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Community structure of Coleoptera in Bethuadahari Wildlife Sanctuary, West Bengal, India

Paramita Basu,[1] **Gautam Aditya**[2] **& A. K. Sanyal**[1, 3]

[1] Zoological Survey of India, M-Block, New Alipore, Kolkata 700053, India
[2] Department of Zoology, University of Calcutta, 35 Ballygunge Circular Road, Kolkata 700019, India
[3] Corresponding author. E-mail: asokzsi@yahoo.co.in

Abstract. We focused on the coleopteran species assemblage in a tropical deciduous forest in the Bethuadahari Wildlife Sanctuary, West Bengal, India. During a 2-year survey, we collected 56 species belonging to 13 families of Coleoptera, in varying relative abundance. Among the species, 15 belong to the family Chrysomelidae, nine to the Staphyllinidae, and four to the Coccinellidae. Our results substantiate the importance of the Bethuadahari Wildlife Sanctuary for the conservation of coleopteran insects.

Key words. Species assemblage; species inventory; Insecta.

INTRODUCTION

Insects are distributed worldwide in all habitats and constitute about half of the global diversity of animals (Gullan & Cranston 1994, Gillott 2005). A majority of insect species are beetles, grouped under the order Coleoptera. Of coleopterans, there are about 15,500 described species (nearly 4.5% of the world fauna) recorded from India to date, being with 3,100 endemic for the country (Ramkrishna & Alfred 2007). Ecosystems are dominated by beetle species with diverse morphologies that correspond to their functional roles within the ecosystem. In almost all habitat types, the richness and abundance of beetles are being explored worldwide, including beetle assemblages associated with agroecosystems (Bambaradeniya et al. 2004, Petrova et al. 2006, Kumar et al. 2009), as well as forests and protected areas (Halme & Niemelä 1993, Chung et al. 2000, Lucky et al. 2002, Apigian et al. 2006, Joshi et al. 2008, Grimbacher & Stork 2009, Sabu et al. 2011, Chandra & Gupta 2012, Thakare & Zade 2012, Campos & Hernández 2013). By assessment of beetle species assemblages, the functional role of beetles in their respective ecosystems can be better understood.

Tropical forests, with ample resources and hospitable habitats, provide an ideal ecosystem for coleopterans (Basset et al. 2003). In comparison to the similar ecosystems, the functions of the forest ecosystems are in part dependent on the foraging (Mattson & Addy 1975, Brown 1985, Schowalter 1995) and litter processing (Pfeiffer 1996, Nair 2007) by the beetles and other insects. The beetles represent the single major group of insects that explore both live and dead plant parts thereby accounting for the dynamic nature of the flow of energy and matter in the ecosystem concerned (Losey & Vaughan 2006, 2008). Appraisal of the beetle assemblages in forest ecosystems is being emphasized in several studies spanning different geographical areas and suggests their dominance over other insect orders (Schowalter et al. 1986, Novotny & Basset 2005). Our study is an account of the diversity of Coleoptera in the tropical moist deciduous forest of Bethuadahari Wildlife Sanctuary, West Bengal, India, and highlights the need for conservation planning and management in the reserve. Keeping in view the significance of the beetles in forest ecosystems, the information of the present study may be utilized for their conservation and maintaining the forest as a reserve area.

MATERIALS AND METHODS

Study area

The 66.77 ha Bethuadahari Wildlife Sanctuary (BWS; 23°35′N, 088°23′E; 5 m above sea level) is located in the Nadia district of West Bengal, India (Fig. 1). The wildlife sanctuary now supports a tropical moist deciduous forest, but previously it was degraded and planted forest. The wildlife sanctuary was declared as such on 19 August 1998, under the Notification No. of 2772 of the Department of Forest, Government of West Bengal, India.

The upper canopy of the forest comprised of Teak (*Tectona grandis* Linn. F.), Arjun (*Terminalia arjuna* (Roxb.)), Siris (*Albizia lebbeck* (L.) Benth.), Sissoo (*Delbergia sissoo* Roxb.), Sal (*Shorea robusta* Gaertn.), Mahogany (*Swietenia macrophyla* King), and Ficus (*Ficus* spp.), while the middle and lower canopies are less demarcated. Trees such as Jamun (*Syzigium cumini*), Minjiri (*Cassia* sp.), Bael (*Aegle marmelos* (Linn)), Atha (*Annona squamosa* Linn), and Hamjam (*Polyalthia suberosa* (Roxb.)), comprise the middle and lower canopy. The shrubs *Cassia tora* Linn, *Ageratum* sp., and *Polygonum* spp., as well as various species of *Colocasia,* dominate the ground vegetation. There are also sparse grasses such as *Imperata* sp. (Ulloo grass), *Paspalum* sp., *Panicum* sp., *Cynodon* sp., and *Brachiaria* sp. that form a mosaic of green patches and

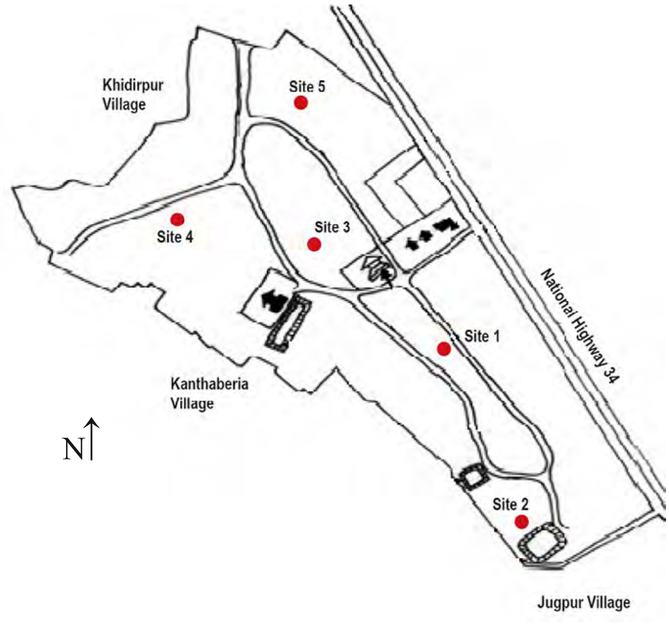

Figure 1. Map of Bethuadahari Wildlife Sanctuary, West Bengal, India, with the sampling plots denoted by red dots.

open soil.

Data collection and analysis

To collect coleopterans, we employed the quadrat method (Brower et al. 1998, Krebs 1999), following the random selection of five survey plots in various parts of the forest. Each plot constituting an area of 625 m² (25 × 25 m²) which were separated one from another by at least a distance of 200 m. The plots consisted of a heterogeneous mixture of grass and barren soil as well as shrubs and trees. Within each plot, three quadrats, each 5 × 5 m² were randomly selected, in compliance with the norms of interspersion and randomization such that the samples represent true replicates (Hurlbert 1984).

In each quadrat, we used sweep netting, pitfall trapping, fluorescent light trapping, and hand picking with a net to capture beetles. Different collection methods were employed to ensure that most species were captured. The sweep net used was 30 cm in diameter, 90 cm deep, and with 1.5 mm mesh. Each sweep represented a horizontal swing 0.5 to 2 m above the ground and with an arc between 135° to 180° (against the horizontal plane). At each quadrat, 100 random sweeps were made. One pitfall trap was placed at the center of each quadrat and left for 24 h. These were transparent plastic jars (10 × 10 cm), ⅓ filled with a 2:1 solution of propylene glycol in water (Halme & Niemelä 1993, Taboada et al. 2010, Earnst & Buddle 2013). A light trap was set up at the center of each plot for 10 h (18:00–4:00 h) (Lee et al. 2008). Therefore, beetles collected from each plot comprised of cumulative collections by 3 light trap, 3 pitfall traps, and 3 sweep net samples. Additional collections by hand picking was also employed to include insects directly observed within the quadrat. The hand picking method used a 15 cm net, with each search lasting15 min each. Consequently, we collected 45 samples from the 5 plots at each sampling operation involving all the methods. Twenty-four sampling operations were carried out, 1 in each month, from January 2010 to December 2011.

Collected insects were placed in plastic bags or specimen containers and brought to the laboratory in Zoological Survey of India (ZSI), Kolkata. Specimens were separated into families using Crowson (1956) and Choate (1999), and mainly the numerous volumes on Coleoptera in the *Fauna of British India, including Ceylon and Burma* (Gahan 1906, Jacoby 1908, Fowler 1912, Marshall 1916, Maulik 1919, 1926, 1936, Andrewes 1929, 1935, Cameron 1930, 1932, 1934, 1939a, 1939b). Identifications of genera or species were made with the help of the Scientists of the Coleoptera section in the Zoological Survey of India (ZSI), Kolkata. Specimens were deposited in the ZSI (Kolkata).

The data on the relative abundance of each species was used for diversity analysis using BDPro software (McAleece et al. 1997). In order to estimate the diversity indices, raw data of each species collected from the plots were pooled together into 24 monthly samples. Using relative abundance as a measure, a discriminant function analysis (Manly 1994, Legendre & Legendre 1998) was performed to show differences between families of Coleoptera.

RESULTS

The 2-year survey of the forest revealed the presence of at least 56 species of coleopterans belonging to 13 families (Tables 1 and 2). Among the families, Chrysomelidae, Cerambycidae, Brentidae, and were the phytophagous groups (Weiss 1922, Sarooshi et al. 1979, Silfverberg 1989). With 16 species found, Chrysomelidae was the most abundant and species-rich family. Beetles that prey on macro-invertebrates and vertebrates (Weiss 1922, Dixon 2000, Omkar & Pervez 2000) were represented by 18 species belonging to the families Carabidae, Coccinellidae, Lampyridae, Lycidae, Dytiscidae, and Hydrophilidae. There were 16 saprophagous species belonging to 4 families, Scarabaeidae (dung beetles), Staphylinidae (rove beetles), Tenebrionidae (darkling beetlea), and Elateridae

Table 1. Representative families of Coleoptera with ascertained species numbers observed in course of sampling of the Bethuadahari Wildlife Sanctuary, West Bengal, India, during 2010–2011.

Family	Number of species
Phytophagous (about 38%)	
Chrysomelidae	16
Cerambycidae	2
Curculionidae	2
Brentidae	2
Predaceous (about 33%)	
Coccinellidae	6
Lampyridae	1
Lycidae	1
Hydrophilidae	2
Dytiscidae	4
Carabidae	4
Saprophagous (about 30%)	
Scarabaeidae	3
Tenebrionidae	2
Elateridae	2
Staphylinidae	9

Table 2. Species of Coleoptera recorded from Bethuadahari Wildlife Sanctuary, West Bengal, India (n_i represents relative proportion of the species collected in the total sample; description of 56 species given).

Species name	n_i	Voucher no.	Characters
Family Chrysomelidae			Antennae not longer than body; not inserted on frontal prominence; tibial spurs absent
Altica unicolor (Olivier, 1808)	0.0005	ZSI/5510/17	Possession of a femoral spring mechanism
Phygasia sp.	0.005	ZSI/5511/17	Elytra bicolor. Intermediate antennal segments thickened in male
Monolepta signata (Olivier, 1808)	0.0057	ZSI/5512/17	Elytra black, each elytron with two yellow stains; head, pronotum, legs and abdominal sternites; reddish-brown
Monolepta bifasciata (Hornstedt, 1788)	0.0714	ZSI/5513/17	Body shining pale yellow with two dark red spot on each elytron
Monolepta limbata (Olivier, 1808)	0.0057	ZSI/5514/17	Body pale brown; elytra, epipleuron, humerous, and scutellum rounded by black border
Monolepta sp.	0.0025	ZSI/5515/17	Body brownish yellow with black antennae
Aloria sp.	0.002	ZSI/5516/17	Body metallic blue with labrum, antennae, tibiae and tarsi blackish
Phaedon sp.	0.0042	ZSI/5517/17	Head small, deeply inserted into prothorax; pronotum with coarse punctures
Oides flava (Olivier, 1807)	0.0063	ZSI/5518/17	Dorsally brown; metasternum and abdominal sternites black
Galerucella placida Baly, 1878	0.0035	ZSI/5519/17	Dorsally dark brown; antenna, apical area on head, scutellum, ventral side and legs black
Calomicrus flavovittis Motschulsky, 1858	0.0037	ZSI/5520/17	Body shining brown with blackish brown longitudinal stripe on each elytron from humerus towards the apex
Aphthona sp.	0.0035	ZSI/5521/17	Strongly developed hind femora
Hoplasoma unicolor (Illiger, 1800)	0.009	ZSI/5522/17	Yellowish brown shining coloration; elytra with subregular punctation and without carinae on disc
Sphenoraia bicolor (Hope, 1831)	0.0023	ZSI/5523/17	Body dark brown with seven black spots on each elytron
Aspidomorpha dorsata (Fabricius, 1787)	0.0018	ZSI/5524/17	Body rounded with smooth elytra
Caryedon sp.	0.001	ZSI/5525/17	Pronotum wider at base; pronotal carina absent in front
Family Coccinellidae			Tarsal claws toothed or appendiculate; first ventral abdominal segment with distinct curved coxal lines
Coccinella transversalis Fabricius, 1781	0.0107	ZSI/5526/17	Triangular black stain on the sub-humeral area of elytra followed by a wavy, black post-median band
Cheilomenes sexmaculata (Fabricius,1781)	0.0065	ZSI/5527/17	Each elytron with three zigzag transversal stripes
Illeis indica Timberlake,1943	0.0115	ZSI/5528/17	Eyes large, distance between eyes as wide as an eye or less; mandibles finely serrate
Stethorus sp.	0.0123	ZSI/5529/17	Body black; prosternum broadly rounded anteriorly and without longitudinal carinae
Sticholotis sp.	0.0118	ZSI/5530/17	Pronotum black; prosternum enlarged and concealing mouth parts entirely
Rodolia sp.	0.0073	ZSI/5531/17	Pubescence slightly yellowish and moderately dense; absence of elytral punctations
Family Lampyridae			Metathorax epimeron long; many species with glowing organ
Luciola sp.	0.0068	ZSI/5532/17	Posterior angles of the pronotum acute and backwardly pointed
Family Lycidae			Middle coxae distant; epipleura absent; elytra reticulated
Lycostomus sp.	0.0183	ZSI/5534/17	Reddish brown coloration with one black spot at the end of each elytron
Family Scarabaeidae			Antennae with lamellate club and the plates composing antennal club flattened
Apogonia sp.	0.009	ZSI/5533/17	Light brown colour with deep puctuation, emarginated clypeus, elytra elevated along the sutures
Onthophagus sp.	0.0128	ZSI/5535/17	Presence of punctation in pronotum; clypeal margin tridentated; dorsal surface glabrous
Anomala sp.	0.0323	ZSI/5536/17	Mesosternum without intercoxal process
Family Hydrophilidae			Hind tarsi clearly 5 segmented; maxillary palpi as long as or longer than antennae; antennae with terminal 3-4 segments forming a distinct club
Berosus fairmairei Zaitzev, 1908	0.01	ZSI/5537/17	elytra with apical spine and the upper surface malted
Coelostoma sp.	0.0085	ZSI/5538/17	Antennal club very long and nine jointed, not carinate
Family Brentidae			Antennae straight, without distinct club; beak present at least in female and pointing directly forward
Apion sp.	0.0974	ZSI/5539/17	Elytra unicolor, entirely brown; body length 3.5–4 mm
Alocentron curvirostre(Gyllenhal, 1833)	0.0451	ZSI/5540/17	Rostrum arched, with deep longitudinal ventral fovea; pronotum campanulate
Family Curculionidae			Antennae short with broad club; eyes oval, emarginated, or divided
Xylosandrus sp.	0.0172	ZSI/5541/17	Smaller species with widely separated procoxae
Hypothenemus sp.	0.0025	ZSI/5542/17	Elytral striae marked by comparatively small punctures; frons convex
Family Dytiscidae			Hind legs modified for swimming, posterior margin with fringes of hairs; scutellum visible
Hydrovatus sp.	0.011	ZSI/5543/17	Elytra ferruginous with profound punctation in elytra and metacoxae
Hydroglyphus sp.	0.011	ZSI/5544/17	Elytra without spine at apex and with lateral pale stripe
Copelatus freudei Guignot, 1955	0.007	ZSI/5545/17	Hind coxal lines touching median line; sides of pronotum distinctly margined
Laccophilus sp.	0.008	ZSI/5546/17	Punctation on elytra uniform; presence of single tarsal claw in posterior legs
Family Carabidae			Antennae moniliform; eyes not divided by lateral margin of head
Cicindela sp.	0.008	ZSI/5547/17	Antennae long, filiform; elytra black
Coptodera sp.	0.006	ZSI/5548/17	Body dark-brown; each elytron with three yellowish orange patches

Continued

Table 2. *Continued.*

Species name	n_i	Voucher no.	Characters
Clivina sp.	0.021	ZSI/5550/17	Large body size greater than 5mm; last visible abdominal segment without any projection; tips of apical segment of maxillary palpi not finely produced
Colliuris sp.	0.06	ZSI/5551/17	Pronotum narrow, longer than wide; elytron with apex truncate, exposing last abdominal tergite
Family Tenebrionidae			Tarsal claws simples; front of head with protruding margin extending between the eyes
Gonocephalum sp.	0.029	ZSI/5552/17	Large body, with head, pronotum, and elytra strongly depressed
Scleron sp.	0.055	ZSI/5553/17	Larger in size; pronotum and elytra strongly tuberculated
Family Elateridae			Prothorax firmly joined to mesothorax; antennae inserted under margin of front
Agrypnus sp.	0.077	ZSI/5554/17	Scutellum simples, pentagonal, with dense punctation and without longitudinal carina
Aeoloderma sp.	0.045	ZSI/5555/17	Frons convex, rarely flat, rounded anteriorly, rarely truncated, base usually with fine longitudinally raised carina
Family Staphylinidae			Elytra very short, dorsally exposing 4-7 abdominal segments
Bledius sp.	0.059	ZSI/5556/17	Presence of small well defined pit in prosternum
Acanthoglossa brachycera Kraatz, 1859	0.002	ZSI/5557/17	Head and thorax with reticulate, umbilicate sculpture
Stenus sp.	0.054	ZSI/5558/17	Eyes very large; seventh abdominal segment with a short spine
Astenus sp.	0.005	ZSI/5559/17	Last antennal segment longer than 10th segment
Philonthus sp.	0.004	ZSI/5560/17	The suture and apical margin of elytra broadly reddish yellow
Dibelonetes bengalensis Biswas & Sengupta, 1980	0.004	ZSI/5561/17	Posterior margin of elytra broadly ferruginous red
Cryptobium sp.	0.008	ZSI/5562/17	Antennae geniculate; elytra entirely red
Lathrobium unicolor Kraatz, 1859	0.003	ZSI/5563/17	Species reddish and testaceous; strong punctation in front of head
Paederus fuscipes Curtis, 1826	0.005	ZSI/5564/17	Head dark blue; anterior femora entirely testaceous
Family Cerambycidae			Body elongate; antennae frequently longer than body, inserted on frontal prominence; tibial spurs well developed
Batocera sp.	0.003	ZSI/5565/17	Large body size with greyish black coloration; antennae long
Mesosa sp.	0.017	ZSI/5566/17	Antennae filiform, unarmed and short, extend beyond elytral apices; lateral margins of pronotum without spines

(click beetles) (Chittenden 1915, Weiss 1922). Of all species, about 38% species were phytophagous, mostly chrysomelids, followed by predaceous (about 33%), and saprophagous (about 30%) species.

The relative abundance was higher for *Apion* sp., *Monolepta bifasciata* (Hornstedt, 1788), *Agrypnus* sp. *Colluris* sp., *Bledius* sp., *Scleron* sp. and *Stenus* sp. while the species such as *Altica unicolor* (Olivier, 1808) and *Caryedon* sp. were least often collected.

On the basis of the species richness and abundance of coleopteran in the 24 monthly samples, the Shannon–Weaver diversity index (H′) was between 1.17 and 3.44, with a mean value of 3.11. The corresponding evenness values (H_{even}) was 0.65 and 0.85 with a mean value of 0.81. However, the monthly differences in the species representation was obvious, possibly a reflection of the environmental regulation of the population of the concerned species (SHE analysis; Fig. 2). In terms of the

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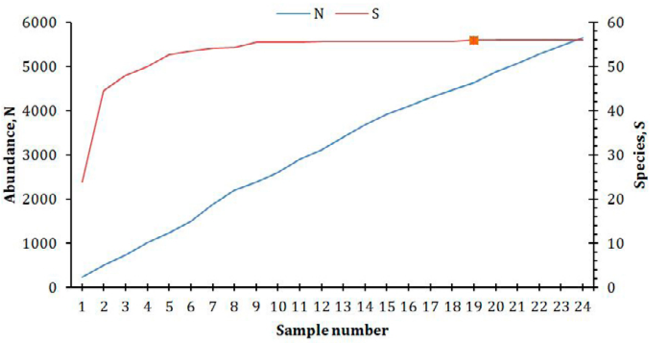

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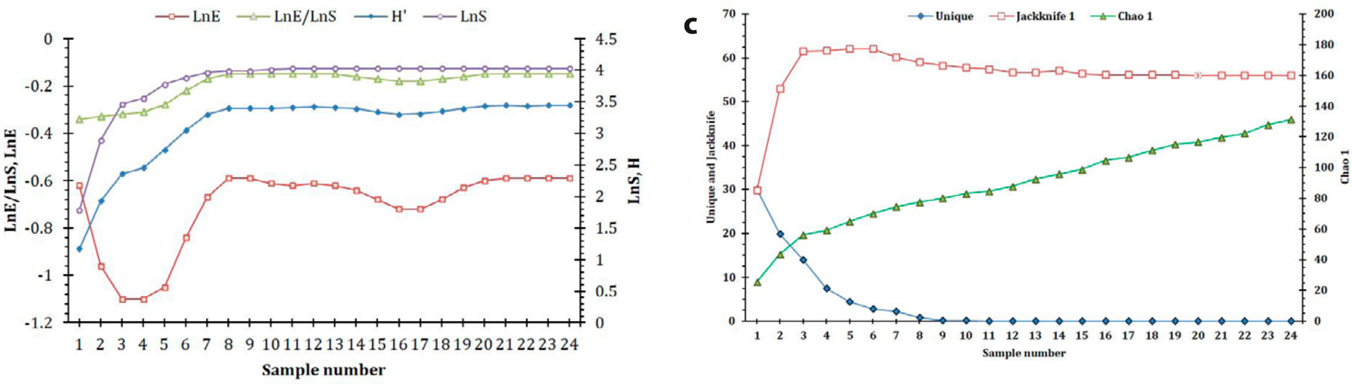


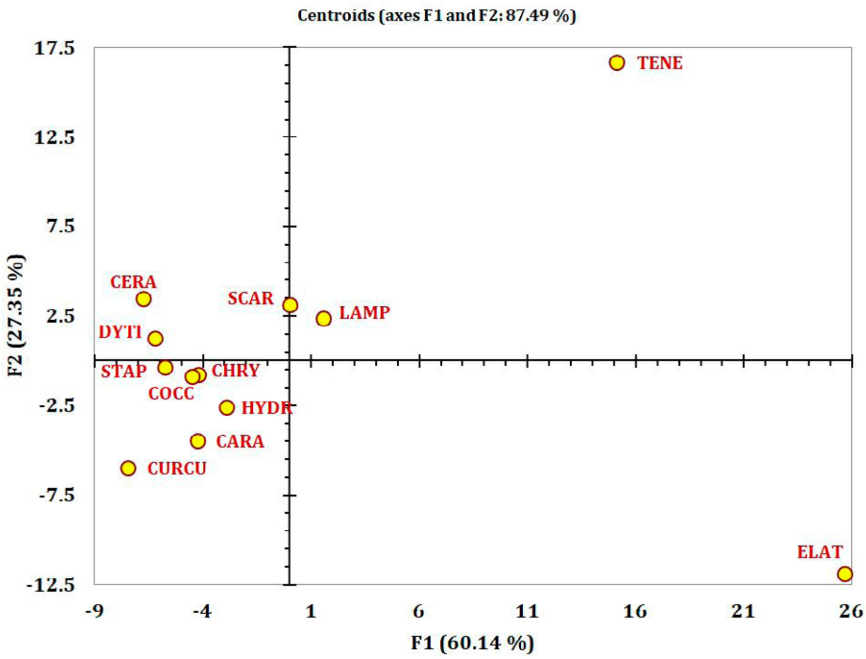
Figure 2. The SHE analysis [S (species richness), H (information) and E (evenness) in the samples] (**a**), species richness S, and abundance N (b), and various measures of species richness (Unique species, Chao1, and Jacknife1) (**c**), for Coleoptera, calculated on the data of 24 samples of different months from January, 2010 to December, 2011, in Bethuadahari Wildlife Sanctuary, West Bengal, India. The filled in triangles mark the sample where the species saturation was reached in the estimates in **b** and **c**.

beetle individuals in the samples and the species richness, the saturation was reached at the sample number 19 (Fig. 2), which is also reflected through the non-parametric measures of the species diversity such as Jackknife 1 (species saturation in 20th sample) (Fig. 2). The differences in the species richness among the samples were also reflected through the Chao 1 estimator, estimator of the unique and doubleton species in the samples. In comparison to the Chao 1, the Jackknife 1 estimate provided a better descriptor owing to similarity with the observed saturation of the species richness in the samples.

The discriminant function analysis indicates considerable differences in the relative representations of families of Coleoptera as shown in the biplot of Table. 3. The axes of the biplot explained about 87% of the variability of the data on the relative abundance of the coleopteran families. On comparison, the two families, Elateridae and Tenebrionidae, were oriented in different coordinates to rest of the families. The Fisher's distance among the pairs of the families remained significant for

Table 3. The results of Discriminant function analysis (DA) represented through the biplot (a), Eigen values (b) and the Fisher's distance among the different families of Coleoptera observed. (CARA: Carabidae, CERA: Cerambycidae, CHRY: Chrysomellidae, COCC: Coccinellidae, DYTI: Dytiscidae, ELAT: Elateridae, HYDR: Hydrophilidae, LAMP: Lampyridae, SCAR: Scarabaeidae, CURCU: Curculionidae, STAP: Staphylinidae, TENE: Tenebrionidae).

a. Biplot showing ordination of the Coleoptera families presented in centroids.



b. Eigen values of factors and canonical correlation coefficients.

Measures	F1	F2	F3	F4	F5	F6
Eigen value	120.2	54.7	15.1	2.871	2.468	2.06
Discrimination (%)	60.1	27.4	7.557	1.437	1.235	1.031
Cumulative %	60.1	87.5	95.1	96.5	97.7	98.8
Canonical correlations function	0.996	0.991	0.968	0.861	0.844	0.82

c. Fisher's distance (significant values, $P < 0.05$, are indicated in bold).

	CARA	CERA	CHRY	COCC	DYTI	ELAT	HYDR	LAMP	SCAR	CURCU	STAP
CERA	**8.01**										
CHRY	**3.03**	**2.91**									
COCC	**2.7**	**2.73**	0.5								
DYTI	**4.25**	**1.92**	0.72	0.83							
ELAT	**48.65**	**63.46**	**49.66**	**50.56**	**58.14**						
HYDR	**1.46**	**4.95**	**1.36**	**1.15**	**2.64**	**44.94**					
LAMP	**5.99**	**6.5**	**3.11**	**4.33**	**4.71**	**39.57**	**3.87**				
SCAR	**11.47**	**4.79**	**4.59**	**5.2**	**4.9**	**45.3**	**6.98**	**5.91**			
CURCU	**1.77**	**9.18**	**4.02**	**4.34**	**5.34**	**57.59**	**3.28**	**8.75**	**14.31**		
STAP	**2.8**	**3.2**	0.38	0.74	0.79	**54.98**	**1.71**	**4.05**	**5.85**	**3.67**	
TENE	**40.39**	**35.62**	**34.33**	**35.08**	**35.47**	**46.76**	**34.57**	**20.2**	**26.82**	**50.34**	**36.48**

most of the cases reflecting the differences in the representation of the different species under the families.

DISCUSSION

Locally, terrestrial insect diversity depends on the resource availability and habitat, while climate determines diversity of insects and terrestrial arthropods, which is evident from biogeographical studies worldwide (Barberena-Arias & Aide 2002, Deans et al. 2005, Hirao et al. 2007, Richards & Windsor 2007). For example, about 1470 beetle species were recorded over a 4-year period in lowland tropical rainforests of Australia, but with a patchy distribution of species over time (Grimbacher & Stork 2009). In comparison, 50 species of beetles belonging to 11 families recorded from mesic undisturbed tundra in Nunavut, Canada (Ernst & Buddle 2013). In tropical forests of Brazil, dung beetle assemblages vary between locations (21 species in Bahia, Vieira & Silva 2012; 33 species in Santa Catarina, Campos & Hernández 2013) and are considerably greater than the present observation of just 3 species. In pine-dominated forests, Vanderwel et al. (2006), found that xylophagous families Cerambycidae and Scolytidae were more abundant; in the present study, these families were represented by 4 species. The number of carabid species recorded (4 species) in the present study also is low compared to a study by Abdel-Dayem (2012) in Egypt (39 species in 28 genera). In Bandhavgarh National Park, Madhya Pradesh, India, a moist deciduous forest bordered with marsh and interspersed hillocks, is rich in beetles, with at least 44 scarabaeid species (Chandra & Ahirwar 2005). However, in terms of the number of species, the present observation (57 species) was greater than the 26 species recorded from deciduous forests of Achanakmar-Amarkantak Biosphere Reserve, central India (Chandra & Gupta 2012) and the 12 species recorded from Melghat Tiger Reserve, Maharashtra, India (Thakare & Zade 2012). In comparison to the tropical moist deciduous forests of Bethuadahari Wildlife Sanctuary, the steppe grasslands of Czech Republic appears to have a more diverse beetle assemblage with 103 being weevil (Curculionoidea), while rest were representatives of Anthribidae (4 species), Rhynchitidae (5 species), Apionidae (14 species) and Nanophyidae (1 species) (Stejskal 2004). From these comparisons, it is apparent that plant assemblages, landscapes, and climatic factors strongly influence beetle species richness. Apart from human-induced disturbance, the seasonal factors and resource availability in Bethuadahari Wildlife Sanctuary may cause variations in beetle abundance in the survey area. In Buxa National Park, West Bengal, high quality habitats in a mosaic of forest types account for a much greater richness of beetles (Sarkar et al. 2014, 2015a, 2015b).

The dynamics of plant succession and the resultant variations in the habitat complexity influences the insect species assemblages (Brown 1985). Such changes (Buskirk & Buskirk 1976, Arun & Vijayan 2004) may limit the spatial distribution and encounter in course of collection using the pitfall traps or sweep nets. The cryptic species residing in the litters and within the degrading woods may have been missed by the sampling methods used.

In moist deciduous forests, such as found in the Bethuadahari Wildlife Sanctuary, the depth of leaf litter, as well as the litter-dwelling invertebrate fauna, including coleopterans, varies with the seasons. The forest of the Bethuadahari Wildlife Sanctuary is dominated by *Tectona grandis*, which may account for less variability in the detritus on the forest floor. In a stable forest ecosystem, the availability of the detritus, including decaying wood and faecal matter of larger herbivores, are high in relation to live leaves. Although abundance of detritivore species of coleopterans was higher than the strictly phytophagous species, in general, the 2 groups varied in accordance with seasonal variations of the resources available. Among the coleopterans, the Scarabaeidae are relatively specialized detritus-associated taxa and involved in the decomposition process (Chittenden 1915, Weiss 1922, Weinreich 1968). The presence of scarabaeids accelerates litter decomposition and helps maintain soil quality (Halffter & Edmonds 1982, Hanski & Cambefort 1991, Slade et al. 2007, Nichols et al. 2008, Simmons & Ridsdill-Smith 2011). The representatives of Staphylinidae, Tenebrionidae, and Elateridae, contribute to the multiple functional roles (Mattson & Addy 1975, Brown 1985, Schowalter 1995, Pfeiffer 1996, Dixon 2000, Omkar & Pervez 2000, Basset et al. 2003, Nair 2007) in sustaining the forest ecosystem. The ecological role of coleopteran and other insect groups in deciduous forests such as in Bethuadahari Wildlife Sanctuary may be better assessed by evaluating the trophic guild structure and the resources available over the entire season. Further studies would be beneficial to decipher interactions between the insect species and forest resources and sustaining the forest ecosystem.

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