Jonathan & Kundu 2003; Kundu *et al*. 2006; Pulawski 2021).

d. *Sceliphron madraspatanum pictum* (F. Smith, 1856)

(Figs. 51–55)

Pelopaeus pictus F. Smith, 1856: 231, ♂. Syntypes: India: no specific locality (OXUM).

Diagnosis. **Female.** Similar to *S. madraspatanum madraspatanum* (Fabricius) in general morphology and colouration except propodeal dorsum with large yellow marks, confluent with large yellow mark on apex; scutellum with large yellow spot (Fig. 53); distinct yellow mark below tegula (Fig. 54).

Male. Similar to female.

Material Examined. India: Rajasthan, Pali Dist., Thar desert, Bhandari, 1♀, 28.iii.2019, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14878; Jodhpur Dist., Thar desert, Kailana Lakeside, 1♂, 18.xi.2013, Coll. Gaurav Sharma and party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14879. Uttar Pradesh; Ghaziabad Dist., Salarpur Kalan, 1♀, 06.vi.1989, Coll. M.S. Shishodia and party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 14880.

Distribution. India: Maharashtra, Punjab, Rajasthan (new state record), Uttar Pradesh (new state record), West Bengal. ***Elsewhere***: Afghanistan; Iran; Oman; Pakistan; Qatar; Turkmenistan; United Arab Emirates (van der Vecht & van Breugel 1968; Gadallah 2020; Pulawski 2021).

10. a. *Sceliphron rectum pulchellum* Gussakovskij, 1933

As *Sceliphron bilineatum* Maxwell-Lefroy, 1909: 207 (described from Western India, but occurring also in other parts of India; nest).

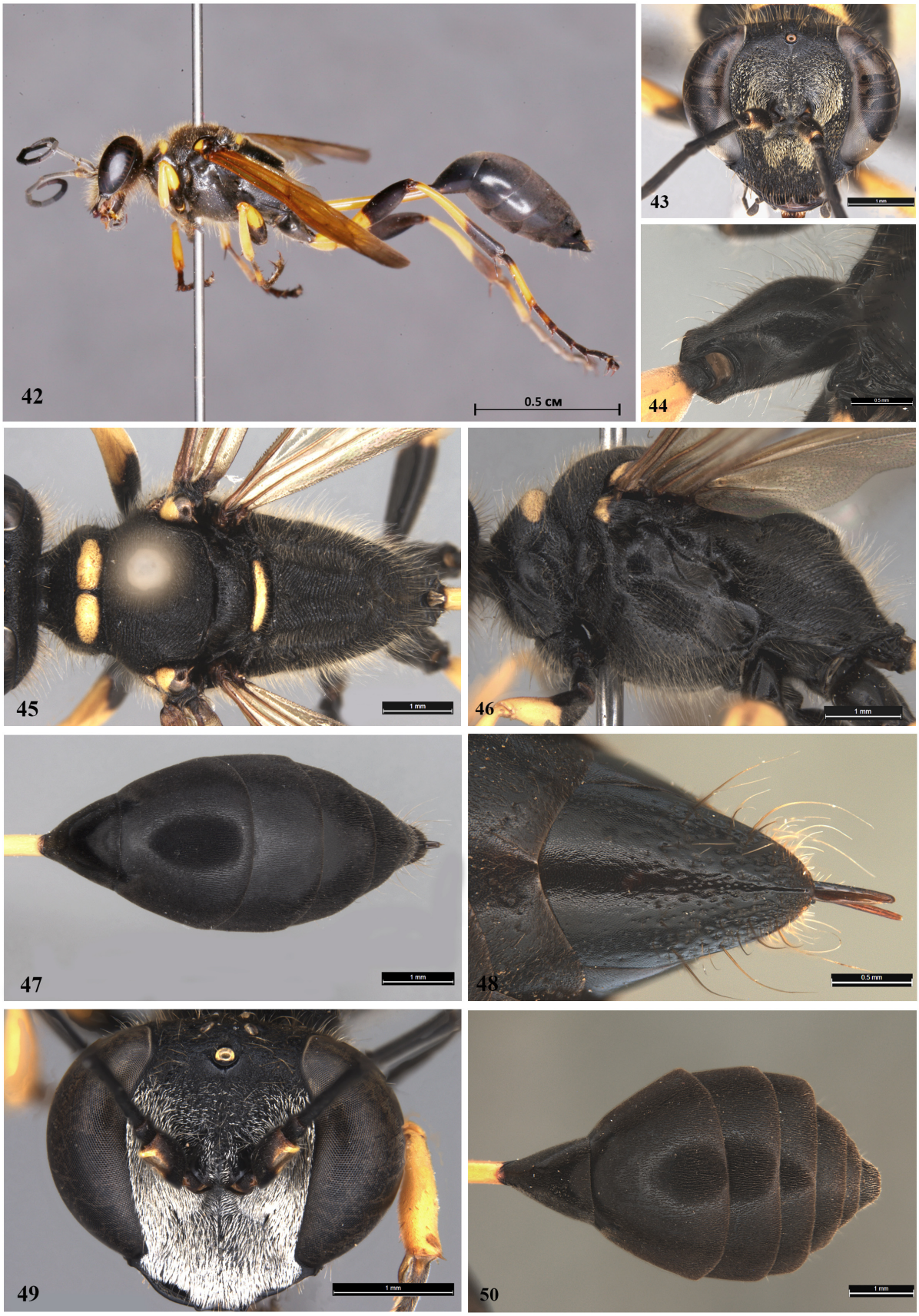
Sceliphron pulchellum Gussakovskij, 1933: 275, ♂. Holotype: ♀, Iran: Bushire, now Bushehr (ZIN). As *Sceliphron rectum pulchellum*: Hensen, 1987: 226 (new status).

Diagnosis. **Female**. Clypeus apico-medially incised, without lateral incisions (see Fig. 12 of Hensen (1987: 223); metanotum with broad yellow band; propodeum with yellow basal spots and very large terminal yellow mark confluent with pair of spots in dorsal enclosure; legs yellow except basal third of femora and hind tibia black; first tergum with large yellow markings; petiole in lateral view nearly straight.

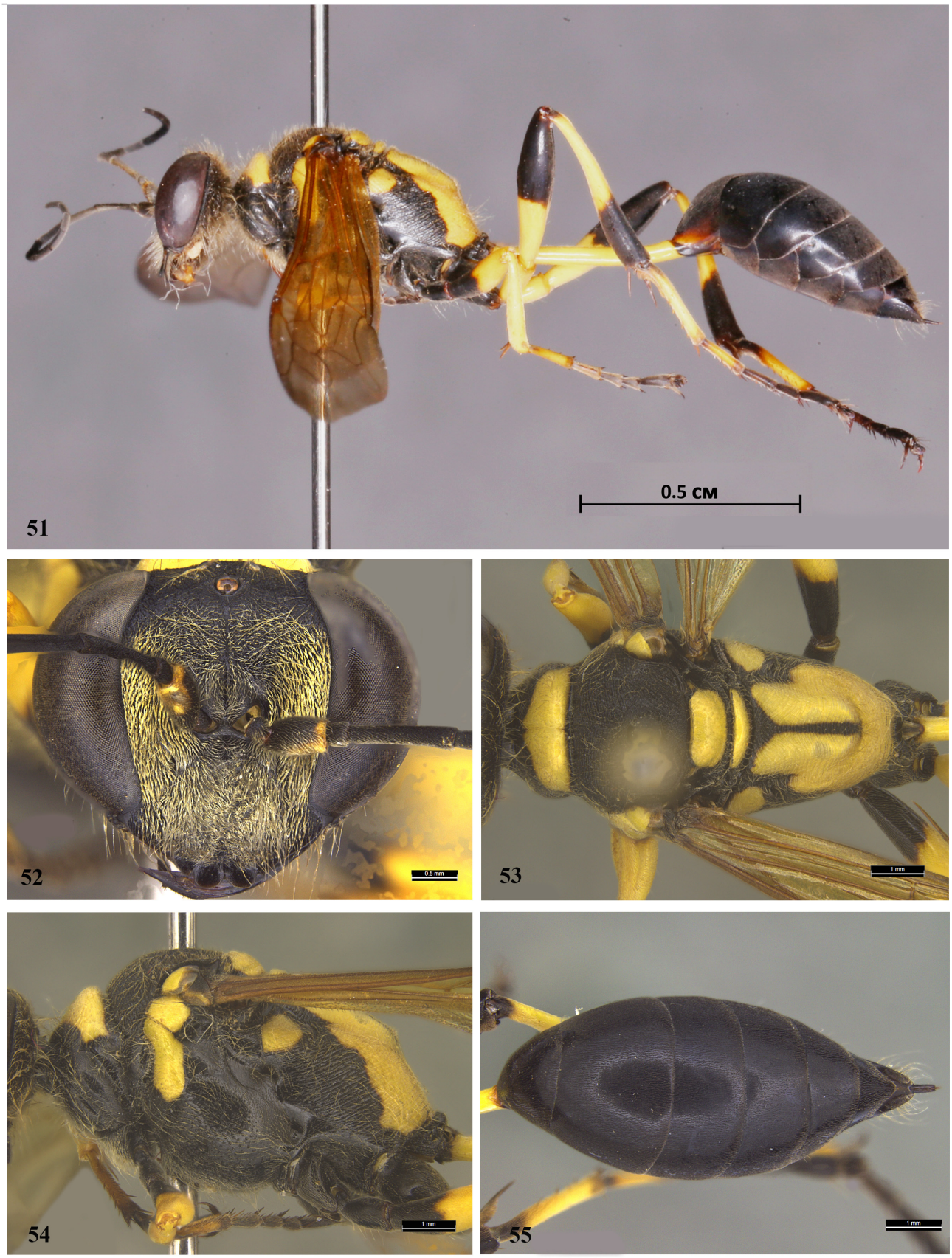
Male. Similar to female except additional yellow spot on all coxae; first tergum nearly entirely yellow, third to seventh terga with yellow apical bands. Hensen (1987) notes that the third and fourth terga are black in specimens from India and Pakistan.

Note: No specimens were seen during the present study, so the above diagnosis has been based on the description by Hensen (1987).

Distribution. India: Bihar, Gujarat. ***Elsewhere***: Iran; Iraq; Oman; Pakistan; Russia; United Arab Emirates (Hensen, 1987; Gadallah, 2020; Pulawski, 2021).



FIGURES 42–50. *Sceliphron madraspatanum madraspatanum* (Fabricius), 42–48 ♀. 42. Habitus, lateral view; 43. Head, frontal view; 44. Hind coxa, dorsal view; 45. Mesosoma, dorsal view; 46. Mesosoma, lateral view; 47. Metasoma, dorsal view; 48. Apical metasomal sterna; 49–50 ♂. 49. Head, frontal view; 50. Metasoma, dorsal view.



FIGURES 51–55. *Sceliphron madraspatanum pictum* (F. Smith), ♀. 51. Habitus, lateral view; 52. Head, frontal view; 53. Mesosoma, dorsal view; 54. Mesosoma, lateral view; 55. Metasoma, dorsal view.

b. *Sceliphron rectum rectum* Kohl, 1918

Sceliphron rectum rectum Kohl, 1918: 124, ♀. Holotype: ♂, India: Sikkim: no specific locality (ZMHU).

Diagnosis. Female. Frons distinctly pilose; clypeus apico-medially without lateral incisions (*c.f.* Fig. 12 of Hensen (1987: 223)); pronotal collar and scutellum dorsally with yellow band; petiole in lateral view nearly straight, yellowish; propodeum and metasoma black.

Male. Metanotum, propodeum and metasoma black; hind tibiae yellow on outer side.

According to Hensen (1987), *S. rectum rectum* Kohl is similar to *S. rectum pulchellum* Gussakovskij in general morphology and differs only in colouration.

Note. No specimens were seen during the present study, so the above diagnosis has been based on the published descriptions (Kohl 1918; Hensen 1987).

Distribution. India: Sikkim. ***Elsewhere***: Croatia; Iran; Iraq; Italy; Oman; United Arab Emirates (Gadallah 2020; Pulawski 2021).

Unplaced species

Key characters to identify the following species were not provided in their original descriptions and no material was seen during the present study, in spite of our efforts to locate the type specimens. Hence, they are unplaced for the time being. Available diagnostic characters from the original descriptions are provided to help recognition of these species if encountered in the future. Excluded from consideration is *Sceliphron seistaniensis* Jha and Farooqi, as it was described from Seistan, now parts of Iran and Afghanistan (although in a paper whose title suggests Indian origin).

1. Sceliphron isaaci Jha & Farooqi, 1995

Sceliphron isaaci Jha & Farooqi, 1995: 13, ♀, ♂. Holotype: ♀, India: Andaman Islands: Port Blair: North Bay (repository?).

Diagnosis. Female. Frons with fine longitudinal diverging striation mixed with punctures; clypeus apico-medially incised with lateral incisions (see Fig. 5 of Jha & Farooqi (1995: 14)); pronotal collar notched in middle, transversely finely striate, side punctate; mesoscutum finely striate, transverse anteriorly and oblique posteriorly; scutellum longitudinally striate; metanotum with fine sparse punctuation; propodeal enclosure with longitudinal depression in middle; mesopleuron punctate; petiole yellow.

Male. Resembles female in general morphology, clypeus similar as in *pictum* but lobes more pronounced (See Fig. 4 of Jha & Farooqi (1995: 14)); lobes of collar more pronounced with front surface rather densely striate; metanotum narrow, longitudinally and roughly striate; petiole longer than in female.

Distribution. India: Andaman Islands (Jha & Farooqi 1995; Pulawski 2021).

2. Sceliphron neobilineatum Jha & Farooqi, 1995

Sceliphron neobilineatum Jha & Farooqi, 1995: 15, ♀, ♂. Holotype: ♀, India: Bihar: Pusa (repository?).

Diagnosis. **Female**. Frons with fine striation diverging from ocellar region; clypeus apico-medially incised, without lateral incisions (see Fig. 10 of Jha & Farooqi (1995: 18)); pronotal collar with yellow band, transversely striate and finely pitted anteriorly; mesoscutum with regular transverse striation; scutellum and top of metanotum yellow, scutellum longitudinally and metanotum transversely striate; propodeal enclosure transversely striate, with narrow longitudinal furrow in middle, posterior half of propodeum yellow except along median line; mesopleuron striate and punctate; petiole, anterior half of first metasomal tergum sub-apically and sub- basally yellow.

Male. Striation on mesoscutum posteriorly usually circular; mesopleural striation broken and distantly placed; petiole longer than in female.

Distribution. India: Bihar (Jha & Farooqi 1995; Pulawski 2021).

3. Sceliphron paraintrudens Jha & Farooqi, 1995.

Sceliphron paraintrudens Jha & Farooqi, 1995: 17, ♀, ♂. Holotype: ♀, India: Bihar: Pusa (repository?)

Diagnosis. **Female**. Frons with very fine shallow close punctures; clypeus apico-medially incised, forming two lobes, outer margin of each lobe obliquely truncate, incision on either side delimiting middle lobe (see Fig. 15 of Jha & Farooqi (1995: 18)); pronotal collar with fine shallow crowded punctation; mesonotum with very fine striation, transverse anteriorly, becoming oblique posteriorly; scutellum and metanotum longitudinally finely striate; propodeal enclosure with longitudinal depression in middle, striation comparatively bold, but similar as in *S. madraspatanum* in arrangement; mesopleuron with crowded punctation; petiole reddish yellow.

Male. Metanotum transversely striate; petiole longer than female and pale yellow except apex.

Distribution. India: Bihar (Jha & Farooqi 1995; Pulawski 2021).

4. Sceliphron javanum chinenense van Breugel, 1968

Sceliphron javanum chinense van Breugel *in* van der Vecht & van Breugel 1968: 244, ♀, ♂. Holotype: ♀, China: Island of Hainan: Fan Heang (MCZ).

Diagnosis. Mesoscutum more or less distinctly striate, but striae not sharply defined; scutellum longitudinally striate; second submarginal cell anteriorly as a rule narrower than third; hind tibia black; hind femur yellow, with usually ill defined fuscous mark at apex above; at least apical third of fore and mid femora yellow to yellowish brown; fore and mid tibiae orange yellow.

According to van der Vecht & van Breugel (1968: 244), *S. javanum chinense* van Breugel is very similar to *S. javanum javanum* (Lepeletier) and *S. javanum petiolare* Kohl, but differs mainly by leg colour.

Note. van der Vecht & van Breugel (1968) tentatively placed specimens from Sikkim, West Bengal, Assam (presently Meghalaya) under *S. javanum chinenense* van Breugel as sufficient materials from these areas were not available for them. For this reason this subspecies has been excluded from the present study.

Distribution. India: Meghalaya, Sikkim (?), West Bengal. ***Elsewhere***: China; Laos; Vietnam (van der Vecht & van Breugel 1968; Pulawski 2021).

Discussion

Members of *Sceliphron* are mostly recognized by the colouration of the body while the sexual dimorphism is pronounced in the shape of the clypeus (Bohart and Menke 1976; van der Vecht and van Breugel 1968; Hensen 1987, 1988) and in most cases sex can easily be determined by simply looking at this structure (Abenis *et al.* 2020).

Colour polymorphism is thought to be raw material for sympatric speciation as variation within species occur in microevolution (Murayama *et al.* 2011; Abenis *et al.* 2020), which can also be correlated with other traits that can either be morphological or behavioural (Gray & McKinnon 2006; Mckinnon & Pieroti 2010). Insect pigments are products of metabolic processes and polymorphism of this raw material within species in distant spatial and temporal distributions can be correlated with their morphological or behavioural traits. These fluctuations also occur depending on the existing climatic conditions and with these pigments probably having evolved as a form of excretion storage, change in colour can be very well correlated with abiotic factors (Chapman 1998; Abenis *et al.* 2020).

Maculae or patches of yellow colour on the dorsal surface in Hymenoptera (produced by granules of pterins in the epidermis) are often associated with intraspecific sexual signals or even serve as aposematic colouration (Chapman 1998). The brightness of yellow colour in Hymenoptera may fade, but it will never disappear nor change in size (Holloway *et al.* 2002; Abenis *et al.* 2020) and a change in the nominal colouration may suggest microevolution. Variation in maculation which does not exhibit geographical patterns among Sphecidae *sensu lato* is quite common, but the probable cause for this variation has not been explained yet. A thermoregulatory hypothesis (changes with respect to differences in climatic conditions) (van der Vecht & van Breugel 1968), which suggests that increased lighter color patterns may be produced to reduce absorbance of heat (black or darker colors absorb more radiation

(Cech 2011), is apparently not applicable to species (both males and females) occurring in the same locality in both wet and dry seasons.

In the present study, differences in clypeus, antennal segments and metasomal segments were seen as sexual differentiation within the same species, whereas maculation on the mesosoma was seen to be quite constant in males and females of the same species. Quantitative assessment of colour on dorsum used by Hensen (1988) proves less effective as the ranges of these indices are very variable and often overlap with other species. Hence, it is necessary to carry out further molecular and phylogenetic studies to uncover the relatedness or divergence of the subspecies. These studies may also resolve the lack of information on the variant yellow patterns, which may either reflect different species or variation within the same populations or merely phenotypic plasticity.

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A study of the genus *Sphex* Linnaeus (Hymenoptera: Sphecidae) from India

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ABSTRACT. The genus *Sphex* Linnaeus (Hymenoptera: Sphecidae) is studied from India and key to Indian species is provided. The state-wise distributions of four species of *Sphex* are augmented here. A new synonymy is proposed: *Sphex zubaidiyacus* Augul, 2013 = *S. obscurus* (Fabricius, 1804).

Key words: Digger wasps, *Sphex*, India, new records, taxonomy, key

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Introduction

Digger wasps of the genus *Sphex* Linnaeus, 1758 are moderate to large wasps of the family Sphecidae (Insecta: Hymenoptera) and subfamily Sphecinae (Bohart & Menke, 1976). They show a variable distribution along various zoogeographical lines with most species reported from the Afrotropics followed by Australia (pers. comm. Thorleif H. Dörfel). However, this speciose group is scarcely reported from India with only nine recorded species till date. They are *Sphex argentatus* Fabricius, 1787; *S. deplanatus* Kohl, 1895; *S. diabolicus* F. Smith, 1858; *S. neoumbrosus* Jha & Farooqi, 1996; *S. obscurus* (Fabricius, 1804); *S. praedator* Smith, 1858; *S. pruinosus* Germar, 1817; *S. sericeus* (Fabricius, 1793); and *S. subtruncatus* Dahlbom, 1843. Female wasps of the genus are powerful predators, in which many species hunt on Orthoptera of the families Tettigoniidae, a few on Gryllacrididae and some on Gryllidae as provision for their larvae (Bohart & Menke, 1976; Evans et al., 1982; Kazenas, 2001; Roche, 2007; Dörfel & Ohl, 2015).

The genus *Sphex* was established by Linnaeus in 1758 based on the type species *S. flavipennis* Fabricius, 1793. Generic revisions were published by Menke & Pulawski (2000), Schmid-Egger (2014, 2019) and Dörfel & Ohl (2015). Taxonomic study of Indian *Sphex* remains scarce and limited. Here we aim to provide a study on the taxonomy and distribution of the *Sphex* species from India. Key characters of the species present in India were studied from relevant literatures (Smith, 1858a, 1858b; Cameron, 1889; Kohl, 1895; Bingham, 1897; Hensen, 1991; Jha & Farooqi, 1996; Dörfel & Ohl, 2015) and working key was prepared for the identification of Indian species which is provided below. *Sphex*

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https://dorl.net/dor/20.1001.1.24238112.2021.7.4.8.4

zubaidiyacus Augul, 2013 described from the Palaearctic region (Iraq, Baghdad) is newly synonymised here with *S. obscurus* Fabricius. *S. fumicatus* Christ, 1791 and *S. ichneumoneus* (Linnaeus, 1758) reported from India and reports of some Indian species from the African region by previous workers are omitted here due to the need of validation.

Material and methods

Specimens from the National Collections of Zoological Survey of India, Western Ghat Regional Centre, Kozhikode (ZSIK) along with fresh specimens collected from various localities in India were examined for the present study. The specimens mounted on entomological pins were studied under LEICA M205 stereoscopic binocular microscope and images were captured using attached LEICADFC 500 camera. Habitus images of the species were captured with digital camera (Canon Power Shot SX540bHS). Measurements were obtained using Leica LAS (Leica Application Suite V3.80) microsystems by Leica (Heerburg, Switzerland). Images at varying focal planes were stacked using Leica Automontage Software V3.80 and the final illustrations were processed for contrast and brightness using Adobe® Photoshop® CS5 (Version 6.1) software. After curation, freshly collected specimens are added to the 'National Zoological Collections' of ZSIK. The morphological terminology used in this paper mostly follows Bohart & Menke (1976).

Museum abbreviations: **NHMW**: Naturhistorisches Museum, Wien, Austria; **NHRCM**: Natural History Research Center and Museum, University of Baghdad, Iraq**; OXUM**: Hope Department of Entomology, Oxford, Great Britain; **ZMUC**: Zoological Museum, University of Copenhagen, Copenhagen, Denmark; **ZSIK**: Western Ghat Regional Centre, Zoological Survey of India, Kozhikode, India.

Results

Genus *Sphex* Linnaeus, 1758

Sphex Linnaeus, 1758: 569. Type species: *Sphex flavipennis* Fabricius, 1793, designated by International Commission on Zoological Nomenclature, 1946: 571 (Opinion 180) which reversed its earlier designation as type of *Sphex sabulosus* Linnaeus, 1758 (1911: 76, Opinion 32).

Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. Length of basal veinlet of submarginal cell II equal to or (more often) shorter than anterior veinlet; inner orbits straight below but curving towards ocelli above; hind tibial spur closely, usually finely pectinate inside; length of petiole as measured along dorsum less than combined length of hind tarsomeres II–IV (Bohart & Menke, 1976).

Sphex argentatus Fabricius, 1787 (Figs 1–9, 38)

Sphex argentatus Fabricius, 1787: 274, sex not indicated (as *argentata*, incorrect original termination). Lectotype: ♀, southeastern India: Coromandel coast: no specific locality (ZMUC).

Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. **Female** (Figs 1–6). Body entirely black; frons and clypeus with appressed silvery white pubescence and long erect setae of same colour, clypeus slightly convex, anterior margin medially with two indistinct lobes (Fig. 2); pronotal collar and scutum with moderately dense silvery white pubescence, scutum with slightly denser pubescence

laterally than medially; scutellum with shallow median impression near posterior margin; metanotum strongly bituberculate; propodeal enclosure transversely striate and covered with erect silvery white setae (Fig. 4); mesepisternum with silvery white setae (Fig. 5); metasoma finely pubescent (visible as aciculations under low magnification); fore wings hyaline with fuscous patch at apex, base darkened (Fig. 3).

Male (Figs 7–9). Resembles female in most aspects except, free clypeal margin truncate, slightly concave towards center with short median lobe (Fig. 8); antennae of male with placoids on fifth flagellomere.

Male genitalia (Fig. 38). Gonostyle pointed towards apex and covered with thick pubescence subapically; head of digitus in volsella with pyramid-shaped and clothed with moderately dense pubescence, apex of cuspis distinctly acuminate; penis valve long and slender with short head.

Material examined. INDIA: Kerala, Kozhikode district, Madappally, 4♂♂ and 2♀♀, 11.iii.2020, Coll. S. Anagha, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17338–17343; Kozhikode district, Ashokapuram, 1♀, 11.i.2020, Coll. S. Anagha, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17868; Kozhikode district, East Hill, 3♂♂, 14.x.2015, Coll. P. Girish Kumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17877–17879; Kozhikode district, Chaliyam, 2♂♂ and 1♀, 7.x.2016, Coll. P. Manju, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17880–17882. Tamil Nadu, Tirunelveli district, Rosemiyapuram, 1♀, 25.ix.2018, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17860; Tirunelveli district, Kalakkad Mundanthurai Tiger Reserve (KMTR), 1♀, 28.ix.2018, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17861; Tirunelveli district, Kodumudiyar dam site, 1♀, 28.ix.2018, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17862; Tirunelveli district, Ramanadi dam site, 1♀, 2.x.2018, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17869. Telangana, Ranga Reddy district, Rajendra Nagar, 1♂ and 4♀♀, 24-25.x.2016, Coll. P. Girish Kumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17863–17867; Medak district, 1 ♀, 27.x.2016, Coll. P. Girish Kumar, ZSIK Regd. No.ZSI/WGRC/I.R.–INV. 17870.

Distribution. India: Arunachal Pradesh, Assam, Bihar, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Sikkim, Tamil Nadu, Telangana (new record), Uttarakhand, Uttar Pradesh, West Bengal. ***Elsewhere***: Australia; Cambodia; China (including Hong Kong); Dableeh Island; Indonesia; Israel; Japan; Kazakhstan; Korea; Kuwait; Laos; Malaysia; Myanmar; New Guinea; Pakistan; Philippines; Sri Lanka; Taiwan; Thailand; Vietnam (Jonathan & Kundu, 2003; Kundu et al., 2006; Barthélémy, 2014; Anagha & Girish Kumar, 2020; Gadallah, 2020; Pulawski, 2021).

Sphex deplanatus Kohl, 1895

Sphex deplanatus Kohl, 1895: 53, ♂. Holotype: ♂, Sri Lanka: no specific locality (NHMW).

Diagnosis. **Male**. Body black except metasoma red on side; head and thorax with silvery white pubescence; scutellum not convex, almost flattened; propodeal enclosure with five transverse wrinkles; fore wings infuscate violaceo-resplendentes.

Note. As no specimens were seen during the present study, the above diagnosis has been based on original description (Kohl, 1895). The description of the female of *S. deplanatus* by Kohl was based on misidentified specimens (pers. comm. Thorleif H. Dörfel) so the diagnosis of female has been excluded.

Figures 1–9. *Sphex argentatus* Fabricius, **1–6** ♀. **1.** Habitus, lateral view; **2.** Head, frontal view; **3.** Fore wing; **4.** Mesosoma, dorsal view; **5.** Mesosoma, lateral view; **6.** Metasoma, dorsal view. **7–9** ♂. **7.** Habitus, lateral view; **8.** Head, frontal view; **9.** Metasoma, dorsal view.

Sphex diabolicus F. Smith, 1858

Sphex diabolicus F. Smith, 1858a: 100, ♀. Lectotype: ♀, Malaysia: Sarawak: no specific locality (OXUM), designated by van der Vecht, 1973: 342.

Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. Body black; head pubescent; scutellum prominent with slight shallow longitudinal furrow; metanotum bituberculate; propodeal enclosure densely pubescent; fore wings strongly yellowish to yellowish brown.

Note. As no specimens were seen during the present study, the above diagnosis has been based on published descriptions (Smith, 1858a; Bingham, 1897, Strand, 1913; Hensen, 1991).

Variability. Vestiture on frons and propodeum of species is found to be variable from black to yellow (Smith, 1858a; Bingham, 1897; Strand, 1913).

Sphex neoumbrosus Jha & Farooqi, 1996

Sphex neoumbrosus Jha & Farooqi, 1996: 13, ♀. Holotype: ♀, India: Karnataka: South Coorg District: Polibetta.

Diagnosis. **Female**. Body black; clypeus broader than long with paired minute lobes, not delimited by submedian notches, lateral margin slightly wavy (see Fig. 1 of Jha & Farooqi (1996: 14)); dark brown long and short pubescence all over body except on flagellomeres, tibiae, tarsi and metasomal terga; scutellum with median longitudinal furrow; metanotum more or less bituberculate; propodeal enclosure transversely and finely striate; fore wings hyaline with bright yellow fulvescens, apex smoky.

Male. Unknown.

Note. As no specimens were seen during the present study, the above diagnosis has been based on original description (Jha & Farooqi, 1996).

Sphex obscurus (Fabricius, 1804) (Figs 10–22, 39)

Pepsis obscura Fabricius, 1804: 213, sex not indicated, junior secondary homonym of *Sphex obscurus* Schrank, 1802 (now in Pompilidae), valid under Article 59.2 of the Code. Lectotype: ♂, India: no specific locality (ZMUC).

As *Sphex obscurus*: Dalla Torre, 1897: 419.

Sphex zubaidiyacus Augul, 2013: 476, ♀, ♂, misspelled *zubaidiyanis* in Abstract. Holotype: ♂, Iraq: Wasit Province: center of Al-Zubaidiya region (NHRCM). **NEW SYNONYMY.**

Justification of new Synonymy. Analysis of key characters of fresh specimens of *Sphex obscurus* collected from Southern India, lectotype of species available from Zoological Museum Copenhagen (http://www.daim.snm.ku.dk/digitized-type-collection-details-simple?catno=zmuc00241276) and from related literature, the authors find it judicious to assign *S. zubaidiyacus* Augul described from Iraq (Augul, 2013) as a junior synonym of *S. obscurus*.

Diagnosis. Female (Figs 10–15). Body black; frons and clypeus with distinct appressed silvery white pubescence and long erect setae of same colour; anterior clypeal margin medially with two lobes (Fig. 11); pronotal collar, scutum and scutellum with moderately dense silvery white pubescence, scutum with slightly denser pubescence laterally than medially; metanotum simple, not bituberculate, with pubescence similar as on scutellum;

propodeal enclosure with erect and appressed silvery white and golden yellow setae (Fig. 12); mesepisternum with silvery white setae (Fig. 13); metasoma finely pubescent (visible as aciculations under low magnification) (Fig. 15); fore wings subhyaline with orange tinge (Fig. 14).

Male (Figs 16–22). Resembles female in most aspects, vary in colour of pubescence, pubescence on head and thorax golden yellow (Figs 18 & 19); clypeus elongate, clearly swollen at middle (Fig. 18); antennae with placoids on the proximal third of flagellomere five and six (Fig. 18).

Male genitalia (Fig. 39). Gonostyle pointed towards apex covered with sparse pubescence; head of digitus in volsella pyramid-shaped (broader than in *Sphex argentatus*) and clothed with moderately dense pubescence, apex of cuspis distinctly acuminate; penis valve long and slender with short head.

Material examined. INDIA: Kerala, Kozhikode district, Madappally, 3♂♂ and 1♀, 6.ii.2020, Coll. S. Anagha, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17871–17874; Kannur district, Kannapuram, 1♂, 17.iii.2019, Coll. C. Charesh, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17875; Kozhikode district, Peruvannamuzhi, 1♂, 20.v.2019, Coll. K. Anju, ZSIK Regd. No.ZSI/WGRC/I.R.–INV. 17876.

Distribution. India: Kerala (new record), Uttarakhand, West Bengal. *Elsewhere*: Iraq; Sri Lanka; Thailand; Turkmenistan; United Arab Emirates (Pulawski, 2021).

Sphex praedator F. Smith, 1858

Sphex praedator F. Smith, 1858b: 14, ♂. Holotype or syntypes: ♂, Indonesia: Sulawesi: no specific locality (OXUM).

Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. Body black with black pubescence; frons with silvery white pubescence and black setae; pronotal collar entire; scutellum naked and shining; metanotum simple; propodeal enclosure transversely finely rugulose; fore wings strongly yellowish to dark brown with violaceous effulgence.

Note. As no specimens were seen during the present study, the above diagnosis has been based on published descriptions (Smith, 1858b; Bingham, 1897).

Sphex pruinosus Germar, 1817

Sphex pruinosus Germar, 1817: 261, ♂ (as *pruinosa*, incorrect original termination). Holotype or syntypes: Dalmatia: Spalatro, now Croatia: Split (depository?).

Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. Body black with metasoma partly or entirely red or ferruginous; head and thorax with silvery white pubescence; scutellum with median furrow; metanotum with indistinct tubercles; propodeal enclosure with broad transverse ridges; fore wings hyaline with smoky apex.

Note. As no specimens were seen during the present study, the above diagnosis has been based on published descriptions (Kohl, 1885; Cameron, 1889; Nurse, 1903; Roche, 2007).

Variability. Male show variation in colour of metasoma being entirely black or red or ferruginous or partly red or ferruginous (Kohl, 1885; Cameron, 1889; Nurse, 1903; Roche, 2007).

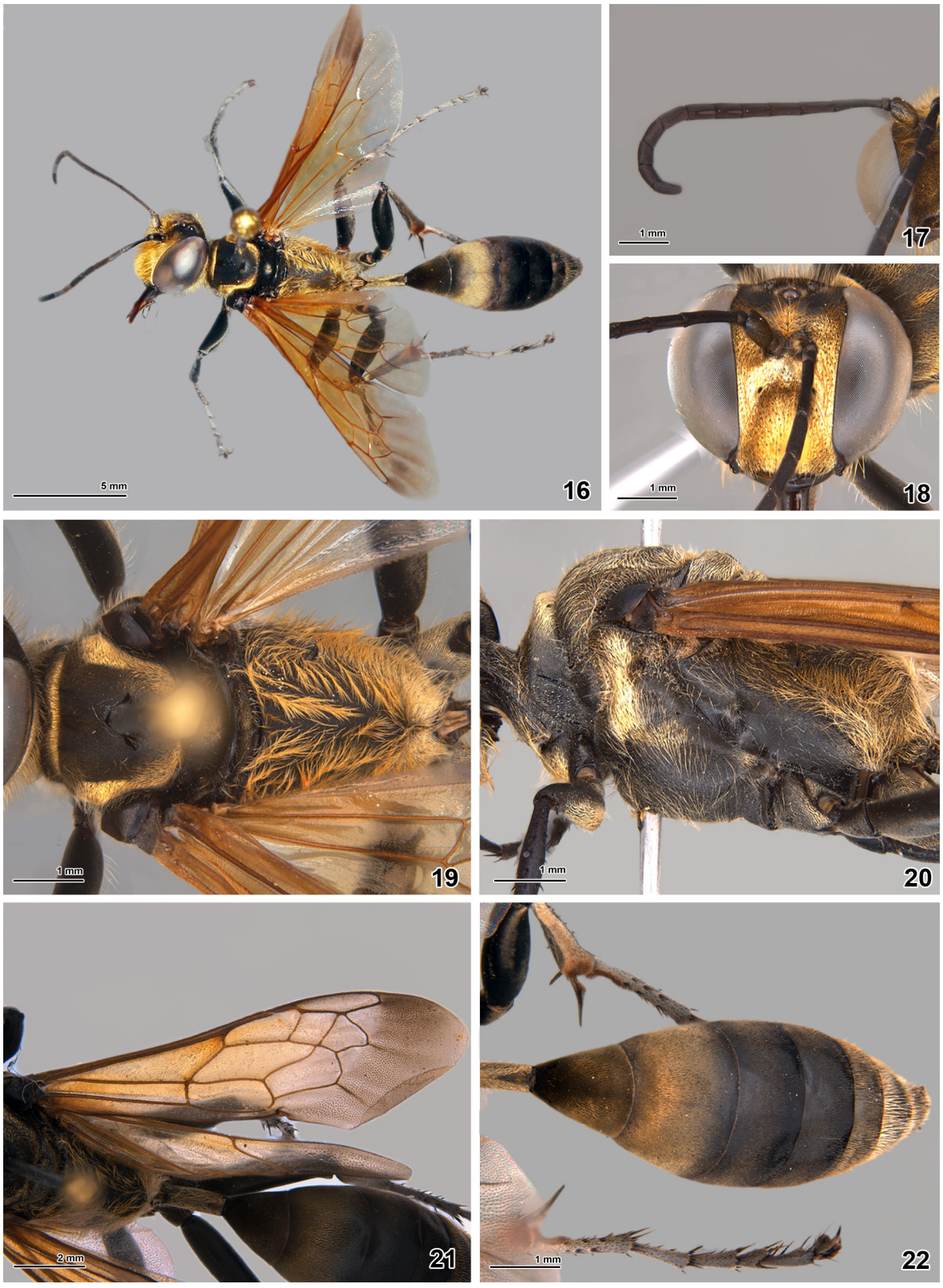
Sphex sericeus (Fabricius, 1793) (Figs 23–31, 40)

Sphex aurulentus Fabricius, 1793: 201, sex not indicated, junior primary homonym of *Sphex aurulentus* Fabricius, 1787 (now in *Liris*). Holotype or syntypes: India: Tranquebar (depository unknown).

As *Sphex sericeus*: Dahlbom, 1843: 26.

Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Figures 10–15. *Sphex obscurus* (Fabricius), ♀. **10.** Habitus, lateral view; **11.** Head, frontal view; **12.** Mesosoma, dorsal view; **13.** Mesosoma, lateral view; **14.** Fore wing; **15.** Metasoma, dorsal view.



Figures 16–22. *Sphex obscurus* (Fabricius), ♂. **16.** Habitus, lateral view; **17.** Antennae; **18.** Head, frontal view; **19.** Mesosoma, dorsal view; **20.** Mesosoma, lateral view; **21.** Fore wing; **22.** Metasoma, dorsal view.

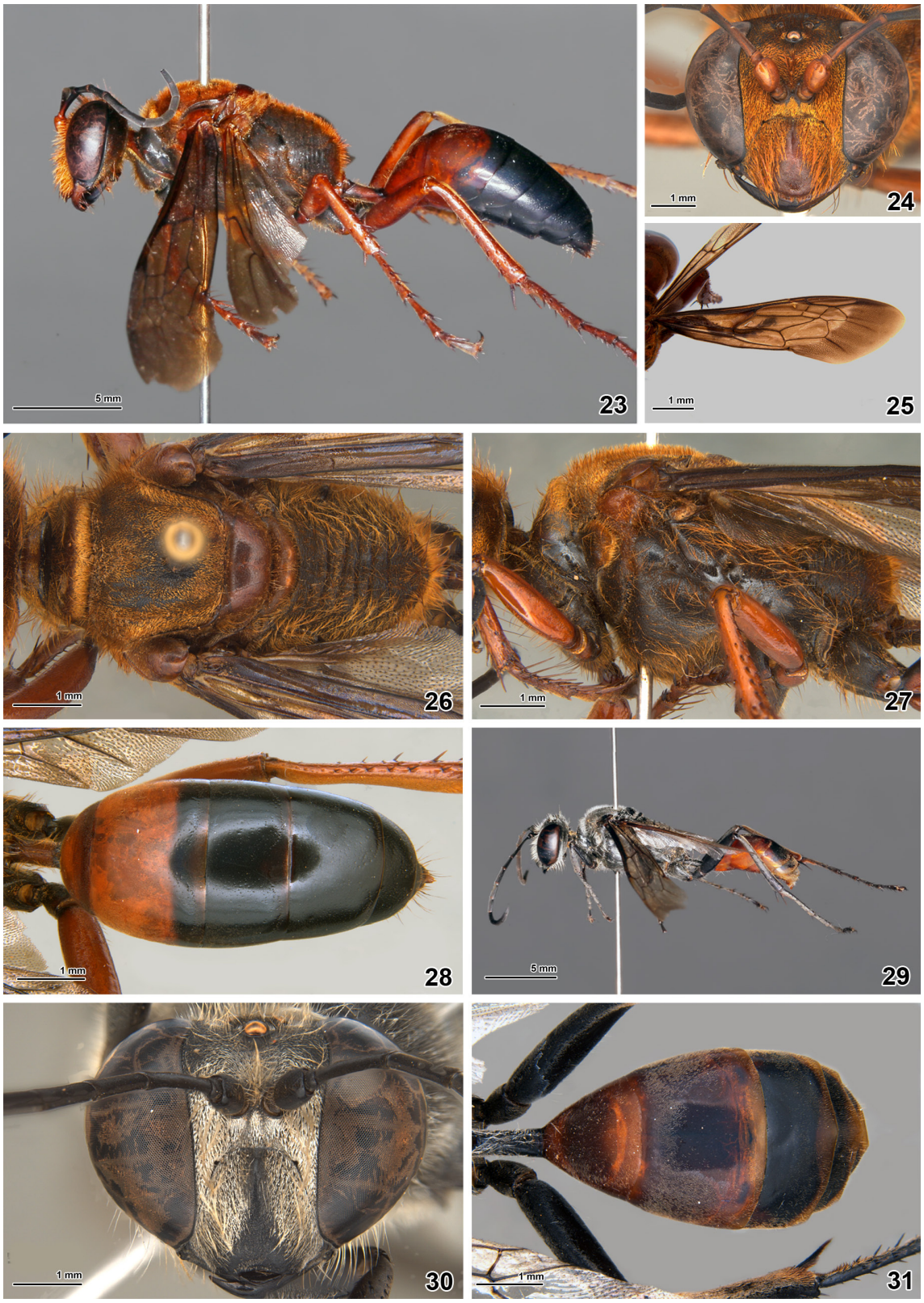
Diagnosis. **Female** (Figs 23–31). Body black with following parts orange: basal half of mandible, clypeus, scape, pedicel, base of flagellomere I, scutellum, metanotum, first and anterior two third of second metasomal segments, and legs excluding claw; frons and clypeus with appressed orange pubescence and long erect setae of same colour; clypeus swollen at middle with glabrous stripe, anterior margin notched in middle (Fig. 24); pronotal collar and scutum with moderately dense orange pubescence,scutum with slightly denser pubescence laterally than medially; scutellum with shallow median impression near posterior margin; metanotum strongly bituberculate; propodeal enclosure with three to four broad transverse ridges, appressed orange pubescence and sparse, erect setae of same colour (Fig. 26); mesepisternum with orange setae (Fig. 27); metasoma finely pubescent (visible as aciculations under low magnification) (Fig. 28); fore wings fuscous with slight blue iridescence (Fig. 25).

Male (Figs 29–31). Vary largely in colour with female, body black except metasoma; pubescence on head and thorax silvery white; metasoma mixed with red and black colours (Fig. 31); free clypeal margin concave towards center (Fig. 30); antennae of male with placoids on fifth to sixth flagellomere.

Male genitalia (Fig. 40). Gonostyle slightly pointed towards apex, digitus in volsella with short head, apex of cuspis acuminate; penis valve long and slender.

Variability. One female specimen from South Andaman examined here shows colour variation in metasoma being completely black; all the female specimens examined here have petiole black and wings fuscous with blue iridescence while petiole is red or orange and wings subhyaline with yellow tinge according to previous workers (Bingham, 1897; Dörfel & Ohl, 2015).

Material examined. INDIA: Andaman & Nicobar Island, South Andaman, Ranchi Basthi, 1♀, 9.viii.2016, Coll. A.K. Dubey, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17990. Goa, North Goa district, Mhadei Wildlife Sanctuary, 1♂, 15.v.2018, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17892. Kerala, Kozhikode district, Balussery, 1♀, 7.x.1998, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17345; Thiruvananthapuram district, Peppara Wildlife Sanctuary, Peppara dam site, 1♂, 28.ix.2018, Coll. S. Anagha, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17895; Kozhikode district, Madappally, 1♂, 11.iii.2020, Coll. S. Anagha, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17896; Thrissur district, Vellanikkara, 1♂, 5–16.x.2020, Coll. Anusree Padmanabhan, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17897; Kannur district, Munderi Kadavu, 2♂♂, 10.iii.2016, Coll. Rajesh, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17899–17900. Tamil Nadu, Tirunelveli district, Kalakkad Mundanthurai Tiger Reserve (KMTR), Kalakkad, 1♀, 26.ix.2018, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17887; Tirunelveli district, Courtallam, Shenbegadevi temple, 1♀, 26.iii.2019, Coll. B.H.C.K Murthy & Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17889; Kanyakumari district, Kanyakumari Wildlife Sanctuary, Kulashekaram range, 1 ♀, 19.iii.2020, Coll. S. Sen & Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17890; Kanyakumari district, Kanyakumari Wildlife Sanctuary, Alagiyapandipuram range, 1♀, 16.iii.2020, Coll. S. Sen & Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17891; Tirunelveli district, Rosemiyapuram, 1♂, 25.ix.2018, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17893; Tirunelveli district, Koonthankulam Bird Sanctuary, 1♂, 27.ix.2018, Coll. P. Girish Kumar & Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17894; Kanyakumari district, Kanyakumari Wildlife Sanctuary, Boothapandi range, Sengamal Saragam, 1♂, 18.ii.2020, Coll. S. Sen & Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17898. Uttarakhand, Dehradun district, Wildlife Institute of India Campus, 1♀, 10–13.viii.2017, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17885.



Figures 23–31. *Sphex sericeus* (Fabricius), **23–28** ♀. **23.** Habitus, lateral view; **24.** Head, frontal view; **25.** Fore wing; **26.** Mesosoma, dorsal view; **27.** Mesosoma, lateral view; **28.** Metasoma, dorsal view. **29–31** ♂. **29.** Habitus, lateral view; **30.** Head, frontal view; 31. Metasoma, dorsal view.

Distribution. India: Andaman & Nicobar Island (new record), Assam, Goa (new record), Karnataka, Kerala, Maharashtra, Meghalaya, Odisha, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. ***Elsewhere***: Australia; Cambodia; Chagos Archipelago; China (including Hong Kong); Indonesia; Japan; Korea; Laos; Malaysia; Myanmar; New Guinea; Pakistan; Philippines; Sri Lanka; Taiwan; Thailand; Vietnam (Sudheendrakumar & Narendran, 1989; Jonathan & Kundu, 2003; Barthélémy, 2014; Anagha & Girish Kumar, 2020; Pulawski, 2021).

Sphex subtruncatus Dahlbom, 1843 (Figs 32–37)

Sphex subtruncatus Dahlbom, 1843: 25, ♀ (as *subtruncata*, incorrect original termination). Lectotype: ♀, "Africa": no specific locality but actually Oriental Region according to W. Schulz, 1912: 94 (Lund).

Pulawski (2021) gives a list of the synonymy, which is not repeated here.

Diagnosis. **Female**. Body black, femora and tibiae orange; frons and clypeus with appressed silvery white pubescenceand long erect black setae; clypeus slightly convex, anterior clypeal margin medially emarginate (Fig. 33); pronotal collar and scutum with brown or black pubescence; scutellum and metanotum with median impression; metanotum simple, not bituberculate; propodeal enclosure transversely ruguloso-striate with median impression and erect black setae (Fig. 34); mesepisternum with black setae (Fig. 35); metasoma finely pubescent (visible as aciculations under low magnification)(Fig. 37); fore wings subhyaline with yellowish tinge and fuscous patch at apex (Fig. 36).

Male. Not seen in the present study. Similar to female except smaller size; wings darker; clypeus longer, anterior margin slightly arched, almost truncate (Bingham, 1897).

Variability. Colour of wings and legs of species is found to be variable. Wings in certain specimens are dark fuscous with a brilliant purple effulgence, and have very little of the yellow tinge on the disc; femora and tibiae of the intermediate and posterior pair, or of the posterior pair only, may be wholly or partially red or orange (Bingham, 1897).

Material examined. India: Kerala, Kozhikode district, Nadakkavu, 1♀, 6.viii.2020, Coll. J.B. Terine,ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17908; Kozhikode district, Madappally, 1♀, 6.vii.2020, Coll. S. Anagha, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17909; Kozhikode district, Jaferkhan Colony, ZSI Campus, 1♀, 3.ix.2019, Coll. K.P. Hanima Raveendran, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17910. Uttarakhand, Dehradun district, Wildlife Institute of India Campus, 5♀♀, 10–13.viii.2017, Coll. P. Girish Kumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17903-17907.

Distribution. India: Arunachal Pradesh, Himachal Pradesh, Karnataka, Kerala, Meghalaya, Sikkim, Tripura, Uttarakhand, Uttar Pradesh, West Bengal. ***Elsewhere***: Bhutan; China (including Hong Kong); Indonesia; Japan; Korea; Laos; Myanmar; Nepal; Philippines; Singapore; Sri Lanka; Taiwan; Thailand; Vietnam (Barthélémy, 2014; Dollfuss, 2008; Kundu et al., 2006; Anagha & Girish Kumar, 2020; Pulawski, 2021).

Note. Girish Kumar et al. (2018) misidentified the species as *Sphex praedator* F. Smith, 1858.

Figures 32–37. *Sphex subtruncatus* Dahlbom, ♀. **32.** Habitus, lateral view; **33.** Head, frontal view; **34.** Mesosoma, dorsal view; **35.** Mesosoma, lateral view; **36.** Fore wing; **37.** Metasoma, dorsal view.

Key to Indian species of *Sphex* (except *S.* ***deplanatus*** Kohl, 1895 due to unavailability of key characters)

1. Metanotum with medially raised tubercles (Figs 4 & 26). **2**
— Metanotum without medially raised tubercles (Figs 12, 19 & 34) (indistinct tubercles in *S. pruinosus* Germar, 1817). **5**

2. Propodeal enclosure with broad transverse ridges (Fig. 26). .... ***Sphex sericeus*** (Fabricius, 1804)
— Propodeal enclosure without broad transverse ridges (Fig. 4). **3**

3. Cellular wing area clearly hyaline without yellow tinge (Fig. 3). ..... ***Sphex argentatus*** Fabricius, 1787
— Cellular wing area subhyaline with yellow tinge. **4**

4. Pubescence on propodeal enclosure concealing sculpture. ..... ***Sphex diabolicus*** F. Smith, 1858
— Pubescence on propodeal enclosure not concealing sculpture. ..... ***Sphex neoumbrosus*** Jha & Farooqi, 1996

5. Propodeal enclosure with broad transverse ridges. ..... ***Sphex pruinosus*** Germar, 1817
— Propodeal enclosure without broad transverse ridges. **6**

6. Legs entirely or partly red or orange. ..... ***Sphex subtruncatus*** Dahlbom 1843
— Legs entirely black. **7**

7. Pubescence on propodeal enclosure silvery white or golden yellow (Figs 12 & 19). ..... ***Sphex obscurus*** (Fabricius, 1793)
— Pubescence on propodeal enclosure light brown or black. ..... ***Sphex praedator*** F. Smith, 1858

Figures 38–40. Male genitalia. **38.** *Sphex argentatus* Fabricius; **39.** *Sphex obscurus* (Fabricius); **40.** *Sphex sericeus* (Fabricius)

Discussion

Wasps of genus *Sphex* are cosmopolitan in distribution with 132 species worldwide. Of these, *Sphex neoumbrosus* Jha & Farooqi, 1996 is the last Indian species to be reported from the Indian subcontinent and of the Oriental region. The scarcity of studies most likely points to a shortage of accessible taxonomic resources (Forbes et al., 2018) and the present paper aims in providing one such comprehensive study to understand *Sphex* fauna of India. Key and figures of species included may help in the easy identification of the group in future and it is expected that further integrated studies and collection methods may help in identifying more species from the area.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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مطالعه جنس *Sphex* Linnaeus (Hymenoptera: Sphecidae) از هند

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چکیـده: جنس *Sphex* Linnaeus (Hymenoptera: Sphecidae) در هند مورد مطالعه قرار گرفت و کلید گونه‌ها ارایه شد. پراکنش چهار گونه از جنس *Sphex* تکمیل گردید. گونه *Sphex zubaidiyacus* Augul, 2013 به عنوان مترادف کم‌سابقهٔ نام *S. obscurus* (Fabricius, 1804) پیشنهاد شد.

واژگـان کلیدی: زنبورهای حفار، *Sphex*، هند، گزارش‌های جدید، رده‌بندی، کلید شناسایی

NEW RECORD OF *AMPULEX RUFICORNIS* (CAMERON, 1889) (HYMENOPTERA: AMPULICIDAE) FROM SOUTHERN INDIA

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Abstract: *The species Ampulex ruficornis (Cameron) is recorded for first time from Southern India. Key to Indian species of Ampulex Jurine by Anagha & Girish Kumar (2019) is partly modified here.*

Key words*: Ampulex, key, record.*

Introduction

The genus *Ampulex* Jurine is the largest genus within the family Ampulicidae and the members are commonly known as cockroach wasps. It is a widespread tropical genus distributed in Australia, Ethiopian, Nearctic, Neotropical, Oriental and Palearctic Regions. One hundred and thirty three species are recorded in this genus worldwide, of which twenty six species are known to occur in India (Anagha & Girish Kumar, 2019; Pulawski, 2021). Five species of *Ampulex* namely *A. ceylonica* Krombein, 1979, *A. compressa* (Fabricius, 1781), *A. dissector* (Thunberg, 1822), *A. major* Kohl, 1893 and *A. sadiyae* Anagha & Girish Kumar, 2019 are recorded from Kerala so far (Anagha & Girish Kumar, 2019).

Ampulex ruficornis (Cameron, 1889) is slender ant-like cockroach hunting wasp of the family Ampulicidae with rufous and black colouration. The species is characterised by the apically nodose first abdominal segment and abruptly angulate mandible of female (Krombein, 1979). The species has been

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reported from Northern India (West Bengal), Laos, Sri Lanka, and Thailand (Cameron, 1889; Krombein, 1979; Ohl *et al*., 2014; Dollfuss, 2017; Pulawski, 2021). In the present paper, *A. ruficornis* is newly recorded to Southern Indian fauna and a modified part of key to Indian species of the genus *Ampulex* (Anagha & Girish Kumar, 2019) is provided.

Materials and Methods

The species *A. ruficornis* (Cameron) was collected from ZSI Campus, Kozhikode, Kerala and Kollur, Mookambika Wildlife sanctuary, Karnataka. The specimens mounted on entomological pins were studied under LEICA M205 stereoscopic binocular microscope and images were captured using attached LEICA DFC 500 camera. Images at varying depth were stacked using Leica Automontage Software V3.80 and the final illustrations were processed for contrast and brightness using Adobe® Photoshop® CS5 (Version 6.1) software. Key to Indian species of *Ampulex* Jurine by Anagha & Girish Kumar (2019) is partly modified in the couplets 23 and 24 here. The collected specimens were added to the 'National Zoological Collections' of ZSIK.

Museum abbreviations: **OXUM**: Hope Department of Zoology, Oxford, England; **ZSIK**: National Zoological Collections, Western Ghat Regional Centre, Zoological Survey of India, Kozhikode, India.

Results

***Ampulex ruficornis* (Cameron, 1889) (**Figs 1–6)

Rhinopsis ruficornis Cameron, 1889: 115, ♀. Holotype: ♀, India: Barrackpore (OXUM), type identity established by Krombein, 1979: 11.

Ampulex constanceae: Bingham, 1897: 255 (in revision of aculeates of British India), corrected to *Ampulex ruficornis* by Krombein, 1979: 11.

Material examined. India: Kerala, Kozhikode district, ZSI Campus, Jaferkhan colony, 1 ♀, 25.iii.2021, Coll. J.B. Terine, ZSIK Regd. No. ZSI/WGRC/IR/INV/ 18309. Karnataka, Udupi district, Kollur, near Mookambika Check dam, 1 ♂, 5.ix.2021, Coll. V.D. Hegde & Party, ZSIK Regd. No. ZSI/WGRC/IR/INV/ 19352.

Diagnosis. Female. Head not elongate behind eyes; frons finely granulate; clypeus with a median carina that project at apex in to sharp tooth, two tooth on either side of lateral margins of clypeus; mandible abruptly angulate at basal third of outer margin (Fig. 2); pronotum with a median furrow; mesoscutum and mesopleuron with close fine punctures and scattered small punctures; posterolateral angle of propodeal dorsum with small blunt tooth (Fig. 3); first abdominal segment nodose at apex (Fig. 6); forewing with infumation in second submarginal cell, at apex of first submarginal cell, and at apex of submedian cell (Fig. 5).

Male. Sculpturing as in female; mandible normal with rather evenly rounded outer margin; clypeus without tooth on either side of clypeal margin (Fig. 8).

Variability. Colour of male is found to be more rufous than that of female except for antennae; forewing weakly infumated compared to female.

Distribution. India: Kerala (new state record), Karnataka (new state record), West Bengal. *Elsewhere*: Laos; Sri Lanka; Thailand (Cameron, 1889; Krombein, 1979; Ohl *et al*., 2014; Dollfuss, 2017; Pulawski, 2021).

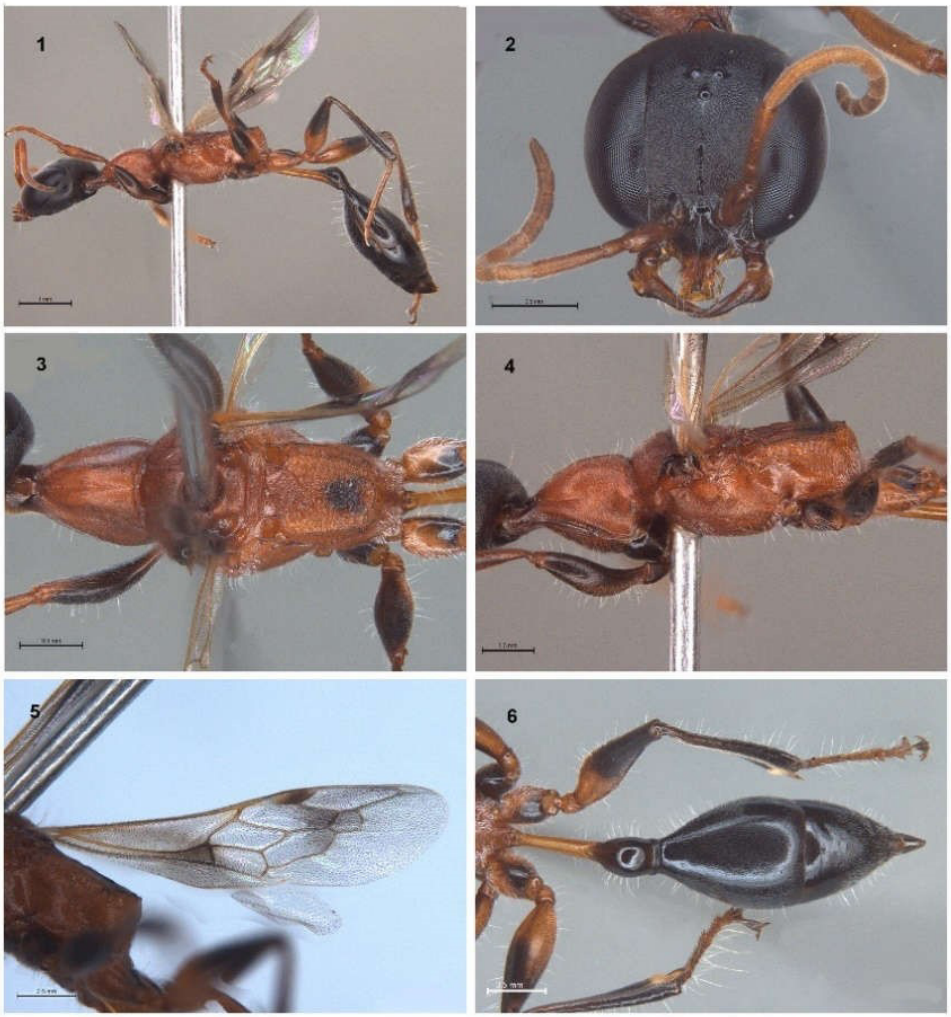
Modified part of key to Indian species of *Ampulex* Jurine (from Anagha & Girish Kumar, 2019)

22. Postero-lateral angle of propodeal dorsum with long curved tooth. ..... *ceylonica* **Krombein**

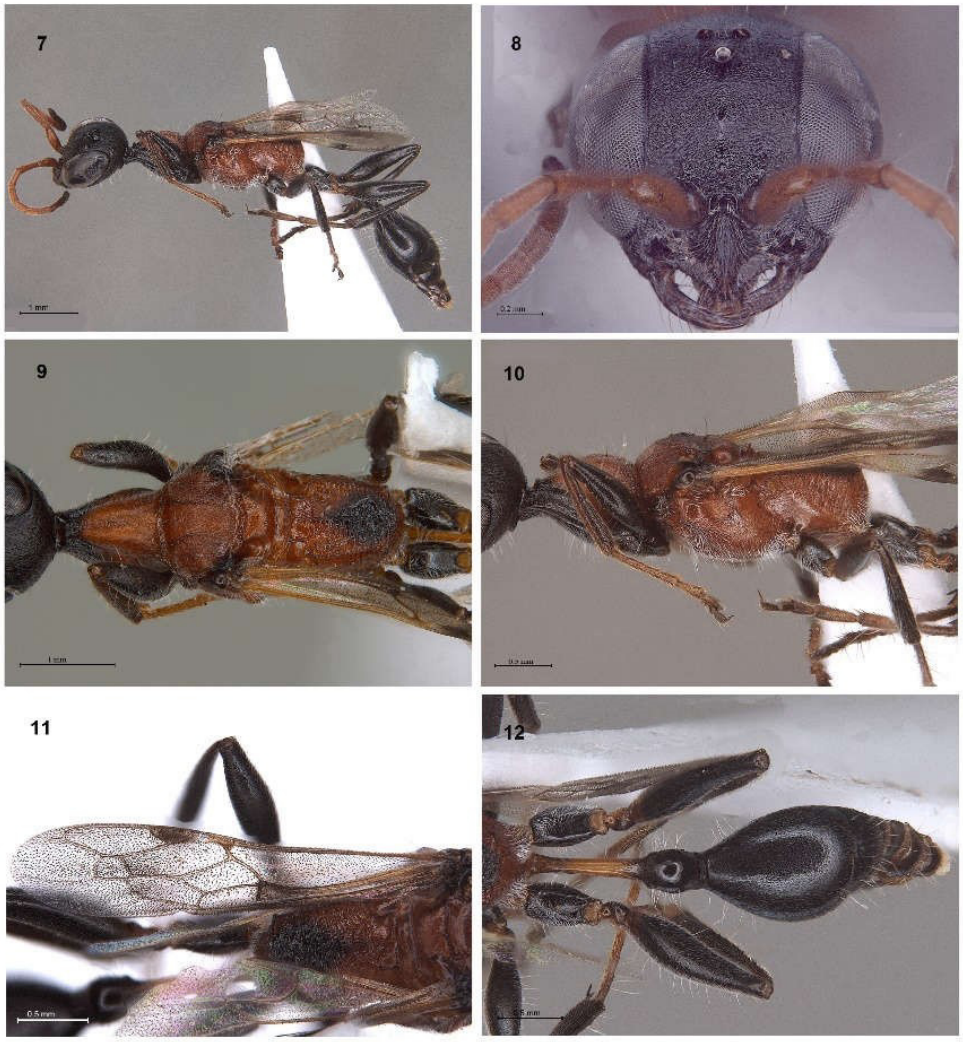
— Postero-lateral angle of propodeal dorsum with blunt tooth. … 23

23. Mandible abruptly angulate at basal third of outer margin (Fig. 2); petiole rufous … ..... ***ruficornis* (Cameron)**

— Mandible normal with evenly rounded outer margin; petiole white. … ..... ***sadiyae* Anagha and Girish Kumar**



Figures 1-6. *Ampulex ruficornis* (Cameron) ♀. 1. Habitus, lateral view; 2. Head, frontal view; 3. Mesosoma, dorsal view; 4 Mesosoma, lateral view; 5. Fore wing; 6. Metasoma, dorsal view.



Figures 7-12. *Ampulex ruficornis* (Cameron) ♂. 7. Habitus, lateral view; 8. Head, frontal view; 9. Mesosoma, dorsal view; 10. Mesosoma, lateral view; 11. Fore wing; 12. Metasoma, dorsal view.

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A study of the genus *Chalybion* Dahlbom, 1843 (Hymenoptera, Sphecidae) in India

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ABSTRACT. Species of the genus *Chalybion* Dahlbom, 1843 from India are studied. The species *C. gracile* Hensen, 1988 is recorded for the first time from India. The reported distributions of *C. bengalense* Dahlbom, 1845 within various states of India are augmented here. A modified key to the species of *Chalybion* from India is provided. Diagnosis, figures, and table showing comparison of newly recorded species, i.e., *C. gracile* with the widely distributed *C. bengalense* is provided. Diagnostic morphological characters of both *C. gracile* and *C. bengalense* are illustrated here.

Key words: blue mud dauber, new record, India, key, morphology

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INTRODUCTION

Blue mud dauber wasps of the genus *Chalybion* Dahlbom (Hymenoptera: Sphecidae) are cosmopolitan in distribution with 51 species worldwide (Pulawski, 2022). Members of this genus normally nest in pre-existing cavities or reuse vacated nests of other wasps such as *Sceliphron* and *Trypoxylon* (Bohart and Menke, 1976). The wasp cleans the nest cell and provisions it with paralyzed spider prey as food for developing larvae (Landes et al., 1987; Pham, 2020). *Chalybion* species hunt for various spiders with the preference to the families Araneidae and Theridiidae (Fateryga et al., 2020). To date, 16 species of *Chalybion* are reported from the Oriental region. Although common in collection, very few species of *Chalybion* are encountered in India with only three described species: *C. bengalense* (Dahlbom), *C. spinolae* (Lepeletier), and *C. malignum* (Kohl). Among them, *C. bengalense* is the most common species. Here we add a fourth species *C. gracile* Hensen, 1988 to the list of Indian *Chalybion*. The present study shed in to light that it is necessary to carefully examine even common species like *C. bengalense* because rare cryptic species may also hide among them.

MATERIAL AND METHODS

The *Chalybion* specimens studied here belong to the Western Ghat Regional Centre, Zoological Survey of India, Kozhikode (ZSIK), along with fresh specimens collected from various localities in India. The

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specimens mounted on entomological pins were studied under a LEICA® M205 stereoscopic binocular microscope and images were captured using the attached LEICA® DFC 500 camera. Habitus images of the species were captured with a digital camera (Canon® Power Shot SX540bHS). Measurements were obtained using Leica® LAS (Leica Application Suite V3.8.0) microsystems by Leica® (Heerburg, Switzerland). Images at varying depths were stacked using Leica Automontage Software V3.80 and the final illustrations were processed for contrast and brightness using Adobe® Photoshop CS5 (Version 6.1) software. Freshly collected specimens after curation are added to the National Zoological Collections of ZSIK. The morphological terminology used in this paper mostly follows Bohart and Menke (1976). The differences between *C. bengalense* and *C. gracile* are presented in Table 1.

Museum abbreviations used in the text: **BMNH** – The Natural History Museum, formerly British Museum (Natural History), London, England; **USNM** – National Museum of Natural History, Washington, D.C., U.S.A; **ZMUC** – Zoological Museum, University of Copenhagen, Denmark.

RESULTS

Taxonomic hierarchy

Class Insecta Linnaeus, 1758

Order Hymenoptera Linnaeus, 1758

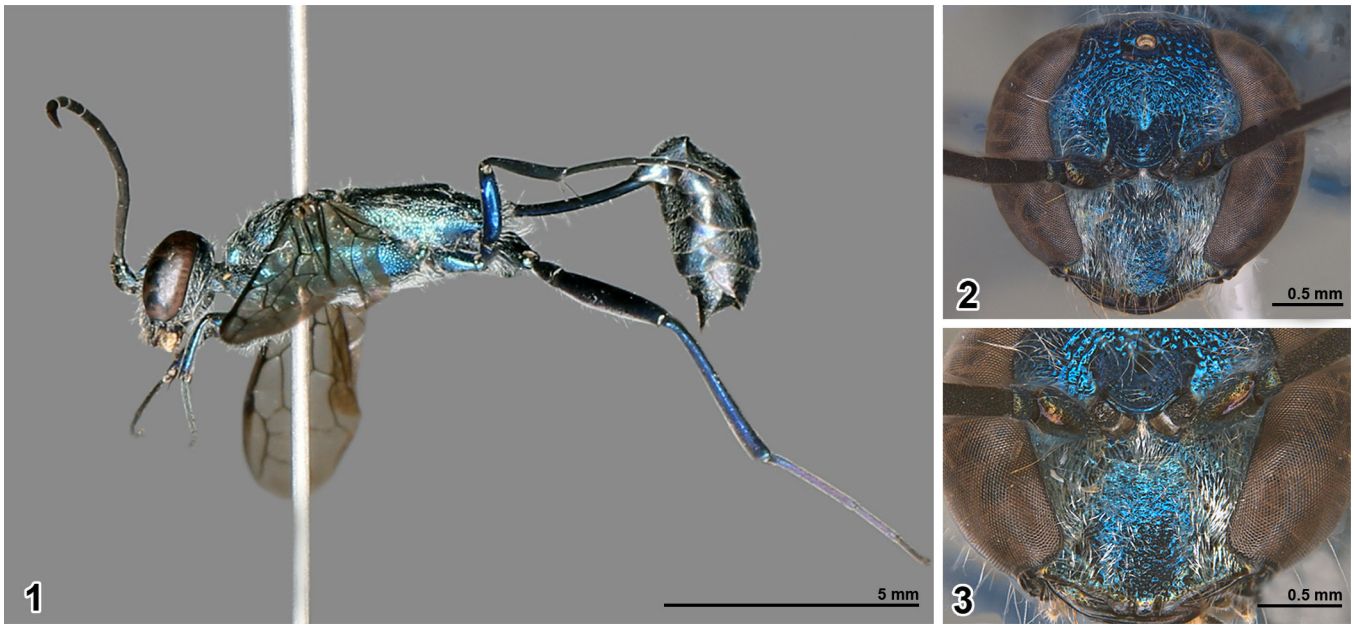
Family Sphecidae (Latreille, 1802)

Genus *Chalybion* Dahlbom, 1843

***Chalybion gracile* Hensen, 1988** (Figs 1–9)

Chalybion gracile Hensen, 1998:28, ♀. Holotype: ♀, Sri Lanka: Ratnapura District: Sinharaja Forest (USNM).

Diagnosis. Female. Frons strongly rugose reticulate (Fig. 2); clypeus with three teeth (Fig. 3); supra-antennal plate strongly protruding and ventrally delimited by carina which runs along and between antennal sockets, ventral margin forms about quarter of a circle (Figs 2 & 3); pronotal collar medially indented with distinct punctures; mesoscutum transversely strigose with shallow punctuation between striae; scutellum and metanotum with distinct punctures; propodeum transversely strigose, posterior part of propodeum with well differentiated median furrow (Fig. 4); mesepisternum with distinct punctures (Fig. 5);

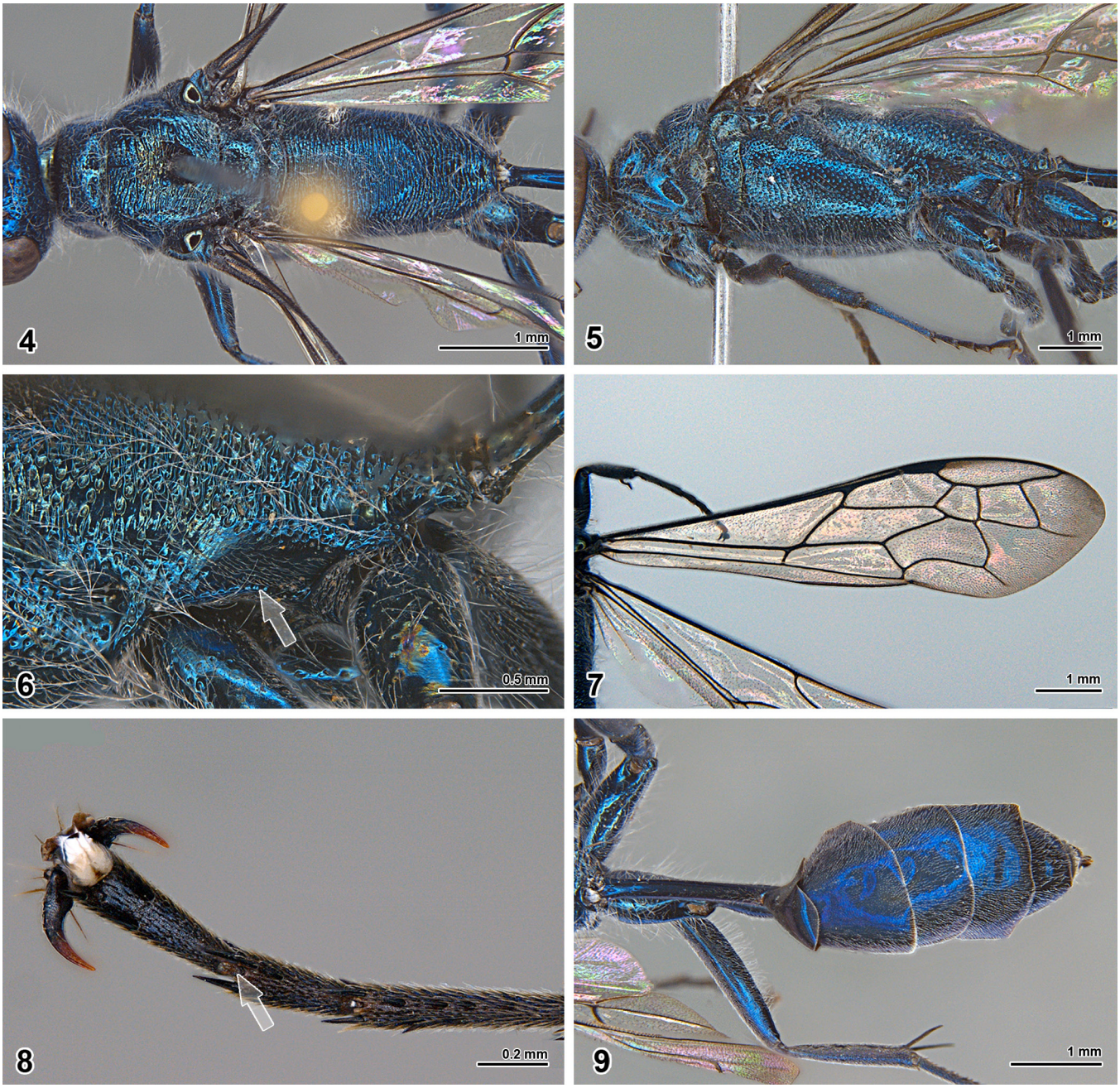


Figures 1–3. *Chalybion gracile* Hensen, 1988, ♀. **1.** Habitus, lateral view; **2.** Head, frontal view; **3.** Clypeus.

first metasomal tergite slender, pubescence of metasoma silvery white (Fig. 9); cellular wing area clearly hyaline (Fig. 7).

Material examined. INDIA: Karnataka, Udupi, Golihole, 1 ♀, 17.vi.2022, Coll. V.D. Hegde & Party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 21313. Kerala, Idukki district, Kulamavu, 1♀, November 2019, Coll. Tessy Rajan, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18066; Wayanad district, Ponkuzhi, 1♀, 7.ii.2021, Coll. K.A. Subramanian & party, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18067; Palakkad district, Silent Valley, 1♀, 12.iii.2021, Coll. S. Anagha, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18175.

Distribution in India (**new record**). Karnataka, Kerala. ***Elsewhere***: Sri Lanka (Pulawski, 2022).



Figures 4–9. *Chalybion gracile* Hensen, 1988, ♀. **4.** Mesosoma, dorsal view; **5.** Mesosoma, lateral view; **6.** Metapleuron (arrow mark shows carina); **7.** Fore wing; **8.** Hind tarsi (arrow mark shows plantula); **9.** Metasoma, dorsal view.

Chalybion bengalense (Dahlbom, 1845) (Figs 10–19)

Sphex violaceus Fabricius, 1775:346, ♀, ♂ (as *violacea*, incorrect original termination), junior primary homonym of *Sphex violaceus* Scopoli, 1763. Lectotype: ♀, South Africa: Cape of Good Hope (ZMUC).
Pelopoeus bengalensis Dahlbom, 1845:433, ♀, ♂. Holotype or syntypes: India: Bengal: no specific locality (Lund).
Chalybion bengalense: F. Smith, 1871:360 (new combination, in catalog of Oriental Aculeata).
Pelopoeus convexus F. Smith, 1876:449, ♂. Syntypes: ♂, Mascarenes: Island of Rodriguez (BMNH).

Diagnosis. Female (Figs. 10–17). Frons punctate to punctate reticulate (Fig. 11); clypeus with five teeth (Fig. 12); supra-antennal plate not strongly protruding (Fig. 11); pronotal collar, mesoscutum, scutellum, and metanotum distinctly punctate; propodeum transversely strigose with shallow punctures, punctate to rugose punctate laterally (Fig. 13); mesepisternum densely coarsely punctate to rugose-punctate (Fig. 14); first metasomal tergite slender, with white pubescence (Fig. 16); cellular wing area subhyaline with a brownish tinge (Fig. 15). **Male** (Figs. 18–19). Resembles female in most aspects except clypeus with three teeth (Fig. 19).

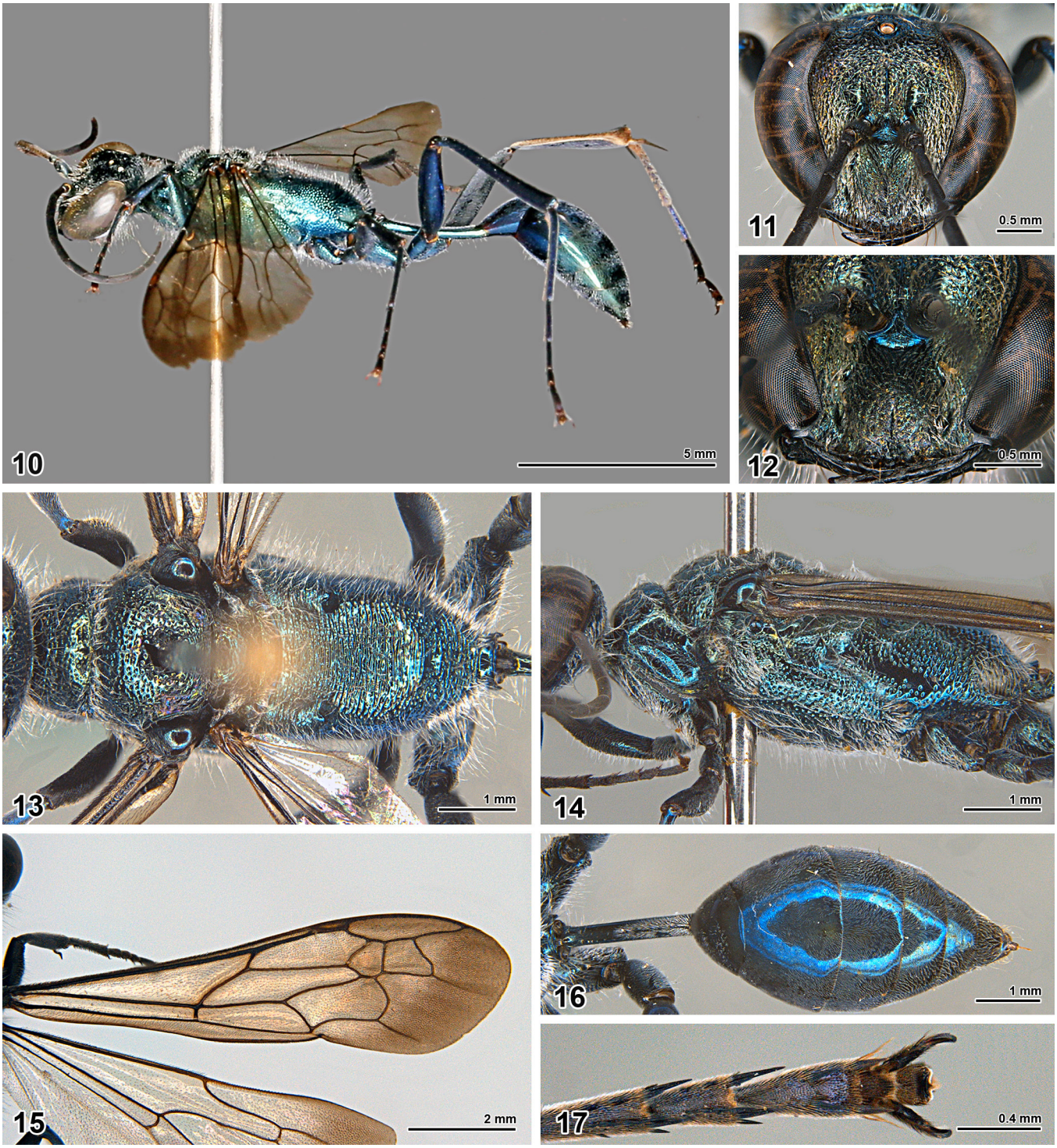
Material examined. INDIA: **Andaman and Nicobar Island**, South Andaman district, Port Blair, 1♂ & 1♀, 7.iv.2021 & 16.v.2021, Coll. A.K. Dubey, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17976 & 17977. **Karnataka**, Kodagu district, Thondoor, 1♂, 22.xii.2019, Coll. P. Girish Kumar, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18049; Kodagu district, Bettathur near Madikeri, 1♀ & 3♂♂, 24.xii.2019, Coll. P. Girish Kumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18050–18053. **Kerala**, Kozhikode district; Kottooli wetland, 2♀♀, 20.vi.2017, Coll. P. Girish Kumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 10004–10005; Kannur district, Madayipara, 1♀, 2.xii.2018, Coll. Sandra, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 12842; Thiruvananthapuram district, Agasthyamalai, Neyyar WLS, 5♀♀ & 3♂♂, 16.i.2019, Coll. P. Girish Kumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16881–16888; Idukki district, Chinnar, Koottaram, 1♂, 28.xi.2018, Coll. S. Anagha, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 17112. **Tamil Nadu**, Tirunelveli district, Rosemiyapuram, 6♂, 25.ix.2018 & 27.ix.2018, Coll. P. Girish Kumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16855–16857 & 16858–16860; Kanyakumari district, Kanyakumari WLS, Alagiyapandipuram range, Kalikesham, 4♂♂, 16.ii.2020, Coll. Souvik Sen & party, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16889–16892; Kanyakumari district, Kanyakumari WLS, Kulashekaram range, 2♀♀, 19.ii.2020, Coll. Souvik Sen & party, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 16893–16894. **Uttarakhand**, Dehradun district, WII Campus, 3♀♀ & 1♂, 10–13.viii.2017, Coll. P. Girish Kumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 17251–17254; Dehradun district, Kalsi, 4♀♀ & 11♂♂, 18.vii.2019, Coll. P. Girish Kumar, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18032–18046. **Madhya Pradesh**, Mandla district, Kanha National Park, 1♀, 18.vi.2019, Coll. David Raju, ZSIK Regd. No. ZSI/WGRC/I.R.–INV. 18030. **West Bengal**, S-24 Parganas, Sunderban, Sagar island, 2♀♀ & 2♂♂, 17.iii.2018 and 25.iii.2018, Coll. Sunita Patra, ZSIK Regd. Nos. ZSI/WGRC/I.R.–INV. 18058 and 18059–18061.

Distribution in India. Andaman and Nicobar Island, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal. ***Elsewhere***: Australia; Bangladesh; Chagos Archipelago; China (including

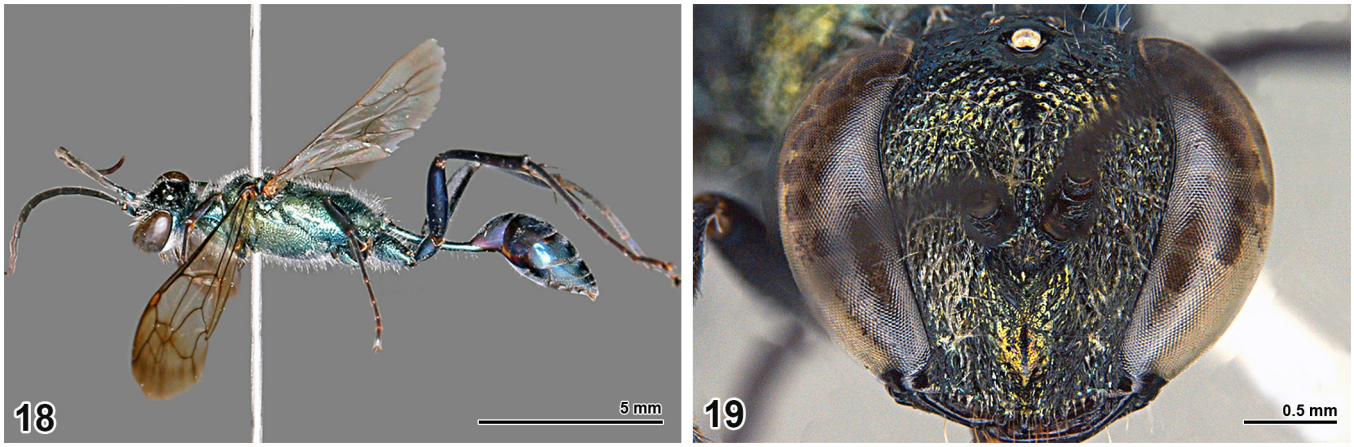
Table 1. *Chalybion bengalense* (Dahlbom) *vs. Chalybion gracile* Hensen (Based on Females).

Characters	*Chalybion bengalense* (Dahlbom)	*Chalybion gracile* Hensen
Tarsi of legs	Without plantulae	With plantulae
Metapleuron	Acarinate	With angular carina above midcoxa
Supra-antennal plate	Not protruding, ventrally without carina	Strongly protruding, ventrally delimited by carina
Dentition at clypeal margin	Five teeth	Three teeth
Mesoscutum	Distinctly punctate	Transversely strigose
Cellular area of fore wing	subhyaline with brownish tinge	Clearly hyaline

Hong Kong); Egypt; Eritrea; Ethiopia; French Polynesia; Gilbert Island; Greece; Guam Island; Hawaiian island; Indonesia; Iraq; Italy; Japan; Kenya; Laos; Madagascar; Malaysia; Maldives; Mascarenes; Mauritius; Micronesia; Mozambique; Myanmar; Nepal; New Caledonia; Philippines; Phoenix island; Seychelles islands; Singapore; South Africa; Sri Lanka; Taiwan; Tanzania; Thailand; Vietnam; Yemen (Anagha & Girish Kumar, 2020; Pulawski, 2022).



Figures 10–17. *Chalybion bengalense* (Dahlbom, 1845), ♀. **10.** Habitus, lateral view; **11.** Head, frontal view; **12.** Clypeus; **13.** Mesosoma, dorsal view; **14.** Mesosoma, lateral view; **15.** Fore wing; **16.** Metasoma, dorsal view; **17.** Hind tarsi.



Figures 18–19. *Chalybion bengalense* (Dahlbom, 1845), ♂. **18.** Habitus, lateral view; **19.** Head, frontal view.

Key to Indian species of genus *Chalybion* Dahlbom (modified from Hensen, 1988)

1 Ventral margin of clypeus with broadly projecting median lobe, which may be weakly emarginate medially in female or bi or trilobate in male (see Fig. 2 of Hensen, 1988); petiole and legs with partly yellow markings; tarsi without plantulae. ..... ***spinolae*** (Lepeletier)

– Ventral margin of clypeus with three or five teeth or lobes; petiole and legs without yellow markings; tarsi with or without pantulae. **2**

2 Tarsi with plantulae (Fig. 8); metapleuron with carina, which run along outer side of midcoxa and bend sharply outwards posteriorly, to end above base of hind coxa (Fig. 6). .....***gracile*** Hensen

– Tarsi without plantulae (Fig. 17); metapleuron without angular carina. **3**

3 Clypeus with five teeth, the median three close together, more or less fused, lateral teeth sharp and rather distant from others; sixth sternite of female flat and wide, apically broadly truncate. .... ***malignum*** (Kohl)

– Clypeus with three or five teeth, in latter lateral teeth not sharply pointed and not distant from median three (Fig. 12); sixth sternite of female not markedly wide, apically rounded..... ***bengalense*** (Dahlbom)

DISCUSSION

With the new record of *C. gracile*, the Indian Sceliphroninae is having 16 species under 2 genera. After the present study, out of 16 species of *Chalybion* reported from the Oriental region, only four species are known to occur in India. Since India is a tropical country with vast biodiversity, there is a chance to get more species of *Chalybion*. So, further intensive and extensive surveys are needed especially on those areas such as north-east and western India which are comparatively less explored. Distribution of newly recorded species *C. gracile* is very limited and so far recorded only from Sri Lanka and southern India. The Western Ghats of southwestern India and the highlands of southwestern Sri Lanka are similar in their geology, climate and evolutionary history. Hence, *C. gracile* may be an endemic species to Sri Lanka – Western Ghats hotspot. Instead, *C. bengalense* is a widely distributed species.

AUTHOR'S CONTRIBUTION

The authors confirm their contribution in the paper as follows: S. Anagha & P. Girish Kumar: designed methodology; S. Anagha: wrote the manuscript with support from P. Girish Kumar & V.D. Hegde. All authors discussed the results and contributed to the final manuscript. All authors read and approved the final version of the manuscript.

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AVAILABILITY OF DATA AND MATERIAL

Not applicable.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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بررسی گونه‌های جنس *Chalybion* Dahlbom, 1843 (Hymenoptera, Sphecidae) در هند

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چکیـده: گونه‌های جنس *Chalybion* Dahlbom, 1843 در هند بررسی شدند. گونهٔ *C. gracile* Hensen, 1988 برای اولین بار از هند گزارش شد. پراکنش ثبت شده گونهٔ *C. bengalense* Dahlbom, 1845 در ایالت‌های مختلف هند مستندسازی شدند. یک کلید تغییریافته برای شناسایی گونه‌های جنس *Chalybion* در هند، ارایه شد. ویژگی‌های افتراقی، تصاویر و جدول مقایسه‌ای گونهٔ گزارش جدید، یعنی *C. gracile* با گونهٔ دارای پراکنش وسیع *C. bengalense* ارایه شد. خصوصیات مرفوژیک افتراقی هر دو گونه *C. gracile* و *C. bengalense* به تصویر کشیده شد.

واژگـان کلیدی: زنبور گِل آبی، گزارش جدید، هند، کلید شناسایی، ریخت‌شناسی