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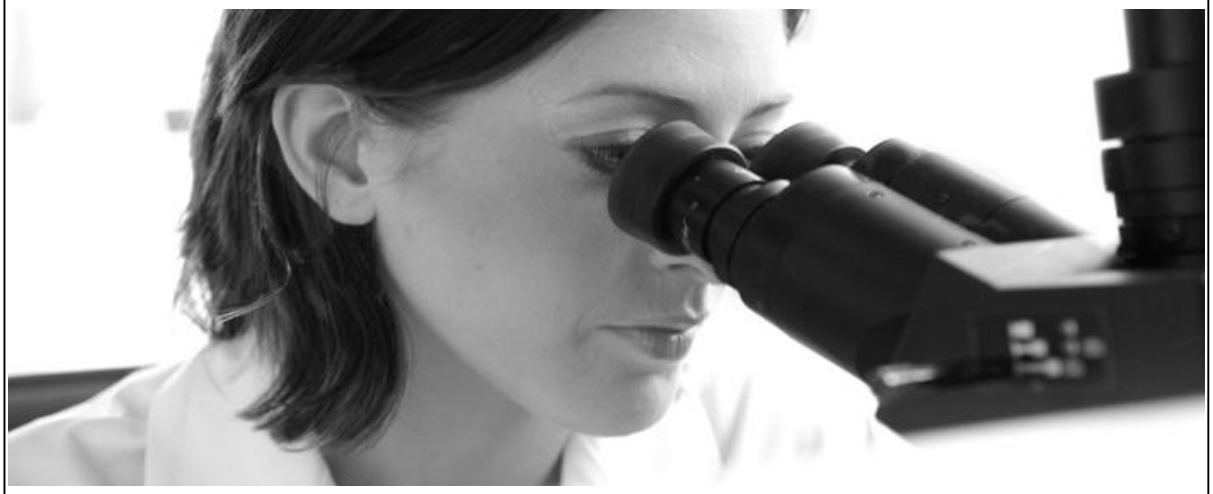

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RESEARCH ARTICLE

ELEVATIONAL VARIATION AND THE RELATIVE BIODIVERSITY OF FAMILY DROSOPHILIDAE IN SIKKIM, INDIA

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ABSTRACT

India possesses diversified physio-geographical and topological conditions which affects the geographical distribution of animals including *Drosophila* with reference to elevational (altitudinal), latitudinal and longitudinal variation of physio-geographical areas. To explore the species richness of family *Drosophilidae* with respect to altitudinal changes, a survey conducted in North-Eastern state of Sikkim, reveals a collection of 2595 species of *Drosophila* representing seven (7) genera of family *Drosophilidae*. Also, the survey conducted at two places of different elevations reveals detection of 14 new species and 3 new records from India along with remarkable variation in species distribution as indicated by biodiversity assessment using different indices. Gangtok being situated at height of 1650 meter showed Simpson index of 0.93, Shannon-Wiener index 2.84 and Berger – Parker index 0.17 as compare to the diversity index at Ranipool 900 meter which shows Simpson index 0.92, Shannon-Wiener index 2.72 and Berger- Parker index 0.17 respectively.

INTRODUCTION

The species of family Drosophilidae is a large family of dipteran flies of worldwide distribution. It was W.E. Castle (1906) who first reported the potential use of *Drosophila melanogaster* in understanding genetics. In about eight decades since then, *Drosophila* has become a premier experimental organism in the studies of genetics and evolution. As a matter of fact, it would not be an exaggeration to say that *Drosophila* still continues to be an organism of innovation and surprises. In recent years, the species of *Drosophila* has been becoming a good research model in all field of bio research and is regarded as better model over other species like *C.elegans*, zebra fishes, bacteria and rat.

Bachlli (1988) described 3500 species distributed in various ecosystems. This pattern of eco distribution and their biodiversity, clinal and altitudinal Variations have been well studied in *Drosophila* (Guru Prasad *et al*., 2010; Guru Prasad and Hegde, 2006).

Together with the development of genetics, developmental and evolutionary biology in the *Drosophila*, taxonomic studies in the genera of the family *Drosophilida*e are poorly explored as compared to other parts of the world. However, in recent few decades, attempts were made to collect the species for the taxonomy purposes which have helped in considerably exploring some data on Indian *Drosophilidae* but in view of great size of the country, the available records are meagre and no way furnish a complete picture of family *Drosophilidae* in India.

Sikkim is a small mountainous Indian state in the eastern Himalayas, covering an area of about 7096 sq.km. One third of its land is covered with dense forests. It also harbors a large number of different kinds of Orchid plants. Despite of its remarkable varied physiographic conditions, the state remained unexplored for its *Drosophilidae* fauna until recently.

MATERIALS AND METHODS

Intensive field collection were undertaken at two localities Gangtok and Ranipool in Sikkim belonging to different altitudes 1650 m and 900m respectively from the sea level using Net -sweeping, Trap-bait method. The flower- visiting *Drosophila* was collected by using Aspirator at these two places belonging to two different altitudes.

In net sweeping method, the place of collection were spread with various rotting fruits such as *Musca paradisca* (banana), *Vitas vanifera* (grapes) etc., one day ago to attract flies. After a day of spreading, the flies were collected by sweeping using fine net. The flies were then transferred to the bottles containing medium (agar-agar, maize powder, sugar, dried

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yeast, nepagin, propanic acid, and tap water) and brought to laboratory for identification. Bottle trapping method was also followed for collection. In this technique, culturing bottles containing smashed banana sprayed with live yeast were tied to twigs of bushes under shaded areas. The following day, bottles with attracted flies were collected by plugging the bottles and later transferring to culture bottles containing medium and brought to the laboratory for identification. The collected males were identified using taxonomical markers such as body pigmentation, sex comb and genital plate. Since there are no such taxonomical markers in females of *Drosophila* species, therefore the collected females were subjected to isofemale lines. The male flies obtained from the progenies of isofemale lines were used for species identification. Uniformity was maintained in using the techniques and in the number of baits used at the collection sites.

The abundance, richness and diversity relationship of flies collected were assessed by Simpson (D), Shannon-Wiener (H) and Berger-Parker (1/d) indices (Mateus *et al*., 2006). The Simpson index (D) that measures the probability of two individuals, randomly selected from a sample that belong to the same species, was calculated using the formula:

$$D=n(n-1)/N(N-1)$$

where, n = total number of organisms of a particular species and N = total number of organisms of all population.

Shannon-Wiener measures the value of species as a function of their frequency in the community and was calculated using the formula: $\mathbf{H' = -\sum [(pi) \ln (pi)]}$

p_i= the proportion of individuals belonging to the i^{th} species in the dataset of interest.

Berger- Parker index (1/d) which shows the relative abundance was calculated using the formula: $1/d=N/N_{max}$

Where, N = number of individuals of all species and N_{max} = number of individuals in the most common species.

RESULTS AND DISCUSSION

Species of an animal or plant found all over the world is frequently adjudged successfully (Carson, 1965). *Drosophila* is one such constellation, which is distributed throughout the world. It is estimated that there are more than 2241 biologically valid species of *Drosophila* (wheeler, 1986). In the present study, altogether 45 species representing seven genera of *Drosophilidae* were collected. Out of them, 14 species were detected as new while three species were newly recorded (Gupta & Gupta, 1990, 1991; Kumar & Gupta, 1990, 1991, 1992 a, 1992 b). Comparison of species distributions with respect to altitudinal variation in Sikkim, Gangtok being situated to a height of 1650 meters displays the presence of 30 species (62%) while Ranipool being situated at the altitude of 900 meters indicates the presence of 26 species (38%) of the total flies collected. Table- I, II & Fig.1, represent the number and percentage of flies belonging to different genera and sub genera at these elevations. In Gangtok, dominant genus is *Drosophila* (93.7%) within which subgenus *Sophophora*-81.9%; and *Scaptodrosophila* being the least dominant (1.12%).other subgenera are represented by *lordiphosa* (1.66%); *Drosophila*(12.85%); *Dorsilopha* (2.52%). Similarly in Ranipool, the domimant genus is also *Drosophila* (91.7%) which includes subgenera *Lordiphosa* (0.75%); *Sophophora* (84.44%), *Scaptodrosophila* (1.99%), *Drosophila* (10.18%) and *Drosilopha* (2.54%) as represented in Fig.3. Overall, Genus *Drosophila* is equally distributed and other subgenera are more or less distributed evenly while subgenus *Lordiphosa* & *parascaptomyza*, genera *Liodrosphila* and *Zaprionus* reveals comparatively more abundance in Gangtok than Ranipool indicating impact of altitudiunal variation and climatic condition. Moreover, 19 species are endemic to Gangtok and 15 are endemic to Ranipool while 11 species show common distribution in both (Table –III & Fig-2).

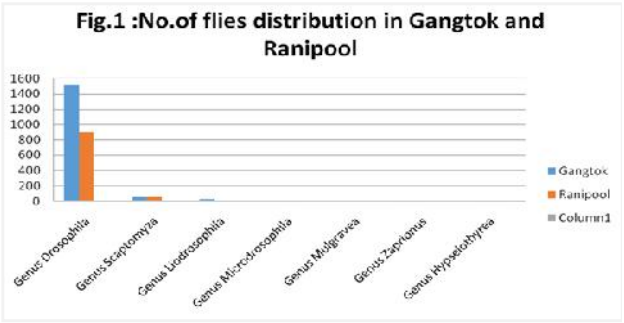

Fig.-1

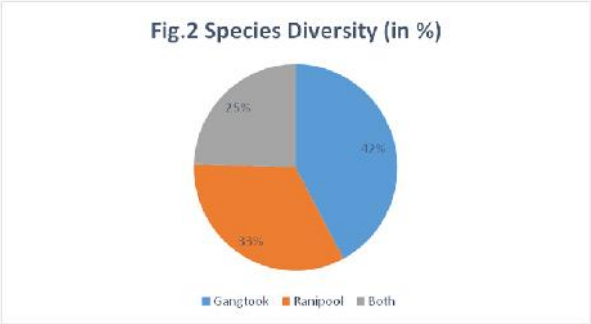

Fig.-2

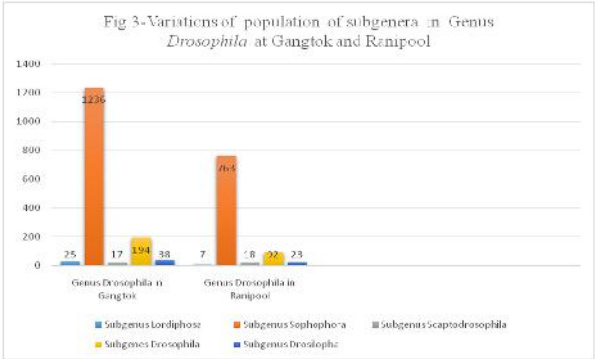

Fig.-3

Our biodiversity assessment indicates Simpson index (D) as 0.93 and 0.92; Shannon –Weiner (H) as 2.83 & 2.72 and Berger-Parker (1/d) as 0.17 &0.17 in Gangtok and Ranipool respectively. Sikkim as such has highest elevation domain of 8586 meter while lowest domain is 280 meter. Our studied areas are somewhat situated below the mid elevation. Lower value of D indicates high diversity and D=1 indicates no

diversity, reverse is true for H and (1/d) (Ludwig and Reynold 1988; Mateus *et al*., 2006).

In the present study D indicates equal diversity at the two different elevations, which very much follows the Mid Domain Effect and Mountain Mass Effect (Colwell *et al*., 2004).

Table -1 Number and Distribution of *Drosophilid* Species at Different Localities in Sikkim, India

Genus	Subgenus	Species	In Gangtok	In Ranipool	Total
Drosophila	*Lordiphosa*	*D.acutissima*	03	0	03
		D.himalayana	22	0	22
		D.parantillaria	0	04	04
		D.peniglobosa	0	03	03
	Sophophora	*D.ananassae*	133	115	248
		D.biarmipes	0	11	11
		D.bipectinata	121	74	195
		D.eugracilis	272	128	400
		D.kikkawai	28	22	50
		D.kurseongensis	17	0	17
		D. malerkotliana	91	168	259
		D.nepalensis	145	59	204
		D.prolongata	0	15	15
		D.pulchrella	117	74	191
		D.punjabiensis	97	0	97
		D.suborosa	0	03	03
		D.takahashii	82	48	130
		D.trapezifrons	68	23	91
		D.trilutea	65	0	65
		D.tristipennis	0	23	23
	Scaptodrosophila	*D.paratriangulata*	17	0	17
		D.vazrae	0	07	07
		D.zingiphila	0	11	11
	Drosophila	*D.annulipes*	10	0	10
		D.fuscicostata	0	24	24
		D.immigrans	140	57	197
		D.ovilongata	10	0	10
		D.paralongifera	12	0	12
		D.setitarsa	0	11	11
		D.sikkimensis	22	0	22
	Dorsilopha	*D.busckii*	38	23	41
Scaptomyza	*Scaptomyza*	*S.tistai*	0	53	53
		S.clavata	02	0	02
		S.parasplendens	18	0	16
	Parascaptomyza	*S.elmoi*	33	0	33
Liodrosophila		*L.quadrimaculata*	10	0	10
		L.penispinosa	17	0	17
		L.angulata	03	0	03
Microdrosophila		*M.bilineata*	0	09	09
		M.sikkimensis	0	02	02
		M.gangtokensis	04	0	04
Mulgravea		*M.ranipoolensis*	0	06	06
Zaprionus		*Z.cercociliaris*	11	0	11
		Z.pyinoolwinensis	03	0	03
Hypselothyrea		*H.gutata*	0	11	11
		Total No. of flies	1611	984	2595
	Total No. of species		30 (62%)	26(38%)	46

Table – 2 No &Percentage of Flies Distribution

S.No.	Genus	Subgenus	No. and % of flies in Gangtok -1650 m	No and % of flies in Ranipool -900 m
1	*Drosophila*		1510 (93.7%)	903 (91.7%)
		Lordiphosa	25 (1.66%)	7 (.75%)
		Sophophora	1236(81.9%)	763(84.44%)
		Scaptodrosophila	17(1.12%)	18 (1.99%)
		Drosophila	194(12.85%)	92 (10.18%)
		Dorsilopha	38(2.52%)	23 (2.54%)
2	*Scaptomyza*		53(3.3%)	53(5.3%)
		Scaptomyza	20	53
		Parascaptomyza	33	0
3	*Liodrosophila*		30 (1.86%)	0 (0%)
4	*Microdrosophila*		4(0.25%)	11(1.12%)
5	*Mulgravea*		0(0%)	6(0.60%)
6	*Zaprionus*		14(0.87%)	0(0%)
7	*Hypselothyrea*		0(0%)	11(1.12%)
		Total flies	1611	984

Mid Domain Effect explain that, at the mid of any elevation there is species richness as compare to lower and higher ecological domain on a mountainous areas. This pattern has received empirical support to the distribution of small mammals and plants (Mc Cain 2004, Sander 2002). Alternatively the microbes diversity decreases from low to high elevation. The trend is monotonic (Bryant *et al*., 2008) The occurrence of more or less equal SI of Gangtok (0.93) and Ranipool (0.92) is due to mid elevation condensational zones indicating elevational species richness in the mid hump zone..

Table-3 Type of species distribution (Species Diversity)

S. No	Genus	Subgenus	Gantok	Ranipool	In both	Total
1.	*Drosophila*	*Lordiphosa*	2	2	-	4
		Sophophora	3	4	9	16
		Scaptodrosophila	1	2	-	3
		Drosophila	4	2	1	7
		Drosilopha	-	-	1	1
2.	*Scapiomyza*	*Scaptomyza*	2	1	-	3
		Parascapiomyza	1	-	-	1
3.	*Liodrosophila*		3	-	-	3
4.	*Microdrosophila*		1	2	-	3
5.	*Mulgravea*		-	1	-	1
6.	*Zaprionus*		2	-	-	2
7.	*Hypselothyrea*		-	1	-	1
	Total no of Species		19	15	11	45

Table 4 Diversity Indices of Drosophila at two altitudes in Sikkim

Diversity indices	Gangtok	Ranipool
Simpson index (D)	0.93	0.92
Shannon-Wiener index (H)	2.83	2.72
Berger-Parker index (1/d)	0.17	0.17

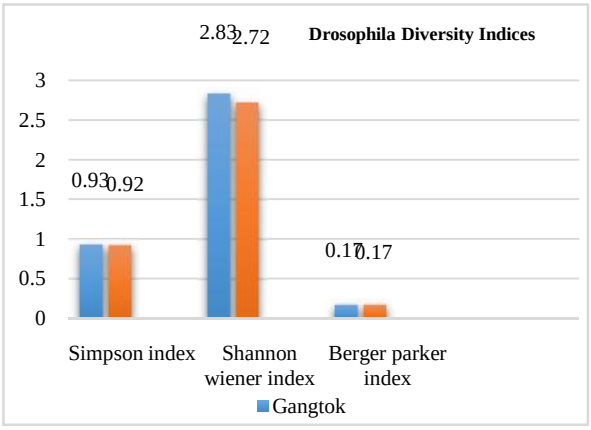

Fig – 4

However, environmental factors and other climatic factors which are similar in mid elevational domain promoted the similar species richness as far as mountain mass effect is concerned There is a co- relation between mountain mass and the occurrence of physiognomically vegetation type of this large mountain mass at two elevation where climatically driven mountain mass effect exposed a positive linear trend i.e. , the diversity increases with mountain height. Since the Sikkim is isolated mountain peak in the north- eastern Himalayan region with its maximum height 8586 m and studied area lies somewhat nearer to the mid domain elevation, it very much disposed Mountain Mass Effect with equal species richness. Further, it also very much follows the EDG (Elevational diversity gradient) rules of diversity which state that the species richness trends at certain points create diversity bulge at middle. The two places have very little fluctuation in seasonal variation which accounts for similar diversity. However, rainfall and humidity are also accountable for little variation in the diversities at these two elevations.

Our results thus predicts a humped species richness pattern where species ranges are randomly distributed within a geometrically constrained domain (i.e. base and top of the mountain).

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