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Diversity of odonates at agricultural college campus, Killikulam, Tamil Nadu, India

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Abstract
A study was conducted to assess the diversity of odonates at Agricultural College Campus, Killikulam, Tamil Nadu, India. A total of 29 species of odonates including 17 species of Anisoptera (dragonflies) and 12 species of Zygoptera (damselflies) were recorded at Agricultural College Campus, Killikulam. The family Libellulidae dominated with 15 species among Anisoptera followed by Aeshnidae (1) and Gomphidae (1). Among Zygoptera, Coenagrionidae (7) was the dominant family followed by Lestidae (2), Euphaeidae (1), Synlestidae (1) and Platycnemididae (1). *Diplocodes trivialis* (Libellulidae) was the most dominant Anisoptera and *Ischnura aurora* (Coenagrionidae), the most abundant Zygoptera among the 29 species recorded.

Keywords: Odonata, damselflies, dragonflies, species diversity, Killikulam, Tamil Nadu

1. Introduction
Odonata (dragonflies and damselflies) are gorgeous aquatic insects distributed throughout the world. Globally, 5952 species of Odonates under 652 genera have been reported. India harbours 474 species and 50 subspecies belonging to 142 genera in 18 families [22]. The Odonata fauna of the Western Ghats diverse with 176 species, 68 of which endemic [21, 23]. They are highly specific to their niche, depend heavily on water bodies for feeding and breeding and are extremely sensitive to the alteration of the locale [8, 5, 20]. Hence, dragonflies and damselflies are considered as indicators of wetland health. Besides, they are important elements of the food chain; many birds feed on them while odonates predate on other small insects like mosquitoes, moths, butterflies and conspecific and heterospecific Odonata [6].

2. Materials and Methods
2.1 Study Area
The study area Agricultural College Campus is located in the foothills of Vallanadu Blakbuck Sancturay about 35 km from Thoothukudi, Tamil Nadu, Southern India with an area of about 476.61 ha (Fig. 1). It is situated at an altitude of 40 m above MSL and lies between 8^0 46' N latitude and 77^0 42' E longitude. The area receives good rainfall during north-east monsoon (October - December). The mean annual rainfall of the area during the study period was 728 mm. The temperature ranges from minimum of 21.6 ^{0}C - 26.8 ^{0}C and maximum 30.1 ^{0}C - 37.9 ^{0}C with a relative humidity of 74 - 91%. The study area is predominantly covered by Agricultural, Horticultural, Agri-horticultural and Silvicultural ecosystems.
Collections were made from December, 2015 to March 2016 and only adult Odonata were collected with the help of a sweep net by slowly walking around the fields. The specimens were photographed for various identification features. Voucher specimens were collected, wherever possible, using insect sweep net and deposited in the Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam. Collection and estimation of population density was done once in a week and the data was compiled on a monthly basis. The identity of the collected Odonata was carried out by the keys given by [21]. The odonates observed were categorized into five groups based on their abundance during the period of study. Accordingly, those species observed 80 - 100% of the survey days were categorized as very common (VC), 60-80% as common (C), 40-60% as occasional (O), 20-40% as rare (R) and below 20% as very rare (VR) [1].

2.2 Statistical Analysis
Odonata diversity was computed using the Simpson's Index (D), Simpson's Index of Diversity (1-D), Simpson's Reciprocal Index (1/D) by using the software 'Biodiversity Calculator'
(http://www.alyoung.com/labs/biodiversity_calculator.html).
Simpson's Index (D) varies from 0 to 1. An increase in the value of the index indicates a decrease in diversity and vice-versa.

3. Results and Discussion
Three families *viz*., Libellulidae, Aeshnidae and Gomphidae were recorded under Anisoptera (dragonflies) and five families *viz*., Coenagrionidae, Lestidae, Euphaeidae, Synlestidae and Platycnemididae were recorded under Zygoptera (damselflies) (Table 1 & 4). A total of 29 species of odonates including 17 species of Anisoptera (dragonflies) and 12 species of Zygoptera (damselflies) were recorded from the study area. The family Libellulidae dominated with 15 species among Anisoptera followed by Aeshnidae (1) and Gomphidae (1). Among Zygoptera, Coenagrionidae (7) was the dominant family followed by Lestidae (2), Euphaeidae (1), Synlestidae (1) and Platycnemididae (1). *Diplocodes trivialis* (Libellulidae) was the most dominant Anisoptera and *Ischnura aurora* (Coenagrionidae), the most abundant Zygoptera among the 29 species recorded.

3.1 Species composition and relative abundance of Anisoptera (dragonflies)
A total of 412 individuals of dragonflies belonging to 17 species and 3 families were recorded during the study period (Table 1). On the basis of number of collected species, Libellulidae was the most dominant family with 15 species followed by Aeshnidae and Gomphidae with one species each (Table 1 & 2). The Ground Skimmer, *Diplocodes trivialis* was the most dominant species which constituted 28.40% of the total individuals followed by Wandering Glider, *Pantala flavescens* (15.31%), Green Marsh Hawk, *Orthetrum sabina* (15.06%), Asiatic Blood Tail, *Latherisista asiatica* (13.58%), Coral Tailed Cloud Wing, *Tholymis tillarga* (10.37%), Ruddy Marsh Hawk, *Crocothemis servilia* (4.69%), Common Picture Wing, *Rhyothemis variegata* (3.21%), Greater Crimson Glider, *Urothemis signata* (2.47%), Ditch Jewel, *Brahythemis contaminata* (2.22%), Yellow Tailed Ashy Skimmer, *Potmarcha congener* (1.48%), Red Marsh Trotter, *Tramea barilaris* (1.23%), Granite Ghost, *Brandinopyga germinata* (0.74%), Black Marsh Trotter, *Tramea limbata* (0.49%), Long Legged Marsh Glider, *Trithemis pallidinervis* (0.25%). The abundance of Libellulidae (Anisoptera) in the present study might be due to their shorter life cycle and widespread distribution [16] and tolerant to wide range of habitats [9, 17]. Anisoptera was abundant in most of the areas sampled. This might be due to their high dispersal ability [3, 27, 14, 12] and their adaptability to wide range of habitats [11, 24, 25]. Family Libellulidae was found to be the most specious and common. This was in accordance with the result of [19] which states that "common species has more individuals than rare species and had the ability to survive in existing environmental condition".
The relative abundance of dragonflies showed that out of 17 dragonfly species recorded, one is very common (5.88%), 2 each in common (11.76%) and occasional (11.76%), 12 are very rare (70.59%) to the study area (Table 1).
The abundance of dragonflies fluctuated widely over the months and December 2015 was the most active month (n=172) followed by January 2016 (n=126), February 2016 (n=73) and the dragonflies were in less proportion during March 2016 (n=41). The highest peak in the monsoon month December was due to high abundance of the members of Libellulidae representing higher number of individuals (n=171) followed by Aeshnidae (1) (Table 3). The maximum number of dragonflies were recorded during the rainy season when the humidity and temperature were favourable for the growth and development of dragonflies. The monsoon being the major factor in density and distribution of plants leads to increase in abundance of herbivourous insects, the prey for odonates. The various environmental factors such as temperature, humidity, rainfall, vegetation and food sources directly affecting the diversity and distribution of insect populations [15, 13, 4, 10]. Thus, influence of rainfall in the form of humidity on density and diversity in environment is likely to be an indirect effect operating via effects on food availability.

3.2 Species composition and relative abundance of Zygoptera (damselflies)
The relative abundance of damselflies were calculated and presented in Table 4. Among the five families, Coenagrionidae was the dominant family with five genera followed by Lestidae (1), Euphaeidae (1), Synlestidae (1) and Platycnemididae (1). *Ischnura* was the most dominant genera with 41 individuals followed by *Ceriagrion* (34) and *Agriocnemis* with 23 individuals. Coenagrionidae was the most dominant family which constituted 70.95% of the total collected damselflies and represented by 7 species followed by Lestidae (15.54%), Euphaeidae (11.49%), Synlestidae (1.35%) and Platycnemididae (0.68%). Golden Dartlet, *Ischnura aurora* was the most dominant species which represented 39.05 per cent of total individuals (n=41) of this family followed by *Ceriagrion coromandalianum* (30.48%) (n=32), *Agriocnemis splendidissima* (11.43%) (n=12), *Agriocnemis pygmaea* (10.48%) (n=11), *Pseudagrion rubricepts* (4.76%) (n=5), *Ceriagrion olivaceum* (1.91%) (n=2) and *Morotonagrion varrali* (1.91%) (n=2). The abundance of Coenagrionidae (Zygoptera) in the present study might be due to their shorter life cycle and widespread distribution [16] and tolerant to wide range of habitats [9, 17]. Less abundance of damselflies was probably due to their limited dispersal ability [26] and partial or absence of shade cover [7]. The abundance of damselflies could be attributed to the presence of shade over the habitat from the trees present over the water bodies and to the presence of aquatic vegetation [2].
The abundance of damselfies fluctuated widely over the months and January 2016 was the most active month (n=108) and the dragonflies were in less proportion during December 2015 (n=40). The highest peak in the month of January was due to high abundance of the members of Coenagrionidae representing higher number of individuals (n=81) followed by Euphaeidae (n=14), Lestidae (n=11) and Synlestidae (n=2) (Table 3).
Simpson's Index (D) showed maximum Anisoptera (dragonflies) diversity compared to Zygoptera (damselflies) whereas the Simpson's Index of Diversity (1 - D) was higher in Zygoptera (damselflies) than Anisoptera (dragonflies).
Odonates are rapacious in nature and also serve as good source of energy for birds, other insects and spiders. Benthic aquatic insects are sensitive indicators of environmental changes. Odonates, being both aquatic and terrestrial can contribute much to the evaluation of environmental quality. They are known to be very sensitive to habitat quality and therefore can be used as a tool to evaluate landscape degradation and have been used as an indicator species [7, 18].

Fig 1: Study Area - Map showing Agricultural College campus, Killikulam, Tamil Nadu

Table 1: Species richness and composition of dragonflies at Agricultural College Campus, Killikulam, Tamil Nadu, India

Genus	Scientific name	Common Name	Dec	Jan	Feb	Mar	Total	Status
Family : Libellulidae (Skimmers)								
Brachythemis	*Brachythemis contaminata*	Ditch jewel	-	8	1	-	9	VR
Brandinopyga	*Brandinopyga germinata*	Granite Ghost	1	1	-	-	2	VR
Crocothemis	*Crocothemis servilia*	Ruddy Marsh Hawk	8	5	5	1	19	VR
Diplocodes	*Diplocodes trivialis*	Ground Skimmer	25	44	27	19	115	VC
Latherisista	*Latherisista asiatica*	Asiatic blood tail	32	9	11	3	55	O
Orthetrum	*Orthetrum sabina*	Green Marsh Hawk	17	23	12	9	61	C
Pantala	*Pantala flavescens*	Wandering Glider	49	2	8	3	62	C
Potamarcha	*Potamarcha congener*	Yellow Tailed Ashy Skimmer	4	2	-	-	6	VR
Rhyothemis	*Rhyothemis variegata*	Common picture wing	3	5	4	1	13	VR
Tholymis	*Tholymis tillarga*	Coral tailed cloud wing	23	17	-	2	42	O
Tramea	*Tramea barilaris*	Red Marsh Trotter	1	4	-	-	5	VR
	Tramea limbata	Black Marsh Trotter	2	-	-	-	2	VR
Trithemis	*Trithemis pallidinervis*	Long Legged Marsh Glider	-	-	1	-	1	VR
Urothemis	*Urothemis signata*	Greater Crimson Glider	5	4	1	-	10	VR
Zygomma	*Zygomma petiolatum*	Brown dusk hawk	1	-	1	1	3	VR
		Sub Total (A)	171	124	71	39	405	
Family: Aeshnidae (Darners)								
Anax	*Anax gluttatus*	Blue Tailed Green Darner	1	2	2	1	6	VR
		Sub Total (B)	1	2	2	1	6	
Family: Gomphidae (Clubtails)								
Ictinogomphus	*Ictinogomphus rapax*	Common Clubtail	-	-	-	1	1	VR
		Sub Total (C)	-	-	-	1	1	
		Sub Total (A+B+C) = Total	172	126	73	41	412	

VC - Very Common; C - Common; O - Occasional; R - Rare; VR - Very Rare

Table 2: Relative abundance of dragonflies at Agricultural College Campus, Killikulam

Family	Number of Genus	Number of species	Number of individuals
Libellulidae	14 (87.50%)	15 (88.23%)	405 (98.30%)
Aeshnidae	1 (6.25%)	1 (5.88%)	6 (1.48%)
Gomphidae	1 (6.25%)	1 (5.88%)	1 (0.25%)
Total	16 (100%)	17 (100%)	412 (100%)

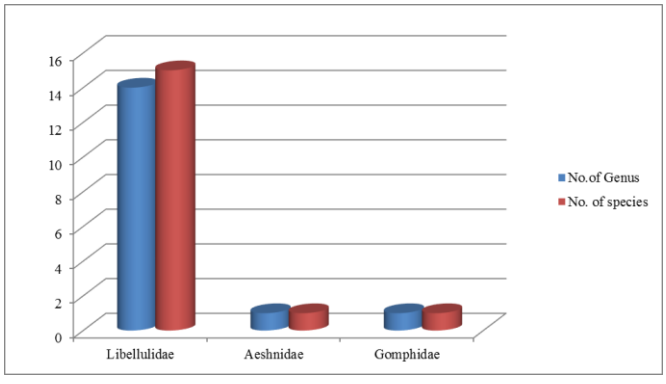


Fig 2: Relative abundance of dragonflies at Agricultural College Campus, Killikulam, Tamil Nadu

Table 3: Monthwise abundance of dragonflies at Agricultural College campus, Killikulam

Family	Dec	Jan	Feb	Mar	Total
Libellulidae	171	124	71	39	405
Aeshnidae	1	2	2	1	6
Gomphidae	-	-	-	1	1
Total	172	126	73	41	412

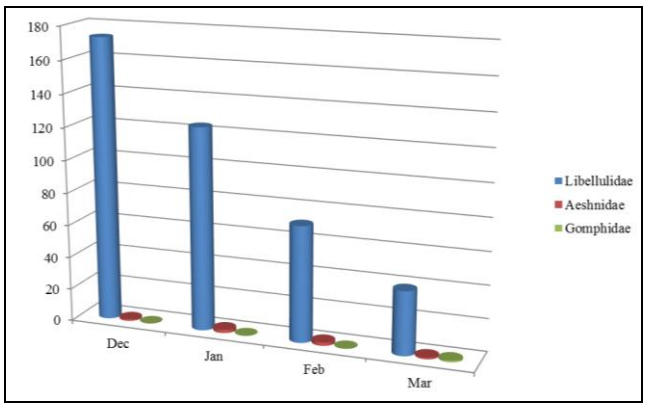


Fig 3: Month wise occurrence of dragonflies at Agricultural College Campus, Killikulam

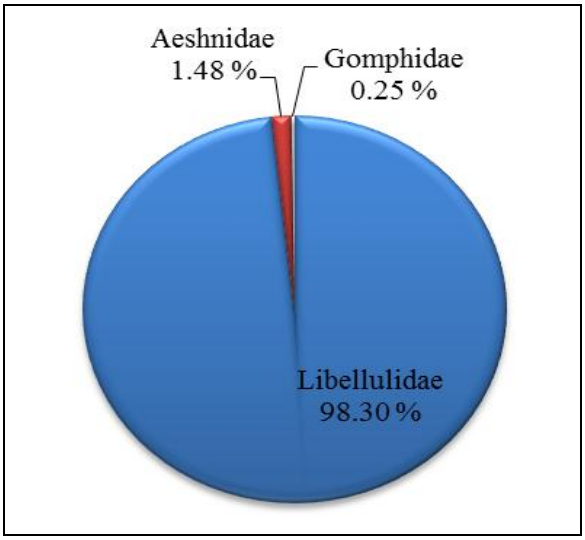


Fig 2.1: Abudnance of different families of Anisoptera (dragonflies) at Agricultural College Campus, Killikulam

Table 4: Species richness, composition and status of damselflies at Agricultural college campus, Killikulam, Tamil Nadu

Genus	Scientific Name	Common Name	Dec	Jan	Total	Status
Family: Coenagrionidae						
Agriocnemis	*Agriocnemis splendidissima*	Splendid Dartlet	8	4	12	VR
	Agriocnemis pygmaea	Pigmy Dartlet	1	10	11	VR
Ceriagrion	*Ceriagrion coromandalianum*	Coromandal Marsh Dart	2	30	32	R
	Ceriagrion olivaceum	Rusty Marsh Dart	1	1	2	VR
Ischnura	*Ischnura aurora*	Golden Dartlet	11	30	41	O
Morotonagrion	*Morotonagrion varrali*	Brown Dartlet	1	1	2	VR
Pseudagrion	*Pseudagrion rubricepts*	Saffron Faced Blue Dart	-	5	5	VR
		Sub Total (A)	24	81	105	
Family : Lestidae (Spreadwings)						
Lestes	*Lestes elatus*	Emerald Spreadwing	10	11	21	R
	Lestes malabarica	Malabar Spreadwing	2	-	2	VR
		Sub Total (B)	12	11	23	
Family : Synlestidae (Giant Spreadwings)						
Megalestes	*Megalestes major*	Giant Emerald Spreadwing	-	2	2	VR
		Sub Total (C)	-	2	2	
Family : Euphaeidae (Torrent Darts)						
Euphaea	*Euphaea fraresi*	Malabar Torrent Dart	3	14	17	VR
		Sub Total (D)	3	14	17	
Family : Platycnemididae (Bush Darts)						
Copera	*Copera marginipes*	Yellow Bush Dart	1	-	1	VR
		Sub Total (E)	1	-	1	
		Sub Total (A+B+C+D+E) = Total	40	108	148	

VC - Very Common; C - Common; O - Occasional; R - Rare; VR - Very Rare

Table 5: Relative abundance of damselflies at Agricultural College Campus, Killikulam, Tamil Nadu

Family	Number of Genus	Number of Species	Number of Individuals
Coenagrionidae	5 (55.56%)	7 (58.33%)	105 (70.95%)
Lestidae	1 (11.11%)	2 (16.67%)	23 (15.54%)
Synlestidae	1 (11.11%)	1 (8.33%)	2 (1.35%)
Euphaeidae	1 (11.11%)	1 (8.33%)	17 (11.49%)
Platycnemidae	1 (11.11%)	1 (8.33%)	1 (0.68%)
Total	9 (100%)	12 (100%)	148 (100%)

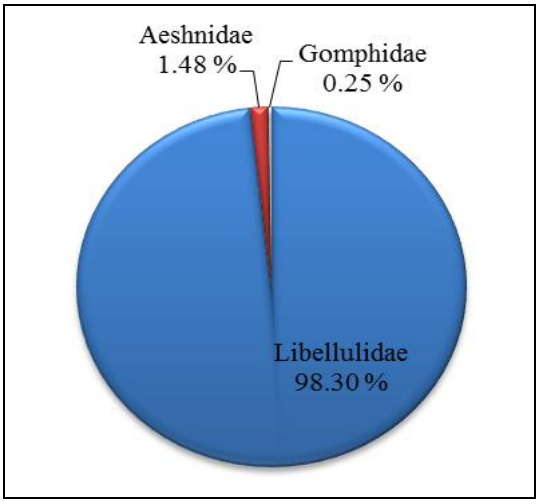


Fig 4: Relative abundance of damselflies at Agricultural College Campus, Killikulam, Tamil Nadu

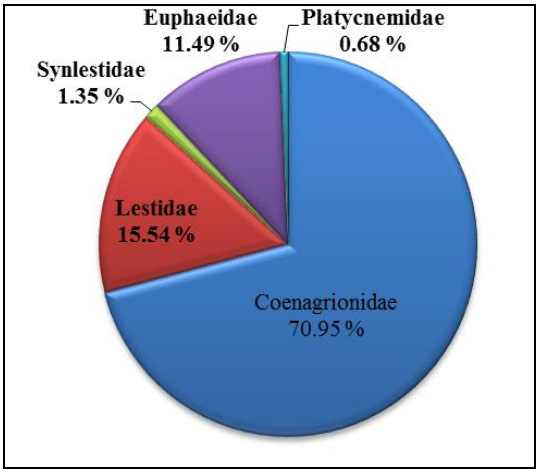


Fig 4.1: Abudnance of different families of Zygoptera (damselflies) at Agricultural College Campus, Killikulam

Table 6: Monthwise abundance of damselflies at Agricultural College Campus, Killikulam

Family	Dec	Jan	Total
Coenagrionidae	24	81	105
Lestidae	12	11	23
Synlestidae	-	2	2
Euphaeidae	3	14	17
Platycnemidae	1	-	1
Total	40	108	148

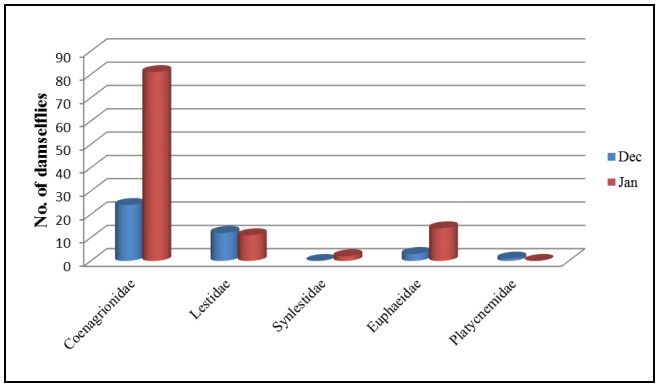
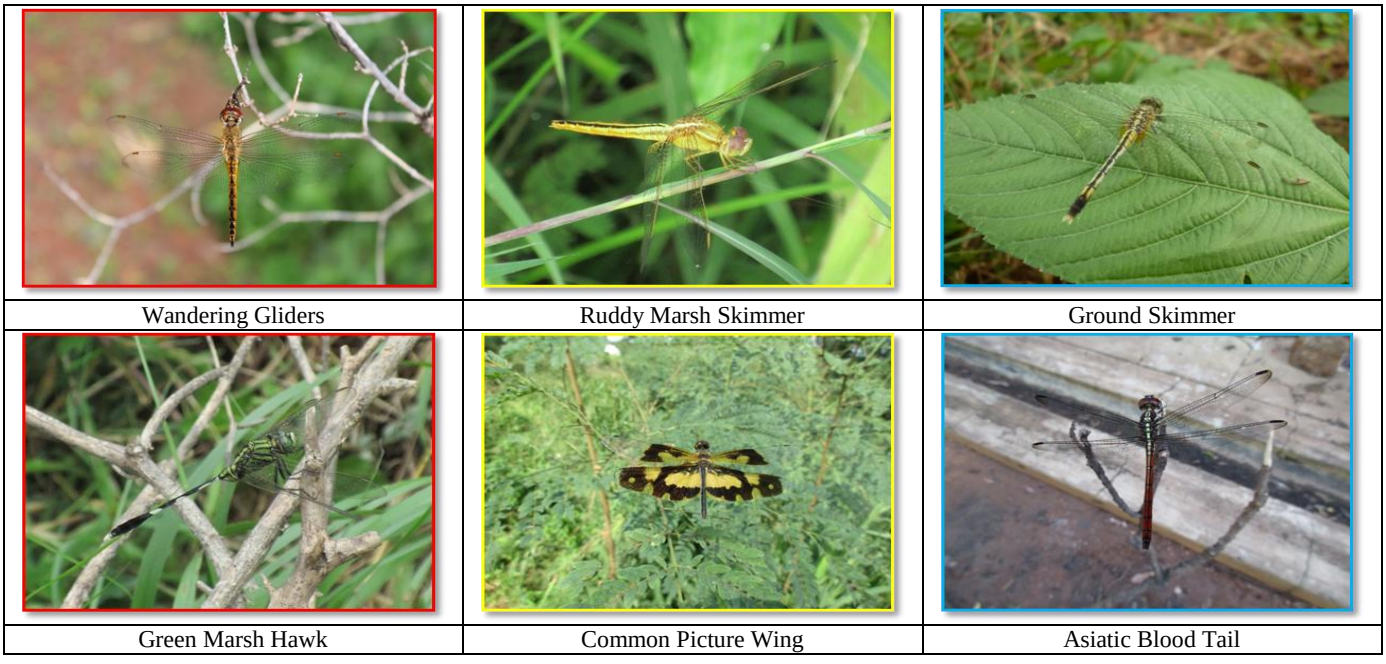


Fig 5: Monthwise occurrence of damselflies at Agricultural College Campus, Killikulam

Table 7: Species diversity (Simpson) of Odonata at Agricultural College Campus, Killikulam

Sub order	Simpson's Index (D)	Simpson's Index of Diversity (1 - D)	Simpson's Reciprocal Index (1/D)
Anisoptera (Dragonflies)	0.15	0.85	6.51
Zygoptera (Damselflies)	0.17	0.83	6.10

Diversity of odonates at Agricultural College Campus, Killikulam



		
Blue-tailed Green Darner	Trumpet Tail	Rufous Marsh Glider

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