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The Dragonflies and Damselflies (Odonata) of Kerala – Status and Distribution

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ABSTRACT: The odonate fauna of Kerala, their status and distribution are reviewed. Based on personal records from field work since 2010 and published literature, all the recent additions and range extensions to the region are critically analyzed and a revised checklist of odonates of Western Ghats and Kerala is provided. The current checklist of odonates of the Western Ghats stands at 207 species, including 80 endemics. A total of 181 species of Odonates, including 68 Western Ghats endemics, belonging to 87 genera under two suborders and 14 families were recorded from the geographical boundary of Kerala. The suborder Zygoptera comprises 74 species of damselflies (30 genera in seven families) and the suborder Anisoptera has 107 species (57 genera in seven families). Endemic species and those in IUCN Red List categories are enlisted. None of the odonate species from the region are protected under the Indian Wildlife Protection Act (WPA) 1972. A detailed discussion on odonates occurring in Kerala has been provided in the systematic part.

KEY WORDS: Western Ghats, endemics, range extension, IUCN, Red List, WPA 1972

INTRODUCTION

Global diversity of odonates has been estimated at 6335 species classified in 693 genera (Paulson *et al.*, 2021) of this 493 species and 27 subspecies in 152 genera and 18 families are known to exist in India (Subramanian and Babu, 2020). One hundred and ninety five species group taxa, belonging to 69 genera are endemic to India and, high endemism is found in Western Ghats where it is concentrated mainly in the mountains south of Coorg in Karnataka and Kerala (Subramanian and Babu, 2020). In India, high diversity and endemism of odonates are found in southern Western Ghats, Eastern Himalayas, Western Himalayas and the Andaman and Nicobar Islands. Subramanian (2007) reported 176 species, including 68 endemics in Western Ghats. Subsequently, species diversity of odonates of Western Ghats has been updated to 196 (Subramanian and Babu, 2020). According to

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Emiliyamma (2014), southern Western Ghats have 169 species of odonates with 68 endemic species. Here, streams and rivers of Coorg, Wayanad, Nilgiris, Anamalais, Cardamom Hills and Agasthyamalais are rich in endemic species (Subramanian, 2007; Subramanian *et al*., 2011, Babu *et al.,* 2013; Kiran *et al.,* 2015; Emiliyamma and Palot, 2016 b; Subramanian *et al.,* 2018; Joshi and Sawant, 2019; Babu and Subramanian, 2019; Rangnekar *et al.,* 2019; Sadasivan *et al.,* 2021; Sadasivan and Palot, 2021; Bhakare *et al.,* 2021). The Western Ghats are known to host 74 endemic species including two, which are considered *species inquirenda* (Subramanian *et al.,* 2018), however, according to Kalkman *et al*. (2020) Western Ghats (WG) harbours 73 endemic species. The major compilations for Kerala state are the lists compiled by Radhakrishnan and Emiliyamma (2003) and later Emiliyamma *et al.* (2007), which included 137 species. Kiran and Raju (2013) enlisted 154 species of odonates for Kerala. As per Subramanian *et al.* (2020) the diversity of Odonata in the WG is represented by 203 species with 84 endemics. There are a few recent additions, range extensions and rediscoveries which have to be taken into account to generate the latest list of odonates of Kerala.

MATERIALS AND METHODS

This work is based on field data collected by the authors since 2010. Species photographs were taken with special emphasis on the structure of the prothorax and anal appendages. Taxonomy of the group follows Fraser (1933). The current checklist follows Subramanian and Babu (2017) and Paulson *et al*. (2021). The conservation status follows IUCN (2021) Red List assessment updated as on 03 June 2021. The current distribution of odonates of Western Ghats (WG) is based on Subramanian *et al.* (2018). The morphological descriptions follow Fraser (1933) and Garrison *et al.* (2006, 2010). All the recent additions and range extensions to the region are critically analyzed and added to the checklist. In addition to our personal records from field work since 2010, we reviewed all the peer reviewed published literature. In addition to the historical records of Fraser (1924a, 1924b, 1931, 1933, 1934, 1936), Rao and Lahiri (1982) and Mathavan and Miller (1989), unpublished personal field records of Kalesh Sadasivan (KS), Vinayan P Nair (VPN), Abraham Samuel (AS) and Md. Jafer Palot (MJP) from 2010 to 2020 were taken for the distribution data. Recent works referred were Radhakrishnan and Emiliyamma (2003), Subramanian (2007), Emiliyamma *et al.* (2007), Kiran and Raju (2013), Babu *et al.* (2013), Kiran *et al.* (2015), Emiliyamma and Palot (2016 b), Subramanian *et al.* (2018), Babu and Subramanian (2019), Joshi and Sawant (2019, 2020), Rangnekar *et al*. (2019), Joshi *et al*. (2020), Kalkman *et al.* (2020), Subramanian and Babu (2020), Sadasivan *et al.* (2021), Dawn (2021), Sadasivan and Palot (2021), Arunima and Nameer (2021) and Bose *et al.* (2021). A few spot records from other fellow naturalists and researchers were added as personal communication attributed to them, after verification by the authors. Data from non-peer reviewed publications and predatory journals were excluded. Regarding the distribution, a landscape based approach, modified from Sankar (2013), is taken here for WG part of Kerala (Table 1).

RESULTS

Kerala has a rich and diverse Odonata fauna with a total of 169 species as compiled from published records (Emiliyamma and Radhakrishnan, 2006; Sharma *et al.,* 2007; Kiran and Raju, 2013; Subramanian *et al.,* 2013; Varghese *et al*., 2014; Kiran *et al.,* 2015; Emiliyamma and Palot, 2016 a, b; Subramanian *et al.,* 2018; Thumboor and Jose, 2018; Rangnekar *et al.,* 2019; Emiliyamma *et al.,* 2020; Joshi *et al.,* 2020). To the 169 species compiled from the above publications, the authors have added the following eight species based on their personal records and publications. *Amphiallagma parvum* (Selys, 1876) in 2017, *Ceriagrion chromothorax* Joshi and Sawant, 2019 and *Platylestes platystylus* Rambur, 1842 in 2018 by VPN (all from Varadoor, Kannur district); *Pseudagrion australasiae* Selys, 1876 in 2019 by AS from Thumboormuzhi, Thrissur district; *Crocothemis erythraea* (Brullé, 1832) in 2019 from Munnar, *Protosticta rufostigma* Kimmins 1958 from Shendurney, Kollam and *Protosticta sholai*

Table 1. Summary of the Landscapes, Units, and subunits of Western Ghats in Kerala (modified from Sankar, 2013)

Landscape	Subunit with Location, average altitude above sea-level (ASL), land area in square kilometre and Rivers draining them	Protected Areas: Wildlife Sanctuaries (WLS)/ National Park (NP)/ Reserve forests (RF)/ Tiger Reserves (TR)	Borders
Agasthyamala	**Agasthyamalais** 8°15'16.37"N, 77°28'6.14"E to 9° 1'14.97"N, 77° 8'6.04"E 800 sq. km in Kerala ***Drainage*** Thamirabararni Neyyar Karamana Vamanapuram Ithikkara Kallada	Neyyar WLS, Peppara WLS, Trivandrum Forest Division, Kulathupuzha RF, Thenmala RF, and Shendurney WLS	Aralvaimozhi Pass to south of Ariyankavu Gap (Watershed area between Kallada and Achankovil on the Ambanad Hills). Kerala state, Trivandrum, Kollam to westand Tamil Nadu Plains Nagercoil, Kanyakumari, Tirunelveli to East. The Kalakkad Mundanthurai Tiger Reserve (KMTR) lies on the eastern slopes of this subunit.
Periyar	**Pandalam Hills** $9^0$5'N–$9^0$35'N $76^0$55'E–$77^0$17'E 1800 sq. km 500–1500 m ASL ***Drainage*** Achankovil Pamba	Achankovil RF, Punalur RF, Konni RF, Ranni RF, and Periyar TR (West Division)	Ariyankavu Gap to Ridge between Pamba and Periyar river watershed starting from Chokkampattymala. Tirunelveli and Rajapalayam, Tamil Nadu plains Ramanadapuram on east and Kollam, Pattanamthitta, Kottayam districts of Kerala on west.
	Cardamom Hills $9^0$15'N–$10^0$0'N to $76^0$45'E–$77^0$25'E 700–1000m ASL 2500 sq. km in Kerala High Wavys 1500 sq. km ***Drainage*** Periyar Manimala Meenachil	Periyar TR East, Peermedu Plateau, Vagamon, Idukki WLS, Mathikettan Shola NP (Lower/Western Slopes), and Munnar forest division (Kumili Range)	Ridge between Pamba and Periyar river watershed starting at Chokkampattymala in south to the Munnar Saddle (from Adimali–Panniyar–Deviyar–Chokkanadmala–Kolukkumala). Lower Periyar Subunit (Kottayam, Moovattupuzha) to west. Thirunelveli RF & Srivilliputhur sanctuary lies on its eastern slopes. Cumbum–Theni–Madura Plains to north and east. The Meghamalais, Varusanad hills and Andipatty hills are the north–eastern extension of the Periyar Hills of this subunit.
Munnar	**High Range Hills** $10^0$0'N –$10^0$15'N $76^0$55'E–$77^0$15'E 1800m ASL 1000 sq. km ***Drainage*** Periyar	Mankulam(High), Eravikulam NP, Munnar forest division (Devikulam Range), and Mathikettan Shola NP crest)	Munnar Saddle to Anamalai Ridge (Rajamala–Anamudi–Umayamala) Kolukkumala to Top station along Border to Bodinayakkanur RF on east and Lower Periyar Valleys on west.
	Anjanad Valley–Palni Hills $10^0$7'N – $10^0$23'N $77^0$5'E – $77^0$18'E Chinnar & Marayur and adjoining areas in Kerala (400 sq. km) Anjanad valley Amravati and Kukkal (700 sq. km) and	Marayur, Chinnar WLS, Anamudi Shola NP, Kurunjimala WLS, Pampadumshola NP, Palnis, and Amaravati Valley	Anamalais on west, Coimbatore plains, to the north. Madura plains to the east and High Range and Bodi Plains to the south. Palnis is the north–eastern extension of this subunit to its south.

Landscape	Subunit with Location, average altitude above sea-level (ASL), land area in square kilometre and Rivers draining them	Protected Areas: Wildlife Sanctuaries (WLS)/ National Park (NP)/ Reserve forests (RF)/ Tiger Reserves (TR)	Borders
	Palnis 1500 sq. km (both regions mainly falling in Tamil Nadu) ***Drainage*** Amaravati (Pambar and Chinnar)		
	Lower Periyar $10^0$0'N – $10^0$18'N $76^0$40'E – $77^0$0'E 1200 sq. km ***Drainage*** Periyar Edamalayar Pooyamkutty Moovattupuzha	Mankulam(Low), Munnar forest division (Neriyamangalam, Adimali), Malayattoor Division (Kuttampuzha, Edamalayar, Thundam), Kothamangalam Division (Mullaringad, Kothamangalam), and Thattaekkad Sanctuary	Anamalais and High Ranges on the north and northeast to Peermedu Plateau on south. Idukki Plateau of Cardamom Hills subunit on east and (Thattaekkad to Neriamangalam) Ernakulam and Kottayam districts on west,
	Nelliampathies – Anamalais $10^0$10'N – $10^0$35'N $76^0$22'E – $76^0$50'E 2500 sq. km in Kerala (1500 sq. km forest) 600 sq. km in Tamil Nadu ***Drainage*** Chalakudy river Bharathpuzha (GayathriPuzha) Aliyar Karuvannur (Chimmony) and Keecheri Rivers in Trissur	Nellimapathy, Parambikulam TR, Chalakudy, Athirapally–Vazhachal, Sholayar, Peechi–Vazhani WLS, Chimmony WLS, and Nenmara Division	Palghat Gap on the north to Valparai Spur separates it from Edamala Valley of Lower Periyar subunit on the south. Peechi–Vazhani hills extension into Thrissur district on west and extends in to the Anjnad valley on the Northeast, Pollachi and Coimbatore plains on the east.
Nilgiri	**Palghat hills** $10^0$48'N – $11^0$35'N $76^0$22'E – $76^0$50'E (Shiruvani–Palamalai range) ***Drainage*** Bhavani Walayar Malampuzha Noyil	Malamapuzha Hills, Chenat Nair RF Walayar RF Shiruvani RF Kanjirapuzha RF, Elival–Palamala and their northern slopes on Attapadi	Attapadi Valley in the North to Palghat Gap on south. Bolumpatty valley and Coimbatore plains on the east, Palghat district on the east. These extend as a ridge from the Shiruvani hills, through Walayar to reach Palamala through Elival Peak. The northern sides slope into the Attapadi valley and the southern part into the Palghat plains.
	Attapadi Plateau Attapadi plateau=1600 sq. km (500–600 sq. km forest) ***Drainage*** Bhavani	Attapadi Reserve	Attapadi Plateau to the southern slopes of Nilgiris.
	Silent Valley $10^0$48'N – $11^0$35'N $76^0$22'E – $76^0$50'E Nilambur slope=1500 sq. km (500–600 sq. km forest) Attapadi plateau except	Silent Valley, New Amarambalam, Nilambur slope, Attapady RF, and Mannarghat RF	Attapadi valley in the south to Nilambur valley–Gudalur. Palghat and Malappuram districts on the west and Coimbatore Plains and the Nilgiri plateau on east.

Landscape	Subunit with Location, average altitude above sea-level (ASL), land area in square kilometre and Rivers draining them	Protected Areas: Wildlife Sanctuaries (WLS)/ National Park (NP)/ Reserve forests (RF)/ Tiger Reserves (TR)	Borders
	Nilgiri slopes and Muthikulam = 350 sq. km Silent Valley Plateau 90 sq. km ***Drainage*** Kunthi Bhavani Chaliyar		
	Nilambur Slopes ***Drainage*** Karimpuzha Chaliyar	Karimpuzha WLS, and Nilambur Division	Western Slopes of Nilgiris.
Wayanad	**Wayanad** 2200 sq. km 900m ASL From North of Nilambur valley to Iritty Valley ***Drainage*** Kabani Kuttiady Korappuzha Mahe Thalasserry	Vellarimala, Periya RF, Lady Smith RF, Chembra, Wayanad WLS, Thirunelli RF, and Wayanad Forest Division (North & South)	Nilambur slope forests of Nilgiri Landscape from Gudalur gap to the Thirunelli Region of Brahmagiris and Coorg. Kozhikode and Kannur plains on west and Mudumalai, Bandipur, Nagarhole on east. The subunit extends as the Mysore Plateau eastwards.
Coorg	**Kannur Ghats** 1800 sq. km From Iritty Valley to Netravati Valley ***Drainage*** Anjarakandy Valapattanam Kuppam Kariangode Chandragiri Bavalipuzha	Kottiyoor WLS, Aaralam WLS, Kannur forest division, Kannavam RF, Vaythalmala, Brahmagiris, Thalacauvery, and Laterite Hillocks of Kannur and Kasaragod	Northern edge of Wayanad Plateau near Thirunelli to Netravati Valley in the north. Kannur and Kasaragod districts on the west and Thalacauvery and Brahmagiri WLS on the north and east.

Subramanian & Babu, 2020 in 2017 from PTR by KS; and *Zygonyx torridus isis* Fraser, 1924 by MJP from Aralam WLS, Kannur district has been added to Kerala list in the present publication elevating the total Odonata fauna of Kerala to 177 species. Another four species have been added, making the total number to 181, based on personal records of other workers, namely, *Paracercion malayanum* Selys, 1876 (Bo Nielson, per. com.) from Varkala, Thiruvananthapuram, *Indothemis limbata sita* Campion, 1923 (Muneer PK, per. com.) and *Indolestes pulcherrimus* Fraser, 1924 (Muneer PK, per. com.) from Wayanad and *Anax indicus* Leiftinck 1942 (Suhas RK, per. com.) from Chinnar. Recently Bhakare *et al.* (2021) described two new species of *Euphaea* from Maharashtra, northern Western Ghats and Koli *et al.* (2021) added a range extension of *Gynacantha khasiaca* MacLachlan, 1896 to WG. Thus, considering the above, the current checklist of Odonates of the WG stands at 207 species with 80 endemics and that of Kerala at 181 species with 68 endemics (Table 2). A detailed discussion on all taxa occurring in Kerala has been provided in the systematic part.

SYSTEMATIC ACCOUNT OF ODONATES OF KERALA

A total of 181 species of Odonates belonging to 87 genera under two suborders and 14 families were recorded from the geographical boundary of Kerala. The suborder Zygoptera comprises 74 species of damselflies (30 genera in seven families) and the suborder Anisoptera has 107 species (57 genera in seven families).

Suborder Anisoptera Selys, 1854

Superfamily Aeshnoidea Leach, 1815

Family Aeshnidae Leach, 1815

Aeshnidae in Kerala comprises nine species belonging to three genera, *Anaciaeschna* Selys, 1878 (2 species), *Anax* Leach, 1815 (5 species) and *Gynacantha* Rambur, 1842 (2 species). Among the 10 species of Aeshnidae found in the WG, except *Gynacantha rotundata* Navas, 1930 and *Gynacantha khasiaca* MacLachlan, 1896, all are found in Kerala. Subramanian and Babu (2017) considered *G. rotundata* as *species inquirenda.* There are no endemic species in WG and Kerala, belonging to the family Aeshnidae when taken *G. rotundata* as *species inquirenda.*

Genus *Anaciaeschna* Selys, 1878

Anaciaeschna is represented by two montane and crepuscular species in WG and Kerala. *Anaciaeschna jaspidea* (Burmeister, 1839) has been reported from Palghat hills (KS) and Nelliampathies–Anamalais landscapes (Gnanakumar *et al.,* 2012; KS). *Anaciaeschna martini* Selys, 1897 is found in Nelliampathies–Anamalais and Chinnar landscapes (Fraser, 1936). Coniff *et al.* (2019) synonymized *A. martini* with *A. donaldi* Fraser, 1922. Specific location of *A. martini* includes Palani hills, Anamalai hills and Nilgiris (Fraser, 1936). The species was rediscovered from Munnar and Pampadum Shola (Kalesh *et al.,* 2021). *Anaciaeschna jaspidea* was recorded from Kuzhalmannam, in Palakkad (KS), Chimmony WLS (Gnanakumar *et al.,* 2012) and at Athirappally and Peechi (KS). These are montane crepuscular species.

Genus *Anax* Leach, 1815

Anax is represented by five species both in WG and Kerala. *Anax ephippiger* (Burmeister, 1839) is rare in Kerala and is present in Coorg–Kannur landscape (KS), Palghat Hills (KS), Agasthyamalais (KS) and Coastal wetland landscapes (KS). It is said to be migratory (Fraser, 1936). *Anax guttatus* (Burmeister, 1839) is common throughout the plains of India and Fraser (1936) has an exceptional record of this insect at 6000 ft. from Anamalais. It has been reported from Coorg–Kannur landscape (Palot and Kiran, 2016; Nair, 2014), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Fraser 1936, KS), Chinnar (Adarsh *et al*., 2015), High Ranges (KS), Lower Periyar (AS; KS), Cardamom hills (Emiliyamma *et al*., 2007; KS), and Coastal wetlands landscape of Kuttanad (Raju, 2007), and Kattampally, Kannur (Roshnath, 2020). *Anax immaculifrons* (Rambur, 1842) is riverine in habitat and found in varying altitudes of 1500 – 7500 ft in montane areas (Fraser, 1936). It is found in Coorg–Kannur landscape (Palot and Kiran, 2016; Palot and Radhakrishnan, 2005; VPN), Wayanad (Palot and Emiliyamma, 2015; MJP), Nilgiri – Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2014; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015; KS), High Ranges (Sadasivan, 2018), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS) and Agasthya-malais landscape (KS). *Anax indicus* Leiftinck, 1942 (Fig. 1A), is found in Wayanad (KS), Nilgiri–Silent Valley (KS), Chinnar (Suhas R.K., per. com; Sadasivan, 2018), High Range (KS), Cardamom hills (AS; KS) and Agasthyamalai landscapes (KS). *Anax parthenope* (Selys, 1839) is a crepuscular migratory one usually found flying in company with *A. ephippiger* (Fraser, 1936). It is a rare odonate in Kerala and is reported from a coastal wetland landscape, Kumarakom of Alappuzha (KS; AS).

Genus *Gynacantha* Rambur, 1842

Gynacantha dravida Leiftinck, 1960 (Fig. 1D), is the commonest species of the genus in the state. This is a crepuscular mosquito hunter, and often

comes to light. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015; Sadasivan, 2018), High range (KS), Lower Periyar (Varghese *et al*., 2014; KS), Cardamom Hills (KS), Pandalam Hills (KS), Agasthyamalais (KS), and coastal wetlands landscape of Kadalundi and Ponnani, Malappuram (Emiliyamma, 2014), Kuttanad (Raju, 2007) and Kattampally, Kannur (Roshnath, 2020). *Gynacantha bayadera* Selys, 1891 is a crepuscular mosquito hunter in India. It also gets attracted to light. As per Kalkman *et al.* (2020) *G. millardi* Fraser, 1920 (Fig. 1C) is known from India and Sri Lanka. *Gynacantha bayadera* Selys, 1891 is found only in North East India. *Gynacantha millardi* has been reported from Coorg–Kannur landscape (Nair, 2014; Palot and Kiran, 2016), Wayanad (Palot and Emiliyamma, 2015), Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Adarsh *et al*., 2014; Gnanakumar *et al.,* 2012; KS), Chinnar (Adarsh *et al*., 2015; KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (KS), Agasthyamalais (KS) and coastal wetland landscape of Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020). *Gynacantha khasiaca* MacLachlan, 1896 has been added to WG fauna by Koli *et al.* (2021) but is not found in Kerala.

Superfamily Cordulegasteroidea Needham, 1903

Family Chlorogomphidae Needham, 1903

Genus *Chlorogomphus*

Chlorogomphidae of Kerala has single genus *Chlorogomphus* with two species. Among the three described Chlorogomphids in the WG, two endemic species are found in Kerala. *Chlorogomphus campioni* (Fraser, 1924) is found in Coorg–Kannur landscape (Fraser, 1931; Palot and Kiran, 2016), Wayanad (Fraser, 1931; Emiliyamma *et al*., 2007) and Nilgiri–Silent Valley (Fraser, 1931), whereas *C. xanthoptera* (Fraser, 1919) (Fig. 1B) was found to occur in Nelliampathies–Anamalais landscape (Fraser, 1931; KS), Chinnar (KS), High ranges (Fraser,1931; KS), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalai landscapes (KS). It is also considered as vulnerable as per IUCN Red List (Subramanian *et al.,* 2018). The third endemic species of WG, *C. brittoi* Navas, 1934, is considered *species inquirenda* (Subramanian and Babu, 2017) and later it was synonymized with *C. xanthoptera* (Kalkman *et al.,* 2020).

Superfamily Gomphoidea Rambur, 1842

Family Gomphidae Rambur, 1842

Gomphidae is the second family with highest species diversity in WG as well as in Kerala. All 17 genera found in WG are found in Kerala with 22 species in Kerala, out of 32 in WG.

Genus *Acrogomphus* Laidlaw, 1925

Genus *Acrogomphus* is represented by a single species, *A. fraseri* (Fig. 1F) which has been found in both WG as well as Kerala. *Acrogomphus fraseri* has been reported from Coorg–Kannur (Fraser, 1934), Nelliampathies–Anamalais (Fraser, 1934), High Ranges (Fraser, 1934), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalais landscapes (Toms Augustine per. com. AS; KS).

Genus *Asiagomphus* Asahina, 1985

Genus *Asiagomphus* has a single species *A. nilgiricus* (Laidlaw, 1922) (Fig. 1H) which has been found in High Range (KS), Cardamom hills (KS), Pandalam hills (KS) and Agasthyamalai landscapes (KS).

Genus *Burmagomphus* Williamson, 1907

Burmagomphus is represented by three species in WG and two in Kerala. *B. cauvericus* Fraser, 1926 has been reported in WG but not from Kerala. *B. laidlawi* Fraser, 1924 (Fig. 1G) has been reported from Wayanad (Fraser 1934), Nilgiri–Silent Valley (KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014; KS), Cardamom Hills (KS) and Agasthyamalai (KS) landscapes. *B. pyramidalis* Laidlaw, 1922 is found in Nilgiri–

Silent Valley (KS) and Agasthyamalai landscape (KS) only.

Genus *Cyclogomphus* Selys, 1854

Cyclogomphus is represented by two species in Kerala, out of four in WG. *Cyclogomphus heterostylus* Selys, 1854 was reported for the first time from Kerala as range extension by Emiliyamma and Radhakrishnan (2006) from Urukunnu at Thenmalai, Kollam district of Pandalam Hills landscape. Previously it has been reported from West Bengal, Maharashtra and Tamil Nadu. Later, it has been reported from Agasthyamalai landscape (Emiliyamma, 2014; KS). Rangnekar *et al*. (2019) described *C. flavoannulatus* (Fig. 2H) from Goa and Kerala. It is found in Nilgiri–Silent Valley landscape (Rangnekar *et al*., 2019), Lower Periyar (Rangnekar *et al*., 2019; KS), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalai landscapes (KS). Although the other two, *C. wilkinsi* Fraser, 1926 and *C. ypsilon* Selys, 1854 were reported from WG and no reports are there from Kerala. *Cyclogomphus wilkinsi* Fraser, 1926 and *C. ypsilon* previously thought to be endemic to WG was reported from West Bengal recently (Dawn, 2021).

Genus *Davidioides* Fraser, 1924

Davidioides is represented by a monotypic endemic species of WG, *D. martini* Fraser, 1924 and is found in Coorg–Kannur landscape (Fraser, 1934), Nilgiri–Silent Valley (Subramanian, 2007), Nelliampathies–Anamalais (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), and Pandalam Hills landscapes (KS).

Genus *Gomphidia* Selys, 1854

Gomphidia is represented by a single species in Kerala out of five in WG. Recently in the WG a new species *G. podhigai* Babu and Subramanian, 2019 described from Kanyakumari Wildlife Sanctuary has been identified as the fifth (Babu and Subramanian, 2019). *Gomphidia kodaguensis* Fraser, 1923 (Fig. 2F) is found in Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (Fraser, 1934; Palot and Emiliyamma, 2015; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (KS; Pradeepkumar *et al*., 2014), and Agasthyamalai landscapes (KS; AS).

Genus *Heliogomphus* Laidlaw, 1922

Both the species of *Heliogomphus* Laidlaw, 1922 found in WG are also found in Kerala. *Heliogomphus kalarensis* Fraser, 1934 is endemic to WG. *Heliogomphus promelas* (Selys, 1873) (Fig. 2C) is found in Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (MJP; Palot and Emiliyamma, 2015), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Fraser, 1934; Adarsh *et al*., 2014; KS), Lower Periyar (KS), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalai landscapes (KS; AS) where *H. kalarensis* Fraser, 1934 is found only at Nilgiri–Silent Valley landscape (KS). *Heliogomphus promelas* (Selys, 1873) is endemic to India and is considered near threatened (Subramanian *et al.,* 2018).

Genus *Ictinogomphus* Cowley, 1934

Ictinogomphus is represented by a single species *I. rapax* (Rambur, 1842) (Fig. 2E) in Kerala as well as in WG. It is present in Coorg–Kannur landscape (Emiliyamma *et al*., 2007; Nair, 2014; Palot and Kiran, 2016), Wayanad (Palot and Emiliyamma, 2015; MJP; Susanth and Anooj 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Sharma *et al*., 2007; Adarsh *et al*., 2015), High Range (KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamala landscape (KS) and Coastal wetland landscape of Kadalundi (Emiliyamma, 2014), Chempallikundu, Kannur (Palot and Soniya, 2004) and Kattampally (Roshnath, 2020).

Genus *Lamelligomphus* Fraser 1922

Lamelligomphus Fraser, 1922 is endemic to WG. *Lamelligomphus nilgiriensis* (Fraser, 1922) (Fig. 2B) is found in Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (Fraser, 1934),

Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Fraser, 1934) and Chinnar landscapes (Fraser, 1934). Two subspecies of *Lamelligomphus viz., L. nilgiriensis nilgiriensis* (Fraser, 1922) and *L. nilgiriensis annamallaicus* Fraser, 1934 are found in WG (Fraser, 1934).

Genus *Macrogomphus* Selys, 1857

Macrogomphus is represented by a single species *M. wynaadicus* Fraser, 1924 (Fig. 2A) in Kerala, out of the two in WG, the other being *M. annulatus* (Selys, 1854). *Macrogomphus wynaadicus* Fraser, 1924 is an endemic species of WG and is found in Coorg –Kannur landscape (KS), Wayanad (KS; Sushanth and Anooj, 2020; Fraser, 1934), Nilgiri–Silent Valley (KS), Palghat Hills (VPN; KS), Nelliampathies–Anamalais (KS), Lower Periyar (KS; AS), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalai landscapes in Kerala (KS).

Genus *Megalogomphus* Campion, 1923

Megalogomphus has two representative species in WG, *M. hannyngtoni* (Fraser, 1923) and *M. superbus* Fraser, 1931 and both are found in Kerala. *Megalogomphus hannyngtoni* (Fraser, 1923) is present in Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (Fraser 1934, Roshnath, per. com.), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (KS), Lower Periyar (Varghese *et al*., 2014), Pandalam Hills (KS) and Agasthyamalai landscapes (KS). *M. superbus* Fraser, 1931 is present in Nilgiri landscape only (Fraser, 1934). *Megalogomphus hannyngtoni* (Fraser, 1923) is endemic to India and is considered near threatened as per IUCN Red List (Subramanian *et al*., 2018). *Megalogomphus superbus* is a very rare odonate in Kerala, a WG endemic and not recorded after Fraser (1934).

Genus *Melligomphus* Chao, 1990

Melligomphus was originally described as *Onychogomphus,* however, Kalkman *et al.* (2020) separated it based on the shape of the anal appendages. *Melligomphus acinaces* Laidlaw, 1922 (Fig. 1E), is a WG endemic species. It is found in Coorg–Kannur (Vibhu V, per. com.), Wayanad (Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (KS), Chinnar (KS), Lower Periyar (KS), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalai landscapes (KS).

Genus *Merogomphus* Martin, 1904

Merogomphus has two endemic species in WG, *M. longistigma* (Fraser, 1922) and *M. tamaracherriensis* Fraser, 1931 (Fig. 2G) and both are found in Kerala. *Merogomphus longistigma* (Fraser, 1922) is a high altitude species present in the upper reaches of Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (Fraser, 1934, Manoj per. com.), Nelliampathies–Anamalais (KS), Chinnar (Fraser, 1934), Lower Periyar (KS), Cardamom Hills (KS) and Agasthyamalai landscapes (KS). *Merogomphus tamaracherriensis* Fraser, 1931, is found in low altitudes and is present in Coorg–Kannur landscape (VPN), Wayanad (Fraser, 1934), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (AS; KS), Pandalam Hills (KS) and Agasthyamalai landscapes (KS).

Genus *Microgomphus* Selys, 1858

Microgomphus is represented by three endemic species in WG of which only *M. souteri* Fraser, 1924 is present in Kerala. *Microgomphus souteri* (Fig. 2D) was first reported from Kerala at Aaralam WLS, Kannur by Emiliyamma *et al.* (2014). It is found in Coorg–Kannur (Nair, 2017; Emiliyamma *et al*. 2012, Palot and Kiran, 2016; VPN), Wayanad (VPN), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalai landscapes (KS). *Microgomphus verticalis* (Selys, 1873) of WG was considered as *species inquirenda* (Subramanian and Babu, 2017). However, Kalkman *et al.* (2020) considered it as valid and is a WG endemic species. *Microgompus torquatus* (Selys, 1854) is the third species endemic to WG yet to be reported from Kerala.

Genus *Nychogomphus* Carle, 1986

Nychogomphus is represented by a single species in WG and Kerala. *Nychogompus striatus* (Fraser,

1924) is a rare species present in Lower Periyar landscape (Varghese *et al*., 2014), Pandalam Hills (KS) and Agasthyamalais landscape (KS).

Genus *Onychogomphus* Selys, 1854

Onychogomphus malabarensis (Fraser, 1924) is a very rare odonate and has been reported only from Palakkad Hills landscape (Fraser, 1934). It is a WG endemic species. There are no records after Fraser (1934).

Genus *Paragomphus* Cowley, 1934

Paragomphus is represented by a single species *P. lineatus* (Selys, 1850) in both Western Ghats and Kerala and is found commonly in all landscapes including coastal wetlands. It has been reported from Coorg–Kannur (Palot and Kiran, 2016; Nair, 2017), Wayanad (Emiliyamma *et al*., 2007; MJP), Nilgiri–Silent Valley (KS), Palghat Hills (Fraser, 1934; KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015; Sadasivan, 2018; KS), High Ranges (Sadasivan, 2018; KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS) and Coastal wetland landscape of Kattampally (Roshnath, 2020).

Superfamily Libelluloidea Leach, 1815

Family Corduliidae Selys, 1850

Genus *Hemicordulia* Selys, 1870

Corduliidae in Kerala is represented by a single genus, *Hemicordulia* with a single species, *H. asiatica* (Selys, 1878). It is recorded from Coorg–Kannur landscape (Vibhu, V, per. com.), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Fraser, 1936;, KS), High Range (Fraser, 1931; KS), Lower Periyar (KS), Cardamom Hills (KS), Pandalam Hills (KS), Agasthyamalai landscapes (KS) and coastal wetlands of Kozhikode district (MJP).

Family Libellulidae Leach, 1815

Libellulidae has maximum species diversity in the WG as well as in Kerala. In WG, the family is represented by 31 genera with 54 species whereas in Kerala there are all 31 genera with 50 species. Adding a range extension of a species to both WG and Kerala in Libellulidae, *Crocothemis erythraea* (Brullé, 1832), and range extension to Kerala, *Zygonyx torridus isis* Fraser, 1924 raise the species diversity of Libellulidae to 55 in WG and 52 in Kerala.

Genus *Acisoma* Rambur, 1842

Acisoma is represented by only one species both in WG and Kerala, *A. panorpoides* Rambur, 1842 and is a widespread dragonfly present in Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016; Emiliyamma, 2014), Wayanad (Emiliyamma *et al*., 2007; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Sharma *et al*., 2007; Adarsh *et al*., 2015), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS; AS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscapes of Kadalundi (Emiliyamma, 2014), Ambalapuzha in Alleppy (AS), Chempallikkundu, Kannur (Palot and Soniya 2004), Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020).

Genus *Aethriamanta* Kirby, 1889

Aethriamanta has a single species both in WG and Kerala. *Aethrimanta brevipennis* (Rambur, 1842) is present in Coorg–Kannur landscape (VPN; Palot and Radhakrishnan, 2005, Emiliyamma, 2014; Palot and Kiran, 2016), Wayanad (Susanth and Anooj, 2020), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015; Sadasivan, 2018; KS), High Ranges (Sadasivan, 2018; KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscape of Kadalundi,

(Emiliyamma, 2014), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and Kumarakom (Manoj P, per. com.).

Genus *Brachydiplax* Brauer, 1868

Brachydiplax is represented by two species both in WG and Kerala and *Brachydiplax chalybea* Brauer, 1868 is found in Coorg–Kannur landscape (Nair, 2014), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), Lower Periyar (Varghese *et al*., 2014; Emiliyamma, 2005; AS), Cardamom Hills (KS), Pandalam Hills (KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and Coastal wetland landscape of Kadalundi (Emiliyamma, 2014), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and Kumarakom (Manoj P, per. com.). *B. sobrina* (Rambur, 1842) is found in Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), Lower Periyar (Emiliyamma *et al*., 2007; Varghese *et al*., 2014; AS), Pandalam Hills (KS), Agasthyamalais (KS) and Coastal wetland landscape of Kumarakom, Chempallikkundu (Emiliyamma, 2014), Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020).

Genus *Brachythemis* Brauer, 1868

Brachythemis has a single species both in WG and Kerala and *B. contaminata* (Fabricius, 1793) is found in Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Emiliyamma, 2014; Palot and Emiliyamma, 2015; MJP), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007), Palghat plains (Palot *et al.,* 2006), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan 2014, Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Sharma *et al*., 2007; Adarsh *et al*., 2015), High ranges (Sadasivan, 2018; KS), Lower Periyar (Varghese *et al*., 2014; Emiliyamma, 2005; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalai landscape (Emiliyamma and Radhakrishnan, 2002; KS), and coastal wetlands landscape of Mannar, Alleppy (Emiliyamma, 2014), Chempallikundu (Palot and Soniya, 2004), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020), mangroves of north Kerala (Radhakrishnan *et al*., 2006). This species is commonly found in most of the wetlands including polluted waters all over Kerala.

Genus *Bradinopyga* Kirby, 1893

Bradinopyga is represented by two species in WG, *B. geminata* (Rambur, 1842) and *B. konkanensis* Joshi & Sawant, 2020. *Bradinopyga konkanensis* is a recent addition to WG Odonata fauna from Maharashtra (Joshi and Sawant, 2020), there are no confirmed records of the species from Kerala. Having examined numerous *Bradinopyga* specimens from Kannur and Kasaragod in North Kerala, the recent record from Kasaragod district, Kerala (Haneef *et al.,* 2021), needs further confirmation with detailed examination of male secondary genitalia. *Bradinopyga konkanensis* is endemic to WG. *Bradinopyga geminata* (Rambur, 1842) is a common species and is found in Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Palot and Emiliyamma, 2015; MJP), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015, Sadasivan, 2018; KS), High ranges (Sadasivan, 2018; KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan 2002; KS) and coastal wetlands landscape of Kadalundi (Emiliyamma, 2014), Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020).

Genus *Cratilla* Kirby, 1900

Cratilla Kirby, 1900 is also represented by a single species in WG and Kerala and the only species *C. lineata calverti* (Forster, 1903) (Fig. 4C) is found in Coorg–Kannur landscape (Nair, 2014; Emiliyamma, 2014; Palot and Kiran, 2016; VPN),

Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; KS), Chinnar (KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS) and Agasthyamalais landscape (KS).

Genus *Crocothemis* Brauer, 1868

Crocothemis Brauer, 1868 is represented by *C. servilia* (Drury, 1770) in both Western Ghats and Kerala so far and a range extension of *C. erythraea* (Brullé, 1832) to Western Ghats and Kerala is added now. *Crocothemis erythraea* (Brullé, 1832) (Fig. 3A) is an ice age relict present only at high altitudes in High Ranges (KS; Sadasivan, 2018) and Cardamom Hills landscape (Sadasivan, 2018; KS). *Crocothemis servilia* (Drury, 1770) is a widespread dragonfly in paddy fields and open lands of Kerala and is found in Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri – Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS; Emiliyamma, 2014), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; KS), Chinnar (KS; Sharma *et al*., 2007; Sadasivan, 2018), High Range (Sadasivan, 2018), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS; Peters,1981; Emiliyamma and Radhakrishnan, 2002) and Coastal wetlands landscape of Kadalundi (Emiliyamma, 2014), Chempallikundu (Palot and Soniya, 2004), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006).

Genus *Diplacodes* Kirby, 1889

Diplacodes is represented by three species in WG and Kerala. *Diplacodes trivialis* (Rambur, 1842) is very common in Coorg – Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Emiliyamma, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007), Palghat Hills (Emiliyamma *et al*., 2007; Emiliyamma, 2014; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015; Sharma *et al*., 2007; Sadasivan, 2018), High Ranges (Sadasivan, 2018), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS; Emiliyamma, 2014), Pandalam Hills (Pradeepkumar *et al*., 2014; KS; Emiliyamma, 2014), Agasthyamalais (KS; Peters, 1981; Emiliyamma and Radhakrishnan, 2002) and Coastal wetlands landscape of Kadalundi, Ponnani (Emiliyamma, 2014), Chempallikkundu (Palot and Soniya 2004), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and Mangroves of North Kerala (Radhakrishnan *et al*., 2006). *Diplacodes nebulosa* (Fabricius, 1793) is an uncommon species present in Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; MJP), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), High Ranges (Sadasivan, 2018; KS), Lower Periyar (KS; Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS) and coastal wetlands landscape (Raju, 2007; Emiliyamma, 2014; Roshnath, 2020). *Diplacodes lefebvrii* (Rambur, 1842) is a very rare species in WG and Kerala and is found only in Coorg–Kannur landscape of north Kerala (VPN; MJP).

Genus *Epithemis* Laidlaw, 1955

Epithemis is represented by a single species both in WG and Kerala. *Epithemis mariae* (Laidlaw, 1915), one of the monotypic endemic odonates (Fig. 3H), is a typical forest species present in Coorg–Kannur landscape (Emiliyamma, 2014; Palot and Kiran, 2016; VPN), Wayanad (Emiliyamma *et al*., 2007; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; KS; MJP),

Lower Periyar (Varghese *et al*., 2014; KS; AS; MJP), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (KS) and Agasthyamalais landscape (KS; MJP). It is usually found near water in thick forests and breeds in marshy areas at the foot hills (Emiliyamma *et al*., 2007). Das *et al.* (2013) reported that this species is exclusively found in lowland forest swamps of southern WG.

Genus *Hydrobasileus* Kirby, 1889

Hydrobasileus is represented by a single species *H. croceus* (Brauer, 1867) in WG and Kerala. It is present in Coorg–Kannur landscape (Nair, 2014; Palot and Kiran, 2016; VPN), Wayanad (VPN), Nilgiri-–Silent Valley (KS; VPN), Palghat Hills (Fraser, 1936; KS), Nelliampathies–Anamalais (Adarsh *et al*., 2014; KS), Lower Periyar (AS; Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; Emiliyamma, 2014; KS), Agasthyamalais (KS) and coastal wetland landscape of Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020).

Genus *Hylaeothemis* Ris, 1909

Hylaeothemis is represented by single species in both WG and Kerala. Kalkaman *et al.* (2020) synonymized *H. apicalis* Fraser, 1924 with *H. indica* Fraser, 1946. *Hylaeothemis apicalis* (Fig. 4E) is present in Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalais landscape (KS). It is seen in large colonies with short and weak flights looking like gomphids and is usually found settled on plants in high altitudes. It breeds in marshy areas along the banks of mountain streams at about 2000 ft. or above altitude (Emiliyamma *et al*., 2007). Das *et al.* (2013) reported that this species is an inhabitant of lowland forest swamps of southern WG.

Genus *Indothemis* Ris, 1909

Indothemis is represented by two species, *I. carnatica* (Fabricius, 1798) and *I. limbata sita* Campion, 1923 (Fig. 3B), both in WG and Kerala. *Indothemis carnatica* (Fig. 3D) is found in Coorg–Kannur landscape (VPN; KS), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007), Palghat Hills (KS), Nelliampathies–Anamalais (Adarsh *et al*., 2014; KS), Lower Periyar (KS), Cardamom Hills (AS; KS), Pandalam Hills (KS) and Agasthyamalai landscapes (KS). It is considered near threatened species as per the IUCN Red List (Subramanian *et al*., 2007; Subramanian *et al.,* 2020). However, as per the IUCN (2021) Red List, it is considered least concern species. *Indothemis limbata sita* has been reported from Wayanad landscape in June 2020 (Muneer PK, per. com.).

Genus *Lathrecista* Kirby, 1889

Lathrecista is represented by *L. asiatica* (Fabricius, 1798) both in WG and Kerala and is a very common species found in Coorg–Kannur landscape (Nair, 2014; Palot and Kiran, 2016; VPN), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), Lower Periyar (Emiliyamma *et al*., 2007; Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalai landscape (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscape of Kadalundi (Emiliyamma, 2014), Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020).

Genus *Lyriothemis* Brauer, 1868

The genus is represented by two species both in WG and Kerala. *Lyriothemis acigastra* (Selys, 1878) (Fig. 3E) is found in Coorg–Kannur landscape (VPN; KS; Emiliyamma *et al.,* 2013), Nelliampathies–Anamalais (KS), Lower Periyar (KS), Cardamom hills landscape (Jebin J, per. com.) and Kattampally of coastal wetland landscape (Roshnath, 2020). *Lyriothemis acigastra* (Selys, 1878) was first reported in Kerala from a sacred grove, Aravanchal Kavu and a table top laterite hillock, Madayipara of Kannur district, North Kerala (Emiliyamma *et al.*, 2013). The second species *L. tricolor* Ris, 1919 (Fig. 3F) is the only species

using phytotelmata as a breeding habitat in India. It is generally found associated with Myristica swamps. Larval habitat, breeding behavior and range extension to southern WG have been reported at Silent Valley NP, New Amarambalam RF and Salim Ali Bird Sanctuary, Thattaekkad in Kerala (Das *et al.,* 2013). It has also been reported from Aaralam Wildlife Sanctuary (Palot and Kiran, 2016) and Shendurney WLS (KS). As a whole in Kerala it is reported from Coorg–Kannur (Palot and Kiran, 2016), Wayanad (KS), Nilgiri–Silent Valley (Das *et al.,* 2013; KS), Lower Periyar (Das *et al.,* 2013) and Agasthyamalai landscapes (KS).

Genus *Macrodiplax* Brauer, 1868

Macrodiplax Brauer, 1868, is represented only by a single species in WG and Kerala, *M. cora* (Brauer, 1867) and is one of the most dominant dragonflies of the world and the wide distribution is due to its annual migration taking place in October (Fraser, 1936). It is mainly restricted to coastal areas in Kerala; however, Fraser has recorded *M. cora* 50 miles (80.5 km) away from sea in WG which may be due to migration. It commonly breeds in marshes and may be found breeding in brackish water near estuaries. It resembles *P. flavescens* in appearance but is smaller and has conspicuous black mid-dorsal markings over the abdomen. It has been reported from coastal wetland landscapes. Palot and Soniya (2004) reported it from Chempallikkundu coastal wetlands, Alappuzha (KS); Radhakrishnan *et al*. (2006) from mangrove wetlands of Kannur and Roshnath (2020) reported it from Kattampally wetlands.

Genus *Neurothemis* Brauer, 1867

Neurothemis is represented by three species both in WG and Kerala. *Neurothemis fulvia* (Drury, 1773) is a common insect in wet and semi-wet areas and it occurs in large colonies at the borders of jungles and in low lying swampy country (Fraser, 1936). It generally breeds in weedy ponds but prefers marshes mostly. The clear uncolored wing tips will help to distinguish *N. fulvia* males from other *Neurothemis* and females by the uniform golden-amber tint of the ground color of the wings, with or without clear apex in forewing (Fraser, 1936). It is reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad (Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS) and coastal wetland landscapes of Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020). *Neurothemis intermedia intermedia* (Rambur, 1842) is common in paddy fields of Kerala. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Nilgiri–Silent Valley (KS), Palghat hills (Emiliyamma *et al*., 2007; Emiliyamma, 2014; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; KS), Lower Periyar (KS), Pandalam Hills (KS), Agasthyamalais (KS) and coastal wetland landscapes of Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020). *Neurothemis tullia* (Drury, 1773) is a very common insect with black base of wing with opalescent white outer bordering in males and females having apices of the wings with broad black and sickle shaped stripe on basal half (Fraser, 1936). It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015, Sharma *et al*., 2007), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS; Emiliyamma, 2014), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Peters 1981; Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetlands landscape of Chempallikundu (Palot and Soniya, 2004), Kuttanad (Raju, 2007), Kattampally

(Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006).

Genus *Onychothemis* Brauer, 1868

Onycothemis Brauer, 1868 is represented in WG and Kerala by a single species. *Onychothemis testacea ceylanica* Ris, 1912 (Fig. 4B) is large size robust build dragonfly with dark metallic coloring with bright yellow markings and the claws are devoid of usual hooks (Fraser, 1936). It is a bold and strong flier with short flight and mainly found in submontane areas. It has been reported from Coorg–Kannur landscape (Nair, 2017; Palot and Kiran, 2016), Wayanad (VPN;MJP), Nilgiri–Silent Valley (KS; VPN), Nelliampathies–Anamalais (KS), Lower Periyar (Varghese *et al*., 2014; AS; KS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS) and coastal wetland landscape of Kattampally, Kannur (Roshnath, 2020).

Genus *Orthetrum* Newman, 1893

Orthetrum is represented by seven species in Kerala out of eight in WG. Except *O. coerulescens anceps* (Schneider, 1845), all other *Orthetrum* of WG are present here. *Orthetrum chrysis* (Selys, 1891) is a common dragonfly frequenting small brooks and submontane streams and breeds in pools and marshes near such habitats (Fraser, 1936). It has been recorded from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Emiliyamma and Radhakrishnan 2014; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015; KS; Sadasivan, 2018), High ranges (Sadasivan, 2018; KS), Lower Periyar (Varghese *et al*., 2014; Emiliyamma, 2005; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscapes of Kadalundi (Emiliyamma, 2014), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and Mangroves of North Kerala (Radhakrishnan *et al*., 2006). *Orthetrum glaucum* (Brauer, 1865) is a common species found throughout the plains and up to 1200 m altitude. It may vary greatly in color with age and vary in size with altitude. It has a small dark amber spot at the base of the wing and a narrow abdomen with a black tip (Fraser, 1936). It has been reported from Coorg – Kannur landscape (Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Emiliyamma and Radhakrishnan, 2014; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015; KS), High ranges (Sadasivan, 2018; KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS) and coastal wetland landscape of Kattampally (Roshnath, 2020). *Orthetrum luzonicum* (Brauer, 1868) is also a very common species in plains and forests at low altitude. The transparent wing base and bluish green eyes help to distinguish it from related species. It has been reported from Coorg–Kannur landscape (Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri – Silent Valley (KS), Palghat Hills (KS), Nelliampathies – Anamalais (Gnanakumar *et al.,* 2012; Emiliyamma and Radhakrishnan, 2014; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), High ranges (Sadasivan, 2018), Lower Periyar (Varghese *et al*., 2014; Emiliyamma, 2005; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; Emiliyamma, 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscapes of Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006). *Orthetrum pruinosum neglectum* (Rambur, 1842) is a widespread dragonfly in the plains found everywhere and rarely found at high altitudes. It breeds in small tanks and pools in river beds and the adult male can be distinguished by its unique violet colored abdomen (Fraser, 1936). It is usually found in company with its congener *O. chrysis.* It

has been recorded throughout the state from Coorg–Kannur landscape (Nair, 2014; Emiliyamma 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Sharma *et al*., 2007; Adarsh *et al*., 2015, Sadasivan, 2018), High range (KS; Sadasivan, 2018), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscape of Kattampally (Roshnath, 2020), Kadalundi (Emiliyamma, 2014) and mangroves of north Kerala (Radhakrishnan *et al*., 2006). *Orthetrum sabina sabina* (Drury, 1770) is the most predaceous of all dragonflies and even feeds on some species showing cannibalism (Fraser, 1936). In flight it may be confused with gomphids due to markings on abdomen but can be distinguished by extraordinary shape of the abdomen. It is widespread everywhere even at high altitudes. It has been reported from Coorg–Kannur landscape (Nair, 2014; Palot and Radhakrishnan, 2015; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Sharma *et al*., 2007; Adarsh *et al*., 2015; KS; Sadasivan, 2018), High Ranges (Sadasivan, 2018; KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Peters 1981; Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscapes of Kadalundi (Emiliyamma, 2014), Chempallikkundu (Palot and Soniya, 2004), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006). *Orthetrum taeniolatum* (Schneider, 1845) is an uncommon species in the dry areas of Kerala and is found especially in north Kerala. It is found in river beds perched on rocks or the sandy foreshores camouflaged with the background (Fraser, 1936). Small size and greyish dorsum of the thorax help to distinguish it from the congeners. It has been reported from Coorg–Kannur landscape (Emiliyamma *et al*., 2007; Palot and Kiran, 2016), Nelliampathies–Anamalais (KS), Chinnar (Sadasivan, 2018), and Agasthyamalais landscape (KS). *Orthetrum triangulare triangulare* (Selys, 1878) (Fig. 4A) is a high altitude species both in WG and Kerala. It has been reported in the high altitudes of Coorg–Kannur landscape (KS), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (KS), Chinnar (KS; Sadasivan, 2018; Sharma *et al*., 2007), High Ranges (Sadasivan, 2018; KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalais landscape (KS).

Genus *Pantala* Hagen, 1861

These are rather large sized robust built ochreous or reddish colored dragonflies with uncolored wings. *Pantala* is represented by a single species *Pantala flavescens* (Fabricius, 1798) in WG and Kerala. According to Anderson (2009), *P. flavescens* (Fig. 4H) shows massive movement as a part of their annual migration across the western Indian Ocean from India to East Africa. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Sharma *et al*., 2007Adarsh *et al*., 2015, Sadasivan, 2018), High Range (Sadasivan, 2018; KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma, 2014; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Peters 1981; Emiliyamma and Radhakrishnan, 2002; KS) and

coastal Wetlands landscape of Kadalundi (Emiliyamma, 2014), Chempallikundu (Palot and Soniya, 2004), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006).

Genus *Paplopleura* Rambur, 1842

Paplopleura is represented by a single species in WG and Kerala. *Paplopleura sexmaculata* (Fabricius, 1787) is a small but robust dragonfly which occurs in large colonies in marshy spots. They usually breed in bamboo jungles and are the smallest dragonfly in Kerala and WG (Fraser, 1936). They mimic hymenopteran insects in appearance and flight. It has been reported from Coorg–Kannur landscape (Emiliyamma 2014; Palot and Radhakrishnan 2015; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; KS), Chinnar (Sharma *et al*., 2007), Lower Periyar (KS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (KS; Emiliyamma, 2014) and Agasthyamalais landscapes (KS).

Genus *Potamarcha* Karsch, 1890

Potamarcha Karsch is represented by a single species both in WG and Kerala. *Potamarcha congener* (Rambur, 1842) is very similar to *Cratilla* with moderate size but never metallic, blackish brown colored marked with yellow but the markings are partly or entirely covered by an overlay of bluish pruinescence (Fraser, 1936). Abdomen varies greatly in color according to age. It is a common insect fond of dry areas and breeds in small weedy ponds and marshes. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Sadasivan, 2018), High Ranges (Sadasivan, 2018; KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetlands landscape of Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020).

Genus *Rhodothemis* Ris, 1909

Rhodothemis is also represented by a single species both in WG and Kerala. The representative member *R. rufa* (Rambur, 1842) is characterized by its large size, homogenous scarlet–red appearance which resembles *Crocothemis servilia*, *Crocothemis erythraea*, *Urothemis signata* and *Orthetrum chrysis*. The very short contiguity of the eyes, the discoidal field beginning with a row of three cells and continuing with a row of two cells, for a distance of 5–7, cells, and the characteristic armature of legs help to distinguish it from other species mentioned above. The female has a citron yellow continuous line from occiput to well on to the abdomen. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005, Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad (Palot and Emiliyamma, 2015; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Emiliyamma and Radhakrishnan 2014; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscape of Kadalundi (Emiliyamma, 2014), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006).

Genus *Rhyothemis* Hagen, 1867

Rhyothemis is represented by two species in WG and Kerala. *Rhyothemis triangularis* Kirby, 1889 (Fig. 3G) is an uncommon dragonfly with an opaque black area limited to the base of the wings. It has been reported from Coorg–Kannur landscape (Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Susanth and Anooj,

2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007), Nelliampathies–Anamalais (KS), Lower Periyar (KS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS) and Agasthyamalais landscapes (KS). *Rhyothemis variegata variegata* (Linnaeus, 1763) is gregarious and usually occurs in large colonies over marshy spots or large weedy tanks. With a weak flight they fly low and wing action is fluttering like that of larger Lepidoptera (Fraser, 1936). It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), High Range (KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS; Jebin. J, per. com.), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS), coastal wetland landscape of Mannar, Kumarakom (Emiliyamma, 2014), Chempallikundu (Palot and Soniya, 2004), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006).

Genus *Sympetrum* Newman, 1833

Sympetrum is represented by two species in WG – *S. fonscolombii* (Selys, 1840) (Fig. 3C) and *S. hypomelas* (Selys, 1884) of which only *S. fonscolombii* is known from Kerala. It is a montane species common above 1800 m in Kerala, known only from higher reaches of Chinnar (Sadasivan, 2018; KS), Anamudi Shola NP, Eravikulam NP (MJP), High Ranges (Sadasivan, 2018; KS), Cardamom Hills (KS; AS; Manoj P, per. com.) and Agasthyamalais landscapes (KS).

Genus *Tetrathemis* Brauer, 1868

Tetrathemis platyptera Selys, 1878 (Fig. 4D) is a small dragonfly with abdomen shorter than wings, found throughout the submontane wet areas (Fraser, 1936). The adults usually lay eggs on objects overhanging water and the newly hatched larvae drop into their future habitat. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Palot and Kiran, 2016), Wayanad (VPN; Palot and Emiliyamma, 2015; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (VPN; KS) and coastal wetland landscape of Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020).

Genus *Tholymis* Hagen, 1867

Tholymis is represented by a single species *T. tillarga* (Fabricius, 1798) both in WG and Kerala and is a crepuscular insect which rests under heavy shade in scrub or bamboo jungle during the day and breeds in marshes and weedy tanks (Fraser, 1936). It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Sharma *et al*., 2007; Adarsh *et al*., 2015), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS), coastal wetland landscape of Chempallikundu (Palot and Soniya, 2004), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006).

Genus *Tramea* Hagen, 1861

Tramea is represented by three species *T. basilaris* (Palisot de Beauvois, 1805), *T. limbata* (Desjardins, 1832), and *T. virginia* (Rambur, 1842) in WG as

well as in Kerala. *Tramea basilaris* is a common insect throughout the plains and may be rarely seen in high altitudes. It may accompany *Pantala* during migration for a shorter distance (Fraser 1936). It has been reported from Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (VPN), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; KS), Chinnar (KS), Lower Periyar (KS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS), and Kattampally of Coastal wetland landscape (Roshnath, 2020). *Tramea limbata* has a very dark, sharply defined basal marking in the hind wing, not surrounded by a golden-yellow areola for distinguishing it from other *Tramea* sp. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2014; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015), Lower Periyar (Varghese *et al*., 2014; Emiliyamma, 2005; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Peters, 1981; Emiliyamma and Radhakrishnan, 2002; KS), coastal wetlands landscape of Kadalundi, Kolavipalam (Emiliyamma, 2014), Chempallikundu (Palot and Soniya, 2004), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006). *Tramea virginia* (Rambur, 1842) has been reported only from Chinnar of Anjanad valley landscape (Sharma *et al*., 2007).

Genus *Trithemis* Brauer, 1868

Trithemis is represented by four species both in WG and Kerala. *Trithemis aurora* (Burmeister, 1839) is a very common dragonfly in forests and country side. The almost general violaceous coloration of males helps to distinguish their males from other congeners. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015, Sadasivan, 2018; KS; Sharma *et al*., 2007), High Range (Sadasivan, 2018; KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma, 2014; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscape of Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020). *Trithemis festiva* (Rambur, 1842) has been reported from Coorg–Kannur landscape (Palot and Kiran, 2016; Nair, 2017), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (KS; Emiliyamma *et al*., 2007), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; KS), Chinnar (Sharma *et al*., 2007; Sadasivan, 2018), High Ranges (Sadasivan, 2018; KS), Lower Periyar (Varghese *et al*., 2014; Emiliyamma, 2005; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS). *Trithemis kirbyi* Selys, 1891, is reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Emiliyamma, 2014; Palot and Kiran, 2016), Palghat Hills (Emiliyamma *et al*., 2007), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Emiliyamma *et al*., 2007; KS), Chinnar (Emiliyamma *et al*., 2007; KS), High Ranges (KS), Lower Periyar (KS), Cardamom Hills (Emiliyamma *et al*., 2007; KS) and Agasthyamalais landscape(KS). *Trithemis pallidinervis* (Kirby, 1889) is a common insect throughout the state, the largest among the genus, and it breeds only in stagnant waters of marshy areas. The adult is usually found perched on top of reeds along with fellow members, all facing the wind, elevating itself by its long spidery legs bunched together like a stalk (Fraser, 1936). Sexes

are alike. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016),Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al*., 2015; Sharma *et al*., 2007), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS), coastal wetland landscape of Kadalundi (Emiliyamma, 2014), Chempallikundu (Palot and Soniya, 2004), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006).

Genus *Urothemis* Brauer, 1868

Urothemis signata (Rambur, 1842) (Fig. 4G) is a moderately large sized red dragonfly with large eyes and broad dark amber colored spots at the base of the hindwing. It is common around marshes, streams, and lakes. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Susanth and Anooj, 2020), Palghat Hills (KS), Nelliampathies–Anamalais (KS), Lower Periyar (Varghese *et al*., 2014; Emiliyamma, 2005; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (KS), Agasthyamalais (KS), coastal Wetland landscape of Kadalundi, Kumarakom (Emiliyamma, 2014), Kuttanad (Raju, 2007), Kattampally (Roshnath, 2020) and mangroves of north Kerala (Radhakrishnan *et al*., 2006).

Genus *Zygonyx* Hagen, 1867

Zygonyx is represented by two species – *Z. iris malabarica* Fraser, 1926 and *Z. torridus isis* Fraser, 1924 in WG and Kerala. *Zygonyx iris malabarica* Fraser, 1926, looks like Corduliidae in general appearance and breeds in swift montane streams (Fraser, 1936). It has been reported from Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; KS), Lower Periyar (Varghese *et al.,* 2014), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), and Agasthyamalais landscapes (KS). *Zygonyx torridus isis* has been reported from Meenmutti Falls area of Aaralam WLS, of Coorg–Kannur landscape in August, 2017 (MJP).

Genus *Zyxomma* Rambur, 1842

Zyxomma petiolatum Rambur, 1842 (Fig. 4F) is a moderate sized slender crepuscular dragonfly (Fraser, 1936). It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016;), Wayanad (Emiliyamma *et al*., 2007; Palot & Emiliyamma, 2015), Nilgiri–Silent Valley (KS), Palghat hills (KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Chinnar (Adarsh *et al.,* 2015; KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS; VPN), and coastal wetlands landscape of Kadalundi (Emiliyamma, 2014), Kuttanad (Raju, 2007) and Kattampally (Roshnath, 2020).

Family Macromiidae Needham, 1903

Large odonates, with swift flight, usually restricted to fast flowing streams of WG and the foot hills. Two genera are found in the region–*Epophthalmia* Burmeister, 1839 and *Macromia* Rambur, 1842. The adult of the former has the cells of the forewings traversed.

Genus *Epophthalmia* Burmeister, 1839

Epophthalmia Burmeister, 1839 is diagnosed from the related genus *Macromia* Rambur, 1842 by the cell in forewing and hindwing in *Macromia* being entire and not traversed by veins, while in *Epophthalmia* the cells in forewing are always traversed. *Epophthalmia vittata vittata* Burmeister, 1839 is a common lowland species of open areas and in general appearance resembles a

well-marked *Macromia flavicincta*. Recently recorded from Varadoor, Kannur (Nair, 2017) Trichambaram, Kannur (VPN), Wayanad (KS), Walayar (Emiliyamma *et al*., 2007), Thrissur (Adarsh *et al*., 2014), Chimmony, Athirapally, Peechi (KS), Meenachil, Kottayam (AS), Thattaekkad (KS), Periyar Tiger Reserve (KS), Achankovil (KS), Trivandrum City and Attingal (KS), Shendurney (KS), Peppara (KS), Neyyar (KS). *Epophthalmia frontalis binocellata* Fraser, 1936, is a rare forest insect distinguished from the previous species by the dark coloration resembling *Macromia ellisoni* and the paired dorsal spots S4–6 instead of annules. The regional records of occurrence are from Aaralam of Coorg–Kannur (MJP), Thamaracherry of Wayanad (Fraser, 1936), Walayar of Palghat Hills (Fraser, 1936), Chimmony and Peechi of Nelliampathies–Anamalais (KS), Thattaekkad, Pooyamkutty of Lower Periyar (KS), Achankovil of Pandalam Hills (KS) and Shendurney WLS of Agasthyamalai landscape (KS).

Genus *Macromia* Rambur, 1842

Macromia is represented by nine species both in Kerala and in WG and are generally rare insects. *Macromia annaimallaiensis* Fraser, 1931 was reported from Anamalai landscape Kallar and Shaliyar (Chaliyar?) rivers in Kerala (Fraser, 1936) and is confined to hills south of Palghat Gap (Fraser, 1936). There are no recent confirmed records of the species. We are including this species based on a sighting at Ponmudi Dam, Munnar (KS). *Macromia bellicosa* Fraser, 1924 (Fig. 6D), was observed at Kannur Ghats, Aaralam, and Thirunelli in Wayanad (KS). Varghese *et al*., 2014, recorded it from Lower Periyar Valley. *Macromia cingulata* Rambur, 1842 (Fig. 6B), is reported from Munnar, Palghat Plains (KS) and Nilambur (Divin Murukesh M, per. com.). *Macromia ellisoni* Fraser, 1924 (Fig. 6A) is not an uncommon species in the Anamalais and Agasthyamalais. The recent records are Pandipathu in Agasthyamalais and Pampadum Shola National Park (KS), Konni Forest Division (Pradeepkumar *et al*., 2014), and Aaralam, Kannur (Palot and Kiran, 2016). *Macromia flavocolorata* Fraser, 1922 (Fig. 6E) is not uncommon in the low to mid-elevations of the state in all landscapes. The historical records are from Cannannore Ghat, Kerala (Fraser 1924) and Anamalai (Fraser, 1936). The recent records are from Thenmalai (KS), Thirunelli in Wayanad (KS), and Mukkali, Silent Valley NP (Biju PB, per. com.). *Macromia ida* Fraser, 1924, is reported from Gudalur, Wayanad–Nilgiris (Malappuram border) (Fraser, 1924), WG both north and south of Palghat gap, up to south Kanara (Subramanian *et al.,* 2018). Thus, they are distributed in Coorg, Nilgiris and Annamalai Landscapes. *Macromia indica* Fraser, 1924 is found in WG north of Palghat gap according to Subramanian *et al.* (2018). Thus, the current distribution is Coorg, Wayanad and Nilgiris Landscapes of WG north of Palghat gap. As there is no recent record from Kerala, this species is included based on Subramanian *et al.* (2018). *Macromia irata* Fraser, 1924 (Fig. 6C) is not an uncommon species in the lower elevations and foot hills of all the landscapes in Kerala; from Vythiri, Malabar, Wayanad, Kerala (Fraser 1931, 1936) and WG above the Palghat gap till Coorg (Subramanian *et al.,* 2018) and Thenmalai (KS). *Macromia flavicincta* Selys, 1874 is included based on a single record from Ponmudi Hills (KS). Except *M. cingulata, M. flavocolorata,* and *M. flavicincta,* all other *Macromia* species are endemic to WG.

Anisoptera Genera, *Incertae Sedis*

The dragonflies belonging to the genera *Idionyx* and *Macromidia* are currently treated as *Incertae Sedis* since their family level affinities are not known (Kalkman *et al*., 2020). These are medium sized, slow flying odonates characterized by their dipping flight and loose gregarious assemblages. Generally they are insects of jungles and foothills. Larvae are washed down in monsoons and adults may eclose in the midlands and plains, only to ascend the streams to reach their breeding grounds. The groups are represented by two genera, *Macromidia* Martin, 1907 and *Idionyx* Hagen, 1867.

Genus *Idionyx* Hagen, 1867

Idionyx are generally montane species seen above 800 m in the state, though the larvae may be washed down to emerge at the foot hills in strong pre–

monsoon rains. There are nine species in Kerala and ten in WG. *Idionyx nilgiriensis* (Fraser, 1918) has not been recorded from Kerala. *Idionyx corona* Fraser, 1921 (Fig. 5A) and *I.c. burliyarensis* (Fig. 5F) are not uncommon in Kerala. The recent records of the species are Thusharagiri (Palot and Emilyamma, 2015), Silent Valley (Subramanian *et al.* 2013), Mathikettan Shola (KS), Neriamangalam (KS), Achankovil (KS), Ponmudi Hills (KS), Shendurney WLS (KS), Peppara WLS (KS). *Idionyx galeata* Fraser, 1924 is an uncommon species recorded from Aaralam (Palot and Kiran, 2016), Kurichiyar Mala, Wayanad (Emiliyamma *et al*., 2007), Achankovil RF (KS), Ponmudi Hills (KS), Shendurney WLS (KS) and Peppara WLS (KS). *Idionyx minima* Fraser, 1931 (Fig. 5E) is relatively rare and records are from Aaralam (KS), Muthanga (Emiliyamma in Subramanian *et al.,* 2013), Rajakkad, Munnar (KS), Mathikettan Shola (KS), Ponmudi Hills (KS), Shendurney WLS (KS) and Peppara WLS (KS). *Idionyx nadganiensis* Fraser, 1924 was described from Nadgani Ghat (Malappuram) in Nilgiri–Wayanad; there are no recent records of the species. *Idionyx periyashola* Fraser, 1939 was described probably from eastern slopes of Munnar High Range; however, there is no other record of the species. *Idionyx nilgiriensis* (Fraser, 1918) is known only from its original description from the Nilgiri Landscape. There are no recent records from Kerala and even from Nilgiris. *Idionyx rhinoceroides* Fraser, 1934 is a rare species with records from Thusharagiri (Palot and Emilyamma, 2015) and Dhoni (Emiliyamma *et al*., 2007). *Idionyx saffronata* Fraser, 1924, is the commonest member of the genus and has been recorded in all major landscapes of Kerala. The localities include Aaralam (Palot and Kiran, 2016), Payyavoor and Kottiyoor (Vibhu V, per. com.), Vannathimala (Emiliyamma *et al*., 2007), Thusharagiri (Palot and Emilyamma, 2015; Emiliyamma *et al*., 2007), Malabar WLS (MJP), Silent Valley (Subramanian *et al*., 2013), Anamalais (Fraser, 1936), Nelliampathies (KS), Thattaekkad (Varghese *et al*., 2014), Periyar Tiger Reserve (KS), Punalur RF (KS), Achankovil (KS), Shendurney WLS (KS), Peppara WLS (KS) and Neyyar WLS (KS). *Idionyx travancorensis* Fraser, 1931 (Fig. 5B), is a common species of mid to high elevations of Anamalais and Agasthyamalais. The regional records are from Thusharagiri (Palot and Emilyamma, 2015), Silent Valley (KS), Munnar (Fraser, 1936), Mathikettan Shola (KS), Thattaekkad (KS), Periyar Tiger Reserve (KS), Punalur RF (KS), Achankovil (KS), Shendurney WLS (KS), Ponmudi Hills (KS) and Peppara WLS (KS). *Idionyx gomantakensis* Subramanian, Rangnekar & Nayak, 2013 recorded from Punalur RF (KS), Shendurney WLS (KS), Ponmudi Hills (KS) and Peppara WLS (KS).

Genus *Macromidia* Martin, 1907

The genus has only one species in Kerala and WG, *M. donaldi donaldi* (Fraser, 1924) (Fig. 5D), which is a relatively uncommon species in foothills up to 800 m. Regional records are Aravanchal sacred grove, Kannur district (MJP), Kasaragod (KS), Thamaracherry (Fraser 1936), Nelliampathies, and Vazhachal (KS), Thattaekkad (Varghese *et al*., 2014), Kadavoor (Jose 2016), Periyar Tiger Reserve (KS), Edamalayar, Pooyamkutty (KS) Achankovil (KS), Shendurney WLS (KS), Ponmudi Hills (KS), Peppara WLS (KS).

Suborder Zygoptera Selys, 1854

Superfamily Lestoidea Calvert, 1901

Family Lestidae Calvert, 1901

Lestidae in Kerala comprises three genera, *Indolestes* Fraser, 1922 (2 species), *Lestes* Leach, 1815 (8 species) and *Platylestes* (Selys, 1862). *Platylestes* has been added to Kerala fauna with a single species *P. platystylus* Rambur, 1842 and its distribution is discussed. Recently, Emiliyamma *et al*. (2020) reported a new species *P. kirani* Emiliyamma, Palot & Charesh, 2020 from the coastal areas of Kannur district.

Genus *Indolestes* Fraser, 1922

Indolestes is represented by two endemic species, *I. gracilis davenporti* (Fraser, 1930) and *I. pulcherrimus* Fraser, 1924 in WG, and both have been reported in Kerala. *Indolestes gracilis*

davenporti (Fig. 8G) has been reported from Wayanad (KS), Nelliampathies–Anamalais (KS), Anjanad Valley (KS), High Ranges (KS; AS), Cardamom hills (KS; MJP) and Pandalam Hills landscapes (Pradeepkumar *et al*., 2014; KS). *Indolestes pulcherrimus* (Fig. 8H) was recently reported by Muneer PK (per. com.) from Wayanad.

Genus *Lestes* Leach, 1815

Lestes comprises eight species in WG and seven species in Kerala. *Lestes dorothea* Fraser, 1924 (Fig. 9A) has been reported for the first time from Kerala by Thumboor and Jose (2018) from Athirapally, Thrissur. It is comparatively larger than *L. praemorsus decipiens* (Fig. 9B), mostly found in company with it and absence of markings on segment 8, 9 and higher postnodal index serve to distinguish it. It has been reported from Coorg–Kannur (VPN), Wayanad (MJP; Manoj.P, per. com.), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Manoj P, per. com.; KS), Lower Periyar (Thumboor and Jose, 2018; KS), Cardamom Hills (KS) and Pandalam Hills landscapes (AS; KS; Manoj P, per. com.). *Lestes elatus* Hagen in Selys, 1862 is the commonest *Lestes* found in WG and Kerala around pools and tanks in monsoon months and hiding in scrub jungles during summer (Fraser, 1933). Its flight is short and when settled, like *L. praemorsus decipiens* and *P. platystylus* and it has the peculiar habit of swaying its abdomen. It can be separated from other *Lestes* by its metallic thoracic stripe with only an upper dilatation. It has been reported from Coorg–Kannur (Palot and Radhakrishnan, 2005; Palot and Kiran, 2016; Nair, 2017; VPN), Wayanad (Emiliyamma *et al*., 2007; MJP), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Palghat plains (Palot *et al.,* 2005), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (Emiliyamma *et al.,* 2007; KS), Pandalam Hills (KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; VPN; KS), and Coastal Wetlands landscape (Roshnath, 2020). *Lestes malabaricus* Fraser, 1929 (Fig. 9F) is a rare in Kerala and WG. Fraser (1933) reported its annual migration northwards to north Malabar just before the south west monsoon. The superior appendages which are bent sharply inwards at the junction of apical and middle thirds at right angles and the shape of metallic humeral stripes help to separate it from the related ones. It has been reported from Coorg–Kannur (Palot and Radhakrishnan, 2005; KS), Palghat (Palot *et al.,* 2005), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; KS) and Agasthyamalai landscapes (KS). *Lestes nodalis* Selys, 1891 was first reported from Kerala by Emiliyamma and Palot (2016 a). The longitudinally bicolorous pterostigma and peculiar anal appendages help to distinguish it. It is restricted to north of Palghat gap. It has been reported from Coorg–Kannur (VPN; Balakrishnan VC, per. com.; MJP), Wayanad (Emiliyamma and Palot, 2016 a), Nilgiri–Silent valley (KS) and Palghat Hills landscapes (KS). *Lestes patricia* Fraser, 1924 is a very rare odonate both in WG and Kerala. It can be separated from other *Lestes* by a single mid-dorsal black band with straight borders. Subramanian *et al.* (2018) mentioned its occurrence in Kerala and is endemic to WG. There are reports of its occurrence in Jammu and Kashmir and Pakistan which has to be confirmed (Kalkman *et al.,* 2020). *Lestes praemorsus decipiens* Kirby, 1893 has been reported from Coorg – Kannur (Nair, 2014; Palot and Kiran, 2016), Wayanad (VPN; Palot and Emiliyamma, 2015; Susanth and Anooj, 2020), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS; VPN) and Coastal wetland landscapes (KS; Raju, 2007) as well as the temporary pools of midland hillocks of Kannur and Kasaragod districts (MJP). *Lestes concinnus* Hagen in Selys, 1862, has been synonymized with *L. umbrinus* Selys, 1891 and *L. thoracicus* Laidlaw, 1920 (Kalkman *et al.*, 2020). It has been reported from Palakkad Hills (KS), Nelliampathies–Anamalais (KS), Lower Periyar (KS), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalais landscapes (KS; VPN; AS). *Lestes viridulus* Rambur, 1842, has been reported from WG but not yet from Kerala.

Genus *Platylestes* Selys, 1862

Platylestes is represented by two species in WG and Kerala. *Platylestes platystylus* Rambur, 1842 (Fig. 9C), a beautiful insect with green eyes and characteristic anal appendages, is found near paddy fields and ponds. Its flight period is April - August and is reported from Coorg–Kannur (VPN; MJP; Balakrishnan VC, per. com.), Nilgiri–Silent Valley (VPN), Palghat Hills (KS), Nelliampathies–Anamalais (AS; KS), Lower Periyar (KS), Cardamom Hills (KS), Pandalam Hills (KS) and in midland hills of northern Kerala (MJP). *Platylestes kirani* Emiliyamma, Palot & Charesh, 2020 has been recently described from the coastal wetlands of Kannur district (Emiliyamma *et al.,* 2020). It is very similar to *P. platystylus* and can be distinguished from the latter by the broad black marking on the synthorax and the blunt and round apex of the superior anal appendages (Fig. 9D). Flight period is August to November and is commonly found near paddy fields, ponds and mangrove swamps in Kannur district. It has been reported from Coorg–Kannur (VPN), Nelliampathies–Anamalais (AS) and Coastal wetland landscapes (Emiliyamma *et al.,* 2020). It has been recorded by VPN from Varadoor, Kannur district in 2018.

Superfamily Platystictoidea Kennedy, 1920

Family Platystictidae Kirby, 1890

Family Platystictidae includes two genera–*Indosticta* (1 species) and *Protosticta* (12 species) in WG and Kerala (12 species) and all are WG endemics.

Genus *Indosticta* Bedjanič, 2016

Indosticta deccanensis Laidlaw, 1915 (Fig. 10B), a medium sized saffron damsel with turquoise blue terminal abdominal segments, is a rare damsel in WG and Kerala found in streams with dense riparian vegetation and the unique blue spot of the tail is distinct from its dark surroundings (Subramanian, 2009). It is a WG endemic species considered vulnerable as per IUCN. *Indosticta* is a monotypic genus with *I. deccanensis* represented in WG and Kerala and is an uncommon species distributed in all the landscapes of Kerala below 900 m elevation. It is the sole representative of *Indosticta* Bedjanič, 2016, in the region. The site records are Aaralam of Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (KS) of Wayanad landscape, Silent Valley (KS) of Nilgiri–Silent Valley landscape, Chimmony (Gnanakumar *et al.,* 2012), Athirapally and Peechi (KS) of Nelliampathies–Anamalais landscape, Thattaekkad (Varghese *et al*., 2014) and Pooyamkutty (KS) of Lower Periyar landscape, Periyar Tiger Reserve (KS), Idukki (KS) and Kattappana (KS) of Cardamom Hills landscape, Konni (Pradeepkumar *et al*., 2014) and Achankovil (KS) of Pandalam Hills landscape, Rockwood in Shendurney WLS, Ponmudi–Kallar valley (KS), Peppara and Neyyar (KS) of Agasthyamalais landscape.

Genus *Protosticta* Selys, 1885

Protosticta Selys, 1885, consists of zygopterous damselflies of small size and slender built commonly called Reed–tails or Shadow–damsels, inhabiting hill streams of tropical, subtropical and temperate jungles of Indian subcontinent and south-east Asia. In India, they are distributed in the WG and in the north–eastern region towards Burma (Fraser, 1933). The genus was described from Sulawesi (Celbes) in Indonesia, with *P. simplicinervis* Selys as the type species. Genus *Protosticta* has 49 extant species (Paulson *et al.,* 2021), distributed from Pakistan through Indian subcontinent to Indo–China and south-east Asian Islands (van Tol, 2000). There are 15 species of *Protosticta* in the Indian region and 12 in WG of Peninsular India of which 11 are found in Kerala. These are *P. gravelyi* Laidlaw, 1915 (Fig. 10D); *P. hearseyi* Fraser, 1922; *P. sanguinostigma* Fraser, 1922; *P. antelopoides* Fraser, 1924; *P. mortoni* Fraser, 1924 (Fig. 10F); *P. davenporti* Fraser, 1931; *P. rufostigma* Kimmins, 1958 (Fig. 10E); *P. ponmudiensis* Kiran, Kalesh & Kunte, 2015; *P. monticola* Emiliyamma & Palot, 2016; *P. cyanofemora* Joshi, Subramanian, Babu & Kunte, 2020; and *P. sholai*, Subramanian & Babu 2020. *Protosticta myristicaensis* Joshi & Kunte, 2020 was reported only from its type locality in Karnataka (WG). van

Tol (2000) commented that *P. mortoni* Fraser, 1924 may be a synonym of *P. gravelyi* Laidlaw, 1915. Subsequently, Subramanian *et al.* (2018) did not include it in the WG list. However, later Joshi *et al.* (2020) reinstated *P. mortoni* Fraser, 1924. *Protosticta antelopoides* Fraser, 1931 is a rare species with very few records. The reports from Kerala are Thusharagiri (Palot and Emilyamma, 2015) and Malabar WLS (MJP) of Wayanad landscape and Munnar (Fraser, 1933) of High Range Landscape. *Protosticta cyanofemora* Joshi, Subramanian, Babu & Kunte, 2020 was recently described from Pandimotta in Shendurney WLS (Agasthyamalais landscape). KS has photographed the species from KMTR and it was also sighted at Peppara WLS (Agasthyamalais landscape). *Protosticta davenporti* Fraser, 1931 is restricted to the Anamalai Hills and the type locality is Anamalais and Mudis Hills, Tamil Nadu 3000 – 4000 ft (Fraser, 1931, 1933); Munnar (Fraser, 1933). The specific records are from Mathikettan shola NP (KS) of High Range landscape. *Protosticta gravelyi* Laidlaw, 1915 is a common damselfly distributed throughout the lower foothills of WG of Kerala. Regional records are Aaralam (Palot and Kiran, 2016), Vythiri, Wayanad (Fraser, 1931), Thusharagiri (Palot and Emiliyamma, 2015), Malabar WLS (MJP), Silent Valley (KS), Nilambur (Fraser 1933), Chimmony and Peechi (KS), Chinnar (Adarsh *et al*., 2015), Marayur (KS), Munnar (KS), Thattaekkad (Varghese *et al*., 2014), Periyar Tiger Reserve (KS), Konni (Pradeepkumar *et al*., 2014), Achankovil (KS), Shendurney WLS, Ponmudi(KS), Peppara and Neyyar (KS). The species was also recorded from the wetland habitats of sacred groves in midland hills of Kannur and Kasaragod districts (MJP). *Protosticta stevensi* was described from Coonoor–Mettupalayam by Fraser in 1922, differing from *P. gravelyi* in the abdominal segment 8 being entirely black in *P. gravelyi*, while basal one-third to half is bluish white in *P. stevensi*. Later, this taxon was recognized as a variant of *P. gravelyi* and hence synonymized with *P. gravelyi* by Fraser (1931) after his personal examination of the types in Selys collections. *Protosticta hearseyi* Fraser, 1922 is an uncommon species and the type locality was Gudalur, Nilgiris, Tamil Nadu 4500 ft, collected in June (Fraser, 1922), other historical records are Ouchterlony Valley in Nilgiris and Mudis in Anamalais 3000 ft (Fraser, 1931). The species has been reported from Aaralam (Palot and Kiran, 2016) and New Amarambalam region by Fraser (1933) and later by Emiliyamma (2014). *Protosticta sanguinostigma* Fraser, 1922 (Fig. 10H) is a common species seen from 200–1200 m. The locality records from Kerala are Aaralam (Palot and Kiran, 2016), Thusharagiri (Palot and Emilyamma, 2015), Vythiri (Fraser 1933), Malabar WLS (MJP), Nilambur (Fraser 1931), Silent Valley (KS), Dhoni (Fraser 1924), Mankulam and Kallar (KS), Thattaekkad (Varghese *et al.,* 2014), Neriamangalam (KS), Achankovil (KS), Rockwood in Shendurney WLS, Ponmudi (KS), Bonaccord, Peppara and Neyyar (KS). *Protosticta monticola* Emiliyamma & Palot, 2016 is a rare and local montane shola species recorded only from the High Ranges of Munnar. The type locality is Kambilipparachola and Nagamalachola of Marayur forest division and Mathikettan Shola National Park in Idukki District, Annamalai Hills, Kerala State, India (Emiliyamma and Palot, 2016 b). Recent records are from montane forests of Bhadrakali Shola in Eravikulam National Park, and Chinna–Poovar, in higher reaches of Chinnar Wildlife Sanctuary in Kerala (KS). *Protosticta mortonii* Fraser, 1924 is a species that was described from Sampaje Ghat in Coorg, Karnataka, by Fraser. The regional records are Wayanad (Emiliyamma, 2014) and Aaralam WLS (MJP). *Protosticta ponmudiensis* Kiran, Kalesh & Kunte, 2015 is a rare and local species (Fig. 10G) described from Ponmudi hills in Agasthyamalais. The species has not been found outside its type locality in Ponmudi–Kallar valley in Trivandrum. *Protosticta rufostigma* Kimmins, 1958 was not known from Kerala or Western Ghats after its initial description. In 2006, the species was photographed from Malabar WLS (KS & MJP); Bonaccord Estate, 800 m, 2006 January, April 2012; May–June 2013 in Ponmudi, 900 m, in Trivandrum; Pandimotta in Shendurney 900 m, May 2017 in Kollam and Kakkayam in Malabar Wildlife Sanctuary January 2013. The recently described species, *P. sholai* Subramanian & Babu, 2020, was recorded from Manalar, in Periyar Tiger Reserve (KS).

Superfamily Calopterygoidea Selys, 1850

Family Calopterygidae Selys, 1850

Calopterygoidea includes three families, Calopterygidae Selys, 1850, Chlorocyphidae Cowley, 1937 and Euphaeidae Yakobson & Bainchi, 1905. These are large iridescent colored damselflies with broad head, conspicuous round eyes and broad rounded hindwing. Calopterygidae comprises two genera and four species both in WG and Kerala.

Genus *Neurobasis* Selys, 1853

Neurobasis in WG and Kerala is represented by *Neurobasis chinensis* (Linnaeus, 1758) and is a widespread species in most of Asia, found from sea level up to 7500 ft, but common at 3000–4000 ft (Fraser, 1934). It is a riverine insect and breeds in montane and submontane streams and is reported from Coorg – Kannur landscape (Nair, 2014; Emiliyamma, 2014; Palot and Kiran, 2016), Wayanad landscape (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007; KS), Palakkad Hills (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,*2012; KS), Anjanad Valley (Adarsh *et al*., 2015), High Ranges (Sadasivan, 2018; KS), Lower Periyar (Emiliyamma *et al*., 2007; Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS) Pandalam Hills (Pradeepkumar *et al*., 2014; KS) and Agasthyamalais landscape (KS).

Genus *Vestalis* Selys, 1853

It is a gregarious insect breeding in montane and submontane streams. In forests, large colonies are found inhabiting the rides of open spaces and along shaded pathways and almost every twig would be found occupied by it (Fraser, 1934). Females generally oviposit on blades of grass or juicy stems overhanging the streams, several feet above the water surface, larvae drop down into streams later. Genus *Vestalis* includes three species in WG and Kerala. *Vestalis apicalis* Selys, 1873 is a large damsel having metallic green thorax with long, less iridescent green and more coppery abdomen with wing tips blackish brown. It has the apex of all wings broadly tipped to blackish brown about 5 mm and cheeks bright yellow. Commonly found along hill streams, large numbers can be found resting among bushes in forest paths in association with its congener *V. gracilis* (Subramanian, 2009). It has been reported from Coorg–Kannur landscape (Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad landscape (VPN; Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007; KS), Palghat hills (Emiliyamma *et al*., 2007; KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Anjanad Valley (Adarsh *et al*., 2015), High ranges (KS), Lower Periyar (KS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; Emiliyamma, 2014; KS), Agasthyamalai landscape (Emiliyamma and Radhakrishnan, 2002; KS), and coastal wetlands landscape (Raju, 2007; Roshnath, 2020). *Vestalis gracilis* (Rambur, 1842) shares the habitat of *V. apicalis,* and *V. gracilis* can be separated by its clear wing tips. *V. gracilis* has been reported from Coorg – Kannur landscape (Palot and Radhakrishnan, 2005; Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad landscape (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley landscape (KS), Palghat Hills (KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Anjanad Valley (Adarsh *et al*., 2015), High Range (KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; Emiliyamma, 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetlands landscapes (Raju, 2007; Roshnath, 2020). *Vestalis submontana* Fraser, 1934 was described by Fraser (1934) as *V. gracilis submontana,* however, Hamalainen (2011) recognized it as a distinct species and upgraded its status to *V. submontana* Fraser, 1934 (Fig. 7A). It is an Indian endemic species and a high altitude species found only above 800 m. It can be distinguished from *V. apicalis* by the glossy black genae; much restricted black apex

of wing and peculiar shape of anal appendages. It has been reported from Coorg–Kannur landscape (Emiliyamma, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP), Nilgiri–Silent Valley landscape (Emiliyamma *et al*., 2007; KS), Palghat Hills (Emiliyamma *et al*., 2007), Nelliampathies – Anamalais (Emiliyamma and Radhakrishnan, 2000; KS), Anjanad Valley (KS), High Ranges (KS), Lower Periyar (Emiliyamma, 2005), Cardamom Hills (KS) and Agasthyamalais landscape (Emiliyamma and Radhakrishnan, 2002; KS).

Family Chlorocyphidae Cowley, 1937

These are small damselflies with large bulb-like eyes, protruding face, short and stout thorax, iridescent male wings, transparent female wings and cylindrical abdomen shorter than hindwings (Subramanian, 2009). Three genera *viz., Calocypha* Fraser, 1928, *Heliocypha* Fraser, 1949 and *Libellago* Selys, 1840 are found with single species each, both in WG and Kerala.

Genus *Calocypha* Fraser, 1928

Calocypha Fraser is represented by *Calocypha laidlawi* (Fraser, 1924) in WG and Kerala and is endemic to WG. It is an azure blue and black damsel with vermilion marks on the thorax and forehead (Fig. 7B). The damsel is closely associated with Myristica swamps of WG and breeds in the streams of the swamps (Subramanian, 2009). It is commonly found along with *Heliocypha bisignata* in streams. Rarely it is seen associated with the streams of swamps in other areas. It has been reported from Wayanad landscape (Fraser, 1934), Nelliampathies –Anamalais (KS; Thumboor, 2018), High Ranges (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom hills (KS), Pandalam Hills (KS) and Agasthyamalai landscape (KS).

Genus *Heliocypha* Fraser, 1949

Heliocypha Fraser is represented by *Heliocypha bisgnata* (Hagen in Selys, 1853) both in WG and Kerala and it is endemic to India. It is a small black and red damsel with red iridescent streaks on wings. It is widespread in hill streams where it breeds (Subramanian, 2009). It is also found associated with streams of wooded country. It has been reported from Coorg–Kannur landscape (Palot and Kiran, 2016; Nair, 2017), Wayanad (Emiliyamma *et al*., 2007; MJP; Palot and Emiliyamma 2015, Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007; KS), Palghat Hills (Emiliyamma *et al*., 2007), Nelliampathies – Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; KS), Anjanad Valley (Adarsh *et al*., 2015), High Range (KS), Lower Periyar (Emiliyamma, 2005; AS; Varghese *et al*., 2014), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; Emiliyamma, 2014; KS) and Agasthyamalai landscape (Emiliyamma and Radhakrishnan, 2002; KS).

Genus *Libellago* Selys, 1840

Libellago Selys is represented by *Libellago indica* (Fraser, 1928) both in WG and Kerala and is endemic to WG. It is a small black and yellow damsel with black–tipped transparent wing and is confined to hill streams and rivers of forested landscapes (Subramanian, 2009) and is a common damsel in the streams of wooded country. It has been reported from Coorg–Kannur landscape (Emiliyamma *et al*., 2007; Palot and Kiran, 2016; Nair, 2017), Wayanad (Palot and Emiliyamma 2015, Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Anjanad Valley (Adarsh *et al*., 2015), High ranges (Sadasivan, 2018), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalai (KS) and coastal wetland landscapes (Raju, 2007).

Family Euphaeidae Yakobson & Bainchi, 1905

Euphaeidae is represented by the genera *Dysphaea* Selys, 1853 (one species) and *Euphaea* Selys, 1840 (three species) both in WG and Kerala. Bhakare *et al.* (2021) recently described two new species, *Euphaea pseudodispar* Sadasivan & Bhakare, 2021 and *Euphaea thosegharensis* Sadasivan & Bhakare, 2021 from northern WG.

Genus *Dysphaea* Selys, 1853

Dysphaea is represented by a single species, *D. ethela* Fraser, 1924 and is endemic to India. It is a large black damsel with amber colored wings (Fig. 8C) and is found in torrential hill streams from 50-–1000 m a.s.l. It is rare and usually sits in the middle of streams on boulders or emergent twigs (Subramanian, 2009). It is found in Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Adarsh *et al*., 2014; KS), Anjanad Valley (Adarsh *et al*., 2015, KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (AS; KS) and Agasthyamalai landscape (AS).

Genus *Euphaea* Selys, 1840

Euphaea is represented by three species both in WG and Kerala and all are endemic to WG. Recent additions are *E. pseudodispar* and *E. thosegharensis* from Maharashtra. *Euphaea cardinalis* (Fraser, 1924) is a large bright ochre and black damsel (Fig. 8D) with half of the underside of the hindwings iridiscent blue. It is found perched on boulders and riparian vegetation of second-order streams (Subramanian, 2009). It is a montane species generally found above 900 m though occasionally reported from foothills after monsoons and restricted to south of Palakkad gap. It has been reported from Nelliampathies–Anamalais (KS), High ranges (KS), Cardamom Hills (KS; Emiliyamma *et al*., 2007) and Agasthyamalais landscape (KS). *Euphaea dispar* (Rambur, 1842) (Fig. 8E) is a montane species found in streams of evergreen forests North of Palakkad gap from 700 to 1828 m and rarely much below after rains. It has been reported from Coorg–Kannur (Palot and Kiran, 2016), Wayanad (Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS) and Palghat hills landscape (KS; VPN). *Euphaea fraseri* (Laidlaw, 1920) (Fig. 8F) is common in hill streams from about 50–1000 m and males have a habit of displaying iridescent copper markings on the upper hindwing (Subramanian, 2009). It can be seen up to 2000 m in forests and is common in the streams of sacred groves and wooded country. It is found in Coorg–Kannur landscape (Nair, 2017; VPN; Palot and Kiran, 2016), Wayanad (Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (KS), Anjanad Valley (KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS) and Agasthyamalai landscape (KS). It has been rarely recorded from streams in lowland sacred groves in northern Kerala (MJP).

Family Platycnemididae Yakobson & Bainchi, 1905

Platycnemididae includes 10 genera, *Caconeura* Kirby, 1890, *Copera* Kirby, 1890, *Disparoneura* Selys, 1860, *Elattoneura* Cowley, 1935, *Esme* Fraser, 1922, *Melanoneura* Fraser, 1922, *Onychargia* Selys, 1865, *Phylloneura* Fraser, 1922, *Prodasineura* Cowley, 1934 and *Pseudocopera* Fraser, 1922 in WG, and all except *Pseudocopera,* found in Kerala.

Genus *Caconeura* Kirby, 1890

Caconeura includes four species in WG and three in Kerala. Except *C. t–coerulea,* the other three are found in Kerala. In *Caconeura,* anal bridge is incomplete curving down to meet the posterior margin of the wing. *Caconeura gomphoides* (Rambur, 1842) is a very rare odonate in Kerala. It has been included in this account as per the reports of Kiran and Raju (2013). According to them it is found in North Kerala. It is endemic to WG and no recent records are available. *Caconeura ramburi* (Fraser, 1922) is usually found perched on riparian vegetation along shaded streams (Subramanian, 2009). It is an Indian endemic. It has been reported from Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (MJP; Palot and Emiliyamma, 2015), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS) and Agasthyamalai landscape (AS). *Caconeura risi* (Fraser, 1931) is endemic to WG. It is a medium sized azure blue and black damsel (Fig. 9G) usually found perched on riparian vegetation (Subramanian, 2009). It is found at Coorg–Kannur landscape

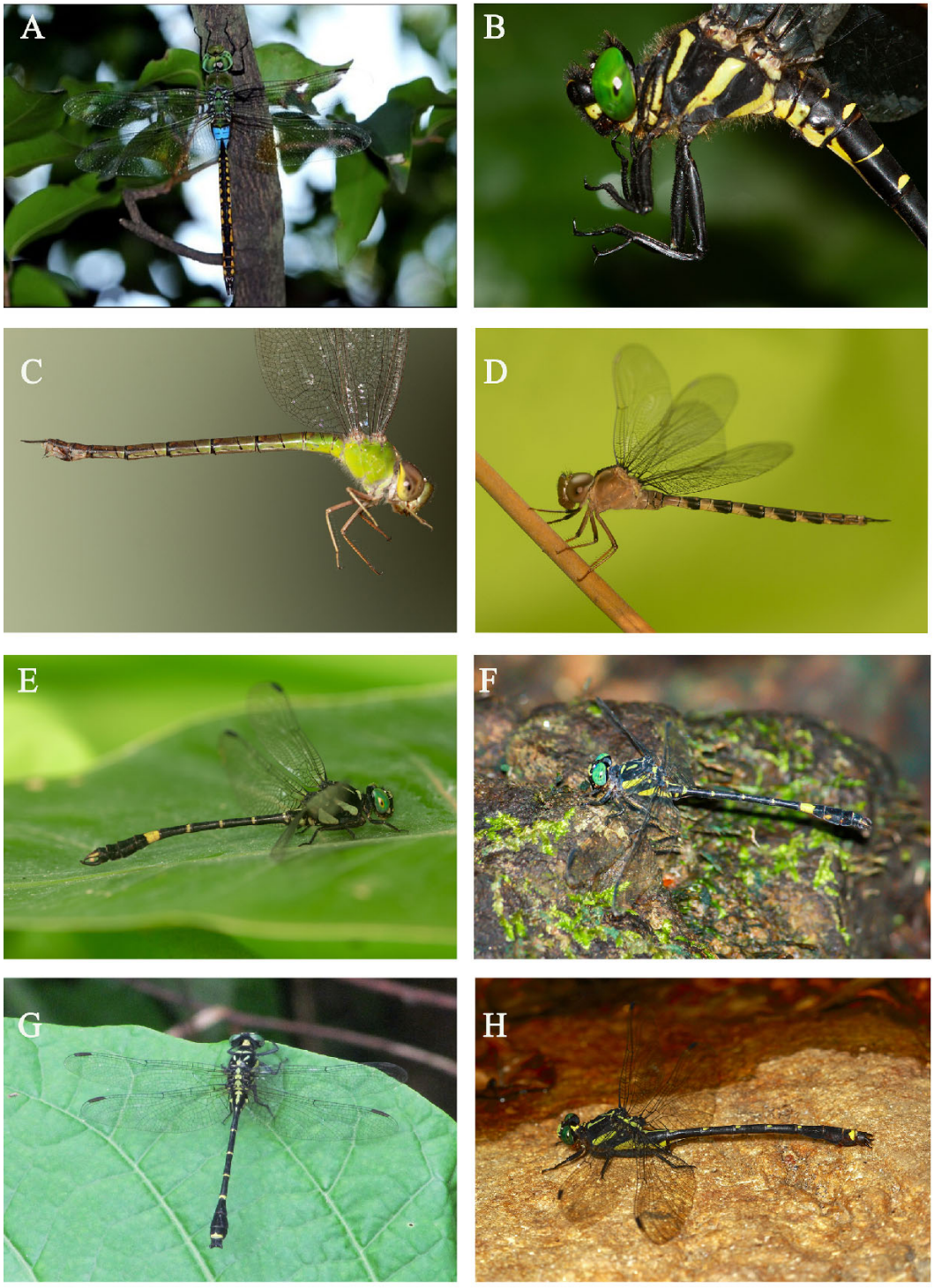

Fig. 1 A – *Anax indicus* Lieftinck,1942 © Suhas RK; B – *Chlorogomphus xanthoptera* (Fraser, 1919) © Kalesh Sadasivan; C – *Gynacantha millardi* Fraser,1920 © Kalesh Sadasivan; D – *Gynacantha dravida* Lieftinck,1960 © Kalesh Sadasivan; E – *Melligomphus acinaces* Laidlaw, 1922) © Kalesh Sadasivan; F – *Acrogomphus fraseri* Laidlaw, 1925 © Toms Augustine; G – *Burmagomphus laidlawi* Fraser, 1924 © Kalesh Sadasivan; H – *Asiagomphus nilgiricus* Laidlaw, 1922 © Kalesh Sadasivan

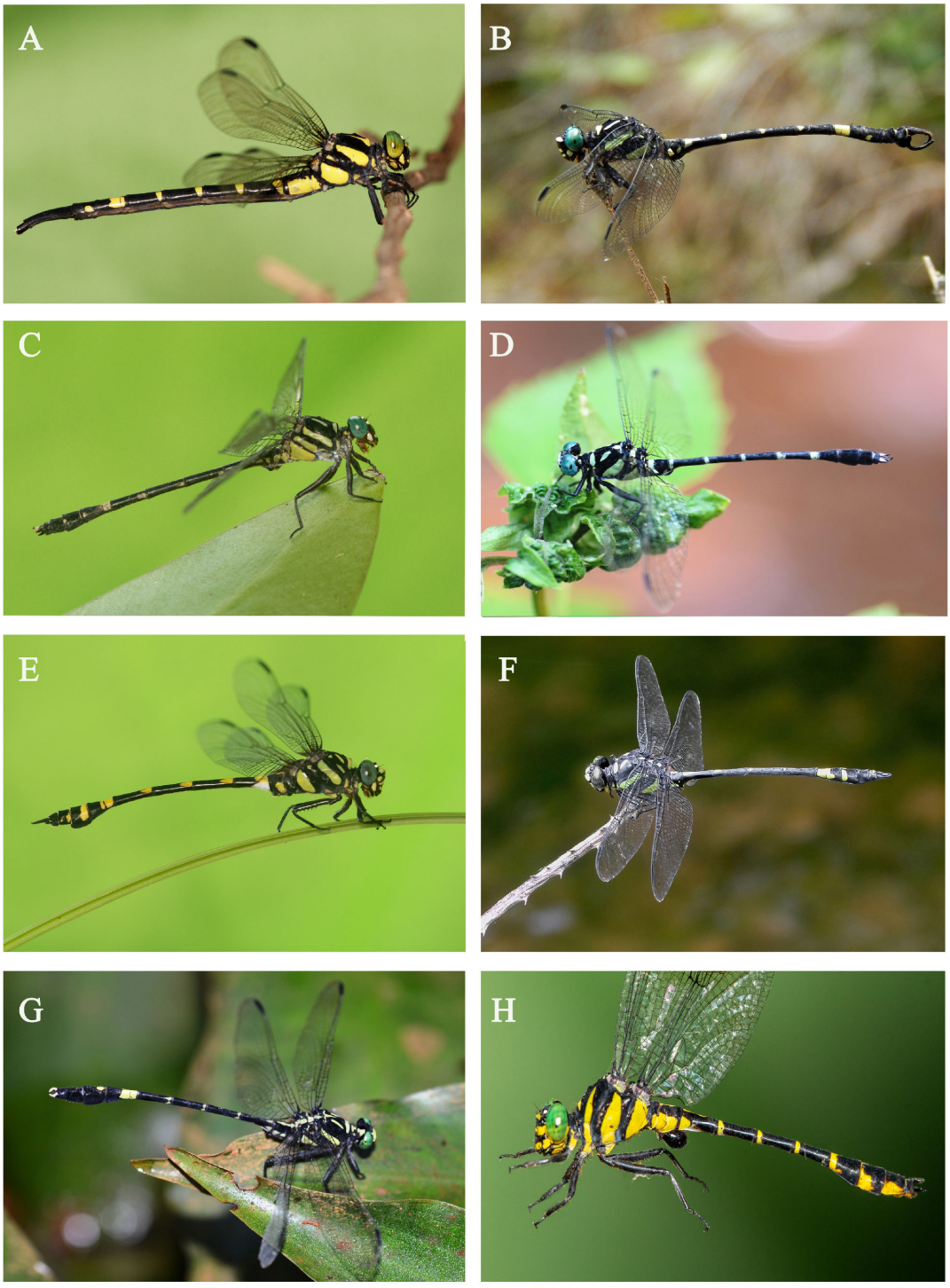

Fig. 2 A – *Macrogomphus wynaadicus* Fraser, 1924 © Kalesh Sadasivan; B – *Lamelligomphus nilgiriensis* (Fraser, 1922*)* © Sharan V; C – *Heliogomphus promelas* (Selys, 1873) © Kalesh Sadasivan; D – *Microgomphus souteri* Fraser, 1924 © Vinayan P Nair; E – *Ictinogomphus rapax* (Rambur, 1842) © Kalesh Sadasivan; F – *Gomphidia kodaguensis* Fraser, 1923 © Kalesh Sadasivan; G – *Merogomphus tamaracherriensis* Fraser, 1931 © Vinayan P Nair; H – *Cyclogomphus flavoannulatus* Rangnekar, Dharwadkar, Kalesh & Subramanian, 2019 © Kalesh Sadasivan

Fig. 3 A – *Crocothemis erythraea* (Brulle´, 1832) © Kalesh Sadasivan; B – *Indothemis limbata sita* Campion, 1923 © Munner PK; C – *Sympetrum fonscolombi* (Selys, 1840) © Abraham Samuel; D – *Indothemis* carnatica (Fabricius, 1798) © Abraham Samuel; E – *Lyriothemis acigastra* (Selys, 1878) © Vinayan P Nair; F – *Lyriothemis tricolor* Ris, 1919 © Kalesh Sadasivan; G – *Rhyothemis triangularis* Kirby, 1889 © Vinayan P Nair; H – *Epithemis mariae* (Laidlaw, 1915) © Kalesh Sadasivan

Fig. 4 A – *Orthetrum triangulare triangulare* (Selys, 1878) © Kalesh Sadasivan; B – *Onychothemis testacea ceylanica* Ris, 1912 © Vinayan P Nair; C – *Cratilla lineata calverti* (Forster, 1903) © Kalesh Sadasivan; D – *Tetrathemis platyptera* Selys, 1878 © Kalesh Sadasivan; E – *Hylaeothemis apicalis* Fraser, 1924 © Kalesh Sadsivan; F – *Zyxomma petiolatum* Rambur, 1842 © Kalesh Sadasivan; G – *Urothemis signata* (Rambur, 1842) © Abraham Samuel; H – *Pantala flavescens* (Fabricius, 1798) © Abraham Samuel

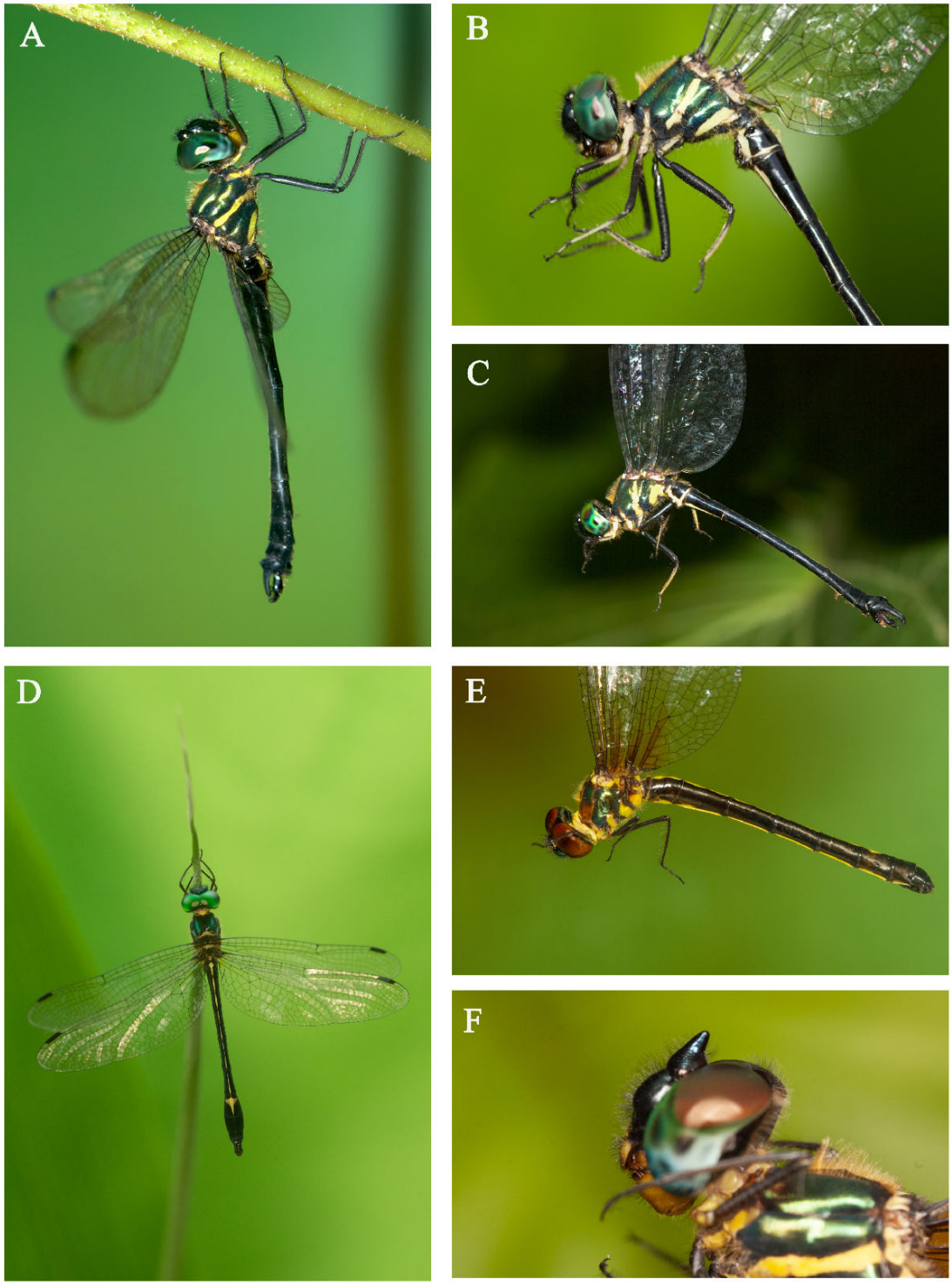

Fig. 5: A – *Idionyx corona* Fraser, 1921 © Kalesh Sadasivan; B – *Idionyx travancorensis* Fraser, 1931 © Kalesh Sadasivan; C – *Idionyx saffronata* Fraser, 1924 © Kalesh Sadasivan; D – *Macromidia donaldi donaldi* (Fraser, 1924) © Kalesh Sadasivan; E – *Idionyx minima* Fraser, 1931 © Kalesh Sadasivan; F – *Idionyx corona burliyarensis* Fraser, 1924 © Kalesh Sadasivan

Fig. 6: A – *Macromia ellisoni* Fraser, 1924© Kalesh Sadasivan; B – *Macromia cingulata* Rambur, 1842 © Kalesh Sadasivan; C – *Macromia irata* Fraser, 1924 © Kalesh Sadasivan; D – *Macromia bellicosa* Fraser, 1924 © Daniel VR; E – *Macromia flavocolorata* Fraser, 1922 © Biju PB

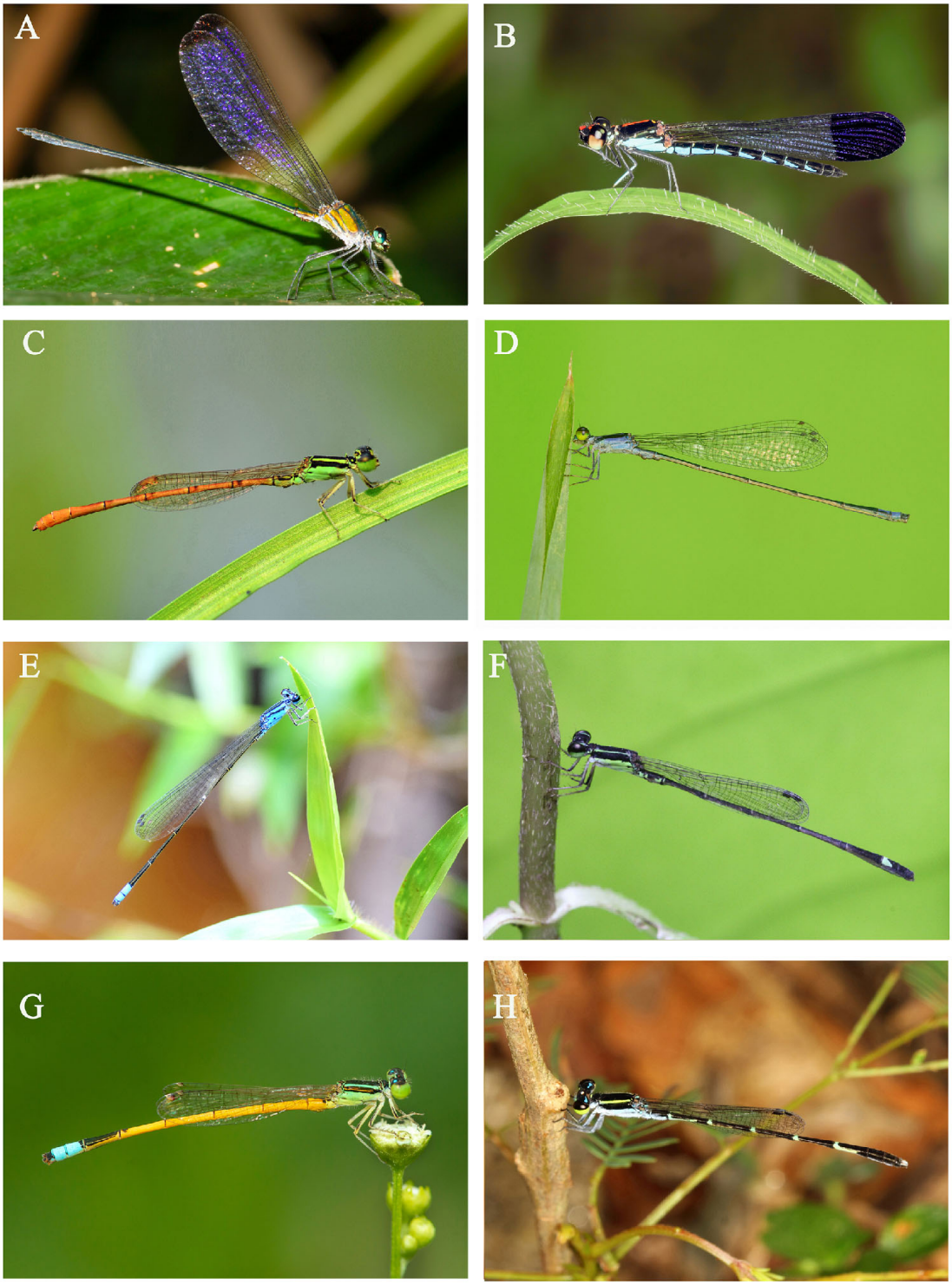

Fig. 7 A – *Vestalis submontana* Fraser, 1934 © Kalesh Sadasivan; B – *Calocypha laidlawi* (Fraser, 1924) © Baiju K; C – *Agriocnemis keralensis* Peters, 1981 © Vinayan P Nair; D – *Aciagrion approximans krishna* Fraser, 1921 © Kalesh Sadasivan; E – *Archibasis oscillans* (Selys, 1877) © Vinayan P Nair; F – *Mortanagrion varralli* Fraser, 1920 © Abraham Samuel; G – *Ischnura rubilio* Selys, 1876 © Kalesh Sadasivan; H – *Agriocnemis splendidissima* Laidlaw, 1919 © Baiju K

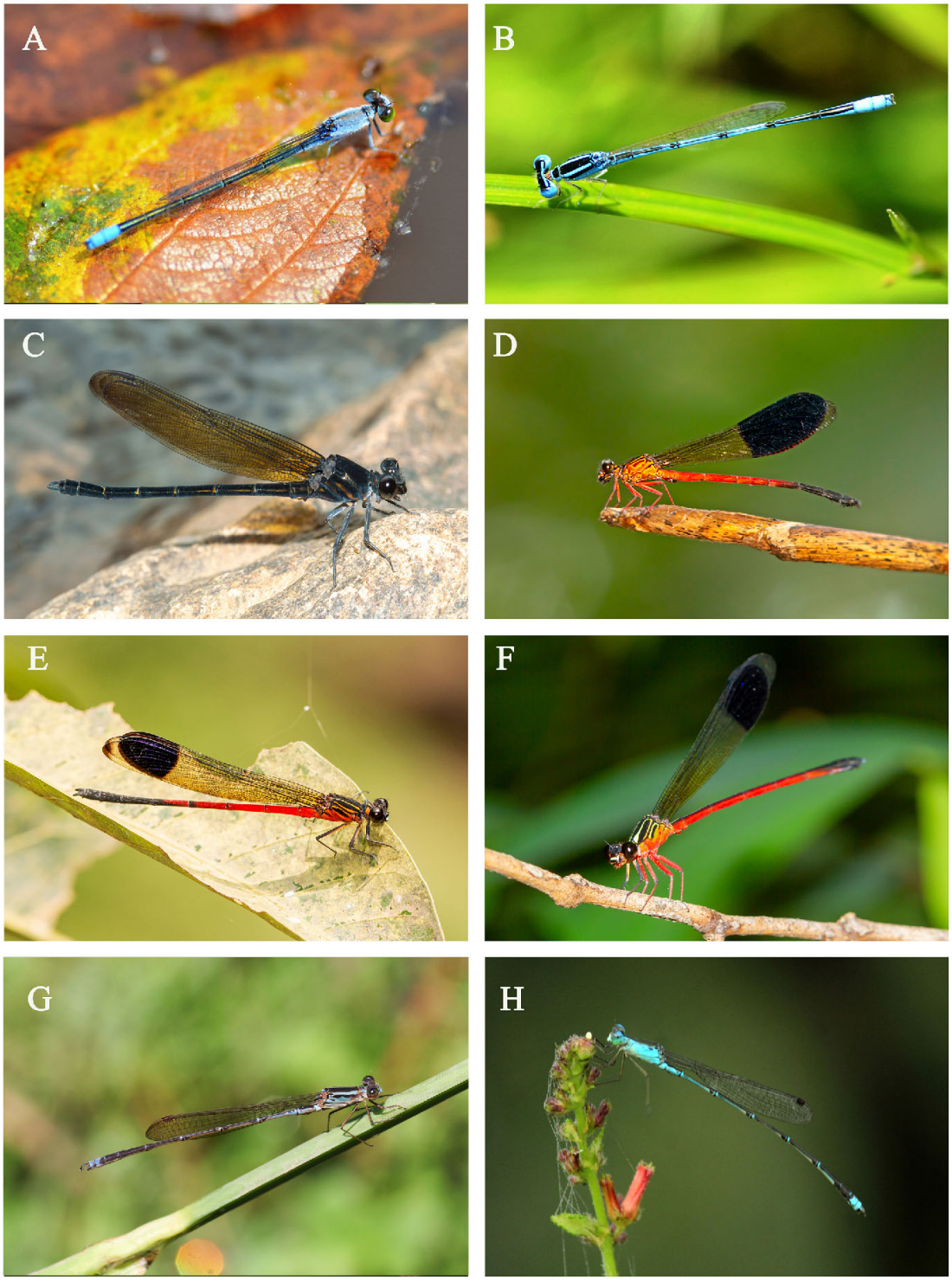

Fig. 8 A – *Paracercion calamorum* (Ris, 1916) © Vinayan P Nair; B – *Amphiallagma parvum* (Selys, 1876) © Vinayan P Nair; C – *Dysphaea ethela* Fraser, 1924 © Sunny Joseph; D – *Euphaea cardinalis* (Fraser, 1924) © Kalesh Sadasivan; E – *Euphaea dispar* (Rambur, 1842) © Kalesh Sadasivan; F – *Euphaea fraseri* (Laidlaw,1920) © Kalesh Sadasivan; G – *Indolestes gracilis davenporti* Fraser, 1930 © Abraham Samuel; H – *Indolestes pulcherrimus* © Muneer PK

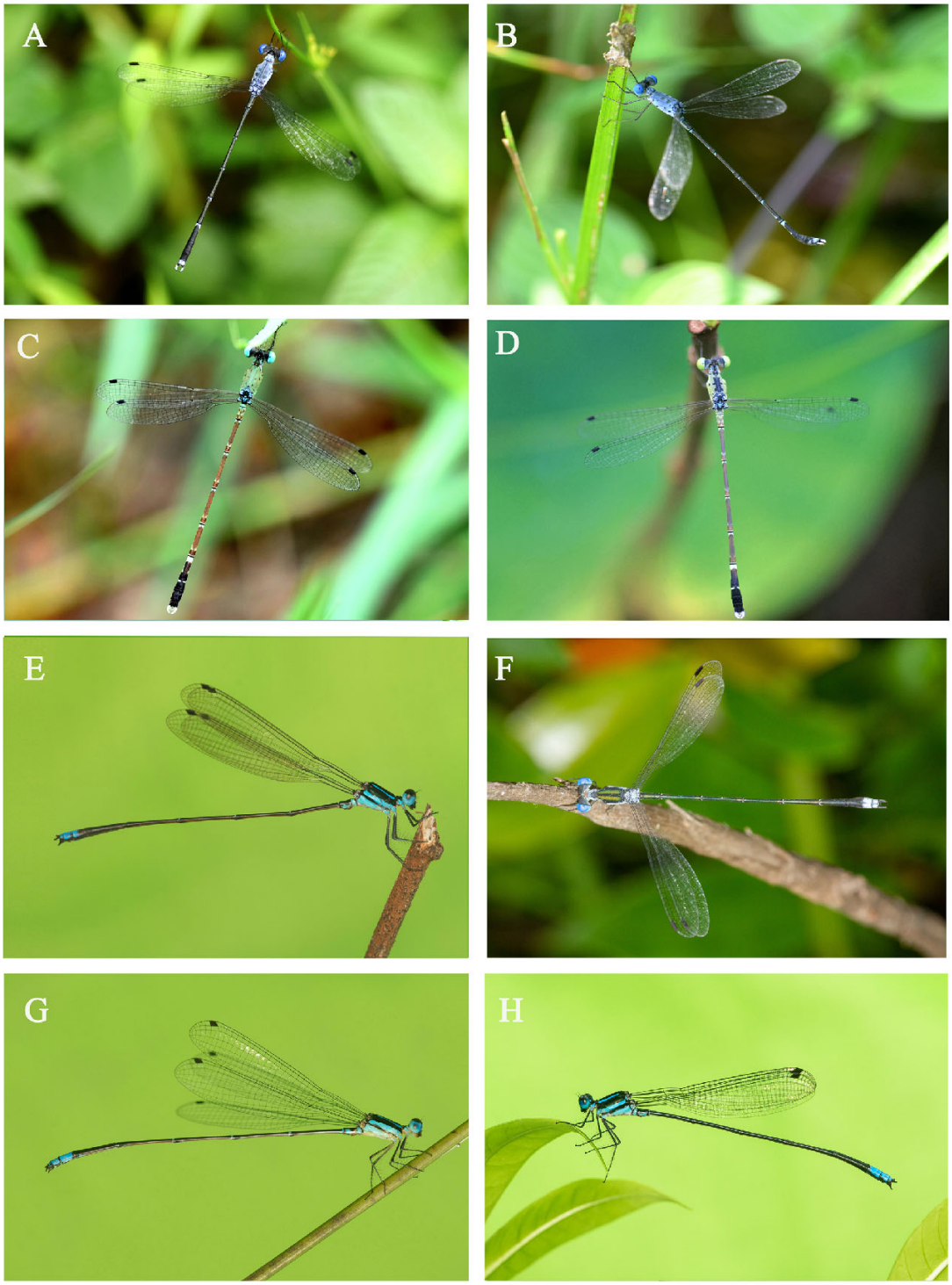

Fig. 9 A – *Lestes dorothea* Fraser, 1924 © Vinayan P Nair; B – *Lestes praemorsus decipiens* Kirby,1893 © Vinayan P Nair; C – *Platylestes platystylus* Rambur, 1842 © Vinayan P Nair; D – *Platylestes kirani* Emiliyamma, Palot & Charesh, 2020 © Vinayan P Nair; E – *Melanoneura bilineata* Fraser, 1922 © Kalesh Sadasivan; F – *Lestes malabaricus* Fraser 1929 © Kalesh Sadasivan; G – *Caconeura risi* (Fraser, 1931) © Kalesh Sadasivan; H – *Esme mudiensis* Fraser, 1931© Kalesh Sadasivan

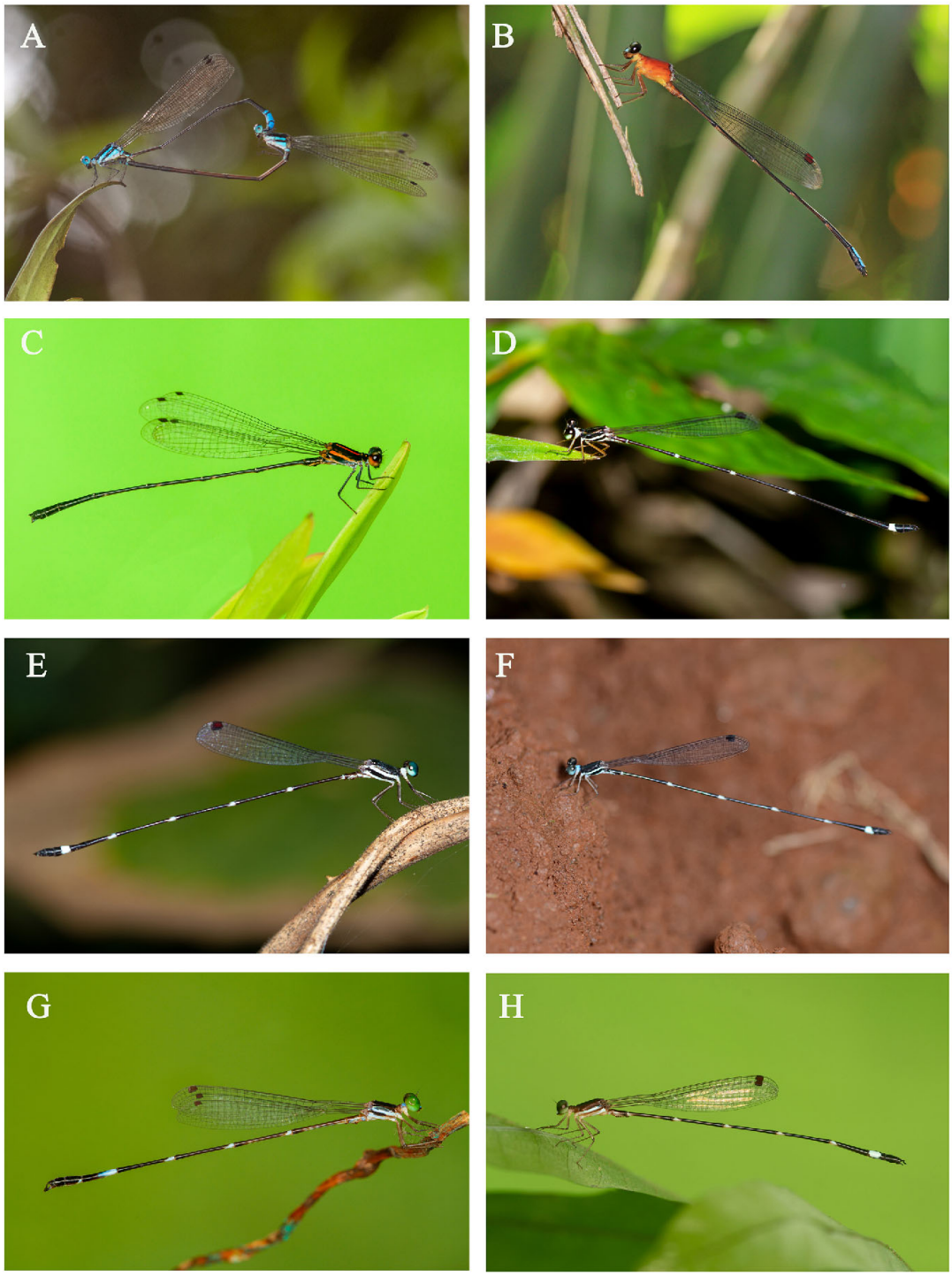

Fig. 10 A – *Phylloneura westermanni* (Hagen in Selys, 1860) © Kalesh Sadasivan; B – *Indosticta deccanensis* Laidlaw, 1915 © Abraham Samuel; C – *Prodasineura verticalis annandalei* (Fraser, 1921) © Kalesh Sadasivan; D – *Protosticta gravelyi* Laidlaw, 1915 © Kalesh Sadasivan; E – *Protosticta rufostigma* Kimmins 1958 © Kalesh Sadasivan; F – *Prorosticta mortonii* Fraser, 1924 © Manoj P; G – *Protosticta ponmudiensis* Kiran, Kalesh & Kunte, 2015 © Kalesh Sadasivan; H – *Protosticta sanguinostigma* Fraser, 1922 © Kalesh Sadasivan

Fig. 11 A – *Ceriagrion chromothorax* Joshi & Sawant, 2019 © Vinayan P Nair; B – *Ceriagrion rubiae* Laidlaw,1916 © Baiju K; C – *Pseudagrion indicum* Fraser, 1924 © Vinayan P Nair; D – *Pseudagrion rubriceps* (Selys,1876) © Kalesh Sadasivan; E – *Pseudagrion australasiae* Selys, 1876 © Abraham Samuel; F – *Elattoneura tetrica* (Laidlaw, 1917) © Vinayan P Nair; G – *Disparoneura apicalis* (Fraser, 1924) © Abraham Samuel; H – *Onychargia atrocyana* (Selys, 1865) © Abraham Samuel

(Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2014; KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014; Emiliyamma, 2005; KS), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalai landscapes (Emiliyamma and Radhakrishnan, 2002; VPN; KS). *Caconeura t–coerulea* (Fraser, 1933) is a WG endemic but not found in Kerala.

Genus *Copera* Kirby, 1890

Copera is represented by two species both in WG and Kerala. *Copera marginipes* (Rambur, 1842) is a common damsel found along ponds, puddles, canals, and streams. The cerci have only ¼ as long as paraprocts. It has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007), Palghat Hills (Emiliyamma *et al*., 2007; KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Anjanad Valley (Emiliyamma *et al*., 2007; Adarsh *et al*., 2015), High Range (KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and Coastal wetlands landscape (Emiliyamma, 2014; Raju, 2007; Roshnath, 2020). *Copera vittata deccanensis* Laidlaw, 1917 shares habitat with *C. marginipes*. The cerci are only half as long as paraprocts. It is reported from Coorg–Kannur landscape (Palot and Kiran, 2016; Nair, 2017), Wayanad (Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007), Palghat Hills (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; KS), High Range (KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma *et al*., 2007; Emiliyamma, 2014; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetlands landscape (Raju, 2007; Emiliyamma, 2014; Roshnath, 2020). *Copera vittata deccanensis* is endemic to India.

Genus *Disparoneura* Selys, 1860

The genus is represented by two species in both WG and Kerala. *Disparoneura apicalis* (Fraser, 1924) is a rare endemic damsel of WG with a black thorax with brick red line, and black wing tips (Fig. 11G). It is a very rare damsel in WG and Kerala. In Kerala it has been reported only from Wayanad landscape (AS; MJP). *Disparoneura quadrimaculata* (Rambur, 1842) is another very rare damsel in WG and Kerala. It is endemic to India. It is a medium sized brick red damsel with black banded wing, found only in streams of north Kerala. It has been reported only from Coorg–Kannur landscape (Palot and Kiran, 2016) and Wayanad (MJP).

Genus *Elattoneura* Cowley, 1935

Elattoneura is represented by three species in WG but only two in Kerala. *Elattoneura souteri* (Fraser, 1924) is a beautiful and conspicuously colored insect that usually hides in shaded spots beneath overhanging bamboo, cane or bushes on the banks of submontane streams. Whole head, thorax and base of abdomen appear red in sunlight (Fraser, 1933). It has been reported from Coorg–Kannur (Vibhu V, per. com.), Wayanad (Fraser, 1933), Nelliampathies–Anamalais (KS), Pandalam Hills (KS) and Agasthyamalais landscape (KS). *Elattoneura tetrica* (Laidlaw, 1917) (Fig. 11F) is a shy retiring insect frequenting dark shady spots on sub-montane streams, mainly in thick forests. Although it closely resembles *E. niggerima* can be easily identified by its larger size and higher nodal index (Fraser, 1933). But as per Koparde *et al.* (2021) *E.niggerima* is significantly larger than *E.tetrica. Elattoneura tetrica* has been reported only from Coorg–Kannur (Nair, 2017; KS) and Agasthyamalais landscapes (KS). *Elattoneura niggerima* (Laidlaw, 1917) is an Indian endemic species present in WG and other parts of India but not reported from Kerala so far. *Elattoneura souteri* and *E. tetrica* are WG endemics.

Genus *Esme* Fraser, 1922

Esme includes three species endemic to WG and all are present in Kerala. They are moderate sized slender built damsels with complete anal bridge. *Esme cyaneovittata* Fraser, 1922 is confined to south of Palakkad Gap and can be distinguished from *E. mudiensis* (Fig. 9H) by its labrum marked with azure blue and from *E. longistyla* by its black legs unmarked with blue, very stout inferior anal appendages and broken blue lateral stripe on prothorax (Fraser, 1933). It is reported from Anjanad valley landscape (Fraser, 1933; KS; MJP), High Ranges (KS), Cardamom Hills (KS), and Pandalam Hills landscape (KS). *Esme longistyla* Fraser, 1931 is a rare insect and is considerably smaller than other *Esme* species. It has been reported from Wayanad landscape (KS), Nelliampathies–Anamalais (KS), High Ranges (KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS) and Agasthyamalai landscape (KS). *Esme mudiensis* Fraser, 1931 is a high altitude species and can be separated from other *Esme* species by labrum entirely unmarked with azure blue (Fraser, 1933). It is found at Wayanad landscape (Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Fraser, 1933, KS), Anjanad Valley (Adarsh *et al*., 2015; KS), High Ranges (Fraser 1931a; KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (KS) and Agasthyamalai landscapes (KS).

Genus *Melanoneura* Fraser, 1922

Melanoneura is a monotypic genus found both in WG and Kerala. These are moderately sized slender built damsels with the anal bridge entirely absent as in *Caconeura* but bigger in size and are represented by *M. bilineata* Fraser, 1922 (Fig. 9E). It is WG endemic and is included under near threatened category of IUCN Red List. It is always found along with *C. ramburi* but can be easily separated by the absence of conspicuous blue basal annules (Fraser, 1933). It has been reported from Coorg–Kannur landscape (MJP), Wayanad (Fraser, 1933; Palot and Emiliyamma, 2015; MJP), Nelliampathies–Anamalais (KS), Lower Periyar (KS), Pandalam Hills (KS) and Agasthyamalai landscape (KS).

Genus *Onychargia* Selys, 1865

Onychargia is another monotypic genus in WG and Kerala with a representative species *O. atrocyana* (Selys, 1865). It is a small glossy black damsel (Fig. 11H) found in forested marshlands. It has been reported from Coorg–Kannur landscape (Vibhu V., pers. com),Wayanad (Emiliyamma *et al*., 2007), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (KS), Lower Periyar (KS), Cardamom Hills (AS; KS), Pandalam Hills (KS) and Agasthyamalai landscape (KS). It is a migratory species (Fraser, 1933).

Genus *Phylloneura* Fraser, 1922

Phylloneura is another endemic monotypic genus found in WG and Kerala and is represented by *P. westermanni* (Selys, 1860). It is a slender built damsel (Fig. 10A) similar to *Caconeura* but differing in venation with higher network, high nodal index and complete anal bridge. The wings are longer, narrower, more pointed and falcate at the apex; azure blue markings are more extensive at terminal abdominal segments (Fraser, 1933). It is placed in the near threatened category of IUCN Red List. It has been reported from Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (Fraser, 1933; Palot and Emiliyamma, 2015; MJP), Nilgiri – Silent Valley (KS), Nelliampathies–Anamalais (KS), High ranges (KS), Lower Periyar (KS) and Cardamom Hills (KS) landscape.

Genus *Prodasineura* Cowley, 1934

Prodasineura is represented by a single species *P. verticalis annandalei* (Fraser, 1921) (Fig. 10C) in WG and Kerala and is an Indian endemic species. It is found in Coorg–Kannur landscape (Palot and Kiran, 2016; VPN; Nair, 2017), Wayanad (Emiliyamma *et al*., 2007; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Nelliampathies–Anamalais (Emiliyamma *et al*., 2007; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Anjanad Valley (Adarsh *et al*., 2015), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS)

and Agasthyamalai landscape (KS; Emiliyamma and Radhakrishnan, 2002).

Family Coenagrionidae Kirby, 1890

Coenagrionidae is the largest family of Zygoptera in WG and Kerala with nine genera *viz*., *Aciagrion* Selys, 1891, *Agriocnemis* Selys, 1877, *Amphiallagma* Kennedy, 1920, *Archibasis* Kirby, 1890, *Ceriagrion* Selys, 1876, *Ischnura* Charpentier, 1840, *Mortonagrion* Fraser, 1920, *Paracercion* Weeker & Dumont, 2004 and *Pseudagrion* Selys, 1876.

Genus *Aciagrion* Selys, 1891

Aciagrion is represented by three species in WG *viz*., *A. approximans krishna* Fraser,1921, *A. occidentale* Laidlaw, 1919 and *A. pallidum* Selys, 1891. The former two alone are found in Kerala. *Aciagrion approximans krishna* was previously considered as *A. hisopa* (Selys, 1876) but later Shantanu *et al.*(2016) reinstated it as *A. approximans krishna* (Fig. 7D) Subramanian and Babu (2017) considered *A. hisopa* as *species inquirenda.* It is a high altitude WG endemic species. It has been reported from Coorg–Kannur landscape (Palot and Kiran, 2016), Wayanad (Susanth and Anooj, 2020), Nigiri–Silent Valley (Emiliyamma *et al*., 2007), Nelliampathies–Anamalais (KS), Anjanad Valley (Adarsh *et al*., 2015; Sadasivan, 2018), High Ranges (KS), Lower Periyar (AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS) and Agasthyamalai landscape (KS). *Aciagrion occidentale* Laidlaw, 1919 is reported from Coorg–Kannur landscape (Emiliyamma *et al*., 2007; Palot and Kiran, 2016; Nair, 2017), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (KS), High range (KS), Lower Periyar (AS; KS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscape (Palot and Soniya, 2004; Radhakrishnan *et al*., 2006; Roshnath, 2020). This species shows local movement and migration (Fraser, 1933).

Genus *Agriocnemis* Selys, 1877

Agriocnemis is represented by five species viz., *A. femina* (Brauer, 1868), *A. keralensis* Peters, 1981, *A. pieris* Laidlaw, 1919, *A. pygmaea* (Rambur, 1842) and *A. splendidissima* Laidlaw, 1919 in WG, and all except *A. femina* are present in Kerala. *Agriocnemis keralensis* (Fig. 7C) is a WG endemic and was described from Kerala by Peters (1981) and a redescription was done by Nair and Subramanian (2014). Later it has been reported from Goa (Rangnekar *et al*., 2010) and Maharashtra (Koli *et al.,* 2021). It is found at Coorg–Kannur landscape (Nair 2017), Wayanad (Susanth and Anooj, 2020), Palghat Hills (KS), Nelliampathies–Anamalais (KS), Lower Periyar (Emiliyamma 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and Coastal Wetlands landscape (KS; Raju, 2007; Roshnath, 2020). *Agriocnemis pieris* was previously considered as an Indian endemic but as per Kalkman *et al.* (2020) it is also found in Bangladesh. It has been reported from Coorg–Kannur landscape (Emiliyamma, 2014Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007; KS), Palghat Hills (KS), Nelliampathies – Anamalais (Emiliyamma and Radhakrishnan, 2014; Adarsh *et al*., 2014; KS), Anjanad Valley (KS), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS; AS; VPN) and coastal wetlands landscape (Emiliyamma, 2014; Roshnath, 2020). *Agriocnemis pygmaea* has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005, Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al.,* 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2000; Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Anjanad Valley (Adarsh

et al., 2015), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma *et al*., 2007; Emiliyamma, 2014; KS), Pandalam Hills (KS), Agasthyamalais (Peters,1981; Emiliyamma and Radhakrishnan, 2002; KS), and coastal wetlands landscape (Palot and Soniya, 2004; Radhakrishnan *et al*., 2006; Raju, 2007; Emiliyamma, 2014; Roshnath, 2020). *Agriocnemis splendidissima* (Fig. 7H) has been reported from Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007), Nilgiri – Silent Valley (Emiliyamma *et al*., 2007; KS), Palghat Hills (KS), Nelliampathies–Anamalais (Emiliyamma *et al*., 2007; KS), Anjanad Valley (Sadasivan, 2018), High Range (KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS) and Agasthyamalais landscape (Emiliyamma and Radhakrishnan, 2002; KS).

Genus *Amphiallagma* Kennedy, 1920

Amphiallagma in WG and Kerala has a single species *A. parvum* (Selys, 1876) (Fig. 8B). It has been reported from Coorg–Kannur landscape (VPN) and Wayanad (KS).

Genus *Archibasis* Kirby, 1890

Archibasis is represented by *A. oscillans* (Selys, 1877) (Fig. 7E) and is found in Coorg–Kannur landscape (Nair, 2017; KS; VPN),Wayanad (Emiliyamma *et al*., 2007), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (KS; AS), Anjanad Valley (Sadasivan, 2018), High ranges (Kalesh, 2018), Lower Periyar (KS), Agasthyamalais (KS) and Coastal wetlands landscape (Raju, 2007; Roshnath, 2020).

Genus *Ceriagrion* Selys, 1876

According to Subramanian *et al*. (2018), four species of *Ceriagrion* were found in WG *viz., C. cerinorubellum* (Brauer, 1865), *C. coromandelianum* (Fabricius, 1798), *C. olivaceum* Laidlaw, 1914 and *C. rubiae* Laidlaw, 1916. *Ceriagron chromothorax* Joshi & Sawant (2019) (Fig. 11A) was later added to the WG list from Maharashtra (Joshi and Sawant, 2019). *Ceriagrion olivaceum aurantiacum* Fraser, 1924 is considered as a subspecies found in WG. Fraser (1924) described *C. aurantiacum* and synonymized it with *C. olivaceum* Laidlaw (Fraser, 1933) and explained it as a race of the former and named *C. olivaceum aurantiacum*. *Ceriagrion olivaceum aurantiacum* has been reported from Coorg–Kannur landscape (VPN), Wayanad (Fraser, 1924a) and Nilgiri – Silent Valley landscape (Rao & Lahiri, 1982). *Ceriagrion olivaceum olivaceum* Laidlaw, 1914, is found in Coorg–Kannur landscape (Nair, 2014; Palot and Kiran, 2016; VPN), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007) and Nelliampathies–Anamalais landscape (Gnanakumar *et al.,* 2012; KS). *Ceriagrion cerinorubellum* has been reported from Coorg– Kannur landscape (Nair, 2014; Palot and Kiran, 2016; Palot and Radhakrishnan, 2005), Wayanad (Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Anjanad Valley (Sharma *et al*., 2007; Adarsh *et al*., 2015), Lower Periyar (Emiliyamma, 2005; Varghese *et al*., 2014; AS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS; Peters, 1981; Emiliyamma and Radhakrishnan, 2002) and coastal wetlands landscape (Soniya, 2004; Radhakrishnan *et al*., 2006; Palot and Raju, 2007; Emiliyamma *et al*., 2007; Emiliyamma, 2014; Roshnath, 2020). *Ceriagrion chromothorax* Joshi & Sawant, 2019 is reported only from Coorg – Kannur landscape (VPN) and coastal wetlands so far (VPN). It is a WG endemic species and is supposed to be distributed north of Palakkad gap. *Ceriagrion coromandelianum* (Fabricius, 1798) is found in Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007; KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies – Anamalais (Emiliyamma *et al*., 2007; Gnanakumar *et al.,*2012;

Table 2. Systematic checklist of Odonates of Western Ghats and Kerala with their endemicity & IUCN status

Sl.No.	ODONATES	IUCN**
	SUBORDER ANISOPTERA	
	FAMILY AESHNIDAE	
1.	*Anaciaeschna jaspidea* (Burmeister, 1839)	LC
2.	*Anaciaeschna martini* Selys, 1897	LC
3.	*Anax ephippiger* (Burmeister, 1839)	LC
4.	*Anax guttatus* (Burmeister, 1839)	LC
5.	*Anax immaculifrons* (Rambur ,1842)	LC
6.	*Anax indicus* Lieftinck,1942	LC
7.	*Anax parthenope* (Selys ,1839)	LC
8.	*Gynacantha dravida* Lieftinck,1960	DD
9.	*Gynacantha khasiaca* MacLachlan,1896#	DD
10.	*Gynacantha millardi* Fraser,1920	LC
	FAMILY CHLOROGOMPHIDAE	
11.	*Chlorogomphus campioni* (Fraser, 1924)*	LC
12.	*Chlorogomphus xanthoptera* (Fraser, 1919) *	VL
	FAMILY CORDULIIDAE	
13.	*Hemicordulia asiatica* (Selys, 1878)	LC
	FAMILY GOMPHIDAE	
14.	*Acrogomphus fraseri* Laidlaw, 1925*	DD
15.	*Asiagomphus nilgiricus* Laidlaw, 1922*	DD
16.	*Burmagomphus cauvericus* Fraser, 1926*#	DD
17.	*Burmagomphus laidlawi* Fraser, 1924	DD
18.	*Burmagomphus pyramidalis* Laidlaw, 1922*	LC
19.	*Cyclogomphus flavoannulatus* Rangnekar, Dharwadkar, Kalesh & Subramanian, 2019*	NA
20.	*Cyclogomphus heterostylus* Selys,1854	DD
21.	*Cyclogomphus wilkinsi* Fraser, 1926 #	DD
22.	*Cyclogomphus ypsilon* Selys, 1854 #	NA
23.	*Davidioides martini* Fraser, 1924*	DD
24.	*Gomphidia fletcheri* Fraser, 1923* #	DD
25.	*Gomphidia kodaguensis* Fraser, 1923*	DD
26.	*Gomphidia platyceps* Fraser, 1953*#	NA
27.	*Gomphidia podhigai* Babu & Subramanian, 2019*#	NA
28.	*Gomphidia t-nigrum* Selys, 1854#	LC
29.	*Heliogomphus kalarensis* Fraser, 1934*	DD
30.	*Heliogomphus promelas* (Selys, 1873)	NT
31.	*Ictinogomphus rapax* (Rambur, 1842)	LC
32.	*Lamelligomphus nilgiriensis* (Fraser, 1922)*	LC
33.	*Macrogomphus annulatus annulatus* (Selys, 1854)#	DD
34.	*Macrogomphus wynaadicus* Fraser, 1924*	DD
35.	*Megalogomphus hannyngtoni* (Fraser, 1923)	NT
36.	*Megalogomphus superbus* Fraser, 1931*	DD
37.	*Melligomphus acinaces* (Laidlaw, 1922) *	DD
38.	*Merogomphus longistigma* (Fraser, 1922) *	DD
39.	*Merogomphus tamaracherriensis* Fraser, 1931*	NA
40.	*Microgomphus souteri* Fraser, 1924*	LC
41.	*Microgomphus torquatus* (Selys, 1854)*#	DD
42.	*Microgomphus verticalis* (Selys, 1873) *#	DD
43.	*Nychogomphus striatus* Fraser, 1924	DD
44.	*Onychogomphus malabarensis* (Fraser,1924) *	DD
45.	*Paragomphus lineatus* (Selys,1850)	LC
	FAMILY LIBELLULIDAE	
46.	*Acisoma panorpoides* Rambur, 1842	LC
47.	*Aethriamanta brevipennis* (Rambur, 1842)	LC
48.	*Brachydiplax chalybea* Brauer, 1868	LC
49.	*Brachydiplax sobrina* (Rambur,1842)	LC
50.	*Brachythemis contaminata* (Fabricius, 1793)	LC
51.	*Bradinopyga geminata* (Rambur, 1842)	LC
52.	*Bradinopyga konkanensis* Joshi & Sawant 2020*#	NA
53.	*Cratilla lineata calverti* (Forster,1903)	LC
54.	*Crocothemis erythraea* (Brulle´, 1832)	LC
55.	*Crocothemis servilia* (Drury,1770)	LC
56.	*Diplacodes lefebvrii* (Rambur,1842)	LC
57.	*Diplacodes nebulosa* (Fabricius, 1793)	LC
58.	*Diplacodes trivialis* (Rambur, 1842)	LC
59.	*Epithemis mariae* (Laidlaw, 1915) *	LC
60.	*Hydrobasileus croceus* (Brauer, 1867)	LC
61.	*Hylaeothemis apicalis* Fraser, 1924	DD
62.	*Indothemis carnatica* (Fabricius, 1798)	LC
63.	*Indothemis limbata sita* Campion, 1923	LC
64.	*Lathrecista asiatica* (Fabricius, 1798)	LC
65.	*Lyriothemis acigastra* (Selys, 1878)	DD
66.	*Lyriothemis tricolor* Ris, 1919	LC
67.	*Macrodiplax cora* (Kaup in Brauer, 1867)	LC
68.	*Neurothemis fulvia* (Drury, 1773)	LC
69.	*Neurothemis intermedia intermedia* (Rambur, 1842)	LC
70.	*Neurothemis tullia* (Drury, 1773)	LC
71.	*Onychothemis testacea ceylanica* Ris, 1912	LC
72.	*Orthetrum chrysis* (Selys, 1891)	LC

Sl.No.	ODONATES	IUCN**
73.	*Orthetrum coerulescens anceps* (Schneider,1845)#	LC
74.	*Orthetrum glaucum* (Brauer, 1865)	LC
75.	*Orthetrum luzonicum* (Brauer, 1868)	LC
76.	*Orthetrum pruinosum neglectum* (Rambur, 1842)	LC
77.	*Orthetrum sabina sabina* (Drury, 1770)	LC
78.	*Orthetrum taeniolatum* (Schneider, 1845)	LC
79.	*Orthetrum triangulare triangulare* (Selys, 1878)	LC
80.	*Pantala flavescens* (Fabricius, 1798)	LC
81.	*Paplopleura sexmaculata* (Fabricius, 1787)	NA
82.	*Potamarcha congener* (Rambur, 1842)	LC
83.	*Rhodothemis rufa* (Rambur, 1842)	LC
84.	*Rhyothemis triangularis* Kirby, 1889	LC
85.	*Rhyothemis variegata variegata* (Linnaeus, 1763)	LC
86.	*Sympetrum fonscolombi* (Selys, 1840)	LC
87.	*Sympetrum hypomelas* (Selys, 1884)#	LC
88.	*Tetrathemis platyptera* Selys, 1878	LC
89.	*Tholymis tillarga* (Fabricius, 1798)	LC
90.	*Tramea basilaris* (Palisot de Beauvois, 1805)	LC
91.	*Tramea limbata* (Desjardins, 1832)	LC
92.	*Tramea virginia* (Rambur, 1842)	LC
93.	*Trithemis aurora* (Burmeister,1839)	LC
94.	*Trithemis festiva* (Rambur, 1842)	LC
95.	*Trithemis kirbyi* Selys, 1891	LC
96.	*Trithemis pallidinervis* (Kirby, 1889)	LC
97.	*Urothemis signata* (Rambur, 1842)	LC
98.	*Zygonyx iris malabarica* Fraser, 1926	LC
99.	*Zygonyx torridus isis* Fraser, 1924	LC
100.	*Zyxomma petiolatum* Rambur, 1842	LC
	FAMILY MACROMIIDAE	
101.	*Epophthalmia frontalis binocellata* Fraser, 1936	LC
102.	*Epophthalmia vittata vittata* Burmeister, 1839	LC
103.	*Macromia annaimallaiensis* Fraser, 1931*	LC
104.	*Macromia bellicosa* Fraser, 1924*	LC
105.	*Macromia cingulata* Rambur, 1842	LC
106.	*Macromia ellisoni* Fraser, 1924*	LC
107.	*Macromia flavicincta* Selys, 1874	DD
108.	*Macromia flavocolorata* Fraser, 1922	LC
109.	*Macromia ida* Fraser, 1924*	LC
110.	*Macromia indica* Fraser, 1924*	DD
111.	*Macromia irata* Fraser, 1924*	LC
	GENERA INSERTAE SEDIS	
112.	*Idionyx corona* Fraser, 1921*	DD
113.	*Idionyx galeata* Fraser, 1924*	EN
114.	*Idionyx gomantakensis S*ubramanian, Rangnekar & Nayak, 2013*	NA
115.	*Idionyx minima* Fraser, 1931*	DD
116.	*Idionyx nadganiensis* Fraser, 1924*	DD
117.	*Idionyx nilgiriensis* (Fraser, 1918) *#	DD
118.	*Idionyx periyashola* Fraser, 1939*	DD
119.	*Idionyx rhinoceroides* Fraser, 1934*	LC
120.	*Idionyx saffronata* Fraser, 1924*	DD
121.	*Idionyx travancorensis* Fraser, 1931*	DD
122.	*Macromidia donaldi donaldi* (Fraser, 1924)*	LC
	SUBORDER ZYGOPTERA	
	FAMILY CALOPTERYGIDAE	
123.	*Neurobasis chinensis* (Linnaeus, 1758)	LC
124.	*Vestalis apicalis* Selys , 1873	LC
125.	*Vestalis gracilis* (Rambur, 1842)	LC
126.	*Vestalis submontana* Fraser, 1934	NA
	FAMILY CHLOROCYPHIDAE	
127.	*Calocypha laidlawi* (Fraser, 1924)*	DD
128.	*Heliocypha bisignata* (Hagen in Selys, 1853)	LC
129.	*Libellago indica* (Fraser, 1928)	LC
	FAMILY COENAGRIONIDAE	
130.	*Aciagrion approximans krishna* Fraser, 1921*	LC
131.	*Aciagrion occidentale* Laidlaw, 1919	LC
132.	*Aciagrion pallidum* Selys, 1891#	LC
133.	*Agriocnemis femina* (Brauer, 1868)#	LC
134.	*Agriocnemis keralensis* Peters, 1981*	LC
135.	*Agriocnemis pieris* Laidlaw, 1919	LC
136.	*Agriocnemis pygmaea* (Rambur, 1842)	LC
137.	*Agriocnemis splendidissima* Laidlaw, 1919	LC
138.	*Amphiallagma parvum* (Selys, 1876)	LC
139.	*Archibasis oscillans* (Selys, 1877)	LC
140.	*Ceriagrion cerinorubellum* (Brauer, 1865)	LC
141.	*Ceriagrion chromothorax* Joshi & Sawant, 2019*	NA
142.	*Ceriagrion coromandelianum* (Fabricius, 1798)	LC
143a.	*Ceriagrion olivaceum aurantiacum* Fraser, 1924	LC
143b.	*Ceriagrion olivaceum olivaceum* Laidlaw, 1914	LC
144.	*Ceriagrion rubiae* Laidlaw,1916	NA

Sl.No.	ODONATES	IUCN**	Sl.No.	ODONATES	IUCN**
145.	*Ischnura nursei* Morton, 1907#	LC	177.	*Caconeura ramburi* (Fraser, 1922)	DD
146.	*Ischnura rubilio* Selys, 1876	LC	178.	*Caconeura risi* (Fraser, 1931) *	DD
147.	*Ischnura senegalensis* (Rambur, 1842)	LC	179.	*Caconeura t-coerulea* (Fraser, 1933) *#	DD
148.	*Mortanagrion varralli* Fraser, 1920	DD	180.	*Copera marginipes* (Rambur, 1842)	LC
149.	*Paracercion calamorum* (Ris , 1916)	LC	181.	*Copera vittata deccanensis* Laidlaw, 1917	LC
150.	*Paracercion malayanum* Selys, 1876	LC	182.	*Disparoneura apicalis* (Fraser, 1924) *	VL
151.	*Pseudagrion australasiae* Selys, 1876	LC	183.	*Disparoneura quadrimaculata* (Rambur, 1842)	LC
152.	*Pseudagrion decorum* (Rambur, 1842)	LC	184.	*Elattoneura nigerrima* (Laidlaw, 1917)#	DD
153.	*Pseudagrion hypermelas* Selys, 1876#	LC	185.	*Elattoneura souteri* (Fraser, 1924) *	DD
154.	*Pseudagrion indicum* Fraser, 1924*	LC	186.	*Elattoneura tetrica* (Laidlaw, 1917) *	LC
155.	*Pseudagrion malabaricum* Fraser, 1924	LC	187.	*Esme cyaneovittata* Fraser, 1922*	DD
156.	*Pseudagrion microcephalum* (Rambur, 1872)	LC	188.	*Esme longistyla* Fraser, 1931*	LC
157.	*Pseudagrion rubriceps* (Selys, 1876)	LC	189.	*Esme mudiensis* Fraser, 1931*	DD
	FAMILY EUPHAEIDAE		190.	*Melanoneura bilineata* Fraser, 1922*	NT
158.	*Dysphaea ethela* Fraser, 1924	DD	191.	*Onychargia atrocyana* (Selys, 1865)	LC
159.	*Euphaea cardinalis* (Fraser, 1924) *	LC	192.	*Phylloneura westermanni* (Hagen in Selys, 1860) *	NT
160.	*Euphaea dispar* (Rambur, 1842) *	LC	193.	*Prodasineura verticalis annandalei* (Fraser, 1921)	LC
161.	*Euphaea fraseri* (Laidlaw,1920) *	LC	194.	*Pseudocopera ciliata* (Selys, 1863)#	LC
162.	*Euphaea pseudodispar* Sadasivan & Bhakare, 2021*#	NA		**FAMILY PLATYSTICTIDAE**	
163.	*Euphaea thosegharensis* Sadasivan & Bhakare, 2021*#	NA	195.	*Indosticta deccanensis* Laidlaw, 1915*	VL
	FAMILY LESTIDAE		196.	*Protosticta antelopoides* Fraser, 1931*	DD
164.	*Indolestes gracilis davenporti* Fraser, 1930*	LC	197.	*Protosticta cyanofemora* Joshi, Subramanian, Babu & Kunte 2020*	NA
165.	*Indolestes pulcherrimus* Fraser, 1924*	DD	198.	*Protosticta davenporti* Fraser, 1931*	LC
166.	*Lestes concinnus* Hagen in Selys, 1862	DD	199.	*Protosticta gravelyi* Laidlaw, 1915*	LC
167.	*Lestes dorothea* Fraser, 1924	LC	200.	*Protosticta hearseyi* Fraser, 1922*	DD
168.	*Lestes elatus* Hagen in Selys, 1862	LC	201.	*Protosticta monticola* Emiliyamma & Palot, 2016*	DD
169.	*Lestes malabaricus* Fraser 1929	DD	202.	*Prorosticta mortonii* Fraser, 1924*	LC
170.	*Lestes nodalis* Selys, 1891	LC	203.	*Protosticta myristicaensis*Joshi & Kunte,2020*#	NA
171.	*Lestes patricia* Fraser, 1924*	NA	204.	*Protosticta ponmudiensis* Kiran, Kalesh & Kunte, 2015*	DD
172.	*Lestes praemorsus decipiens* Kirby,1893	LC	205.	*Protosticta rufostigma* Kimmins 1958*	DD
173.	*Lestes viridulus* Rambur, 1842#	LC	206.	*Protosticta sanguinostigma* Fraser, 1922*	VL
174.	*Platylestes kirani* Emiliyamma, Palot & Charesh 2020*	NA	207.	*Protosticta sholai* Subramanian & Babu, 2020*	NA
175.	*Platylestes platystylus* Rambur, 1842	LC			
	FAMILY PLATYCNEMIDIDAE				
176.	*Caconeura gomphoides* (Rambur, 1842)*	DD			

* Endemic to Western Ghats; # not reported from Kerala

**DD–Data Deficient, NA–Not assessed, LC–Least Concern, EN–Endangered, VL–Vulnerable, NT–Near Threatened

Adarsh *et al*., 2014; KS), Anjanad Valley (Sharma *et al*., 2007; Adarsh *et al.,* 2015), Lower Periyar (Emiliyamma, 2005; AS ; Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (Peters 1981; Emiliyamma and Radhakrishnan 2002, KS) and coastal wetlands landscape (Palot and Soniya, 2004; Radhakrishnan *et al*., 2006; Raju, 2007; Emiliyamma, 2014; Roshnath, 2020). *Ceriagrion rubiae* Laidlaw, 1916 (Fig. 11B) is found in Coorg – Kannur landscape (VPN; Emiliyamma, 2014; Nair, 2014; Palot and Kiran, 2016), Wayanad (KS), Nilgiri–Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Emiliyamma *et al*., 2007; Adarsh *et al.,* 2014; KS), Lower Periyar (Varghese *et al*., 2014), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS) and coastal wetlands (Roshnath, 2020).

Genus *Ischnura* Charpentier, 1840

Ischnura in WG is represented by three species viz., *Ischnura rubilio* Selys, 1876, *Ischnura senegalensis* (Rambur, 1842) and *Ischnura nursei* Morton, 1907. In Kerala, only the former two species are found. *Ischnura rubilio* Selys, 1876 (Fig. 7G) has been reported from Coorg – Kannur landscape (Palot and Radhakrishnan, 2005; Nair, 2014; Palot and Kiran, 2016), Wayanad (Emiliyamma *et al*., 2007; Palot and Emiliyamma, 2015; MJP; Susanth and Anooj, 2020), Nilgiri– Silent Valley (Emiliyamma *et al*., 2007; KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies – Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Anjanad Valley (Sharma *et al*., 2007; Adarsh *et al*., 2015; Sadasivan, 2018; KS), High Ranges (Sadasivan, 2018; KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (Emiliyamma, 2014; KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and Coastal Wetland landscapes (Palot and Soniya, 2004; Radhakrishnan *et al*., 2006; Raju, 2007; Emiliyamma, 2014; Roshnath, 2020). *Ischnura senegalensis* (Rambur, 1842) has been reported from Coorg–Kannur landscape (Palot and Kiran, 2016; Nair, 2017), Wayanad (Palot and Emiliyamma, 2015), Nilgiri – Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007), Nelliampathies –Anamalais (KS), High Ranges (KS), Lower Periyar (KS; AS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetland landscapes (Palot and Soniya, 2004; Raju, 2007; Emiliyamma, 2014; Roshnath, 2020). This species is migratory (Fraser, 1933).

Genus *Mortonagrion* Fraser, 1920

Mortonagrion is found both in WG and Kerala. The representative species, *M. varalli* Fraser, 1920 (Fig. 7F), has been reported from Coorg–Kannur landscape (VPN; Emiliyamma, 2014), Wayanad (Emiliyamma *et al*., 2007), Nilgiri–Silent Valley (Emiliyamma, 2014), Lower Periyar (KS; Varghese *et al*., 2014), Pandalam Hills (KS), Agasthyamalais (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetlands landscape (Palot and Soniya, 2004; Radhakrishnan *et al*., 2006; Raju, 2007; Emiliyamma, 2014; Roshnath, 2020).

Genus *Paracercion* Weeker & Dumont, 2004

Paracercion is represented by two species in both WG and Kerala viz., *P. calamorum* (Ris, 1916) and *P. malayanum* Selys, 1876 and *P. calamorum* (Fig. 8A) is found in Coorg–Kannur landscape (Nair 2017), Nelliampathies–Anamalais (AS; KS), Lower Periyar (AS), Pandalam Hills (KS) and coastal wetlands landscapes (KS). Subramanian *et al.* (2020) omitted *P.malayanum* in the WG list of odonates. *Paracercion malayanum* is found in Agasthyamalais landscape only (Bo Nielson, per. com.).

Genus *Pseudagrion* Selys, 1876

Pseudagrion Selys, 1876 includes small slender built non–metallic colored damsels with bright blue marked with black, red, orange, or green or it may be dull colored, black, brown or pruinosed (Fraser, 1933). It is represented by seven species in WG viz., *P. australasiae* Selys, 1876, *P. decorum* (Rambur, 1842), *P. hypermelas* Selys, 1876, *P. indicum* Fraser, 1924, *P. malabaricum* Fraser

1924, *P. microcephalum* (Rambur, 1872) and *P. rubriceps* (Selys, 1876). Except *P. hypermelas,* all other species are found in Kerala. *Pseudagrion* species identification is based on anal appendages and cannot be done based on prothoracic markings. *Pseudagrion australasiae* (Fig. 11E) has an entire blue abdominal segment 8 and 9 with an apical fringe of black spines of which on eighth it appears as black ring and cerci shorter than segment 10 and bifid at apex. Subramanian *et al.* (2020) has not included *P. australasiae* in WG odonata list. It is found in Coorg–Kannur (VPN), Nelliampathies–Anamalais (AS), Lower Periyar (KS), Cardamom Hills (KS) and Pandalam Hills landscapes (KS). *Pseudagrion decorum* is found in Coorg–Kannur landscape (Nair 2017), Wayanad (KS) Palghat Hills (KS), Nelliampathies–Anamalais (KS), Anjanad Valley (KS), Lower Periyar (KS), Cardamom Hills (Emiliyamma *et al*., 2007; KS), Pandalam Hills (KS), Agasthyamalais (KS) and coastal wetlands (Roshnath, 2020). It is a migratory species (Fraser, 1933). *Pseudagrion indicum* (Fig. 11C) is found in Coorg–Kannur landscape (Palot and Kiran, 2016; Nair, 2017), Wayanad (Palot and Emiliyamma, 2015; Emiliyamma *et al* 2007, Susanth and Anooj, 2020), Nilgiri – Silent Valley (KS), Palghat Hills (KS), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan 2014, KS), Anjanad Valley (KS), High Range (KS), Lower Periyar (Varghese *et al*., 2014; AS; KS), Cardamom Hills (KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS), Agasthyamalais (KS) and coastal wetlands (Roshnath, 2020). *Pseudagrion malabaricum* has an entire blue abdominal segment 8 and 9 with an apical fringe of black spines of which on eighth it appears as black ring and cerci shorter than segment 10 and not bifid at the apex which curl strongly inward as a robust tooth. It has been reported from Coorg–Kannur landscape (Nair, 2014), Wayanad (VPN; Susanth and Anooj, 2020), Nilgiri–Silent Valley (Emiliyamma *et al*., 2007), Palghat Hills (VPN), Nelliampathies–Anamalais (KS), Lower Periyar (KS), Cardamom Hills (Emiliyamma, 2014; KS), Pandalam Hills (Pradeepkumar *et al*., 2014; KS) and Agasthyamalais landscape (Emiliyamma and Radhakrishnan, 2002; KS). *Pseudagrion microcephalum* has abdominal segments 8 and 9 blue with apical fringe of black spines and the eighth apical dorsal ring is thick and cerci is as long as segment 10, narrow at base, deeply cupped within and bifid at apex. It is found in Coorg–Kannur landscape (Nair, 2017; Palot and Kiran, 2016; Palot and Radhakrishnan, 2005, Emiliyamma, 2014), Wayanad (Palot and Emiliyamma, 2015; MJP), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Gnanakumar *et al.,* 2012; Adarsh *et al*., 2014; KS), Anjanad Valley (Emiliyamma *et al*., 2007; Adarsh *et al*., 2015), High Range (KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma, 2014; KS), Pandalam Hills (KS), Agasthyamalais landscape (KS) and Coastal wetlands landscape (Palot and Soniya, 2004; Radhakrishnan *et al*., 2006; Raju, 2007; Emiliyamma, 2014; Roshnath, 2020). It is migratory (Fraser, 1933). *Pseudagrion rubriceps* (Fig. 11D) is found in Coorg–Kannur landscape (Palot and Radhakrishnan, 2005; Palot and Kiran, 2016; Nair, 2017), Wayanad (MJP; Susanth and Anooj, 2020), Nilgiri–Silent Valley (KS), Palghat Hills (Emiliyamma *et al*., 2007; KS), Palghat plains (Palot *et al*., 2005), Nelliampathies–Anamalais (Emiliyamma and Radhakrishnan, 2014; Gnanakumar *et al.*, 2012; Adarsh *et al* 2014; KS), Anjanad Valley (Emiliyamma *et al*., 2007; Adarsh *et al*., 2015; Sharma *et al*., 2007), High ranges (Kalesh, 2018; KS), Lower Periyar (Varghese *et al*., 2014; AS), Cardamom Hills (Emiliyamma, 2014; KS), Pandalam Hills (KS), Agasthyamalais landscape (Emiliyamma and Radhakrishnan, 2002; KS) and coastal wetlands landscape (Roshnath, 2020).

DISCUSSION

Endemism:

Kalkman *et al.* (2020) found 73 endemic species in WG. Subramanian *et al.,* 2020 stated that the number of endemic species in WG is 84. Within family Aeshnidae, Kalkman *et al.* (2020) mentioned only *G. rotundata* endemic to India. *Gynacantha rotundata* Navas, 1930 is only known from its type description. Kalkman *et al.* (2020) considered it as

identical to *G. dravida* but Subramanian *et al*. (2020) mentioned it as endemic to WG. Since *G. rotundata* is not treated as a separate species, it is not included as a WG endemic and hence Aeshnidae have no endemic member in WG and Kerala. Among Gomphidae, Kalkman *et al*. (2020) mentioned 24 endemic species in WG, while Subramanian *et al.* (2020) reported 26 endemic Gomphids in WG. *Lamelligomphus nilgiriensis* Fraser, 1922 is found both in WG and Kerala and is endemic to WG. Two subspecies of *Lamelligomphus viz. L. n. nilgiriensis* (Fraser, 1922) and *L. n. annamallaicus* Fraser, 1934 are found. According to Fraser (1934) the race *annamallaicus* is found south of Palghat gap and the type locality is Mudis hills, south India. Specimens from Coorg and Nilgiris belong to race *nilgiriensis* and hence the specimens found north of Palghat gap are race *nilgiriensis*. As per Kalkman *et al*. (2020) *L. n. nilgiriensis* is endemic to WG and *L. n. annamallaicus* is endemic to India. However both races are endemic to WG. *Burmagomphus laidlawi* is considered endemic to India and *B. pyramidalis* as WG endemic by Kalkman *et al*. (2020). Nonetheless, Subramanian *et al.* (2020) considered both as WG endemics. *Heliogomphus promelas* (Selys, 1873) was historically considered endemic to WG (Babu *et al*., 2013), however, according to Subramanian *et al*. (2018, 2020) and Kalkman *et al.* (2020) the taxon is considered endemic to the wider Indian region. Dawn (2021) recently reported certain taxa from West Bengal, previously thought to be endemic to WG. This removes *Cyclogomphus wilkinsi* Fraser, 1926 and *C. ypsilon* Selys, 1854 from their WG endemic status. Thus, only one species *C. flavoannulatus* is endemic to WG. In summary there are 21 endemic species of Gomphidae in WG and 15 endemic species in Kerala. Chlorogomphidae includes two endemic species and Macromiidae has six endemics both in WG and Kerala. Corduliidae lacks any endemic species in WG or Kerala. Libellulidae has two endemic species in WG and only one in Kerala. As per Kalkman *et al*. (2020) *Bradinopyga konkanensis* is endemic to India. Subramanian *et al.* (2020) mentioned it as endemic to WG and is followed regarding endemicity of *B. konkanensis*. *Bradinopyga konkanensis* has not been authentically reported from Kerala. The genera *Macromidia* Martin, 1907 and *Idionyx* Hagen, 1867 (Genera *Incertae sedis*) have 11 species endemic to WG, of which 10 are found in Kerala. Among Lestiidae Subramanian *et al.* (2020) mentioned four WG endemic species. There are reports of the occurrence of *Lestes patricia* in Jammu and Kashmir and Pakistan which have to be confirmed (Kalkman *et al*., 2020). Family Platystictidae of WG has 13 endemic species (Subramanian *et al.,* 2020) of which Kerala has 12. As per Kalkman *et al.* (2020) *Protosticta hearseyi* Fraser, 1922 is also reported from Pakistan. However, it needs to be reconfirmed and therefore here it is considered as WG endemic. Family Calopterygidae does not have any WG endemic species where as Chlorocyphidae have one endemic species in WG and Kerala. Euphaeidae have five endemic species in WG but three in Kerala. Platycnemididae has 11 endemic species in WG but only 10 are found in Kerala. Family Coenagrionidae has four endemic species both in WG and Kerala. *Mortonagrion varalli* is considered as endemic to WG (Subramanian *et al.,* 2020) but as per Kalkman *et al.* (2020) it is also found in Bangladesh. Thus the WG harbours 80 endemic species of odonates of which Kerala has 68 species (See Table 2 for the list of endemic species).

***IUCN Status*:**

As per the IUCN (2021) Red List assessment one species, *Idionyx galeata* is categorized endangered and four species *viz., Heliogomphus promelas, Megalogomphus hannyngtoni, Melanoneura bilineata* and *Phylloneura westermanni* categorized near threatened and four species– *Chlorogomphus xanthoptera, Disparoneura apicalis, Indosticta deccanensis* and *Protosticta sanguinostigma* as vulnerable. Apart from above, 130 species of Odonata in WG belong to least concern status and 50 species to the data deficient categories. The status of 18 odonates has not been assessed so far (See Table 2 for the list of IUCN status of species).

In conclusion, we recognize 181 species belonging to 87 genera and 14 families of Odonata for Kerala, including 68 endemics. Studies on odonates of the Western Ghats have been meagre compared to vertebrate groups. There are many species that have been described in the times of FC Fraser in the first half of 1900's, but never found after the initial records. This means that there is a dearth of serious scientific works from the region. This paper provides an updated checklist of odonates of WG and Kerala and also enlists endemic species and those in IUCN Red List categories. Interestingly, none of the species is listed in Indian Wildlife (Protection) Act of 1972. The present study will open the way for more systematic assessment of odonates.

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Potential of *Blaptostethus pallescens* Poppius (Hemiptera: Anthocoridae) on *Tetranychus truncatus* Ehara (Prostigmata: Tetranychidae)

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ABSTRACT: Efficiency, functional and numerical responses of anthocorid bug *Blaptostethus pallescens* Poppius on the spider mite, *Tetranychus truncatus* Ehara were examined under laboratory conditions. Nymphs of *B. pallescens* exhibited a Hollings type II functional response when females of spider mite were offered at densities of 10, 20, 30, 40, 50, 60 and 70 mites/bug. Individual fifth instar bugs consumed up to 45.3 adult females of *T. truncatus* in 24 h at prey mite densities of 60 mites/ bug. Studies on numerical response revealed that the nymphs of the anthocorid bug failed to complete development when the food was restricted to mite alone. Numerical response studies on adult bugs, when offered *T. truncatus* at densities of 10, 20, 30, 40 and 50 females showed no significant differences in the average fecundity of the female bug. Results indicate that the anthocorid predator, *B. pallescens* has a very high predatory potential though with a weak numerical response.

KEYWORDS: Anthocorid bug, spider mite, functional and numerical responses

INTRODUCTION

Spider mites are highly polyphagous and have been reported to be serious pests of nearly 150 economically important species of plants. Farmers routinely resort to application of synthetic acaricides for mite in polyhouses, which results in pest resurgence as well as residue problems. Biological control of phytophagous mites using predators can be a much safer alternative to chemical control especially in protected cultivation (Yang *et al.,* 2014). Several arthropod natural enemies have been evaluated for their efficacy against spider mites under protected conditions. Predatory mites like *Neoseiulus longispinosus*, coccinellids such as *Stethorus* spp., thrips, lacewings and bugs have been evaluated for the biological control of phytophagous mites with varied results. Predatory anthocorids, remains the most sought-after natural enemies for mite pest management across countries like France, the United Kingdom, the Netherlands, Germany *etc.* (Ballal and Yamada, 2016). *Blaptostethus*

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pallescens Poppius (Hemiptera: Anthocoridae), has long been a promising natural enemy of spider mites, especially in protected cultivation.

Studies on functional and numerical responses of a predator help to assess its potential as a biocontrol agent since density responsiveness is considered as a desirable attribute for an effective natural enemy. Functional response is defined as number of hosts attacked by an individual natural enemy in relation to host density over a given time interval, while; numerical response is the increase in predator density as prey density increases and can result from increased rate of predator reproduction (reproductive response) and also from attraction of predators to prey aggregations (aggregation response) (Solomon, 1949). Very few studies have been reported on the functional and numerical responses of anthocorids in general and *B. pallescens* in particular. Hence, an attempt was made to assess its potential against the spider mite, *Tetranychus truncatus* Ehara (Prostigmata: Tetranychidae).

MATERIALS AND METHODS

Stock cultures

Nucleus culture of anthocorid bug *B. pallescens* was obtained from ICAR- National Bureau of Agricultural Insect Resources, Bengaluru. The bugs were reared in transparent plastic jars (1 l capacity, 9 cm diameter x 12.5 cm height) lined with tissue paper. A thin layer of absorbent cotton was provided at the base. UV sterilized eggs of rice meal moth were sprinkled over cotton on alternate days as food for the bug. Bean pods (*Phaseolus vulgaris* L.) cut into pieces were provided for oviposition. These jars were covered using muslin cloth, held in position by using rubber bands. The bean pod pieces in the jars were replaced daily with fresh pieces. Bean pods with eggs laid were placed in plastic jars with cotton at base for the eggs to hatch. The freshly emerged nymphs were provided UV sterilized rice meal moth eggs. Newly hatched adults (0-24 h old) were transferred into new plastic jars and rearing was carried out as described by Ballal *et al.* (2003).

Nucleus culture of spider mite *T. truncatus* was obtained from All India Network Project on Agricultural Acarology, College of Horticulture, Kerala Agricultural University and were multiplied on mulberry leaves as described by Bachhar *et al*. (2019). Mulberry leaves washed in water and wiped dry using a tissue paper were kept upside down on moistened synthetic absorbent sponge in plastic trays. Gravid females of *T. truncatus* were transferred onto the above mulberry leaves using a camel hair brush. Leaves were replaced with fresh ones every four days.

Functional response of *B. pallescens*

Mulberry leaf discs (4x4cm²) were placed upside down in Petri plates of 9 cm diameter and 1.5 cm height and lined with moistened absorbent cotton. Newly emerged adult females of *T. truncatus* were transferred on to leaf bits using camel hair brush to obtain densities of 10, 20, 30, 40, 50, 60 and 70 mites/ leaf disc. A single, 0-24 h old fifth instar nymph of *B. pallescens,* pre- starved for two hours, was released into each Petri plate. Petri plates were closed and sealed using cling film. Petri plates with mites but devoid of predator were maintained for each prey density to assess natural mortality if any. Each treatment was replicated four times. Number of mites killed by the anthocorid bug in 24 h was counted.

Numerical response of *B. pallescens*

Studies on numerical response of *B. pallescens* on *T. truncatus* involved two experiments. The first experiment attempted studying the numerical response of *B. pallescens* reared on the prey mite right from first instar onwards. The second experiment involved exposure of adult female bugs reared on *C. cephalonica* to prey mite, *T. truncatus* at varying densities.

a. Reared on *Tetranychus truncatus*

Mulberry leaf discs (4x4 cm²) were placed upside down in plastic boxes (10.5 cm diameter x 4.5 cm height) lined with moistened absorbent cotton. Females of *T. truncatus,* transferred on to the leaf bits using camel hair brush at five different densities

of 10, 20, 30, 40 and 50 per box constituted the treatments. Subsequently, a single 0-24h old first instar nymph of *B. pallescens* was released into each box. Each treatment was replicated thirty times. Number of prey in each box was maintained by replacing dead mites with live ones daily. The boxes were observed daily under stereo microscope to record the duration of different instars.

b. Reared on *Corcyra cephalonica*

Studies on numerical response were also carried out by using adult female bugs reared on *C. cephalonica* eggs. *B. pallescens* were reared on *C. cephalonica* eggs as described in stock culture. Fifth instar nymphs were separated out and reared to adults under constant observation. Newly emerged (0-24h old) male and female bugs were paired and transferred to individual boxes containing 20, 40, 60, 80 and 100 adult females of *T. truncatus* to yield predator prey ratio of 1:10, 1:20, 1:30, 1:40 and 1:50 respectively. Mulberry leaf discs containing prey mites were replaced daily with fresh pieces to maintain prey- predator ratio a constant. After the average pre oviposition period of four days, the females alone were retained in the container furnished with a piece of bean pod as oviposition substrate. The bean pods were replaced daily with fresh pieces. The bean pods provided on the previous day were examined under stereo microscope (30X) to count the number of eggs laid. Female longevity was also recorded.

Statistical Analysis

Functional response curve was determined by logistic regression of proportion of mites consumed as a function of initial density (Trexler *et al.*, 1988). Polynomial function from Juliano (1993) as given below was used to fit the data on proportion of *T. truncatus* killed.

$$\frac{N_e}{N_0} = \frac{\exp (P_0 + P_1N_0 + P_2 N_0^2 + P_3 N_0^3)}{1 + \exp (P_0 + P_1N_0 + P_2 N_0^2 + P_3 N_0^3)}$$

Where N_0 - was the initial prey density, Ne - the number of mites killed and Ne/N_0 represented the probability of mites being killed. The maximum likelihood estimates of the parameters P_0, P_1, P_2, and P_3 were obtained using logistic regression (CATMOD in SAS). The positive and negative signs of the significant linear (P_1), quadratic (P_2), and cubic (P_3) terms were used to determine the functional response type (Juliano 1993). Linear terms that did not differ significantly from zero indicated a type I functional response, a significant negative linear term suggested a type II response, and significant positive linear term indicated a type III functional response.

After determining the type of functional response curve, non- linear least square regression (proc NLIN in SAS) was done to estimate the parameters associated with Holling type models (Holling, 1966). As the prey mite numbers depleted during the experiment, the type II functional response random predator equation used was:

$$Ne = N_0 [1-\exp \{a (T_hNe - T)\}]$$

where, T_h is the handling time, T is the total time for which the bugs were exposed to prey mite and a is the predator attack coefficient or instantaneous searching rate (Rogers, 1972).

RESULTS AND DISCUSSION

Functional response of *B. pallescens*

Fifth instar nymphs of *B. pallescens* readily preyed upon adult females of *T. truncatus*. Highest mean mortality of 45.33 mites was observed at the predator – prey ratio of 1:60 and lowest mean mortality observed was 7.5 mites at density of 10 mites/ nymph (Fig. 1). Results from logistic regression showed that linear parameters were negative and significant (P value < 0.05) (Table 1), indicating *B. pallescens* exhibited a type II functional response.

Parameters associated with Holling's type models were estimated by non-linear least squares regression (Table 2). The attack rate (a) and handling time (T_h) for *B. pallescens* estimated using the random predator equation was respectively $0.041h^{-1}$ (SE = 0.0173) and $0 < T_h < 0.5060$ h (SE =0.3366).

Table 1. Maximum likelihood estimates of the parameters by logistic regression of proportion of *T. truncatus* killed by *B. pallescens* as a function of initial density

Parameter	Estimate	Standard error	X^2	P- value
Intercept	-0.3412	0.4500	0.57	0.4484
Linear (P1)	-0.0724	0.0215	11.34	0.0008
Quadratic (P2)	0.00101	0.000233	18.92	<0.0001

Numerical response of *B. pallescens*

a.* Reared on *T. truncatus

Though the developmental duration of different instars decreased as the density of prey mite offered increased, there was no significant difference between the various densities (Table 2).

Table 2. Mean duration of different instars of *B. pallescens* at varying prey density

Prey density	Duration of instars (days)				
	I	II	III	IV	V
T1 (1:10)	3.10				
T2 (1:20)	3.00				
T3 (1:30)	2.82	4.28	4.75		
T4 (1:40)	2.95	3.58	3.28	5	
T5 (1:50)	3.00	3.10	3.25	3.75	8

Further, the nymphs failed to complete nymphal stage in treatments offering *T. truncatus* at 10, 20, 30 and 40 mites/ nymph. Only one nymph at the predator prey ratio of 1:50 moulted into adult but was deformed.

b. Reared on *Corcyra cephalonica*

The mean number of eggs laid varied from 0.8 per female bug at a prey density of 1:20 to 3.4 at prey density of 50 mites/ female bug. No significant difference was observed among the different treatments. The number of female bugs that laid eggs were also recorded, and varied from 5 (50%) at the lower ratios of 1:20 and 1:30 to 8 (80%) at the higher predator prey ratios of 1:40 and 1:50.

Table 3. Mean fecundity and longevity of *B. pallescens* females at varying prey densities

Predator-prey ratio	Fecundity	No. of females that laid eggs	Longevity (days)
1:10	1.2	5	15.6
1:20	0.8	5	14.9
1:30	2.4	7	14.4
1:40	3.3	8	13.2
1:50	3.4	8	15.0

Mean longevity of females of *B. pallescens* varied from 13.2 days to 15.6 days and no significant variation was observed at different prey densities (Table 3).

B. pallescens exhibited a type II functional response on its prey, *T. truncatus* as the proportion of prey killed decreased as the prey density increased before reaching an upper plateau (predator prey density at 1:50 and beyond) at which satiation occurred (Fig. 2). The nature of response was further confirmed through logistic regression analysis in which the linear parameters were negative and significant.

These results are in agreement with the findings of Varshney *et al.,* (2020) who obtained a Hollings type II functional response curve of *B. pallescens* at different densities of blossom thrips, *Frankliniella schultzei* Trybom and that of Devi (2012) who obtained same type of functional response curve on eggs of *C. cephalonica* and handling time for the bug as 48 minutes. Type II functional response has also been reported in several

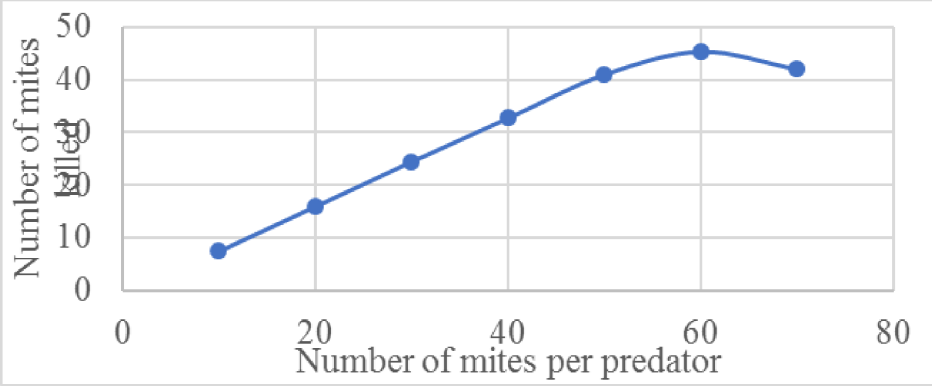

Fig 1. Number of mites killed at varying density

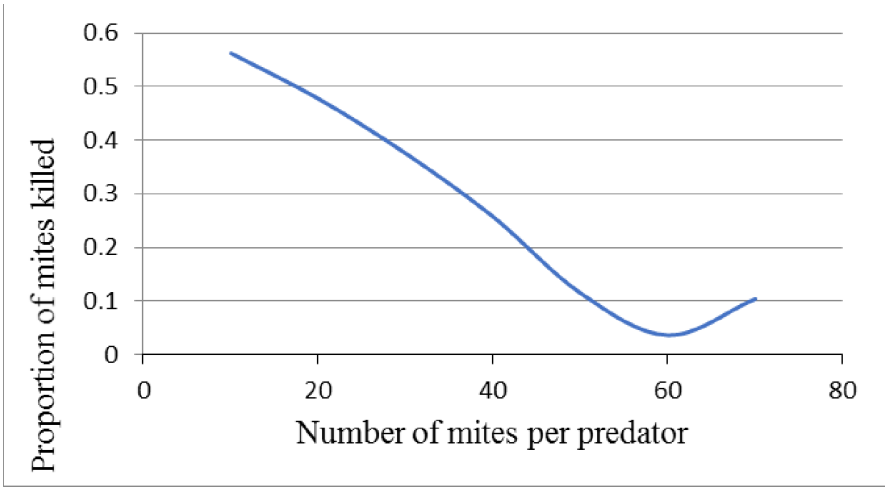

Fig 2. Proportion of mites killed at varying density

species of anthocorids like, *Orius. insidiosus* (Say) (Coll and Ridgway (1995) and *Anthocoris nemoralis* (F.) (Emami *et al*., 2014). Also, a number of studies have credited anthocorid bugs, including *B. pallescens,* with type III functional response. Queiroz *et al.* (2015) reported that *B. pallescens* and *Amphiareus constrictus* (Stal) showed a type III functional response when fed on eggs of tomato pin worm, *Tuta absoluta* (Meyrick) at different densities. The influence of environmental conditions on predator responses, as brought out in case of *B. pallescens* at two different temperatures also could account for the variability among different studies (NBAIR, 2019).

The type II nature of functional response of *B. pallescens* reveals that the bug does not show any delay in initiating predation. Hence, the bug would be an efficient predator at low prey densities. Many predators that have shown type II functional response under laboratory conditions have proved to be successful biocontrol agents in field (Xiao and Fadamiro, 2010). Further, the shorter handling time for *B. pallescens* in the study also indicates its higher predation rate as predators with longer handling time shows a tendency to saturate faster (Kisdi and Liu, 2006).

Numerical response studies showed that *B. pallescens* nymphs were unable to complete development (Table 2) on *T. truncatus.* Similar results were reported by Devi (2012), who observed that nymphs of *B. pallescens* failed to complete fourth instar stage when reared on

T. urticae, suggesting that spider mites could be poor hosts for anthocorid bugs. On the other hand, Srikumar *et al*. (2017) and Ballal *et al*. (2009) reported that *B. pallescens* was able to complete development when reared on spider mites. Inability of *B. pallescens* to effect complete control of *T. urticae* was also observed by Ballal *et al.* (2009) and the effect of host plants of two spotted spider mite on the reproductive biology of *B. pallescens* was reported by El- Basha (2016).

In numerical response studies using adult female bugs, the average number of eggs laid per female bug on the whole increased as the prey mite density increased with no significant difference among various treatments (Table 3). The highest mean fecundity of 3.4 eggs, was recorded at the peak density of 50 mites/female. It is noteworthy that the number of female bugs that laid eggs also had increased progressively as the prey mite density increased. While there are few studies of a similar nature for comparison of the above results, Viswanathan and Ananthakrishnan (1974) observed an increase in field population of anthocorid predator following a rise in population of *Megalurothrips distalis, Frankliniella schultzei* and *Haplothrips ganglbaueri*, though the contribution of resident females to the population increase is not clear. Coll and Ridgway (1995), likewise observed an increase in egg laying by the anthocorid bug *Orius insidiosus* at increased densities of *Frankliniella occidentalis* on bean and corn. A positive density response was also reported by Scutareanu *et al.* (1999) who observed that number of anthocorid bugs showed a positive correlation with that of pear psyllids.

Apparently, longevity of adult females of *B. pallescens* was not affected by the quantity of prey mite offered. Tangkawanit *et al*. (2018) similarly observed that the longevity of mirid predator, *Cyrtorhinus lividipennis* was not affected by the density of its prey, *Nilaparvata lugens*.

On closer observation, duration of different nymphal instars of *B. pallescens* found to have been extended on *T. truncatus,* when compared with that on *C. cephalonica* eggs. Further, average fecundity and adult longevity of the bug was far less when compared with those on other hosts. Average duration of different nymphal instars was 2.64, 1.93, 2.01, 2.5 and 5.1 days respectively from first to fifth instars when reared on *C. cephalonica*. An average of 134 eggs was laid and females lived for 52 days on rice meal moth eggs (Jose and Subramanian, 2020). This is consistent with earlier studies with extended nymphal period when *B. pallescens* was reared on mites. (Ballal *et al.*, 2009; Devi, 2012). Sudies have pointed out the significant reduction in fecundity of *B. pallescens* reared on mites. Tawfik and El- Husseini (1971), for instance, recorded mean fecundity of *B. pallescens* as 78 when the bugs were fed with lepidopteran larvae as against 5.7 eggs when reared on mites. Devi (2012) documented that no egg laying was observed when newly emerged adults of the bug were given *T. urticae* as food. Remarkably lower adult longevity was also documented by Ballal *et al*. (2009), who observed that the longevity of adult female of *B. pallescens* bugs was only 21 days when fed on *T. urticae*, while it lived up to two months on *C. cephalonica*. El- Basha (2016) also reported that female longevity was only 17.7 days when fed on spider mites on cucumber. Even though *B. pallescens* exhibited a very weak numerical response with *T. truncatus*, predatory capacity of the bug is very high and hence, can bring down the population of spider mites to a safer level with augmentative releases at initial stages of spider mite infestation.

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Distribution pattern of chigger mites in south Tamil Nadu, India

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ABSTRACT: Chiggers, the larval Trombiculid mites are the vectors for scrub typhus. Rodents and shrews are the preferred host. Study made at different habitats of chiggers collected in rodents and shrews, revealed more number to *Rattus rattus* 95(63%) and *Suncus murinus* 33(22%). *Rattus rattus* 31(54%) and *Suncus murinus* 17(30%) alone contributed more in chigger positivity. Chigger mites belonged to eight species under five genera. *Leptotrombidium deliense* (66%), *Schoengatiella ligula* (15%), and other chiggers (9%) were collected from 57 positive rodents. Seasonally, there was a significant difference in rodent positivity, and there was no significant difference in the number of chiggers collected. The study indicated the prevalence of chiggers in the various hosts and their variation in rodent/shrew hosts. *R. rattus* 31(54%) and *S. murinus* 17(30%) contributed more in chiggers infestation and seasonally wet-cool months favored more chiggers and host positivity from different habitats.

KEY WORDS: Trombiculidae, larval mites, abundance, rodents, shrews

INTRODUCTION

There are 700 harmful species of mites described worldwide (Goddard, 2012) and 250 species are recognized in public health importance (Hoy, 2012). All mites are hemimetabolous, very tiny, microscopic parasites showing with four pairs of legs, but larvae have three pairs (Johnston, 1982; Evans, 1992). Trombiculoidea, superfamily of mites (Acari: Acariformes) are more medically-important (Shatrov and Kudryashova, 2006). In the subfamily trombiculinae of trombiculide family, 195 species in 24 genera of mites have been recorded in India which is being associated with animal hosts includes tribes Trombiculini, Schoengastiini, and Gahrliepiini (Stan Fernandes and Kulkarni, 2003). Larval stage of Trombiculide mites known as chiggers a vector for scrub typhus, which is transmitted through the rodent hosts (Pratt, 1963) and chiggers are parasites to mammals, reptiles, birds, and occasionally arthropods (Azad, 1986). Chiggers are usually found on parts of the animal hosts that have been in contact with the ground and are also localized in and around the ears (Azad, 1986). The chiggers are habitat-specific and host-specific (Nadchatram, 1970; Sasa, 1961) and occur on multiple host taxa,

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but rodents and shrews are the most commonly infested (Lawrence, 1951; Goff, 1979; Dong *et al*., 2009; Mariana *et al*., 2000). Goff (1979) confirmed that trombiculids are more adopted in habitat-specific rather than host-specific. A large number of chiggers that are found as a group usually attack the host, resulting in multiple grouped bites on infested hosts (Traub and Wissernan, 1974).

Leptotrombidium deliense is a species of chigger mite, the main vector of scrub typhus (tsutsugamushi disease) found in many parts of the world, particularly in the Asia-Pacific region called the Tsutsugamushi triangle with the countries, South Korea, Japan, China, Thailand, India, Indonesia, Taiwan, the Philippines, and northern Australia (Oaks *et al*., 1983; Xu *et al*., 2017; Kelly *et al*., 2009). In India, among the various species of chiggers recorded, *L. deliense* is the dominant species for the spread of scrub typhus (Chakraborty and Sarma, 2017). *Schoengastiella* sp. has also been suggested as a vector for the spread of scrub typhus, but remains controversial (Santibanez *et al*., 2015; Tilak *et al*., 2011). Philip Samuel *et al*. (2021a) reported in the scrub typhus reported areas in Madurai District. A follow up longitudinal study was made at different habitats to observe the seasonal distribution and host preference of chiggers collected in rodents and shrews and results reported here..

MATERIALS AND METHODS

Study sites: The Madurai district is located in south Tamil Nadu of India, lies between 9°33'30''N to 10°18'50'' N Latitude, 77°29'10''E to 78°28'45''E Longitude and has an area extent of 3710 sq. km (https://madurai.nic.in/district-profile/). The selection of different habitats was made based on surrounding agro-ecosystem and nine study sites each as B.B.Kulam, Tirumangalam, Usilampatti (Urban), Peraiyur, Keelaiyur, Sholavandan (Semi-urban), Vadapalanji, Katchaikatti, and Chatrapatti (Rural).

Seasonal classification of the study sites: The Madurai district is experienced with four different seasons which are South-West Monsoon, North-East Monsoon, winter, and summer. Continuous southwest and northeast monsoons in the region for a period of 7 months from June to December was the main water resource, used for agriculture and drinking purposes, led to the increased vegetations by agronomy practices developed fertile soils and the abundance of rodent pests. For data analysis, all monthly data was grouped according to seasons. Madurai district received a total annual rainfall of 848 mm from July 2017 to June 2018 with 74% rain (626 mm) and very low total rainfall of 13.4 mm during winter (January to March 2018) and 115.6 mm during summer was notice. The mean temperature during from wet-cool to dry-cool months (January-February 2018) was 26.2°C (Statistical Hand Book, 2019) (Fig.1).

Collection of mites from rodents: At every site, before the dusk hours (5-6 pm), Sherman traps (width 7.5 cm, length 18.5 cm, and depth 9 cm) were kept in and around residential areas in indoor and outdoor households and withdrawn after dawn time (6-7 am) in the next day. All the rodents were attracted by fried eatables smeared with coconut oil kept within the Sherman traps and captured. The design of the Sherman trap was made to capture only a single rodent at a time and, after trapping a single rodent, the door of the trap will close automatically (Philip Samuel *et a*l., 2020, 2021a). Captured pest rodents and shrews were identified based on external morphology (Shakunthala and Tripathi, 2005; Dinesan *et al*., 2006).

To collect various small rodents, 1080 Sherman traps were placed in the study sites during the study period from July 2017 to June 2018, as a total of 360 Sherman traps were placed in each urban, semi-urban and, rural habitats (i.e., 120 traps were placed/site/year in the 9 study sites). For every month, 9 visits were made with three sites each from the urban, semi-urban, and rural habitats selected, for the collection of rodent chiggers. All the trapped rodents were placed in separate cloth bags and brought to the laboratory and the captured rodents were anesthetized for the collection of mites as per the guideline followed by Philip Samuel *et al*. (2020, 2021a). Collected mites and other ectoparasites were mounted in Hoyer's medium (Philip Samuel *et al*., 2021b), examined under the

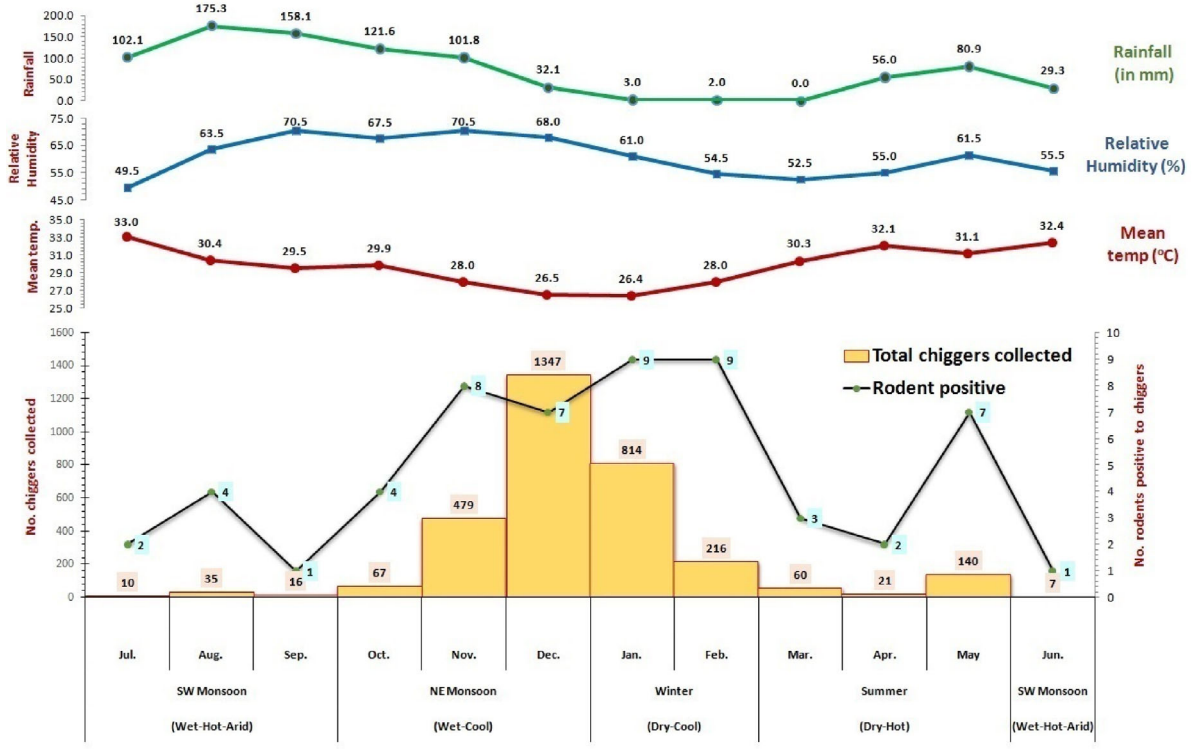

Fig. 1. Season wise positive rodents trapped and number of mites collected from study sites

microscope, and identified up to species level, following standard taxonomical keys (Stan Fernandes and Kulkarni, 2003). All collected specimens were deposited in the Mosquito and Ectoparasites Museum, Entomology laboratory of ICMR-Vector Control Research Centre Field station, Madurai, Tamil Nadu, India. This study was approved by the Institutional Committee (IAEC) of ICMR-Vector Control Research Centre, Puducherry.

Data analysis: The computer software IBM SPSS Ver.25 was used to analyze statistical data. For spot mapping and location measures, GPS-based Epi Map - Epi Info Ver. 7.2.2.6 of CDC, Atlanta, USA (powered by ESRI) was used. The website www.d-map.com was helpful to download Indian states and district-level politically. To estimate Trap Positivity Rate (TPR) for the trapped rodents, the following formula was used (Philip Samuel *et al*., 2020, 2021a).

$$\text{Trap Positivity Rate} = \frac{\text{No. of positive trap collected}}{\text{No. of traps fixed}} \times 100$$

$$\text{Chigger Infestation Rate} = \frac{\text{No. of chigger mites collected}}{\text{No. of rodents/shrew collected with chigger mites}} \times 100$$

$$\text{Chigger Index} = \frac{\text{No. of chigger mites collected}}{\text{No. of rodents/shrew collected}}$$

RESULTS AND DISCUSSION

A total of 1080 Sherman traps were placed in the 9 study sites of three different habitats. Only 151 rodents/shrews were trapped. The overall trap positivity rate was 14per cent, and rural habitat was showing with high trap positive rate (18.06%) and there was a significant difference ($\div^2$=10.409, df 2, $p<0.05$) in the trap positivity for the rodents trapped at the different habitats, which means there was no equality of rodents trapped at all the habitats

Table 1. Host positive, number chiggers and indices calculated month-wise during 2017- 2018

Month	No. hosts trapped (R/S)			No. hosts positive			Chigger collected			Chigger Infestation Rate			Chigger Index		
	U	SU	R	U	SU	R	U	SU	R	U	SU	R	U	SU	R
July 2017	2	2	3	0	1	1	0	7	3	0.00	0.00	3.00	0.00	3.50	1.00
August	3	2	3	1	2	1	10	11	14	10.00	5.50	14.00	3.33	5.50	4.67
September	2	3	2	0	1	0	0	16	0	0.00	0.00	0.00	0.00	5.33	0.00
October	2	3	3	1	1	2	13	23	31	13.00	23.00	15.50	6.50	7.67	10.33
November	4	6	7	1	3	4	43	125	311	43.00	41.67	77.75	10.75	20.83	44.43
December	4	7	9	2	2	3	324	402	621	162.00	201.00	207.00	81.00	57.43	69.00
January18	6	9	11	2	3	4	250	321	243	125.00	107.00	60.75	41.67	35.67	22.09
February	3	6	9	2	2	5	85	47	84	42.50	23.50	16.80	28.33	7.83	9.33
March	1	3	5	1	1	1	33	6	21	33.00	6.00	21.00	33.00	2.00	4.20
April	3	3	4	0	1	1	0	12	9	0.00	0.00	9.00	0.00	4.00	2.25
May	3	5	6	2	2	3	27	44	69	13.50	22.00	23.00	9.00	8.80	11.50
June	2	2	3	0	0	1	0	0	7	0.00	0.00	7.00	0.00	0.00	2.33
Total	35	51	65	12	19	26	785	1014	1413	65.42	53.37	54.35	22.43	19.88	21.74

Note: R/S- Rodents/ Shrews; U-Urban; SU- Semi Urban; R-Rural

Table 2.Host-wise chigger mite species examined at different habitats in Madurai, India

Habitat	Chigger mite species	Host/ number of chiggers					Total chiggers
		Rr	*Rn*	*Sm*	*Bb*	*Ti*	
Urban	*Leptotrombidium deliense*	122	11	155	23	0	311
	Leptotrombidium indicum	8	0	11	2	0	21
	Leptotrombidium rajesthanensis	0	0	9	0	0	9
	Oribatida mites*	1	0	0	0	0	1
	Schoengastia sp.	3	0	6	0	0	9
	Schoengatiella ligula	20	2	31	9	0	62
Semi Urban	*Leptotrombidium deliense*	191	3	225	12	0	431
	Schoengatiella ligula	43	0	60	6	0	109
	Leptotrombidium indicum	26	1	44	0	0	71
	Trombicula hypodermata	3	0	12	0	0	15
	Leptotrombidium keukenschrijveri	0	0	9	3	0	12
	Leptotrombidium rajesthanensis	0	0	9	0	0	9
	*Liponyssoides sanguineus**	0	0	0	2	0	2
Rural	*Leptotrombidium deliense*	320	5	250	23	42	640
	Leptotrombidium indicum	114	2	27	0	6	149
	Schoengatiella ligula	40	0	85	0	24	149
	Leptotrombidium keukenschrijveri	25	0	0	0	0	25
	Leptotrombidium rajesthanensis	11	0	13	0	0	24
	Trombicula hypodermata	9	0	12	0	2	23
	Microtrombicula sp.	3	0	11	0	0	14
	Neotrombicula microti	0	0	4	0	3	7
	*Liponyssoides sanguineus**	1	0	0	2	0	3
	Echinolaelaps sp*	1	0	0	0	0	1
	Total	941	24	973	82	77	2097

Note: *-Adult mites; R/S- Rodents/ Shrews; R-Rural; Rr - *Rattus rattus; Rn - Rattus norvigecus; Sm - Suncus murinus; Bb - Bandicota bengalensis; Ti - Tatera indica*

studied. Only 57(37.7%) rodents were positive for chiggers and 12(21.05%), 19(33.33%), and 26(45.61%) positive rodents were trapped from urban, semi-urban, and rural habitats respectively. However, there was no significant difference (÷2=0.3241, df 2, p>0.05) in chigger infestation for the rodents trapped in the different habitats. A total of 3212 chiggers including 7 adult mites were collected in all the habitats and only 2096 (65%) mites were identified. Out of 3212 mites collected, 785(24.44%), 1014 (31.57%), and 1413 (43.99%) were respectively from urban, semi-urban and rural habitats. However, the urban habitat was showing with high chigger Infestation rate of 22.43 (Table 1 and 2).

Among the 151 trapped rodents/shrews, 95 (63%) were *Rattus rattus* and 33 (22%) *Suncus murinus* and only 31 (15%) were other rodents (Fig. 1). *Tatera indica* was trapped only in rural sites. Out of 151 trapped rodents/shrews, 57(37.75%) rodents/shrews were positive to chiggers. *R. rattus* 31 (54%) and *S. murinus* 17(30%) contributed more in chigger positivity. Other rodents contributed less in chigger positivity 9 (16%) and *Mus musculus* was negative in chiggers. From a total 2096 mites identified, 413 (19.70%), 648 (30.92%), and 1035 (49.38%) were collected from urban, semi-urban, and rural sites respectively. Among the 2096 mites, 2089 were chiggers and 10 were different species of mites. There were 1382 *L. deliense* (66%), 320 *S. ligula* (15%), 241 *L. indicum* (12%) , 42 *L. rajesthanensis* (2%) and 104 other chiggers (5%).

There was a significant difference among the seasons in rodent positivity (F=7.093, df 3, p<0.05), and there was no significant difference among the seasons in the number of chiggers collected (F=2.262, df 3, p>0.05). A total of 2437 chigger mites (76%) were collected during cool months (wet and dry cool months) from November 2017 to February 2018, indicating wet and dry cooler months favored chiggers. The total rodents trapped during these four months were 81 (53.64%). Among these 17 (48.57%), 28 (54.90%) and 36 (55.38%) rodents/shrews were trapped at urban, semi-urban and rural sites respectively, during wet and dry cool months (Fig. 1). The lowering temperature was positively correlated with increasing density of chiggers and rodent positivity. However, *M. musculus* was negative to chiggers. The primary scrub typhus vector *L. deliense* collected more during cooler months. Moist soil after rainy seasons and cooler temperature favored rodent mite contact.

Temperature affects development of *L. deliense.* Optimum temperature for the growth and activities of chiggers was 23–25°C, and for scrub, typhus transmission required temperature was 18–30°C (Traub and Wissernan, 1974). The cooler months in south India was favored to scrub typhus cases and increase chiggers' density (Mathai *et al*., 2003). During the cooler months of September 2012 to March 2013 in south India, more scrub typhus cases were recorded (Stephen *et al*., 2015). In Tamil Nadu and Puducherry, more scrub typhus cases occurred during cooler months (October 2013-January 2014) and chigger mites were more from October to December 2013 (Sadanandane *et al*., 2016). Scrub typhus cases were reported in the Madurai district during 2016, but the distribution pattern of chiggers on rodents/shrews were limited and chigger positive *R. rattus, R. norvegicus, M. musculus,* and *S. murinus* trapped were more (Philip Samuel *et al*., 2021a).

In the present study the density of chigger mites increased during cooler months followed by a rainy north-east monsoon, and the temperature was lower after rainy seasons. In Thailand, Burma and India, scrub typhus is most common from June until November, but present throughout the year (Elliot *et al*., 2019). Except in May, scrub typhus cases were reported in all the months in Tamil Nadu and Puducherry (Philip Samuel *et al*., 2021c; Sadanandane *et al*., 2016; Devaraju *et al*., 2020). The study indicated the prevalence of chiggers in various hosts and their variation in rodent/shrew hosts.

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Record of *Apochrysa evanida* Gerstaecker, 1893 (Neuroptera: Chrysopidae) from the Western Ghats, India

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ABSTRACT: *Apochrysa evanida* Gerstaecker, 1893 belonging to the Chrysopidae family of Neuroptera is reported for the first time from the Western Ghats and Kerala state. The species is described with its distribution.

KEYWORDS: Report, *Apochrysa evanida,* Kerala, distribution

The order Neuroptera includes 5,813 species worldwide (Oswald and Machado, 2018; Oswald, 2021) and 327 species reported from India, under 115 genera and 12 families (Singh *et al.,* 2020). Chrysopidae (geen lacewings) is the second-largest family of Neuroptera with over 1,200 species belonging to 80 genera (Brooks and Barnard, 1990) from the world, of which 70 species under 22 genera have been reported from India (Singh *et al.,* 2020). Chrysopidae comprises three extant subfamilies: Nothochrysinae, Chrysopinae and Apochrysinae. Apochrysinae (delicate lacewings) is the smallest subfamily, globally comprises 26 species under six genera. Only three species under two genera are known from India (*Joguina nicobarica* (Brauer, 1864) from Assam, *Joguina unimaculata* Winterton, Balakrishnan and Chenthamarakshan, 2021 from Kerala and *Apochrysa evanida* Gerstaecker, 1893 from Karnataka) (Ghosh, 2000; Winterton and Brooks, 2002; Chandra and Sharma, 2009; Winterton and Gupta, 2020; Winterton *et al.,* 2021). *Apochrysa* Schneider is the predominant genera of Apochrysinae with 10 species reported worldwide (Winterton and Gupta, 2020). Species under this genus are distributed throughout the world, including Afrotropical, Palaearctic, Oriental and Oceanian realms. *A. evanida* (vanishing delicate lacewing) is the only species reported under *Apochrysa* from India, but it is not reported so far from the Western Ghats region (Ankita Gupta, Pers. comm.) (Winterton and Gupta, 2020). *A. evanida* was collected from the Western Ghats as well as from Kerala and details presented.

Specimens were collected using a sweep net from Valliyoorkavu, Wayanad. The surrounding habitat is semi-closed forest with large trees and thick vegetation. Later the collected specimens were killed with 2 to 3 drops of ethyl acetate using a killing jar. After this, specimens were dried and held on entomological pins with proper labelling. The specimens were examined under Labomed Luxeo 6Z Stereomicroscope. The terminology of wing venation and identification followed Breitkreuz *et*

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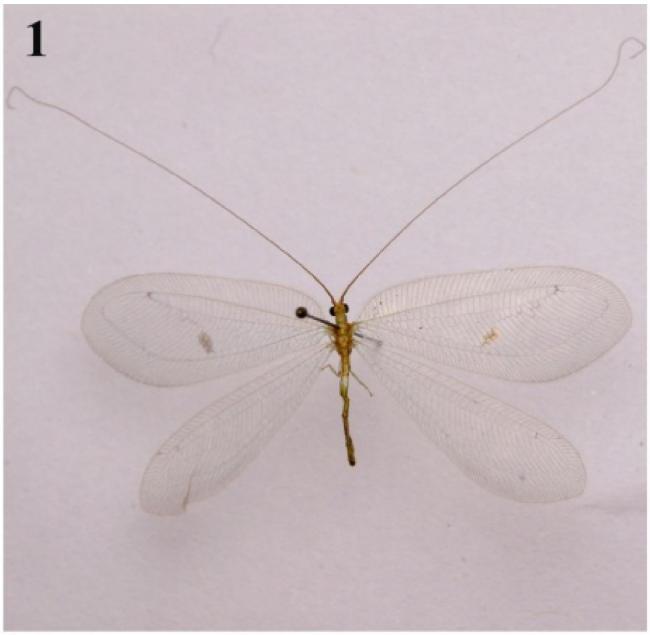

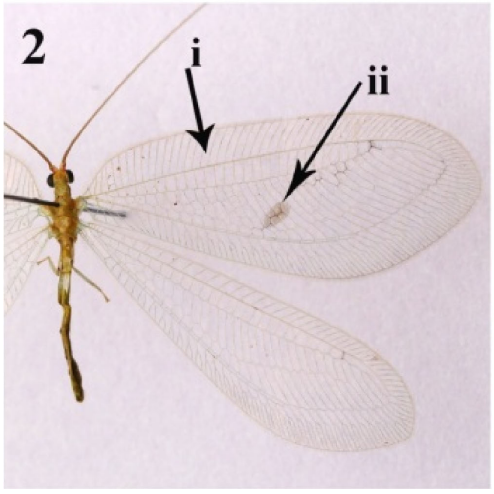

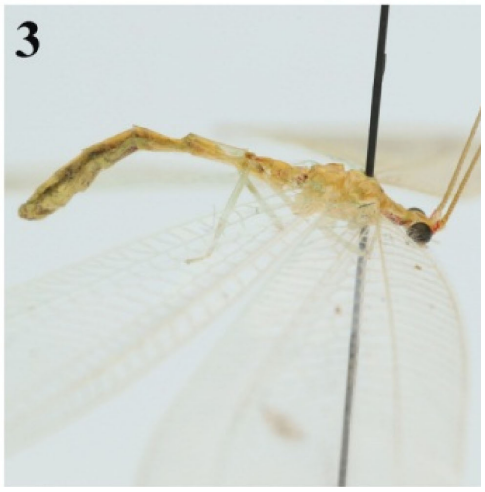

Fig. 1: Habitus of *Apochrysa evanida*
Fig. 2-i: Costal area with un-forked subcostal veinlets; Figure 2-ii: Dark ovoid spot along inner gradate series
Fig. 3: Lateral view of *Apochrysa evanida*

al., (2017) and Winterton and Gupta (2020). The digital photos of the specimens were taken with Canon 7D Mark II digital camera with a 100 mm F/2.8L macro lens. The specimens were deposited in the insect collections of Shadpada Entomology Research Lab (SERL), Kerala, India.

Apochrysa Schneider, 1851

1851. *Apochrysa* Schneider, *Bers. Ent. Ztschr.,* **5** (20):16.

Diagnosis: Costal area of forewing simple, lacking interconnecting cross-veins and subcostal veinlets not forked (Fig. 2-i); markings in wings only along inner gradate series and (sometimes) pterostigma.

Distribution: India, South Africa, Tanzania, Australia (including Norfolk Island), Comoros Islands, Sao Tome, Madagascar, Japan, China (including Taiwan), eastern Indonesia, Papua New Guinea, Rwanda, Kenya, New Caledonia, Vanuatu, Solomon Islands.

***Apochrysa evanida* Gerstaecker, 1893**

1893. *Synthochrysa evanida* Gerstaecker, *Mitteilungen des Naturwissenschaftlichen Vereins fur Neu-Vorpommern u. Rugen* 25: 154.

Diagnosis: Forewing with three gradate series; a dark ovoid spot midway along inner gradate series (Fig. 2-ii); hindwing with two gradate series without markings.

Description: Male: Head and two basal segments of antennae dark yellow and rest of antennal segments light yellow (Figs. 1, 3). Length 19 mm from head to abdomen and 2 mm wide. Pronotum, mesonotum and metanotum light green. Hyaline broad wings with green veins. Costal area with subcostal veinlets mostly simple, unforked and lacking interconnecting cross-veins. Forewing 23 mm long and 9 mm wide. Dark ovoid spot in middle of inner gradate series of forewing. Pterostigma long with light green veins. Hindwing narrower than forewing (22 mm long and 6 mm wide) with two gradate series without any markings. Abdomen greenish yellow with small white hairs. Males are easily distinguished from females by their sternite 8+9 fused and absence of microtholi.

Materials examined: 2♂♂, India: Kerala: Wayanad: Valliyoorkavu, 11.8044° N, 76.0300° E, 12-II-2021, Altitude 747m, Suryanarayanan T. B., SERLNR110, SERLNR111.

Distribution: Karnataka (Bengaluru) and Kerala (Wayanad)

Considering the geographic position of Western Ghats and its diverse ecosystem, the recorded faunal richness of Chrysopidae with only 23 species belonging to 10 genera (Singh *et al.,* 2020) indicates a need of further exploration. *A. evanida* was recorded for the first time from the Western Ghats as well as from Kerala.

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Report of *Sastroides besucheti* Medvedev (Coleoptera: Chrysomelidae) on Malabar nutmeg

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ABSTRACT: Massive infestation of *Sastroides besucheti* Medvedev (Coleoptera: Chrysomelidae), is reported on Malabar nutmeg *Myristica malabarica* Lam.(Myristicaceae), endemic to south India. All the 25 trees in the study area were infested; however, the intensity was lesser on male plants. Eggs, larvae, prepupae and pupae were observed. Pattern of egg laying, feeding habit of grubs and site of pupation were recorded. Infested female trees shed more than 70 per cent of the leaves and the branches dried up from tip downwards. Survival and regeneration of heavily infested female trees are doubtful. This is the first report of *S. besucheti* on *M. malabarica*.

KEY WORDS: Infestation, biology, native host, Western Ghats, India

The pantropical family Myristicaceae in India is represented by 20 species in five genera (Banik *et al*., 2017; Govind *et al*., 2020; Govind and Dan, 2020). The genus *Myristica* Gronov. comprises six species in India, including the introduced *M. fragrans* Houtt., the nutmeg of commerce (Banik *et al*., 2017; Govind *et al*., 2020). Of the six species of *Myristica* found in India, all except *M. andamanica* Hook., occur in south India. All the four native species in the mainland India *viz. M. beddomei* King, *M. magnifica* Beddome, *M. malabarica* Lamarck and *M. trobogarii* Govind & Dan are endemic to south India (Nayar *et al*., 2014; Banik *et al*., 2017; Govind *et al*., 2020).

Myristica malabarica, commonly called Malabar nutmeg, false nutmeg or Bombay nutmeg, is an evergreen tree reaching a height of 25 – 30 m. Its seeds are harvested from the wild and are used as an adulterant of nutmeg of commerce (Khare, 2007). In homesteads, farmers retain stray plants as they yield seeds and aril, which is a source of additional income. The plant is placed in the IUCN Red List as 'vulnerable'.

The leaf beetle *Sastroides besucheti* (Coleoptera, Chrysomelidae) was described by Medvedev (1999) based on 15 specimens collected at Periyar in Idukki District in Kerala. Prathapan and Balan (2016) reported *S. besucheti* as a pest of nutmeg, *M. fragrans* for the first time, from the same district. They observed heavy leaf shedding and drying up of branches, however, no immature stage of the beetle was observed. They also commented that nutmeg being an introduced plant; it is most likely that the beetle has other native plants as hosts.

Massive infestation of *S. besucheti* on *M. malabarica* was observed in Koottakkal, Kamakshi Panchayath, Idukki District, Kerala (N 9^0 49' 26'',

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E 77^0 02' 20''). The infestation was noticed in a farm of nearly 15 acres. Main crops were cardamom, nutmeg, banana, mango, citrus, jack as well as a few subtropical fruit trees. Twenty five Malabar nutmeg trees (four 16-year old and twenty one 12-year old) were present in the field and they were widely spaced. Among the 25 trees in the study area, only two were male plants. Field visits were carried out on 10 and 28 July and 8 August, 2021 and the nature of damage and immature stages of the pest were observed.

At the time of our first observation on 10 July, 2021, several thousands of beetles were seen feeding on the leaves. The beetles were not active but had a tendency to move to the nearby plants when disturbed. All Malabar nutmeg trees were infested, however, the intensity was low on the two male plants. During our first observation, adults alone were seen feeding on the leaves by scraping the green matter, leaving characteristic scars (Fig. 6). Feeding scars were also seen on the tender stem. Almost all the beetles were in copula during the initial observation (Fig. 1). During the second visit on 28 July, 2021, 17 days after the first observation, adult population was reduced to about one tenth of the earlier, and they were not in copula (Fig. 2). However, immature stages such as eggs and larvae of various instars were observed. The number of egg masses on male trees was lesser than those on the females. The population of grubs was very high on each tree and all larval instars were observed feeding by scraping the green matter of the leaves. On 8 August 2021, 28 days after the first visit, the adult beetles had vanished, however, grubs of all instars were seen feeding on the remaining 10 % of the green leaves. Thousands of final instar grubs, which had stopped feeding, were also noticed in groups on the soil surface as well as on the nearby walls. Hundreds of quiescent grubs, in the prepupal stage were seen in soil (Fig. 12).

Plenty of egg masses were observed on the abaxial surface of leaves. A characteristic pattern of egg laying was noticed on the leaves. Round, creamy white eggs were closely packed. The egg masses were mostly attached to the side of the midrib and were covered with frass (Figs. 9 and 10). Frass covering of the fresh egg masses were wood colored and later turned to black. Number of eggs per clutch was 12 - 16. In the heavily infested trees, 70% of the leaves had more than one egg mass on its abaxial surface.

First instar grubs were nearly 1.5 mm in length and started scraping the green matter on the adaxial surface of the leaves, soon after emergence. They were flat and remained in the feeding area in thickly packed aggregations. They continued feeding till the green matter was finished. Fecal pellets were attached to the posterior end as a thread, which on detachment formed a mass of thread behind the larval aggregations (Fig. 3). Size of the grubs ranged from 1.5 - 13 mm, depending on the instar (Fig. 11). Grubs were creamy white to dark gray. The size of grubs on the same leaf varied greatly. A few sluggish ones were observed among plenty of very small and large active grubs. Grubs feeding on the remaining green leaves on the trees were mostly early instars, however, those feeding on the fallen leaves were late instars. Final instar grubs measured 12 – 13 mm. Light green, C-shaped prepupae confined to specific small pockets, in earthen cells, were observed in soil at a depth of about 3 - 7 cm (Fig. 12). Within three days, the prepupae moulted to form pupae which were exarate, yellow, about 5 - 5.5 mm long and 3.5 – 4 mm wide (Figs. 13 and 14).

Trees shed more than 70% of the leaves and the branches dried up from tip downwards. Heavy leaf shedding and dried up feeding scars on the remaining leaves together presented a completely dried up appearance to the evergreen host trees (Figs 4, 5, 7 and 8). Survival and regeneration of the heavily infested female trees are doubtful.

The adults and larvae fed only on the Malabar nutmeg while the nearby crops in the field were left unscathed. Nutmeg plants, *M. fragrans*, present amongst the infested Malabar nutmeg trees in the study area also escaped the infestation. Previous report of *S. besucheti* Medvedev (Prathapan and Balan, 2016) on nutmeg plants in Idukki district may be an example of host shift from a native plant species to an introduced host. This is

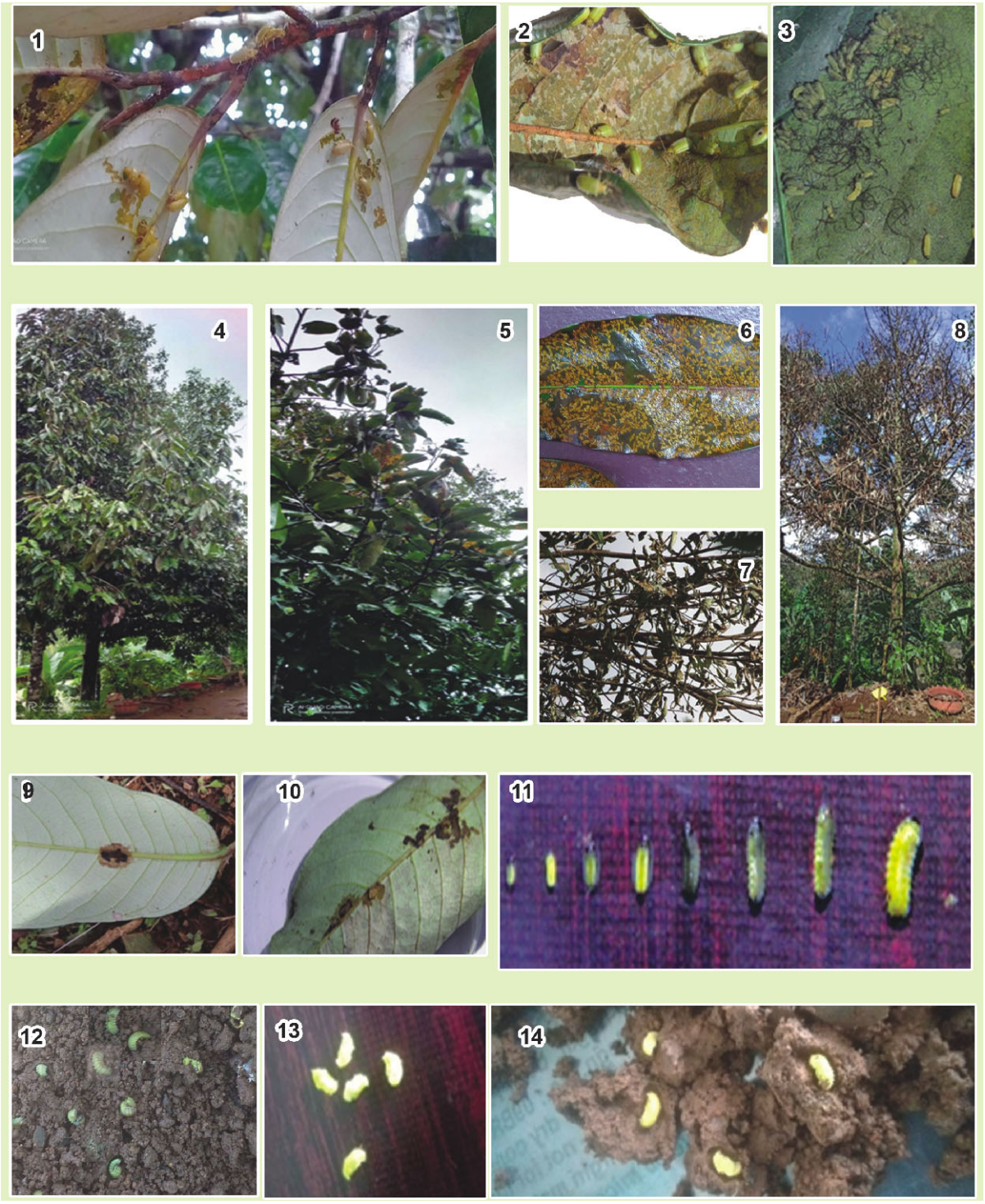

Fig. 1-14. *Sastroides besucheti* on *Myristica malabarica*. 1, 2. Adults feeding on leaves, 3. Feeding troughs of grubs, 4, 5. A female plant and its branches during first visit; 6. Adult feeding troughs, 7, 8. Heavily infested tree with dried up leaves, 9, 10. Egg masses on the abaxial surface of the leaves attached to the midrib, 11. Grubs, 12. Pre-pupae, 13, 14. Pupae

the first report of *S. besucheti* on its native host *M. malabarica* as well as its immature stages . Voucher specimens of *S. besucheti* are deposited in the Travancore Insect Collection, Kerala Agricultural University, Vellayani.

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Comparative efficacies of insecticides and botanicals against rice gall midge, *Orseolia oryzae* (Wood-Mason) and their effect on the parasitoid *Platygaster oryzae* in rice ecosystem of Odisha, India

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ABSTRACT: A field experiment was carried out to determine the comparative efficacy of newer insecticides with botanical insecticides, viz., Chlorantraniliprole 0.4G @ 10 kg ha^{-1}, Fipronil 5 SC @ 1500 ml ha^{-1}, Acephate 95 SG @ 750 g ha^{-1}, Lambda cyhalothrin 4.9 CS @ 550 ml ha^{-1}, Thiamethoxam 25 WG @ 150 g ha^{-1} @ Carbofuran 3 CG @ 30 kg ha^{-1}, Carbosulfan 25 EC @ 875 ml ha^{-1}, Cedarwood oil @ 1000 ml ha^{-1}, Azadirachtin 0.03 EC @ 2500 ml ha^{-1}, applied at 20 and 35 DAT, against rice gall midge, *Orseolia oryzae* (Wood-Mason) in rice during *kharif,* 2019 and 2020. All the treatments were effective for gall midge. Lambda cyhalothrin 4.9 CS @ 550 ml ha^{-1} was significantly superior (>80% reduction over control) for gall midge management and grain yield was 4.75 t ha^{-1}. Both botanical and untreated plots had more number of parasitized gall midge (40- 53.3%) than other chemical treated plots.

KEYWORDS: Gall midge, management, newer insecticides

Rice is an important cereal crop of the world and staple food crop for more than two third of the Indian population and more than 65 per cent of the world population (Mathur *et al.,* 1999). More than 90 per cent of the world's rice is grown and consumed in Asia. But, its production is affected by the infestation of various insect pests. Almost 300 species of insect pests attack the rice crop at different growth stages and among them only 23 species cause notable damage. Asian rice gall midge (GM), *Orseolia oryzae* (Wood-Mason) is one of them. Although occasional outbreaks of this insect were reported prior to the 1960s (Bennett *et al*., 2004), but the problem became extensive after the introduction and widespread cultivation of dwarf and high-yielding rice varieties. It has been prevalent in almost all the rice growing states in India except the Western Uttar Pradesh, Uttaranchal, Punjab, Haryana and Hill states of Himachal Pradesh and Jammu & Kashmir (Bennett *et al.,* 2004; Seni and Naik, 2019). In Asia it has been reported in several countries including India, Bangladesh, China, Cambodia, Indonesia, Lao PDR, Myanmar, Sri Lanka, Thailand, and Vietnam. Whereas, the African rice gall midge, *Orseolia oryzivora* Harris and Gagne (AfRGM) is reported in several African

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countries (Bennett *et al*., 2004). They attack rice from seedling to the end of tillering stage and cause an annual yield loss of 0.8% of the total production, amounting to US$80 million (Bennett *et al*., 2004). It is also observed that in some areas in Odisha, hybrid rice recorded as much as 90% crop damage with a yield loss of about 70% (Seni and Naik, 2019). The external symptom of damage caused by gall midge is the production of a silvery-white, tubular leaf sheath gall called *silver shoot* or *onion shoot*. This is due to the feeding and salivary secretion by the larvae which turn the growing shoot meristem into a gall (Bentur *et al.,* 1992). This renders the tiller sterile and do not bear panicle (Seni and Naik, 2017).

The pest occurs regularly in Hirakud command area of Sambalpur district of Odisha and is regarded as a key pest of rice. Farmers of this region apply mainly red level insecticides like carbofuran 3G, phorate 10G indiscriminately in order to manage them. However, increased use of these insecticides causes environmental pollution, mortality of natural enemies and health problems. Although previously many conventional insecticides have been evaluated against this insect, most of the chemicals have failed to provide adequate control (Misra and Sahithi, 2006; Das and Mukherjee, 2003). Application of some botanicals against gall midge showed some promising results (Seni, 2019). Use of botanicals not only reduce the use of synthetic insecticides but also reduce the cost of pest management programme as well as they are eco-friendly in nature. Therefore, an effort was made to find suitable alternative insecticides and use in a rational way. Beside this, the effect of the insecticide

Table 1. Efficacy of different insecticides and botanicals against gall midge in rice in 2019 and 2020

Treatment and dose	% SS* in 2019		Mean % SS	% SS 2020		Mean % SS
	30 DAT#	45 DAT		30 DAT	45 DAT	
Carbofuran 3 CG @ 30 kg ha^{-1}	6.34 (2.61)	4.44 (2.22)	5.39 (2.42)	8.76 (3.04)	4.66 (2.26)	6.71 (2.68)
Acephate 95 SG @ 750 g ha^{-1}	11.78 (3.50)	9.75 (3.20)	10.76 (3.36)	15.77 (4.03)	11.50 (3.46)	13.63 (3.75)
Fipronil 5 SC @ 1500 ml ha^{-1}	5.69 (2.48)	4.31 (2.19)	5.00 (2.34)	11.84 (3.49)	7.35 (2.79)	9.60 (3.16)
Carbosulfan 25 EC @ 875 ml ha^{-1}	9.59 (3.17)	6.52 (2.64)	8.05 (2.92)	15.58 (3.99)	9.49 (3.15)	12.53 (3.61)
Lambda cyhalothrin 4.9 CS @ 550 ml ha^{-1}	4.66 (2.26)	2.85 (1.82)	3.75 (2.06)	6.10 (2.57)	3.26 (1.93)	4.68 (2.27)
Azadirachtin 0.03 EC @ 2500 ml ha^{-1}	8.06 (2.92)	7.25 (2.78)	7.66 (2.85)	13.51 (3.66)	8.50 (3.00)	11.00 (3.37)
Cedar wood oil @ 1000 ml ha^{-1}	7.27 (2.78)	6.43 (2.63)	6.85 (2.71)	13.30 (3.71)	7.78 (2.87)	10.54 (3.32)
Thiamethoxam 25 WG @ 150 g ha^{-1}	9.84 (3.21)	8.11 (2.93)	8.98 (3.08)	18.19 (4.32)	13.03 (3.68)	15.61 (4.01)
Chlorantraniliprole 0.4G @ 10 kg/ha	12.55 (3.61)	11.02 (3.39)	11.79 (3.50)	15.79 (4.03)	13.22 (3.69)	14.51 (3.86)
Untreated control	17.77 (4.26)	24.36 (4.98)	21.07 (4.64)	27.15 (5.25)	30.31 (5.55)	28.73 (5.40)
S.Em	0.14	0.11	0.08	0.21	0.15	0.13
CD (5%)	0.41	0.31	0.25	0.63	0.45	0.39

Figures in parentheses are square root transformed values, SS: Silver shoot, DAT: Days after transplanting

Table 2. Efficacy of different insecticides and botanicals against gall midge, % SS reduction over control and gall midge parasitization in rice (Mean of 2019 and 2020)

Treatment and dose	SS (%)	SS reduction (%)	Parasitization (%)	yield (t/ha^{-1})
Carbofuran 3 CG @ 30 kg ha^{-1}	6.05 (2.56)	76	0.00	4.47
Acephate 95 SG @ 750 g ha^{-1}	12.20 (3.56)	51	13.33	4.31
Fipronil 5 SC @ 1500 ml ha^{-1}	7.30 (2.79)	71	13.33	4.57
Carbosulfan 25 EC @ 875 ml ha^{-1}	10.29 (3.28)	59	6.67	4.32
Lambda cyhalothrin 4.9 CS @ 550 ml ha^{-1}	4.22 (2.17)	83	20.00	4.75
Azadirachtin 0.03 EC@ 2500 ml ha^{-1}	9.33 (3.12)	62	40.00	4.34
Cedar wood oil @ 1000 ml ha^{-1}	8.69 (3.03)	65	46.67	4.28
Thiamethoxam 25 WG @ 150 g ha^{-1}	12.29 (3.58)	50	13.33	4.28
Chlorantraniliprole 0.4G @ 10 kg/ha	13.15 (3.69)	47	33.33	4.82
Untreated control	24.90 (5.04)	-	53.33	3.27
SEm	0.08			0.05
CD	0.24			0.14

Figures in parentheses are square root transformed values, SS: Silver shoot, DAT: Days after transplanting

on egg-larval parasitoid *Platygaster oryzae* was also studied.

The experiment was conducted in the experimental farm of Regional Research and Technology Transfer Station (OUAT), Chiplima, Sambalpur, Odisha, during *kharif,* 2019 and 2020 in Randomized Block Design (RBD), having 9 treatments which were replicated thrice in a net experimental area of 5 m x 4 m each. The Station is situated at 20^{0}21' N latitude and 80^{0}55'E longitude in Dhankauda block of Sambalpur district at an altitude of 178.8 m above MSL. The climate of the area is warm/sub humid. Nursery of rice variety MTU-7029 (Swarna) was sown in the July and transplanting was done after 25 days of sowing at 20 cm x 15 cm hill spacing. All the agronomic practices were followed during crop growth period. The treatments (Table 1- 2) were applied at 20 and 35 days after transplanting (DAT) except untreated control. Gall midge incidence as silver shoot was recorded from 10 randomly selected hills per plot from each replication at 30 and 45 DAT and then percentage of silver shoot was worked out. To observe the effect of insecticides on natural enemies of gall midge, silver shoots were collected at 45 and 60 DAT from the treated plot and were kept in test tubes and waited for the emergence of natural enemies if any parasitization occurred there. The mean value of data obtained from field experiments were transformed into square root values and analyzed statistically by ANOVA. The grain yield was recorded in plot basis and expressed in ton per hectare.

Among different treatments, lambda cyhalothrin 4.9 CS @ 550 ml ha^{-1} was recorded to be significantly superior (>80% reduction over control) in efficacy against gall midge in both seasons. Next best treatment was carbofuran 3 CG (76% reduction over control) followed by fipronil 5 SC (71% reduction over control). thiamethoxam 25 WG, acephate 95 SG and chlorantraniliprole 0.4G treatments were at par with each other in gall midge management. From the experimental results, it was also observed that all the tested products minimized the infestation of gall midge and reducing the formation of silver shoots as compared to the

untreated control. It was also observed that infestation of gall midge in terms of silver shoot was higher in *kharif* 2020 in comparison to *kharif* 2019. In the treated plots, in 2019 the gall midge infestation recorded as silver shoot ranged from 3.75 to 11.79% as against 21.07% in control. Whereas, in 2020 the silver shoot ranged from 4.68 to 15.61% as against 28.73% in untreated control (Table 1). All botanical treatments also reduced gall midge (6.85-7.66% and 10.54-11% in *kharif* 2019 and 2020, respectively) and among them cedarwood oil @ 1000 ml ha^{-1} showed better efficacy than other treatments (average 8.69%).

Gall midge parasitization was more (53.33%) in untreated plots (Table 2) followed by azadirachtin 0.03 EC and cedarwood oil (40 and 46.67% respectively). Shrivastava *et al.* (1987) studied the natural enemies of gall midge at Raipur, India and found that the predominant parasitoid was *P. oryzae* and was responsible for 0- 68% parasitization of gall midge. Among insecticide treatments Carbofuran treated plots had no parasitized gall midge whereas Chlorantraniliprole treated plots had more parasitized gall midge.

Significant differences were observed in grain yield among the treatments and control in both the seasons. Based on yield, chlorantraniliprole treated plot recorded the highest mean grain yield of 4.82 t ha^{-1}, followed by lambda cyhalothrin 4.9 CS with 4.75 t ha^{-1} and were significantly at par with each other whereas in control yield was 3.27 t ha^{-1}. Among the botanicals, azadirachtin 0.03 EC treated plot recorded highest yield of 4.34 t ha^{-1} followed by cedarwood oil treated plot and which was significantly at par with each other (Table 2).

The present findings revealed that all the tested products were effective in reducing the infestation of gall midge as compared to the untreated control. But, among the different treatments, application of lambda cyhalothrin 4.9 CS @ 550 ml ha^{-1} at 20 and 35 days after transplanting was very effective for the management of rice gall midge and next best treatment was the application of carbofuran 3 CG. Our results in accordance with the findings of Misra and Parida (2004) who observed that the synthetic pyrethroid containing other combined insecticides like acephate, quinolphos, profenophos and chlorpyriphos were effective against gall midge. The present findings are in line with the findings of Mardi *et al.* (2009) and Seni and Naik (2018) who reported the effectiveness of carbofuran against gall midge. Das and Mukherjee (2003) reported that fipronil was effective against rice gall midge. Among the botanicals, both (azadirachtin 0.03 EC and cedarwood oil) had moderate effects against gall midge. It was observed that although chlorantraniliprole was not so much effective against gall midge during both the years but the yield was highest in this treatment. This may be due to its greater efficacy against various key lepidopteran pests like yellow stem borer and leaf folder in rice than other treatments. Regarding parasitization botanicals were safe against *P. oryzae* whereas carbofuran was toxic to them. Application of lambda cyhalothrin 4.9 CS @ 550 ml ha^{-1} or azadirachtin 0.03 EC @ 2500 ml ha^{-1} or cedarwood oil @ 1000 ml ha^{-1} at 20 and 35 days after transplanting can effectively manage the gall midge in rice.

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Biology of *Attagenus fasciatus* Thunberg (Coleoptera: Dermestidae) on four different diets of animal origin

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ABSTRACT: Biology of dermestid beetle, *Attagenus fasciatus* was studied on four different diets of animal origin included dried silkworm pupae and moths of *Bombyx mori*, feathers of white leghorn and on an equal mixture of fur of goat and sheep under laboratory conditions, to know the dietary effect on the developmental process. The mean incubation period was 12-16 days. There were 10-12 larval instars. The life-cycle on four different diets of animal origin varied. On dried silkworm pupae, total larval period ranged from 243 to 298 days and total life-cycle 267-326 days; on dried silk moths, total larval period was 251-307 and total life-cycle 272-330 days; on feathers of white leghorn, total larval period was 264-329 and total life-cycle was 288-355 days, and on an equal mixture of fur of goat and sheep, total larval period was 273-317 and total life-cycle was 297-343 days.

KEY WORDS: Dermestid beetle, dried silkworm pupae, silk moths, feathers and fur

According to Hava (2015) the family Dermestidae includes 66 genera and 1648 species and subspecies. Ecology and classification of dermestid beetles of Palearctic fauna is given by Zhantiev (2009). Dermestid beetles feed on a wide variety of food materials of both animal and vegetable origin (Hinton, 1945). According to review article (Rajendran and Hajira Parveen, 2005) insect pests including dermestid beetles found attacking different types of animal products. *Attagenus fasciatus* Thunberg (Coleoptera: Dermestidae) was reported attacking on different materials such as peanuts, skins, furs, feathers, silk, woolen goods, insects and ground nuts as summarized by Hinton (1945). It has been reported as a pest of house-hold articles in Sweden (Mathlein, 1971). The beetle is widely spread in the tropics and sub-tropics where it is found in stored products and house-hold articles (Halstead, 1974-75), in pharmacies and drug stores in West Germany (Weidner, 1973), on cotton seed meal, cereals and legumes in Humberg (Piltz, 1975), on tobacco seeds in India (Patel and Chari, 1977), in Cargoes from India in U.S.S.R (Belskaya and Popova, 1978), in feed mills and feed stores (Loschiaro and Okumura, 1979), on silkworm cocoons in India (Ansari and Basalingappa, 1985, 1989), on stored groundnuts (Rao *et al.,* 1987), from stored woolen and other keratenaceous materials form India (Veer *et al.,*1991), stored silkworm cocoons in India (Veer *et al.,* 1996), from Italy (Hava and Nardi, 2007), from Qatar (Hava and Pierre, 2008), from UAE (Hava, 2009), found damaging silkworm cocoons in grainages and stores (Shashi Kanta, 2016), from Guatemala (Ochaeta and Hava, 2019), from Nambia (Herman and Hava, 2019) and from Bali Island (Hava and Suprayitno, 2020). Attempts were made to study the biology of *A. fasciatus* by Patel and Chari (1977), Rao *et al.,*

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(1987), Veer *et al.,* (1991) and Ali *et al.,* (2011) on different food materials, temperature and relative humidity. The aim of present study was to know the biology of the beetle *A. fasciatus* on four different diets at room temperature and relative humidity and the dietary effect on the developmental process.

The larvae of different instars of *A. fasciatus* were collected from the mini filature center and grainage at Rayapur, Hubli-Dharwad (India) and reared on dried silkworm pupae of *Bombyx mori* in plastic containers under laboratory conditions. Freshly emerged imagines were collected from the laboratory rearing stock and were allowed to mate. The mated females were separated and kept them singly in the plastic containers (3" x 2") provided with silkworm cocoons as substrate for egg-laying. After oviposition, the eggs laid during first two days were collected and used to study the entire life-cycle on four different diets of animal origin such as dried silkworm pupae and moths of *B. mori*, feathers of white leghorn and an mixture of fur of goat and sheep under laboratory conditions, room temperature 22.6° C – 31.9° C (22.63 ± 1.0) and relative humidity 62.5% -88.5% (79.09 ± 0.60).

The incubation period of egg was 8-13 days and there were 11-12 larval instars. The last instar larvae observed, stopped feeding and remained quiescent for 3-5 (4.2 ± 0.3) days. At the last larval instar, the larval skin found split along the mid dorsal line and the split commenced from the epicranial suture and extended backwards up to the seventh abdominal segment. The newly formed pupae remained within the last larval skin, the exuviae. At the end of pupation, the imagines emerged and remained as quiescent stage in the last larval skin for 5-7 (6.2 ± 0.4) days. The pupal covering was found shriveled up and attached to the tip of the abdomen of imagines. Total incubation period, larval period, pupal period and total life-cycle period varied on four different diets of animal origin (Table 1).

The life-cycle parameters on dried silkworm pupae were as follows, observed total larval period was ranged between 243-298 days, with a mean of 272.17 ± 5.16 days pupal period was 13-15 (13.59 ± 0.23) days and total duration to complete life-cycle was 267-326 (295 ± 5.47) days. Further on dried silk moths, total larval period was 251-307 (282.09 ± 6.0) days, pupal period was 12-15 (13.09 ± 0.32) days and total life-cycle was 272-330 (305.09 ± 6.04) days. On feathers of white leghorn, total larval period was 264-329 (294.30 ± 6.44) days, pupal period was 12-15 (14.10 ± 0.32) days and total life-cycle was 288-355 (311.20 ± 6.47) days. Similar observations on another diet (equal mixture of fur of goat and sheep) revealed that total larval period was 273-317 (290.90 ± 4.64) days, pupal period was 12-15 (14.30 ± 0.30) days and total life-cycle was 297-343 (315.80 ± 4.52) days.

The larval period was of 243-298 (272.17 ± 5.16) days, was less when the larvae fed with dried silkworm pupae followed by 251-307 (282.09 ± 6.0) days on dried silk moths. The larval period on feathers and fur was almost same (264-329 (294.30 ± 6.44) and 273-317 (290.90 ± 4.64) respectively. The pupal period was 12-15 days on all the four diets, not much difference was found.

Table 1. Developmental periods (days) of *Attagenus fasciatus* on different diets of animal origin

Diet	Incubation	Larval	Pupal	Total
Dried silkworm pupae	8-13 (10.50 ± 0.46)	243-298 (272.17 ± 5.16)	13-15 (13.59 ± 0.23)	267-326 (295.08 ± 5.47)
Dried silk moths	8-13 (10.07 ± 0.45)	251-307 (282.09 ± 6.0)	12-15 (13.09 ± 0.34)	272-330 (305.09 ± 6.04)
Feathers of white leghorn	8-13 (10.86 ± 0.46)	264-329 (294.30 ± 6.44)	12-15 (14.10 ± 0.32)	288-355 (311.20 ± 6.47)
Mixture of fur of goat and sheep (1:1)	8-13 (10.64 ± 0.39)	273-317 (290.90 ± 4.64)	12-15 (14.30 ± 0.30)	297-343 (315.80 ± 4.52)

Table 2. Comparison of present results of Biology of *Attagenus fasciatus* with earlier reports

Authors, diet, temperature and humidity	Incubation period (days)	Larval period (days)	Larval instars	Pupal period (days)	Total (days)
Patel and Chari (1977) Tobacco Seeds Room temperature and humidity	7-9	204-492	10-18	5-10	——-
Rao et al., (1987) Groundnuts (25 ± 1)° C and 75 ± 10% RH	7	399	——	17	——-
Ali et al., (2011) Dried child milk 30° C and 40% RH	5-9 (6.6 ± 0.3)	657-1000 (889.8 + 83.1)	9-19	8-17 (12.6 + 0.7)	——-
30° C and 60% RH	5-10 (7.4 + 0.5)	535-610 (583.8 + 13.3)	16	7-12 (10.5 + 0.5)	——-
30° C and 80% RH	7-13 (8.5 + 0.5)	254-374 (341.0 + 22.5)	9-13	8-9 (8.3 + 0.3)	——-
35° C and 40% RH	3-5 (4.0 + 0.3)	321-432 (356.8 + 19.8)	12-17	6-9 7.6 + 1.1)	——-
35° C and 60% RH	3-6 (4.5 + 0.4)	226-295 (255.2 + 12.1)	5-15	7-9 (8.0 + 0.7)	——-
35° C and 80%	4-6 (5.1 + 0.3)	101-150 (122.4 + 9.53)	6-9	8-10 (8.5 + 0.7)	——-
Present study: 22.6° C – 31.9° C (22.63 ± 1.0) and 62.5% -88.5% (79.09 ± 0.60)					
Dried silkworm pupae	8-13 (10.50 ± 0.46)	243-298 (272.17 ± 5.16)	11-12	13-15 (13.59 ± 0.23)	267-326 (295.08 ± 5.47)
Dried silk moths	8-13 (10.07 ± 0.45)	251-307 (282.09 ± 6.0)	11-12	12-15 (13.09 ± 0.34)	272-330 (305.09 ± 6.04)
Feathers of white leghorn	8-13 (10.86 ± 0.46)	264-329 (294.30 ± 6.44)	11-12	12-15 (14.10 ± 0.32)	288-355 (311.20 ± 6.47)
Mixture of fur of goat and sheep (1:1)	8-13 (10.64 ± 0.39)	273-317 (290.90 ± 4.64)	11-12	12-15 (14.30 ± 0.30)	297-343 (315.80 ± 4.52)

It is well established fact that the temperature and relative humidity influences the developmental process of insects. Patel and Chari (1977), Rao *et al*. (1987), Veer *et al*. (1991) and Ali *et al*. (2011) reported the biology of *A. fasciatus* by on different food materials, temperature and relative humidity. The present study showed significant variations with that of the earlier studies (Table 2).

The incubation period was 8-13 days and larval instars were 11-12 on all the four diets, differ significantly when compared with that of earlier studies. According to Esperk *et al*. (2007) intraspecific variability in the number of larval instars is a widespread phenomenon across insect taxa; documented for more than 100 species in which various factors affecting the number of instars like temperature, photoperiod, food quality, humidity, injuries, inheritance and sex. The variations were because of the effect of temperature, relative humidity and food materials fed to the larvae of *A. fasciatus*.

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Macrohymenopteran diversity in Thommana Kole wetland, Thrissur, India

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ABSTRACT: The study conducted on the diversity of macrohymenoptera at the Thommana Kole wetland, Thrissur, Kerala revealed 36 species from 24 genera and 9 families.

KEYWORDS: Abundance, Hymenoptera, wetlands.

Wetlands supports rich biodiversity by providing many unique habitats for organisms and hence known as biological supermarkets (Mitsch and Gosselink, 2000). Wetlands in Kerala are very important ecosystems. In 2002, Kole wetlands were declared as Ramsar sites which increased the importance (Jayson, 2018). Kole wetlands are the water-logged, paddy cultivating areas and cover an area of 13,632 ha and spread over the Thrissur and Malappuram districts of Kerala (Johnkutty and Venugopal, 1993).

A study was conducted from October to December 2019 to analyze the relative abundance of macrohymenopteran insects at the Thommana Kole wetland of Thrissur, Kerala. The term macrohymenoptera is followed in this work, which normally includes larger species and with numerous veins in their forewing (Mason and Huber, 1993). Thommana (10^0.3463 N 76^0.2541 E) is a village in Irinjalakuda block in the Thrissur district of Kerala state, India. It is a highly diverse and productive ecosystem. The study site is a part of Muriyad Kole, which is a freshwater wetland (Thomas *et al*., 2003). Line transect method was used to survey the study site. The macrohymenopterans were collected by using a sweep net and by handpicking. Periodic collection of macrohymenopterans was done twice a month, taken in the morning from 8:00 am to 11:00 am. Ethyl acetate was used for killing the collected specimens. The killed specimens were dried and preserved for further study. Liquid preservation is used for the temporary storage of ant specimens until the specimens were card mounted for species identification. 70% ethanol is used as preservation fluid. The specimens were kept in small vials filled with alcohol, labelled and checked periodically. The specimen as such and its photographs were taken for identification. Identification was done up to the maximum possible level with the help of hymenopteran experts.

Altogether 36 species belonging to 24 genera and 9 families of macrohymenoptera were recorded during the period of study. Fig. 1 represent number of individuals collected from each genus. Families include Halictidae, Apidae and Megachilidae of bees; Vespidae, Scoliidae, Ichneumonidae, Mutillidae and Sphecidae of wasps and Formicidae of ants. Specimens were identified to

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morphospecies level or RTU (Recognizable Taxonomic Units). Family Apidae showed the highest relative abundance (30.50%) and Megachilidae and Mutillidae recorded the lowest value (0.85%) (Table 1).

A total of 14 plant species belonging to 8 families were identified from which bees, ants, and wasps are collected. Some of these plants belong to the category of weeds and invasive species. Fifteen species of bees from 6 genera and 3 families were collected from the study area (Table 1). Thirteen species are solitary bees and 2 bees belonging to the genus *Apis* Linnaeus are social bees. Halictidae is the species-rich family with *Nomia* Latreille being the most speciose genus. Prakash *et al*. (2020) prepared a checklist of bees of Kerala and listed 86 species of bees under 19 genera. During this study conducted within a period of 3 months, in Thommana, 15 species reported point towards the richness of bees in the Thommana kole wetland ecosystem.

The most speciose genus of bees was *Nomia* Latreille. Weather conditions had a major influence in the collection of bee specimens. Sunny days were ideal for good collection than rainy or wet conditions. *Mimosa pudica* Linnaeus and *Mimosa diplotricha* Sauvalle are common host plants from which *Nomia* Latreille and *Ceratina* Latreille are collected. In the present study, 6 genera of bees belonging to 3 families were collected from 7 plant species (*Sphagneticola trilobata* (L.) Pruski, *Mimosa diplotricha* Sauvalle, *Mimosa pudica* Linnaeus, *Ipomoea carnea* Jacq., *Spermacoce articularis* Linnaeus, *Mikania micrantha* Kunth and *Ziziphus oenoplia* (L.) Miller) belonging to six families, Asteraceae, Fabaceae, Convolvulaceae, Rubiaceae, Rhamnaceae and Lamiaceae.

A total of 13 species of wasps from 13 genera and 5 families were collected from the study area (Table 1). Vespidae is the species-rich family of wasps. Fifty species of hymenopterous insects under 42 genera were reported during the study done by Rajkumari *et al.* (2014) from Assam in which wasps constitute 13 genera which is similar to our work. Family Vespidae has the second largest relative abundance (19.50%). Observed list of the preferred plants of wasps include *Acacia mangium* Willd., *Ipomoea carnea* Jacq., *Ziziphus oenoplia* (L.) Miller, *Aniseia martinicensis* (Jacq.) Choisy, *Mikania micrantha* Kunth and *Melochia corchorifolia* Linnaeus. The most dominant species was *Ropalidia brevita* Das and Gupta which was recorded from the *Acacia mangium* Willd. and *Aniseia martinicensis* (Jacq.) Choisy. *Vespa*

Table 1: Macrohymenopteran species collected from the wetland and relative abundance (RA) of families

Species	**Family**	RA %
Apis dorsata Fabricius *Apis cerana* Fabricius *Ceratina binghami* Cockerell *Amegilla* sp.; *Xylocopa* sp.	Apidae	30.50
Nomia sp 1. *Nomia* sp 2. *Nomia* sp 3. *Nomia (Leuconomia)* sp 1. *Nomia (Leuconomia)* sp 2. *Nomia (Leuconomia)* sp 3. *Nomia (Gnathonomia)* sp. *Nomia (Curvinomia)* sp. *Nomia (Hoplonomia)* sp.	Halictidae	15.25
Megachile sp.	Megachilidae	0.85
Ropalidia brevita Das and Gupta *Vespa tropica haematodes* Bequaert *Apodynerus troglodytes* (de Saussure) *Antepipona* sp. *Polistes stigma tumulus* (Fabricius)	Vespidae	19.50
Phalerimeris phalerata turneri (Betrem) *Micromeriella marginella* (Klug)	Scoliidae	5.93
Sceliphron madraspatanum (Fabricius) *Chalybion bengalense* (Dahlbom) *Ammophila* sp.	Sphecidae	5.08
Metopius sp.; *Goryphus* sp.	Ichneumonidae	3.39
Karlissaidia sp.	Mutillidae	0.85
Diacamma scalpratum (Smith) *Odontomachus simillimus* Smith *Polyrhachis proxima* Roger *Polyrhachis exercita* (Walker) *Polyrhachis convexa* Roger *Polyrhachis lacteipennis* Smith *Myrmicaria brunnea* Saunders *Monomorium pharaonis* (Linnaeus)	Formicidae	18.64

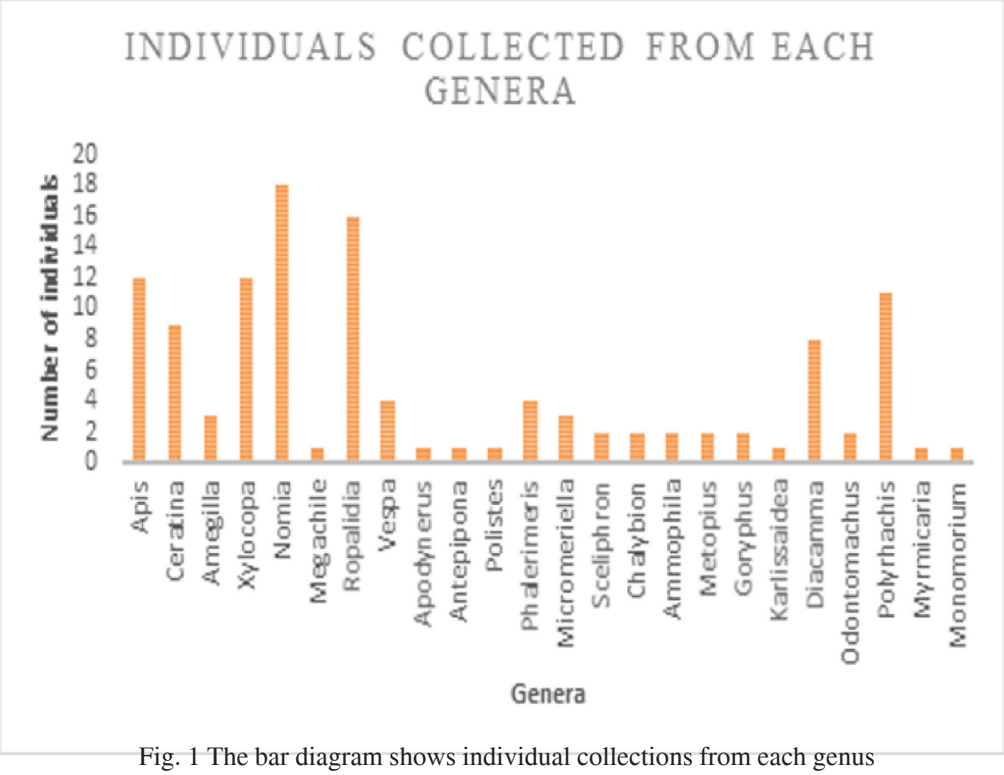

Fig. 1 The bar diagram shows individual collections from each genus

tropica (Linnaeus) was recorded from two plants, *Ipomoea carnea* Jacq. and *Ziziphus oenoplia* (L.) Miller. A common plant, *Mikania micrantha* Kunth supports two species, *Micromeriella marginella* (Klug) and *Metopius* sp.

A total of 8 species of ants from 5 genera (Table 1) were collected from the study area. Formicinae is the species-rich subfamily of ants. The genera *Polyrhachis* Smith dominate the collection with a maximum number of species. Many species of ants were also noted from the plants. Ants were mainly observed from plants *Ziziphus oenoplia* (L.) Miller, *Crotalaria pallida* Aiton and *Mucuna pruriens* (L.) DC. *Polyrhachis* Smith is the most diverse genera with 4 species (*P. proxima* Roger, *P. exercita* (Walker), *P. convexa* Roger and *P. lacteipennis* Smith). *P. proxima* is the most dominant ant species in the study.

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