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Survey on coleopteran diversity in different areas and seasons of Dharwad District (Karnataka) India

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Abstract
The study was carried out to assess the coleopteran diversity of different areas of the Dharwad district. Survey work was carried out in five different areas (viz., forest, agriculture (maize crop), horticulture (mango plantation), plain/grassland and domestic areas) twice in every month for a period of one year i.e. from May-2018 to April-2019. Beetles were collected from different areas directly by hand picking or through pitfall trap method. The highest numbers of coleopteran species were found in forest area (with 899 individuals and 61 species) followed by mango plantation area (with 205 individuals and 29 species), plain/grassland area (with 162 individuals and 24 species) and domestic area (with 60 individuals and 10 species). Lowest number was found in Agriculture area (with only 33 individuals and 5 species). However, maximum number of species was found during monsoon (798 individuals and 55 species) as compared to winter (332 individuals and 35 species) and summer (229 individuals and 28 species) seasons. Statistical analysis of the surveyed data showed, high diversity value (H′= 3.688) and Low Dominance value (D= 0.032) was recorded in the month of May-2018, whereas Low diversity value (H′= 1.386) and High Dominance value (D= 0.285) was recorded in December-2018. Based on the results, it can be concluded that natural vegetation is the main key factor in abundance of insect diversity and it also indirectly affect due to anthropogenic activities and environmental factors through various ways.

Keywords: survey, coleopterans (beetles), diversity, Dharwad district (Karnataka), India

1. Introduction

Approximately 1.4 million species are described so far out of 30 million species expected to be present on this earth. Of these about 7, 50, 000 species are insects (Cheng, 1976) [8]. Coleopterans are also known as beetles with sheathed wings, constitute about 25% of all known life forms (Hammond, 1992; Rosenzweig, 1995; Hunt *et.al.*, 2007) [19, 52, 25]. Beetles are most diversified group of insects estimated to be between 3, 00, 000 and 4, 50, 000 species (Nielsen and Mound, 1999) [44]. Yeates *et al.* (2003) [58] estimated that about 23,000 species of coleopterans belonging to 121 families from Australia and Marske and Ivie (2003) [38] estimated about 25,160 species under 129 families from North America. Alfred (1998) [1] estimated that out of 8, 00, 000 described insect's species, coleopterans share was about 3, 50, 000 belonging to 177 families under four sub-orders. Choate (2003) [7] estimated about more than 3, 50, 000 coleopteran species and they represents about 30% of all known animals and 40% of insects alone. There are about 15, 088 species of beetles are known in Indian region (Kazmi and Ramamurthy, 2004) [30].

Beetles found in all the habitats such as underground and above the ground including in dead or decaying organic matter, they are important scavengers have been used to asses biodiversity and are useful environmental indicators (Ulyshen and Hanula, 2004; Gullan and Cranston, 2010) [57, 18]. Beetles play a vital role in food chain and energy flow for higher vertebrates (Triplehorn and Johnson, 2005) [56], few of the coleopterans are pests but much are beneficial for controlling pests. Ladybug/ ladybird (Coccinellidae) are well known examples, whereas ground beetles (Carabidae) and dung beetles (Scarabaeidae) are few common predators of some arthropods and parasitic worms (Kromp, 1999; Kakkar and Gupta; 2009) [33, 29]. Scarabaeidae beetles are very important components of terrestrial ecosystem as they are natural enemies in mountains and agricultural environment (Kromp, 1999; Holland, 2002) [33, 23].

In tropical and temperate regions, high plant diversity with more number of species has been related (Novotny *et. al.*, 2006) [45]. In recent past, due to interference of humans (Hanski, 2005) [21] variations in climatic conditions (Escobar *et. al.*, 2005) [16] and habitat loss that affects insect diversity severely. The species abundance and their response to seasonal changes in environmental conditions (Devoto *et. al.*, 2005; Hodkinson, 2005) [14, 22] along with insect-plant interactions (Rico-Gray *et. al.*, 2012) were also witnessed.

Agriculture/farming system is one of the major cause of fragmentation of natural ecosystems by anthropization (Barlow *et. al.*, 2016) [5] resulting into loss of native species (Tabareli *et. al.*, 2010; DeClerck *et. al.*, 2010) [13]. Low disturbances in high diversity do not alter functional structure but affect species composition, whereas high disturbance affects both functional structure and species diversity (Mlambo, 2014; Magnago *et. al.*, 2014) [41, 36]. Species diversity and species richness are directly related to the number of rare species present in the community (Chao and Shen, 2003) [6]. Survey on butterfly diversity in undisturbed semi-natural habitats had high diversity compared to human disturbed area (Kitahara and Sei, 2001) [31]. Many studies have been reported that diversity and abundance of arthropods are influenced by plant cover (Humphrey *et. al.*, 1999) [24], plant diversity (Crutsinger, 2006) [12] and inter and intra dependent of arthropods (Koricheva *et. al.*, 2000; Parker, 2010; Mcart and Thaler,

2013) [32, 47, 40]. Therefore, the present survey work was undertaken to assess the coleopteran diversity during various months and seasons of the year in different areas of Dharwad district of Karnataka state in India.

2. Material and Methods

2.1 Study area

The Dharwad district is located in the foothills of Western Ghats of Karnataka region in India (Figure-1). The entire area falls within an altitudinal range of 738-609m. The whole Dharwad district is endowed with different areas such as forest area, agricultural fields (Maize crop), horticultural field (Mango plantation), plains/grassland area and large domestic area with human occupied places etc.

2.2 Survey areas

Five different areas were chosen for coleopteran diversity studies in whole Dharwad district, they are

Area No. 1: Agricultural area (Maize crop): This area is located between 15°15′ 85″.2N & 74°98′81″.3E. Here, maize crop fields were randomly selected from Kalghatgi and Dharwad talukas, it is a seasonal crop commonly grown as pre monsoon and post monsoon cash crop in Dharwad district for the purpose of food and cattle fodder.

Area No. 2: Forest area: This area is located between 15°12′75″.4N & 74°92′73″.2E. Here, the edge areas or boundaries of Western Ghats in Kalaghatgi takula of Dharwad district was chosen for survey work, where human interference and common grazing was done regularly.

Area No. 3: Horticultural area (Mango plantation): It is located between 15°45′41″.8N & 74°96′25″.4E. Here, mango trees, common horticultural plants cultivated in Dharwad and surrounding districts, so it was chosen for our coleopteran survey work.

Area No. 4: Plain/Grassland area: This area is located between 15°19′33″.2N & 74°94′28″.1E. Much area in Dharwad district is of open arid land or grassland; hence it was selected from different parts of Dharwad and Alnavar Talukas. These areas are unused land mass with lack of trees and grazing was common in rainy and winter season whereas in summer season grass was totally dried up.

Area No. 5: Domestic area: It is the area near Karnatak University campus, Dharwad and in Kalaghatagi urban areas were randomly chosen for the survey work, where artificial gardening in and around human inhabitant areas were covered.

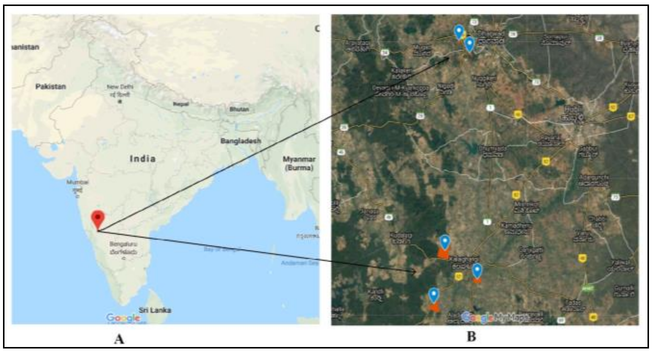


Fig 1: Map showing location of Dharwad (A) and study areas in different parts of Dharwad district (B).

2.3 Sampling

Beetles were collected from five different areas to study and analyze the coleopteran diversity. Sampling was conducted in the morning hours between 07.00AM to 11.00AM for every 15 days interval periods regularly from May-2018 to April-2019. Beetles were collected by hand picking and pitfall traps methods and were photographed in different angles for easy identification and left in the field itself. Further, unidentified samples were taken to laboratory for detail study by using standard identification keys.

2.4 Data analysis

The data of the collected beetles from five different areas during different months and seasons were analyzed through following diversity indices.

- Shannon-Wiener Index:

Species Diversity $H' = -1\times \Sigma\, p_i \ln p_i$

- Simpson's Dominance Index:

$D = \Sigma n\,(n-1)/ N\,(N-1)$

- Simpson's Index of Diversity:

Diversity $D = 1- \Sigma n\,(n-1)/ N\,(N-1)$

- Pielou's Species Evenness Index:

Evenness $E = H'/\ln(S)$

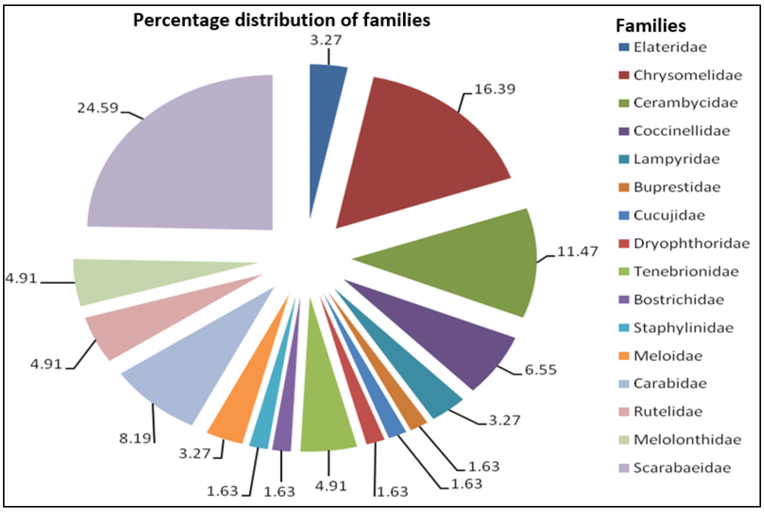
3. Results and Discussion

During one year survey, there are totally 61 species of coleopterans were found belonging to 16 different families from all five study areas. Scarabaeidae family was found to be the dominant family with 15 species comprising of 24.59% followed by Chrysomelidae (16.39%) and Cerambycidae (11.47%) where as individual species was noticed in Buprestidae, Cucujidae, Dryophthoridae, Bostrichidae and Staphylinidae families comprises of about 1.63% each (Graph-1). The more vegetation and much cattle rearing practice might have favored Scarabaeidae family among all other coleopterans. Maximum number of species was recorded from forest area, whereas minimum number was found in domestic areas. More number of species and high species abundance was observed in the month of May-2018 and least number of species and low abundance was noticed in December-2018 and January-2019(Table-1and Table-2).

Again with respect to seasons, maximum number of species (55) was recorded in monsoon season followed by winter (35 species) and summer (28 species) seasons with 798, 332 and 229 individuals respectively observed in all five different areas (Table-1).

Highest number of species (40) and individuals were recorded in May month soon after receiving rain fall of about 133-160mm with an average temperature of about 25.4°C (Table-1). December was the month with lowest diversity value of (H′ 1.386) and highest dominance value (0.285) during our survey (Table-2 and Graph-2). The diversity value of coleopterans slightly decreased from May (H′ 3.688; 1-D 0.967) to August (H′ 2.981; 1-D 0.959) months and it increased in the month of September (H′ 3.219; 1-D 0.962), then again it decreased from September (H′ 3.219) to December (H′ 1.386) months (Table-2 and Graph-2). We witnessed about 235, 197, 214 and 152 beetle individuals during May, June, July and August months respectively (Table -1).

Moitreyee (2014) [42] have reported nine different coleopteran families from three different study sites and recorded highest Shannon diversity index with 1.35 in June and July months. He also recorded high beetle diversity in the months from May to August. Cheo *et al.* (2014) [9] have reported highest abundance and species richness of beetles in June month, thereafter it decreased steadily and re-increased in September month. Errouissi *et. al.* (2009) [15] recorded dung beetle assemblages for a period of one year in Northern Tunisia finding a significant variation in beetle diversity and recorded highest β diversity in October and February months.



Graph 1: Percentage wise distribution of coleopteran species observed under different families.

Table 1: Checklist of coleopteran species recorded in during various months and seasons in different areas of Dharwad district.

Sl. No.	Name of the species	Summer				Monsoon				Winter				Areas/Sites				
		Ja	Fb	Mr	Ap	My	Ju	Jl	Au	Se	Ot	No	De	Ag	F	Ho	P/G	D
1	*Agrypnus fuscipes*			*	*	*		*		*					*	*	*	
2	*Lanelater cf. fuscipes*	*	*	*		*	*								*	*	*	
3	*Altica sp.*				*	*	*	*		*					*	*		
4	*Aspidimorpha miliaris*	*			*	*	*	*							*	*	*	
5	*Aulocophora indica*								*	*	*	*			*	*		
6	*Aulocophora cf. foveicollis*					*	*	*		*					*		*	
7	*Chrysochus sp.*						*	*	*	*	*				*	*		
8	*Clytra succincta*							*	*	*					*		*	
9	*Clytra sp.*							*	*	*	*				*	*		
10	*Neocrepidodera sp.*											*			*			
11	*Sagra cf. femorata*					*									*			
12	*Zygogramma bicolorata*					*	*	*	*	*					*	*		
13	*Apriona sp.*			*		*	*								*		*	
14	*Bactocera rufomaculata*									*	*		*		*		*	
15	*Xystrocera globosa*							*	*	*	*	*			*	*	*	
16	*Coptops aedificator*				*	*	*	*	*						*	*	*	*
17	*Coptops annulipes*		*	*	*	*									*	*	*	
18	*Coptops sp.*								*	*					*			
19	*Stenochorus meridianus*					*	*	*	*	*		*			*	*		
20	*Cheilomenes sexmaculata*					*	*	*	*	*	*			*	*	*	*	
21	*Coccinella transversalis*					*	*	*	*	*	*			*	*	*		*
22	*Paranaemia vittigera*			*	*		*					*	*		*			
23	*Brumoides suturalis*					*	*	*	*	*				*	*	*		
24	*Lamprigera cf. tenebrosa*					*	*	*	*						*	*	*	
25	*Oculogryphus sp.*						*	*							*			
26	*Sternocera chrysis*				*	*	*	*	*	*					*	*	*	*
27	*Cucujus clavipes*							*	*	*	*				*	*	*	
28	*Cyrtotrachelus cf. longimanus*					*									*			
29	*Gonocephalum bilineatum*				*	*									*			
30	*Gonocephalum tuberculatum*				*	*									*			
31	*Penthicoides seriatoporus*					*	*								*			
32	*Sinoxylon sp*			*											*			
33	*Paederus cf. dermatitis*						*	*		*	*				*	*	*	*
34	*Mylabris cf. pustulata*					*									*			
35	*Mylabris phalerata*					*									*			
36	*Pheropsophus sp.*			*	*										*			
37	*Chlaenius sp.*	*	*							*	*	*	*		*		*	
38	*Colliuris sp.*				*	*									*			
39	*Calosoma inquisitor*						*	*	*	*	*	*			*		*	*

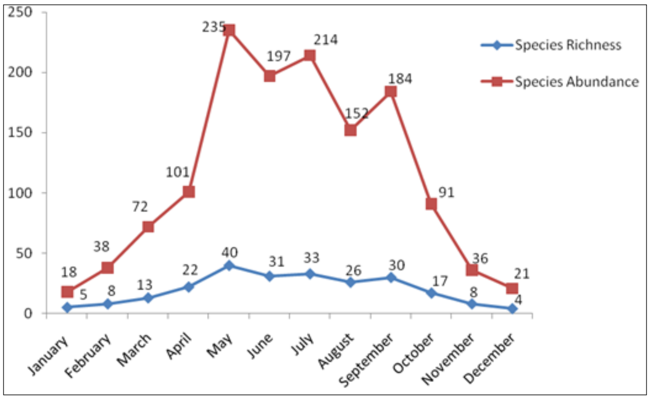
40	*Craspedophorus angulatus*	*	*								*	*	*		*	*		
41	*Anomala dimidiata*					*	*	*	*	*	*				*	*	*	
42	*Anomala sp.*					*		*							*		*	
43	*Popillia sp.*					*									*			
44	*Holotrichia serrata*			*	*	*	*	*	*	*	*				*		*	
45	*Holotrichia sp.*			*	*	*									*			
46	*Phyllophaga sp.*				*	*									*			
47	*Catharsius pithecius*		*	*	*	*									*			*
48	*Catharsius sagax*		*	*	*	*	*	*	*	*				*	*	*	*	
49	*Catharsius molossus*		*		*	*	*	*	*	*	*			*	*	*	*	
50	*Holiocopris bucephalus*				*	*	*	*	*	*					*	*	*	
51	*Onthophagus gazella*					*	*	*		*					*	*		*
52	*Onthophagus spinifex*				*		*		*	*					*	*		*
53	*Onthophagus dama*					*		*			*				*			
54	*Tiniocellus spinipes*					*				*					*			
55	*Scarabaeus sanctus*			*	*		*	*	*	*					*		*	*
56	*Caccobius rufipennis*				*		*	*		*					*	*		
57	*Gymnopleurus miliaris*					*		*	*						*	*		
58	*Cetonia aurata*		*		*	*									*			
59	*Heterorrhina elegans*					*	*		*						*			
60	*Protaetia alboguttata*						*	*			*				*			*
61	*Anatona stillata*	*		*		*	*	*	*						*	*		
	Total	05	08	13	22	40	31	33	26	30	17	08	04	05	61	29	24	10

*- Presence Ja- January; Fb- February; Mr- March; Ap- April; My- May; Ju- June; Jl- July; Au- August; Se- September; Ot- October; No- November; De- December; Ag- Agriculture area; F- Forest area; H- Horticulture area; P/G- Plain/Grassland area; D-Domestic area.

Table 2: Statistical analysis (H′, 1-D, D and E) of the data of coleopterans found during different months of the survey period.

Sl. No.	Months	Statistical analysis			
		H′	1-D	D	E
1	January	1.598	0.843	0.156	0.993
2	February	2.011	0.884	0.116	0.967
3	March	2.280	0.887	0.113	0.889
4	April	2.948	0.955	0.045	0.953
5	May	3.688	0.967	0.032	0.926
6	June	3.241	0.963	0.037	0.944
7	July	3.230	0.958	0.042	0.923
8	August	2.981	0.959	0.041	0.914
9	September	3.219	0.962	0.037	0.946
10	October	2.657	0.935	0.065	0.937
11	November	2.005	0.885	0.115	0.964
12	December	1.386	0.715	0.285	0.890

H′= Shannon-Wiener Index; 1-D= Simpson's Index of Diversity; D=Simpson's Dominance Index; E= Pielou's Species Evenness Index

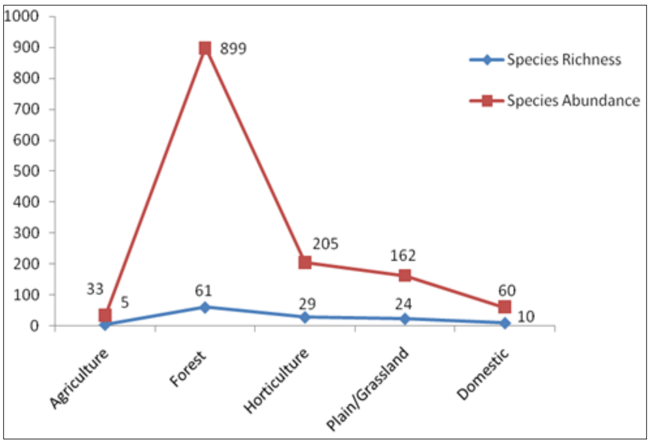


Graph 2: Species richness and abundance of coleopterans in different months during the survey period.

Table 3: Statistical analysis (H′, 1-D, D and E) of the data of coleopterans found in different areas of Dharwad district.

Sl. No.	Areas/ Sites	Statistical analysis			
		H′	1-D	D	E
1	Agriculture area	1.593	0.821	0.179	0.990
2	Forest area	3.789	0.978	0.021	0.921
3	Horticulture area	3.233	0.965	0.035	0.960
4	Plain/Grassland area	3.018	0.954	0.046	0.949
5	Domestic area	2.196	0.896	0.103	0.953

H′= Shannon-Wiener Index; 1-D= Simpson's Index of Diversity; D=Simpson's Dominance Index; E= Pielou's Species Evenness Index



Graph 3: Species richness and abundance of coleopterans in different areas of Dharwad district.

During our one year study, we also noticed highest coleopteran diversity (798 individuals and 55 species) in monsoon season as compared to winter season with 332 individuals with 35 species and summer season with 229 individuals belonging to 28 species (Table -1).

Similar observation was also noticed by Cuartas and Gomez (2015) [10] that higher number of beetles was found during rainy months as compared to drier months in Tropical Mountain Forests.

Lee *et al.* (2005) [35] studied on variation of coleopteran species in different ecosystems and seasons finding that *Nicrophorus quadripunctatus* to be the dominant species. Balakrishnan *et al.* (2014) [4] have also reported high dominance of coleopterans and lepidopteran species in different coastal habitats of Tamil Nadu. Larsen (2012) [34] mentioned that factors such as humidity and temperature are sensitive for the maintenance of dung beetles in a particular habitat. The variations in species composition can be associated with microclimatic changes like both biotic and abiotic factors (Hanski and Cambefort, 1991) [20]. Effect of climate change on biodiversity of insects can be monitored through variations in the species composition during summer and winter seasons, climate changes like severe drought and heavy rainfall like floods can cause reduction or de-homogenization of beetle community and diversity (Rossana *et al*., 2012) [53].

Only 33 individuals belonging to five different species were collected from agricultural fields (Maize crop) or areas (Table-1and Graph-1). Agricultural area was less diversified area with H′= 1.593 (1-D=821) compared to other four areas (Table-3 and Graph-3). This area seems to be high dominant with dominance value (0.179) than that of other four areas. This may be due to human interference in agricultural fields because of crop rotation, tilting along with use of pesticides regularly would have caused the low diversity in agricultural areas. *Cheilomenes sexmaculata* species was found commonly in agriculture area which is a natural predator in maize crops (Tank *et al.,* 2008). Ground beetles are found to be an important enemy group in mountainous areas and agriculture environment (Holland, 2002) [23]. Agricultural area was less diversified area with H′= 1.593 (1-D=821) compared to other four areas (Table-3 and Graph-3). This area seems to be high dominant with dominance value (0.179) than that of other four areas.

Totally 61 species of coleopterans were recorded in forest area with the abundance of 899 individuals (Table-1and Graph-1). Forest area was found to be the highly diversified area with diversity value of H′=3.789 and 1-D=0.9783 as compared to other four sites. Forest area was resulted in lowest dominance value of 0.021(Table-3 and Graph-3) having more number of species. Joshi *et al.* (1999) [28] reported low diversity of insects in moist deciduous forest of India where grazing was highest compared to the forest remaining from deforestation. Joshi *et. al.* (2008) [27] recorded only 18 species of coleopterans from Pinderi forest, Western Himalaya, India. Insect diversity variation is more both quantitative and qualitative in cattle pastures than that of forest fragments (Navarrete and Halffter 2008) [16]. Fragmentation or clearing of forest area leads to loss of forest dwelling insect species and would be replaced by other dominant species, which can tolerate changing environmental conditions (Navarrete and Halffter 2008) [16]. Mathew *et al.* (2003) [39] reported the impact of forest fire on insect species diversity and found that it was higher in undisturbed area than that of disturbed area. Similar observations such as deforestation, land use, forest fire anthropogenic activity and modification in the natural habitat are going to impact on biodiversity of insects have been witnessed (Almedia *et al.*, 2011; Queiroz *et al.*, 2017) [2, 49].

Navarrete and Halffter (2008) [16] were reported that there is an increase in *necrophagous* species diversity in anthropogenic modified areas of forest. The structure and function of forest ecosystem can be analyzed by Carabidae family of coleopterans as bio-indicators for sustainable forest management (Pearce and Venier, 2006) [48]. Himalayan forests are more productive with respect to insects compared to temperate region forests receiving same amount of rainfall, it may be due to constant favorable temperatures with long season (Mani, 1974) [37].

During our survey, we recorded around 29 species out of 205 individuals belonging to 11 different families from mango plantation fields of Dharwad and surrounding area as high mango plantation found, where famers use very less amount of pesticides for insect control (Table-1 and Graph-1). The diversity value of mango plantation area is of H′=3.233 and 1-D=0.965 and with Dominance value (D= 0.035) and Evenness value with 0.960 (Table-3 and Graph-3). Reddy *et al*. (2014) [50] have monitored and collected fresh emerging beetles of tree borers and recorded four varieties of beetles. Paiboon *et al.* (2018) [46] studied on dung beetle assemblage in three human modified landscapes and reported 10 genera and all of them found in agricultural land (Mango and Rubber). Out of 29 species, we too witnessed about eight dung beetle species in mango plantation.

Totally 24 species out of 162 individuals were found in plain/grass land area (Table-1). Maximum number of coleopteran species was found during just before monsoon and during monsoon season. Diversity value of this area was lower than that of Horticulture area with Simpson Index of Diversity value of 0.954 and Evenness of 0.949. Dominance value (0.046) of plain/grassland area was more than that of forest and horticulture areas and less than that of agriculture and domestic areas (Table-3 and Graph-3). Crist and Peters (2014) worked on landscape and control of insect biodiversity in conservation grassland area by surveying bees and beetles and they reported total of 3276 individuals belonging to 143 species. They witnessed 115 species and 85 species in June and August 2009 months only. Fay (2003) [17] also surveyed in two burned and grazed grasslands and reported 7,785 individuals of beetles belonging to 206 species.

Domestic area was also selected along with private and public gardens in human settlement area for survey of coleopterans. A total of about 10 species belonging to six different families were recorded. Shannon-Wiener Diversity value (H′=2.196; 1-D=896) was found to be the second lowest diversified area in this study. During our survey, most of the individuals were found in public gardens compared to private gardens and houses with compounds, the compounds may restricted the easy migration of beetles. Out of ten beetle species observed, five beetles were found to be dung beetles. Jaganmohan *et. al.* (2013) [26] reported 152 individuals of beetles collected by pitfall trap in urban domestic gardens of Bangalore (India).

Natural and anthropized areas occupied by anthropogenic activity are being exploited. Even pesticides and chemicals sprayed in the form of liquids or powders for the control of blood sucking insects may also affect the beetle diversity (Audino *et al*., 2014) [3].

4. Summary and Conclusion

The study on survey of coleopterans shows the dominance of Scarabaeidae family followed by Chrysomelidae, Cerambycidae, Carabidae, Coccinellidae, Tenebrionidae, Melolonthidae, Rutelidae, Elateridae, Lampyridae and Meloidae in different areas of Dharwad district. Species belonging to family Buprestidae, Cucujidae, Dryophthoridae, Bostrichidae and Staphylinidae were less diversified. High diversification of species was noticed near the forest area as compared to other habitats and less in the agriculture area. Highest number of individuals and species abundance was found in the month of May, 2018. However, the number of species might vary in the present survey work, further studies on particular family or order wise survey of coleopterans throughout the year at different habitats would be necessary to get comprehensive information on these insects.

Several studies including the present one demonstrates that the type of natural vegetation is one of the key factors for insect diversity and anthropogenic interference has been affecting the insect diversity. Along with species diversity, species abundance and species evenness are also important to maintain high diversity levels. However, the present study forms a good basis to take up necessary precautions and measures to conserve the insect diversity in different areas/localities to conserve them properly. Conservation policy must include not only the forest areas and grasslands but it should extend to unprotected area and local forest lands so that we can protect and conserve insect diversity in the entire ecosystem.

5. Acknowledgments

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