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Manoj Kumar Arya
Insect Biodiversity Laboratory, Department of Zoology, D.S. B. Campus, Kumaun University, Nainital, Uttarakhand, India

Prachi Tamta
Insect Biodiversity Laboratory, Department of Zoology, D.S. B. Campus, Kumaun University, Nainital, Uttarakhand, India

Dayakrishna
Insect Biodiversity Laboratory, Department of Zoology, D.S. B. Campus, Kumaun University, Nainital, Uttarakhand, India

Correspondence
Manoj Kumar Arya
Insect Biodiversity Laboratory, Department of Zoology, D.S. B. Campus, Kumaun University, Nainital, Uttarakhand, India

Study on Distribution and Diversity of Beetles (Insecta: Coleoptera) in Different Elevational Zones of Binsar Wildlife Sanctuary, Almora, Uttarakhand, India

Manoj Kumar Arya, Prachi Tamta, Dayakrishna

Abstract
Beetles were sampled over two years of study in different elevational zones of Binsar Wildlife Sanctuary in district Almora, Uttarakhand, India. A total of 734 individuals of beetles, representing 23 species, 18 genera and 6 families, were recorded during the study period. On the basis of total number of species Scarabaeidae was the most dominant family with 8 species followed by Chrysomelidae (5 species), Coccinellidae (2 species), Meloidae (2 species), Lagriidae and Tenebrionidae (1 species each), respectively. On the basis of total number of individuals *Coccinella septumpunctata* Linnaeus was the most abundant species and constituted 16.62% of the total beetles followed by *Anomala* sp. (13.21%) and *Altica himensis* Shukla (12.40%). Beetles community showed a significant variation along different elevational zones as abundance and species diversity of beetles declined with increasing altitude across different sites. Climatic variables significantly influenced the beetle community as higher species richness, abundance and diversity were recorded in rainy season followed by summer and winter, respectively.

Keywords: Abundance, beetles, diversity, species richness

1. Introduction
Insects are the most dominating and diverse creatures on the earth. They are truly ubiquitous and usually quite conspicuous members of the phylum Arthropoda under class Insecta. The order Coleoptera, which include beetles, is the most diverse order of class Insecta. The order Coleoptera includes 350,000 species amongst which about 15,088 species are known from Indian region[1]. Coleopteran insects are found in nearly all natural habitats that is vegetative foliage, from trees and their bark to flowers, leaves and underground near roots even inside plants like galls, tissue, including dead or decaying ones. Large numbers of studies have been conducted on the diversity and distribution of beetle fauna worldwide [2-15]. However, few earlier studies have listed the vertebrate fauna and some common butterflies of Binsar Wildlife Sanctuary but no exhausted survey on the beetles has so far been made in this sanctuary. Therefore, keeping in mind the above fact, present work was conducted to study the distribution and diversity of beetles in different altitudinal zones of Binsar Wildlife Sanctuary in district Almora, Uttarakhand, India.

2. Materials and Methods
2.1 Study area: The Indian Himalayan Region is known for its rich biological diversity. The biodiversity rich areas of the Himalaya have been conserved in the form of Biosphere Reserves, National Parks and Sanctuaries [16]. Binsar Wildlife Sanctuary (29°39'-29°44'N and 79°41'-79°49'E) represents one of the oldest protected landscapes in Kumaun Himalayan region of Uttarakhand. Before independence (before 1947) the study area was notified as ''Protected Forest'' in 1893 and later upgraded as Reserve Forest in 1897. After independence the status of this Reserve forest was elevated to Wildlife Sanctuary by Government of India in year 1988. The Binsar Wildlife Sanctuary (BWLS) is extended over an area of 47.67 km^2 between two districts named as Almora and Bageshwar. The sanctuary has two zones i.e. core and buffer zone. The core zone covers an area of 4 km^2 while rest of area (43.67 km^2) is included in buffer zone. Altitude of the sanctuary varies between 1200 to 2500 m above sea level. The mean monthly temperature ranges from 2.2 °C to 15.5 °C during winter and from

17.2 ºC to 30.0 ºC during summer. The average annual precipitation is about 1200 mm. For the present study, three study sites were selected at different elevational zone with varied characteristics in buffer zone of BWLS. Table 1 shows the characteristic features of different study sites. The different sites selected for the collection and study purpose are as under:-

Site-1 (**Ayarpani):** This site is located adjacent to the main highway (Almora-Bageshwar) at an altitude of 1857m. The vegetation is mainly dominated by *Pinus roxburghii* Sarg, along with different species of shrubs and herbs. Because of its proximity to highway it receives high level of disturbances due to transportation, forest fire and various other anthropogenic activities.

Site-2 (Binsar Mahadev): This site is approximately 13 km away from main highway (Almora-Bageshwar) at an altitude of 2191m. The area has a sparse cover of *Quercus* species (*Q. semicarpifolia* Smith and *Q. floribunda* Lindl. ex A. Camus*)* with other species of herbs and shrubs. This study site receives a moderate level of disturbance due to tourism, animal grazing, and collection of minor and major forest products by neighbouring villagers.

Site-3 (Jhandidhar): This site is situated at an altitude of 2409m and 20 km away from the main highway (Almora-Bageshwar). This area is free from anthropogenic disturbances and vegetation is mainly dominated by *Cedrus deodara* (Roxb.) G. This is highly snow prone area of the Sanctuary receiving snow from mid of December which lasts there till the end of March.

Table 1: Characteristic features of different study sites selected during the present study.

Study sites	Geographical Coordinates	Elevation (m)	Dominant plant community
Site-1 (Ayarpani)	N-29˚40.255" E-79˚42.325"	1857	*Pinus roxburghi* Sarg, *Pyrus pashia* Buch-Ham. ex D. Don, *Berberis asiatica* Roxb., *B. aristata* D.C., *Bergenia ciliate* (How) Sternb. and *Carex condensate* Nees
Site-2 **(**Binsar Mahadev)	N-29˚41.965" E-79˚44.950"	2191	*Quercus semicarpifolia* Smith, *Q.floribunda* Lindle.ex A. camus, *Rubus ellipticus* Sm. *Pyracantha crenulata* (D. Don) M. Rome, *Bistorta amplexicaulis* D. Don and *Oenothera rosea* L᾽ Her.ex Aiton
Site-3 (Jhandidhar)	N-29˚42.443" E-79˚45.254"	2409	*Cedrus deodara* (Roxb.), *Querus semicarpifolia* Smith, *Daphne papyracea* Wall. ex. Steud, *Deutzia staminea* R. Brown ex.Wallich, *Potentilla fulgens* Wall. ex Lehm., and *Galium rotundifolium* L.

2.2 Sampling of beetles: Random sampling of beetles was conducted at an interval of 30 days**.** Net sweeps were carried to sample the beetles. The nets used in systematic sweeping were made of thick cotton cloth with a diameter of 30cm at mouth and a bag length of 60cm. The sampled beetles were transferred in to jars containing Ethyl Acetate soaked cotton. These jars were brought to the laboratory and the beetles were stretched and pinned. The entomological pins numbering 1 to 20 were used according to the size of the specimen. These were oven dried at 60ºC for 72 hours to preserve them and then set into wooden boxes and labeled according to their systematic position. The species which could not be identified in the laboratory were sent to Entomological Section of Forest Research Institute, Dehradun, for their identification.

2.3 Population density: Population density of beetles was calculated by dividing the total number of individuals sampled from each site by total number of sampling sites. Effect of temperature and rainfall on population density of beetles was analysed by using software SPSS version 16.0 [17].

2.4 Diversity indices: Various measures of diversity (richness, Shannon diversity index and evenness index) were analysed for the beetles using statistical package Past 3.4 [18].

3. Results and Discussion

3.1 Species composition: A total 734 individuals of beetles belonging to 23 species, 18 genera and 6 families were recorded during the study period. On the basis of total number of species, Scarabaeidae was the most dominant family with 8 species followed by Chrysomelidae (5 species), Coccinellidae (2 species), Meloidae (2 species), Lagriidae and Tenebrionidae (1 species each), respectively. Percent contribution of relative number of species and individuals of beetles collected from study area are presented in Table 2.

Table 2: Percent contribution of relative number of species and individuals of different families of order Coleoptera recorded during the study period.

S.N.	Family	Total no. of species	Percent (%)	Total no. of individuals	Percent (%)
1.	Scarabaeidae	12	52.18	304	41.42
2.	Chrysomelidae	5	21.74	175	23.84
3.	Coccinellidae	2	8.69	146	19.89
4.	Meloidae	2	8.69	82	11.17
5.	Lagriidae	1	4.35	18	2.45
6.	Tenebrionidae	1	4.35	9	1.23
	Total	**23**	**100**	**734**	**100**

In terms of total number of individuals, Scarabaeidae was the most dominant family which accounted for 41.42% of the total collected beetles. *Anomala* sp. was the most abundant species and constituted 31.91% of total individuals of this family followed by *Anomala lineatopennis* Blanchard (15.79%), *Lachnosterna cavifrons* Brenske (14.80%), *Onthophagus rubricollis* Hope (8.55%), *Onthophagus gagates* Hope (7.56%), *Pseudolucanus cantor* Hope (6.25%), *Scarites sulcatus* Olivier (3.95%), *Gymnopleurus subtilis* Walker (3.62%), *Protaetia neglacta* Hope (3.29), *Lytta limbata* Redtenbacher (1.64%), *Protaetia pretiosa* Nonfried (1.64%) and *Jumnos roylei* Hope (0.99%), respectively.

Table 3: Taxonomic composition and relative abundance of different species of Coleopteran insects recorded during the study period 2013-15.

S.N.	Order: Coleoptera	Site-1	Site-2	Site-3
Family: Scarabaeidae				
1.	*Anomala lineatopennis* Blanchard	4.96	6.25	10.89
2.	*Anomala* sp.	11.85	12.95	17.01
3.	*Gymnopleurus subtilis* Walker	3.03	-	-
4.	*Jumnos roylei* Hope	-	1.34	-
5.	*Lachnosterna cavifrons* Brenske	6.61	5.80	5.44
6.	*Lytta limbata* Redtenbacher	0.83	-	1.36
7.	*Onthophagus gagates* Hope	-	10.27	-
8.	*O. rubricollis* Hope	4.13	-	7.48
9.	*Protaetia neglacta* Hope	-	4.46	-
10.	*P. pretiosa* Nonfried	0.55	-	2.04
11.	*Pseudolucanus cantor* Hope	5.24	-	-
12.	*Scarites sulcatus* Olivier	3.31	-	-
Family: Chrysomelidae				
13.	*Altica himensis* Shukla	14.05	12.95	7.48
14.	*Gallerucida rutilans* Hope	2.75	0.89	9.52
15.	*Meristata sexmaculata* (Kollar & Redtenbacher)	2.75	4.46	6.12
16.	*Meristata trifasciata* Hope	5.51	2.68	-
17.	*Mimastra* sp.	-	1.34	-
Family: Coccinellidae				
18.	*Coccinella septumpunctata* Linnaeus	17.36	15.63	16.33
19.	*Haluzia sanscrieta* Muls.	-	8.93	2.72
Family: Meloidae				
20.	*Mylabris cichorii* Linnaeus	10.19	6.25	9.53
21.	*Mylabris* sp.	2.20	2.23	2.72
Family: Lagriidae				
22.	*Cerogria nepalensis* Hope	2.20	3.57	1.36
Family: Tenebrionidae				
23.	*Cistelomorpha* sp.	2.48	-	-

Chrysomelidae was the second most dominant family which constituted 23.84% of the total recorded beetles. *Altica himensis* Shukla was the most abundant species of this family which constituted 52% of total individuals of this family, followed by *Meristata sexmaculatata* (Kollar & Redtenbacher) (16.57%), *Gallerucida rutilans* Hope (14.86%), *Meristata trifasciata* Hope (14.86%) and *Mimastra* sp. (1.71%). Family Coccinellidae was represented by 2 species and constituted 19.89% of total recorded beetles. *Coccinella septumpunctata* Linnaeus was the abundant species of this family which constituted 83.56%, of total individuals of this family followed by *Haluzia sanscrita* Muls. (16.44%). Family Meloidae was represented by 2 species and constituted 11.17% of total recorded beetles. *Mylabris cichorii* Linnaeus was the abundant species of this family which constituted 79.27% followed by *Mylabris* sp. (20.73%). Family Lagriidae was represented by *Cerogria nepalensis* Hope and constituted 2.45% of the total recorded beetles during the study period. Family Tenebrionidae was represented by *Cistelomorpha* sp. which constituted 1.23% of the total recorded beetles during the study period.

Various studies have revealed that Indian Himalayan Region harbors a rich diversity of beetles. Mani[2] reported 186 species of beetles belonging to 18 families of order Coleoptera from Nival Zones of North-East Himalaya. Scarabaeidae was the most dominant family with 84 species followed by Salphylimidae (32), Tenebrionidae (17), Curculionidae (16), Dystiscidae and Hydrophilidae (7 each). Singh [3] reported 190 species of beetles belonging to 26 families from North-East Himalaya. Tenebrionidae was the most dominant family with 55 species followed by Carabidae (23), Scarabaeidae (18) and Haliphidae (16). Biswas[5] reported 105 species of beetles belonging to 9 families from Western Himalayan Ecosystem. Chrysomelidae was the most dominant family with 35 species followed by Tenebrionidae (23), Carabidae (22), Scarabaeidae (21), Elateridae (5) Curculionidae (4), Meloidae (3), Cicindelidae and Lampyridae (1 each). Kumar *et al.* [9] have recorded 49 species of Scarabaeid Coleopteran insects belonging to 4 families from Kullu Valley of Himachal Pradesh. Chandra *et al.* [12] have reported 11 species of Scarabaeid belonging to 11 genera, 5 subfamilies and 2 families of superfamily Scarabaeoidea from Govind Wildlife Sanctuary, Garhwal, Uttarakhand, India. Arya and Joshi [13] have reported 20 species of Coleopteran insects from Nanda Devi Biosphere Reserve, Western Himalayas, Uttarakhand, India. Arya *et al.* [14] have reported 17 species of beetles belonging to 6 families from Shyampur forest range in Shivalik foot hills of Haridwar, India. Recently, Pathania *et al.* [15] have reported 56 species of Scarabaeid beetles belonging to 20 genera and 4 subfamilies from different landscapes of Himachal Pradesh, India.

3.2 Abundance: A total of 734 individuals of beetles belonging to 23 species were recorded from different study sites during the study period. Site no. 1 supported 18 species with 363 individuals followed by site no. 2 with 16 species and 224 individuals, and site no.3 with 14 species and 147 individuals. Table 3 presents the relative abundance of different species of beetles recorded in different study sites during the present study. *Coccinella septumpunctata* Linnaeus (Family: Coccinellidae) was the most abundant species and constituted 16.62% of the total beetles. Maximum number of individuals of this species was recorded during the rainy season. *Anomala* sp. (Family: Scarabaeidae) constituted 13.21% of the total beetles and was the second most abundant species. Maximum number of individuals of this species was recorded from site 1 followed by site 2 and site 3, respectively. *Altica himensis* Shukla (Family: Chrysomelidae) was the third most abundant species and constituted 12.40% of the total beetles recorded. Again the maximum number of individuals of this species was recorded during the rainy season followed by summer and winter. On the other hand, *Jumnos roylei* Hope (Family: Scarabaeidae), *Mimastra* sp. (Family: Chrysomelidae), *Lytta limbata* Redtenbacher and *Protaetia pretiosa* Nonfried (Family: Scarabaeidae) were the less abundant species in the study area. Species richness and abundance of beetles varied across elevational gradient and lower elevation zone (site-1) supported higher number of species and individuals followed by mid elevation zone (site-2) and high elevation zone (site-3), respectively. It is suggested that the number of species and individuals of insects found at the lower elevation is much higher compared to at higher elevation site [13]. During both the year maximum number of species and individuals were collected during the rainy season followed by summer and winter, respectively.

Population density: Monthly variation in population density of beetles recorded during the study period has been presented in Figure 1. Population density of beetles was higher in the month of August (7.92 individuals ha^{-1}), whereas minimum in the month of January (1.25 individuals ha^{-1}) during the study.

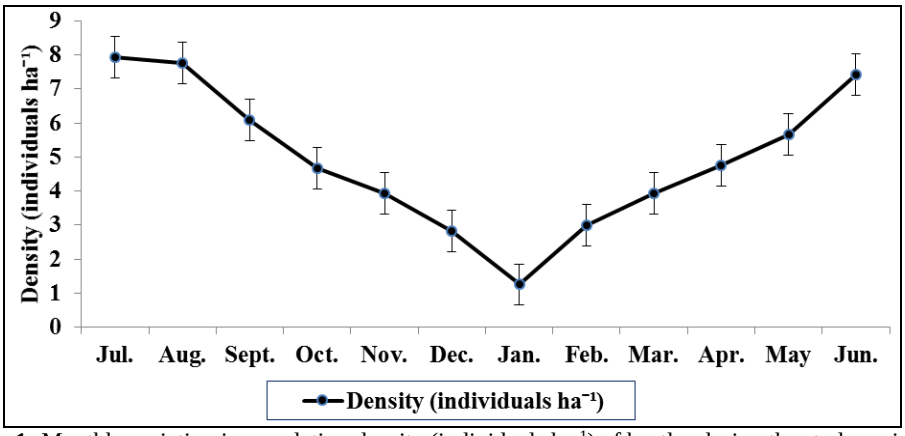

Fig 1: Monthly variation in population density (individuals ha^{-1}) of beetles during the study period.

Figures 2 and 3 show that density of beetles was significantly influenced by temperature as well as rainfall and density was positively associated with temperature ($r = 0.93$, $P < 0.01$, $n = 12$) and rainfall ($r = 0.56$, $P < 0.05$, $n = 12$), respectively.

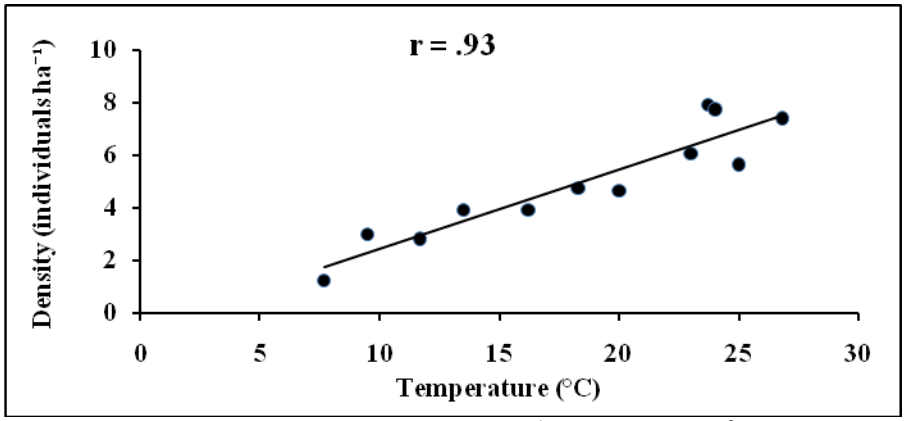

Fig 2: Relationship between Coleopteran density (individuals ha^{-1}) and temperature (^{0}C) during the study period.

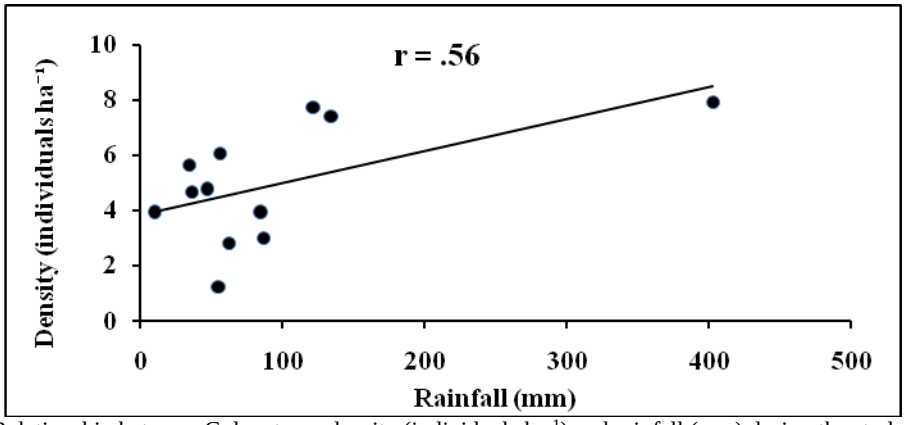

Fig 3: Relationship between Coleopteran density (individuals ha^{-1}) and rainfall (mm) during the study period.

3.3 Species diversity: The richness, abundance and diversity of beetles with their evenness in different study sites are presented in Table 4. The annual species diversity was 2.72 and 2.65 for the first year and the second year of the study period, respectively. Across the study sites diversity decreased with increasing elevation and higher species diversity was found at lower elevation. However, distribution of beetles across different sites was not significantly influenced by elevation. During both the year of study the sites at lowest altitude and longest rainy season had the highest Shannon Wiener diversity Index.

Table 4: Variation in species richness, abundance, diversity and evenness of beetles in different study sites during the study period 2013-15.

Years	Study sites	Species (S)	Abundance	Shannon Index	Evenness
First year	Site-1	17	171	2.50	0.720
	Site-2	16	118	2.55	0.801
	Site-3	14	70	2.47	0.848
	Across the year	22	359	**2.72**	0.693
Second year	Site-1	16	192	2.54	0.796
	Site-2	14	106	2.37	0.771
	Site-3	11	77	2.19	0.872
	Across the year	20	375	2.65	0.712

During the present study different seasons markedly influenced the species richness, abundance, diversity and evenness of beetles (figures 4 and 5, respectively). Species richness, abundance and diversity of beetles were higher in rainy season followed by summer and winter. Although, distribution was more even in winter as compared to rainy and summer seasons. Similar pattern of observations have also been recorded earlier in different ecosystems [13, 14].

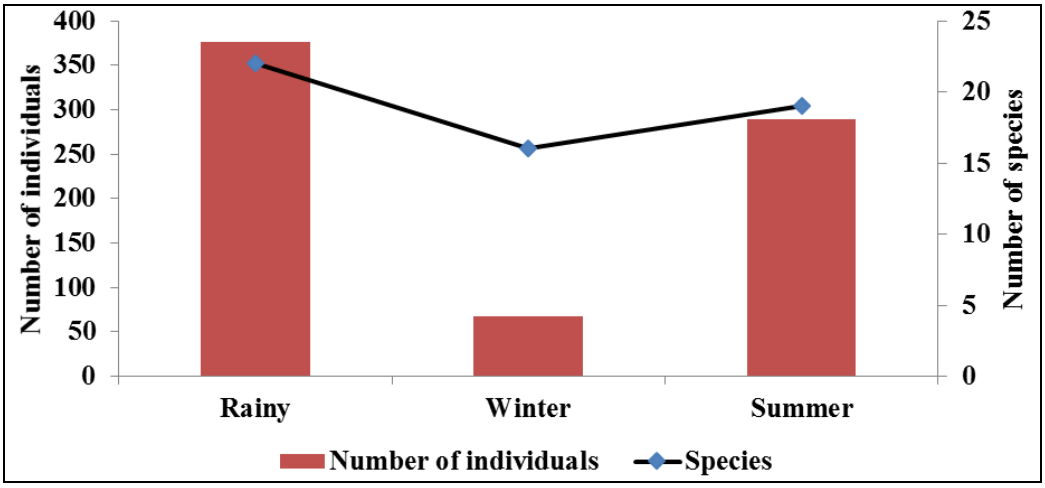

Fig 4: Seasonal variation in number of individuals and species of beetles recorded in the study area.

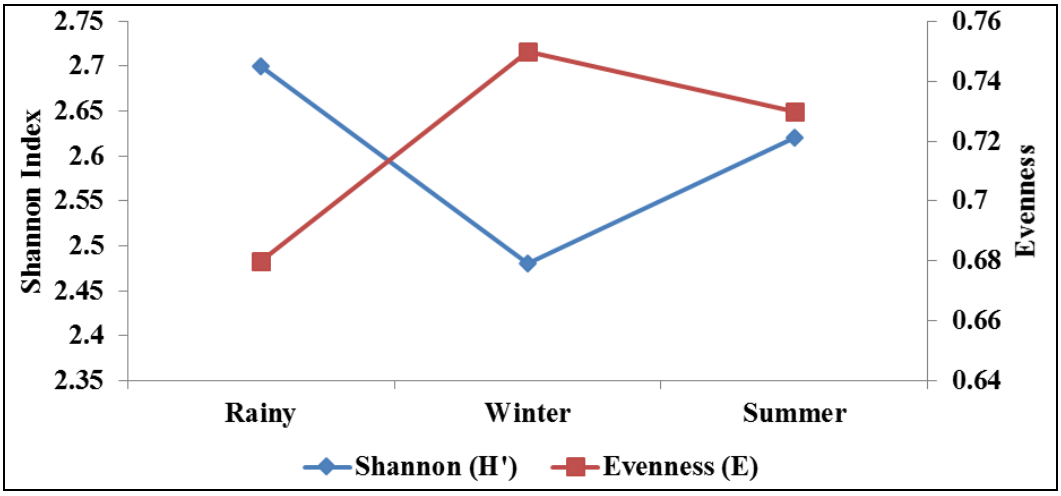

Fig 5: Seasonal variation in species diversity (H') and evenness of beetles during the study period.

The results of present study conclude that rich diversity of beetles in Binsar Wildlife Sanctuary may be due to sufficient food resources, suitable ecological factors and micro habitats. Therefore, proper management of such natural habitats is must because these ecological zones play a significant role in conservation of biodiversity.

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