RESEARCH ARTICLE Agricultural Science Digest, Volume 43 Issue 1: 68-74 (February 2023)

Diversity, Abundance and Composition of Ground Beetles (Coleoptera: Carabidae) in Jhunjhunu District of Rajasthan, India

Rajmohan Meena[1], Vinod Kumari[2]

10.18805/ag.D-5603

ABSTRACT

Background: Jhunjhunu district has semi-arid climatic condition which is favorable to flourish ground beetles. Diversity of ground beetles are beneficial to agricultural ecosystem as carabid beetles are prominent decomposers and reduce population of insect pest specially, caterpillars. The present study aimed to document diversity of ground beetles which will provide first even preliminary information needed for their conservation and use in integrated pest management program.

Methods: Sampling was carried out in Jhunjhunu district from January 2021 to December 2021. Four sampling sites *viz*., Site-A (agriculture land), Site-B (Plains are relatively flat land which is dominated by grasses, herbs and shrubs), Site-C (rocky area) and Site-D (blanks of water bodies) were selected based on different habitats situation. Carabid beetles were collected using pitfall trap, hand picking and light trap and identified by valid taxonomic keys.

Result: Diversity indices authenticated a good diversity and abundance of ground beetles in the district. A total of 956 individuals of carabid beetles, representing 28 species and 19 genera belonging to 11 subfamilies *viz*. Harpalinae (7 species), Trechinae (7 species), Brachininae (3 species), Scaritinae (3 species), Lebiinae (2 species), Paussinae (1 species), Anthiinae (1 species), Carabinae (1 species), Pterostichinae (1 species), Platyninae (1 species), Cicindelinae (1 species) under Carabidae family were collected and identified from various habitats of study area. On the basis of total number of individuals *Dromius quadrimaculatus* is the most dominant species and constituted 18.62% of total beetles followed by *Chlaenius bimaculatus* (8.05%), *Tetragonoderus intermedius* (7.64%) *Lophyra differens* (6.80%) and *Bembidion ambiguum* (5.02%). The highest diversity was observed at Site-B (H=2.72, J=0.83, M=4.43) followed by Site-A (H=2.72, J=0.83, M=4.08), Site-C (H=2.52, J=0.90, M=3.48) and Site-D (H=2.25, J=0.87, M=2.25).

Key words: Abundance, Carabidae, Coleoptera, Diversity, Ground beetles.

INTRODUCTION

Coleopteran playing a fundamental ecological role in all type of ecosystems, accounts for 38% of entire insects and about 387,100 species of the Coleopteran are known to exist in the world (Zhang, 2013). Carabidae family of predaceous beetles is one of the biggest among the Coleopteran families with 40,449 described species, 2142 genera and 92 tribes spread out worldwide, of which 1900 species are reported from India (www.carabidae.org). Both larvae and adult of Carabid beetles prefer common habitats like sandy beaches with scattered vegetation, sandy trails and moisty banks of stream, pond and rivers, under the bark of trees, along forest edges, in rotten stumps and on clay soils (Pearson and Cassola, 2005). In field banks and vegetated lands, ground beetles are predominant. Carabid beetles are considered as biological indicators of environmental changes in agroecosystem and climatic zones (Kromp, 1999) owing to some ground beetles are good indicators of biotic and abiotic disturbances, degradation or purity of their habitat because they live in specific habitats and ecological demands (Felix, 2009; Choi *et al*., 2021). Most ground beetles are nocturnal and flightless, but some are diurnal and poor flyer (Larochelle and Lariviere, 2007). Carabids (both larvae and adults) can be used to manage crop pests that causes economic damage, because they are predators and prey on small insects including caterpillars, aphids, mites, snails and slugs (Rodriquez *et al*., 1998). Cicindelidae family (Tiger beetles) was placed as a distinct family on the basis of major morphological and molecular study (Lopez-Lopez and Vogler, 2017; Duran *et al*., 2018), but now it has been classified as the subfamily Cicindelinae under the family Carabidae (Gough *et al*., 2018). Carabid beetles are important model organisms as environmental indicators because of their extensive diversity. However, Jhunjhunu district of Rajasthan, India is relatively undiscovered area, therefore the present study was conducted to document diversity of carabid beetles which will provide preliminary information to future researchers.

[1]Department of Zoology, Shri Radheshyam R.Morarka Govt. College, Jhunjhunu-333 001, Rajasthan, India.
[2]Department of Zoology, University of Rajasthan, Jaipur-302 004, Rajasthan, India.

Corresponding Author: Rajmohan Meena, Department of Zoology, Shri Radheshyam R.Morarka Govt. College, Jhunjhunu-333 001, Rajasthan, India. Email: rajmohanmeena27@gmail.com

How to cite this article: Meena, R. and Kumari, V. (2023). Diversity, Abundance and Composition of Ground Beetles (Coleoptera: Carabidae) in Jhunjhunu District of Rajasthan, India. Agricultural Science Digest. 43(1): 68-74. doi: 10.18805/ag.D-5603.

Submitted: 04-05-2022 **Accepted:** 20-08-2022 **Online:** 30-08-2022

MATERIALS AND METHODS

Jhunjhunu district (Fig 1) which extends from 27°38′- 28°31′ North latitudes and 75°02′- 76°06′ East longitudes, is geographical area of 5,926 sq. km and very high temperature up to 48°C in summer and low temperature (below 0°C) in winter. Altitude of the district varies between 312 to 368 m above sea level. Rainfall varies from 350-500 mm which is received during monsoon season (July to September). For present study, four sampling sites were chosen *viz*. agriculture lands (Site-A), Plains are relatively flat land which is dominated by grasses and herbs (Site-B), Rocky areas (Site-C) and bank of water bodies (Site-D). Site-A is located at geographical coordinates 28°19′N- 75°31′E, Site-B is situated at coordinates 27°89′N- 75°01′E, Site-C is located at geographical coordinates 28°02′N- 75°63′E and Site-D is situated at coordinates 27°65′N- 75°41′E. The field survey was conducted from January 2021 to December 2021 at selected sampling sites. The sampling was accomplished once in a month at selected sites in morning and evening time throughout the study period.

Carabid beetles were collected using pitfall trap, hand picking and light trap. Pitfall trap (with 12 cm diameter and 15 cm depth) were placed in ground up to the rim, which is the most suitable method for capturing ground beetles. After sampling, beetles were brought to laboratory, Department of Zoology, SRRM Govt. College, Jhunjhunu. After pinning, stretching and drying, beetles were preserved in insect boxes with Paradichlorobenzene. Collected carabid beetles were identified to the species level with the help of Stereo Zoom Binocular Microscope (Magnus MSZ-Bi) according to taxonomic keys by Andrew (1929, 1935); Habu (1967,1973,1978); Kwon and Lee (1984) and photographed for future study.

Statistical analysis

Relative species abundance of Carabidae family was computed by following formula-

$$\text{Relative species abundance (\%)} = \frac{L \times 100}{M}$$

Diversity of carabid beetles were analysed using different diversity indices: Shannon- Weiner diversity index, Margalef's index for species richness and Pielou's index for species evenness.

Shannon-Weiner diversity index

Beetle diversity was computed by the Shannon- Wiener Diversity Index.

$$H^x = - \Sigma Si \ln Si$$

Where,

Si = L/M

L= Individual number of one species.

M= Total number of individuals observed.

In= Log to base n.

Margalef's index for richness

Margalef's index was used for calculating species richness (Margalef, 1958).

$$M^x = \frac{(L-1)}{\ln M}$$

Where,

L= Total number of observed species.

M= Total number of individuals observed.

In= Natural log.

Pielou's index for evenness

Pielou's Index was used for computing species evenness (Pielou, 1975).

$$J^x = \frac{H^x}{\ln L}$$

Where,

H^x= Shannon-Wiener diversity index.

L= Total number of species observed.

RESULTS AND DISCUSSION

A total of 956 individuals of ground beetles belonging to 28 species, 19 genera under of 11 subfamilies of Carabidae family were observed during the study period. On the basis of total number of species, Harpalinae and Trechinae were the most dominant subfamily with 7 species each followed by Brachininae (3 species), Scaritinae (3 species), Lebiinae (2 species), Paussinae (1 species), Anthiinae (1 species), Carabinae (1 species), Pterostichinae (1 species), Platyninae (1 species), Cicindelinae (1 species), respectively (Table 1 and Fig 3). Similar results were also reported by Kumar and Rajagopal (1997) who documented a total of 74 species of carabid beetles belonging to 37 genera of subfamily Harpalinae from Karnataka; Mili *et al*. (2018) reported a total of 8 species of carabid beetles belonging to 4 genera *viz*. *Clivina*, *Harpalus*, *Scarites* and *Sparostes* in *Gerbera* and *Gladiolus* crops of Jorhat, Assam; Ali *et al*. (2015) collected a total of 281 carabid beetles and the species were noted as *Carabus hemprichi*, *Harpalus* sp. 1, *Harplaus* sp. 2, *Calathus* sp. and *Pseudoophonus rufipes* which of them dominant species was *C. hemprichi* in loquat orchard, while *Harpalus* sp. 1 was the predominat species in guava orchard in the agro-ecosystem of the Syrian coast. The observations made in the present study are in favour of Kazmi and Ramamurthy (2004) who reported three species of Carabidae family *viz*. *Carabus orientalis*, *Anthia sexmaculata* and *Calosoma maderae* from the Indian Thar Desert, Rajasthan. Trigunayat and Sharma (2020) reported three species of carabid beetles *viz*. *Carabus orientalis*, *Scarites terricola* and *Anthia sexmaculata* and two species of Cicindellidae family from Keoladeo National Park, Bharatpur, Rajasthan. Thakare and Zade (2012) recorded three species of Carabid beetles *viz*. *Calosoma orientale*, *Chaenius* sp. and *Scarites* sp. from the vicinity of Samadohmakhala road, Melghat Tiger Reserve,

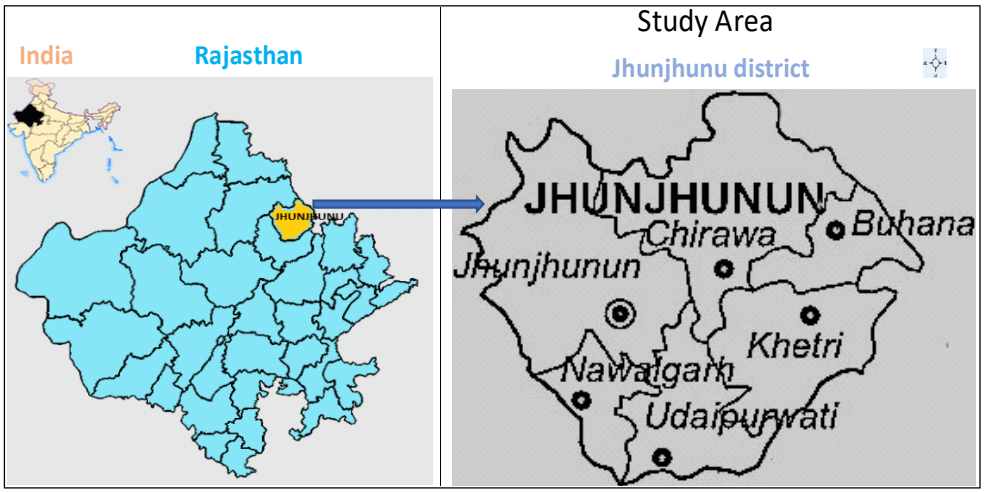


Fig 1: Map of Jhunjhunu district (study area) selected for sampling of Carabid beetles.

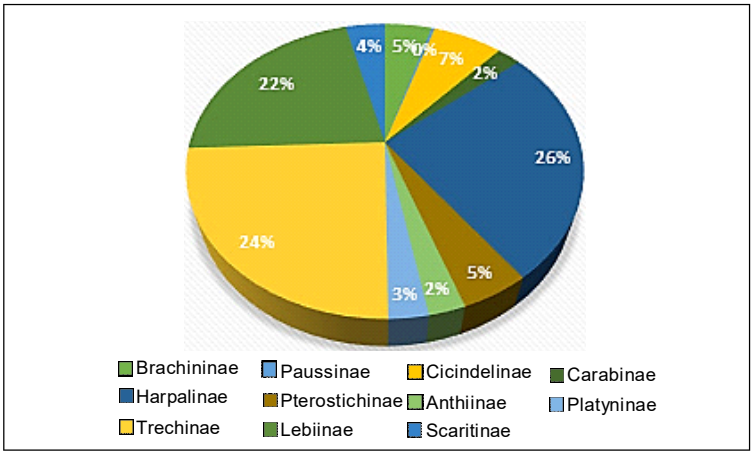


Fig 2: Per cent (%) contribution of individuals of subfamilies observed in Carabidae family of Coleoptera at Jhunjhunu district of Rajasthan, India from January 2021 to December 2021.

Maharashtra. Similiarly, Thakare *et al*. (2013) collected and examined 10 species of carabid beetles belonging to six subfamilies *viz*. Harpalinae, Anthiinae, Paussinae, Scaritinae, Carabinae and Siagoninae from Melghat Tiger Reserve, Maharashtra, India. Kushwaha *et al*. (2015) collected 21 species under 18 genera of ground beetles from five districts of Chhattisgarh, India. Thakkar and Parikh (2016) studied on diversity and abundance of coleopterans and reported 24 species of ground beetles from Gujarat, India. Deshmukh and Gajbhiye (2017) recorded 12 species of carabid beetles belonging to 7 subfamilies *viz*. Paussinae, Licininae, Harpalinae, Scaritinae, Siagoninae, Anthiinae and Panagaeinae from Pench Tiger Reserve (East) Maharashtra, India. Shirbhate and Shirbhate (2020) documented 34 species of ground beetles from forest areas and agricultural areas of Akola district, Maharashtra, India.

In terms of total number of individuals Harpalinae was the most dominant subfamily with 25.83% of the total collected beetles. Trechinae was the second most dominant subfamily which constituted 24.58% of the total recorded beetles. Lebiinae, Cicindelinae, Pterostichinae, Brachininae, Scaritinae, Platinae, Anthiinae, Carabinae and Paussinae subfamilies were subsequently constituted 21.75%, 6.80%, 4.71%, 4.60%, 3.87%, 2.71%, 2.51%, 2.30%, 0.31% of the total collected beetles (Fig 2). These results were similar of findings of Kustasi and Marko, 2007; Igondova and Majzlan, 2015; Nagahata *et al*., 2002, Kadar and Lovei, 1992. About 4.05% abundance of Carabidae family was reported from agri-biodiversity park of Agricultural University, Hyderabad, Telangana (Sahoo *et al*., 2020). Kutasi *et al*., (2004) reported the species richness and composition of carabids in Hungary.

Diversity indices of carabid beetles in all four sites are shown in Table 2. The Shannon-Wiener index of carabidae family is same in both Site-A (agriculture land) and Site-B (Plains) recorded highest diversity value as 2.72 followed by Site-C (Rocky area) as 2.52 and Site-D (banks of water bodies) as 2.25. Species Richness Index is recorded high in Site-B as 4.43 followed by Site-A as 4.08, Site-C as 3.48 and low in Site-D as 2.25. However, the evenness index (J^x)

was greatest in Site-C as 0.90, moderate in Site-D as 0.87 and least in both Site-A and Site-B as 0.83 (Table 2). The lowest evenness index at both the Site A and B were probably due to greatest abundance of the major species (125 individuals of *Dromius quadrimaculatus*, 49 individuals of *Chaenius bimaculatus* and 47 individuals of *Lophyra differens*). Altogether, when the diversity indices were compared for selected four sites (Table 2), it was found that both Sites A (agriculture land) and Site B (Plains are dominated by grasses, herbs and shrubs) have the highest and similar species diversity and species richness. This implies that the availability of different herbs, shrubs, plants and crop cultivars were providing suitable microhabitats for flourished to the diversity and abundance of carabid species. In the previous studies by Gaston, 1991 and Cheng *et al.*, 2007 revealed that plants and insects interrelate by way of mutualism and phytophagy and the structural intricacy of habitat and diversity of vegetation forms showed correlation with insect species diversity (Alarape *et al.*, 2015). Beetles are found where there is a favourable environment for their



Fig 3: Collected species of Carabidae family of Coleoptera in Jhunjhunu district (four selected sites) of Rajasthan, India from January 2021 to December 2021.

Table 1: Diversity and Distribution, Abundance, Relative Abundance, Richness of family Carabidae of Coleoptera observed in Site-A (agriculture land), Site-B (plans), Site-C (rocky areas) and Site-D (banks of water bodies) at Jhunjhunu district of Rajasthan, India from January 2021 to December 2021.

Subfamily	Genus and species	Site-A	Site-B	Site-C	Site-D	Abundance	Relative abundance (%)
Brachininae	*Pheropsophus verticalis* dejean	3	2	2	0	7	0.73
	Pheropsophus sp.	23	5	8	0	36	3.77
	Pheropsophus sp.	0	1	0	0	1	0.10
Scaritinae	*Scarites buparius* forster, 1771	8	3	2	0	13	1.36
	Scarites subterraneus fabricius	13	7	3	0	23	2.41
	Forcipator sp. fabricius, 1775	1	0	0	0	1	0.10
Trechinae	*Bembidion tetracolum* say, 1825	5	9	0	24	38	3.97
	Bembidion ambiguum dejean	17	11	2	18	48	5.02
	Bembidion biguttatum fabricius	17	1	0	28	46	4.81
	Bembidion deletum audinet-Serv	8	3	0	14	25	2.62
	Bembidion petrosum gebler, 1833	13	2	0	24	39	4.08
	Bembidion obtusum audinet-Serv	15	10	5	4	34	3.56
	Bembidion sp.	4	0	0	1	5	0.52
Harpalinae	*Harpalus caliginosus* fabricius	6	4	2	0	12	1.26
	Chlaenius bimaculatus boheman	49	16	12	0	77	8.05
	Acupalpus dubius schilsky, 1888	5	3	0	24	32	3.35
	Microlestes plagiatus duftschmid	9	5	1	0	15	1.57
	Pterostichus singularis tschits	10	6	2	0	18	1.88
	Tetragonoderus intermedius solsk	41	15	12	5	73	7.64
	Stenolophus sp. dejean, 1821	11	3	2	4	20	2.09
Lebiinae	*Dromius quadrimaculatus* linn	125	45	8	0	178	18.62
	Apristus latens LeConte, 1846	15	5	3	7	30	3.14
Paussinae	*Paussus favieri* fairmaire, 1851	2	1	0	0	3	0.31
Anthiinae	*Anthia sexguttata* fabricius, 1775	11	7	6	0	24	2.51
Carabinae	*Calosoma sayi* dejean, 1826	15	7	0	0	22	2.30
Pterostichinae	*Amara fulva* muller, 1776	0	0	0	45	45	4.71
Platyninae	*Platynus assimilis* paykull, 1790	15	7	4	0	26	2.72
Cicindelinae	*Lophyra differens* horn, 1892	12	47	0	6	65	6.80
	Total	453	225	74	204	956	100

Table 2: Diversity indices of Carabidae family of Coleoptera in Jhunjhunu district (four selected sites) of Rajasthan, India from January 2021 to December 2021.

Diversity indices	Site-A	Site-B	Site-C	Site-D
Shannon-Wiener diversity index (H^x)	2.72	2.72	2.52	2.25
Pielou evenness index (J^x)	0.83	0.83	0.90	0.87
Margalef index of species richness (M^x)	4.08	4.43	3.48	2.25

survival (Samways, 2007; Adeduntan and Olusola, 2013). Site-C (rocky areas) has moderate species diversity and species richness which is due to low availability of vegetation forms, increased soil erosion, sedimentation, water run-off and low moisture content in rocky area (Lacey *et al*., 1989). Site-D (banks of water bodies) also has low species diversity and species richness because of low forging sites and little availability of microhabitats for carabid beetles. The pattern of species diversity and composition indicated habitats related with assemblage structure of vicinity area of water bodies (Kubo *et al*., 2013).

CONCLUSION

Preliminary study authenticates good diversity and distribution of carabid beetles in the Jhunjhunu district and concludes that agriculture fields are dominated by carabids beetles. Predator species of carabid beetles are seen predating on small crop pests including aphids, mites, moth larvae, grubs, snails and slugs and more. Because of their voracious feedings behaviour and their abundance in agricultural fields, carabid beetles can be included in future Integrated Pest Management program as biological pest control agent with the potential of restricting the abundance

of many pest species. Altogether, proper conservation strategies will be helpful to conserve natural microhabitats of carabid beetles because these microhabitats and ecological zones play a significant role in conservation of diversity and species richness of carabid beetles.

Conflict of interest: None.

REFERENCES

Adeduntan, S.A. and Olusola, J.A. (2013). Diversity and abundance of arthropods and tree species as influenced by different forest vegetation types in Ondo state, Nigeria. International Journal of Ecosystem. 3: 19-23.

Alarape, A.A., James, K.O. and Georgina, S.M. (2015). Beetle species diversity and abundance in University of Ibadan Botanical Garden. Nigeria Open Journal of Ecology. 5: 352-360.

Ali, Y.A., Rapuzzi, I., Ahmad, A., Ammar, J. and Darwish, R. (2015). Dynamics and diversity of carabid beetles (Coleoptera: Carabidae) in some fruit orchards in Syria. Arab Journal of Plant Protection. 33: 241-247.

Andrew, H. (1929). Fauna of British India, Carabidae part I. In: Taylor and Francis, London. 1: 431.

Andrew, H. (1935). Fauna of British India, Carabidae part II. In: Taylor and Francis, London. 1: 323.

Carabidae of the World 2022, accessed 26 April 2022, <https:www.carabidae.org>

Cheng, S., Kirton, L. and Chua, L. (2007). Overview of insect biodiversity research in Peninsular Malaysia. Status of Biological Diversity in Malaysia and Threat Assessment of Plant Species in Malaysia Proceedings of the Seminar and Workshop. Forest Research Institute.

Choi, J.B., Win, Z.N. and Han, G.Y. (2021). Checklist of the family Nymphalidae (Lepidoptera: Papilionoidea) from Myanmar. Journal of Asia-Pacific Biodiversity. 14: 544-556.

Deshmukh, C.K. and Gajbhiye, S.H. (2017). Base line data of diversity of family Carabidae in Pench Tiger Reserve (East), Maharashtra, India. International Digital Library of Technology and Research. 1: 1-18.

Duran, P., Gough, H., Kuwahara, A. and Toussaint, F.A. (2018). A comprehensive molecular phylogeny of tiger beetles (Coleoptera, Carabidae, Cicindelinae). Systematic Entomology. 44: 305-321.

Felix, R.F. (2009). Order Coleoptera, family Carabidae. Arthropod fauna of UAE. 2: 66-141.

Gaston, K.J. (1991). The magnitude of global insect species richness. Conservation Biology. 5: 283-96.

Gough, H., Duran, D., Kawahara, A. and Toussaint, E. (2018). A comprehensive molecular phylogeny of tiger beetles (Coleoptera, Carabidae, Cicindilinae). Systematic Entomology. 44: 1-17.

Habu, A. (1967). Fauna Japonica, Carabidae truncatipennes group (Insecta: Coleoptera). Biogeographical Society of Japan. Tokyo. Japan. 338pp.

Habu, A. (1973). Fauna Japonica, Carabidae: Harpalini (Insecta: Coleoptera). Keigaku Publishing Co. Ltd. Tokyo. Japan. 430 pp.

Habu, A. (1978). Fauna Japonica, Carabidae: Platynini (Insecta: Coleoptera). Keigaku Publishing Co. Ltd. Tokyo. Japan. 447pp.

Igondova, E. and Majzlan, O. (2015). Assemblages of ground beetles (Carabidae, Coleoptera) in peatland habitat, surrounding dry pine forests and meadows. Folia Oecologica. 42: 21-28.

Kadar, F. and Lovei, G.L. (1992). Light trapping of Carabids (Coleoptera: Carabidae) in an Apple Orchard in Hungary. Acta Phytopathologica et Entomologica Hungarica. 27: 343-348.

Kazmi, S.I. and Ramamurthy, V.V. (2004). Coleoptera (Insecta) fauna from the Indian Thar desert, Rajasthan. Zoos' Print J. 1008: 1447-1448.

Kromp, B. (1999). Carabid beetles in sustainable agriculture: a review on pest control efficacy, cultivation impacts and enhancement, in Invertebrate biodiversity as bioindicators of sustainable landscapes. Elsevier.187-228.

Kubo, J.S., Torgersen, C.E., Bolton, S.M., Weekes, A.A. and Gara, R.I. (2013). Aquatic insect assemblages associated with subalpine stream segment types in relict glaciated headwaters. Insect Conservation and Diversity. 6: 422-434.

Kumar, P. and Rajagopal, D. (1997). Carabid beetles (Coleopter: Carabidae) of Karnataka with their prey and ecological notes. Karnataka J Agric. Sci. 9: 610-615.

Kushwaha, R.K., Hegde, V.D. and Chandra, K. (2015). Ground beetles (Coleoptera: Carabidae) from Chhattisgarh, India. Zoo's Print. volume xxx: 20-23.

Kutasi, C.S., Marko, V. and Balog, A. (2004). Species composition of carabid (Coleoptera: Carabidae) communities in apple and pear orchards in Hungary. Acta Phytopathologica et Entomologica Hungarica. 39: 71-89.

Kutasi, C.S. and Marko, V. (2007). Effect of environmentally safe plant protection methods on the biodiversity and species composition of apple orchard carabid (Coleoptera: Carabidae) assemblages. Természetvédelmi Közlemények. 13: 361-369.

Kwon, Y.J. and Lee, S.M. (1984). Classification of the Subfamily Carabinae from Korea (Coleoptera: Carabidae). Insecta Koreana, Series 4, Editorial Committee of Insecta Koreana, Seoul, Korea.

Lacey, J.R., Marlow, C.B. and Lane, C.R. (1989). Influence of spotted knapweed (*Centaurea maculosa*) on surface runoff and sediment yield. Weed Technology. 3: 627-631.

Larochelle, A. and Lariviere, M-C. (2007). Carabidae (Insecta: Coleoptera): Synopsis of supra specific taxa. Fauna of New Zealand 60.

Lopez-Lopez, A. and Vogler, A.P. (2017). The Mitogenome Phylogeny of Adephaga (Coleoptera). Molecular Phylogenetics and Evolution. 114: 116-174.

Margalef, R. (1958). Information theory in Ecology. Gen. Syst. 3: 36-71.

Mili, P., Devee, A. and Saikia, D.K. (2018). Diversity of carabids in *Gerbera* and *Gladiolus* crops of Jorhat, Assam. Journal of Entomology and Zoology Studies. 6: 116-124.

Nagahata, Y., Honma, T. and Okamoto, M. (2002). Preliminary research on the fauna of carabid ground beetles in the Hiruzen Experimental Forest. Research Bulletin of the Tottori University Forests. 27: 53-59.

Pearson, D.L. and Cassola, F. (2005). A quantitative analysis of species descriptions of tiger beetles (Coleoptera: Cicindelidae), from 1758 to 2004 and notes about related developments in biodiversity studies. The Coleopterists Bulletin. 59: 184-194.

Pielou, E.C. (1975). Ecological Diversity New York: Wiley. (p. 165).

Rodriguez, J.P., Pearson, D.L. and Barrera, R.R. (1998). A test for adequacy of bioindicator taxa: is tiger beetles (Coleoptera: Cicindelidae) appropriate indicators for monitoring the degradation of tropical forests in Venezuela. Biological Conservation. 83: 69-76.

Sahoo, K.C., Sunitha, V., Rao, V.V. and Chary, D.S. (2020). Diversity and abundance of coleopteran fauna at agri-biodiversity park of Professor Jayashankar Telangana state agricultural University, Hyderabad, Telangana, India. Journal of Entomology and Zoology Studies. 4: 902-908.

Samways, M.J. (2007). Connecting Biodiversity: Trends in Ecology and Evolution. pp. 22.

Shirbhate, M. and Shirbhate, A. (2020). Diversity and checklist of beetles (Arthropoda: Coleoptera) from forest areas and agricultural areas of District Akola, (Maharashtra), India. Environmental Conservation Journal. 21: 89-94.

Thakare, V.G. and Zade, V.S. (2012). Diversity of Beetles (Insecta: Coleoptera) From the Vicinity of Semadoh-Makhala Road, Sipna Range, Melghat Tiger Reserve, (M.S.) India. Biosci. Discov. 3: 112-115.

Thakare, V.G. (2013). Ground beetles (Coleoptera: Carabidae) of Melghat Tiger Reserve, Central, India. Journal on Biological Reports. 2: 173-176.

Thakkar, B. and Parikh, P.H. (2016). A Study on diversity and abundance of coleopterans in Gujarat, India. J. Entomol. Zool. Stud. 4: 1082-1089.

Trigunayat, K. and Sharma, J. (2020). Preliminary assessment of Coleopteran fauna in and around Keoladeo National Park, Bharatpur. Int J Recent Sci Res. 11: 40034-40038.

Zhang, Z.Q. (2013). Phylum Arthropoda. In: Animal Biodiversity: An Outline of Higher- level Classification and Survey of Taxonomic Richness (Addenda, 2013) (Ed. Zhang, Z.Q.). Zootaxa. 3703: 17-26.