Studies On The Beetles (Insecta: Coleoptera) In The Nanda Devi Biosphere Reserve, Western Himalayas, Uttarakhand, India

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Abstract: Coleopterans insect communities were studied in three different ecological zones in the buffer zone of Nanda Devi Biosphere Reserve, Western Himalayas, Uttarakhand, India. The altitude of the study area ranged between 2100 m to 3500 m with temperate, sub-alpine and alpine types of vegetation. A significant difference was recorded in the species composition, abundance, population density and species diversity of Coleopterans insect of the three ecological zones, which demonstrate the effect of altitude and as well as other ecological and climatic parameters on insect populations. The site at lowest altitude supported the highest number of 17 species and 527 individuals, whereas the site at the highest altitude supported the lowest number of 9 species and 211 individuals. When all the sites considered, a total of 1093 individuals of Coleopteran insects belonging to 20 species and 4 families were recorded during the study period. The family Scarabaeidae was the most abundant both in terms of number of species (8) and individuals (858), followed by Chrysomelidae 6 species and 263 individuals, Coccinellidae 4 species and 136 individuals and Meloidae with 2 species and 109 individuals. The most abundant species were *Anomala dimidiate* Hope, *Protaetia neglacta* Hope, *Altica himensis* Shukla and *Mylabris cichonni* Linn. The site at the lowest altitude and the longest rainy season had the highest Shannon-Wiener Diversity. Similarly, the maximum population density (29.33 insect ha^{-1}) was recorded from the site at lowest elevation (2100 m).

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Introduction

Coleopterans commonly known as beetles constitutes the largest order of all animals. They have been a favourite group for insect collectors for their versatile habitats, marvelous coloration and sculpture as well as for their economic importance. The major ecological impact of beetles results from their effects on green plants, their contribution to breakdown of plant and animal debris and their predatory activities. India is well known for richness of coleopterans fauna and against an estimated total of 179 families of Coleopterans, about 103 families are known from India, of the 3, 50,000 described species under from all over the world and 15,000 species under 2,000 genera are known from India (Biswas, 1995). The Coleopterans are among the dominant forms of high altitude insects occurring almost on all the mountains of the world. Studies on the species composition of Coleopterans insect in the high altitude ecosystems of the Indian Himalayan regions have been carried out by Mani (1956), Singh (1963), Biswas (1995), Kumar *et al.* (2007) and Chandra *et al.* (2012) and similarly others workers have also studied the species composition and abundance in different parts of the world (Lenski, 1982; Kruger and McGavin, 1997; Gutierez and Menendez, 1997; Weslein and Schroeder, 1999; Martikainen *et al.*, 2000; Gordon and Cobblah, 2000; Stork *et al.*, 2001, Magagula and Samways, 2001; Jukes *et al.*, 2002 and Magagula, 2009). Studies on the species diversity of Coleopterans insect have been carried out by Hutcheson and Jones (1999), Romero- Alcaraz and Avila (2000), Zilihona and Nummelin (2001), Maeto *et al.* (2002) and Aland *et al.* (2010) in the different parts of the world. In addition, several studies conducted to evaluate the relationship between insect diversity and altitudinal variations in habitats of insect populations in the different parts of the world by various workers (Alexander and Hillard, 1969; Claridge and Singhraw, 1978; Wolda, 1987; Joshi *et al.,* 2004; Joshi and Arya, 2007 and Joshi *et al.,* 2008). Similarly, many other workers have also studied the fluctuation in population density of coleopterans (Kaushal and Vats, 1987; Joshi, 1996; Joshi and Sharma, 1997; Arya and Joshi, 2011 and Arya *et al.*, 2013). However, no attempts have so far been made to the beetles (Coleopterans) in the Nanda Devi Biosphere Reserve, Western Himalayas, Uttarakhand, India.

Materials and mathodes

Study area: Nanda Devi Biosphere Reserve (NDBR) is one of the important sites of wilderness and hot spot of biodiversity in the Indian Himalayan region. The NDBR was the second such reserve in India to be established under the Man and Biosphere Program (MAB) launched by UNESCO in 1970. NDBR is located in the northern part of west Himalaya and spread in three districts of Uttarakhand state, namely Chamoli in Garhwal, Bageshwar (Pindari area) and Pithoragarh district in Kumaun. Pindari area is located (30º5'-30º10'N to 79º48'-79º52'E) in the northern part of Bageshwar district (Uttarakhand). This area lies at buffer zone of Nanda Devi Biosphere Reserve in Western Himalaya, India. The entire area represents a characteristic high altitude environs and falls within an altitudinal range of 2100-7000 m. The glaciers in the area viz. Pindari, Kaphni and Sunderdhunga are main attractions for mountain and eco-tourism. Climatically, the area is unique and has three season i.e. winter (November to March), summer (April to June) and rainy from middle of June to middle of October. Due to altitudinal and climatic gradients, the natural vegetation changes from temperate to sub-alpine and alpine type. For, the present study, three study sites were selected in the buffer zone of Pindari area of Nanda Devi Biosphere Reserve. **Table 01** shows the characteristic features of the study sites. The different sites selected for the collection and study purpose are as under:-

Site no.1 (Khati): This study site is connected with road head by a footpath after traveling 22km from Song village (Bageshwar district) and is close to the river Pindar. It is located at an altitude of 2100 m. The forest is more of a Pangur (*Aesculas indica* (Colebr. ex. camb) Hk., which is associated with dominant forest of *Quercus floribunda* Rehder, *Junglens regia* L., *Alnus nepalensis* Don., *Acer villiosum* Wall. and *Cedrus deodara* (Roxb.) Loud. This site is moderately disturbed because of its proximity to Khati village and receives moderate disturbances due to the grazing by cattle and collection of forest products by the neighboring villagers. During the study period temperature of this study site varied between 9ºC to 26ºC, while the relative humidity ranged between 30% to 75%.

Site no.2 (Dawali): The distance between Khati and Dawali is 12 km. This site is located at an altitude of 2800 m and is dominated by colorful Burans (*Rhododendron arboreum* Sm. and *R. barbatum* Wall.) forest associated with mixed forest of *Acer cappadocium* Gled, *Taxus baccatata* L. subsp., *Acer caesium* Wall. ex. Brand, *Abies pindrow* Royle and *Ulmus wallichiana* Plank. This site has very low level of anthropogenic disturbances. The V-shaped valley (both side of Dawali) is drained by river Pindar and very sensitive to geological disturbance i.e. landslides, rock fall and soil-erosion activities. Temperature at Dawali ranged between 6ºC to 22ºC, while relative humidity ranged between 35% to 80%.

Site no.3 (Phurkia): This site is located at an altitude of 3500 m and is close to the Pindari glacier and core zone of Nanda Devi Biosphere Reserve. The distance between Dawali and Phurkia is 7 km. This study area represents to a moist sub alpine scrub and alpine forest. The dominant plant species include Bhoj (*Betula utalis* D. Don), *Acer acuminatum* Wall., *Abies spectablis* (D. Don) Mirle), *Rhododendron campanulatum* D. Don and *R. anthopogon* D. Don. This is a highly snow prone area of buffer zone which starts receiving snow from last week of November, which can be seen their till the end of March. This site is highly disturbed due to altitudinal migration of tribes who use the area as their summer settlement and collect fuel and fodder apart from the area being used for grazing by their cattle and sheep's. Temperature at this site ranged between 4ºC to 19ºC and relative humidity ranged between 40% to 90%.

Floristic composition: A detailed survey of all the sites was carried out in order to find out the composition of the vegetation during the study period. Herbarium of the plants, which could not be identified in the field, was prepared and got identified with the help of Scientists from G. B. Pant Institute of Himalayan Environmental and Development, Kosi-Katarmal, Almora, India.

Sampling of Entomofauna: Sampling of beetles was conducted at an interval of 30 days**.** The beetles were collected by "Sweep Sampling Method", as per Gadagkar *et al.* (1990). The net sweeps were carried to collect the beetles. The nets used in systematic sweeping were made of thick cotton cloth with a diameter of 30 cm at mouth and a beg length of 60 cm. To assure a consistent, systematic sampling, a randomly selected area of each study site was divided in to 100 quadrates of 10x10 m. Sampling was done at random and at an interval of 30 days. The collected beetles were transferred in to jars containing Ethyl Acetate ($CH_3COOC_2H_5$) soaked cotton. These jars were brought to the laboratory and the beetles were stretched and pinned. The entomological pin number 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 in to wooden boxes and labeled according to their systematic position. The species of beetles, which could not be identified in the laboratory, were sent to Northern Regional Station of Zoological Survey of India, Dehradun, Entomological Section of Forest Research Institute, Dehradun, Indian Agricultural Research Institute, Pusa, New Delhi and Zoological Survey of India, Kolkata for their identification.

Population density: Population density of coleopterans was calculated by dividing the total number of coleopterans collected on each sampling date from each site with three. Since, the area of each site selected for collection was 3 ha. Density from each site has been recorded as individuals per hectare.

Species diversity: Survey of diversity is essential for understanding the distribution of the forms. The species diversity was calculated by using "Shannon-Wiener Index (1963)", which is defined as,

$$H'(S) = -\sum_{i=1}^{s} \text{Pi} \log \text{Pi}$$

Results and discussion

Floristic composition: Diversity in the topography, climate, soil and geology has resulted in diverse floristic composition in Nanda Devi Biosphere Reserve. Thus a detailed survey of the vegetation was made in each of the study sites during study period. A total of 144 plant species, including 26 trees, 45 shrubs and 73 herbs were recorded from the three study sites. Along the entire altitudinal range, Pindari area of Nanda Devi Biosphere Reserve supports temperate, sub- alpine and alpine vegetation. A total of 73 species of plants are reported from site-1 (Khati), which included 15 species of trees, 26 species of shrubs and 32 species of herbs. While, a total of 78 species of plants are reported from site-2 (Dawali) during the study period, which included 13 species of trees, 24 species of shrubs and 41 species of herbs and a total of 63 species of plants are reported from site-3 (Phurkia), which included 8 species of trees, 17 species of shrubs and 38 species of herbs.

Species composition: A total 1093 individuals of beetles belonging to 20 species and 4 families were recorded during the study period **(Table 02).** On the basis of number of identified species of beetles (Coleopterans), family Scarabaeidae was the most dominant family of the total beetles with 8 species, followed by Chrysomelidae (6), Coccinellidae (4) and Meloidae (2). Percent contribution of relative number of species and individuals of different families of beetles collected from study area are presented in **Table 03**. Family Scarabaeidae was the most dominant family of this order, which constituted 53.52% of the total collected Coleopterans. *Anomala dimidiata* Hope was the most dominant species of this family which constituted 34.35% of total individuals of this family, followed by *Protaetia neglecta* (Hope) (24.61%), *Jumnos roylei* Hope (15.89%), *Anomala varicolor* Gyll. (11.96%), *Brahmina* sp. (7.92%), *Onthophagus* sp. (2.92%), *Popilla pilosa* Arrow (1.69%) and *Anomala lineatopennis* (0.85%). Family Chrysomelidae was the second most dominant family of this order, which constituted 24.06% of the total collected Coleopterans. *Altica himensis* Shukla was the most dominant species of this family which constituted 52.47% of total individuals of this family, followed by *Meristata sexmaculatata* (Kollar & Redtenbacher) (24.34%), *Mimastra* sp. (7.98%), *Meristata trifasciata* Hope (6.85%), *Cryplocephalus triangularis* Hope (6.46%) and *Aulacophora* sp. (1.9%). Family Coccinellidae was represented by 4 species and constituted 12.45% of total collected Coleopterans. *Coccinella septumpunctata* L. var. divaridata was the dominant species of this family, which constituted 66.91%, of total individuals of this family followed by *Chaeilomenes sexmaculata* (Fabr.) (15.45%), *Haluzia sanscrita* Muls. (11.76%) and *Hippodamia variegate* (Goeze) (5.88 %), respectively. Family Meloidae was represented by 2 species and constituted 9.97% of total collected Coleopterans. *Mylabris cichonni* Linnaeus was the most dominant species of this family, which constituted 91.75% and *Meloe violaceus* Mars. (8.25%).

The species composition of Coleopterans from different parts of Indian Himalayan regions have studied by different workers. Mani (1956) reported 186 species 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 (1963) reported 190 species belonging to 26 families from North-East Himalaya. Tenebrionidae was the most dominant family with 55 species, followed by Carabidae (23), Scarabidae (18) and Haliphidae (16). Biswas (1995) reported 105 species belonging to 9 families of Coleoptera from Western Himalayan Ecosystem. Chrysomelidae was the most dominant family with 35 species followed by Tenebrionidae (23), Carabidae (22), Scarabidae (21), Elateridae (5) Curculionidae (4), Meloidae (3), Cicindellidae and Lampyridae (1 each). Kumar *et al.* (2007) have recorded 49 species of Scarabaeid beetles belonging to 4 families from Kullu Valley of Himachal Pradesh. In a more recent year, Chandra *et al.* (2012) have reported 11 species of Scarabaeid beetles from Govind Wildlife Sanctuary, Garhwal, Uttarakhand, India.

Different ecosystems of the world harbor different species composition with varying number of beetles. Lenski (1982) has reported 43 species of Coleoptera: Carabidae from the Blue Ridge Mountain forest of North Carolina. Kruger and McGavin (1997) reported 113 species of Coleoptera from Mkomazi Game Reserve, North-East Tanzania.

Gutierez and Menendez (1997) reported 90 species belonging to 14 family of Coleoptera from Northern Spain. Weslein and Schroeder (1999) reported 339 species of Bark beetles from Central Part of Sweden. Martikainen *et al.* (2000) reported 43,289 individuals belonging to 553 species of order Coleoptera from the forest of Southern Finland. Gordon and Cobblah (2000) reported 33 species of Coleoptera from Muni Pomadze Ramsar coastal site of Ghana. Romero-Alcaraz and Avila (2000) reported 2398 specimens of Coleopterans belonging to 45 families and 168 species from Sierra de Baza, Spain. Stork *et al.* (2001) reported 144 species of Coleoptera from canopies of oak trees in Richmond Park, U. K. Magagula and Samways (2001) reported 1654 coccinellid individuals of 31 species from African agricultural/savanna land mosaic, Swaziland. Jukes *et al*. (2002) reported 202 species (11,074 individuals) of Coleoptera from coniferous plantations in Britain. Magagula (2009) has documented 64 species of dung beetles belonging to 2 families and 21 genera from Mlawula, Nature Reserve, a protected area in Swaziland. In a more recent study, Aland *et al.* (2010) have reported 17 species of longicorn beetles belonging to 16 genera and 3 subfamilies from Amba Reserve Forest of Western Ghats, Maharashtra.

Abundance: In the present study, site- 1 supported 17 species with 527 individuals followed by site- 2 with 12 species and 355 individuals and site-3 with 9 species and 211 individuals. *Anomala dimidiata* Hope (Family: Scarabaeidae) was the most abundant species constituting 18.38% of the total Coleopterans collected from all the three sites during the study period. The maximum number of this species was recorded from site-1 followed by site-.2 and site-3, respectively and 50% individuals of this species were collected during rainy season. *Protaetia neglacta* Hope (Family: Scarabaeidae) constituted 13.17% towards the total number of individuals collected and was the second most abundant species. The maximum individuals of this species were recorded from site-1 and followed by site-2 and site-3, respectively. Again the maximum numbers of this species were recorded during the rainy season. *Altica himensis* Shukla (Family: Chrysomelidae) was the third abundant species, constituting 12.62% of the total Coleopterans collected. Maximum numbers of individuals of this species were collected from site-1 followed by site-2 and site-3, respectively. Maximum individuals of this species were recorded during rainy season. The less abundant species included *Anomala lineatopennis* Bl. (Family: Scarabaeidae), *Aulacophora* sp. (Family: Chrysomelidae), *Hippodamia varietata* (Goeze) (Family: Coccinelidae), *Meloe violaceus* Mars. (Family: Meloidae) and *Popilla pilosa* Arrow (Family: Scarabaeidae). In the present investigations, maximum numbers of species and individuals were collected during the rainy season but no insects were collected during winter season. The impact of altitude is clearly evident as the maximum number of species and individuals were recorded from lower altitude site, which is as the lowest altitude (2100m) supporting the observation of Joshi and Arya (2008) that the number of species and abundance of insects found at the lower elevation is much higher as compared to the higher elevation site.

Population density: Table 04 shows the fluctuations in density of Coleopterans during first and second year, respectively. During first year, the density of Coleopterans insect varied from 4.33 ha-1 (October) to 22.33 ha-1 (July) in the site-1. While, in site-2 density varied from 1.00 ha-1 (April) to 17.00 ha-1 (August) and in site-3 density varied from 2.33 ha-1 (May) to 8.33 ha-1 (August). During second year, the density of Coleopterans varied from 0.33 ha-1 (April) to 29.33 ha-1 (July), 4.3 ha-1 (May) to 21.67 ha-1 (August) and 1.00 ha-1 (October) to 14.33 ha-1 (August) in site-1, 2 and 3, respectively. During both the years, maximum population density 22.33 insects ha^{-1} and 29.33 insects ha^{-1} in the month of July was recorded during first year and second year of the study from the site at lowest elevation (2100 m).

Vats and Kaushal (1980) reported a maximum density of insects during rainy season (1.37 m^{-2}) whereas no insects could be collected during winter season. Gupta and Vats (1983) reported the maximum insect density during rainy season (1.13 m^{-2} first year and 1.50 m^{-2}, second year) and minimum during summer season (0.41 m^{-2} first year and 0.56 m^{-2} during second year). Vats and Mittal (1984) studied insect population density in a tropical deciduous forest and reported density of insects varied from 0.11 m^{-2} to 2.51 m^{-2} and the peak value was recorded in the late rainy season. Joshi and Sharma (1997) also reported the maximum insect density during rainy season (1.3 m^{-2}) and minimum during winter (0.1 m^{-2}) in a crop land ecosystem. Arya and Joshi (2011) studied the population density of Hymenopterans insect in the Nanda Devi Biosphere Reserve and reported that the population density of Hymenopterans fluctuated between 25.67 ha^{-1} (July) to 0.66 ha^{-1} (November). In a more recent study, Arya *et al.* (2013) reported the maximum population density of Hymenopterans during rainy season (7.33 insects ha^{-1} and 11.33 insects ha^{-1} during first and second year, respectively) and minimum during winter season (0.33 insects ha^{-1} in both the years) in the Shyampur forest range in the Shivalik foot hills, Hardwar. Meteorological factors have always been considered vital for maintaining insect populations in a given ecosystem.

Species diversity: The annual species diversity was 6.710 and 6.706 for the first year and the second year of the study period, respectively. The richness of Coleopterans insect species, abundance with diversity indices and their evenness of different study sites are presented in **table 05**. The highest insect diversity was found in site-1, which has a Shannon-Wiener diversity Index of (2.563). The next highest level of diversity was found in the site-2, which has a diversity index of 2.306. Finally the lowest amount of diversity was observed in site-3 (1.841). During both the years of study the site at lowest altitude and longest rainy season had the highest Shannon-Wiener diversity Index.

Alexander and Hillard (1969) have reported that the maximum species diversity of Orthopteran occurs at lower altitudes (1530 m) in comparison of high altitudes (4265 m) because of the longer seasons at lower altitudes. Wolda (1987) studied altitudinal diversity of tropical insects along the different localities of Panama Republic. He reported that species richness as well as sample size decreased gradually with increasing altitude. Hutcheson and Jones (1999) studied the species diversity in plantation forest of *Pinus radiata* and reported that the maximum species diversity of beetles was in thirty year old plantation forest, while the minimum was recorded in fourteen year old plantation forest. Romero-Alcaraz and Avila (2000) studied the beetle diversity into four habitat types i.e. scrublands, meadows, natural forests and planted forests and reported that the diversity at natural pine forests (H'= 1.86 ±0.10) was significantly greater than that found at any of the other types of forest. Zilihona and Nummelin (2001) studied the Coleopteran diversity at the family level in three micro-habitats viz. Spray zone, forest site and Riverine site, near Kihansi water fall, in the Udzungwa Mountains, Tanzania and reported that the Shannon-Weaver index of family level diversity in the Spray zone was highest (0.71) followed by Riverine site (0.50) and Forest site (0.31). Maeto *et al.* (2002) studied the species richness of longicorn beetles in humid warm temperate forests from southwestern Japan and reported that the species richness of longicorn beetle was poorer in second-growth forest and conifer plantations than in old-growth forests. Joshi and Arya (2007) studied the butterfly communities along altitudinal gradients in a protected forest in the Western Himalayas, India and reported that the higher values of richness, abundance and diversity were recorded for the habitats at lower altitude and Shannon-Wiener diversity indices were 1.607 and 1.491 for lower and higher altitude sites, respectively. Joshi *et al.* (2008) studied the assessment of insect diversity along an altitudinal gradient in Pindari forest of Western Himalaya, India and reported that the maximum Shannon-Wiener diversity was 5.420 in the site at lowest elevation (2100m) and the lowest amount of diversity 3.610 was observed from the site at highest elevation (3500m). In a more recent study, Arya *et al.* (2013) reported that the total species diversity of Hymenopterans insect was 3.421 and 3.465 during first year and second year, respectively and during both the years maximum species diversity of Hymenopterans observed during rainy season (3.37 first year and 3.421 and minimum during winter season (1.173 in the first year and 1.073 in the second year) in the Shyampur forest range in the Shivalik foot hills, Hardwar, India.

Presence of a very good number of abundance of species and individuals of Coleopterans insect in the Pindari area of Nanda Devi Biosphere Reserve with a high density of Coleopterans insects than what has been reported by some earlier workers in different ecosystems of the world indicate the availability of sufficient food plants, adaptability of Coleopterans to the ecological factors prevailing in the study area and necessity of a proper management of the natural habitats, as these ecological zones are the main centers of diversity of insects providing them micro habitats with required food material.

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

Study sites	Ecological zone	Altitude	Dominant plant community	Disturbances
Site no. 1 (Khati)	Temperate	2100 m	*Quercus floribunda* Rehder *Junglens regia* L. *Acer villiosum* Wall. *Aeculus indica* (Colebr. ex. Camb) Hk.	Moderate level
Site no. 2 (Dawali)	Sub-alpine	2800 m	*Rhododendron barbatum* Wall. *Acer cappadocium* Gled. *A. caesium* Wall. ex. Brand	Low level
Site no. 3 (Phurkia)	Alpine	3500 m	*Betula utalis* D. Don *Acer accminatum* Wall. *Rhododendron campanulatum* D. Don.	High level

Table 2: Number of individuals of different species of Coleopterans insect collected from different study sites during study period.

Sl. No.	Taxonomic Composition	First year of study				Second year of study			
		Site-1	Site-2	Site-3	Total	Site-1	Site-2	Site-3	Total
	Order: Coleoptera								
	Family: Scarabeidae								
1.	*Anomala dimidiata* Hope	40	27	21	88	57	41	15	113
2.	*Anomala lineatopennis* Bl.	-	-	-	-	-	-	5	5
3.	*Anomala varicolor* (Gyll.)	12	6	7	25	20	15	10	45
4.	*Protaetia neglacta* Hope	28	16	16	60	40	25	19	84
5.	*Popilla pilosa* Arrow	11	-	-	11	-	-	-	-
6.	*Jumnos roylei* Hope	19	11	15	45	15	21	12	48
7.	*Onthophagus* sp.	10	-	-	10	6	-	-	6
8.	*Brahimina* sp.	13	5	-	18	15	12	-	27
	Family: Chrysomelidae								
9.	*Altica himensis* Shukla	35	33	23	91	21	10	16	47
10.	*Cryplocephalus triangularis* Hope	17	-	-	17	-	-	-	-
11.	*Meristata sexmaculatata* Kollar & Redtenbacher	5	22	-	27	10	27	-	37
12.	*Meristata trifasciata* Hope	6	-	-	6	12	-	-	12
13.	*Mimastra* sp.	16	-	-	16	5	-	-	5
14.	*Aulacophora* sp.	5	-	-	05	-	-	-	-
	Family: Coccinelidae								
15.	*Coccinella septumpunchtata* L. var. divaridata	20	10	-	30	26	22	13	61
16.	*Cheilomenes sexmaculata* (Fabr.)	4	6	-	10	4	7	-	11
17.	*Haluzia sanscrieta* Muls.	-	10	6	16	-	-	-	-
18.	*Hippodamia varietata* (Goeze)	2	1	-	3	1	4	-	5
	Family: Meloidae								
19.	*Mylabris cichonni* Linn.	28	15	9	52	24	9	15	48
20.	*Meloe violaceus* Mars.	-	-	-	-	-	-	9	9
	Total	**271**	**162**	**97**	**530**	**256**	**193**	**114**	**563**

Table 3: Percent contribution of relative number of individuals and species of different families of coleopterans recorded from study area during the study period.

S. No.	Family	No. of species	% of species	No. of individuals	% of individuals
1.	Scarabaeidae	08	40	585	53.52
2.	Chrysomelidae	06	30	263	24.06
3.	Coccinelidae	04	20	136	12.45
4.	Meloidae	02	10	109	9.97
	Total	**20**	**100**	**1093**	**100**

Table 4: Variation in density (insects ha^{-1}) of Coleopteran insects in different study sites during study period.

Sl. No.	Months	Site-1 (Khati)		Site - 2 (Dawali)		Site-3 (Phurkia)	
		First year	Second year	First year	Second year	First year	Second year
		Density (ha^{-1})	Density (ha^{-1})	Density (ha^{-1})	Density (ha^{-1})	Density (ha^{-1})	Density (ha^{-1})
1.	October	3.33	4.33	4.67	2.00	1.00	2.67
2.	November	-	-	-	-	-	-
3.	December	-	-	-	-	-	-
4.	January	-	-	-	-	-	-
5.	February	-	-	-	-	-	-
6.	March	-	-	-	-	-	-
7.	April	0.33	2.67	-	1.00	-	-
8.	May	4.33	10.33	4.3	3.33	1.67	2.33
9.	June	24.67	19.33	14.00	7.33	4.00	5.33
10.	July	29.33	22.33	11.00	13.33	9.33	8.00
11.	August	17.00	20.00	21.67	17.00	14.33	8.33
12.	September	6.3	11.33	5.00	10.00	7.67	5.67

Table 5: Species diversity, evenness, richness and abundance of coleopteran insects collected from different study sites.

Years	Study sites	Diversity Index (H')	Evenness	Richness	Abundance
First year	Site -1	2.563	0.904	17	271
	Site-2	2.306	0.928	12	162
	Site-3	1.841	0.946	7	97
	Across the year	**6.710**	**2.778**	**18**	**530**
Second year	Site-1	2.337	0.885	14	256
	Site-2	2.226	0.928	11	193
	Site-3	2.143	0.986	9	114
	Across the year	**6.706**	**2.799**	**16**	**561**

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