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ORIGINAL ARTICLE

The attractiveness of Dung Beetles (Coleoptera, Scarabaeidae, Scarabaeinae) to different dung types in a Coffee plantation belt in the Nilgiri Biosphere Reserve of the South Western Ghats, India

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ABSTRACT
Degree of the attractiveness of dung beetles towards the dung of pig (omnivore), cattle and goat (herbivore) was assessed using dung baited pitfall traps in a shaded coffee plantation belt in the Nilgiri Biosphere Reserve of the South Western Ghats. Results showed high preference of dung beetles towards the dung of omnivorous mammals than herbivores. Thirty-eight species of dung beetles were collected from three dung types with 30 species in pig dung, 25 in cattle and 16 in goat dung. High abundance of generalists with no preference towards any dung type was recorded. Based on Indval analysis, five species namely, Onthophagus unifasciatus, O. insignicollis, O. bronzeus, O. furcilifur and Caccobius unicornis, were specialists in pig dung type and Onthophagus pacificus and Onitis subopacus were identified as specialists in cattle and goat dung respectively.
Keywords: *Coffee plantation, Dung beetles, Onthophagus, Specialist, Pig dung, South Western Ghats.*

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INTRODUCTION

Dung beetles belong to the subfamily of Scarabaeinae (Insecta: Coleoptera: Scarabaeidae) are characterized by their use of faeces at both the larval and adult stages (42). By feeding on faeces, dung beetles play a role in nutrient cycling, secondary seed dispersal and diminish the populations of parasitic disease causing flies and nematodes by killing larvae and eggs in the faeces [22]. They have a long evolutionary history of ecological specialization to feeding and breeding in dung (8), so their diversity is tightly linked to terrestrial vertebrates [23, 22]. Large and diverse mammal fauna are crucial for maintaining diverse dung beetle fauna [26, 23, 14, 12, 43]. Also, decline in mammal populations has cascading effects on ecosystem functioning provided by dung beetles [31, 35, 36].

Dung beetles partition their food and breeding resources according to their physico-chemical characteristics, such as odour profile, fibre size, dropping size, water content and faeces texture, and nutritional quality [22, 23, 21, 10]. Volatile compounds released by the food source are important components in determining the dung beetle niche, and this can vary depending on the vegetation structure of a given habitat (6). Moreover, moisture content and quality of dung is maintained for a longer period under the shade which enables better colonization of dung beetles [25, 13]. Many studies recorded distinct trophic preference of dung beetles for omnivorous mammal faeces in Neotropical [17, 15, 16, 29, 4, 35], Australian [24, 44], African [7, 43, 9] and Oriental forests [38, 41]. Studies from Palaearctic agriculture fields showed differences in the abundance of beetles among various herbivorous dung types [28, 30, 20, 18].

Dung specificity of dung beetles towards different dung types in the agribelts is virtually non-existent from Indian mainland. In the present effort, the dung beetle community in a shaded coffee plantation belt

in the Western Ghats, a global hot of biodiversity in south west India using odoriferous omnivore dung (pig); fine fibered dung pad of ruminant herbivore (cattle) and pellet dung of ruminant herbivore (goat) is analysed. This study will give information about the attraction of dung beetles to different dung types and their trophic preference in a shade coffee plantation belt in the South Western Ghats.

MATERIAL AND METHODS

Study area: The study was carried out in a shaded coffee plantation belt at Ambalavayal in the Wayanad region (Kerala) of Nilgiri Biosphere Reserve (NBR) of the South Western Ghats (SWG).

Sampling: Ninety pit fall traps (3 dungs ×10 pitfall traps × 3 seasons) made of plastic basin (10 cm diameter, 15 cm deep), spaced at 50m interval between traps were placed to minimize trap interference (Larsen & Forsyth, 2005). 200 g of newly defecated dung (ten traps with each dung) was placed on a strip of wire grid at the top of the basin. Trap contents were collected at 24 h and preserved in 70% alcohol and identified to species levels using Arrow (1) and Balthasar (2) and by comparing with type specimens available in the research centre and Zoological Survey of India, Western Ghats regional station, Calicut.

Data analysis: Data used for statistical analysis were tested for normality with Anderson-Darling test. As the mean abundance of dung beetles were not normally distributed, non-parametric statistics (Mann – Whitney U tests) after comparison through Kruskal –Wallis H tests [40], were used for pair wise comparison of data (significance was determined at $P<0.05$). All statistical analyses were done with Megatstat version 10.3 (34).

Attraction of dung beetles to different dung types was assessed based on the indicator species value (ISV) using Indicator Value Method (*Indval*) (11). Indicator species analysis was performed in R Studio using multipatt in indicspecies package and significance levels were set at $p < 0.05$. Rare species were classified as those represented by singletons and doubletons [32] and excluded from *Indval* analysis.

RESULTS AND DISCUSSION

Abundance and richness: Thirty eight species of dung beetles were collected from three dung types with 30 species in pig dung, 25 in cattle and 16 in goat dung. *Onthophagus fasciatus* was the prominent species in all dung types. Other major species (mean>1) were *Paracopris davisoni, Onthophagus turbatus, Caccobius meridionalis*, *Onthophagus faveri*, *O. dama, Catharsius molossus and Onthophagus andrewesi* in pig dung; *Paracopris davisoni, Onthophagus dama, Caccobius meridionalis, Onthophagus andrewesi* and *O turbatus* in cattle dung; *Paracopris davisoni* in goat dung (Table:1). Fifteen rare species (singletons, doubletons) were recorded. Among rare species, 7 species (*Caccobius ultor, Ochicanthon laetus, Onthophagus cervus, O. kchatriya, O. ludio, O. socialis,* and *Sisyphus longipes*) recorded exclusively in pig dung and three species, *Ochicanthon tristis, Onthophagus tnai,* and *O. truncaticornis* reported exclusively in cattle dung. *Oniticellus cinctus* reported only in goat dung. Rare species *Onthophagus illiputanus* recorded from both pig and cattle dung and *Onthophagus discedens* recorded from both pig and goat dung. Overall abundance of dung beetles was high in pig followed by cattle and goat dung types ($H= 82.39$, $df=2$, $p <0.05$).

Dung specificity: *Indval* analysis identified seven specialist species among three dung types. *Onthophagus unifasciatus, O. insignicollis, O. bronzeus, O. furcilifur* and *Caccobius unicornis* were the specialists in pig dung. Among these, *Onthophagus furcilifur* and *Caccobius unicornis* were recorded exclusively in pig dung. *Onthophagus pacificus* and *Onitis subopacus* were the specialists in cattle and goat dung respectively (Table: 2; Figure 1).

This study provides first time data on the dung type preferences of dung beetles in an agriculture belt in the south Western Ghats as well as from the Indian mainland. A pattern of very few specialists and more of generalists are seen indicating low dung specificity in the plantation belts. *Onthophagus unifasciatus, O. insignicollis*, *O. bronzeus*, *O. furcilifur* and *Caccobius unicornis* with specificity towards pig dung and *Onthophagus pacificus* and *Onitis subopacus* with specificity towards cattle and goat dung respectively are the most vulnerable species in the study region. Specificity of dung specialists towards specific dung type indicates that the availability of specific dung types (pig, cattle and goat dung) and hence the population dynamics of these specific dung contributing mammals have strong influence on the occurrence and abundance of dung specialists in the region. It might be possible that they need this dung type to complete their life cycle and to attain the abundance recorded. If the specific dung types are not available, they may sustain on other dung types possibly on the omnivore dung of domestic dogs and cat and also on herbivorous dung, but to understand whether the reproductive potential will be same or not, needs analysis of the life cycle of the specialist species on different dung types.

Two specialists (*Onthophagus furcilifur* and *Caccobius unicornis*) recorded only in pig dung indicates that these species are strongly influenced by the availability of pig dung. The availability of dung of wild boar

which enters the coffee plantations will be its source as pig rearing is not done by the natives. Abundance of specialists was lower compared to other major species. Very low abundance of specialists agrees with the findings of other studies done in forests [19, 35, 33, 41]. Low abundance of specialists indicates that specialists depend on specific dung type for their existence and absence of that specific dung may cause local extinctions of specialist species [35, 33]. Among the pig dung specialists, *Caccobius unicornis* is a rare species in the forest and agrilandscapes in the moist South Western Ghats [39]. Preference towards scarce omnivore pig dung and the dominance of superior competitors who will compete for the omnivore dung could be the reason for the low abundance of *Caccobius unicornis*.

High abundance of generalists with flexible food preferences is recorded in the coffee plantations. Flexibility in the food preferences of coprophagous insects were stressed in many studies [3, 18, 10, 19, 33, 41]. Hanski & Cambefort [23] also reported dung beetles were generally opportunistic with respect to exploitation of wide variety of dung types and absence of extreme specialization is arising from the scarcity of the dung resources.

The fifteen rare beetle species whose *Indval* values and dung preferences cannot be determined are the less prominent dung beetles in the forests and agriland scapes [39] or tourist species. Braga et *al.,* [5] also supported that agricultural areas have many tourist species and nearly 50% of all species in agriculture are singletons. However, the presence of most of these rare beetle species (7 out of 15) in pig dung shows that they have specific attraction towards pig dung and pig dung availability (boar dung or omnivore dung) is a major factor deciding the sustainability of rarest species in the region.

Pig dung remains uniquely different because of high species richness and the presence of rare species in the samples. Similar result of high species richness, abundance, exclusive presence of specialists and rare dung beetle in boar dung from forest regions of Western Ghats was recorded (37, 41). In conclusion, dung beetles in coffee plantation belts are more attracted to omnivorous mammalian feces than to herbivorous feces types. Non-availability of omnivore dug types may alter competitive interactions between dung beetles species and may even cause local extinction of highly specialized species and the rare species.

Table 1. Abundance (Mean ± SD) of dung beetles associated with the three mammalian dung types (pig, cattle, goat) in the coffee plantation belt of the South Western Ghats.

Sl No.	Species	Pig Mean ± SD	Cattle Mean ± SD	Goat Mean ± SD
1	*Caccobius meridionalis*	1.53 ±2.34	1.20 ± 1.40	0.67 ±0.96
2	*Caccobius ultor*	0.03 ±0.18	0 ± 0	0 ± 0
3	*Caccobius unicornis*	0.47 ±1.17	0 ± 0	0 ± 0
4	*Catharsius molossus*	1.23 ±1.87	0.33 ± 0.71	0 ± 0
5	*Catharsius sagax*	0.40 ±0.67	0.40 ± 0.62	0.17± 0.38
6	*Paracopris davisoni*	3.80 ±6.17	2.57 ± 3.07	1.50±2.03
7	*Copris repertus*	0.53 ±0.82	0.50 ± 0.73	0.07±0.25
8	*Tibiodrepanus setosus*	0 ± 0	0.10 ± 0.31	0 ± 0
9	*Ochicanthon laetus*	0.03 ±0.18	0 ± 0	0 ± 0
10	*Ochicanthon tristis*	0 ± 0	0.03 ± 0.18	0 ± 0
11	*Oniticellus cinctus*	0 ± 0	0 ± 0	0.03± 0.18
12	*Onitis falcatus*	0 ± 0	0.10 ± 0.31	0.03± 0.18
13	*Onitis subopacus*	0 ± 0	0.03 ± 0.18	0.27± 0.69
14	*Onitis virens*	0 ± 0	0.03 ± 0.18	0.20±0.61
15	*Onthophagus amphicoma*	0.23±0.50	0.17 ± 0.46	0.13±0.35
16	*Onthophagus andrewesi*	1.07 ±1.17	1.17 ± 1.70	0.43±0.86
17	*Onthophagus bifasciatus*	0.23 ±0.50	0.20 ± 0.41	0 ± 0
18	*Onthophagus bronzeus*	0.50 ±0.97	0.03 ± 0.18	0 ± 0
19	*Onthophagus cervus*	0.07±0.25	0 ± 0	0 ± 0
20	*Onthophagus dama*	2.30 ±2.59	1.33 ± 2.14	0.10± 0.40
21	*Onthophagus devagiriensis*	0.10±0.40	0.10 ± 0.40	0.13±0.43
22	*Onthophagus discedens*	0.03 ±0.18	0 ± 0	0.07±0.25
23	*Onthophagus duporti*	0.10 ±0.55	0 ± 0	0 ± 0
24	*Onthophagus fasciatus*	4.40 ±3.60	4.03 ± 3.97	1.97±2.59
25	*Onthophagus faveri*	2.37 ±2.36	0.57 ± 0.97	0.57±0.86
26	*Onthophagus furcilifur*	0.17 ±0.46	0 ± 0	0 ± 0
27	*Onthophagus insignicollis*	0.83 ±1.18	0.07 ± 0.25	0 ± 0
28	*Onthophagus kchatriya*	0.07 ±0.25	0 ± 0	0 ± 0
29	*Onthophagus lilliputanus*	0.03±0.18	0.03 ± 0.18	0 ± 0
30	*Onthophagus ludio*	0.07±0.25	0 ± 0	0 ± 0
31	*Onthophagus pacificus*	0.03 ±0.18	0.10 ± 0.31	0 ± 0
32	*Onthophagus socialis*	0.03 ±0.18	0 ± 0	0 ± 0
33	*Onthophagus tnai*	0 ± 0	0.03 ± 0.18	0 ± 0

34	*Onthophagus truncaticornis*	0 ± 0	0.07± 0.25	0 ± 0
35	*Onthophagus turbatus*	2.77 ±2.47	1.13 ± 1.07	0.23±0.50
36	*Onthophagus unifasciatus*	0.43 ±0.77	0.03 ± 0.18	0 ± 0
37	*Onthophagus urellus*	0.23±0.68	0 ± 0	0 ± 0
38	*Sisyphus longipes*	0.03 ±0.18	0 ± 0	0 ± 0

Table 2. *Indval* values of dung preference of dung beetles towards pig, cattle, goat dung types in a coffee plantation belt in the Nilgiri Biosphere Reserve of South Western Ghats

Dung types	Species	Indval	P value
Pig	*Onthophagus unifasciatus*	0.973	0.001 ***
	O. insignicollis	0.875	0.001 ***
	O. bronzeus	0.843	0.001 ***
	Caccobius unicornis	0.636	0.023 *
	O. furcillifer	0.650	0.022*
Cattle	*Onthophagus pacificus*	0.603	0.023 *
Goat	*Onitis subopacus*	0.636	0.019 *

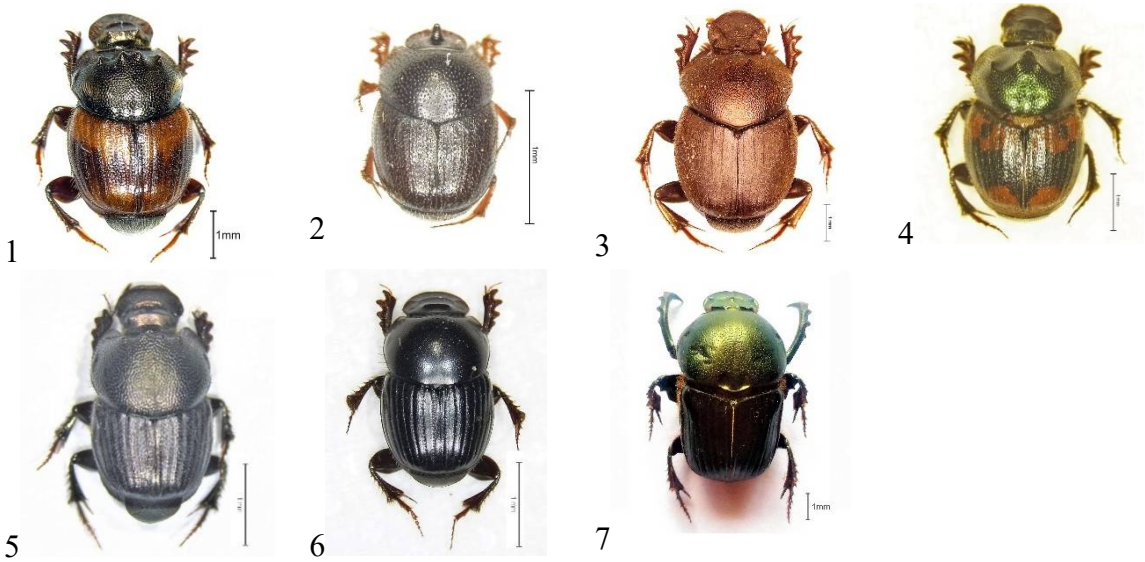

Figure 1: Pig, cattle and goat dung specialists in a coffee plantation belt in the Nilgiri Biosphere Reserve of South Western Ghats. 1) *Onthophagus insignicollis* 2) *Caccobius unicornis* 3) *Onthophagus bronzeus* 4) *O. unifasciatus* 5) *O. furcilifur* 6) *O. pacificus* 7) *Onitis subopacus*

CONCLUSION

In the present study we found that dung beetles communities displayed low dung specificity and high generalism in a coffee agriculture belt in the south Western Ghats of India. However, high species richness, majority of specialists and rare species in pig dung indicates the significance of this omnivore dung for the survival of specialists and rare species.

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COMPETING INTERESTS

The authors have declared that no competing interest exists.

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