



## ATTRACTIVENESS OF DUNG BEETLES TO DIFFERENT TYPES OF DUNG IN A COFFEE PLANTATION

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### ABSTRACT

The attractiveness of dung beetles to the dung of pigs (omnivores), cattle and goats (herbivores) 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 a 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. A high abundance of non specialists with no preference was recorded. Based on Indval analysis, five species namely, *Onthophagus unifasciatus* Schaller, *O. insignicollis* Frey, *O. bronzeus* Arrow, *O. furcillifur* Bates and *Caccobius unicornis* F were observed as specialists in pig dung and *Onthophagus pacificus* Lansberge and *Onitis subopacus* Arrow were as specialists in cattle and goat dung, respectively.

**Key words:** Dung beetles, *Onthophagus* sp., coffee plantations, dung preference, South Western Ghats, *Caccobius*, *Onitis*, cattles pig, goat, specialists

Dung beetles belong to the subfamily of Scarabaeinae (Insecta: Coleoptera: Scarabaeidae) and are characterized by their use of feces at both the larval and adult stages (Scheffler, 2002). By feeding on feces, 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 feces (Halfpeter and Matthews, 1966). Large and diverse mammal fauna are crucial for maintaining diverse dung beetle fauna (Klein, 1989; Hanski and Cambefort, 1991; Estrada et al., 1998; Escobar, 2004; Tshikae et al., 2008). Decline in mammal populations has cascading effects on ecosystem functioning provided by dung beetles (Nichols et al., 2016; Raine et al., 2018; Raine and Slade, 2019). Dung beetles partition their food and breeding resources according to their physico-chemical characteristics, such as odour profile, fibre size, dropping size, water content, feces texture and nutritional quality (Halfpeter and Matthews, 1966; Hanski and Cambefort, 1991; Halfpeter and Edmonds, 1982; Dormont et al., 2004). 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 (Correa et al., 2016). Moreover, moisture content and quality of dung is maintained for a longer period under the shade

which enables better colonization of dung beetles (Horgan, 2005; Escobar et al., 2007). Many studies recorded distinct trophic preference of dung beetles for omnivorous mammal feces in Neotropical (Estrada et al., 1993; Filgueiras et al., 2009; Marsh et al., 2013; Bogoni and Hernandez, 2014; Raine et al., 2018), Australian (Hill, 1996; Vernes et al., 2005), African (Davis, 1994; Tshikae et al., 2008; Davis et al., 2010) and Oriental forests (Sabu, 2012; Sathiandran et al., 2021). Studies from Palaearctic agriculture fields showed differences in the abundance of beetles among various herbivorous dung types (Lumaret and Iborra, 1996; Martin-Piera and Lobo, 1996; Galante and Cartagena, 1999; Finn and Giller, 2002). Dung specificity of dung beetles towards different dung types in the agribelts is virtually non-existent from Indian mainland. This study aims to explore dung beetle attraction and trophic preferences to different dung types in a shaded coffee plantation in the Nilgiri Biosphere Reserve.

### MATERIALS AND METHODS

The study was carried out in a shaded coffee plantation belt at Ambalavayal ((11.6073° N and 76.2284° E) in the Wayanad region (Kerala) of Nilgiri Biosphere Reserve (NBR) of the South Western Ghats (SWG). Ninety pit fall traps (3 dungs x 10 pitfall traps

x 3 seasons) made of plastic basin (10 cm diameter, 15 cm depth), spaced at 50m interval between traps were placed to minimize trap interference (Larsen and Forsyth 2005). Newly defecated dung of omnivore (pig) and herbivore (goat and cattle) (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 hr and preserved in 70% alcohol and identified to species levels using keys of Arrow (1931) and Balthasar (1963), and by comparing with type specimens available in the Zoological Survey of India, Western Ghats regional station, Calicut. Attraction of dung beetles to different dung types were assessed based on the indicator species value (ISV) using Indicator Value Method

(Indval) (Dufrene and Legendre, 1997). Indicator species analysis was performed in R software (Cáceres and Legendre, 2009). As the data were not normally distributed, non-parametric statistics (Mann-Whitney U tests) after comparison through Kruskal-Wallis H tests were used for pair wise comparison of data. All statistical analyses were done with Megastat version 10.3 (Orris, 2005).

## RESULTS AND DISCUSSION

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* Boucomont was the prominent species in all dung types

Table 1. Abundance (Mean± SD) and Indval values of dung preference of dung beetles associated with the three mammalian dung types in the coffee plantation belt of the South Western Ghats

Sl No.	Species	Pig mean± SD	Cattle mean± SD	Goat mean± SD	Indval	P value
1	<i>Caccobius meridionalis</i>	1.53± 2.34	1.20± 1.40	0.67± 0.96		
2	<i>Caccobius ultor</i>	0.03± 0.18	0 ± 0	0± 0		
3	<i>Caccobius unicornis</i>	0.47± 1.17	0 ± 0	0± 0	0.636	0.023 *
4	<i>Catharsius molossus</i>	1.23± 1.87	0.33± 0.71	0± 0		
5	<i>Catharsius sagax</i>	0.40± 0.67	0.40± 0.62	0.17± 0.38		
6	<i>Paracopris davisoni</i>	3.80± 6.17	2.57± 3.07	1.50± 2.03		
7	<i>Copris repertus</i>	0.53± 0.82	0.50± 0.73	0.07± 0.25		
8	<i>Tibiodrepanus setosus</i>	0± 0	0.10± 0.31	0± 0		
9	<i>Ochicanthon laetus</i>	0.03± 0.18	0 ± 0	0± 0		
10	<i>Ochicanthon tristis</i>	0± 0	0.03± 0.18	0± 0		
11	<i>Oniticellus cinctus</i>	0± 0	0 ± 0	0.03± 0.18		
12	<i>Onitis falcatus</i>	0± 0	0.10± 0.31	0.03± 0.18		
13	<i>Onitis subopacus</i>	0± 0	0.03± 0.18	0.27± 0.69	0.636	0.019 *
14	<i>Onitis virens</i>	0± 0	0.03± 0.18	0.20± 0.61		
15	<i>Onthophagus amphicoma</i>	0.23± 0.50	0.17± 0.46	0.13± 0.35		
16	<i>Onthophagus andrewesi</i>	1.07± 1.17	1.17± 1.70	0.43± 0.86		
17	<i>Onthophagus bifasciatus</i>	0.23± 0.50	0.20± 0.41	0± 0		
18	<i>Onthophagus bronzeus</i>	0.50± 0.97	0.03± 0.18	0± 0	0.843	0.001 ***
19	<i>Onthophagus cervus</i>	0.07± 0.25	0± 0	0± 0		
20	<i>Onthophagus dama</i>	2.30± 2.59	1.33± 2.14	0.10± 0.40		
21	<i>Onthophagus devagiriensis</i>	0.10± 0.40	0.10± 0.40	0.13± 0.43		
22	<i>Onthophagus discedens</i>	0.03± 0.18	0± 0	0.07± 0.25		
23	<i>Onthophagus duporti</i>	0.10± 0.55	0± 0	0± 0		
24	<i>Onthophagus fasciatus</i>	4.40± 3.60	4.03± 3.97	1.97± 2.59		
25	<i>Onthophagus faveri</i>	2.37± 2.36	0.57± 0.97	0.57± 0.86		
26	<i>Onthophagus furciligur</i>	0.17± 0.46	0± 0	0 ± 0	0.650	0.022*
27	<i>Onthophagus insignicollis</i>	0.83± 1.18	0.07± 0.25	0± 0	0.875	0.001 ***
28	<i>Onthophagus kchatriya</i>	0.07± 0.25	0± 0	0± 0		
29	<i>Onthophagus lilliputanus</i>	0.03± 0.18	0.03± 0.18	0± 0		
30	<i>Onthophagus ludio</i>	0.07± 0.25	0 ± 0	0± 0		
31	<i>Onthophagus pacificus</i>	0.03± 0.18	0.10± 0.31	0± 0	0.603	0.023 *
32	<i>Onthophagus socialis</i>	0.03± 0.18	0 ± 0	0± 0		
33	<i>Onthophagus tnai</i>	0± 0	0.03± 0.18	0± 0		
34	<i>Onthophagus truncaticornis</i>	0± 0	0.07± 0.25	0± 0		
35	<i>Onthophagus turbatus</i>	2.77± 2.47	1.13± 1.07	0.23± 0.50		
36	<i>Onthophagus unifasciatus</i>	0.43± 0.77	0.03± 0.18	0± 0	0.973	0.001 ***
37	<i>Onthophagus urellus</i>	0.23± 0.68	0± 0	0± 0		
38	<i>Sisyphus longipes</i>	0.03± 0.18	0± 0	0± 0		

(Table 1). Overall abundance of dung beetles was high in pig followed by cattle and goat dung types ( $H=82.39$ ,  $df=2$ ,  $p<0.05$ ). Thirteen rare species (singletons, doubletons) were recorded including *Caccobius ultor* Sharp, *Ochicanthon laetus* Arrow, *O. tristis* Arrow, *Oniticellus cinctus* Fabricius, *Onthophagus cervus* Fabricius, *O. discedens* Sharp, *O. kchatriya* Boucomont, *O. lilliputanus* Lansberge, *O. ludio* Boucomont, *O. socialis* Arrow, *O. tnai* Nithya and Sabu, *O. truncaticornis* Schaller and *Sisyphus longipes* Olivier. 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, *O. 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 1, Fig. 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 non specialists are seen indicating low dung specificity in the plantation. Specialists reported are the most vulnerable species. 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 these dung types to complete their life cycle and to attain the abundance recorded. If the specific dung types are not available, dung specialists may sustain on other dung types possibly on the omnivore dung of domestic dogs and cats, as well as 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 (Frank et al., 2018; Raine et al., 2018; Ong et al., 2020; Sathiandran et al., 2021). 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 (Raine et al., 2018; Ong et al., 2020). Among the pig dung specialists, *Caccobius unicornis* is a rare species in the forest and agri-landscapes in the moist South Western Ghats (Sabu et al., 2011). 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 *C. unicornis*.

A high abundance of non specialists with flexible food preferences is recorded in the coffee plantations. Flexibility in the food preferences of coprophagous insects were stressed in many studies (Finn and Giller, 2002; Dormont et al., 2004; Frank et al., 2018, Ong et al., 2020; Sathiandran et al., 2021). Hanski and Cambefort (1991) also reported dung beetles were generally opportunistic with respect to exploitation of wide variety of dung types and absence of extreme specialization

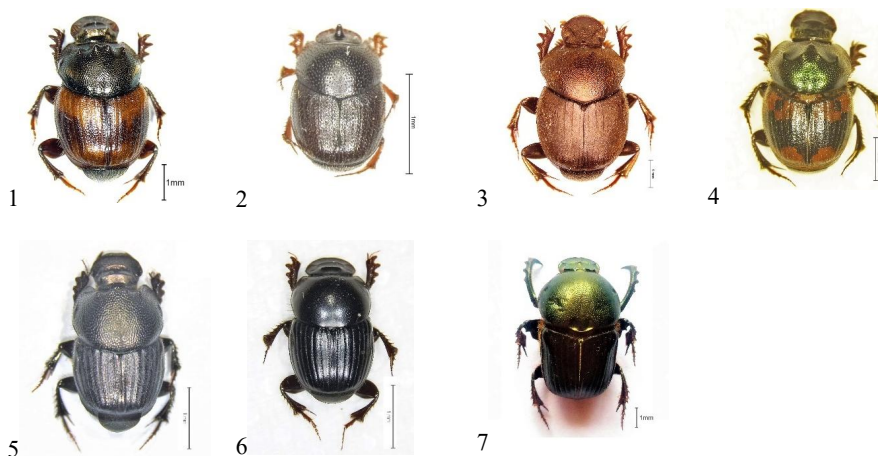


Fig. 1. Specialist dung beetles in a coffee plantation belt in the Nilgiri Biosphere Reserve of South Western Ghats. 1) *Onthophagus insignicollis* 2) *Caccobius unicornis* 3) *Onthophagus bronzeus* 4) *O. unifasciatus* 5) *O. furcilifur* 6) *O. pacificus* 7) *Onitis subopacus*

is arising from the scarcity of dung resources. The thirteen rare beetle species whose Indval values and dung preferences cannot be determined are the less prominent dung beetles in the forests and agrilandscapes (Sabu et al., 2011). Braga et al. (2013) 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 a 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 attracts more diverse and rare dung beetle species than herbivore dung in coffee plantations, likely due to the preference of beetles for omnivorous mammal feces. This strong attraction to pig dung is linked to its distinct physicochemical properties, such as the type of fiberfibre, the presence of volatile compounds (odor), water content, and the resources it contains. These properties differ depending on the animal's digestive system (Noriega, 2012). Moreover, omnivore dung is more nutritious than dung from megaherbivores, meaning that smaller quantities are sufficient to attract beetles (Davis et al., 2000). Mobile adult beetles are especially drawn to nitrogen-rich omnivore dung to satisfy their nutritional needs, while they use the more abundant, carbohydrate-rich herbivore dung to nourish their offspring (Hanski and Cambefort, 1991; Halffter and Matthews, 1966; Seena and Priyadharsanan, 2016). Similar results of high species richness, abundance, exclusive presence of specialists and rare dung beetle in boar dung from forest regions of Western Ghats were recorded earlier (Sabu, 2011; Sathiandran et al., 2021). Non-availability of omnivore dung types may alter competitive interactions between dung beetle species and may even cause local extinction of highly specialized species and the rare species. So in the present study, dung beetle communities displayed low dung specificity and high generalism in the coffee agriculture belt of the Nilgiri Biosphere Reserve in the south Western Ghats of India. However, high species richness, majority of specialists and rare species in pig dung indicates the significance of omnivore pig dung for the survival of specialists and rare species.

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#### AUTHOR CONTRIBUTION STATEMENT

SKT designed the research. Sample collection, preliminary sorting and species level identification done by SBJ. Data analysis, interpretation and writing part done by NS and SBJ. All authors read and approved the manuscript.

#### CONFLICT OF INTEREST

No conflict of interest.

#### REFERENCES

- Arrow G J. 1931. The Fauna of British India including Ceylon and Burma, Coleoptera: Lamellicornia (Coprinae), Taylor and Francis, London. Vol III, 428 pp.
- Balthasar V. 1963. Monographie der Scarabaeidae und Aphodiidae der Palaearktischen und Orientalischen Region (Coleoptera: Lamellicornia). Verlag der Tschechoslowakischen Akademie der Wissenschaften, Prague Volume I, 391 pp; Volume II, 627 pp.
- Bogoni JA, Hernandez MIM. 2014. Attractiveness of native mammal's feces of different trophic guilds to dung beetles (Coleoptera: Scarabaeinae). *Journal of Insect Science* 14: 299.
- Braga R F, Korasaki V, Andresen E, Louzada J. 2013. Dung beetle community and functions along a habitat-disturbance gradient in the Amazon: A rapid assessment of ecological functions associated to biodiversity. *PLoS ONE* 8(2): e57786.
- Cáceres M D, Legendre P. 2009. Associations between species and groups of sites: Indices and statistical inference. *Ecology* 90(12): 3566-3574.
- Correa C M A, Puker A, Korasaki V, Ferreira K R, Abot A R. 2016. The attractiveness of baits to dung beetles in Brazilian Cerrado and exotic pasturelands. *Entomological Science* 19: 112-123.
- Davis A L V. 1994. Habitat fragmentation in southern Africa and distributional response patterns of five specialist or generalist dung beetle families (Coleoptera). *African Journal of Ecology* 32: 192-207.
- Davis A J, Huijbregts J, Krikken J. 2000. The role of local and regional processes in shaping dung beetle communities in tropical forest plantations in Borneo. *Global Ecology and Biogeography* 9: 281-292.
- Davis A L V, Scholtz H C, Kryger U, Deschodt M C, Strumpher P W. 2010. Dung beetle assemblage structure in Tswalu Kalahari Reserve: Responses to a Mosaic of landscape types, vegetation communities, and dung types. *Environmental Entomology* 39(3): 811-820.
- Dormont L, Epinat G, Lumaret J P. 2004. Trophic preference mediated by olfactory cues in dung beetles colonizing cattle and horse dung. *Environmental Entomology* 33: 370-377.
- Dufrêne M, Legendre P. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monograph* 67: 345-366.

- Escobar F. 2004. Diversity and composition of dung beetle (Scarabaeinae) assemblages in a heterogeneous Andean landscape. *Tropical Zoology* 17: 123-136.
- Escobar F, Halfiter G, Arellano L. 2007. From forest to pasture: An evaluation of the influence of environment and biogeography on the structure of dung beetle (Scarabaeinae) assemblages along three altitudinal gradients in the Neotropical region. *Ecography* 30: 193-208.
- Estrada A, Coates-Estrada R, Anzures A, Cammarano P. 1998. Dung and carrion beetles in tropical rainy forest fragments and agricultural habitats at Los Tuxtlas, Mexico. *Journal of Tropical Ecology* 14: 577- 593.
- Estrada A, Halfiter G, Coates-Estrada R, Merritt D A. 1993. Dung beetles attracted to mammalian herbivore (*Alouatta palliata*) and omnivore (*Nasua narica*) dung in the tropical rain forest of Los Tuxtlas, Mexico. *Journal of Tropical Ecology* 9: 4-54.
- Filgueiras B K C, Liberal C N, Aguiar C D M, Hernández M I M, Iannuzzi L. 2009. Attractivity of omnivore carnivore and herbivore mammalian dung to Scarabaeinae (Coleoptera Scarabaeidae) in a tropical Atlantic Forest remnant. *Revista Brasileira de Entomologia* 53: 422-427.
- Finn J, Giller P S. 2002. Experimental investigations of colonisation by north temperate dung beetles of different types of domestic herbivore dung. *Applied Soil Ecology* 20: 1-13.
- Frank, Kevin, Krell, Frank-Thorsten, Slade, Eleanor M, Raine, Elizabeth H, Chiew, Li Yuen, Schmitt, Thomas, Vairappan, Charles S, Walter, Philippe, Blüthgen, Nico, Novotny, Vojtech 2018. Global dung webs: high trophic generalism of dung beetles along the latitudinal diversity gradient. *Ecology Letters* 21(8): 1229-1236.
- Galante E, Cartagena C. 1999. Comparison of Mediterranean dung beetles (Coleoptera: Scarabaeidae) in cattle and rabbit dung. *Environmental Entomology* 28: 420-424.
- Halfiter G, Edmonds W D. 1982. The nesting behaviour of dung beetles (Scarabaeinae): an ecological and evolutionary approach. *Instituto de Ecologia, Mexico*. 176 p.
- Halfiter G, Mathews E G. 1966. The natural history of dung beetles of the sub family Scarabaeinae (Coleoptera, Scarabaeidae). *Folia Entomológica Mexicana* 12(14): 1-132.
- Hanski I, Cambefort Y. 1991. *Dung beetle ecology*. Princeton University Press, Princeton.
- Hill C J. 1996. Habitat specificity and food preferences of an assemblage of tropical Australian dung beetles. *Journal of Tropical Ecology* 12: 449-460.
- Horgan F G. 2005. Effects of deforestation on diversity, biomass and function of dung beetles on the eastern slope of the Peruvian Andes. *Forest Ecology and Management* 216: 117-133.
- Klein B C. 1989. Effects of forest fragmentation on dung and carrion beetle communities in central Amazonia. *Ecology* 70: 1715-1725.
- Larsen T H, Forsyth A. 2005. Trap spacing and transect design for dung beetle biodiversity studies. *Biotropica* 37(2): 322-325.
- Lumaret J P, Iborra O. 1996. Separation of trophic niches by dung beetles (Coleoptera, Scarabaeoidea) in overlapping habitats. *Pedobiologia* 40: 392-404.
- Marsh C J, Louzada J, Beiroz W, Ewers R M. 2013. Optimising bait for pitfall trapping of Amazonian dung beetles (Coleoptera: Scarabaeinae). *PLoS One* 8(8): e73147.
- Martin-Piera F, Lobo J M. 1996. A comparative discussion of the trophic preferences in dung beetles communities. *Miscellanea Zoologica* 19: 13-31.
- Nichols E, Spector S, Louzada J, Larsen T, Amezcuita S, Favila M E. 2016. Ecological functions and ecosystem services provided by Scarabaeinae dung beetles. *Biological Conservation* 132(1): 103–114.
- Noriega J A. 2012. Dung beetles (Coleoptera: Scarabaeinae) attracted to *Lagothrix lagotricha* (Humboldt) and *Alouatta seniculus* (Linnaeus) (Primates: Atelidae) dung in a Colombian Amazon Forest. *Psyche*, Article ID: 437589.
- Ong X R, Slade E M, Lim M L M. 2020. Dung beetle-megafauna trophic networks in Singapore’s fragmented forests. *Biotropica* 52(5): 818-824.
- Orris J B. 2005. *Megastat version 10.0*. Butler University, College of Business Administration, 4600 Sunset Ave, Indianapolis. Distributed by McGraw-Hill.
- Raine E H, Mikich S B, Lewis O T, Riordan P, Vaz-de-Mello F Z, Slade E M. 2018. Extinctions of interactions: quantifying a dung beetle–mammal network. *Ecosphere* 9(11): e02491.
- Raine E H, Slade E M. 2019. Dung beetle –mammal associations: methods, research trends and future directions. *Proceedings of the Royal Society B: Biological Sciences* 286: 20182002.
- Sabu T K. 2011. Guild structure, taxonomic diversity and biosystematics of dung beetles (Coleoptera: Scarabaeinae) in the Agriculture and Forest Habitats of South Western Ghats. Project report submitted to University Grant Commission, India.
- Sabu T K. 2012. Dung specificity, guild structure, seasonality and species composition of dung beetles (Coleoptera: Scarabaeinae) associated with the dung droppings of major mammals (elephant, gaur, wild boar, deer and macaque) and composition of arboreal dung beetles in the wet and dry forests of the Western Ghats. Project report submitted to Ministry of Environment and Forests.
- Sabu T K, Nithya S, Vinod K V. 2011. Faunal survey, endemism and possible species loss of Scarabaeinae (Coleoptera: Scarabaeidae) in the western slopes of the moist South Western Ghats, South India. *Zootaxa* 2830: 29-38.
- Sathindran N, Vineesh P J, Thomas S K. 2021. Dung preferences and trophic association of dung beetles (Coleoptera: Scarabaeidae) in the moist forests of the south-Western Ghats of the Indian Subcontinent. *Journal of Asia-Pacific Entomology* 24: 739-748.
- Scheffler P Y. 2002. *Dung beetle (Coleoptera: Scarabaeidae) ecology in the intact and modified landscape of Eastern Amazonia*. Ph.D. Thesis submitted to Pennsylvania State University.
- Seena N K, Priyadarsanan D R. 2016. Report of dung beetles (Scarabaeidae: Scarabaeinae) attracted to unconventional resources, with the description of three new species. *Entomon* 41(4): 265–282.
- Tshikae B P, Davis A L V, Scholtz C H. 2008. Trophic association of a dung beetle assemblage (Scarabaeidae: Scarabaeinae) in a Woodland Savanna of Botswana. *Environmental Entomology* 37: 431-441.
- Vernes K, Pope L C, Hill C J, Barlocher F. 2005. Seasonality, dung specificity and competition in dung beetle assemblages in the Australian Wet Tropics, north-eastern Australia. *Journal of Tropical Ecology* 21: 1-8.

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