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THE DIVERSITY OF TRUE DUNG BEETLES (COLEOPTERA: SCARABAEIDAE) IN LARGE MAMMAL DUNG WITHIN THE WASGOMUWA NATIONAL PARK, SRI LANKA

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Abstract
This paper reports the species richness and abundance of true dung beetles (Family Scarabaeidae: subfamily Scarabaeinae) in the Wasgomuwa National Park, Sri Lanka. This survey was conducted during the prolonged dry season using active and passive methods of sampling and revealed the presence of 25 species (637 individuals), including one endemic, *Onthophagus martialis*, representing eight genera. This finding is interesting as it suggests the possibility that this forest is equally as rich in dung beetles as forests of the wet zone reported by others. There was considerable disparity in abundance among the genera and species. The best represented genus was *Onthophagus* with a total of 16 species, whilst the most common species, with 159 individuals, was *O. pygmaeus.* All dung beetle species were unevenly distributed within the park. The information generated on this ecologically important group can be used to determine the true conservation value of the dry zone protected areas.

***Key words*:** Abundance, occurrence, *Onthophagus*, *Scarabaeinae*, species richness

Introduction

The dung beetles referred to in this paper are the true dung beetles that belong to the subfamily Scarabaeinae (in the Family Scarabaeidae) and are solely dependent on dung for survival. The dung beetles have a greater importance than other coleopterans, in terms of ecological functions such as nutrient recycling, seed dispersal, improving soil structure and in the control of pests and parasites (Cambefort, 1991). Despite their significance, these beetles have been poorly investigated in Sri Lanka. Prior to the year 2000 only three studies have documented evidence of the presence of dung beetles on the island. The first record of dung

beetles in Sri Lanka is by Arrow in 1931, where he documented the presence of 81 species. The other two were by Balthasar (1963) who recorded 50 species and Gillet (1924) who reported the presence of 47 species. More recently, however, two separate studies carried out on dung beetles have reported 22 species not previously recorded (Kudavidanage, 2011; Lekamge, 2014). At present the number of dung beetles recorded from the island stands at 103 species (provisional list for Sri Lanka in Kudavidanage & Lekamge, 2012). The identity of a further 14 morphotypes is yet to be confirmed; a few of them would most likely be new species (Kudavidanage, 2011). Of the 103 species, 21 (i.e. 20%) are endemic to the island (Kudavidanage & Lekamge, 2012). As evident in other faunal taxa, one could expect dung beetles to also show zonal distributional patterns across the island. One broad study has covered the variation of dung beetle communities across the island (Lekamge, 2014), while another has specifically focused on ascertaining the composition of dung beetle communities in the Sri Lanka's rainforests (Kudavidanage, 2011).

No study has yet attempted to characterize dung beetle communities in any of the dry zone forests of the island. This study therefore attempted to study the diversity and abundance of dung beetles found in one of the largest dry zone forests in Sri Lanka, the Wasgomuwa National Park (WNP), during the prolonged dry season.

Material and methods

***Study site*:** The WNP, 39385 ha in extent, located in a seasonally dry area referred to as the dry zone of Sri Lanka, is bordered by three rivers (Kalu, Amban and Mahaweli) and lies within the two districts of Matale and Polonnaruwa (7°43′0″N, 80°56′0″E). The park has a dry hot monsoon climate and experiences a dry spell from May to September. The annual temperature of the park is reported to be 32 ^{o}C and the annual rainfall is between 1250–1900 mm. The park has a vast array of habitat types (dry-mixed evergreen forest, riverine forest, scrub, rock outcrops), of which the dry-mixed forest predominates (Green, 2008). This national park serves as an ideal assembly of resources for dung beetles as it supports a high diversity of large mammals and comprises a mosaic of vegetation types.

***Dung beetle survey*:** The survey was conducted from April to September, the months of the prolonged dry season, in 2012. Data was collected using both active and passive methods. Passive collections were done along jeep tracks and further within the other areas of the park. The dung pats that were found were thoroughly searched for the presence of dung beetles. Additionally, the soil for a few centimeters below the dung pat was also searched. Active collections were done using 125 pitfall traps–plastic transparent cups (200 ml) baited with five different types of mammalian dung (elephant, cervids, leopard, bear and buffalo). A constant volume of dung was placed in all traps, which were left open for 24 h. Pitfalls were placed in all major habitat types within the national park. Traps were located at least 5 m apart. Collections were done by covering the top of the dung pile or cup with a polythene sheet and taking the dung pat or cup along with it. This reduced the chances of escape of the trapped animals. The samples were transported to the camp for identification which was based on available keys.

Results

A total of 637 true dung beetles of the subfamily Scarabaeinae representing eight genera and 25 species were recorded from within the WNP (Appendix 1). It is noteworthy that only one species i.e. *Onthophagus martialis* Boucomont, 1914 is endemic to Sri Lanka. A total of 14 of the species and 180 individuals were collected using the passive method i.e. field searches of dung pats (n=53 dung pats), while a total of 22 species and 455 individuals were collected by active sampling (pitfall traps). It is interesting that three of the species, *O. rectecornutus* Lansberge, 1883, *O. gazella* Fabricius, 1787 and *Onitis philemon* Fabricius, 1801 were recorded only from the dung pats but not from traps. Capture rates of 0.27 and 0.18 species and 3.12 and 3.64 individuals, respectively, were recorded for dung pats and pit fall traps.

There was a marked disparity in the abundance of the various genera and species. The most well represented genus, by virtue of the greater number of species, was *Onthophagus*, with as many as 16 species. Within this genus the most common species was *O. pygmaeus* Schaller, 1783 with 159 individuals. The other relatively common species were *O. negligens* Walker, 1858 and *O. favrei* Boucomont, 1914 (n>15).

Some species, *O. cervus* Fabricius, 1798 and *O. quadridentatus* Fabricius, 1798 were rare, with only one individual of each species being recorded during the survey. Two species of *Onthophagus* have yet to be identified. With regard to the other genera, *Sisyphus longipes* Olivier, 1789 was represented by a comparatively high number of individuals whilst *Paragymnopleurus melanarius* Harold, 1867 and *Catharsius pethecius* Fabricius, 1775 recorded only one individual each during the survey.

The Shannon-Weiner diversity Index $H' = Pi (log Pi)$ and Evenness $J' = H'/log S$, where *Pi* indicates the number of observations made of a given species as a proportion of the total number of observations, and *S* is the total number of species recorded (Zar, 1984), was calculated for the entire park. The Shannon-Weiner diversity index was 1.05, whilst the Evenness value was 0.75. Additionally, the percentage occurrence i.e. the percentage of dung pats or pitfalls in which a given species was present was calculated for each of the species, as it gives some indication of their distribution within the park. Based on this, four species had a relatively high occurrence value (over 10%) while eight species had extremely low occurrence values (around 1 %). Three of the four functional groups i.e. tunnelers, rollers and dwellers were represented by the true dung beetles recorded at WNP. Of these, the majority, both in terms of the percentage of species and individuals, were the tunnelers with 18 species and 464 individuals. The other group, the kleptoparasitic dung beetles, was not recorded during the study.

Discussion

In the present survey the overall species richness of the true dung beetles, i.e. those belonging to the subfamily Scarabaeinae, recorded in the WNP was 25, which is nearly a quarter of the true dung beetle richness recorded for the whole island. This indicates that this forest, with its characteristic tropical monsoon forest type vegetation, supports a relatively high species richness of dung beetles, which could be observed even during the dry season. All the species recorded in the present study (other than the three awaiting identification) have been previously recorded in the island. That species richness among the dung beetles in a dry zone forest, as evident from the present survey, is nearly equal to that in forests of the wet zone, is apparent when comparing the value obtained for WNP (a single park), with the results of a previous study of three rainforest fragments. The latter study documents a total species richness of 24 in the wet zone forests (Kudavidanage, 2011). This is not in accord with the overall pattern observed for the dry and wet zone richness in other faunal taxa – for vertebrate groups such as the fish, amphibians, birds, mammals, and for invertebrates such as butterflies and snails – where the wet zone has a markedly richer species assemblage than the dry zone (IUCN/WCMC, 1997; Bambaradeniya, 2006). One of the plausible explanations for this trend observed with the dung beetles in WNP is its relatively higher diversity of large mammals. It has been found that the primary suppliers of food resources for these true dung beetles that rely entirely on dung are large mammals (Nichols *et al*., 2009). Even though the wet zone is said to be rich in overall mammalian diversity, the dry zone forest contains the highest diversity of large mammals. This is particularly so for WNP, which supports large populations of species of cervids, elephants, wild buffalos, and bear (Green, 2008). Manifestation of rich dung beetle communities with increasing large mammal diversity has been evident in Africa and South America (Ridshill-Smith & Edwards, 2011). Combined with this diverse dung types WNP also contains a mosaic of vegetation types allowing more beetle species to co-exist in this dry zone protected area.

Contrasting results were, however, seen with abundance. The present study at WNP, which was carried out during the dry season, yielded 3.6 dung beetles per trap which is markedly lower than that recorded in primary forests in the wet zone (26 dung beetles per trap: Kudavidanage, 2011). WNP lacks large water sources although many small water holes, which shrink during dry weather, are available. Hence, one of the probable explanations for the lower abundance of dung beetles during the dry season in this forest is the migration of the large mammals to more permanent water sources such as reservoirs, located outside the park.

Focusing on the individual species of true dung beetles recorded during the present study, it is apparent that there were marked disparities between the abundance of the different species, very likely due to the interspecific differences in habitat preference (Vinod & Sabu, 2007). The

most represented genus, by virtue of the greater number of species, was *Onthophagus* (60%) which is reported to have a wide distribution in the island (Kudavidanage & Lekamge, 2012). The most common species was *O. pygmaeus* which is also reported to be relatively common (Arrow, 1931). The identity of three species, two belonging to the genus *Onthophagus* and one to *Caccobius*, is yet to be confirmed; one closely resembles *O. amphinasus* Arrow, 1931 (as suggested by Kudavidanage & Lekamge, 2012 in their previous work), which has not been described for Sri Lanka as yet. It is significant that the prior report of this morphotype is from the wet zone. It is also noteworthy that *Paragymnopleurus melanarius* Harold, 1867, the largest roller recorded from the wet zone and which shows a wide distribution in that zone (Kudavidanage, 2011), was recorded only once in the present study, suggesting that it is rarer in the dry zone.

Although the species richness of dung beetles was high in WNP, the diversity value (which takes into account both species richness and abundance) was lower (1.05) than that recorded for the wet one (2.34; Kudavidanage, 2011). This was also confirmed by the low evenness (0.75) and percentage occurrence values (less than 10% for most species) recorded for WNP in comparison to that recorded for the wet zone. These values indicate that the dung beetles in WNP were not homogenously distributed across the park. A fact to note is that dung beetles, in addition to the dung, are also influenced by habitat characteristics (Hanski & Cambefort, 1991). The WNP comprises a mosaic of habitats, some being more favourable than others, which are not evenly distributed across the park. For instance, the riverine habitats are restricted to small stretches bordering rivers and streams. Such habitat selection could be expected to be more pronounced during the dry season causing uneven distributions of the beetles.

Although WNP had comparatively high species richness, this included only one endemic species, *Onthophagus martialis*. This species is said to be restricted in its distribution (Kudavidanage, 2011) but was found in reasonable numbers within WNP, suggesting that this dry zone forest may be the preferred habitat for this species. The lack of endemics in the dry zone, where speciation is generally much less, is a general phenomenon seen across all floral and faunal taxa. This has been attributed to the close proximity of the dry zone of Sri Lanka to the southern tip of India and the similar climatic features of the two regions, which prevents reproductive isolation of the species within the dry zone (Erdelen, 1989).

Despite the recent interest in the dung beetles, they still remain a poorly studied group in Sri Lanka in comparison to the other faunal taxa. This survey which provides information on the high level of species richness of the dung beetle community in one of the largest dry zone parks of Sri Lanka highlights that a study of this nature could be crucial in ascertaining the true conservation value of a given protected area in Sri Lanka. Furthermore, the information generated will serve as an important checklist of dung beetle species for WNP as well as for the dry zone parks which could be used for both research and management purposes.

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Appendix 1: The species of true dung beetles recorded during the present survey in the WNP, Sri Lanka. The functional role and the distribution are according to Arrow (1931). SL, Sri Lanka; In, India; SA, South Asia; A, Asia; Af, Afghanistan; Ch, China; Ba, Bangladesh; Ta, Taiwan; E, Endemic; * recorded only from dung pats; T, tunnelers; D, dwellers; R, rollers.

Species	Functional role	Total abundance	Percentage occurrence	Distribution
Onthophagus pygmaeus Schaller, 1783	T	159	30.3	SL, In
O. dama Fabricius, 1798	T	14	5.6	SA
O. spinifex Fabricius, 1781	T	21	6.2	SL, Ba, In, Ch
O. refulgens Arrow, 1931	T	7	2.8	SL, In
O. centricornis Fabricius, 1798	T	8	2.8	SL, In, Af
O. negligens Walker, 1858	T	96	20.2	SL, In
O. martialis Boucomont, 1914 [E]	T	35	8.4	SL
O. favrei Boucomont, 1914	T	63	14.0	SL, In
O. turbatus Walker, 1858	T	22	6.7	SL, In
O. unifasciatus Schaller, 1783	T	10	3.9	SL, In
O. cervus Fabricius, 1798	T	1	0.6	A
O. quadridentatus Fabricius, 1798	T	1	0.6	SA
O. gazella Fabricius, 1787*	T	19	8.4	Global
O. rectecornutus Van Lansberge, 1883*	T	1	0.6	A, Ch, Ta
Onthophagus sp.1	T	1	0.6	SL
Onthophagus sp. 2	T	4	2.2	SL
Onitis philemon Fabricius, 1801*	T	1	0.6	A, Ch
Caccobius sp. 1	D	2	1.1	SL
C. meridionalis Boucomont, 1914	D	2	1.1	SL, In
Catharsius pethecius Fabricius, 1775	T	1	0.6	A
Drepanocerus setosus Wiedemann, 1823	R	2	1.1	SL, In
Sisyphus longipes Olivier, 1789	R	80	9.0	SA
S. hirtus Wiedemann, 1823	R	21	5.6	SL, In
Paragymnopleurus melanarius Harold, 1867	R	1	0.6	A
Copris signatus Walker, 1858	T	65	28.7	SA