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DIVERSITY, GEOGRAPHICAL HABITAT USAGE AND DISTRIBUTION ASSESSMENT OF FLIES (INSECTA: DIPTERA) IN NILGIRI HILLS, TAMIL NADU, INDIA

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ABSTRACT

In the study of diptera diversity and distribuiton conducted in 2020-2021 we found insect species in 23 families out of 64 common individual species. Site-A Hidden Valley is considered to be the place with the highest number of individual (861nos). In this study we found that most pollination in the Nilgiris in the diptera order is done on small flowering plants. Fruit fly insect are never harmful to the fruits of the Nilgiris eg- *Rhagoletis* sp. Stomoxys sp, Musca sp species of insect found mostly in cattle and gaur in the Nilgiris The study was conducted in four different forest areas in the Nilgiris and in the lake area, Ooty Lake is the most associated area for humans and flies. This study is not only about this period but also about the future studies of these insects mostly because they are important for all types of ecological environment.

Contribution/Originality: This study will be an important study to identify diptera species in the nilgiris and to continue further research on these insects in the future. Because studies on diptera are not much in the westernghats.

1. INTRODUCTION

The order Diptera is one of the largest insect orders in the world. In the order documented 2,70,219 species worldwide, under 150 families [1]. Some diptera families are both beneficial and harmful to natural with human environment most flies are diurnal and may visit flower for nector include some species of *syrphidae, Bombylidae* and *culucidae calliphora vicina* more than 500 flies per week per day is an efficient and cost-effective pollinator for scale production [2]. While numerous others feed upon decaying organic matter and diverse third substances. Several groups of flies are predators on smaller insects or parasitoids as larva and adults including Asilidae, Empididae, Dolicophodidae, Syrphidae and Tachinidae. Some are found in decomposing organic substance and some groups play a major role in forensic entomology. Many dipterans are blood suckers and are harmful to humans and animals and cause economic losses. Mosquitoes are important as vectors of several tropical diseases including malaria, filariases, dengue, Japanese encephalitis and yellow fever. In temperate countries, mosquitoes and biting midges are nuisance pests than vectors. In India, fruit crops such as mango and guava suffer great economic yield losses due to the Oriental fruit fly, *Bactocera dorsalis* [3]. Hepatitis B is transmitted by *Chrysops* sp. (Family Tabanidae) and many people have been affected by this pathogen [4]. Research has been done on mosquitoes in the Nilgiri hills, but studies on other dipteran insects in the Nilgiris have not been extensive [5-10]. The Nilgiris Range boasts of a

diverse array of flora and fauna, including unique wildlife and there is an important relationship between flies and animals.

2. METHODOLOGY

This study was conducted in the Nilgiri hills covering a range of habitats such as margin of the mountain rain forest, shola forest, grass lands, lake, and endangered shola forest in the year 2020-2021. Four locations with geographical and climatical differences were studied and surveys were conducted four days a month in a year. Specimens were collected only photographs various location with a Nikon P900 camera. GPS locations were recorded with the help of Garmin GPS Location device. We identified the species with the help of key studies and books [11, 12]. The numbers of flies on the flowers, grasses, leaves and animal faeces in all seasons were counted. Study Methods: two types of calculation was conducted in the study diversity calculated on the basis of individual families, and basis of species diversity collected from four locations. Shannon-Weiner index (H') [13] Simpson diversity index (D) [14] Margalefe index (D_{mg}) [15] Pielou Evenness (J') [16]. We compiled the results of the study using these Calculation.

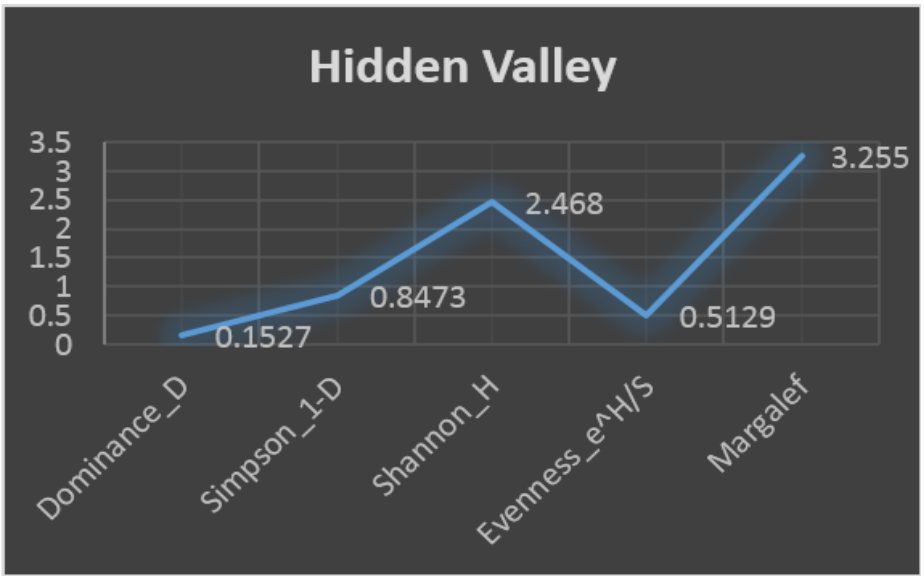

Figure 1. Shows the diversity indices for Diptera in Hidden Valley study site

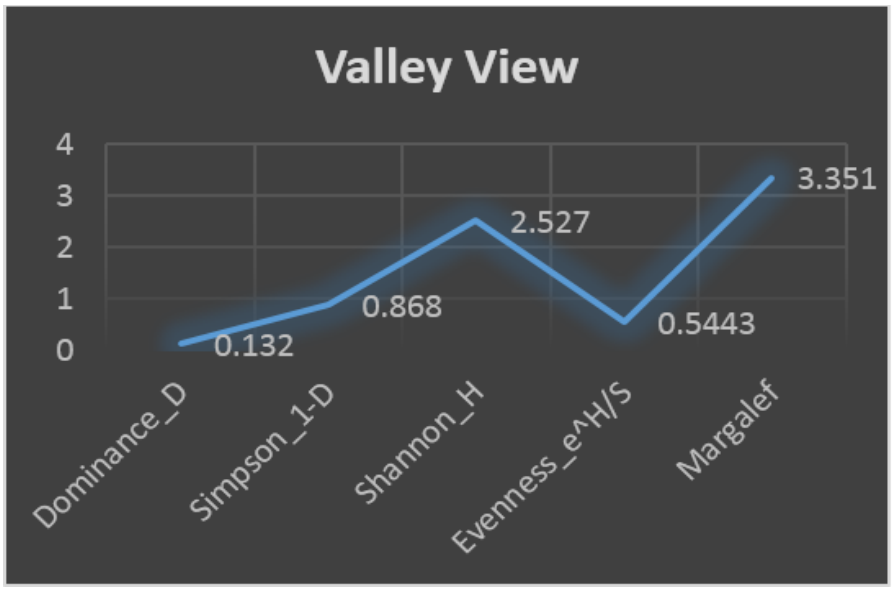

Figure 2. Shows the diversity indices for Diptera in Valley View study site.

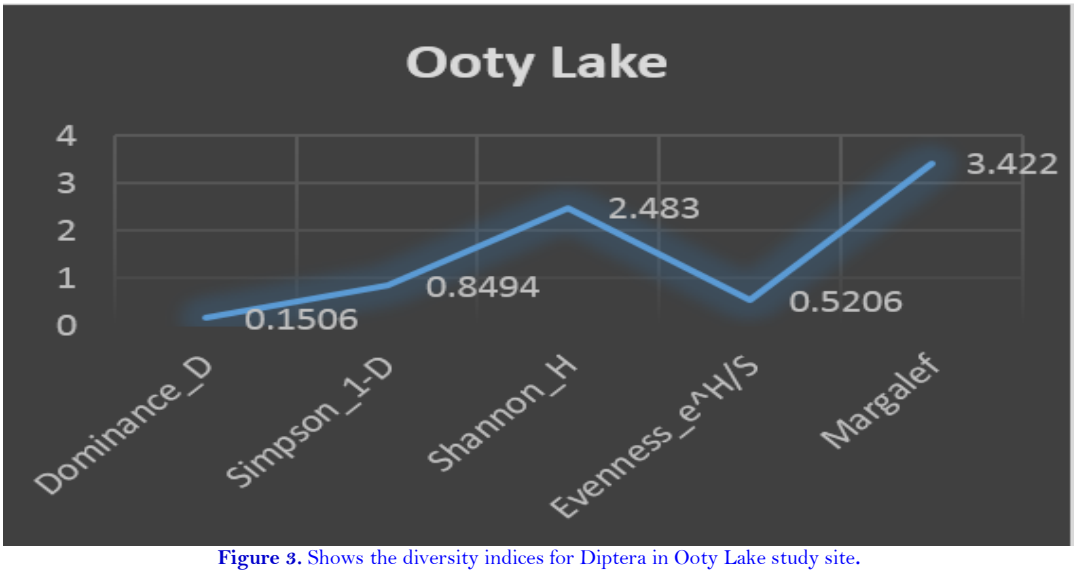

Figure 3. Shows the diversity indices for Diptera in Ooty Lake study site.

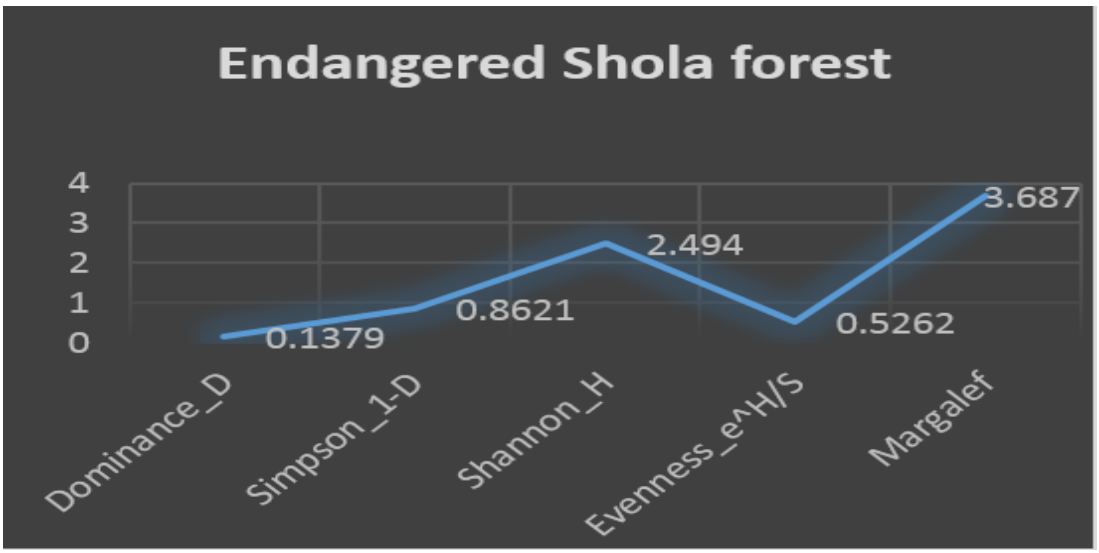

Figure 4. Shows the diversity indices for Diptera in Endangered shola forest study site.

2.1. Study Area

2.1.1. Site-A Coonoor – Hidden Valley

This forest area in the Coonoor range belongs to the mountain rain forest type (Lat: 11°22'07 Long: 76°47'47 Figure 5, which is a water rich area. Totally 0.76 km² forest area has been surveyed. The region receives an annual rainfall of 70.8 inch and annual temperature is 21°C. This area is rich in wild, endemic and endangered flora and fauna.

2.1.2. Site-B Valley View

This forest is a rocky part of the mountain range (Lat: 11°23'31 Long: 76°43'23 Figure 5) with a mixture of grassy shola forest and forest plantation rich with wild, endemic and endangered flora and fauna. Totally 0.89 km² Forest has been surveyed. The region receives an annual rainfall of 40.98 inch. Annual temperature is 17°C.

2.1.3. Site-C Ooty Lake

Ooty Lake (Lat: 11°24'90 Long: 76°41'21 (Figure 5)) is a man-made lake built by John Sullivan. The area around the lake is covered with plastic wastes, aquatic plants and sediments and also a grazing area for cattle. The

lake is owned by the state tourism and fisheries department. Totally km² area around the lake was surveyed. The region receives an annual rainfall 40.98 inch. Annual temperature is 17°C.

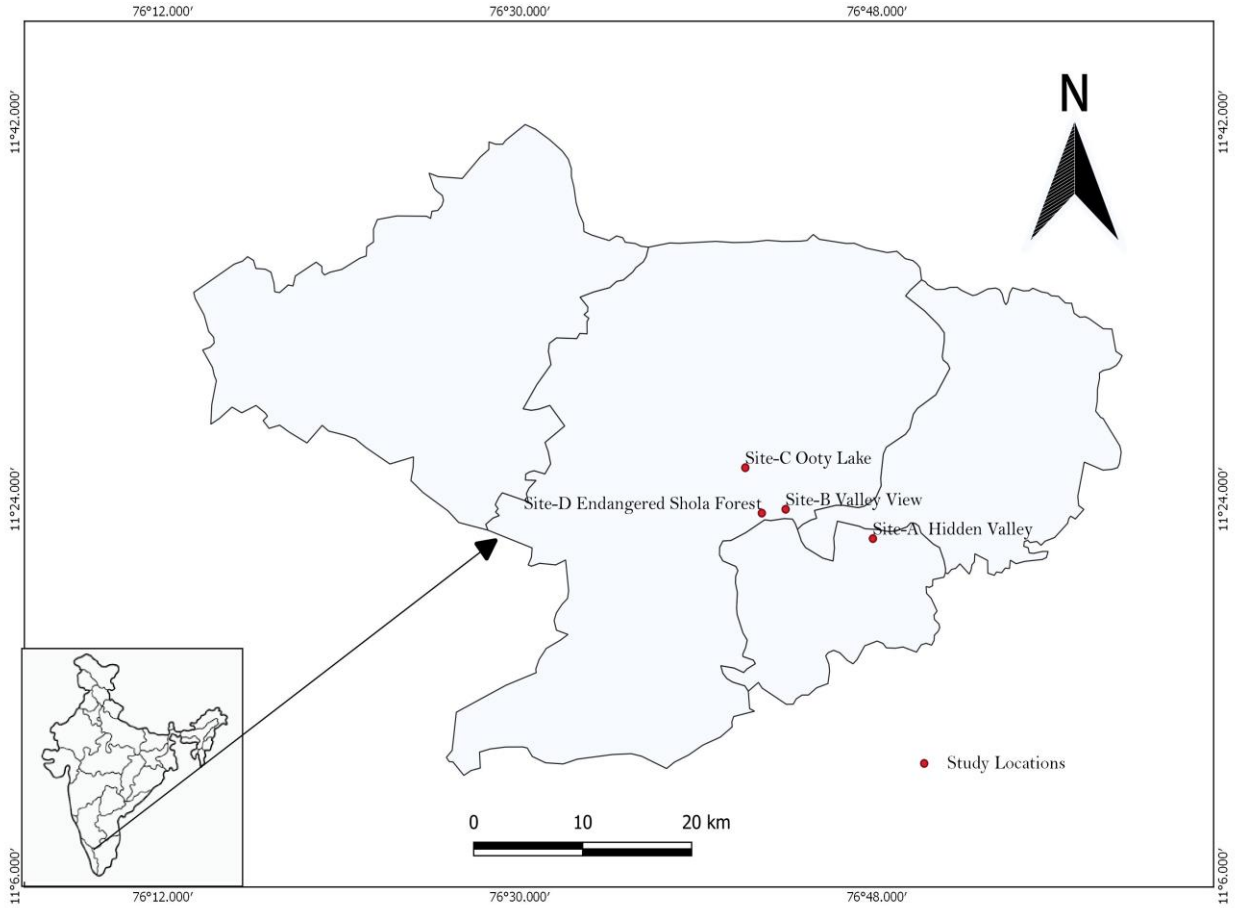

Figure 5. Localities surveyed in the Nilgiri hills.

2.1.4. Site-D Endangered Shola Forest Patch

This area is a small endangered shola forest (Lat: 11°23'20 Long: 76°42'11(Figure 5)) in the middle of the forest plantation in Lovedale town and it is frequented by cattle, deer and wild gaur. Totally 3.37 ha forest was surveyed. The region receives an annual rainfall of 59.6 inch. Annual temperature is 17°C.

3. RESULTS

In the study we recorded 2581 individuals belonging to 64 species in 23 families of the Order Diptera order commonly found in the Nilgiris and the Diversity Indices at the four locations are listed Table 1.

Table 1. Diversity indices for Diptera collected from four locations.

Calculation	Site-A Hidden Valley	Site-B Valley View	Site-C Ooty Lake	Site-D Endangered Shola Forest
Dominance_D	0.152	0.132	0.150	0.137
Simpson_1-D	0.847	0.868	0.849	0.862
Shannon_H	2.468	2.527	2.483	2.494
Evenness_e^H/S	0.512	0.544	0.520	0.526
Margalef	3.255	3.351	3.422	3.687
Individuals	861	710	620	390

Figure 6. Diptera collected and identified in the study.

Note: 1. *Episyrphus*, 2. Lauxaniidae, 3. *Lispe*, 4. Muscidae, 5. Dolicopodidae, 6. *Asarkina*, 7. Bibionidae, 8. Sciaridae, 9. Anthomyiidae, 10. *Stomoxys*, 11. Dolicopodidae, 12. Tachinidae, 13. *Phaonia*, 14. *Haematopota*, 15. Asilidae, 16. *Tabanus*, 17. *Gonia*, 18. *Nephrotoma*, 19. *Pselliophora laeta*, 20. Dolicopodidae, 21. *Chrysopilus*, 22. Anthomyiidae, 23. *Eristalinus arvorum*, 24. *Campiglossa product*, 25. *Haematopota*, 26. *Eriocera nepalensis*, 27. Stratiomyidae, 28. Tipulidae, 29. Tipulidae, 30. *Episyrphus*, 31. *Argyra*, 32. Keroplatidae, 33. Muscidae, 34. Muscidae, 35. *Morellia*, 36. Muscoidea, 37. *Prosena*, 38. Sciaridae, 39. *Stomoxys calcitrans*, 40. Sarcophagidae, 41. Psychodidae, 42. Dexiinae, 43. Athericidae, 43. *Neomyia*, 44. Rhiniidae, 45.Tipulidae. 46. Hybotidae,47. *Zaprionus*, 48. *Drosophila ananassae*, 49. *Baccha* sp., 50. *Bibio* sp., 51. Asilidae, 52. *Musca domestica*, 53. Sarginae, 54. Tabanidae, 55. Bombyliidae, 56. *Lucilia*, 57. *Tabanus*, 58. *Rhagoletis cingulata*, 59. Asilidae, 60. Tachinidae, 61. *Melanostoma mellinum*, 62. *Rioxoptilona inermis.*

The images of 62 flies are featured in Figure 6. The Diptera fauna of the study area were indication good diversity index. Site-A Hidden Valley recorded the highest number of individuals (861nos) but with the lowest diversity index (>2.468) (Figure 1). Site-D Endangered Shola forest yielded the least number of individuals (390 nos) but had a high diversity and the diversity value was >2.527. Site-B also had the highest Simpson Diversity Index of >0.868 (Figure 2). The next highest diversity was found at Site-D (Diversity index >2.494) (Figure 4) which had the least individual counts. Site-C Ooty Lake third had the highest diversity (diversity index >2.483) (Figure 3). The site with the lowest diversity index value (>2.468) had the highest individual counts. The Diversity Indices were also calculated on the basis of individual families (Table 2).

The highest number was found at Site-D (margalef index rate >3.687). Excessive evenness was seen at site-B with a Pielou evenness index of >0.5443. Shannon diversity, Margaliefs and Pielous evenness indices for the dipteran fauna of the study area were 2.953, 2.949 and 0.896, respectively, indicating their good diversity and richness [17]. Mumbai Metropolitan Region is represented by 57% (n=50) of family-level diversity of Diptera in India [18]. We found 41332 flies based on direct evidence, which is important for other inferences on the conservation of natural tropical and non-tropical environments in the world [19].

Table 2. Diversity indices calculated on the basis of individual families.

Diptera Family Name	Common Names	Margalefe index (D_{mg})	Simpson diversity index (D)	Shanon-Weiner index (H')	Pielou Evenness (J')
Anthomyiidae	Root-maggot flies	0.581	0.503	1.034	0.431
Asilidae	Robber flies	0.461	0.247	0.531	0.242
Athericidae	Athericid flies	0.582	0.241	0.523	0.218
Bombyliidae	Bee flies	0.461	0.131	0.320	0.146
Bibionidae	Fever flies	0.574	0.227	0.535	0.223
Calliphoridae	Blow flies	0.587	0.189	0.455	0.189
Dolicophodiae	Long legged flies	0.491	0.142	0.348	0.158
Drosophilidae	Small fruit flies	0.593	0.381	0.882	0.368
Hybotidae	Dance flies	0.788	0.653	1.165	0.840
Keroplatidae	Fungus gnats	1.136	0.780	1.333	0.962
Lauxaniidae	Lauxaniid flies	0.697	0.666	1.187	0.856
Muscidae	House flies	0.444	0.729	1.341	0.967
Mycetophilidae	Fungus gnats	0.882	0.751	1.340	0.967
Rhagionidae	Snipe flies	0.644	0.682	1.249	0.901
Rhiniidae	Blow flies	0.890	0.716	1.266	0.913
Sarcophagidae	Flash flies	0.910	0.660	1.166	0.841
Sciaridae	Fungus gnats	0.824	0.741	1.325	0.956
Syrphidae	Flower flies	0.558	0.700	1.248	0.900
Stratiomyidae	Soldier flies	0.713	0.695	1.218	0.878
Tachinidae	Tachinid flies	0.609	0.700	1.267	0.914
Tephritoidea	Fruit Flies	0.824	0.701	1.240	0.894
Tabanidae	Horse flies	0.648	0.728	1.333	0.961
Tipulidae	Crane flies	0.593	0.749	1.375	0.992

Table 3. Diptera feeding habitat using flowers and decaying materials.

S.No	Diptera Names	Flora and other Materials									Decaying Fauna					
		Tagetes erecta	Bidens pilosa	Cynoglossum Zeylanicum	Justicia simplex	Nicandra physalodes	Euphorbia helioscopia	Fruits	Flies Predatory	Blood Sucking	Decaying wood/plants/mud	wild Gaur Defecat	Leopard Defecat	Domestic Cattle Defecat	BirdsDefecat	Monkey Defecat	WildCats Defecat
1	*Condylostylus*	•	•	•	•	•	•					•		•			
2	Syrphidae	•	•	•	•	•	•				•						
3	*Gonia* sp.	•		•	•			•			•	•					
4	*Rioxoptilona inermis*							•								•	
5	*Tabanus* sp.											•	•	•	•	•	•
6	Asilidae	•		•		•			•								
7	Tachinidae: Dexiinae	•	•		•							•	•		•		
8	*Melanostoma*	•	•	•	•	•	•	•									
9	*Mydaea*	•		•		•					•	•	•	•		•	
10	*Chrysotoxum* sp.	•	•		•	•	•										
11	Tachinidae	•			•		•				•		•		•		•
12	*Tabanus* cf *striatus*	•		•		•	•				•				•		
13	*Bengalia* sp.	•	•		•				•				•	•	•		
14	*Lucilia* sp.	•	•	•	•	•	•					•	•	•		•	

15	*Sargus* sp.	•	•	•	•	•											
16	*Haematopota*									•			•				
17	*Chrysomya megacephala*										•	•	•	•	•	•	•
18	Rhagionidae	•		•				•							•		
19	*Melinda* sp.		•		•						•				•		
20	*Anthomyia* sp.	•	•	•	•	•		•	•					•			•
21	*Amblypsilopus*	•	•	•	•	•	•	•		•							
22	*Condylastylus*	•	•	•	•	•	•	•									
23	*Dasysyrphus*	•			•			•									
24	*Stomoxys* sp.									•			•	•	•		•
25	Dexiinae	•		•		•								•		•	
26	*Phaonia* sp.	•		•							•	•			•		•
27	*Nephrotoma*										•						
28	*Pselliophora laeta*										•						
29	*Musca*							•						•	•		
30	Bombyliidae	•	•	•	•	•	•	•									
31	*Rhagoletis cingulata*							•									
32	*Eriocera nepalensis*										•						
33	Anthomyiidae	•	•	•	•	•						•			•		
34	Bibionidae	•	•	•								•		•		•	
35	Sciaridae	•			•						•						
36	*Chrysopilus*	•	•	•				•									
37	*Asarkina* sp.	•	•	•	•	•	•										
38	Lauxaniidae (*Homoneura* sp.)							•					•	•	•	•	•
39	Muscidae				•			•				•		•	•	•	
40	*Bibio* sp.	•	•			•					•						
41	*Lispe* sp.				•		•				•			•			
42	*Episyrphus* sp.	•	•	•	•	•		•			•						
43	Rhagionidae		•			•					•						
44	*Baccha* sp.	•	•	•	•	•											
45	*Drosophila ananassae*				•			•					•				
46	*Zaprionus* sp.		•		•								•		•		
47	Hybotidae								•					•			
48	Rhiniidae	•		•			•					•					
49	*Neomyia* sp.	•	•	•	•	•	•	•				•	•	•	•	•	•
50	Athericidae	•			•	•					•						
51	*Morellia* sp.		•					•			•	•		•		•	
52	Sarcophagidae		•			•		•		•		•		•			•
53	Dexiinae (*Trichodura*)		•		•					•							
54	*Musca* sp.			•								•		•	•	•	
55	Muscidae sp.											•		•	•		•
56	Muscoidea		•									•	•			•	
57	*Prosena* sp.	•	•	•	•	•	•				•	•		•	•		
58	Limoniidae										•						

59	*Stomoxys calcitrans*	•		•		•				•	•		•		•		•
60	Sciaridae					•					•						
61	*Neoempheria*							•			•						
62	Keroplatidae							•			•						
63	Tipulidae										•						
64	Psychodidae										•						

In this study, we have documented the habitat and food habits of 64 individuals (Table 3). Most Diptera species are seen during the winter and post-winter seasons. In this study we found 6 out of 47 species of Diptera were found on six types of flowering plants and most of these Diptera species used these flowering plants. Syrphidae, *Melanostoma*, *Lucilia* sp., *Amblypsilopus*, *Condylastylus* sp., Bombyliidae, *Asarkina* sp., *Neomyia* sp., and *Prosena* sp. were more common on the flowering plants which play an important role in pollination. Among all flower-visiting flies, the family Syrphidae with approximately 6000 species and 300 genera plays an important role in pollination [20]. Syrphids also act as alternative pollinators in the higher elevation landscapes of Himachal Pradesh [21]. Of the 14 families recorded study the family syrphidae having the highest number of species [22]. Syrphidae is the dominant group among the flower visiting flies of India [23]. 357 species of hover flies, more than 100 species are restricted in India. In Tamil Nadu (14.5%) widespread [24]. 21 Insect species are fruit bearing species. *Rioxoptilona inermis* this species was first spotted in the Nilgiris in this study and is a fruit-bearing species. *Anthomyia sp*, *Condylastylus sp*, *Musca domestica*, *Rhagolets Cingulata*, *Drosophila ananassae*, are the most abundant Nilgiri fruit suckers. Indicating a differential effect of density on the pollination efficiency of *M. domestica* and *Calliphora vicina* the linear trend for fly density and nonparallel regressions for the effect of fly species on seed yield per cage were significant [2]. Some species prey on small insects or their own species, in this study we observed four predatory species there are Asilidae, Hybotidae, *Anthomyia* sp., and *Bengalia* sp. A total of 6 species of blood-sucking Diptera order are commonly found in cows and domestic dogs *Haematopota sp*, *Amblypsilopus sp*, *Stomoxys sp*, *Sarcophagidae*, *Dexiinae (Trichodura)*, *Stomoxys calcitrans*. We find out how many dipteran species are present in the defecations of six species of Wild and Domestic animals. In this study total of 10 flies made extensive use of animal defecates there are *Stomoxys calcitrans*, *Neomyia* sp., Muscidae, Lauxaniidae (*Homoneura* sp.), *Stomoxys* sp., *Chrysomya megacephala*, Bibionidae, *Morellia*, *Musca* sp., and Sarcophagidae. 15 species of blood sucking flies caught, the genus *Stomoxys* represented by *S.Nigra and S.Calcitrans* were most abundant, occurring throughout the year in large number [25]. Nectar and Cattle blood are the major food source for tabanid flies [26]. Tabanus, Chrysops, Haematopota these flies are facultative hematophagous ectoparasites, thus important from medical and veterinary point of view [27].

4. DISCUSSION & CONCLUSION

The flies identified in this study play an important role in the pollination of small plant species in the Nilgiris. The effect of fly pollination was significant in plants such as *Tagetes erecta*, *Bidens pilosa*, *Cynoglossum zeylanicum*, *Justicia simplex*, *Nicandra physalodes*, and *Euphorbia helioscopia.* Dipteran diversity in the Nilgiris varies from place to place but in some parts includes species harmful to human lives and animals. The Site-C Ooty Lake is a hazard to humans and animals because during the winter season, the waste water from the lake is drained and the waste soil is stagnant with the waste water. Thus Diptera is a factor in the development of certain blood-sucking insect species that are harmful to humans. Larvae of aquatic midges in the diverse water bodies of Jammu, Kashmir and Ladakh serve as food for fishes and are valuable bio-indicators of water quality [28]. In the Ooty Lake area, an important site of this study, Diptera have not been known to cause any health problems so far, as migratory birds naturally assist in controlling the high seasonal mosquitoes and blood sucking species in winter and summer. There are many medicinal plants in the valley view and hidden valley area. The family Syrphidae plays an important role in pollinating these plants. Syrphidae, *Lucilia* sp., and Bombyliidae pollinate most of the small flowering plants in the

Nilgiris. In addition, there are some species of Diptera that feed on insects that protect them from harm by eating insects that are harmful to humans. We found a large number of species in the Hidden Valley where fly larvae are found in humid places. Keroplatidae (*Orfailia fultoni*, *Arachnocompa* spp. and *Keroplatus* spp.) emit a bioluminescent blue/green light as larvae. In some instances these "glow-worms" congregate in large numbers and form impressive displays [29]. Interaction with local cow breeders indicate there are no problems due to pests of This is because if the cows are exposed to any of the pests' infestations, the insects will be more likely to be found in the affected area of the cows, causing the cattle to become slightly sluggish. *Stomoxys* sp. and *Musca* sp. are found mostly in association with cattle and wild gaurs in the Nilgiris. This study suggests that these dipteran species also play an important role in climate change. Parasitize livestock and wildlife various parts of the world are transmitted by a variety of Muscid flies, including stomoxys species [30]. Although there are not many species at Site-D (Endangered Shola forest), there are more blood-sucking insects such as *Haematopota* sp., *Amblypsilopus* sp., and *Stomoxys* sp., due to the presence of cattle, gaur and deer. Most of the diptera insect species sit on the remains of wild and domestic cows. Cows which were left for grazing in the forest areas were the main source of blood meal for tabanid flies [31]. Orange, peach, plum, pear fruit, grapes, and guava are economically important fruits in the Nilgiris, but they are not significantly affected for yield loss by fruit flies. Genus Bactrocera are the most serious pest of guava, apricot, peach and plum [32]. Bactrocera Zonata is the predominant infesting mango fruit [33].

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