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Quantitative and Qualitative Assessment of Species Diversity and Distribution Pattern of Drosophila Species in North Chotanagpur Division of Jharkhand, India

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Abstract Jharkhand is a naive Indian state in terms of study related to Drosophila species distribution, despite of being rich in varied ecological resources. The present study was carried out to assess the species absolute abundance (A), relative abundance (R), constancy (C) evenness (J´), species richness and diversity indices like Shannon – Weaver index (H´), which is based on the survey done during 2016 - 2018 in the seven representative districts of North Chotanagpur division of Jharkhand. Our intensive field surveys in the wild areas of the seven districts of North Chotanagpur have recognized 20 different species distributed within 4 genera, 6 subgenra in a total of 2909 flies collected by using three traditional methods. Our major results indicated that 90.5 % of abundance was in species of genus *Drosophila* and 0.1% of *Amiota* species. Moreover, *D. malerkotliana* (R = 0.189) and *D. melanogaster* (R = 0.176) are more or less equally abundant as accessory species, while *A. shillongensis* (R = 0.00068) is accidental species. Species richness showed Hazaribag having more species richness (D_{Mg} = 2.78) in comparison to Ramgarh and Giridih (D_{Mg} = 1.92 & 1.96) respectively. Species evenness pattern is more or less similar in three districts while Hazaribag has less evenly distribution due to unequal occurrence of some species. It concludes that Hazaribag has more species diversity and species richness as compared to other districts due to specific niche preferences.

Keywords Species Richness, Relative Abundance, Constancy, Drosophilidae

1. Introduction

Global Biodiversity Assessment, projected by the United Nation Environmental Program (UNEP), has described only 1.75 million out of a total 13-14 million species [1]. Of these, approximately 61% of the known species belong to the class insecta, which also includes the species of *Drosophila.*

The first complete catalogue of the family [2] listed more than 2,500 species in 55 genera. Moreover, recent taxonomic documentations have revealed a list of 3962 described species (3950 extant and 12 extinct), classified under 70 genera [3] and together within two subfamilies, Steganinae and Drosophilinae. Among these two, the subfamily Steganinae contains 697 species belonging to 28 genera whiles the subfamily Drosophilinae is considerably larger, with 43 genera and 3265 species. However, recently available online database on TaxoDros - http://www.taxodros.uzh.ch [4], accessed in March 2017 revealed the occurrence of 963 species within the 29 genera of Steganinae and 3497 species of Drosophilinae distributed within the 48 genera.

Jharkhand, a newly carved Indian state from parental Bihar in 2000, holds an enormous potential with respect to

ecological diversity owing to its major forest and hilly areas. These regions truly harbor huge natural inventories of *Drosophila* species at par. As far as the state is concerned, no detailed account of the family Drosophilidae is available except for the occurrence of *D. quadrilineata* from Bhagalpur (now within the parental State–Bihar) which was a new record from India [5]. The natural population of *D. ananassea* [6], [7] and *Zaprionus indianus* [8] were studied from some regions of Bihar and Jharkhand. Our study gives a recent holistic picture of diversity and distribution status of *Drosophila* species surveyed in seven representative districts of North Chotanagpur division of Jharkhand.

2. Material and Methods

2.1. Sites of Collection (Figure 1) – North Chotanagpur Division of Jharkhand

North Chotanagpur is division of Jharkhand, situated in north-central region, covering 21658 km^2 areas, extended from 23° 52' 51" N - 24° 44' 44′' N latitudes and 84° 27' 45" E - 86° 47' 42" E longitudes. It consists of seven districts: - Bokaro (BK), Chatra (CH), Dhanbad (DN), Giridih (GR), Hazaribag (HZ), Koderma (KO) and Ramgarh (RM). The altitude range of these districts lies in between 214m to 619m and mean temperature ranges from 23.7ºC to 26.2ºC. Moreover, all these districts have many diversified geo-geographical areas encompassing deep deciduous forests which are comprised of *Shorea robusta, Madhuca latifolia, Terminalia tomentosa, Buchanania latifolia, Anogeissus latifolia, Bamboo, Butea frondosa, Mangifera indica, Acacia auriculiformis, Zizyphus jujuba, Cassia siamea, Azadirachta indica, Maringa species, Artocarpus integrifolia, Buchanania lanzan, Madhuca indica, Diospyros melanoxylon, Butea monosperma* and some invasive species like *Lantana camara, Chromolaena odorata, Ageratum houstonianum, Acacia farnesiana, Imperata cylindrica* have influenced the habitat of many organisms including members of species *Drosophila.*

BOKARO: - It is bounded by Giridih in North, Dhanbad and West Bengal State in the East, Ramgarh and Hazaribag district in the West and Ramgarh district and Bengal state in the South. It extends between 23°25′22″N - 23°57′04″N latitude and, 85°34′38″E - 86°27′02″E longitude. The district is located at an elevation of 214.436 m from mean sea level. The mean temperature of the district is 26.2°C. Out of total geographical area 2883 km^2, 20% is covered by forest.

CHATRA: - It is bounded by district Gaya of Bihar in the North, Palamu in the West, Ranchi and Latehar in the South and Hazaribag in the East. It extends between 23°40′56″N - 24°31′29″N latitude and, 84°26′15″E - 85°20′22″E longitude. The district is located at an elevation of 428.832 m from mean sea level. The mean temperature of the district is 24.7°C. Out of total geographical area 3718 km^2, 48% is covered by forest.

DHANBAD: - The District is bounded on the West by Giridih, Dumka in the North, Asansol (West Bengal) in the East and in South by Purulia district of West Bengal. It extends between 23°37′56″N - 24°03′21″N latitude and, 86°06′46″E - 86°49′02″E longitude. The district is located at an elevation of 246.254 m from mean sea level. The mean temperature of the district is 25.9°C. Out of total geographical area 2040 km^2, 10% is covered by forest.

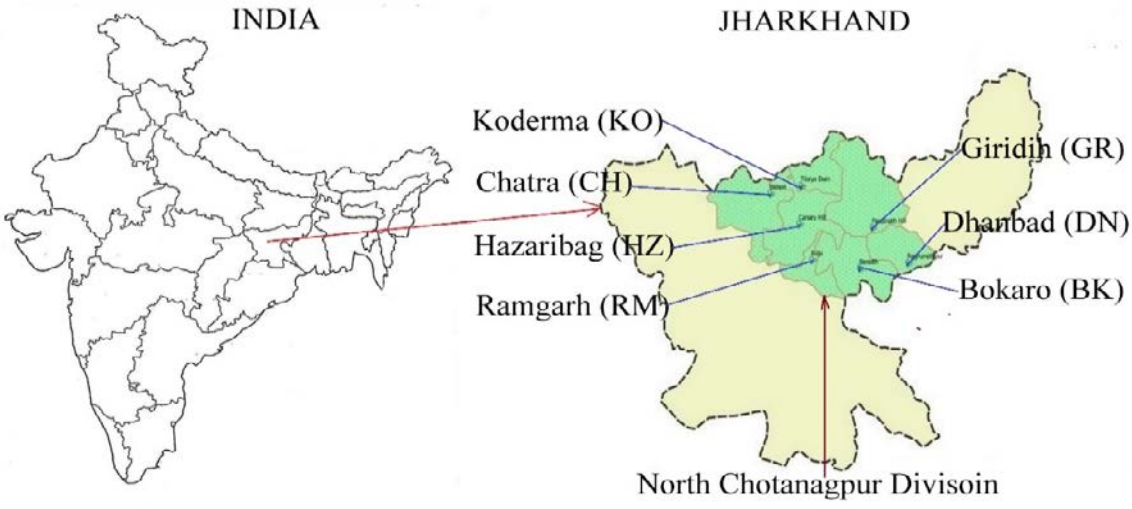

Figure 1. Collection site of Districts of North Chotanagpur of Jharkhand

GIRIDIH: - The district is bounded by Jamui and part of Nawada district of Bihar in the North, Dhanbad and Bokaro in the South, Deoghar and Jamtara in the East and Hazaribag and Koderma in the West. It extends between 23°43′21″ N - 24°46′36″N latitude and, 85°39′55″E - 86°33′36″E longitude. The district is located at an elevation of 280.034 m from mean sea level. The mean temperature of the district is 25.4°C. Out of total geographical area 4962 km^2, 18% is covered by forest.

HAZARIBAG: - It is situated in the North-Eastern part of the North Chotanagpur. It is bounded by district Koderma and state Bihar in the North, Bokaro and Giridih in the East, Ramgarh and Chatra in the West. It extends between 23°39′22″ N - 24°32′37″N latitude and, 85°00′48″E - 85°55′21″E longitude. The district is located at an elevation of 619.389 m from mean sea level. The mean temperature of the district is 23.7°C. Out of total geographical area 3555 km^2, 38% is covered by forest.

KODERMA: - It is surrounded in the North by Nawada district of Bihar, in the South by Hazaribag, in the East by Giridih and in the West by Gaya district of Bihar. It extends between 24°17′38″ N - 24°49′19″ N latitude and, 85°26′47″ E - 85°53′46″ E longitude. The district is located at an elevation of 390.020 m from mean sea level. The mean temperature of the district is 24.2°C. Out of total geographical area 2540 km^2, 40% is covered by forest.

RAMGARH: - It is bounded by Hazaribag in the North, Ranchi in the East-South and Bokaro in the West. It extends between 23°25′03″N - 23°57′05″N latitude and, 85°12′38″E - 85°54′02″E longitude. The district is located at an elevation of 342.070 m from mean sea level. The mean temperature of the district is 25.6°C. Out of total geographical area 1341 km^2 25% is covered by forest.

2.2. Method of Collections (Figure 2)

Flies of the family Drosophilidae in the wild areas generally exploit varieties of natural resources. To procure a large number of flies, three methods (trap-bait, net sweeping and direct method) were adopted. The collections were done during the favorable months (mid-June to October) of year 2016 – 2018.

2.3. Sorting, Rearing and Preservations (Figure 3)

The collected flies were etherized with ether. Preliminary, by observing some clear and distinct morphologically discriminating characters, they were sorted out and kept separately. Few live males and females were kept in culture vials containing *Drosophila* food medium (a mixture of corn flour (100gm), jiggery (100gm) and yeast (20gm) prepared in 500 ml of water into another solution containing dissolved agar in 500ml Luke water) and rests were preserved in 70% alcohol for further taxonomic studies.

Figure 2. Method of collection (A - Trap-bait, B – Net sweeping, C – Direct collection by Aspirator)

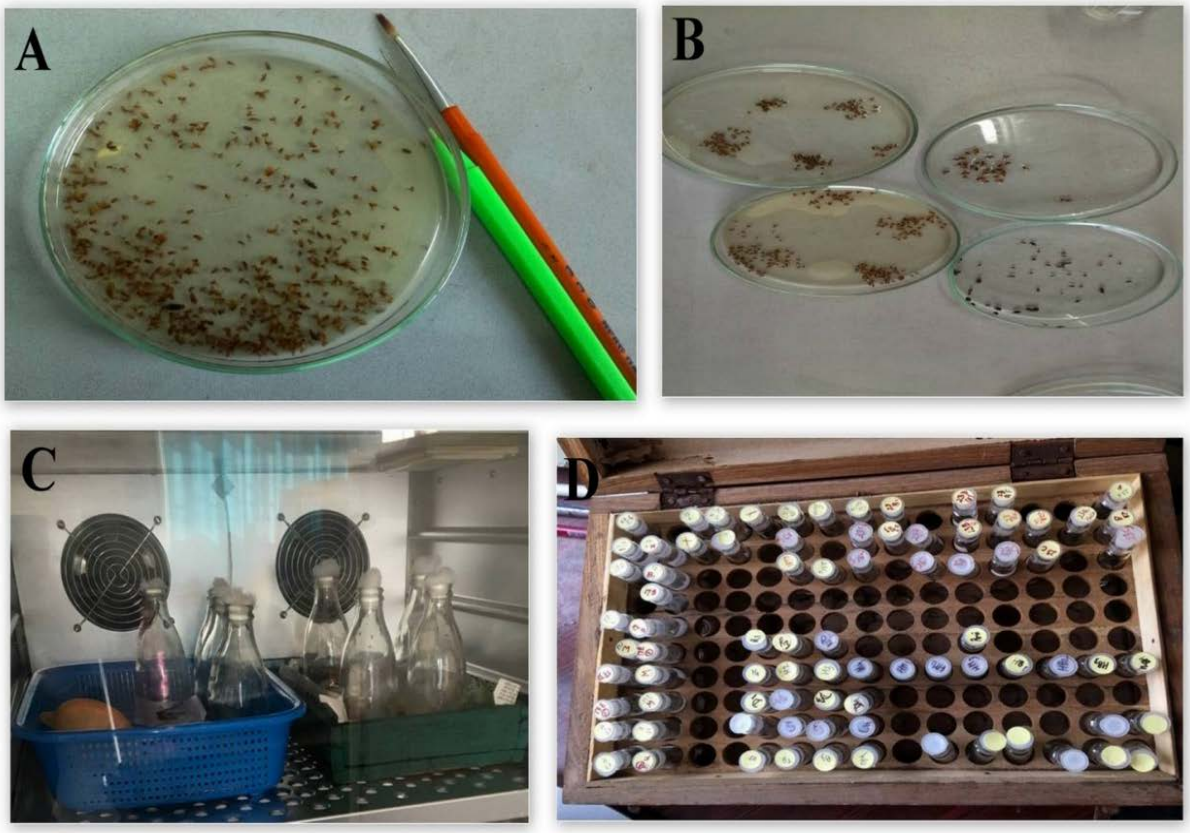

Figure 3. Sorting (A & B), Rearing (C) & Preservation (D)

2.4. Taxonomic Categorizations

It is the most important part of the research in biosystematics and species diversity which focuses on identifications of species based on established taxonomical parameters. Preserved flies were taken out and again observed minutely with respect to species specific characters in both the sexes under the stereo binocular (Magnus MS13/MS24), using 2X & 4X objectives and eye piece 10X, following the method of Gupta (2005) [9], Markow & O Grady (2006) [10] and online identification tools like Biocis, JDD & Fly base. For morphometric characters and confirmation of the species, slides of wing, leg, head, male and female genitalia were prepared after boiling (10 minutes in 10% KOH) or keeping the preserved flies in 100ºC warmed 10% KOH for 20-30 minutes followed by dissection and mounting in glycerol/euparal. Further, for taxonomic details of identified species, body indices of various parts were measured, and details of the male specific phallic and periphallic organs were studied following the morphological terminology used by McAlpine (1981) [11], Zhang & Toda (1992) [12], Hsu & Toda (2001) [13] and Cumming & Wood (2017) [14] wherever appropriate (Figure 4).

2.5. Statistical Analysis of the Data

2.5.1. Estimation of Diversity

To calculate the biodiversity of *Drosophilids* in the studied areas, Shannon weaver diversity index (H') and evenness (e^H/S) were calculated using PAST software (PAST; version = 4.03).

2.5.2. Constancy Value (C)

Constancy method was adopted to calculate the C Value. It was calculated using formula

$$C = \frac{\text{Number of Collection in which species are found}}{\text{Total number of collection}} \times 100$$

Constancy (C) value indicates the grouping of species as constant species ($C \geq 50$), accessory species ($C \geq 25$ or $C < 50$), accidental species ($C < 25$) and the species that occurred in only one area as exclusive species.

2.5.3. Relative Abundance (R)

It was calculated by dividing the number of flies from one group by the total number of flies from all groups.

$$R = \frac{\text{Number of flies from one group}}{\text{Total number of flies from all group}}$$

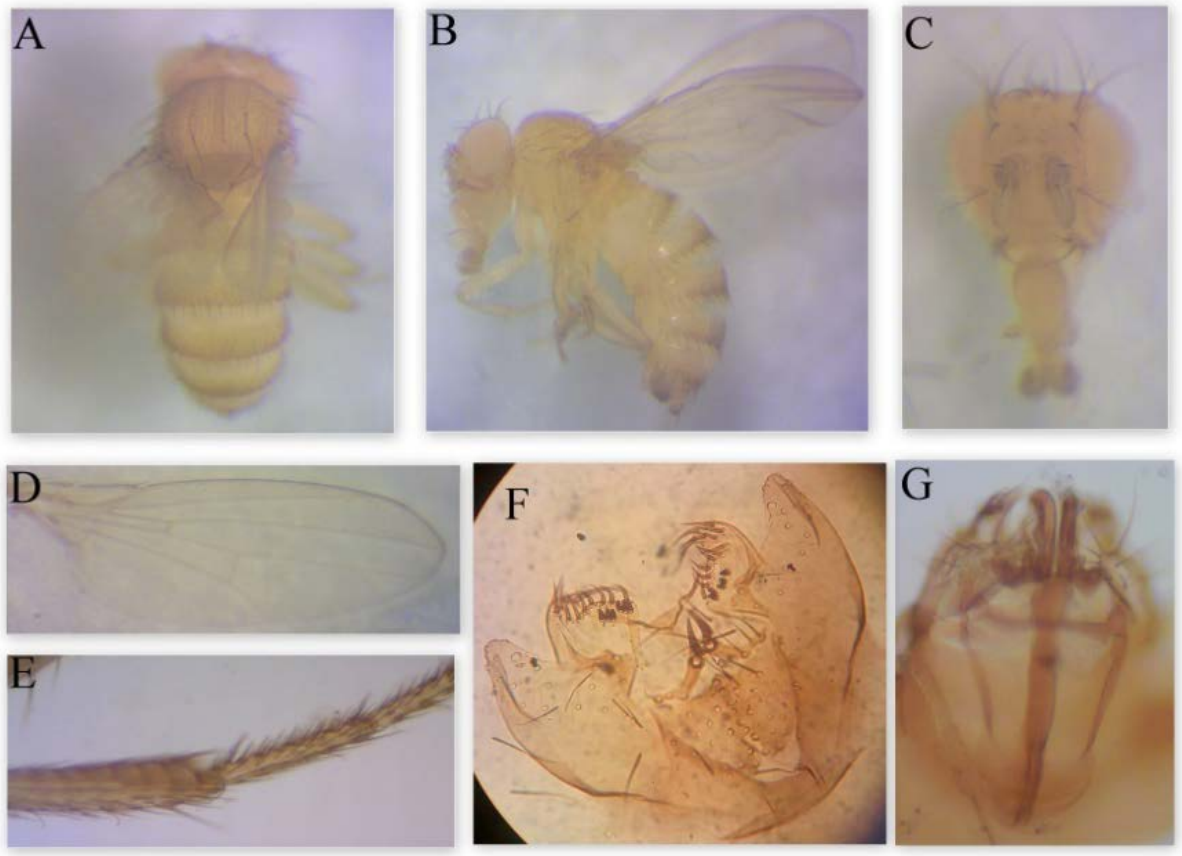

Figure 4 (A-G). Diagrammatic illustration of some of the important taxonomic characters routinely employed in the description of a species: A: Whole fly (dorsal view); B: Whole fly (lateral view); C: Head; D: Wing; E: Leg; F: Periphallic organ; G: Phallic organ.

3. Results

A total 2909 flies were collected from all the proposed seven districts of North Chotanagpur division during the mid-June 2016 to October 2018 following a wide range of survey and sampling strategies. Altogether, entire collection indicated the distribution of 20 different types of species belonging to 4 genera and 6 subgenera which are tabulated in Table 1.

It indicated D. malerkotliana and D. melanogaster as the most abundant species. Abundance of remaining species were in the order of D. trilutea > Z. indianus > D. busckii > D. nasuta > D. takahashii > D. kikkawai > D. bipectinate > D. immigrans > D. ananassae > D. eugracilis > D. biarmipes > D. albomicans > D. annulipes > D. penispina > Z. pyinoolwinensis > D. jambulina > A. shillongensis.

Species richness in all seven districts indicates that Hazaribag has maximum species richness with 20 species where as other districts like Chatra, Koderma has 15 species, Giridih has 13 and Bokaro, Dhanbad & Ramgah have 12 species shown in figure 5.

Diversity indices of *Drosophila* species of all seven districts Shannon-Weaver index (H′) are 2.306, 2.34, 2.252, 2.379, 2.578, 2.454 & 2.215 respectively for districts Bokaro, Chatra, Dhanbad, Giridih, Hazaribag, Koderma and Ramgarh shown in figure 6.

Species evenness (e^H/S) of Bokaro (0.83), chatra (.069), Dhanbad (0.79), Giridih (0.83) Hazaribag (0.65), Koderma (0.77) and Ramgarh (.76) shown in Figure 7.

Calculated species wise relative abundance exhibited *D. malerkotliana* with highest relative abundance (R = 0.189) followed by *D. melanogaster* (R = 0.176) *D. trilutea* & *Z. indianus* (R = 0.09), *D. busckii* (R = 0.08) and others. *Amiota shillongensis* which was only in the collection of Hazaribag overall displayed least abundance (R = 0.00068). This pattern was almost visualized in all districts (Table 2).

Constancy values (C) of thirteen species like D. immigrans, D. nasuta, D. ananassae, D. bipectinata, D. eugracilis, D. kikkawai, D. malerkotliana, D. melanogaster, D. takahashii, D. trilutea, D. annulipes, D. busckii and Zindianus were (C > 50) regarded as constant species, three species D. albomicans, D. penispina and D. biarmipes were (C > 25 or C<50) were as accessory species and remaining four species i.e., D. bryani, D. jambulina, Amiota shillongensis and Z. pyinoolwinensis (C<25) declared as accidental as well as exclusive species which are tabulated in table 3.

Table 1. Distribution of Species, Genera and Subgenera in districts of North Chotanagpur

S. No.	Districts	Genus	Subgenus	Types of species	Total types of species	No. of total flies
1	Bokaro	*i. Drosophila*	*i. Drosophila*	2	12	276
			ii. Sophophora	8		
			iii. Dorsilopha	1		
		ii. Zaprionus	*iv. Zaprionus*	1		
2	Chatra	*i. Drosophila*	*i. Drosophila*	4	15	478
			ii. Sophophora	9		
			iii. Dorsilopha	1		
		ii. Zaprionus	*iv. Zaprionus*	1		
3	Dhanbad	*i. Drosophila*	*i. Drosophila*	2	12	217
			ii. Sophophora	8		
			iii. Dorsilopha	1		
		ii. Zaprionus	*iv. Zaprionus*	1		
4	Giridih	*i. Drosophila*	*i. Drosophila*	3	13	334
			ii. Sophophora	8		
			iii. Dorsilopha	1		
		ii. Zaprionus	*iv. Zaprionus*	1		
5	Hazaribag	*i. Drosophila*	*i. Drosophila*	5	20	926
			ii. Sophophora	10		
			iii. Dorsilopha	1		
		ii. Scaptodrosophila		1		
		iii. Zaprionus	*iv. Zaprionus*	1		
			v. Anaprionus	1		
		iv. Amiota	*vi. Phortica*	1		
6	Koderma	*i. Drosophila*	*i. Drosophila*	5	15	373
			ii. Sophophora	8		
			iii. Dorsilopha	1		
		ii. Zaprionus	*iv. Zaprionus*	1		
7	Ramgarh	*i. Drosophila*	*i. Drosophila*	2	12	305
			ii. Sophophora	8		
			iii. Dorsilopha	1		
		ii. Zaprionus	*iv. Zaprionus*	1		
Total	7	4	6	20	20	2909

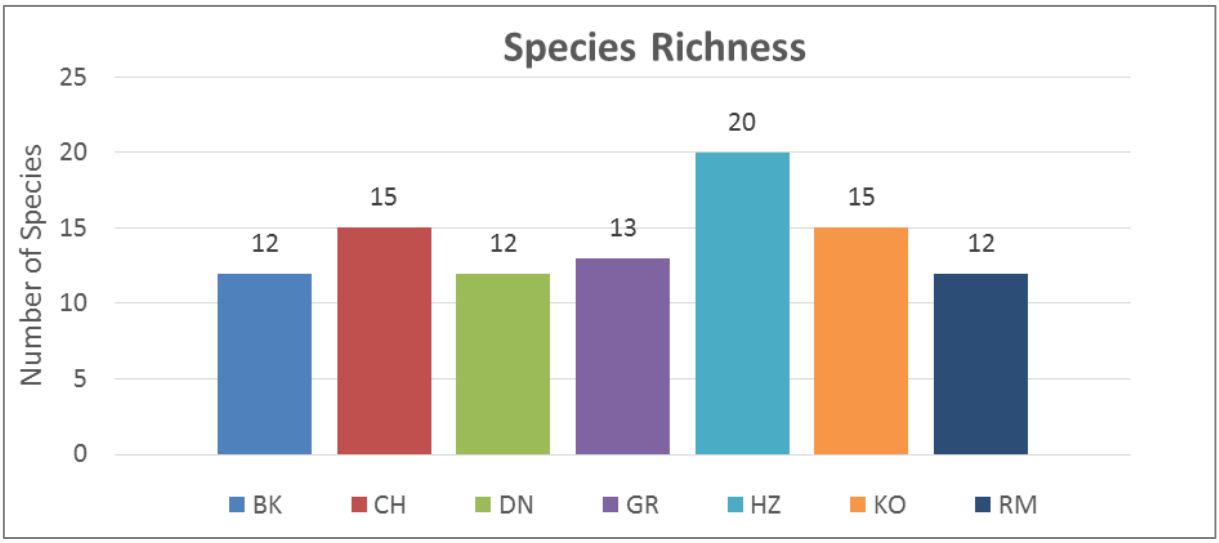

Figure 5. Species richness in seven districts of North Chotanagpur

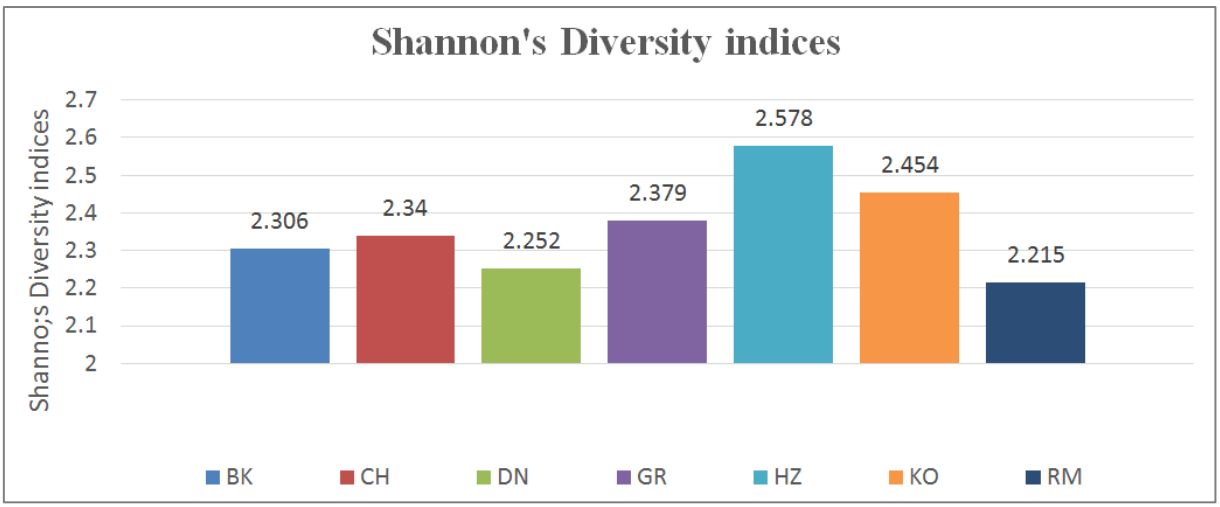

Figure 6. Shannon's diversity indices in seven districts of North Chotanagpur

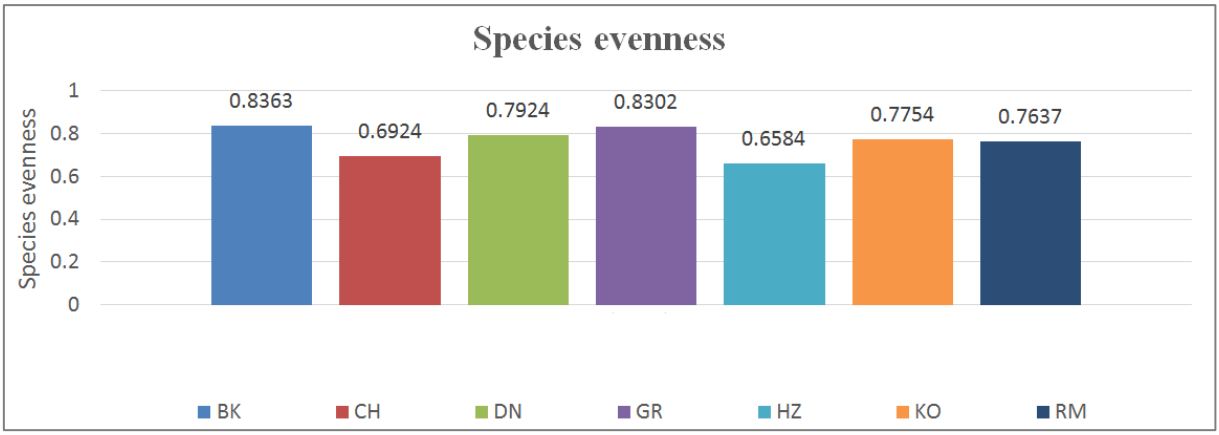

Figure 7. Species evenness in seven districts of North Chotanagpur

Table 2. Absolute (A) and Relative abundance (R) for each species collected in the seven districts of North Chotanagpur, Jharkhand.

	District	**BK**		**CH**		**DN**		**GR**	
S. No.	**Species**	**A**	**R**	**A**	**R**	**A**	**R**	**A**	**R**
1	***D. albomicans***	0	0.00	8	0.0167	0	0.00	0	0.00
2	***D. annulipes***	0	0.00	10	0.0209	0	0.00	4	0.0119
3	***D. immigrans***	12	0.0435	23	0.0481	5	0.0230	13	0.0389
4	***D. nasuta***	15	0.0543	25	0.0523	12	0.0553	14	0.0419
5	***D penispina***	0	0.00	0	0.00	0	0.00	0	0.00
6	***D. ananassae***	8	0.0289	19	0.0397	3	0.0138	12	0.0359
7	***D. biarmipes***	0	0.00	12	0.0251	0	0.00	0	0.00
8	***D. bipectinata***	11	0.0398	21	0.0439	11	0.0507	15	0.0449
9	***D. eugracilis***	10	0.0362	11	0.0230	9	0.0415	11	0.0329
10	***D. kikkawai***	17	0.0616	24	0.0502	11	0.0507	28	0.0838
11	***D. malerkotliana***	54	0.1956	121	0.2539	45	0.2074	50	0.1497
12	***D. melanogaster***	50	0.1811	103	0.2154	40	0.1843	54	0.1616
13	***D. takahashii***	21	0.0761	23	0.0481	12	0.0553	23	0.0688
14	***D. trilutea***	32	0.1159	21	0.0439	23	0.106	32	0.0958
15	***D. jambulina***	0	0.00	0	0.00	0	0.00	0	0.00
16	***D. busckii***	23	0.0833	23	0.0481	23	0.106	44	0.1317
17	***D. bryani***	0	0.00	0	0.00	0	0.00	0	0.00
18	***Z. pyinoolwinensis***	0	0.00	0	0.00	0	0.00	0	0.00
19	***Z. indianus***	23	0.0833	34	0.0711	23	0.106	34	0.1018
20	***A. shillongensis***	0	0.00	0	0.00	0	0.00	0	0.00
	Total	**276**	**1**	**478**	**1**	**217**	**1**	**334**	**1**

Table 2. Continued

	District	**HZ**		**KO**		**RM**		**Total**	
S. No.	Species	A	R	A	R	A	R	A	R
1	***D. albomicans***	21	0.0226	3	0.0080	0	0.00	32	0.011
2	***D. annulipes***	10	0.0107	3	0.0080	0	0.00	27	0.0092
3	***D. immigrans***	35	0.0377	15	0.0402	10	0.0327	113	0.0388
4	***D. nasuta***	76	0.08207	32	0.0857	12	0.0393	186	0.0639
5	***D penispina***	12	0.0129	4	0.0107	0	0.00	16	0.0055
6	***D. ananassae***	30	0.0323	15	0.0402	8	0.0262	95	0.0327
7	***D. biarmipes***	21	0.0226	0	0.00	0	0.00	33	0.0113
8	***D. bipectinata***	43	0.0464	14	0.0375	10	0.0327	125	0.0429
9	***D. eugracilis***	23	0.0248	12	0.0321	9	0.0295	85	0.0292
10	***D. kikkawai***	52	0.05615	25	0.0670	15	0.0491	172	0.0592
11	***D. malerkotliana***	165	0.1781	50	0.1340	67	0.2196	552	0.1897
12	***D. melanogaster***	134	0.1447	65	0.1742	67	0.2196	513	0.1763
13	***D. takahashii***	43	0.0464	34	0.0911	25	0.0819	181	0.0622
14	***D. trilutea***	95	0.1025	34	0.0911	28	0.0918	265	0.0911
15	***D. jambulina***	3	0.0032	0	0.00	0	0.00	3	0.0010
16	***D. busckii***	66	0.0712	33	0.0884	22	0.0721	234	0.0804
17	***D. bryani***	5	0.0053	0	0.00	0	0.00	5	0.0017
18	***Z. pyinoolwinensis***	7	0.0075	0	0.00	0	0.00	7	0.0024
19	***Z. indianus***	83	0.0896	34	0.0911	32	0.1049	263	0.0904
20	***A.shillongensis***	2	0.0021	0	0.00	0	0.00	2	0.00068
	Total	**926**	**1**	**373**	**1**	**305**	**1**	**2909**	1

*BK - Bokaro, CH - Chatra, DN - Dhanbad, HZ - Hazaribag, GR - Giridih, KO - Koderma, RM - Ramgarh

Table 3. Constancy Value

S. No.	Species	C value	S. No.	Species	C value
1	*D. albomicans*	43	11	*D. malerkotliana*	100
2	*D. annulipes*	57	12	*D. melanogaster*	100
3	*D. immigrans*	100	13	*D. takahashii*	100
4	*D. nasuta*	100	14	*D. trilutea*	100
5	*D penispina*	29	15	*D. jambulina*	14
6	*D. ananassae*	100	16	*D. busckii*	100
7	*D. biarmipes*	29	17	*D. bryani*	14
8	*D. bipectinata*	100	18	*Z. pyinoolwinensis*	14
9	*D. eugracilis*	100	19	*Z. indianus*	100
10	*D. kikkawai*	100	20	*A. shillongensis*	14

4. Discussion

Systematic study concerning the variation in species composition and the pattern of distribution in various members of family Drosophilidae in different geographical regions of planet earth will enable us to understand the concept of underlying adaptive radiation and certain mechanisms involved in evolutionary phenomenon of speciation [15].

Further, the pattern of distribution of species in any ecosystem depends on various factors which may be geographical, environmental, biological or abiotic [16], [17], [18]. Though, there are also other diverse factors that may be considered in deciding the distribution pattern in terms of primary productivity in the ecosystem, elevation points and limitations in climatic conditions [19]. Moreover, species diversity is under threat due to such ecological losses and other climatic factors.

With this view, the Drosophilid species distribution and their species diversity status in North Chotanagpur of Jharkhand were assessed which were based on the survey results carried out in seven representative districts of North Chotanagpur division of Jharkhand. All these districts had their own floristic composition and physiographic conditions.

Altogether 20 different types of species were taxonomically recognized under four genera which were *Amiota, Drosophila, Scaptodrosophila* and *Zaprionus* in the present study. Out of them, genus *Drosophila* was predominantly distributed, whereas among allied genera i.e., *Zaprionus* was poorly distributed and very poorly distributed were the members of *Scaptodrosophila* and *Amiota*.

However, the results were in accordance with the concept of [20] who pointed that *Drosophila* is the most important genus of the family Drosophilidae which shows rich species diversity at global level which is perhaps due to great adaption in the ecosystem, while other genera were endemic, probably due to specific niche preferences. According to Gause's competitive exclusion theory, related species competing for the same natural resources cannot coexist together in the same ecological niche [21]. Also, abundance of many species of genus *Drosophila* coexisting together were phylogenetically and taxonomically related.

Shannon Weaver index (H′) shows the nature of community. The value of H′, when lies, from 1.5 to 3.5, represents real communities. The value of H′ from 0 – 1.5 or less than 1.5 indicates community with low diversity, 1.5 – 2.5 indicates medium diversity and 2.5 or more than 2.5 indicates high diversity. Our results revealed that the value of H′ in all districts lied in between 1.5-2.5 representing all districts as real community showing medium diversity except Hazaribag comparatively showed high diversity (H′= 2.578).

The results species richness of seven districts clearly supported the spatial heterogeneity and productivity theory as proposed by Siemann [22] who explained that herbivores insect's richness is influenced by plant richness. Moreover, Hazaribag had highly diversified natural resources which corresponded to the greater achieved species richness.

Species evenness (e^H/S) comparison revealed more or less similar evenness in Bokaro (0.83), Dhanbad (0.79), Giridih (0.83), Koderma (0.77) and Ramgarh (0.76). However, in Hazaribag the evenness (0.65) was found to be less, despite the higher species richness. This was due to unequal occurrence of some species like *Amiota* (2) and *Scaptodrosophila* (2) out of 926 in number. It might be due to their preferences towards specific ecological niches which require more focus.

Qualitative occurrence of species as verified with the calculation of constancy values (C), Jaccard index and cluster analysis which represented, grouped the species into different types of groups due to partitioning their resource, and species avoided competition and were able to

co-exist in same limited resources [23].

Species diversity also tends to fluctuate with reference to temperature, latitude, longitude and altitude. It is due to the fact that poikilothermic species above its optimum physiological temperature the abundance seems to decline due to inbreeding depression [24], [25]. It also, states [19] that changes occurring as one ascends at an altitudinal transect, potentially involve changes in temperature, precipitation and partial pressure of atmosphere.

It also mentions in literature that abundance or species richness decreases with elevations [26], [27], [28]. However, it also demonstrates that species richness has an increasing trend from bottom to mid of the mountains and the gradually decreasing [29], [30], [31]. The Phenomenon is called Mid Domain Effect / Mountain Mass Effect. In the present research, however, diversity was found to increase with respect to altitude thereby supporting the mid domain effect but better considered to be as hill effect due to the fact that there were large differences in the altitude of hills and mountains.

Species abundance with respect to latitude and longitude of the districts were not remarkably showing any relationships since there existed very little differences in their geographical dimensions. However, the results tended to follow the area theory of species richness [32]. Further it revealed Hazaribag with more species diversity and species richness encompassing large forest cover area of 1352.71 km^2 [33] as compared to other districts covering small forest areas like Dhanbad and Ramgarh.

5. Conclusion

Despite the efforts made to procure a large number of species utilizing various collection techniques in assessing the species diversity status, many more surveys are still required to present a complete picture of species diversity. Considering the overall findings of the present study, it is well apparent that members of the family Drosophilidae in North Chotanagpur were fairly distributed in the studied districts. However, the present data in no way projected a gross picture of the species inhabiting in this division and also the quantitative and qualitative diversity status. Therefore, further sampling with special attention to micro niches is required to unveil the existence of many more species and their diversity assessment other than those which were incorporated in this paper. Of course, it is not the last word on family Drosophilidae of Jharkhand since many other divisions of the Jharkhand state still await explorations.

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