

# APPENDICES

## APPENDICES

**Appendix 1:** List of collection sites, geographical coordinates, and habitats.

Sl. No.	Collection sites	Districts	Latitude (N)	Longitude (E)	Habitat type
1.	Thycaud	Thiruvananthapuram	8°29'30.11"	76°57'53.61"	Irrigation canal
2.	Vellayani	Thiruvananthapuram	8°25'31.46"	76°59'33.37"	Lake
3.	Chemmanmukku	Kollam	8°53'10.89"	76°36'7.41"	Pond
4.	Aranmula	Pathanamthitta	9°19'41.42"	76°41'3.22"	River
5.	Punnamada	Alappuzha	9°30'3.57"	76°20'46.93"	Lake
6.	Kuttanad	Alappuzha	9°30'56.49"	76°22'42.62"	Lake
7.	Chengalam	Kottayam	9°35'34.03"	76°27'17.25"	Agricultural fields
8.	Kumarakom	Kottayam	9°37'40.95"	76°25'46.09"	Backwaters
9.	Kodimatha	Kottayam	9°34'39.82"	76°31'8.51"	Lake
10.	Kavanattinkara	Kottayam	9°37'42.23"	76°25'35.75"	Lake
11.	Vembanad	Kottayam	9°37'58.22"	76°25'21.02"	Backwaters
12.	Parampuzha	Kottayam	9°36'15.84"	76°32'21.92"	River
13.	Kumaranalloor	Kottayam	9°37'24.43"	76°31'38.67"	Pond
14.	Muttom	Idukki	9°50'31.88"	76°44'24.32"	Forest streams
15.	Adimali	Idukki	10°0'41.41"	76°57'10.01"	Forest streams

16.	Ooramana	Ernakulam	9°57'58.64"	76°30'24.21"	Pond, irrigation canal
17.	Peruvammuzhi	Ernakulam	9°57'59.45"	76°30'21.4"	Irrigation canal
18.	Muvattupuzha	Ernakulam	9°58'19.62"	76°30'23.08"	River
19.	Aasharikkadu	Thrissur	10°29'27.78"	76°19'35.29"	Quarry pools & rock pools
20.	Keerangulangara	Thrissur	10°31'25.22"	76°13'9.24"	Man-made pools
21.	Vazhani	Thrissur	10°38'10.69"	76°18'22.30"	Man-made pools
22.	Athirapilly	Thrissur	10°17'9.89"	76°34'15.93"	River
23.	Chalakkudy	Thrissur	10°17'25.42"	76°32'40.23"	River
24.	Ayyampuzha	Thrissur	10°17'25.58"	76°32'40.09"	River
25.	Pariyaram	Thrissur	10°19'19.71"	76°22'38.27"	Irrigation canal
26.	Vetilappara	Thrissur	10°18'5.85"	76°26'48.31"	Irrigation canal
27.	Pillappara	Thrissur	10°17'34.85"	76°28'16.83"	Irrigation canal
28.	Poomala	Thrissur	10°36'5.58"	76°14'23.6"	Lake
29.	Panamukku	Thrissur	10°29'26.08"	76°12'8.22"	Man-made pools
30.	Wadakkanchery	Thrissur	10°39'45.96"	76°15'34.19"	Man-made pools
31.	Kodumbu	Palakkad	10°45'22.3"	76°40'33.27"	Pond
32.	Kinassery	Palakkad	10°43'40.24"	76°39'57.95"	Pond
33.	Mambaram	Palakkad	10°44'42.85"	76°40'6.79"	Agricultural fields
34.	Thiruvallathur	Palakkad	10°44'33.09"	76°41'12.42"	Pond, Irrigation canal, Agricultural fields

35.	Anthimahal	Palakkad	10°41'8.18"	76°44'35.55"	Pond
36.	Kangattuparambu	Palakkad	10°43'59.1"	76°41'22.48"	Pond
37.	Nelliyampathy	Palakkad	10°27'34.83"	76°39'1.91"	Forest streams
38.	Kollengode	Palakkad	10°33'17.59"	76°43'19.71"	Lake
39.	Parali	Palakkad	10°47'16.98"	76°33'52.34"	River, Agricultural fields
40.	Alankode	Palakkad	10°44'19.66"	76°40'59.71"	Pond
41.	Alathur	Palakkad	10°40'3.81"	76°34'25.0"	Irrigation canal
42.	Dhoni	Palakkad	10°48'57.89"	76°38'6.45"	Waterfalls, forest streams
43.	Kuzhalmannam	Palakkad	10°41'40.9"	76°35'13.4"	Pond
44.	Vellappara	Palakkad	10°41'35"	76°35'32"	Quarry pools & rock pools
45.	Kannadi	Palakkad	10°44'55.03"	76°40'2.29"	Pond
46.	Kannanur	Palakkad	10°44'8.43"	76°37'14.06"	Pond
47.	Erattukulam	Palakkad	10°44'14.09"	76°37'7.83"	Pond
48.	Pezhumballam	Palakkad	10°44'34.37"	76°40'24.98"	Pond, Agricultural fields
49.	Tharekkad	Palakkad	10°46'50.13"	76°39'17.78"	Pond
50.	Koppam	Palakkad	10°47'5.22"	76°39'16.11"	Pond
51.	Thasrak	Palakkad	10°43'38.56"	76°41'19.35"	Pond
52.	Uppumpadam	Palakkad	10°44'6.31"	76°40'29.46"	Agricultural fields
53.	Chunnambuthara	Palakkad	10°47'3.69"	76°39'5.58"	Pond

54.	Yakkara	Palakkad	10°44'51.89"	76°39'18.12"	River, Pond
55.	Manapullikavu	Palakkad	10°45'27.92"	76°40'2.89"	Man-made pools
56.	Aalangattuthara	Palakkad	10°45'22.06"	76°39'59.04"	Pond
57.	Nallepilly	Palakkad	10°43'26.0"	76°45'44.54"	Pond
58.	Kanjikode	Palakkad	10°49'3.89"	76°45'4.86"	Lake
59.	Manthakkad	Palakkad	10°48'54.55"	76°39'39.38"	Irrigation canal, Agricultural fields
60.	Mullery	Palakkad	10°44'2.05"	76°40'54.86"	Pond
61.	Nurani	Palakkad	10°45'53.03"	76°38'28.72"	Pond
62.	Vadavannur	Palakkad	10°38'31.82"	76°41'41.68"	Agricultural fields
63.	Kannimari	Palakkad	10°39'48.39"	76°47'55.58"	Pond, Agricultural fields
64.	Chittur	Palakkad	10°40'48.04"	76°42'23.68"	Pond
65.	Walayar	Palakkad	10°50'11.07"	76°51'10.94"	Lake
66.	Olassery	Palakkad	10°43'30.55"	76°41'54.56"	Pond
67.	Kava	Palakkad	10°49'23.59"	76°43'25.68"	River
68.	Anakkal	Palakkad	10°51'33.05"	76°42'39.87"	Torrential streams
69.	Malampuzha	Palakkad	10°49'31.19"	76°40'43.96"	Lake
70.	Peruvembu	Palakkad	10°42'45.79"	76°40'43.0"	Pond
71.	Kalpathy	Palakkad	10°47'40.36"	76°38'39.48"	River
72.	Kulavanmokku	Palakkad	10°42'18.42"	76°36'6.47"	Pond

73.	Kadukkamkunnam	Palakkad	10°48'28.34"	76°39'45.58"	Agricultural fields
74.	Puthunagaram	Palakkad	10°41'0.13"	76°41'14.78"	Man-made pools
75.	Thathamangalam	Palakkad	10°40'58.85"	76°42'27.65"	Pond
76.	Elamannam	Palakkad	10°42'48.47"	76°38'37.71"	Pond
77.	Thenkurissi	Palakkad	10°41'56.11"	76°37'21.89"	Pond
78.	Attappallam	Palakkad	10°49'58.4	76°47'40.25	Streams
79.	Angadippuram	Malappuram	10°58'55.37"	76°12'5.07"	Canal, Agricultural fields
80.	Ayilakkad	Malappuram	10°45'45.54"	76°58'45.32"	Kole wetlands
81.	Manoor	Malappuram	10°47'39.02"	76°0'0.65"	Backwaters
82.	Ponnani	Malappuram	10°46'35.08"	75°57'1.5"	Backwaters
83.	Biyyam	Malappuram	10°47'9.18"	75°57'59.36"	Backwaters
84.	Chamaravattom	Malappuram	10°49'12.65"	75°57'19.42"	Lake
85.	Eswaramangalam	Malappuram	10°48'17.82"	75°57'21.91"	Man-made pools
86.	Kottathara	Malappuram	10°47'43.38"	75°57'15.99"	Pond
87.	Koottoly	Kozhikode	11°16'1.83"	75°47'36.67"	Backwaters, Irrigation canal
88.	Koovor	Kozhikode	11°16'40.3"	75°49'35.01"	Pond
89.	Koyilandy	Kozhikode	11°26'59.96"	75°41'29.4"	Man-made pools
90.	Kakkavayal	Kozhikode	11°30'3.49"	75°58'23.11"	Forest streams, Man-made pools
91.	Kadamanchira	Wayanad	11°41'12.49"	76°15'28.52"	Pond

92.	Sulthan Bathery	Wayanad	11°38'48.92"	76°15'0.43"	Pond
93.	Malavayal	Wayanad	11°38'1.35"	76°15'18.61"	Agricultural fields
94.	Pookode	Wayanad	11°32'32.85"	76°1'38"	Backwaters
95.	Chooralmala	Wayanad	11°32'49.28"	76°9'29.44"	Waterfalls
96.	Kalpetta	Wayanad	11°34'57.4"	76°6'17.4"	Agricultural fields, Irrigation canal
97.	Kuruva Island	Wayanad	11°49'48.55"	76°5'37.06"	River
98.	Malayil Peedika	Wayanad	11°48'54.42"	76°3'32.85"	Agricultural fields
99.	Dharmadam	Kannur	11°46'35.91"	75°27'23.19"	Man-made pools
100.	Kottiyoor	Kannur	11°52'31.01"	75°51'43.67"	River
101.	Thalassery	Kannur	11°45'2.94"	75°29'4.54"	Man-made pools
102.	Payyanur	Kannur	12°5'32.04"	75°13'24.94"	Mangroves
103.	Bakel	Kasaragod	12°23'57.57"	75°1'44.83"	Backwaters
104.	Pallikara	Kasaragod	12°23'16.74"	75°2'27.55"	Man-made pools
105.	Chithari	Kasaragod	12°21'59.14"	75°3'24.46"	Mangroves
106.	Kappilthodu	Kasaragod	12°25'35.8"	75°0'53.87"	Irrigation canal
107.	Karuvakkode	Kasaragod	12°24'27.92"	75°3'27.57"	Pond
108.	Mudiyakkal	Kasaragod	12°25'15.77"	75°1'56.57"	Agricultural fields
109.	Thrikkanadu	Kasaragod	12°24'44.86"	75°1'24.43"	Pond

**Appendix 2: Legends used for locations.**

<b>Sl. No.</b>	<b>Districts</b>	<b>Study sites</b>	<b>Legends</b>
1.	Thiruvananthapuram	Thycaud	THD
2.		Vellayani	VEI
3.	Kollam	Chemmanmukku	CHU
4.	Pathanamthitta	Aranmula	ARA
5.	Alappuzha	Punnamada	PUA
6.		Kuttanad	KUD
7.	Kottayam	Chengalam	CHM
8.		Kumarakom	KUM
9.		Kodimatha	KOA
10.		Kavanattinkara	KAA
11.		Vembanad	VED
12.		Parampuzha	PAA
13.		Kumaranalloor	KUR
14.	Idukki	Muttom	MUM
15.		Adimali	ADI
16.	Ernakulam	Ooramana	OOA



17.		Peruvammuzhi	PEI
18.		Muvattupuzha	MUA
19.	Thrissur	Aasharikkadu	AAU
20.		Keerangulangara	KEA
21.		Vazhani	VAI
22.		Athirapilly	ATY
23.		Chalakkudy	CHY
24.		Ayyampuzha	AYA
25.		Pariyaram	PAM
26.		Vetilappara	VEA
27.		Pillappara	PIA
28.		Poomala	POA
29.		Panamukku	PAU
30.		Wadakkanchery	WDY
31.		Palakkad	Kodumbu
32.	Kinassery		KIY
33.	Mambaram		MAM
34.	Thiruvallathur		THR
35.	Anthimahal		AMH
36.	Kangattuparambu		KAU

37.		Nelliyampathy	NEY
38.		Kollengode	KOE
39.		Parali	PAI
40.		Alankode	ALE
41.		Alathur	ALR
42.		Dhoni	DHI
43.		Kuzhalmannam	KUL
44.		Vellappara	VLA
45.		Kannadi	KAI
46.		Kannanur	KAR
47.		Erattukulam	ERA
48.		Pezhumballam	PEM
49.		Tharekkad	THK
50.		Koppam	KPM
51.		Thasrak	TRK
52.		Uppumpadam	UPM
53.		Chunnambuthara	CMA
54.		Yakkara	YKA
55.		Manapullikavu	MPK
56.		Aalangattuthara	AGT

57.		Nallepilly	NLY
58.		Kanjikode	KJK
59.		Manthakkad	MKD
60.		Mullery	MLR
61.		Nurani	NUI
62.		Vadavannur	VAR
63.		Kannimari	KAN
64.		Chittur	CHR
65.		Walayar	WAL
66.		Olassery	OLY
67.		Kava	KVA
68.		Anakkal	ANL
69.		Malampuzha	MLP
70.		Peruvembu	PMU
71.		Kalpathy	KLY
72.		Kulavanmokku	KUU
73.		Kadukkamkunnam	KDM
74.		Puthunagaram	PUM
75.		Thathamangalam	TMM
76.		Elamannam	ELM

77.		Thenkurissi	TKS	
78.		Attappallam	APM	
79.	Malappuram	Angadippuram	ANM	
80.		Ayilakkad	AYD	
81.		Manoor	MNR	
82.		Ponnani	PNI	
83.		Biyyam	BYM	
84.		Chamaravattom	CHA	
85.		Eswaramangalam	ESW	
86.		Kottathara	KOT	
87.		Kozhikode	Koottoly	KOY
88.			Koovor	KVR
89.	Koyilandy		KDY	
90.	Kakkavayal		KKL	
91.	Wayanad	Kadamanchira	KCA	
92.		Sulthan Bathery	SBY	
93.		Malavayal	MVL	
94.		Pookode	POK	
95.		Chooralmala	CRL	
96.		Kalpetta	KLA	

97.		Kuruva Island	KSD
98.		Malayil Peedika	MPA
99.	Kannur	Dharmadam	DHM
100.		Kottiyoor	KOR
101.		Thalassery	TSY
102.		Payyanur	PYR
103.	Kasaragod	Bakel	BKL
104.		Pallikara	PLK
105.		Chithari	CHI
106.		Kappilthodu	KPU
107.		Karuvakkode	KKE
108.		Mudiyakkal	MKL
109.		Thrikkanadu	TKD

**Appendix 3:** Systematic account of total 65 species in the present study.

<b>Infraorder</b>	<b>Superfamily, Family, &amp; Subfamily</b>	<b>Genus</b>	<b>Species</b>
Nepomorpha	Superfamily Nepoidea	<i>Laccotrephes</i>	<i>Laccotrephes griseus</i> Guerin-Meneville, 1844
	Family Nepidae		<i>Laccotrephes ruber</i> Linnaeus, 1764
	Subfamily Nepinae		
	Subfamily Ranatrinae	<i>Cercotmetus</i>	<i>Cercotmetus pilipes</i> Dallas, 1850
		<i>Ranatra</i>	<i>Ranatra varipes atropa</i> Montandon, 1903
			<i>Ranatra varipes varipes</i> Stal, 1861
			<i>Ranatra filiformis</i> Fabricius, 1790
			<i>Ranatra elongata</i> Fabricius, 1790
	Family Belostomatidae	<i>Diplonychus</i>	<i>Diplonychus molestus</i> Dufour, 1863
	Subfamily Belostomatinae		<i>Diplonychus rusticus</i> Fabricius, 1781
Subfamily Lethocerinae	<i>Lethocerus</i>	<i>Lethocerus indicus</i> Lepeletier and Serville, 1825	

	Superfamily Corixoidea	<i>Sigara</i>	<i>Sigara</i> ( <i>Vermicorixa</i> ) <i>kempi</i> Hutchinson, 1940
	Family Corixidae		<i>Sigara</i>
	Subfamily Corixinae		<i>Sigara</i> ( <i>Tropocorixa</i> ) <i>promontoria</i> Distant, 1910
	Family Micronectidae	<i>Micronecta</i>	<i>Micronecta</i> <i>scutellaris</i> <i>scutellaris</i> Stal, 1858
			<i>Micronecta</i> <i>quadristrigata</i> Breddin, 1905
			<i>Micronecta</i> <i>haliploides</i> Horvath, 1904
			<i>Micronecta</i> <i>ludibunda</i> Breddin, 1905
			<i>Micronecta</i> <i>desertana</i> <i>desertana</i> Distant, 1920
			<i>Micronecta</i> <i>khasiensis</i> Hutchinson, 1940
			Subfamily Micronectinae

	Superfamily Naucoroidea		
	Family Naucoridae	<i>Helocoris</i>	<i>Helocoris indicus</i> Montandon, 1897
	Subfamily Laccocorinae		
	Superfamily Notonectoidea	<i>Anisops</i>	<i>Anisops nasutus</i> Fieber, 1851
			<i>Anisops breddini</i> Kirkaldy, 1901
			<i>Anisops bouvieri</i> Kirkaldy, 1904
			<i>Anisops barbatus</i> Brooks, 1951
			<i>Anisops sardeus</i> <i>sardeus</i> Herrich-Shaffer, 1850
			<i>Anisops niveus</i> Fabricius, 1775
			<i>Anisops paranigrolineatus</i> Brooks, 1951
			<i>Anisops tahitiensis</i> Lundblad, 1934
			<i>Anisops occipitalis</i> Breddin, 1905
		<i>Enithares</i>	<i>Enithares ciliata</i> Fabricius, 1798



	Superfamily Pleoidea	<i>Paraplea</i>	<i>Paraplea frontalis</i> Fieber, 1844
	Family Pleidae		<i>Paraplea liturata</i> Fieber, 1844
	Family Helotrephidae	<i>Tiphotrephes</i>	<i>Tiphotrephes indicus</i> Distant, 1910
Gerromorpha	Superfamily Gerroidea  Family Gerridae  Subfamily Gerrinae	<i>Limnogonus</i>	<i>Limnogonus</i> ( <i>Limnogonus</i> ) <i>fossarum fossarum</i> Fabricius, 1775
			<i>Limnogonus</i> ( <i>Limnogonus</i> ) <i>nitidus</i> Mayr, 1865
		<i>Limnometra</i>	<i>Limnometra fluviorum</i> Fabricius, 1798
			<i>Limnometra anadyomene</i> Kirkaldy, 1901
		<i>Neogerris</i>	<i>Neogerris parvulus</i> Stal, 1859
		<i>Aquarius</i>	<i>Aquarius adelaides</i> Dohrn, 1860
	Subfamily Rhagadotarsinae	<i>Rhagadotarsus</i>	<i>Rhagadotarsus kraepelini</i> Breddin, 1905
	Subfamily Ptilomerinae	<i>Ptilomera</i>	<i>Ptilomera</i> ( <i>Ptilomera</i> ) <i>agroides</i> Schmidt, 1926

			<i>Ptilomera</i> ( <i>Ptilomera</i> ) <i>assamensis</i> Hungerford and Matsuda, 1965
			<i>Ptilomera</i> ( <i>Ptilomera</i> ) <i>laticaudata</i> Hardwicke, 1823
		<i>Pleciobates</i>	<i>Pleciobates nostras</i> Thirumalai, 1986
			<i>Pleciobates indicus</i> Thirumalai, 1986
	Subfamily Eotrechinae	<i>Amemboa</i>	<i>Amemboa kumari</i> Distant, 1910
	Subfamily Halobatinae	<i>Metrocoris</i>	<i>Metrocoris</i> <i>darjeelingensis</i> Basu, Polhemus and Subramanian, 2016
			<i>Metrocoris</i> <i>communoides</i> Chen and Nesar, 1993
		<i>Ventidius</i>	<i>Ventidius</i> ( <i>Ventidius</i> ) <i>aquarius</i> Distant, 1910

	Subfamily Trepobatinae	<i>Naboandelus</i>	<i>Naboandelus signatus</i> Distant, 1910
		<i>Lathriobates</i>	<i>Lathriobates raja</i> Distant, 1910
	Subfamily Cylindrostethinae	<i>Cylindrostethus</i>	<i>Cylindrostethus productus</i> Spinola, 1840
	Family Veliidae Subfamily Microveliinae	<i>Microvelia</i>	<i>Microvelia (Microvelia) douglasi</i> Scott, 1874
			<i>Microvelia (Dilutovelia) leveillei leveillei</i> Lethierry, 1877
			<i>Microvelia albomaculata</i> Distant, 1909
			<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Neolardus</i>	<i>Neolardus typicus</i> Distant, 1903
		<i>Thirumalaia</i>	<i>Thirumalaia ocularis</i> Zettel and Laciny, 2021
	Subfamily Rhagoveliinae	<i>Rhagovelia</i>	<i>(Neorhagovelia) sumatrensis</i> Lundblad, 1936

	Family Mesoveliidae	<i>Mesovelia</i>	<i>Mesovelia vittigera</i> Horvath, 1895
	Subfamily Mesoveliinae		<i>Mesovelia horvathi</i> Lundblad, 1934
	Family Hydrometridae	<i>Hydrometra</i>	<i>Hydrometra greeni</i> Kirkaldy, 1898
Subfamily Hydrometrinae	<i>Hydrometra butleri</i> Hungerford and Evans, 1934		
	Family Hebridae	<i>Timasius</i>	<i>Timasius</i>
	Subfamily Hebrinae		<i>fenestratus</i> Zettel, 2013
Leptopodomorpha	Superfamily Leptopodoidea	<i>Valleriola</i>	<i>Valleriola</i>
	Family Leptopodidae		<i>cicindeloides</i>
	Subfamily Leptopodinae		Distant, 1908

**Appendix 4:** List of previously recorded (35 species), new records from South India (13 species) & Kerala (30 species) in the present study.

#### **Previously recorded species from Kerala**

1. *Laccotrephes griseus* Guerin-Meneville, 1844
2. *Laccotrephes ruber* Linnaeus, 1764
3. *Cercotmetus pilipes* Dallas, 1850
4. *Ranatra filiformis* Fabricius, 1790
5. *Ranatra elongata* Fabricius, 1790
6. *Diplonychus molestus* Dufour, 1863
7. *Diplonychus rusticus* Fabricius, 1781
8. *Lethocerus indicus* Lepeletier and Serville, 1825
9. *Micronecta scutellaris scutellaris* Stal, 1858
10. *Micronecta quadristrigata* Breddin, 1905
11. *Micronecta haliploides* Horvath, 1904
12. *Anisops nasutus* Fieber, 1851
13. *Anisops breddini* Kirkaldy, 1901
14. *Anisops bouvieri* Kirkaldy, 1904
15. *Anisops niveus* Fabricius, 1775
16. *Anisops paranigrolineatus* Brooks, 1951
17. *Enithares ciliata* Fabricius, 1798
18. *Limnogonus (Limnogonus) fossarum fossarum* Fabricius, 1775
19. *Limnogonus (Limnogonus) nitidus* Mayr, 1865

20. *Limnometra fluviorum* Fabricius, 1798
21. *Limnometra anadyomene* Kirkaldy, 1901
22. *Neogerris parvulus* Stal, 1859
23. *Aquarius adelaides* Dohrn, 1860
24. *Rhagadotarsus kraepelini* Breddin, 1905
25. *Ptilomera (Ptilomera) agroides* Schmidt, 1926
26. *Pleciobates nostras* Thirumalai, 1986
27. *Pleciobates indicus* Thirumalai, 1986
28. *Amemboa kumari* Distant, 1910
29. *Ventidius (Ventidius) aquarius* Distant, 1910
30. *Lathriobates raja* Distant, 1910
31. *Cylindrostethus productus* Spinola, 1840
32. *Microvelia (Microvelia) douglasi* Scott, 1874
33. *Mesovelia vittigera* Horvath, 1895
34. *Hydrometra greeni* Kirkaldy, 1898
35. *Hydrometra butleri* Hungerford and Evans, 1934

### **New records from South India**

1. *Sigara (Vermicorixa) kempi* Hutchinson, 1940
2. *Micronecta ludibunda* Breddin, 1905
3. *Micronecta khasiensis* Hutchinson, 1940
4. *Anisops tahitiensis* Lundblad, 1934
5. *Anisops occipitalis* Breddin, 1905
6. *Paraplea liturata* Fieber, 1844
7. *Tiphotrephes indicus* Distant, 1910
8. *Ptilomera (Ptilomera) assamensis* Hungerford and Matsuda, 1965
9. *Ptilomera (Ptilomera) laticaudata* Hardwicke, 1823
10. *Microvelia albomaculata* Distant, 1909
11. *Rhagovelia (Neorhagovelia) sumatrensis* Lundblad, 1936
12. *Neolardus typicus* Distant, 1903
13. *Valleriola cicindeloides* Distant, 1908

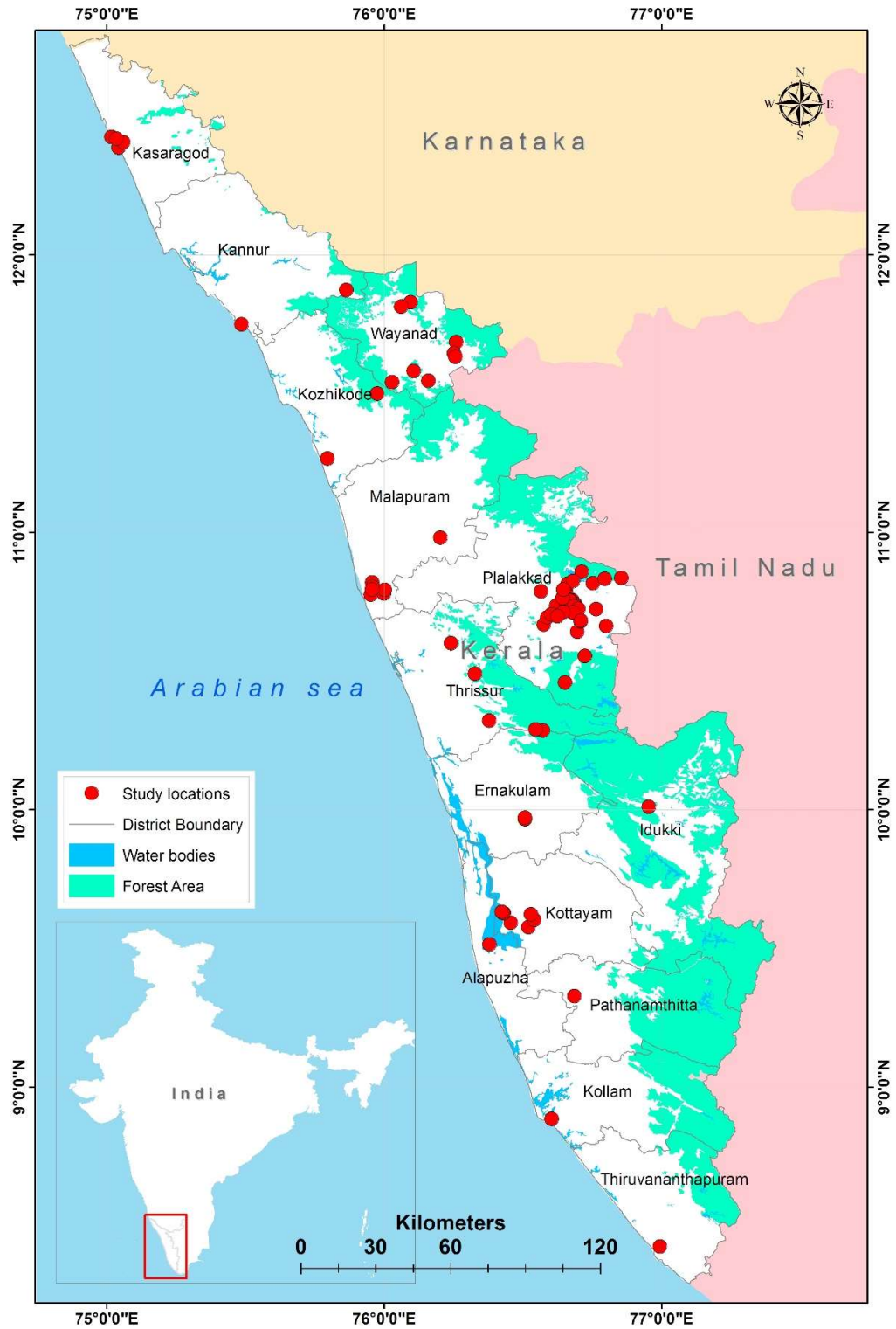
### **New records from Kerala**

1. *Ranatra varipes atropa* Montandon, 1903
2. *Ranatra varipes varipes* Stal, 1861
3. *Sigara (Vermicorixa) kempi* Hutchinson, 1940
4. *Sigara (Tropocorixa) promontoria* Distant, 1910
5. *Micronecta ludibunda* Breddin, 1905
6. *Micronecta desertana desertana* Distant, 1920
7. *Micronecta khasiensis* Hutchinson, 1940
8. *Helocoris indicus* Montandon, 1897
9. *Anisops barbatus* Brooks, 1951
10. *Anisops sardeus sardeus* Herrich-Shaffer, 1850
11. *Anisops tahitiensis* Lundblad, 1934
12. *Anisops occipitalis* Breddin, 1905
13. *Nychia sappho* Kirkaldy, 1901
14. *Paraplea frontalis* Fieber, 1844
15. *Paraplea liturata* Fieber, 1844
16. *Tiphotrephes indicus* Distant, 1910
17. *Ptilomera (Ptilomera) assamensis* Hungerford and Matsuda, 1965



18. *Ptilomera (Ptilomera) laticaudata* Hardwicke, 1823
19. *Naboandelus signatus* Distant, 1910
20. *Metrocoris darjeelingensis* Basu, Polhemus and Subramanian, 2016
21. *Metrocoris communoides* Chen and Nesar, 1993
22. *Microvelia (Dilutovelina) leveillei leveillei* Lethierry, 1877
23. *Microvelia albomaculata* Distant, 1909
24. *Microvelia (Microvelina) diluta* Distant, 1909
25. *Rhagovelina (Neorhagovelina) sumatrensis* Lundblad, 1936
26. *Neolardus typicus* Distant, 1903
27. *Thirumalaia ocularis* Zettel and Laciny, 2021
28. *Mesovelina horvathi* Lundblad, 1934
29. *Timasius fenestratus* Zettel, 2013
30. *Valleriola cicindeloides* Distant, 1908

**Appendix 5:** The distribution map of 30 new recorded species from Kerala.



The details of species given:

Districts	Legends	Species present
Thiruvananthapuram	VEI	<i>Paraplea frontalis</i> Fieber, 1844
		<i>Paraplea liturata</i> Fieber, 1844
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Neolardus typicus</i> Distant, 1903
		<i>Mesovelia horvathi</i> Lundblad, 1934
Kollam	CHU	<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Mesovelia horvathi</i> Lundblad, 1934
Pathanamthitta	ARA	<i>Naboandelus signatus</i> Distant, 1910
		<i>Microvelia (Dilutovelina) leveillei leveillei</i> Lethierry, 1877
		<i>Thirumalaia ocularis</i> Zettel and Laciny, 2021
		<i>Mesovelia horvathi</i> Lundblad, 1934
Alappuzha	KUD	<i>Paraplea frontalis</i> Fieber, 1844
Kottayam	CHM	<i>Mesovelia horvathi</i> Lundblad, 1934
	KUM	<i>Paraplea frontalis</i> Fieber, 1844
	KOA	<i>Micronecta ludibunda</i> Breddin, 1905
	KAA	<i>Micronecta desertana desertana</i> Distant, 1920
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
	VED	<i>Paraplea frontalis</i> Fieber, 1844
	PAA	<i>Nychia sappho</i> Kirkaldy, 1901
<i>Naboandelus signatus</i> Distant, 1910		
KUR	<i>Paraplea frontalis</i> Fieber, 1844	
Idukki	ADI	<i>Microvelia (Microvelia) diluta</i> Distant, 1909
Ernakulam	PEI	<i>Naboandelus signatus</i> Distant, 1910
		<i>Microvelia (Dilutovelina) leveillei leveillei</i> Lethierry, 1877
	MUA	<i>Micronecta desertana desertana</i> Distant, 1920

Thrissur	AAU	<i>Nychia sappho</i> Kirkaldy, 1901
	ATY	<i>Anisops occipitalis</i> Breddin, 1905
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	CHY	<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Microvelia (Dilutovelgia) leveillei leveillei</i> Lethierry, 1877
		<i>Microvelia albomaculata</i> Distant, 1909
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Thirumalaia ocularis</i> Zettel and Laciny, 2021
	PAM	<i>Naboandelus signatus</i> Distant, 1910
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	POA	<i>Ranatra varipes varipes</i> Stal, 1861
<i>Paraplea frontalis</i> Fieber, 1844		
<i>Mesovelgia horvathi</i> Lundblad, 1934		
Palakkad	KOU	<i>Micronecta desertana desertana</i> Distant, 1920
		<i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	KIY	<i>Ranatra varipes atropaha</i> Montandon, 1903
	MAM	<i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
		<i>Paraplea frontalis</i> Fieber, 1844
	THR	<i>Anisops barbatus</i> Brooks, 1951
		<i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	KAU	<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Timasius fenestratus</i> Zettel, 2013
NEY	<i>Ptilomera (Ptilomera) assamensis</i> Hungerford and Matsuda, 1965	
KOE	<i>Mesovelgia horvathi</i> Lundblad, 1934	

	PAI	<i>Nychia sappho</i> Kirkaldy, 1901
	ALE	<i>Sigara (Vermicorixa) kempi</i> Hutchinson, 1940
		<i>Sigara (Tropocorixa) promontoria</i> Distant, 1910
		<i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Naboandelus signatus</i> Distant, 1910
		<i>Mesovelvia horvathi</i> Lundblad, 1934
	ALR	<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Mesovelvia horvathi</i> Lundblad, 1934
	KUL	<i>Paraplea frontalis</i> Fieber, 1844
	ERA	<i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
	PEM	<i>Micronecta ludibunda</i> Breddin, 1905
		<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Naboandelus signatus</i> Distant, 1910
		<i>Mesovelvia horvathi</i> Lundblad, 1934
	THK	<i>Paraplea frontalis</i> Fieber, 1844
		<i>Naboandelus signatus</i> Distant, 1910
		<i>Mesovelvia horvathi</i> Lundblad, 1934
	KPM	<i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
		<i>Paraplea frontalis</i> Fieber, 1844
	TRK	<i>Micronecta khasiensis</i> Hutchinson, 1940
		<i>Anisops occipitalis</i> Breddin, 1905
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Tiphotrephes indicus</i> Distant, 1910
	UPM	<i>Micronecta khasiensis</i> Hutchinson, 1940
		<i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
		<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844

		<i>Naboandelus signatus</i> Distant, 1910
CMA		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Mesovelgia horvathi</i> Lundblad, 1934
YKA		<i>Sigara (Vermicorixa) kempi</i> Hutchinson, 1940
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Microvelgia (Dilutovelgia) leveillei leveillei</i> Lethierry, 1877
MPK		<i>Ranatra varipes atropaha</i> Montandon, 1903
AGT		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Paraplea liturata</i> Fieber, 1844
		<i>Mesovelgia horvathi</i> Lundblad, 1934
NLY		<i>Mesovelgia horvathi</i> Lundblad, 1934
KJK		<i>Metrocoris darjeelingensis</i> Basu, Polhemus and Subramanian, 2016
		<i>Mesovelgia horvathi</i> Lundblad, 1934
MKD		<i>Microvelgia (Microvelgia) diluta</i> Distant, 1909
		<i>Mesovelgia horvathi</i> Lundblad, 1934
MLR		<i>Ranatra varipes atropaha</i> Montandon, 1903
		<i>Micronecta desertana desertana</i> Distant, 1920
		<i>Paraplea frontalis</i> Fieber, 1844
NUI		<i>Ranatra varipes atropaha</i> Montandon, 1903
		<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Naboandelus signatus</i> Distant, 1910
		<i>Mesovelgia horvathi</i> Lundblad, 1934
VAR		<i>Paraplea frontalis</i> Fieber, 1844
KAN		<i>Ranatra varipes atropaha</i> Montandon, 1903
		<i>Mesovelgia horvathi</i> Lundblad, 1934
CHR		<i>Mesovelgia horvathi</i> Lundblad, 1934
WAL		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Mesovelgia horvathi</i> Lundblad, 1934
		<i>Timasius fenestratus</i> Zettel, 2013
OLY		<i>Micronecta ludibunda</i> Breddin, 1905

		<i>Micronecta khasiensis</i> Hutchinson, 1940
		<i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
		<i>Paraplea frontalis</i> Fieber, 1844
	ANL	<i>Rhagovelia (Neorhagovelia) sumatrensis</i> Lundblad, 1936
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	MLP	<i>Micronecta khasiensis</i> Hutchinson, 1940
		<i>Helocoris indicus</i> Montandon, 1897
		<i>Metrocoris communoides</i> Chen and Nesar, 1993
		<i>Rhagovelia (Neorhagovelia) sumatrensis</i> Lundblad, 1936
	PMU	<i>Naboandelus signatus</i> Distant, 1910
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	KLY	<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	KUU	<i>Paraplea frontalis</i> Fieber, 1844
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	TMM	<i>Nychia sappho</i> Kirkaldy, 1901
	ELM	<i>Ranatra varipes atropa</i> Montandon, 1903
	TKS	<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	APM	<i>Mesovelgia horvathi</i> Lundblad, 1935
		<i>Valleriola cicindeloides</i> Distant, 1908
Malappuram	ANM	<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Mesovelgia horvathi</i> Lundblad, 1934
	AYD	<i>Microvelia (Microvelia) diluta</i> Distant, 1909
	MNR	<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844
	PNI	<i>Paraplea frontalis</i> Fieber, 1845
		<i>Mesovelgia horvathi</i> Lundblad, 1934

	CHA	<i>Naboandelus signatus</i> Distant, 1910
	ESW	<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Paraplea liturata</i> Fieber, 1844
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Mesovelia horvathi</i> Lundblad, 1934
	KOT	<i>Paraplea frontalis</i> Fieber, 1844
<i>Mesovelia horvathi</i> Lundblad, 1934		
Kozhikode	KOY	<i>Micronecta ludibunda</i> Breddin, 1905
		<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Mesovelia horvathi</i> Lundblad, 1934
	KKL	<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Ptilomera (Ptilomera) assamensis</i> Hungerford and Matsuda, 1965
<i>Rhagovelia (Neorhagovelia) sumatrensis</i> Lundblad, 1936		
Wayanad	KCA	<i>Nychia sappho</i> Kirkaldy, 1901
	SBY	<i>Nychia sappho</i> Kirkaldy, 1901
	MVL	<i>Nychia sappho</i> Kirkaldy, 1901
	POK	<i>Nychia sappho</i> Kirkaldy, 1901
	CRL	<i>Microvelia (Microvelia) diluta</i> Distant, 1909
		<i>Rhagovelia (Neorhagovelia) sumatrensis</i> Lundblad, 1936
	KLA	<i>Paraplea frontalis</i> Fieber, 1844
	KSD	<i>Ptilomera (Ptilomera) laticaudata</i> Hardwicke, 1823
MPA	<i>Mesovelia horvathi</i> Lundblad, 1934	
Kannur	KOR	<i>Microvelia (Microvelia) diluta</i> Distant, 1909
	TSY	<i>Anisops tahitiensis</i> Lundblad, 1934
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
Kasaragod	PLK	<i>Micronecta ludibunda</i> Breddin, 1905
		<i>Anisops tahitiensis</i> Lundblad, 1934
		<i>Nychia sappho</i> Kirkaldy, 1901
		<i>Paraplea frontalis</i> Fieber, 1844



		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
	KPU	<i>Mesovelia horvathi</i> Lundblad, 1934
	KKE	<i>Micronecta ludibunda</i> Breddin, 1905
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Microvelia (Microvelia) diluta</i> Distant, 1909
	MKL	<i>Micronecta ludibunda</i> Breddin, 1905
		<i>Paraplea frontalis</i> Fieber, 1844
		<i>Paraplea liturata</i> Fieber, 1844
		<i>Mesovelia horvathi</i> Lundblad, 1934

**Appendix 6:** Common names of all the collected families of water bugs.

<b>SL. NO.</b>	<b>FAMILY NAME</b>	<b>COMMON NAME</b>
1.	Nepidae	Water scorpions
2.	Belostomatidae	Giant water bugs
3.	Corixidae	Water boatmen
4.	Micronectidae	Pygmy water boatmen
5.	Naucoridae	Creeping water bugs
6.	Notonectidae	Backswimmers
7.	Pleidae	Pygmy backswimmers
8.	Helotrephidae	Beetle backswimmers
9.	Gerridae	Water striders
10.	Veliidae	Riffle bugs
11.	Mesoveliidae	Water treaders
12.	Hydrometridae	Water measurers
13.	Hebridae	Velvet water bugs
14.	Leptopodidae	Spiny shore bugs

**Appendix 7:** List of studied aquatic habitats based on the presence/absence of collected species.

TYPE OF AQUATIC HABITATS	SPECIES PRESENT
<b>Rivers</b>	1. <i>Laccotrephes griseus</i> Guerin-Meneville, 1844
	2. <i>Laccotrephes ruber</i> Linnaeus, 1764
	3. <i>Cercotmetus pilipes</i> Dallas, 1850
	4. <i>Ranatra filiformis</i> Fabricius, 1790
	5. <i>Diplonychus molestus</i> Dufour, 1863
	6. <i>Diplonychus rusticus</i> Fabricius, 1781
	7. <i>Sigara (Vermicorixa) kemp</i> i Hutchinson, 1940
	8. <i>Micronecta scutellaris scutellaris</i> Stal, 1858
	9. <i>Micronecta quadristrigata</i> Breddin, 1905
	10. <i>Micronecta haliploides</i> Horvath, 1904
	11. <i>Micronecta desertana desertana</i> Distant, 1920
	12. <i>Anisops nasutus</i> Fieber, 1851
	13. <i>Anisops breddini</i> Kirkaldy, 1901
	14. <i>Anisops niveus</i> Fabricius, 1775
	15. <i>Anisops occipitalis</i> Breddin, 1905
	16. <i>Nychia sappho</i> Kirkaldy, 1901
	17. <i>Paraplea frontalis</i> Fieber, 1844
	18. <i>Limnogonus (Limnogonus) fossarum fossarum</i> Fabricius, 1775
	19. <i>Limnogonus (Limnogonus) nitidus</i> Mayr, 1865
	20. <i>Limnometra fluviorum</i> Fabricius, 1798
	21. <i>Neogerris parvulus</i> Stal, 1859
	22. <i>Aquarius adalaides</i> Dohrn, 1860
	23. <i>Rhagadotarsus kraepelini</i> Breddin, 1905
	24. <i>Ptilomera (Ptilomera) agroides</i> Schmidt, 1926
	25. <i>Ptilomera (Ptilomera) laticaudata</i> Hardwicke, 1823
	26. <i>Amemboa kumari</i> Distant, 1910

	27. <i>Pleciobates nostras</i> Thirumalai, 1986
	28. <i>Naboandelus signatus</i> Distant, 1910
	29. <i>Lathriobates raja</i> Distant, 1910
	30. <i>Microvelia (Microvelia) douglasi</i> Scott, 1874
	31. <i>Microvelia (Dilutovelina) leveillei leveillei</i> Lethierry, 1877
	32. <i>Microvelia albomaculata</i> Distant, 1909
	33. <i>Microvelia (Microvelia) diluta</i> Distant, 1909
	34. <i>Thirumalaia ocularis</i> Zettel and Laciny, 2021
	35. <i>Mesovelina vittigera</i> Horvath, 1895
	36. <i>Mesovelina horvathi</i> Lundblad, 1934
	37. <i>Hydrometra greeni</i> Kirkaldy, 1898
	38. <i>Hydrometra butleri</i> Hungerford and Evans, 1934
<b>Ponds</b>	1. <i>Laccotrephes griseus</i> Guerin-Meneville, 1844
	2. <i>Laccotrephes ruber</i> Linnaeus, 1764
	3. <i>Cercotmetus pilipes</i> Dallas, 1850
	4. <i>Ranatra varipes atropa</i> Montandon, 1903
	5. <i>Ranatra filiformis</i> Fabricius, 1790
	6. <i>Diplonychus molestus</i> Dufour, 1863
	7. <i>Diplonychus rusticus</i> Fabricius, 1781
	8. <i>Lethocerus indicus</i> Lepeletier and Serville, 1825
	9. <i>Sigara (Vermicorixa) kempfi</i> Hutchinson, 1940
	10. <i>Sigara (Tropocorixa) promontoria</i> Distant, 1910
	11. <i>Micronecta scutellaris scutellaris</i> Stal, 1858
	12. <i>Micronecta quadristrigata</i> Breddin, 1905
	13. <i>Micronecta ludibunda</i> Breddin, 1905
	14. <i>Micronecta desertana desertana</i> Distant, 1920
	15. <i>Micronecta khasiensis</i> Hutchinson, 1940
	16. <i>Anisops nasutus</i> Fieber, 1851
	17. <i>Anisops breddini</i> Kirkaldy, 1901
	18. <i>Anisops bouvieri</i> Kirkaldy, 1904
	19. <i>Anisops barbatus</i> Brooks, 1951
	20. <i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850

	21. <i>Anisops niveus</i> Fabricius, 1775
	22. <i>Anisops paranigrolineatus</i> Brooks, 1951
	23. <i>Anisops occipitalis</i> Breddin, 1905
	24. <i>Nychia sappho</i> Kirkaldy, 1901
	25. <i>Enithares ciliata</i> Fabricius, 1798
	26. <i>Paraplea frontalis</i> Fieber, 1844
	27. <i>Paraplea liturata</i> Fieber, 1844
	28. <i>Tiphotrephes indicus</i> Distant, 1910
	29. <i>Limnogonus (Limnogonus) fossarum fossarum</i> Fabricius, 1775
	30. <i>Limnogonus (Limnogonus) nitidus</i> Mayr, 1865
	31. <i>Limnometra fluviorum</i> Fabricius, 1798
	32. <i>Limnometra anadyomene</i> Kirkaldy, 1901
	33. <i>Neogerris parvulus</i> Stal, 1859
	34. <i>Aquarius adelaides</i> Dohrn, 1860
	35. <i>Rhagadotarsus kraepelini</i> Breddin, 1905
	36. <i>Amemboa kumari</i> Distant, 1910
	37. <i>Naboandelus signatus</i> Distant, 1910
	38. <i>Microvelia (Microvelia) douglasi</i> Scott, 1874
	39. <i>Microvelia (Dilutovelina) leveillei leveillei</i> Lethierry, 1877
	40. <i>Microvelia (Microvelia) diluta</i> Distant, 1909
	41. <i>Mesovelina vittigera</i> Horvath, 1895
	42. <i>Mesovelina horvathi</i> Lundblad, 1934
	43. <i>Hydrometra greeni</i> Kirkaldy, 1898
	44. <i>Hydrometra butleri</i> Hungerford and Evans, 1934
	45. <i>Timasius fenestratus</i> Zettel, 2013
<b>Waterfalls</b>	1. <i>Micronecta haliploides</i> Horvath, 1904
	2. <i>Aquarius adelaides</i> Dohrn, 1860
	3. <i>Ptilomera (Ptilomera) agroides</i> Schmidt, 1926
	4. <i>Ventidius (Ventidius) aquarius</i> Distant, 1910
	5. <i>Microvelia (Microvelia) diluta</i> Distant, 1909
	6. <i>Rhagovelina (Neorhagovelina) sumatrensis</i> Lundblad, 1936
	1. <i>Cercotmetus pilipes</i> Dallas, 1850

<b>Forest streams</b>	2. <i>Ranatra elongata</i> Fabricius, 1790
	3. <i>Diplonychus molestus</i> Dufour, 1863
	4. <i>Micronecta desertana desertana</i> Distant, 1920
	5. <i>Anisops breddini</i> Kirkaldy, 1901
	6. <i>Anisops niveus</i> Fabricius, 1775
	7. <i>Nychia sappho</i> Kirkaldy, 1901
	8. <i>Enithares ciliata</i> Fabricius, 1798
	9. <i>Paraplea frontalis</i> Fieber, 1844
	10. <i>Limnometra fluviorum</i> Fabricius, 1798
	11. <i>Limnometra anadyomene</i> Kirkaldy, 1901
	12. <i>Aquarius adelaides</i> Dohrn, 1860
	13. <i>Ptilomera (Ptilomera) agroides</i> Schmidt, 1926
	14. <i>Ptilomera (Ptilomera) assamensis</i> Hungerford and Matsuda,
	15. <i>Amemboa kumari</i> Distant, 1910
	16. <i>Lathriobates raja</i> Distant, 1910
	17. <i>Ventidius (Ventidius) aquarius</i> Distant, 1910
	18. <i>Cylindrostethus productus</i> Spinola, 1840
	19. <i>Microvelia (Microvelia) diluta</i> Distant, 1909
	20. <i>Rhagovelia (Neorhagovelia) sumatrensis</i> Lundblad, 1936
	21. <i>Mesovelia horvathi</i> Lundblad, 1934
	22. <i>Valleriola cicindeloides</i> Distant, 1908
	<b>Torrential streams</b>
2. <i>Amemboa kumari</i> Distant, 1910	
3. <i>Microvelia (Microvelia) douglasi</i> Scott, 1874	
4. <i>Rhagovelia (Neorhagovelia) sumatrensis</i> Lundblad, 1936	
5. <i>Mesovelia horvathi</i> Lundblad, 1934	
6. <i>Hydrometra greeni</i> Kirkaldy, 1898	
7. <i>Hydrometra butleri</i> Hungerford and Evans, 1934	
	1. <i>Laccotrephes ruber</i> Linnaeus, 1764
	2. <i>Ranatra filiformis</i> Fabricius, 1790
	3. <i>Diplonychus rusticus</i> Fabricius, 1781
	4. <i>Anisops paranigrolineatus</i> Brooks, 1951

<b>Quarry &amp; rock pools</b>	5. <i>Nychia sappho</i> Kirkaldy, 1901
	6. <i>Enithares ciliata</i> Fabricius, 1798
	7. <i>Limnometra fluviorum</i> Fabricius, 1798
	8. <i>Aquarius adelaides</i> Dohrn, 1860
	9. <i>Hydrometra butleri</i> Hungerford and Evans, 1934
<b>Irrigation canals</b>	1. <i>Laccotrephes ruber</i> Linnaeus, 1764
	2. <i>Cercotmetus pilipes</i> Dallas, 1850
	3. <i>Ranatra filiformis</i> Fabricius, 1790
	4. <i>Diplonychus molestus</i> Dufour, 1863
	5. <i>Diplonychus rusticus</i> Fabricius, 1781
	6. <i>Micronecta scutellaris scutellaris</i> Stal, 1858
	7. <i>Micronecta quadristrigata</i> Breddin, 1905
	8. <i>Micronecta ludibunda</i> Breddin, 1905
	9. <i>Anisops nasutus</i> Fieber, 1851
	10. <i>Anisops breddini</i> Kirkaldy, 1901
	11. <i>Anisops bouvieri</i> Kirkaldy, 1904
	12. <i>Anisops barbatus</i> Brooks, 1951
	13. <i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
	14. <i>Anisops niveus</i> Fabricius, 1775
	15. <i>Nychia sappho</i> Kirkaldy, 1901
	16. <i>Paraplea frontalis</i> Fieber, 1844
	17. <i>Limnogonus (Limnogonus) nitidus</i> Mayr, 1865
	18. <i>Limnometra anadyomene</i> Kirkaldy, 1901
	19. <i>Rhagadotarsus kraepelini</i> Breddin, 1905
	20. <i>Amemboa kumari</i> Distant, 1910
	21. <i>Naboandelus signatus</i> Distant, 1910
	22. <i>Lathriobates raja</i> Distant, 1910
	23. <i>Cylindrostethus productus</i> Spinola, 1840
	24. <i>Microvelia (Microvelia) douglasi</i> Scott, 1874
	25. <i>Microvelia (Dilutovelina) leveillei leveillei</i> Lethierry, 1877
	26. <i>Microvelia (Microvelia) diluta</i> Distant, 1909
	27. <i>Mesovelina vittigera</i> Horvath, 1895

	28. <i>Mesovelia horvathi</i> Lundblad, 1934
	29. <i>Hydrometra greeni</i> Kirkaldy, 1898
	30. <i>Hydrometra butleri</i> Hungerford and Evans, 1934
<b>Agricultural fields &amp; Kole wetlands</b>	1. <i>Laccotrephes griseus</i> Guerin-Meneville, 1844
	2. <i>Laccotrephes ruber</i> Linnaeus, 1764
	3. <i>Cercotmetus pilipes</i> Dallas, 1850
	4. <i>Ranatra varipes atropha</i> Montandon, 1903
	5. <i>Ranatra filiformis</i> Fabricius, 1790
	6. <i>Diplonychus molestus</i> Dufour, 1863
	7. <i>Diplonychus rusticus</i> Fabricius, 1781
	8. <i>Lethocerus indicus</i> Lepeletier and Serville, 1825
	9. <i>Micronecta scutellaris scutellaris</i> Stal, 1858
	10. <i>Micronecta quadristrigata</i> Breddin, 1905
	11. <i>Micronecta haliploides</i> Horvath, 1904
	12. <i>Micronecta ludibunda</i> Breddin, 1905
	13. <i>Micronecta khasiensis</i> Hutchinson, 1940
	14. <i>Anisops nasutus</i> Fieber, 1851
	15. <i>Anisops breddini</i> Kirkaldy, 1901
	16. <i>Anisops bouvieri</i> Kirkaldy, 1904
	17. <i>Anisops barbatus</i> Brooks, 1951
	18. <i>Anisops sardeus sardeus</i> Herrich-Shaffer, 1850
	19. <i>Anisops niveus</i> Fabricius, 1775
	20. <i>Nychia sappho</i> Kirkaldy, 1901
	21. <i>Paraplea frontalis</i> Fieber, 1844
	22. <i>Paraplea liturata</i> Fieber, 1844
	23. <i>Limnogonus (Limnogonus) fossarum fossarum</i> Fabricius, 1775
	24. <i>Limnogonus (Limnogonus) nitidus</i> Mayr, 1865
	25. <i>Limnometra anadyomene</i> Kirkaldy, 1901
	26. <i>Neogerris parvulus</i> Stal, 1859
	27. <i>Aquarius adelaides</i> Dohrn, 1860
	28. <i>Rhagadotarsus kraepelini</i> Breddin, 1905
	29. <i>Amemboa kumari</i> Distant, 1910



	30. <i>Naboandelus signatus</i> Distant, 1910
	31. <i>Microvelia (Microvelia) douglasi</i> Scott, 1874
	32. <i>Microvelia (Microvelia) diluta</i> Distant, 1909
	33. <i>Mesovelia vittigera</i> Horvath, 1895
	34. <i>Mesovelia horvathi</i> Lundblad, 1934
	35. <i>Hydrometra greeni</i> Kirkaldy, 1898
	36. <i>Hydrometra butleri</i> Hungerford and Evans, 1934
<b>Lakes (including dams, check dams &amp; regulators)</b>	1. <i>Laccotrephes griseus</i> Guerin-Meneville, 1844
	2. <i>Laccotrephes ruber</i> Linnaeus, 1764
	3. <i>Ranatra varipes varipes</i> Stal, 1861
	4. <i>Ranatra filiformis</i> Fabricius, 1790
	5. <i>Diplonychus molestus</i> Dufour, 1863
	6. <i>Diplonychus rusticus</i> Fabricius, 1781
	7. <i>Micronecta scutellaris scutellaris</i> Stal, 1858
	8. <i>Micronecta quadristrigata</i> Breddin, 1905
	9. <i>Micronecta haliploides</i> Horvath, 1904
	10. <i>Micronecta ludibunda</i> Breddin, 1905
	11. <i>Micronecta khasiensis</i> Hutchinson, 1940
	12. <i>Helocoris indicus</i> Montandon, 1897
	13. <i>Anisops nasutus</i> Fieber, 1851
	14. <i>Anisops breddini</i> Kirkaldy, 1901
	15. <i>Anisops niveus</i> Fabricius, 1775
	16. <i>Paraplea frontalis</i> Fieber, 1844
	17. <i>Paraplea liturata</i> Fieber, 1844
	18. <i>Limnogonus (Limnogonus) fossarum fossarum</i> Fabricius, 1775
	19. <i>Limnogonus (Limnogonus) nitidus</i> Mayr, 1865
	20. <i>Neogerris parvulus</i> Stal, 1859
	21. <i>Ptilomera (Ptilomera) agroides</i> Schmidt, 1926
	22. <i>Pleciobates indicus</i> Thirumalai, 1986
	23. <i>Metrocoris darjeelingensis</i> Basu, Polhemus and Subramanian,
	24. <i>Metrocoris communoides</i> Chen and Nesar, 1993
	25. <i>Naboandelus signatus</i> Distant, 1910

	26. <i>Microvelia (Microvelia) douglasi</i> Scott, 1874
	27. <i>Microvelia (Microvelia) diluta</i> Distant, 1909
	28. <i>Rhagovelia (Neorhagovelia) sumatrensis</i> Lundblad, 1936
	29. <i>Neolardus typicus</i> Distant, 1903
	30. <i>Mesovelia vittigera</i> Horvath, 1895
	31. <i>Mesovelia horvathi</i> Lundblad, 1934
	32. <i>Hydrometra greeni</i> Kirkaldy, 1898
	33. <i>Hydrometra butleri</i> Hungerford and Evans, 1934
	34. <i>Timasius fenestratus</i> Zettel, 2013
<b>Backwaters</b>	1. <i>Micronecta scutellaris scutellaris</i> Stal, 1858
	2. <i>Micronecta quadristrigata</i> Breddin, 1905
	3. <i>Micronecta ludibunda</i> Breddin, 1905
	4. <i>Anisops nasutus</i> Fieber, 1851
	5. <i>Anisops breddini</i> Kirkaldy, 1901
	6. <i>Nychia sappho</i> Kirkaldy, 1901
	7. <i>Paraplea frontalis</i> Fieber, 1844
	8. <i>Limnogonus (Limnogonus) fossarum fossarum</i> Fabricius, 1775
	9. <i>Rhagadotarsus kraepelini</i> Breddin, 1905
	10. <i>Lathriobates raja</i> Distant, 1910
	11. <i>Microvelia (Microvelia) douglasi</i> Scott, 1874
	12. <i>Mesovelia vittigera</i> Horvath, 1895
	13. <i>Mesovelia horvathi</i> Lundblad, 1934
	14. <i>Hydrometra greeni</i> Kirkaldy, 1898
<b>Mangroves</b>	1. <i>Limnogonus (Limnogonus) fossarum fossarum</i> Fabricius, 1775
	2. <i>Limnometra anadyomene</i> Kirkaldy, 1901
<b>Man-made pools</b>	1. <i>Cercotmetus pilipes</i> Dallas, 1850
	2. <i>Ranatra varipes atropha</i> Montandon, 1903
	3. <i>Ranatra filiformis</i> Fabricius, 1790
	4. <i>Diplonychus molestus</i> Dufour, 1863
	5. <i>Micronecta ludibunda</i> Breddin, 1905
	6. <i>Anisops nasutus</i> Fieber, 1851
	7. <i>Anisops breddini</i> Kirkaldy, 1901

	8. <i>Anisops niveus</i> Fabricius, 1775
	9. <i>Anisops tahitiensis</i> Lundblad, 1934
	10. <i>Nychia sappho</i> Kirkaldy, 1901
	11. <i>Enithares ciliata</i> Fabricius, 1798
	12. <i>Paraplea frontalis</i> Fieber, 1844
	13. <i>Limnogonus (Limnogonus) fossarum fossarum</i> Fabricius, 1775
	14. <i>Limnogonus (Limnogonus) nitidus</i> Mayr, 1865
	15. <i>Limnometra anadyomene</i> Kirkaldy, 1901
	16. <i>Rhagadotarsus kraepelini</i> Breddin, 1905
	17. <i>Ptilomera (Ptilomera) agroides</i> Schmidt, 1926
	18. <i>Ventidius (Ventidius) aquarius</i> Distant, 1910
	19. <i>Microvelia (Microvelia) douglasi</i> Scott, 1874
	20. <i>Microvelia (Microvelia) diluta</i> Distant, 1909
	21. <i>Rhagovelia (Neorhagovelia) sumatrensis</i> Lundblad, 1936
	22. <i>Mesovelia vittigera</i> Horvath, 1895
	23. <i>Hydrometra greeni</i> Kirkaldy, 1898
	24. <i>Hydrometra butleri</i> Hungerford and Evans, 1934

**PUBLISHED PAPER**



## PREDATORY POTENTIAL OF WATER BUGS AGAINST THE FILARIAL VECTOR *CULEX QUINQUEFASCIATUS* SAY

RANJINI S.\* AND FRANCY K. KAKKASSERY

Research and Postgraduate Department of Zoology  
St. Thomas' College (Autonomous), Thrissur 680001, Kerala  
\*Email: ranjinisphd@gmail.com

### ABSTRACT

Three water bugs, *Laccotrephes ruber* L., *Ranatra filiformis* F. and *Diplonychus rusticus* F., are natural biological control agents of mosquito larvae, *Culex quinquefasciatus* Say. These were evaluated for their predation potential on the fourth instar larvae of *C. quinquefasciatus*. Significant difference was observed as regards the predator density and time, and the results indicated that every predator act as natural biological control agent when the density of prey reached 100. Among the three predators selected, *L. ruber* was the best with maximum efficiency (79.16) followed by *D. rusticus* (61.50) and *R. filiformis* (39.16).

**Key words:** *Laccotrephes ruber*, *Ranatra filiformis*, *Diplonychus rusticus*, *Culex quinquefasciatus* larvae, predation potential, density, time

Mosquito-borne diseases are more prevalent due to unplanned urbanization and many anthropogenic activities, and malaria, filariasis, chikungunya, and dengue fever are more common. The lymphatic filariasis is predominant because of the principal vector, *C. quinquefasciatus* Say, prevalent in household areas, and control of this deadly vector is important. Pesticides, that are commonly used for controlling the larval and adult forms of such mosquitoes lead to non-target effects, and resistance, necessitating alternatives. The aquatic heteropterans, one of the prominent groups in freshwater habitats, act as biocontrol agents too. Their diversity had been well documented in the north and northeastern parts of India (Kshirsagar, 2010). In the aquatic habitats, different species of aquatic heteropterans co-occur with other prey and mosquitoes (Das et al., 2006; Bambaradeniya et al., 2004). The aquatic habitat of rice fields and wetlands includes different insect carnivores that consume a wide range of prey including mosquitoes (Kundu et al., 2014). The present study compares the predation potential of the three selected water bugs viz., *Laccotrephes ruber* L., *Ranatra filiformis* F., and *Diplonychus rusticus* F. under laboratory conditions.

### MATERIALS AND METHODS

The adults of *L. ruber* were collected from ditches of rice fields at Thiruvallathur (76°41'22.36"E, 10°43'59.5"N); *R. filiformis* from quarry ponds of Kuzhalmannam (76°35'32"E, 10°41'35"N); and *D. rusticus* from ponds

of Kodumbu (76°41'22.36"E, 10°43'59.5"N) at Palakkad District, Kerala using hand picking method, pond net, small sieve, etc. The collected adults were kept in a separate container (7.5 l) made up of mud filled with same pond water in the garden for a period of ten days before the commencement of experiments. To provide the natural conditions, some quantity of mud collected from the field was provided in the bottom. Aquatic plants such as *Ceratophyllum demersum* L. and *Pistia stratiotes* L. were also placed, and covered with nylon net. The required *C. quinquefasciatus* prey was sufficiently reared using pieces of fresh cabbage leaves mixed with water in a plastic bucket and kept for one week to get fourth instars' larvae and identified using the standard taxonomic key (Barraud, 1934; Reuben et al., 1994).

Three sets of same-sized eight mud pots, 600 ml in total volume, containing 500 ml of pond water were used in each experiment. Among these, the experimental group was comprised of four mud pots, each containing a predator and experimental mosquito larvae (tests). The remaining four mud pots constituted the control with only mosquito larvae and the same quantity of water. The experiments were carried out at 28±2°C and 50-60% RH, with water temperature being 29-30°C and pH 7-7.5. For estimation of predatory potential, before the actual experiments, trials were made. The predation potential of adults of water bugs against fourth instar larvae of *C. quinquefasciatus* was evaluated (25, 50, 75, and 100 were kept in each mud pots of test and control).

Each predator by means of same size was introduced into each set of the test pots with the densities of prey, and allowed to for a period of 12 hr. The control pots constituted only these four densities of mosquito larvae. The parameters such as room temperature, relative humidity, water temperature and pH were noted. The mosquito larvae remained alive at the end of 12 hr was counted. Five replications were maintained.

Statistical analysis of the experimental data was performed using the computer software SPSS 22 with two-way ANOVA. One-sample Kolmogorov-Smirnov test was used to test the normality of the data. This data followed the normal distribution. The post-hoc test was used to compare the significant difference in the predatory potential. Spearman's rank correlation coefficient was also used to study the relation between the time of exposure, density, and death of prey.

### RESULTS AND DISCUSSION

Preliminary study made in the laboratory revealed that the *L. ruber*, *R. filiformis*, and *D. rusticus* are predators of mosquito larvae, and these are potential biological control agents of the *C. quinquefasciatus* (Figs. 1-3). These captured the prey with their modified forelegs and suck the body fluids of mosquito larvae; also captured the second prey while feeding; and after sucking, the remnant body was discarded in the pot. Then they fed another mosquito larva. Venkatesan and D'Sylva (1990) described a similar feeding behaviour in *D. indicus* Venk. and Rao.

The results obtained on the predatory potential revealed significant difference with prey densities, and also with time. The estimated marginal means of death



Fig. 1. *L. ruber* L.



Fig. 2. *R. filiformis* F.



Fig. 3. *D. rusticus* F.

of prey was more by the predator, *L. ruber* (Species 1) followed by *D. rusticus* Fabricius (Species 3) and *R. filiformis* (Species 2) with respect to the time and the density of prey (Figs. 4, 5). At a density of 25 mosquito larvae, it showed a significant difference ( $p < 0.05$ ); but not amongst *L. ruber* and *D. rusticus*. Similar results were obtained from the data with prey densities of 50 and 75; and with prey density of 100 (Table 1).

From the correlation coefficients, it was observed that there exists a positive correlation between the time of exposure and death of prey by predation (Table 2); also, there is a high positive correlation between the density and death of preys, i.e., preys died more with time and density. Vimala (1990) reported the similar observations in Belostomatids. Amongst the predators, *L. ruber* exhibited maximum efficiency (79.16) followed by *D. rusticus* (61.50) and *R. filiformis* (39.16)

(Table 1). These results indicate that these can serve as a natural biological control agents. Saha et al. (2007) also reported similar observations with aquatic heteropterans such as *Anisops bouvieri* Kirkaldy, *D. rusticus* and

*D. annulatus*. The present results indicate that every predator act as natural biological control agent when the density of prey reached at 100, which corroborates with those of Saleeza et al. (2014) in fishes -guppies.

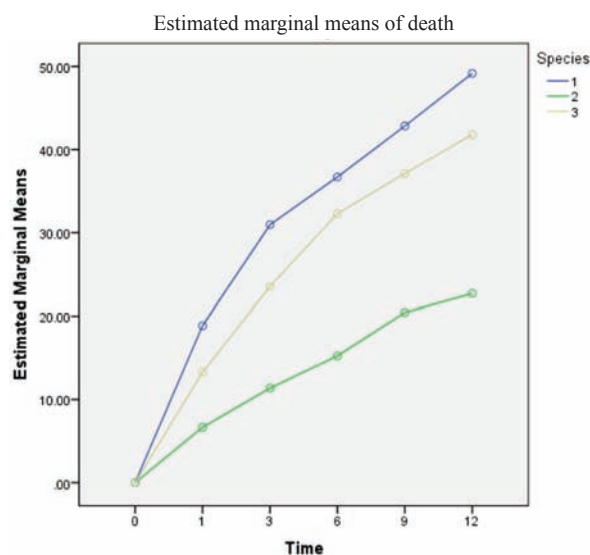


Fig. 4. Estimated marginal means of death of prey by predators vs. time

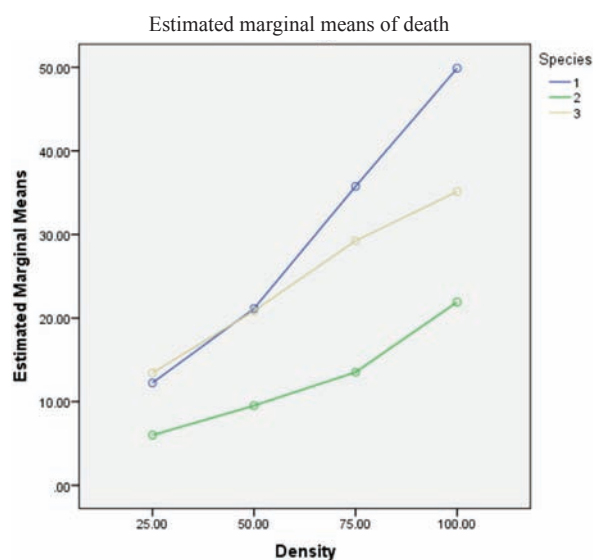


Fig. 5. Estimated marginal means of death of prey by predators vs. density

Table 1. Predation potential of water bugs and death rate - comparison

Dependent Variable	(I) Species	(J) Species	Mean Difference (I-J)	Std. Error	Sig.	Death rate/12 hr
Density - 25	<i>L. ruber</i>	<i>R. filiformis</i>	9.00000*	1.86389	.000	19.50
		<i>D. rusticus</i>	2.16667	1.86389	.263	
	<i>R. filiformis</i>	<i>L. ruber</i>	9.00000*	1.86389	.000	
		<i>D. rusticus</i>	11.16667*	1.86389	.000	
	<i>D. rusticus</i>	<i>L. ruber</i>	2.16667	1.86389	.263	
		<i>R. filiformis</i>	11.16667*	1.86389	.000	
Density - 50	<i>L. ruber</i>	<i>R. filiformis</i>	20.00000*	5.39719	.002	38.00
		<i>D. rusticus</i>	3.83333	5.39719	.488	
	<i>R. filiformis</i>	<i>L. ruber</i>	20.00000*	5.39719	.002	
		<i>D. rusticus</i>	16.16667*	5.39719	.009	
	<i>D. rusticus</i>	<i>L. ruber</i>	3.83333	5.39719	.488	
		<i>R. filiformis</i>	16.16667*	5.39719	.009	
Density - 75	<i>L. ruber</i>	<i>R. filiformis</i>	37.83333*	5.84776	.000	60.00
		<i>D. rusticus</i>	10.00000	5.84776	.108	
	<i>R. filiformis</i>	<i>L. ruber</i>	37.83333*	5.84776	.000	
		<i>D. rusticus</i>	27.83333*	5.84776	.000	
	<i>D. rusticus</i>	<i>L. ruber</i>	10.00000	5.84776	.108	
		<i>R. filiformis</i>	27.83333*	5.84776	.000	
Density - 100	<i>L. ruber</i>	<i>R. filiformis</i>	39.66667*	8.25945	.000	79.16
		<i>D. rusticus</i>	17.66667*	8.25945	.049	
	<i>R. filiformis</i>	<i>L. ruber</i>	39.66667*	8.25945	.000	
		<i>D. rusticus</i>	22.00000*	8.25945	.018	
	<i>D. rusticus</i>	<i>L. ruber</i>	17.66667*	8.25945	.049	
		<i>R. filiformis</i>	22.00000*	8.25945	.018	

\* Significant at p = 0.05

Table 2. Correlation coefficients of time, density and death of prey

		Time	Density	Death
Time	Pearson Correlation	1	.000	.587**
	Sig. (2-tailed)		1.000	.000
	N	432	432	432
Density	Pearson Correlation	.000	1	.464**
	Sig. (2-tailed)	1.000		.000
	N	432	432	432
Death	Pearson Correlation	.587**	.464**	1
	Sig. (2-tailed)	.000	.000	
	N	432	432	432

\*\*Significant at p = 0.01 level (2-tailed).

#### ACKNOWLEDGEMENTS

The authors thank the Principal, St. Thomas' College (Autonomous), Thrissur, Kerala for the facilities and encouragements; and Dr. Sajesh, Department of Statistics, and Dr. Joyce Jose, Department of Zoology, for help with statistical analysis. This research did not receive any specific grant from funding agencies.

#### REFERENCES

- Bambaradeniya C N B, Edirisinghe J P, Silva D N, Gunatilleke C V S, Ranawana K B, Wijekoon S. 2004. Biodiversity associated with rice agroecosystem in Sri Lanka. *Biodiversity and Conservation* 13(9): 1715-1753.
- Barraud P J. 1934. The fauna of British India, including Ceylon and Burma. Diptera Vol. V. Family Culicidae, Tribes Megarhinini and Culicini. Taylor and Francis, London.
- Das P K, Sivagnaname N, Amalraj D D. 2006. Population interactions between *Culex vishnui* mosquitoes and their natural enemies in Pondicherry, India. *Journal of Vector Ecology* 31(1): 84-88.
- Kshirsagar R V. 2010. The diversity of aquatic bugs from lentic water bodies of Pune District, Maharashtra. *International Journal of Advanced Biotechnology and Research* 1(1): 1-4.
- Kundu M, Sharma D, Brahma S, Pramanik S, Saha G K, Aditya G. 2014. Insect predators of mosquitoes of rice fields: the portrayal of indirect interactions with alternative prey. *Journal of Entomology and Zoology Studies* 2(5): 97-103.
- Reuben R, Tewari S C, Hiriyani J, Akiyama J. 1994. Illustrated keys to species of *Culex* (*Culex*) associated with Japanese encephalitis in Southeast Asia (Diptera: Culicidae). *Mosquito Systematics* 26(2): 75-96.
- Saha N, Aditya G, Bal A, Saha G K. 2007. A comparative study of predation of three aquatic heteropteran bugs on *Culex quinquefasciatus* larvae. *Limnology* 8(1): 73-80.
- Saleeza S N R, Rashid Y N, Azirun M S. 2014. Guppies as predators of common mosquito larvae in Malaysia. *Southeast Asian Journal of Tropical Medicine and Public Health* 45(2): 299-308.
- Venkatesan P, D'Sylva, T. 1990. Influence of prey size on choice by the water bug, *Diplonychus indicus* Venk. and Rao (Hemiptera: Belostomatidae). *Journal of Entomological Research* 14(2): 130-138.
- Vimala S D J. 1990. Prey selection by *Diplonychus indicus* Venk and Rao (Hemiptera, Belostomatidae). M.Phil. Thesis, University of Madras. 39 pp.

(Manuscript Received: September, 2018; Revised: January, 2019;  
 Accepted: January, 2019; Online Published: January, 2019)