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Forest vegetation types related variation in the diversity and community structure of dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae) in the moist south Western Ghats

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ABSTRACT: Assessment of diversity and community structure of dung beetles in the shola, evergreen and deciduous forests of Periyar Tiger Reserve (PTR) of the South Western Ghats, south India, revealed that vegetational differences affect the dung beetle population, and abundance and species richness of dung beetles was highest in the evergreen forests. High similarity in species composition between evergreen and shola forests was recorded. No vegetation specific indicator species was recorded with *IndVal* analysis from the three forest types, indicating that PTR is a habitat under stress. Four detector species were recorded and monitoring the detector species would enable in understanding the future direction of change in the various vegetation types in PTR.

KEY WORDS: Dung beetles, Vegetation types, the south Western Ghats

INTRODUCTION

Dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae) are an important group of primary decomposers in the forest ecosystem. They play an important role in the ecosystem by aiding in the recycling of Nitrogen and other nutrients, removing dung from soil surface, protecting seeds from predation, seed dispersal, soil conditioning as primary agents in soil aeration and reducing populations of disease-causing organisms such as hookworms (Hanski, 1991). Dung beetles are affected by the structure of vegetation, which is a main factor determining the organization of dung beetle communities in tropical rainforests (Scheffler, 2005). A change in

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vegetational cover can lead to differences in mammalian fauna which, in turn, affect dung beetle populations (Estrada *et al*., 1999). Very few studies have addressed the ecology and community structure of the forest dung beetles in the Western Ghats (Sabu *et al*., 2006; Vinod and Sabu, 2007; Vinod, 2009) and no data exists on the forest vegetation type specific variation on the community structure of dung beetles from the region. In the present study, dung beetle fauna in different vegetation types in the moist western slopes of the south Western Ghats is analysed.

MATERIALS AND METHODS

The study was carried out in the Periyar Tiger Reserve (9^0 15' N - 9^0 40' N; 76^0 55'E - 77^0 25' E; 800 to 1200 m asl, 777 km^2), Thekkady, located in the southern Western Ghats of Kerala state. Annual rainfall is about 2500mm and humidity 69% (Peeyus kutty, 2008; Kerala forest and wildlife department, 2013). PTR is covered mostly with evergreen, semi-evergreen, moist deciduous forests, and grasslands make up the rest of the area. Sporadic patches of 'sholas', which are sub tropical montane forests, occupy the crest and crevices of high altitude tracts (Peeyus kutty, 2008; Kerala forest and wildlife department, 2013). Elephant (*Elephas maximus* Linnaeus, 1758), Gaur (*Bos gaurus* Hamilton Smith, 1827), Sambar deer (*Cervus unicolor* Kerr, 1792), Barking deer [*Muntiacus muntjak* (Zimmermann, 1780)], Nilgiri langur [*Trachypithecus johnii* (Fischer, 1829)] and Bonnet macaque [*Macaca Radiata* (Geoffroy, 1812)] are the major mammals present in PTR (Kerala forest and wildlife department, 2013).

Sampling: Dung beetles were sampled using dung baited pitfall traps on a seasonal basis during 2009-2011 period from low elevation shola (1200 msl), evergreen (1000 msl) and deciduous (650 msl) forests in the PTR. Ten pitfall traps made of plastic basin (10 cm diameter, 15 cm deep), spaced at 50m interval between traps were placed to minimize trap interference (Larsen and Forsyth, 2005). Trap contents were collected at 12 h interval (6:00-18:00h and 18:00-6:00h) to separate diurnal and nocturnal species. Collected beetles were identified to species level using Arrow (1931) and Balthasar (1963) by the authors and were confirmed by comparing with the verified specimens in the collections of St. Joseph's College, Devagiri, Calicut. Identified specimens will be deposited in the museum of Zoological Survey of India, Western Ghats regional centre, Calicut. Species were sorted into three functional guilds namely, dwellers (endocoprids), rollers (telecoprids) and tunnelers (paracoprids) following Cambefort and Hanski (1991) and three temporal guilds (noctural/diurnal/generalists) following Krell *et al.* (2003). To assess the value of particular species as indicators of habitat change, the indicator species value (ISV) using the Indicator Value Method (IndVal) (Dufreˆne and Legendre, 1997) was calculated. Species with *IndVal* values, greater than 70% were regarded as characteristic indicator species and those between 50% and 70% were considered as detector species (McGeoch *et al*., 2002). Species diversity was calculated using Margalef's richness and Shannon diversity indices. Species compositions among habitats were compared with Bray-Curtis similarity coefficient. Significance of variation in the overall abundance among forest types were tested with Kruskal –Wallis test followed by Mann –Whitney test, diversity and species richness with one-way ANOVA followed by Tukey's test and guild

composition with Chi square test. Diversity analyses were done with PRIMER 5 software version 5.2.9 (Clarke and Gorley, 2001) and statistical analyses were done with MINITAB software (Minitab, 2010).

RESULTS

Thirty species belonging to 9 genera and five tribes were collected with 19 speceis from shola forests, 30 from evergreen forests and 20 from deciduous forests (Table 1). *Onthophagus ensifer* and *Caccobius meridionalis* were the dominant species in the shola and evergreen forests and *O. ensifer* and *O. fasciatus* in the deciduous forests. Overall abundance (H=12.50, DF=2, $P<0.05$) and species richness (F=5.08, DF=2, $P<0.05$) were higher in the evergreen forests. Diversity did not vary between the three forest vegetation types (F=2.01, DF=2, $P>0.05$). Highest similarity was between the dung beetle assemblages of the evergreen and shola forests (59.41%). Eight species namely, *Copris repertus, Onthophagus amphinasus, O. manipurensis, O. bronzeus, O. deflexicollis, O. bifasciatus, O. cavia* and *O. tritinctus* were specific to the evergreen forests and four species namely, *Onthophagus dama, O. duporti, O. favrei* and *O. refulgens* to deciduous forests. Nine generalist species namely, *Caccobius meridionalis, Paracopris cribratus, P. davisoni, P.signatus, Tibiodrepanus setosus, Onthophagus ensifer, O.fasciatus, O.kchatriya* and *O.rectecornutus* were present in all the three forests.

Beetles belonging to tunneler, roller and dweller functional guilds were recorded from the shola and evergreen forests whereas rollers were not recorded from the deciduous forests (Table 1). Functional guild composition based on abundance varied among the three forests (χ^2=21.08, DF=4, $P<0.05$). Tunnelers were the dominant guild (shola:98.01%, evergreen:95.42%, deciduous:99.10%) with low abundance of dwellers and rollers in all the three forest types. Temporal guild composition varied in abundance (χ^2=102.45, DF= 4, $P<0.05$) with diurnal guild dominating the assemblage in all forests types (shola: 87.83%, evergreen: 61.54%, deciduous: 74.35%). No vegetation specific indicator species were recorded. Based on the *Indval* scores, *Caccobius meridionalis*, *Onthophagus ensifer* and *Onthophagus fasciatus* were the detector species in the shola forests, *Paracopris cribratus* in the evergreen forests and *Onthophagus ensifer* and *Onthophagus fasciatus* in the deciduous forests (Table 1; Fig. 1).

DISCUSSION

Comparatively high abundance, species richness and species specificity of dung beetles in the evergreen forests than in the other forest types indicates that vegetation differences directly affect dung beetle populations in PTR. As evergreen forests are the major component of the vegetation in PTR, the resulting large area effect (Nichols *et al.,* 2007) and abundant dung resource availability in the evergreen forests (Kerala Forest and Wildlife Department, 2013) could be the reasons for high species richness in the evergreen forests compared to other forest types. High similarity in species composition between evergreen and shola forests

Table 1. Abundance, guild composition and *Indval* values of dung beetle assemblages in the three forest vegetation types at Periyar Tiger Reserve during 2009-11 period [*T=tunneler, D=dweller, R=roller; N=nocturnal, D=diurnal, G=generalist*].

	Species	Functional guild	Temporal guild	Shola		Evergreen		Deciduous	
				Mean ± SD	*Ind val*	*Mean* ± SD	*Ind val*	*Mean* ± SD	*Ind val*
1	*Onthophagus ensifer*	T	D	6.57 ± 9.13	56.6	3.67± 5.32	46.6	5.17 ± 6.78	63.3
2	*Caccobius meridionalis*	T	D	4.13 ± 5.79	56.6	6.13 ± 14.27	30.0	0.40 ± 1.00	23.3
3	*Onthophagus fasciatus*	T	D	2.10 ± 3.42	50.0	0.83± 1.46	33.3	4.87 ± 7.87	60.0
4	*Onthophagus rectecornutus*	T	N	0.47 ± 1.50	20.0	0.13± 0.35	13.3	1.53 ± 2.46	43.3
5	*Onthophagus furcillifer*	T	D	0.40 ± 0.93	23.3	0.37± 0.96	16.6	0.00 ± 0.00	0
6	*Onthophagus kchatriya*	T	G	0.30 ± 0.92	13.3	0.13± 0.43	10.0	0.07 ± 0.25	6.6
7	*Onthophagus andrewesi*	T	G	0.27 ± 0.64	16.6	0.07 ± 0.25	6.6	0.00 ± 0.00	0
8	*Tibiodrepanus setosus*	D	G	0.20 ± 0.55	13.3	0.07 ± 0.37	3.3	0.03 ± 0.18	3.3
9	*Onthophagus amphicoma*	T	G	0.17 ± 0.38	16.6	0.00 ± 0.00	0	0.13 ± 0.43	10.0
10	*Onthophagus vividus*	T	G	0.10 ± 0.55	3.3	0.00 ± 0.00	0	0.03 ± 0.18	3.3
11	*Catharsius molossus*	T	G	0.07 ± 0.25	6.6	0.13 ±0.57	6.6	0.00 ± 0.00	0
12	*Onthophagus castetsi*	T	G	0.07 ± 0.25	6.6	1.73 ± 2.55	46.6	0.00 ± 0.00	0
13	*Paracopris cribratus*	T	N	0.03 ± 0.18	3.3	1.83 ± 3.30	56.6	0.07 ± 0.37	3.3
14	*Paracopris davisoni*	T	G	0.03 ± 0.18	3.3	0.03 ±0.18	3.3	0.03 ± 0.18	3.3
15	*Paracopris signatus*	T	N	0.03 ±0.18	3.3	0.07 ±0.25	6.6	0.20 ± 0.61	13.3
16	*Ochicanthon nitidus*	R	G	0.03 ± 0.18	3.3	0.03 ± 0.18	3.3	0.00 ± 0.00	0
17	*Onthophagus vladimiri*	T	G	0.03 ± 0.18	3.3	0.10± 0.40	6.6	0.00 ± 0.00	0
18	*Sisyphus longipes*	R	G	0.03 ± 0.18	3.3	0.37± 0.81	20.0	0.00 ± 0.00	0
19	*Sisyphus neglectus*	R	D	0.03 ± 0.18	3.3	0.20±0.55	13.3	0.00 ± 0.00	0
20	*Copris repertus*	T	G	0.00 ± 0.00	0	0.07 ±0.25	6.6	0.00 ± 0.00	0
21	*Liatongus indicus*	D	G	0.00 ± 0.00	0	0.17 ± 0.59	10.0	0.10 ± 0.40	6.6

	Species	Functional guild	Temporal guild	Shola		Evergreen		Deciduous	
				Mean ± SD	*Ind val*	*Mean* ± SD	*Ind val*	*Mean* ± SD	*Ind val*
22	*Onthophagus amphinasus*	T	G	0.00 ± 0.00	0	0.63 ± 2.30	10.0	0.00 ± 0.00	0
23	*Onthophagus bifasciatus*	T	G	0.00 ± 0.00	0	0.03 ± 0.18	3.3	0.00 ± 0.00	0
24	*Onthophagus bronzeus*	T	G	0.00 ± 0.00	0	0.13 ± 0.43	10.0	0.00 ± 0.00	0
25	*Onthophagus cavia*	T	G	0.00 ± 0.00	0	0.03 ± 0.18	3.3	0.00 ± 0.00	0
26	*Onthophagus cervus*	T	G	0.00 ± 0.00	0	0.13± 0.35	13.3	0.27 ± 0.74	13.3
27	*Onthophagus dama*	T	G	0.00 ± 0.00	0	0.10± 0.31	0	0.03 ± 0.18	3.3
28	*Onthophagus deflexicollis*	T	G	0.00 ± 0.00	0	0.00 ± 0.00	10.0	0.00 ± 0.00	0
29	*Onthophagus duporti*	T	G	0.00 ± 0.00	0	0.00 ± 0.00	0	0.07 ± 0.25	6.6
30	*Onthophagus favrei*	T	G	0.00 ± 0.00	0	0.00 ± 0.00	0	0.27 ± 0.69	13.3
31	*Onthophagus laevis*	T	G	0.00 ± 0.00	0	0.37± 0.72	26.6	0.03 ± 0.18	3.3
32	*Onthophagus manipurensis*	T	G	0.00 ± 0.00	0	0.23± 0.68	13.3	0.00 ± 0.00	0
33	*Onthophagus pacificus*	T	N	0.00 ± 0.00	0	0.20± 0.48	16.6	0.07 ± 0.37	3.3
34	*Onthophagus reflugens*	T	G	0.00 ± 0.00	0	0.00 ± 0.00	0	0.07 ± 0.37	3.3
35	*Onthophagus tritinctus*	T	G	0.00 ± 0.00	0	0.03± 0.18	3.3	0.00 ± 0.00	0
36	*Onthophagus turbatus*	T	G	0.00 ± 0.00	0	0.17± 0.59	10.0	0.60 ± 1.13	30.0

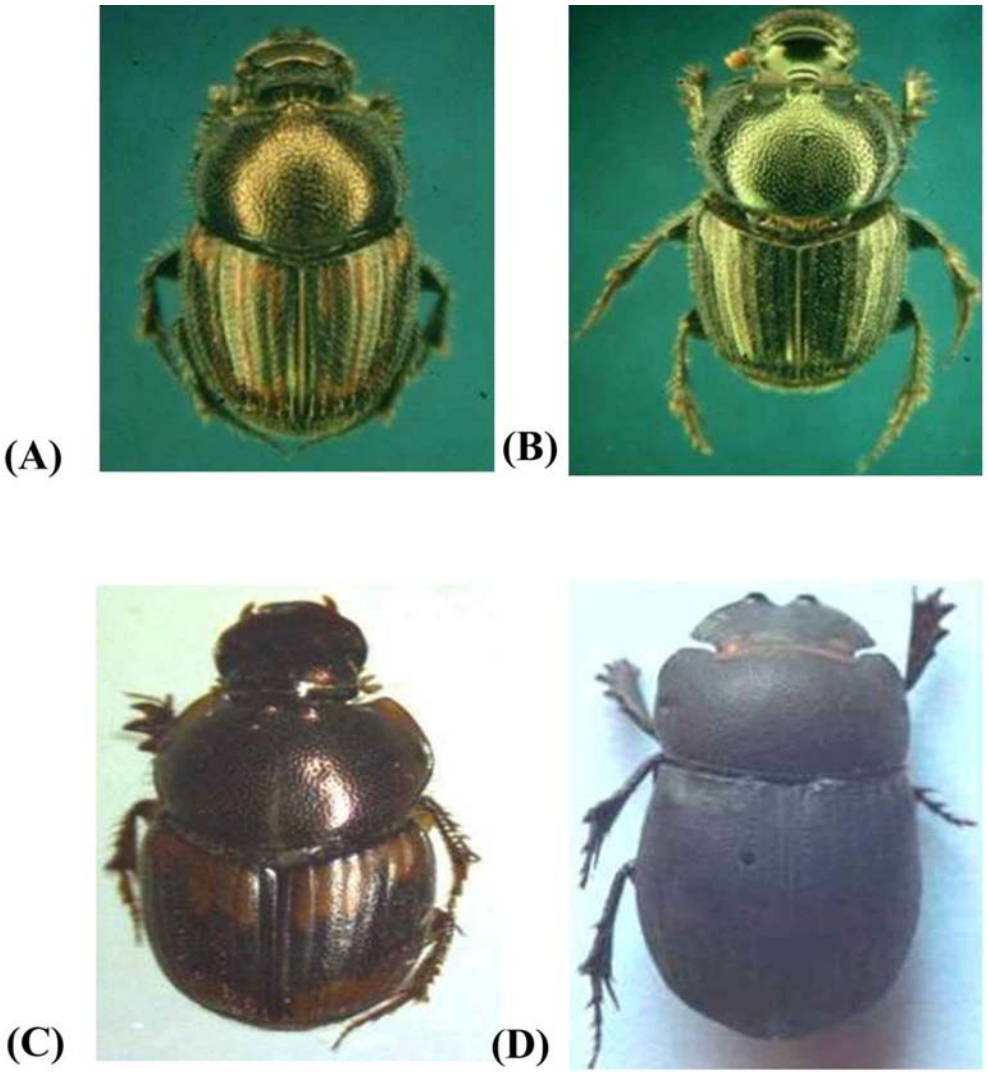

Figure 1. Detector species associated with the forests at Periyar Tiger Reserve: (A) *Caccobius meridionalis* - shola forest, (B) *Onthophagus ensifer* - shola & deciduous fore (C) *Onthophagus fasciatus* - shola & deciduous forests, (D) *Paracopris cribratus* - evergree forest.

is attributed to the movement of species between adjoining shola and evergreen forests and similarity in the habitat conditions in the two forests.

Low species richness in the low elevation shola forests at PTR agrees with the earlier reports from the high elevation shola forests in the Western Ghats (Sabu *et al.*, 2011). However, comparison between low and high elevation shola forests shows that species richness and abundance were higher and species composition was different in the low elevation shola forests at PTR compared to the high elevation shola forests of Eravikulam. *Onthophagus ensifer* and *Caccobius meridionalis* were the dominant species in the low elevation shola forests whereas *Onthophagus refulgens* and the wingless *Ochicanthon devagiriensis* dominated the high elevation shola forests (Sabu *et al.*, 2011). Difference in the species composition and dominance pattern in the low and high elevation shola forests is attributed to the altitudinal variations and the physiological adaptations of upper montane dung beetles to low temperature (Verdu *et al*., 2004).

Caccobius meridionalis and *Onthophagus ensifer* were the dominant species in the evergreen forests at PTR whereas *Onthophagus pacificus* and *O. furcillifer* were the dominant species at Nelliyampathy in the moist south Western Ghats (Latha, 2013). *Onthophagus ensifer* and *O. fasciatus* dominated the assemblage in the deciduous forests in PTR where as *Onthophagus andrewesi* and *Tibiodrepanus setosus* dominated the assemblage in the deciduous forests of Wayanad region in the north of moist south Western Ghats (Vinod, 2009) indicating both forest vegetation wise and region wise variation in the dominance of species in the moist south Western Ghats. Nine generalist species are common dung beetle species in the Western Ghats (Sabu, 2011) and their presence in all the three forests is indicative of their capacity to survive in all the three vegetation types.

Dominance of tunnelers, in all forest vegetation types in PTR and in other forests of the moist south Western Ghats indicate that dominance of tunnelers is typical of dung beetle assemblages in the moist south Western Ghats (Sabu *et al.*, 2006, 2007; Vinod and Sabu, 2007). Aggressive and superior competitive nature of tunnelers in utilizing the dung resources (Krell-Westerwalbesloh *et al*., 2004) might have contributed to their success and dominance in all the three forests. Low abundance of dwellers in all forest types is attributed to the low abundance of gaur in PTR (Veeramani, 2004) and the resulting lesser availability of undisturbed dung pats and the high abundance of tunnelers with superior competitive nature in PTR. Dominance of dwellers over rollers in the low elevation shola forests of PTR is in contrast to the non-record of the dweller guild in the high elevation shola forests of the Western Ghats (Sabu *et al*., 2011). Unlike the upper montane shola forests, shola forests at PTR are more frequented by elephants and steady availability of their dung pats could be the reason for the presence of dwellers.

Low abundance of rollers is attributed to low presence of dung pellet producing mammals such as deer and Nilgiri tahr and the limited availability of dung pellets preferred by rollers. Additionally, thick under storey vegetation in the forests in PTR (Kerala forest and Wildlife

Department, 2013) and the moist wet conditions in the forests that hinders ball rolling activities of roller dung beetles (Krell-Westerwalbesloh *et al*., 2004) could be the other factors leading to the low abundance of rollers in PTR. Occurrence of the rare primitive old world roller, *Ochicanthon*, a genus present in relict patches of moist forests in the Indo- pacific ecoregion (Latha *et al*., 2011) indicates that the forests of PTR has conditions favourable to support the group. Dominance of diurnal guild in the forests of PTR is arising from the preference of dung beetles for warm and dry conditions during day time and their higher activity during diurnal period (Gill, 1991) as well as peak in the defecation of mammals during day time (Davis *et al.*, 1997) and availability of fresh dung during day time.

Non-record of indicator species (habitat specialists) indicates that no species fulfilled the criteria of high specificity and fidelity in the three forest types and PTR is a habitat under stress (Anas *et al.*, 2013). Detector species are useful indicators of direction of change in a habitat than the highly specific indicator species restricted to a single state (Mc Geoch *et al*., 2002) and hence monitoring the detector species (*Caccobius meridionalis*, *Onthophagus ensifer* and *Onthophagus fasciatus* in the shola forests, *Paracopris cribratus* in the evergreen forests and *Onthophagus ensifer* and *Onthophagus fasciatus* in the deciduous forests) would enable in understanding the future direction of change in the various vegetation types in the PTR.

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