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Impact of Elevation on the Distributional Pattern of Drosophilid Diversity (Drosophilidae: Diptera) from Mandakini Valley, Uttarakhand

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ABSTRACT

Present survey was attempted to study the Drosophilid diversity along an altitudinal transect. A total of 4,204 flies comprising 28 species belonging to 6 genera and 3 sub-genera were collected at different altitudes i.e., 690 m, 850 m, 1600 m and 1900 m of Mandakini Valley. Diversity indices were calculated to assess the diversity and Cluster analysis was also used to study the occurrence of species. The distributional pattern of a species was uneven and affected by elevation. Some common species such as *Drosophila immigrans, Drosophila repleta* and *Drosophila melanogaster* were abundant in all four altitudes.

Keywords Drosophilid, Altitudinal transect, Diversity indices, Cluster analysis, Mandakini Valley.

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INTRODUCTION

Insects are present in almost every habitat and niche; play a vital role in biological control, pollination and ecological process (Schowalter *et al*. 2016), which is essential for ecosystem functioning and environmental activity (Didham *et al*. 1996). One of the dipterans fly belonging to genus *Drosophila* and family Drosophilidae are commonly called as "fruit-flies". These flies having some complexities in composition and exhibiting cosmopolitan distribution are considered as the best model organism to study the eco-distributional pattern (Guru Prasad *et al*. 2010) and altitudinal variation (Guru Prasad and Hedge 2006). The family Drosophilidae is divided into two sub-families i.e. Steganinae and Drosophilinae (Throckmorton 1962, Throckmorton 1975, Okada 1990, Grimaldi 1990) and is composed of 4,460 species, belonging to 74 genera (Bächli 2018). There are several environmental factors which affect the distribution pattern of Drosophilid diversity. Physical factors such as temperature, humidity, rainfall and sunlight as well as biotic factors including distribution, completion, population age and density have affected the diversity of Drosophilids (Brncic *et al*. 1985, Torres and Madi-Ravazzi 2006). Apart from environmental factors, season and topographic factors i.e., elevation also influences their distributional pattern. Wakahama 1961, 1962 in Japan have studied the distributional pattern of Drosophilids at different altitudes and found that on increasing altitude total density decreases. After this, few studies has been done in India (Reddy and Krishnamurthy 1977, Hegde *et al*. 2000, Guruprasad *et al*. 2010, Achumi

et al. 2013). Saraswat *et al*. (2015) have also studied Drosophilid diversity along altitudinal transects in Uttarakhand. In our present study we tried to explore the distributional pattern of Drosophilids at different altitudes of Mandakini Valley.

MATERIALS AND METHODS

Sample collection were done for more than a year in the month of November 2018 to March 2020 and collected from the four different altitudes of Mandakini valley especially from Rudraprayag (690 m asl, 30° 16′ N and 78° 58′ E), Agastyamuni (850 m asl, 30° 23′ N and 79° 01′ E), Phata (1600 m asl, 30° 34′ N and 79° 02′ E), Sonprayag (1900 m asl, 30° 37′ N and 79° 59′ E). There are different techniques used for the collection of flies i.e., net sweeping, trap-bait method and direct by aspirator (Fig. 1). Net sweeping were done over rotten fruits, leaves and ground vegetation. For trap-bait method, bottles of 150-250 ml baited with banana or other seasonal fruits like orange, apple, guava, mango, tomato by adding yeast on it were tied about 3-4 feet above the ground. Flies attracted by the baits then transferred to the bottle containing culture medium. Aspirator was used to capture the flies while they were feeding or breeding over the flowers, leaves, fungi or rotten fruits. Flies were transferred in collecting vials containing 70% ethanol. After this, collected flies were observed under stereo zoom microscope; identified using published monographs (Gupta 2005, Markow and O'Grady 2006) and online identification tools like BioCIS (2004) and JDD (2014). For further study, the respective organs of male and female terminalia dissected and cleared by boiling around 100°C in 10% potassium hydroxide (KOH) solution, about 10-15 minutes then observed under light microscope (Magnus MLX-DX model).

Data analysis

Various diversity indices were calculated for the abundance, richness and diversity of species along altitudinal transect: Evenness index (e^H/S), Simpson's index (1-D), Shannon-Wiener index (H'), Margalef index (DMg) and Berger Parker index (1/d). Cluster

Fig. 1. Flies collected from (A, B) Flowers, (C) Mushroom, (D) Fruits.

Table 1. Number of Drosophilids collected at different altitudes during 2018-2020. Note: Species marked species as * are unidentified or may be new and double marked species** are unpublished.

	Genus/ Sub-genus	Rudraprayag (690 m)	Agastyamuni (850 m)	Phata (1600 m)	Sonprayag (1900 m)	Total
Genus *Drosophila*						
Sub-genus Sophophora Sturtevant						
1	*Drosophila melanogaster* (Meigen 1830)	150	90	74	50	364
2	*Drosophila nepalensis* (Okada 1955)	102	110	78	67	357
3	*Drosophila biarmipes* (Malloch 1924)	142	26	38	50	256
4	*Drosophila jambulina* (Prashad and Paika 1964)	25	38	62	94	219
5	*Drosophila punjabiensis* (Parshad and Paika 1964)	110	62	35	10	217
6	*Drosophila kikkawai* (Burla 1954)	46	52	0	0	98
7	*Drosophila trapezifrons* (Okada 1966)	42	60	0	0	102
8	*Drosophila bipectinata* (Duda 1923)	40	56	0	0	96
9	*Drosophila malerkotiliana* (Parshad and Paika 1964)	28	58	0	0	86
10	*Drosophila ananassae* (Doleschell 1858)	108	48	0	0	156
	Total	793	600	287	271	1, 951
Sub-genus Dorsilopa Sturtevant						
11	*Drosophila busckii* (Coquillett 1901)	68	82	54	32	236
	Total	68	82	54	32	236
Sub-genus Drosophila Fallen						
12	*Drosophila immigrans* (Sturtevant 1921)	130	122	100	97	449
13	*Drosophila repleta* (Wollason 1858)	128	133	96	85	442
14	*Drosophila lacertosa* (Okada 1953)	0	15	12	10	37
15	*Drosophila bizonata* (Kikkawa and Peng 1938)	0	18	0	0	18
16	*Drosophila trizonata* (Okada 1966)	0	15	0	0	15
	Total	258	303	216	192	961
Genus Zaprionus Coquilett						
17	*Zaprionus indianus* (Gupta 1970)	45	34	26	0	105
	Total	45	34	26	0	105
Genus Impatiophila Fu and Gao						
18	*Impatiophila curvacuminata***	0	48	87	107	242
19	*Impatiophila hexapseudorecta***	0	38	56	78	172
20	*Impatiophila* sp. I1*	0	20	18	42	80
21	*Impatiophila* sp. I2*	0	0	12	18	30
22	*Impatiophila* sp. I3*	0	0	16	19	35
	Total	0	106	177	264	559
Genus Leucophenga Mik						
23	Leucophenga albiceps (de Meijere 1914)	0	18	67	70	155
24	*Leucophenga bellula* (Bergroth 1894)	0	0	12	42	54
25	*Leucophenga singhii***	0	0	15	38	53
	Total	0	18	97	150	262
Genus Mycodrosophila Oldenberg						
26	*Mycodrosophila* sp. M1*	0	0	18	0	18
	Total	0	0	18	0	18
Genus Liodrosophila Duda						
27	*Liodrosophila* sp.L1*	0	0	50	30	80
28	*Liodrosophila* sp.L2*	0	0	32	0	32
	Total	0	0	82	30	112
	Grand total	1,164	1, 143	958	939	4,204

analysis using SPSS software was also applied to assess the similarity between different species at different altitudes and Euclidean distance was taken to measure the similarity between different species. A Whittaker pair-wise comparison between communities was also calculated.

RESULTS AND DISCUSSION

A total of 4,204 flies comprising 28 species belonging

to 6 different genera and sub-genera were collected from four sampling sites along an altitudinal gradient (Table 1). Genus *Drosophila* was predominant one with sixteen species. Five species belonging to genus *Impatiophila*, three species belonging to genus *Leucophenga* and two species belonging to genus *Liodrosophila* while genus *Mycodrosophila* and *Zaprionus* each with one species. *Drosophila immigrans*, *Drosophila repleta, Drosophila melanogaster* and *Drosophila nepalensis* were considered as abundant and collected from all four sampling sites. These species are not specific to one particular habitat and occurred in all habitats. Species of genus *Impatiophila, Mycodrosophila* and *Liodrosophila* were found only in one place. These species are highly specific and restricted to a specific type of habitat.

Present study showing that on increasing altitude the number of flies decreasing which has been reported earlier by Wakahama 1961, 1962, Reddy and Krishnamurthy 1977 and Guruprasad *et al*. 2010). At low altitude (690 m), the number of flies was the highest (1,164) whereas; at high altitude (1900 m) the number of flies was the lowest (939). (Fig. 2). According to diversity indices, Phata (1600 m) with the highest value generated by Simpson index (0.93), Margalef index (2.91 and Berger-Parker index (9.61) proved to be more diverse than other regions. Further, Agastyamuni (850 m) proved to be the second highest value generated by Simpson index (0.93) and Shannon index (2.85). Rudraprayag (650 m) proved to be the least diverse with the lowest value generated by Simpson index (0.908), Shannon index (2.49), Margalef index (1.84) and Berger-Parker index (7.81) while Sonprayag obtained an intermediate value generated by all Simpson index (0.92), Shannon index (2.71), Margalef (2.48) and Berger-Parker index (8.77). But reverse in case of Evenness (e^H/S),

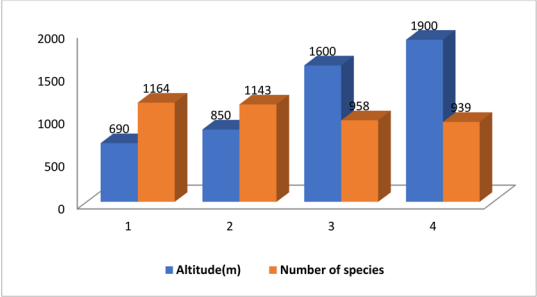

Fig. 2. Variation in number of Drosophilids collected at different altitudes.

Rudraprayag have the highest value generated (0.863) by calculating Evenness index due to abundance of some common species in that particular region whereas Phata have the lowest value (0.814) because the number of common fly species were less in that region (Table 2).

The cluster analysis was calculated by using Ward's method based on the number of flies. The Cluster shows that there are two major clusters of species. These two clusters consist of constant species (species abundant in almost all region), accessory species (species that occurred in more than one region) and accidental species (species that occurred only in one particular region). The first Cluster consists of 4 constant species i.e., *D. melanogaster*, *D. nepalensis, D. immigrans* and *D.repleta* which were abundant in all altitudes. The second Cluster is further divided into 2 sub clusters; sub-cluster first consists of 9 accessory species (seven species belonging to subgenus *Sophophora*, one species from subgenus *Dorsilopha*, another one from genus *Zaprionus*) and sub-Cluster second consists of 15 species belonging to different genus (five species from genus *Impatiophila*, four species from genus *Drosophila*, three

Table 2. Diversity indices showing Drosophild diversity at different altitudes. Highlighted boxes and bold number represents the highest value and the lowest values respectively.

Altitudes	Individuals	Taxa	Evenness (e^H/S)	Simpson index (1-D)	Shannon index (H')	Margalef index (DMg)	Berger Parker index (1/d)
690 m	1164	14	0.863	0.908	2.49	1.84	7.81
850 m	1143	21	0.826	0.933	2.85	2.84	8.62
1600 m	958	21	0.814	0.933	2.83	2.91	9.61
1900 m	939	18	0.839	0.926	2.71	2.48	8.77

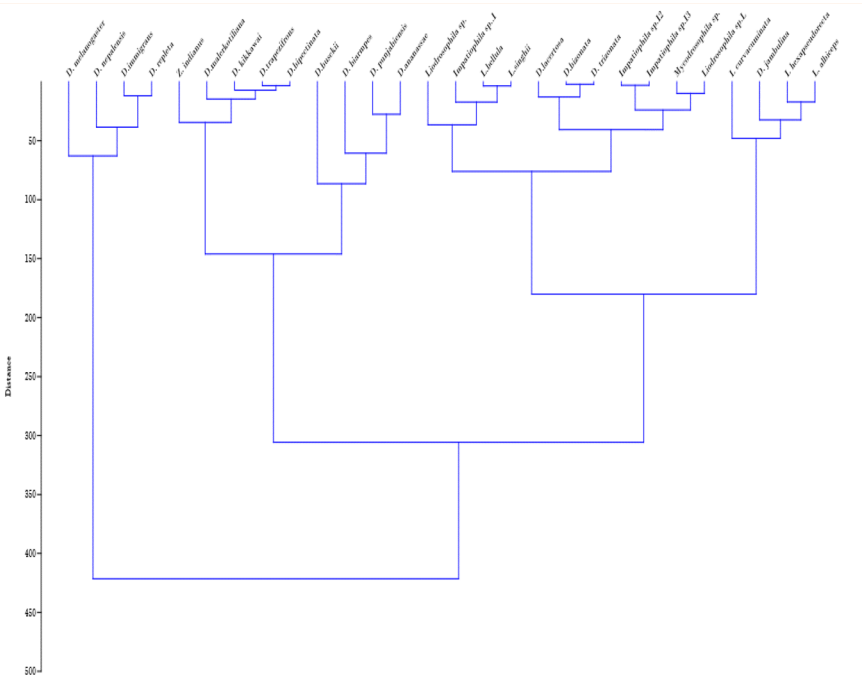

Fig. 3. Cluster analysis of Drosophilds (Dendogram using Ward'method).

species from genus *Leucophenga*, two species from genus *Liodrosophila* and one species from genus Mycodrosophila) are accidental species. The cluster first consists of abundant species whereas the cluster second consists of rare species which are found less in number or only in one or two regions (Fig. 3). Pairwise comparision of all 4 stations using Whittakar showed that Rudraprayag and Sonprayag had the highest similarity (0.5) among all comparisions, while Phata and Sonprayag showed least similarity (0.076) among all comparision (Table 3).

Therefore, from the present study it can be suggested the change in altitude will affect the abundance, richness and distribution pattern of Drosophilid diversity. We observed that species richness and abundance is higher at low altitude; because of the presence of common species which were found more in number. This may be due to the availability of food and suitable temperature for the multiplication of flies at low altitude whereas; mostly rare or specialized species were found at higher altitude due to their specific habitat they are restricted in that particular area.

Table 3. Whittakar pairwise comparison showing comparision between communities. Highlighted boxes and bold number represent the highest and the lowest values, respectively.

	Rudrap rayag	Agasty amuni	Phata	Sonpr ayag
Rudraprayag	-	-	-	-
Agastyamuni	0.2	-	-	-
Phata	0.48571	0.33333	-	-
Sonprayag	0.5	0.33333	0.076923	-

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REFERENCES

Achumi B, Hegde SN, Lal P, Yenisetti SC (2013) Altitudinal and Seasonal Variation in *Drosophila* Species on Mount Japfu

of Nagaland, a Sub-Himalayan Hilly State of India. *J Insect Sci* 13: 117.

Bächli G (2018) The database on Taxonomy of Drosophilidae, Version 3.0 (http://www.taxosdros.unizh.ch/).

Brncic D, Budrik M, Guines R (1985) An analysis of a Drosophilidae community in central Chile during a three years period. *Zeitschrift for Zoologische Syst Kund Evolutionary Evol Scung* 23: 90-100.

Didham RK, Ghazoul J, Stork EN, Davis AJ (1996) Insects in fragmented forest: A functional approach. *Terms in Ecol Evol* 11:255-260.

Grimaldi DA (1990) A phylogenetic revised classification of genera in the Drosophilidae (Diptera). *Bull Am Museum Natural History* 197: 1-139.

Guruprasad BR, Hegde SN, Krishna MS (2010) Seasonal and altitudinal changes in population density of 20 species of *Drosophila* in Chamundi hill. *J Insect Sci* 10:123. Available online: http://www.insectscience.org/10.123

Hedge SN, Vasudev V, Shakunthala V, Krishna MS (2000) Drosophila fauna of Palni hill: Tamil Nadu, India. *Drosophila Information Service* 81: 138.

Reddy GS, Krishnamurthy NB (1977) Distribution of different species of *Drosophila* in Jogimatti hills, Chitradurga district, Karnataka, India. *Drosophila Information Service* 52: 105.

Sarswat M, Sati PC, Dewan S, Fartyal RS (2016) Implying quantitative ecology of Drosophilid fauna as a tool for biodiversity assessment- A case study along an altitudinal transect in the Garhwal region of Central Himalaya, Uttarakhand India. *Trop Ecol* 57(4): 637-647.

Throckmorton LH (1962) The problem of phylogeny in the genus *Drosophila* University of Texas Publication 6205: 207-343.

Throckmorton LH (1975) The phylogeny, ecology and geography of *Drosophila*. Invertebrates of Genetic Interest, pp 421-469.

Torres FR, Madi-Ravazzi L (2006) Seasonal variation in natural population of *Drosophila* spp. (Diptera) in two wood lands in the State of Sao Paulo, Brazil. *Itheringia, Serie Zoologia* 96(4): 437-444.

Wakahama KL (1961) Notes on the seasonal activity of *Drosophila* observed in genetics and biology of *Drosophila. Academic Press, London* 30:1- 97.

Wakahama KL (1962) Studies on the seasonal variation of population structure in *Drosophila* I. Seasonal activity of Drosophilid flies observed on Mt. Dakesan. *Annot Zool Japan* 35: 234-242.