TEMPORAL RESOURCE PARTITIONING OF DUNG BEETLES (COLEOPTERA: SCARABAEIDAE: SCARABAEINAE) IN THE DUNG OF TWO COW BREEDS IN A TROPICAL AGROECOSYSTEM

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ABSTRACT

Dung beetles are important taxon as they decompose the excreta of higher animals, especially vertebrates. These coprophagous coleopterans are considered as biological indicators of healthy and clean ecosystems. Present study was aimed to describe the dung beetle diversity of an agroecosystem in Manjapra village, Ernakulam district of Kerala, South India, which is adjacent to forest areas. The study focused on the assessment of scarabs collected by using two different types of dung which is represented by Vechur (VC) and crossbred Jersey (CB) breeds. This was a preliminary study on dung beetle diversity in Vechur cow, a native breed of Kerala which could become extinct due to the increased preference for crossbred varieties. Identification and cataloguing of indigenous dung beetles associated with this native dung type is done for the first time. Since the dung beetle taxon is characterised by greater adaptability, possible strategies were studied with emphasis on its functional and temporal guild patterns. The sampling was carried out using bait-surface-grid pitfall traps with the dung types mentioned. The study recorded of 22 species of dung beetles belonging to six genera (*Onthophagus, Copris, Oniticellus, Paracopris, Tibiodrepanus, Caccobius*) under three tribes (Onthophagini, Coprini, Oniticellini). Temporal resource partition analysis recorded diurnal dung beetle preference towards crossbreed dung and nocturnal ones towards Vechur dung but with no significant difference (P>0.05). Functional guild composition of beetles showed the dominance of tunneller with *Onthophagus favrei* as the most dominant one. This study gives a glimpse on the checklist of dung beetles of the selected area and stresses the need to protect such agricultural patches in residential areas as potent microhabitats for scarabs and the whole insect community.

Keywords: Agroecosystem, crossbred Jersey, dung beetles, Scarabaeinae, Vechur.

ABSTRAK

Kumbang najis merupakan takson yang penting dalam proses penguraian tinja haiwan dalam kumpulan tinggi, khususnya vertebrata. Kumpulan kumbang *coprophagous* ini dikenalpasti sebagai indikator bagi mengesan ekosistem yang sihat dan bersih. Kajian ini bertujuan untuk memperihalkan kepelbagaian kumbang najis dari agroekosistem di kampung Manjapra, daerah Ernakulam, Kerala, selatan India, yang terletak berdekatan dengan kawasan hutan. Kajian ini memfokuskan penilaian jumlah kumbang scarab yang dikumpul menggunakan dua jenis umpan najis lembu dari kacukan Vechur (VC) dan kacukan silang Jersey (CB). Ini merupakan kajian awalan ke atas kepelbagaian kumbang najis pada najis lembu Vechur, kacukan tempatan dari Kerala yang boleh diancam kepupusan disebabkan peningkatan dalam pemilihan varieti kacukan. Pengecamaan dan pengkatalogan kumbang najis yang berasosiasi dengan najis lembu tempatan merupakan kajian yang pertama kali dijalankan. Memandangkan takson kumbang najis yang dicirikan dengan tahap adaptasi yang tinggi, pelbagai starategi telah dikaji dengan penekanan ke atas fungsi dan corak eksploitasi sumber berdasarkan masa. Persampelan telah dijalankan menggunakan perangkap lubang berumpan grid dengan jenis najis yang dinyatakan. Kajian ini berjaya merekodkan 22 spesies dalam enam genus (*Onthophagus, Copris, Oniticellus, Paracopris, Tibiodrepanus, Caccobius*) dan di bawah tiga suku (Onthophagini, Coprini, Oniticellini). Analisis pembahagian sumber berdasarkan masa merekodkan kumbang diurnal menunjukkan pemilihan ke atas najis kumbang silang, dan kumbang nocturnal pula menunjukkan pemilihan ke atas najis Vechur, namun tiada perbezaan yang signifikan ($P>0.05$). Komposisi kumpulan berfungsi kumbang menunjukkan kumbang pembina terowong, *Onthophagus favrei* adalah yang paling dominan. Hasil kajian memberikan penyenaraian ke atas kumbang najis dari kawasan terpilih dan menekankan keperluan untuk memelihara kawasan pertanian di kawasan penempatan manusia sebagai mikrohabitat yang perlu bagi komuniti kumbang scarab dan keseluruhan komuniti serangga.

Kata kunci: Agroekosistem, kacukan silang Jersey, kumbang najis, Scarabaeinae, Vechur.

INTRODUCTION

Massive cross breeding programmes initiated by the Government of Kerala, India from 1950's between indigenous and exotic cattle breeds resulted in significant loss of native cattle population (Chacko 2005). According to the latest census, indigenous cattle constitute only 6% of total cattle in Kerala whereas crossbreds (CB) constitute 94% of the total cattle available in Kerala (Department of animal husbandry and dairying 2019). Jersey breed was introduced into Kerala from Jersey Island of UK and widely accepted across the world because of its increased milk production and climatic adaptations. In 1963, an Indo-Swiss project was started in Kerala using Brown Swiss and Jersey on indigenous cows (Chacko 2005). With the introduction of exotic varieties and cross breeding programmes, Kerala's Vechur cow (VC), World's smallest cattle, had become almost extinct by 1980s. But consistent efforts in 1989 by Kerala Agricultural University helped in saving this precious breed (Iype 2013).

VC breed originated from a place known as Vechur, Kuttanad in Kerala: a low-lying agricultural region where farming is done below the sea level. Vechur cows (VC) belong to the *Bos indicus indicus* category and the Jersey cows belong to *Bos indicus taurus*. Physical and chemical composition of different breeds of herbivore dung varies with species (Martín-Piera & Lobo 1996). Crossbred jersey (CB) dung develops a crust on its surface whereas VC dung is like goat's or sheep's which dries off easily or is able to rehydrate with dew or rain (Lumaret & Kirk 1987; Wassmer 1995). These different dung types are mostly fed by one of the diverse groups of beetles commonly called as dung beetles coming under the family Scarabaeinae with over 6000 known species and 250 genera (Espinoza & Noriega 2018). Several studies have shown that feeding preferences of dung beetles vary between different mammal trophic groups and species (Raine & Slade 2019). These beetles feed and breed on vertebrate faecal matter; in turn being the facilitators of dung decomposition and nutrient recycling. Dung beetles exhibit variations in food preferences since they are facultative specialists. Studies found that these beetles usually feed on vertebrate dung, especially on domestic ungulates (Katona & Coetsee 2019; Rainio 1966). The suitability of dung as an insect food is influenced by the species of animal that produces it (Edwards 1991). Alterations in the habitat affect the dung beetle community through changes in numbers and species of food-producing vertebrate animals (Fincher et al. 1970). The original food source of dung beetles was gradually replaced by dung of domestic animals. The shift from wild herbivore dung to the dung of domesticated animals was easily achieved by most of the dung beetles. Studies proved that this diet shift depends on the size of dung along with other factors like its texture, nutrients, odour etc. (Davis & Philips 2009; Gittings & Giller 1998; Hanski & Cambefort 1991; Holter 2016). The presence of large mammals showing different scat patterns with diverse size and texture can have greater influence in the resource preferences among dung beetles.

Dung beetles were selected as focal taxon for this study as they are abundant, could be easily sampled and identified, play significant ecological roles and are extensively used as bioindicators (Gillet et al. 2016; Nichols& Gardner 2011). They have been identified as one of the most cost-effective groups for biodiversity surveys (Kessler et al. 2012). Dung beetles exhibit different nesting behaviours (Gregory et al. 2015; Hanski & Cambefort 1991; Inward et al. 2011; Shafiei et al. 2001; Simmons & Ridsdill-Smith 2011) and activity periods (Baird et al. 2010; Caveney et al. 1995; Hernández et al. 2011; McIntyre& Caveney 1998). Based on their nesting behaviour, they are divided into three functional groups: rollers or teleocoprids, roll balls of food across the surface of soil; tunnellers or paracoprids, burrow tunnels near or below the food resources and carry food underground; dwellers or endocoprids, they brood within the dung pats or soil-dung interfaces (Cambefort 1991; Halffter & Edmonds 1982). As dung is a patchy resource, strong competition exists between taxa in local assemblages thus playing a major role in structuring these communities (Hanski & Cambefort 1991). Previous research indicates that most dung beetle species show clear patterns in diel activity such as diurnal, nocturnal or crepuscular (Boonrotpong et al. 2012; Davis 1999; Hanski & Krikken 1991; Slade et al. 2007). However, the degree to which these factors contribute to the diversity of dung beetles in a tropical agroecosystem is still vastly understudied. Crop diversity, varied topographies and other anthropogenic activities make every agroecosystem unique and good choice for diversity studies especially for its insect fauna.

This experiment was conducted in a human modified landscape with patches of natural forests adjoining the land. Since one quarter of world's threatened species lives outside protected areas, human modified landscapes become vital for conserving biodiversity of an area (Ekroos et al. 2016; Gray et al. 2016; Jenkins & Joppa 2009; Rodrigues et al. 2004; Troupin & Carmel 2014). Regional differences in the abundance of dung beetles based on the types of vegetation in the ecosystem is also reported (Hanski & Cambefort 1991). Our study considered only true dung beetles, those belonging to the subfamily Scarabaeinae as they feed exclusively on dung (Arrow 1931). This is the first study conducted on the dung beetle assemblage that exploits VC cow dung as a resource. We have carried out standardized survey using constant dung volume and trap spacing for both type of cow dungs as composition of dung beetles captured in traps are affected by dung volume and trap spacing (Haynes & Williams 1993; Heinrich & Bartholomew 1979; Milotic et al. 2019; Santos-Heredia et al.

2018). The objectives of this study were to discover species diversity and abundance of dung beetles attracted to dung originating from a native and a crossbred herbivore dung type; to confirm whether there are any temporal variation in the diversity of beetles exposed to these two dung types and to characterize the dung beetles based on their functional guilds.

MATERIALS AND METHODS

Study Area

This experimental study was set up in an agricultural field in Kerala (10º13'16.7"N 76º 27'05.6"E), during the post monsoon months from December 2018 to May 2019. The study area Manjapra is a village in Angamaly Block in Ernakulam District of Kerala State, India which belongs to the Central Kerala Division. It is located 42 km towards North from the district headquarters Kakkanad and 9 km from Angamaly, 232 km from the state capital Thiruvananthapuram. This study was conducted in the six-acre agroecosystem with Nutmeg, Coconut and Banana as agriculture commodities and the intervening grasslands are used for cattle grazing. The climate is tropical in the study area which has significant rainfall in most months, with a short dry season. Annual temperature of the area ranged from 23^0C - 33^0C and relative humidity from 65-80%. In 2018, the area received an annual precipitation of 3201 mm (Guhathakurta et al. 2020). During the southwest monsoon season (June- September) the state of Kerala had witnessed one of the severe floods inundating the study habitat for a duration of three days. This agroecosystem is surrounded by Western Ghats range of forests which include Sholayar Reserve Forest, Malayattoor Forest, Kodanad Analoode Natural Park, Athirapally and Vazhachal Waterfalls which belongs to the Malayattoor Forest Division.

Experimental Design

To analyze the diversity, guild structure, temporal variation and specificity of beetles attracted to different types of dung; bait-surface-grid pitfall traps were used (Lobo et al. 1988; Veiga et al. 1989). Each trap consisted of plastic basins (28cm in diameter, 11 cm deep), buried to its rim in soil filled with water-liquid soap mixture. Fresh dung was placed on a wire grid (2 cm × 2 cm) at the top of the basin. All the droppings used as baits were taken from the animals grazing locally (Figure 1). Collected dung types were analysed for its moisture content and noted with average values: 15.76% and 12.88% for CB and VC dung respectively. 500 gms of 0-6 hours old fresh dung pats of different mammals were placed on a strip of wire grid. All the sampling sites were exposed to natural field conditions. Each trap was topped with a plastic sheet supported on bamboo sticks to prevent desiccation and inundation during periods of rain. A set of eight diurnal and eight nocturnal traps were placed for each dung type (CB and VC) within the study area. In the six-acres of study habitat traps were placed approximately 50m apart along each transect to prevent the interference from odour of one dung type (Figure 2) (Noriega 2012; Sabu et al. 2011). A total of 16 pitfall traps were used; eight for each dung type. Diurnal sampling was done between 0600 hrs and 1800 hrs while nocturnal sampling was done between 1800 hrs and 0600 hrs. Dung beetles that were trapped in the individual plastic basins were collected and preserved in 100% ethanol.

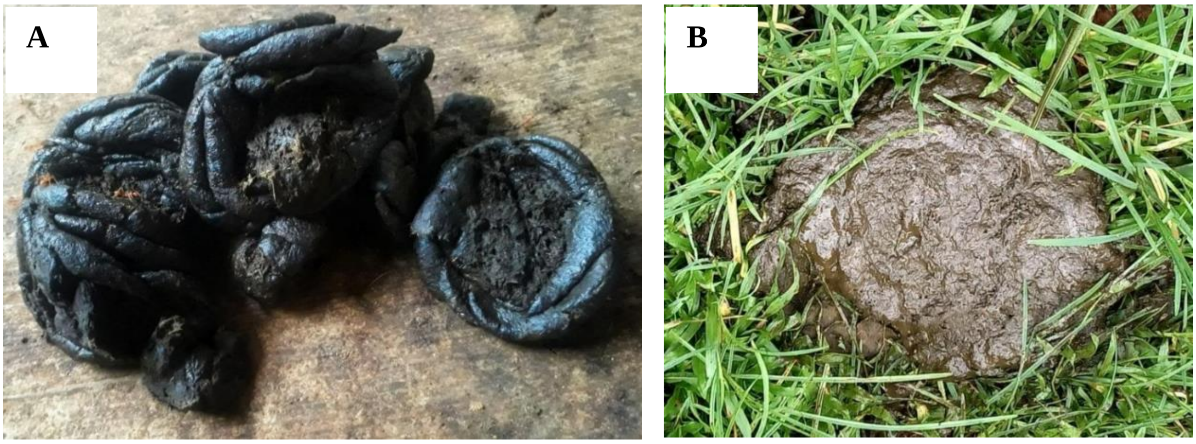

Figure 1. Texture difference of two dung types used for the collection of dung beetles during the study period: A. Vechur dung pat; B. Crossbred Jersey dung pat

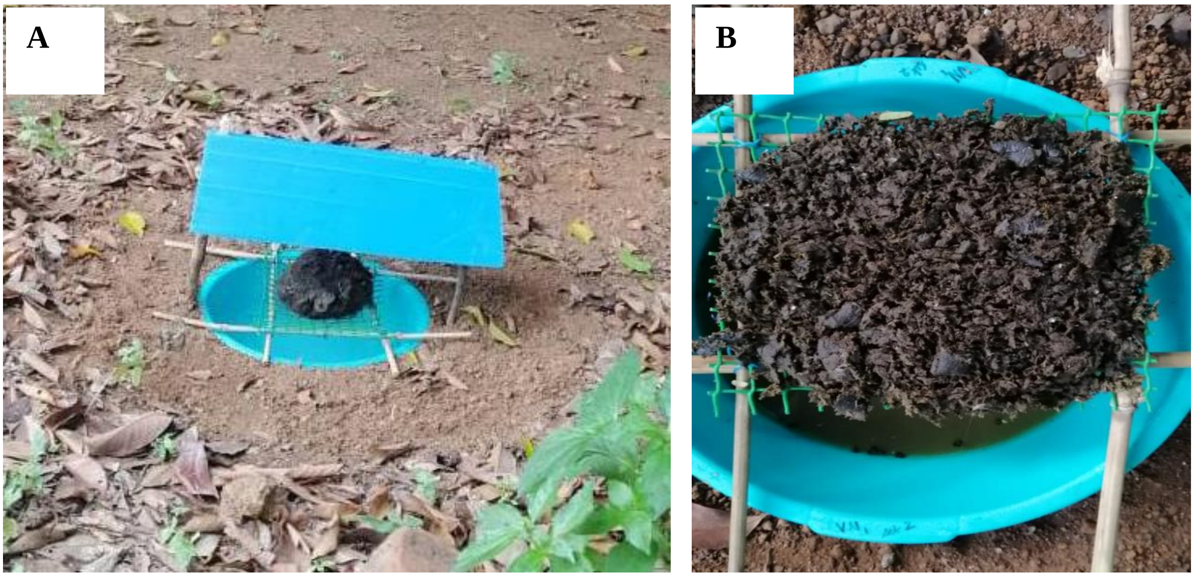

Figure 2. A. Dung baited pitfall trap installed for the collection of dung beetles in the selected agroecosystem during the study period; B. Basic pattern of dung degradation by the dung beetles attracted in response to the selected dung types

Species Identification

The collected dung beetles were observed, identified and captured using CMOS Camera mounted on Magnus Stereo Zoom Microscope. Collected beetles were identified to species level using Arrow (1931), Balthasar (1963) and Cambefort (1985).

Data Analysis

Number of taxa (*S*), mean number of individuals (*n*), dominance (1-Simpson index), Evenness (Simpson index (1-D)), diversity (Shannon Weiner index (H´)), ANOSIM were calculated using PAST Statistical Software (PAST version 3.23). Species dominance index (1-Simpson index) ranges from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely). Simpson index (1-D) measures 'evenness' of the community from 0 to 1. Shannon Weiner index (H´) - diversity index takes into account the number of individuals as well as number of taxa. It varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. ANOSIM (Analysis of Similarities) is a non-parametric test of significant difference between two or more groups, based on any distance measure (Clarke 1993). The distances are converted to ranks. ANOSIM is normally used for taxa-in-samples data, where groups of samples are to be compared. The overall significance of the difference is often assessed by ANOSIM.

Taxonomic diversity (Δ) and taxonomic distinctness as defined by Clarke & Warwick (1998), including confidence intervals were computed from 1000 random replicates taken from the pooled data set (all samples). These measures use information derived from a hierarchical taxonomic tree, such as a Linnaean classification or matrix of phylogenetic distances. Mean values of taxonomic distinctness (Δ*) and diversity (Δ) are considered to be less susceptible to variability in sample size than measures such as species richness (Margalef's *D*) and evenness (Pielou's *J*), and, to some extent, Shannon's species diversity (*H′*), with (Δ) and (Δ*) being considered a truer measure of "biodiversity" than *H′* (Warwick & Clarke 1995). These analyses were done using PAST Ver 3.14. Rarefaction analysis based on the number of individuals captured was used to compare patterns of species richness and sampling effort. This was performed using the software EstimateS 7.5, with 500 randomizations (Colwell 2005).

RESULTS

Overall Diversity Pattern of Dung Beetles

Dung beetles representing 22 species, belonging to six genera and three tribes of the subfamily Scarabaeinae were attracted towards dung traps set in the agroecosystem (Table 1). Vechur dung bait trapped a mean of 46 ± 44.1 individuals; 100 ±77.01 beetles were attracted towards CB dung bait. Crossbred (CB) dung baited traps recorded comparatively high species richness (19) than the indigenous dung baited traps (15). *Oniticellus cinctus*, *Onthophagus rectecornutus* and *O. centricornis* specifically selected VC dung type and *Caccobius unicornis*, *O. dama*, *O. kchatriya*, *Onthophagus* sp. 2, *Onthophagus* sp. 3, *Paracopris signatus* and *Tibiodrepanus sinicus* exclusively appeared in the CB dung type. Dung beetle community collected from both dung types showed an Anosim value of R=0.0009607 (P>0.05), indicating no significant difference in the dung beetle composition between two dung types. The rarefaction curve showed an asymptote between 21-22 species suggesting that the sampling effort was satisfactory.

Onthophagus favrei was the dominant dung beetle collected. Dung of CB attracted more beetles of this species with a mean abundance of 45.5 ±32.68. *Onthophagus cervus* (25.88 ± 19.14) was in the second position. Vechur dung baited traps collected 24.36 ± 23.75 individuals of *O. favrei* which was followed by *O. turbatus* (6.14 ± 4.74) (Figure 3 & 6). Dung beetle diversity of the study habitat with the use of two different dung types revealed that the dung of native breed, VC, supported high values for diversity (Shannon Wiener diversity index (H') = 1.846) and evenness (Simpson's evenness index, 1-D= 0.7439) than the CB dung. But the diversity index values showed no significant difference (P>0.05) (Table 2). At the same time, total taxonomic diversity (Δ) and distinctness (Δ*) was higher for VC dung baited traps with a value of 1.254 (Δ) and 1.653(Δ*) over the CB dung type with 1.094 (Δ) and 1.462 (Δ*) respectively.

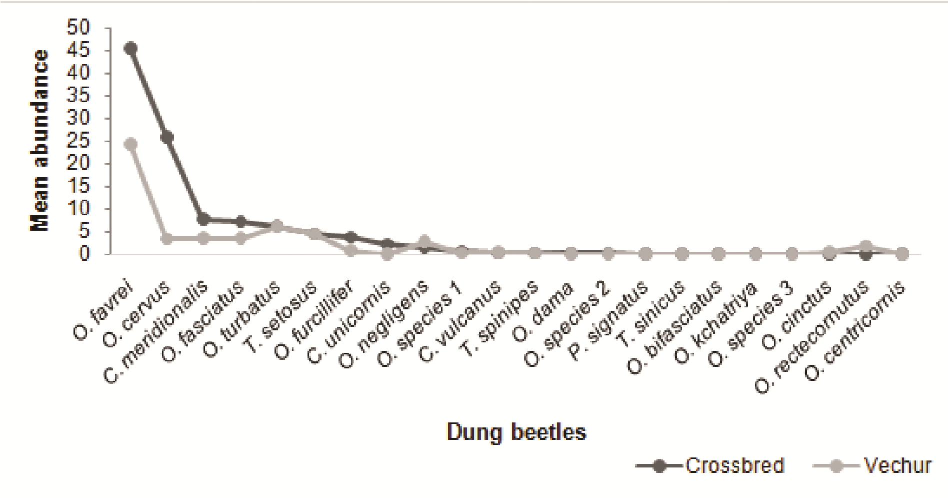

Figure 3. Rank abundance plot of dung beetles collected in response to the preferred dung types from the selected agroecosystem

Table 1. Mean abundance of dung beetles collected using Crossbred and Vechur dung baited traps from the agricultural study habitat

Sl. No	Dung Beetle species	*Tribe	*Functional Guild	Size (mm)	Colour	CB dung bait			VC dung bait		
						Diurnal	Nocturnal	Total	Diurnal	Nocturnal	Total
1	*Caccobius meridionalis* Boucomont , 1914	O	T	4-5	Chestnut brown	15.25±9.63	0.25±0.29	7.75±7.14	6.50±6.03	1.13±0.73	3.43±3.90
2	*Caccobius unicornis* (Fabricius, 1798)	O	T	3-3·5	Black or pitchy black	0.5±0.58	0	0.25±0.41	0	0	0
3	*Caccobius vulcanus* (Fabricius, 1801)	O	T	4-5	Black	2.25±1.22	2±1.15	2.125±1.16	0.33±0.36	0.63±0.43	0.50±0.40
4	*Oniticellus cinctus* (Fabricius, 1775)	ONC	D	8-11	Shining black,	0	0	0	1±0.76	0.13±0.21	0.5±0.52
5	*Onthophagus bifasciatus* (Fabricius, 1781)	O	T	5-7	Black	0	0.25±0.29	0.125±0.20	0	0.13±0.21	0.07±0.17
6	*Onthophagus centricornis* (Fabricius, 1798)	O	T	2.5-3	Black	0	0	0	0	0.13±0.22	0.07±0.17
7	*Onthophagus cervus* (Fabricius, 1798)	O	T	6-7	Shining black	1±0.65	50.75±24.80	25.875±19.14	0.33±0.36	5.5±3.55	3.29±2.90
8	*Onthophagus dama* (Fabricius, 1798)	O	T	8.5-11	Dark greenish coppery	0.25±0.29	0.25±0.29	0.25±0.28	0	0	0
9	*Onthophagus fasciatus* Boucomont, 1914	O	T	5-6.5	Bright yellow	9.75±2.53	4.5±2.61	7.125±2.67	1.33±1.16	5.25±2.65	3.57±2.27
10	*Onthophagus favrei* Boucomont, 1914	O	T	5-7.5	Black or very dark brown not shining	3.75±4.03	87.25±42.36	45.5±32.68	0.50±0.43	42.25±29.10	24.36±23.75

11	*Onthophagus furcillifer* Bates, 1891	O	T	5.5-6	Black not shining	0.25±0.29	7.25±5.05	3.75±3.65	0	1.38±1.26	0.79±1.01
12	*Onthophagus negligens* Walker, 1858	O	T	5-6	Black or dark brown not shining	0	3±1.21	1.5±0.98	0	4.63±3.11	2.64±2.55
13	*Onthophagus rectecornutus* Lansberge, 1883	O	T	7-10	Testaceous yellow with faint metallic greenish lusture, closely mottled with black	0	0	0	0.17±0.27	3.13±1.21	1.86±1.09
14	*Onthophagus* sp. 1	O	T	5.5-6	Black, not very shining	0	1.25±0.67	0.625±0.51	0	0.5±0.39	0.29±0.32
15	*Onthophagus kchatriya* Boucomont, 1914	O	T	5.5-7	Shining black	0	0.25±0.29	0.125±0.20	0	0	0
16	*Onthophagus* sp.2	O	T	3-3.5	Shining black	0	0.5±0.39	0.25±0.28	0	0	0
17	*Onthophagus* sp.3	O	T	5.5-6	Brownish yellow	0	0.25±0.29	0.125±0.20	0	0	0
18	*Onthophagus turbatus* Walker, 1858	O	T	7-8	Bronzy or blackish brown with a slight metallic green lustre above	0.75±0.45	11.5±4.93	6.125±3.88	0.33±0.36	10.5±5.65	6.14±4.74

19	*Paracopris signatus* (Walker, 1858)	C	T	10-15	Black, opaque black	0	0.25±0.29	0.125±0.20	0	0	0
20	*Tibiodrepanus setosus* (Wiedemann, 1823)	ONC	D	4.5-5.5	Black	9±3.74	0	4.5±3.01	9.83±4.66	0.50±0.39	4.50±3.48
21	*Tibiodrepanus sinicus* (Harold, 1868)	ONC	D	4.5-5.5	Black	0.25±0.29	0	0.125±0.20	0	0	0
22	*Tiniocellus spinipes* (Roth, 1851)	ONC	D	5.5-7.5	Opaque dark brown	0.5±0.39	0	0.25±0.28	0.17±0.27	0.25±0.29	0.21±0.28

*Tribe: O: Onthophagini; C: Coprini; ONC: Oniticellini *Functional Guild: T: Tunnellers; D: Dwellers

Table 2. A comparison on the diversity measures of dung beetles attracted to the preferred dung types from the study habitat

Diversity measures	**Number of Taxa (S)**		**Mean number of individuals (n)**		**Dominance index (1-Simpson index (D))**		**Evenness index (Simpson (1-D))**		**Shannon Weiner Index (H´)**	
Dung bait used*	**VC**	**CB**	**VC**	**CB**	**VC**	**CB**	**VC**	**CB**	**VC**	**CB**
Overall	15	19	46	100	0.2561	0.2583	0.7439	0.7417	1.846	1.759
Diurnal	10	12	17	39	0.3389	0.2272	0.6611	0.7728	1.411	1.741
Nocturnal	15	15	71	165	0.3439	0.3623	0.6561	0.6377	1.569	1.351
Tunneler	12	16	42	96	0.3067	0.2817	0.6933	0.7183	1.637	1.633
Dweller	3	3	4	4	0.7557	0.8554	0.2443	0.1446	0.4831	0.3202

*VC- Vechur cow, CB- Crossbred

Analysis of Temporal Resource Partitioning of Dung Beetles

Temporal resource partitioning among dung beetles of the study habitat was noted with a total abundance of 297 diurnal Scarabids under 14 species. Crossbred and Vechur cow dung traps contributed 12 and 10 species respectively. Shannon's diversity and Simpson's index showed no significant difference in the dung beetles collected using different dung types in the diurnal foraging (P>0.05). *Onthophagus rectecornutus* was collected as the exclusive diurnal indigenous dung specialist and four dung beetles, namely *Caccobius unicornis*, *Tibiodrepanus sinicus*, *O. dama* and *O. furcillifer* selectively considered CB dung baited traps during their diurnal foraging (Figure 4).

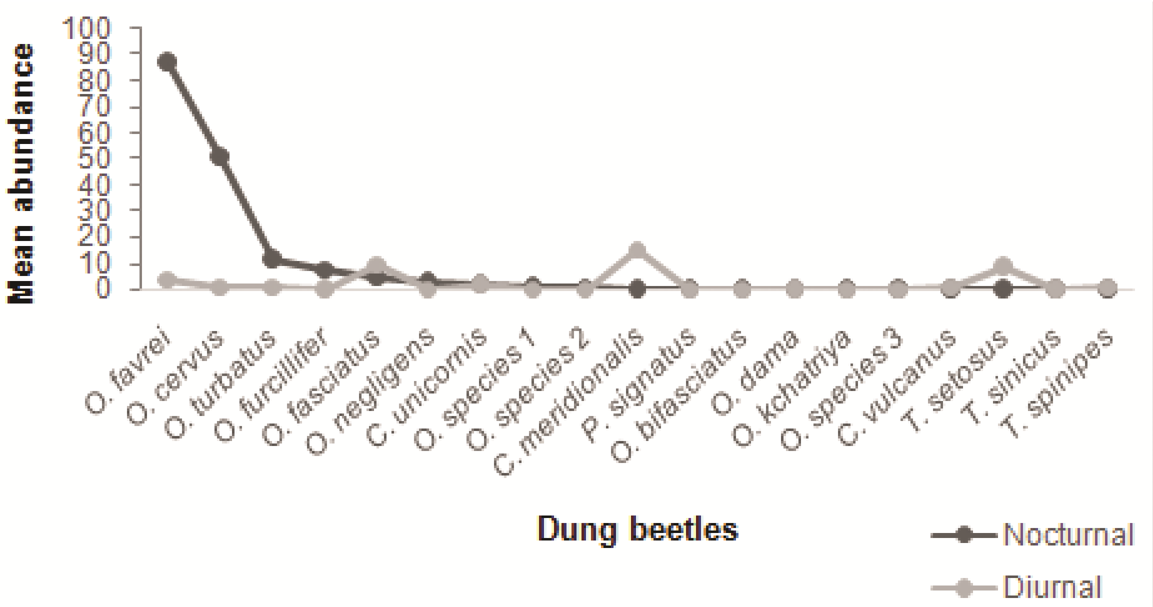

Figure 4. Pattern of temporal distribution of dung beetles collected in response to the crossbred dung baited traps

Increased collection of dung beetles with an abundance of 1286 individuals revealed nocturnal foraging as the most preferable temporal guild among scarabids in the study habitat. Out of the 20 species reported in the nocturnal collection, 10 were common to both dung types. Distribution of *Oniticellus cinctus*, *Tibiodrepanus setosus*, *Tiniocellus spinipes*, *Onthophagus rectecornutus* and *O. centricornis* was limited to the native dung type (VC) (Figure 5).

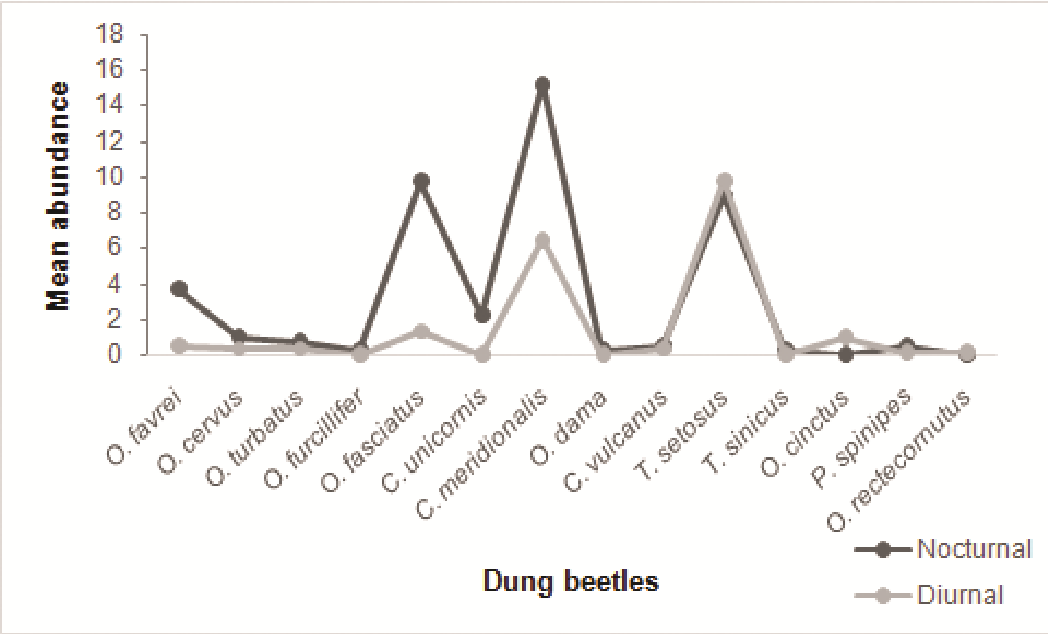

Figure 5. Pattern of temporal distribution of dung beetles collected in response to the Vechur dung baited traps

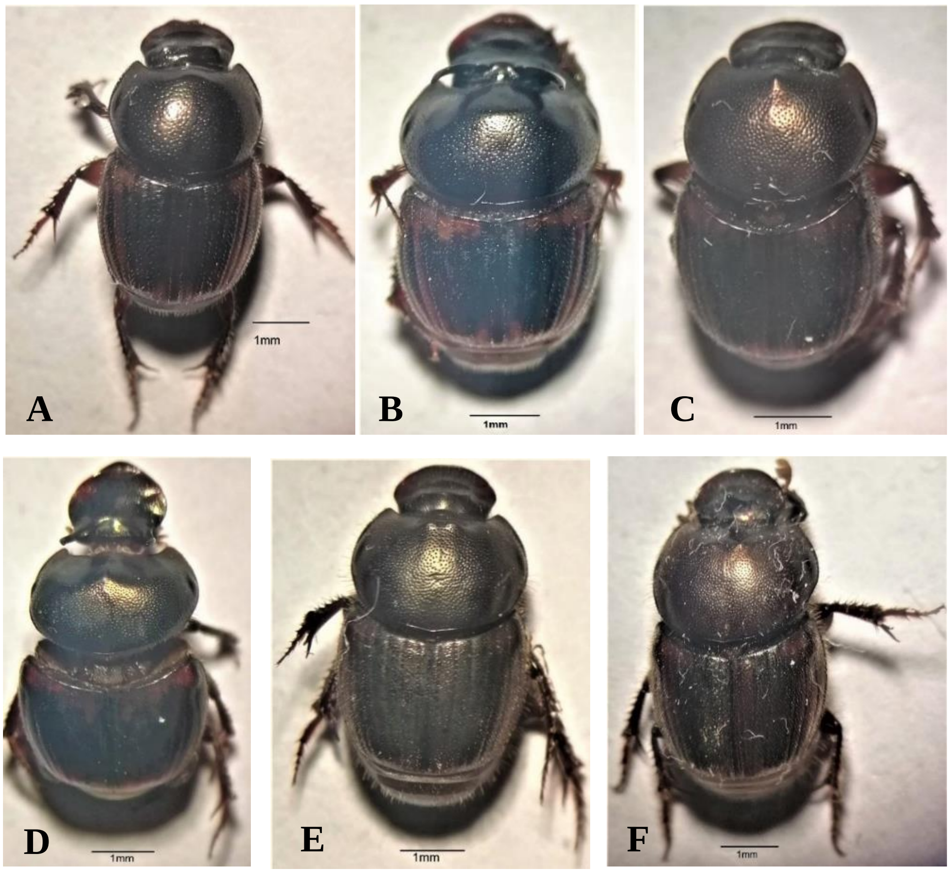

Figure 6: Dominant dung beetles collected from the selected agroecosystem during the study period: A. *Onthophagus cervus* (♀) B. *Onthophagus cervus* (♂) C. *Onthophagus favrei* (♀) D. *Onthophagus favrei* (♂) E. *Onthophagus turbatus* (♀) F. *Onthophagus turbatus* (♂)

Temporal guild comparison came up with a different result of higher species diversity with CB dung for the diurnal collection. Shannon Wiener diversity index (H') for CB and VC of diurnal dung bait were 1.741 and 1.411 respectively which indicated the relatively increased beetle diversity attracted to the CB dung type. At the same time, nocturnal patterns gave opposite observations to the above (Table 2).

Analysis of Dung Beetle Functional Guild Composition

Functional guild classification of dung beetles showed the dominance of tunnellers in the study habitat followed by dwellers. Rollers were completely absent in the collection. Among the 1471 tunnelers reported, CB dung type represented 813 individuals and the rest were attracted to VC dung type. The most abundant species, *Onthophagus favrei* is a tunneller that contributed 45.5 ± 32.68 individuals in response to the CB dung type and 24.36±23.75 to the VC dung type. *Tibiodrepanus setosus* was the most abundant dweller in CB and VC dung types with a mean abundance of 4.5±3.01 and 4.5 ±3.48 respectively.

Across the functional guild types, H' for tunnellers were 1.637 and 1.633 and dwellers were 0.4831 and 0.3202 with the use of VC and CB dung types respectively. In terms of dominance and evenness, CB type was found to be the good dung resource to the tunneller community.

DISCUSSION

Dung beetles are specialists in their food preferences (Vernes et al. 2005). At the same time, they are reported as a flexible and adaptive taxon for its ability to switch the food resources from one type to another (Goh and Hashim 2020). The decrease in the diversity of mammals and associated dung resources force them to change their specialist nature and shift their diets (Enariet al. 2013). Present study compares the food source preferences and possible specificity among scarabs with two different cow dung types. Though species level dung preferences are noted, statistical analysis reveals no significance in this difference. It infers the decreased or zero resource particularities of the taxon in its community level.

The study area accounts for 22 species of dung beetles under six genera and three tribes. The species richness is comparable to the reports from Latha & Sabu (2018) and Venugopal (2012) for the studies conducted in agroecosystems. Even though the sampling period was short, the selected agroecosystem stands as a potential habitat for its scarab diversity. The presence of species like *O. kchatriya* and *O. cinctus* indicate the quality of the habitat to maintain rare and native members of dung beetles (Venugopal 2012). Increased presence of *O. favrei* and *O. turbatus* marks that the scarab diversity of the site is influenced by adjoining forest areas. The faunal community is expected to have diversified by the addition of tourist species from the forest areas which are able to cope up with the anthropogenic disturbances (Latha & Sabu 2018). *Caccobius meridionalis* and *O. fasciatus* are typical agro habitat species (Sabu et al 2011). The above observations explain the potential of the study area to support a mixture of scarab fauna, both agricultural and the forest type along with rare species. At the same time, *P. signatus* (10-15mm) is the only representative of the larger dung beetles. Complete absence of larger species belonging to *Catharsius, Heliocopris, Gymnopleurus* etc. may be a pattern that correlates with the decreased canopy cover, difference in the dung type and size (Muhaimin et al. 2015) and increased desiccation levels (Chown 2001). More long term and advanced studies from different sites of the same area are recommended for the confirmation of this fact.

Temporal guild pattern reveals nocturnal dung beetles as the dominant group over the diurnal fauna. The dominant species, *O. favrei*, *O. cervus* and *O. turbatus* are marked as general category as they were present in both diurnal and nocturnal collections and was collected in response to both native and CB dung types. It may be assessable as a strategy to reduce their intraspecific competition (Niino et al. 2014). Partitioned foraging times along with the preference for both dung types may help them to reduce their resource overlapping. In addition to this, the increased night foraging is reported with various physiological constraints like temperature, day light intensity etc. (Krell-Westerwalbesloh et al. 2004). Predator avoidance by temporal guild preferences is also a considerable benefit. More studies on this beetle are recommended for the complete understanding of temporal guild partitioning and its advantages. Studies report cryptic colouration of nocturnal dung beetles to avoid predation with black or dark members vary from the diurnal fauna having more colourful elytra patterns (Hernandez 2002; Young 2015). Most of the nocturnal species collected from the study habitat are noted for its dark colouration with limited elytral patterns follow the above report.

Higher proportion of tunnellers explains the good soil texture of the study habitat due to proper irrigation and other agricultural practices. It follows the typical pattern of nest segregation in Western Ghats forest floor and related agro ecotones (Sabu et al. 2006; 2007; Vinod & Sabu 2007). Complete absence of rollers could be due to the fragmented nature of the habitat as it is a discontinuous agricultural patch in a residential area (Venugopal et al. 2012). Since the study area is associated with human habitations, chances of light pollution could be a possible reason for the zero reports of rollers as they are the only guild of dung beetles which uses Moon light for its navigation (Byrne et al. 2003; Foster et al. 2017). Tunnellers, the intermediate competitors and dwellers, the least competitors are active during the dusk and night times (Krell-Westerwalbesloh et al. 2004). This study supports the above facts. Coexistence of tunnellers of different sizes results in efficient niche partitioning and reduction in competition among beetles (Sullivan et al. 2017). The study habitat supports a well-balanced scarab community with an equitable sharing of the available resources as evidenced by the different sizes of beetles (2.5 -15mm) occupying the dung baits.

CONCLUSION

In conclusion, the present study stands as a preliminary one to account the difference in dung beetle diversity across two different dung types of the two breeds of cattle: VC and CB of Jersey. The study reports no difference across the scarab diversity with the selected dung types. However, the study reveals the capacity of an isolated patchy urban agroecosystem to support a well-balanced dung beetle community and emphasise the importance of maintenance of such microhabitats for the conservation of various ecologically important species.

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