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Seasonal Activity of Dung Beetles (Scarabaeinae) in a Forest in South Western Ghats

Thomas Latha

Dept. of Science, Faculty of Science & Technology, University of Belize, Belize
lthomas@ub.edu.bz

***Abstract*—** *Scarabaeinae dung beetle activity is strongly influenced by rainfall seasonality. Rainfall affects the quality and quantity of dung available, affects reproductive performance and triggers emergence and activity indung beetles. Effects of rainfall seasonality oncommunity attributes of dung beetles such as abundance, species richness and diversity in a forest in South Western Ghats was studied. Dung beetles were collected using cow dung baited pitfall traps during the southwest monsoon, northeast monsoon and summer season from the forest habitat. Though abundance was highest during the heavy rainy periods of southwest monsoon season, favoring the two dominant species Onthophaguspacificus and O. furcillifer, species richness and diversity was higher during the moderate rainy periods of northeast monsoon. The heavy rains ofsouthwest monsoon season may not be favorable to some of the species, especially of the roller and dweller guild as the rains maintain the dung in a fluid state which makes dung ball rolling and dwelling a difficult task to perform.This was observed by the absence of the roller, Sisyphus araneolus and dweller Tibiodrepanussetosus during the southwest monsoon season. Favorable microclimatic conditions and availability of abundant trophic resourceduring the moderate rainy periods of northeast monsoon season in the forest led to the high species richness and diversity in that season.*

Keywords*— *Scarabaeinae, dung beetles, South Western Ghats, forest, rainfall seasonality.

I. INTRODUCTION

Seasonal activity in Scarabaeinaedung beetles is determined by factors like temperature, rainfall, resource availability and life history strategies (Doube, 1991; Hanskiand Cambefort, 1991a; Lumaretand Kirk, 1991). Dung beetle activity is strongly influenced by rainfall seasonality (Medina and Lopes, 2014). Rainfall determines the quality and quantity of dung,which is the primary source of food for most dung beetles (Cambefort,1991);affects the reproductive performance of dung beetles (Edwards, 1991); provides humidity to the soil and triggers the emergence andthe onset of activity in the beetle species (Doube, 1991; Halffter, 1991; HanskiandCambefort 1991a, Novais*et al*., 2016). Dung beetle activity is greatest during moist and minimal during dry periods (Doube,1991; Hanski and Cambefort,1991a) and abundance of scarab beetles increases strongly after heavy rainfall (Walter, 1985). Majority of dung beetle species that exhibit environmentally induced seasonality are active during favourable periods. However there are species which avoid competition by increasing their activity during periods of harsh environmental conditions because fewer species are active during environmentally unfavourable periods and those that are active, experience much less competition for resources (Montes de Ocaand Halffter, 1995). Seasonal activity is more pronounced in areas with pronounced dryseason (Howden and Young, 1981; Janzen, 1983; Medina and Lopez, 2014) than in areas without a severe dry season (Peck and Forsyth, 1982; Waageand Best, 1985; BerytenbachandBerytenbach, 1986; HanskiandKrikken, 1991).

The Western Ghats in the Indian Subcontinent is a 1,600 km long chain of mountains running parallel to India's western coast. Western Ghats with its exceptionally high level of biological diversity and endemism is one among the 34 biodiversity hotspots of the world. The mountain range has profound influence on the rainfall pattern of peninsular India (Nair, 2006). The Western Ghats strongly influences the rainfall pattern of Kerala state in the Indian subcontinent. The Kerala state is a strip of land running almost in North–South direction and is situated between the Arabian Sea on the West and the ranges of Western Ghats and NilgiriHills on the East both running parallel to each other. According to Koppen's climatic classification, Kerala's climate is tropical monsoon in most part of the state and tropicalsavanna in the southern most part. The state normally experiences excessive seasonal rainfall, with hot summers. Thethree main seasons of the state are the hot season(March–May), southwest

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monsoon season (June–September), and northeast monsoon season (October–February) (Nathan, 2000). The potential rainy season for Kerala is the southwestmonsoon period, which contributes 67.9%to the annual rainfall, the post-monsoon and winter rainfall (October–February) contributes 18.1% to the annual rainfall and pre-monsoon (March–May) contributes 14.0% to the annual rainfall (Krishnakumar*et al*., 2008).

Very little studies exists on the effects of rainfall seasonality on dung beetle community attributes in the forest ecosystems of South Western Ghats.In the present study the effects of rainfall seasonality on dung beetle community attributes such as abundance, species richness, and diversity was studiedin a forest ecosystem in South Western Ghats.We hypothesize that the species richness, abundance and diversity of dung beetles will vary with rainfall seasonality and that wet seasons will harbor more species, abundance and diversity than dry season. Such studies are important as it helps us to understand how changing rainfall seasonality over a region can affect community attributes of beneficial insects such as dung beetles.

II. MATERIALS AND METHODS

2.1 Study site

The study was carried out in Kaikattyin Nelliampathi, located at 10^0 31'N and 76^0 40'E, at an elevation of 960 msl in the South Western Ghats (Fig. 1). The temperature of the region varies between 15^0C-30^0C and annual rainfall exceeds 3000 mm (Nair, 1991). The vegetation in the study site is characterized by West Coast Semi-Evergreen forest (Champion and Seth, 1968).Evergreen undergrowth is rather copious and climbers tend to be very heavy. Epiphytes are abundant, including many ferns and orchids. About 40% to 80% of trees are evergreen(Kerala Forests and Wildlife Department, 2004).Three seasons characterizes the region,hot season referred to as summer (March–May), a period of heavy rainfall called the southwest monsoon season (June–September), and a period of moderate rainfall called the northeast monsoon season(October–February).

2.2 Sampling

Dung beetles were collected using dung baited pitfall traps of the bait-surface-grid type (Lobo *et al*., 1988; Veiga*et al*., 1989). Beetles were collected on a seasonal basis in May (summer season), September (southwest monsoon season) and December (northeast monsoonseason) during the 2007-2008 study period.Each collection effort involved placing ten baited pitfall traps containing 200g cow dung as bait, placed 50 m apart in the forest habitat.The trap contents were collected at 12 h intervals (6:00-18:00h and 18:00-6:00h) for each collection effort. Collected beetles were preserved in 70% alcohol overnight and later identified to species levels using taxonomic keys and by verifying with type specimens available in the Coleoptera collections of St. Joseph's College, Devagiri, Calicut.

2.3 Analysis

Since the data was not normally distributed,non-parametric statistics Kruskal-Wallis test was used to test the significant levels of variation in overall abundance of beetles, Shannon diversity (H') and abundance of individual species of dung beetles with seasons.Differences with a p-value <0.05 was compared using Mann-Whitney Test. The beetles were classified as seasonal beetles if they showed significant difference in abundance with seasons, and aseasonalif they did not show significant variation in abundance with seasons. Singletons were considered as rare and excluded from seasonality studies.

III. RESULTS

A total of 259 beetles belonging to 17 species were collected during the northeast monsoon season, ten species and 94 beetles in summer and ten species and 269 beetles in southwest monsoon season from the forest habitat in Nelliampathi (Fig. 2, 3; Table 1). Overall abundance of dung beetles varied significantly with seasons (H= 25.531, df=2, p=<0.001).Pair wise comparisons of abundance between seasons showed significant variation in abundance between southwest monsoon and summer (p=<0.001), between northeast monsoon and summer (p=<0.001) but not between southwest monsoon and northeast monsoon (p=0.480).Shannondiversity (H') in northeast monsoon season was 1.87, summer was 1.47 andsouthwest monsoon season was 1.80 (Fig. 4).Shannon diversity (H') did not vary significantly with seasons (H=2.604, df=2, p=0.272). Of the 21 species collected from forest, nine species were seasonal, five species were aseasonal and seasonality in seven species could not be determined due to rarity in collection (Table 1).Seasonal species showed peak in abundance during different seasons.Tunnelers*Onthophaguspacificus* in northeast and southwest monsoon*; Onthophagusbronzeus*, *O. laevis*, *O. manipurensis* and *Paracopriscribratus* in southwest monsoon; *Onthophagusandrewesi*, *O. vladimiri*and *O. turbatus*innortheast monsoon and roller *Sisyphus araneolus* in northeast monsoonseason (Fig.5; Table 1).

IV. DISCUSSION

Significant seasonal effect on abundance was noticed in dung beetle population in the forest of South Western Ghats, with southwest and northeast monsoonseasons recording higher abundance. The seasonal

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activity of dung beetles at a site depends on the temperature and precipitation cycles (Lumaretand Kirk, 1991). High abundance in northeast monsoon season and southwest monsoon in the Nelliampathi forests could be attributed to the optimum conditions prevailing during these seasons with respect to physical parameters, vegetation and trophic resources. Similar results were observed in forests of Wayanadin the region (Vinod, 2009). Southwest monsoonseason is the period of maximum rainfall in the region followed by northeast monsoonseason. The prevalence of rain during these seasons favoured dung beetle abundance as rain affects the amount and quality of dung available to dung beetles by affecting the nature of vegetation and abundance of mammals (Simmons and Riddle-Smith, 2011). Similar observations of increased dung beetle activity during moist periods and decreased activity during dry periods were recordedin earlier studies (Walter, 1985; Doube*et al*.,1991; HanskiandKrikken, 1991; Andresen, 2005; Neves*et al*., 2010).

In tropical biomes in which temperature fluctuations are small, rainfall is the most important climatic factor affecting dung beetle communities (HanskiandCambefort, 1991b), with lower abundance and often also lower species richness recorded during dry season (Andresen, 2005). Changes in vegetation cover leads to differences in mammalian fauna which in turn, affects dung beetle populations (Cambefortand Walter, 1991; Estrada *et al*., 1999). Drying up of under storey vegetation and shedding of leaves by the deciduous trees of the semi-evergreen forests in Nelliampathi reduces food availability for herbivores which migrates to other evergreen patches in the region and this reduces dung availability. Similar observations were made in the forests of Wayanad (Vinod, 2009). Also, dung pads exposed to higher temperatures develops surface crust rapidly, reducing the time they are usable by the beetlesand rapid drying up of the dungincreases larval mortality (Klein, 1989; Galante*et al*., 1995; Durães*et al*., 2005; SowigandWassmer, 1994; Horgan, 2001).

Though wet season is generally more taxonomically rich (Noriega, 2015), in the present study northeast monsoon season with intermediate rainfall (17 species) was more species rich than the southwest monsoon season (ten species) which is characterized by heavy rainfall. This could be due to the fact that the heavy rains in the southwest monsoon season can especially affect roller and dweller species as dung remains in a fluid state during the season due to heavy rain and this makes dung ball rolling and dwelling a difficult taskfor the beetles (Vinod, 2009).This was observed in the absence of roller *Sisyphus araneolus* and dweller *Tibiodrepanussetosus* in the southwest monsoon season. Moreover, after the heavy rains, favourable microclimatic conditions such as temperature, light intensity, humidity and abundant growth of vegetation along with presence of mammals prevails during the northeast monsoon season in these forests which provides adequate conditions for dung beetles which led to the observance of higher species richness and diversity during this season.

Amongst the seasonal tunnelers, *Onthophagusbronzeus*, *O. laevis*, *O. manipurensis*, *O. pacificus*and *Paracopriscribratus*showed higher abundance during southwest monsoonperiod which is attributed to their tolerance to heavy rains and capacity to use the dung rapidly before they are washed away with the heavy rains that is characteristic of the season. Tunnelers *Onthophagusandrewesi*, *O. turbatus*, *O. vladimiri* showed high abundance in the northeast monsoon period with moderate rainfall. Their peak in abundance may be related to the events in lifecycle such as oviposition period or emergence of immature stages as dung beetle species shows increase in abundance coinciding with their life cycle (Doube, 1991; Lumaretand Kirk, 1991) or their avoidance of the heavy rains of the southwest monsoon season.

V. CONCLUSION

In the present study, rainfall seasonality affected the community attributes of dung beetles such as abundance, species richness and diversity in a forest habitat in South Western Ghats. Dung beetles showed increased species richness, abundance and diversity during the wet seasons than in the dry season. But increased species richness and diversity in the moderate rainy period of northeast monsoon season shows the preference of the beetles for that season over the heavy rainy periods of southwest monsoon season. But changing rainfall pattern over the region with increase in rainfall over the northeast monsoon periods can affect dung beetle community attributes in the future.

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Fig. 1: (A) Study site Nelliampathi in South Western Ghats in Kerala; (B) Forest habitat in Nelliampathi.

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*Table.1: Seasonal abundance (NEM=Northeast monsoon, S=Summer, SWM=Southwest monsoon); and seasonality (SE=Seasonal, AS=Aseasonal, *=Seasonality not determined) of dung beetle species in a forest habitat in Nelliampathi in South Western Ghats during the 2007-2008 study period.*

Species	NEM	S	SWM	Seasonality
Catharsiusmolossus	0	0	1	*
Coprisrepertus	4	13	11	AS
Onthophagusamphicoma	1	0	0	*
Onthophagusandrewesi	8	0	0	SE
Onthophagusbronzeus	6	1	22	SE
Onthophaguscastetsi	8	1	7	AS
Onthophaguscavia	1	0	0	*
Onthophaguscentricornis	1	0	0	*
Onthophagusensifer	3	0	0	AS
Onthophagusfavrei	2	0	0	AS
Onthophagusfurcillifer	61	37	57	AS
Onthophagusinsignicollis	1	0	0	*
Onthophaguslaevis	0	0	18	SE
Onthophagusmanipurensis	2	0	17	SE
Onthophaguspacificus	100	32	103	SE
Onthophagusturbatus	11	1	4	SE
Onthophagusvladimiri	7	0	0	SE
Paracopriscribratus	5	6	29	SE
Paragymnopleurussinuatus	0	1	0	*
Sisyphus araneolus	38	1	0	SE
Tibiodrepanussetosus	0	1	0	*

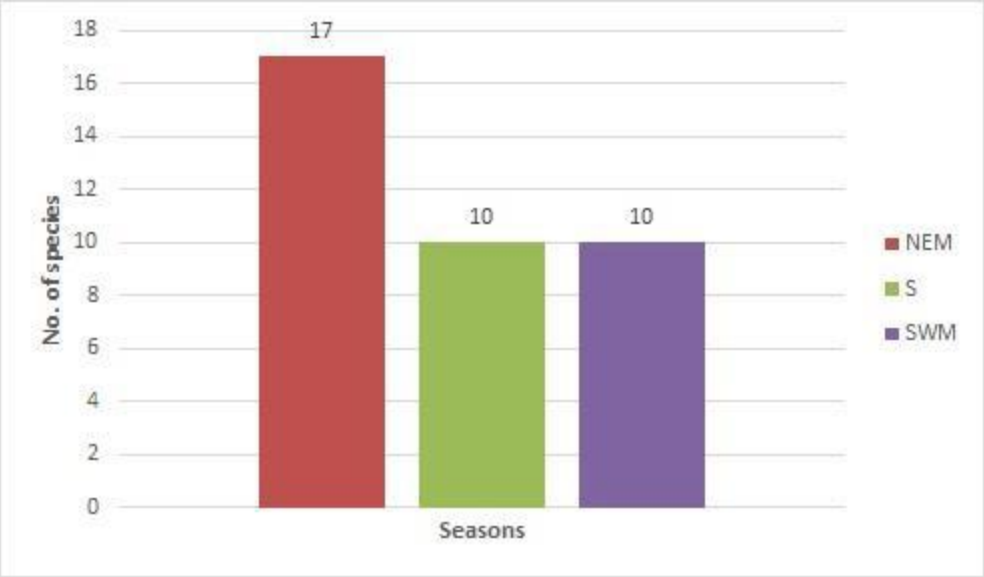

Fig. 2: Dung beetle species richness in the northeast monsoon (NEM), summer (S) and southwest monsoon (SWM) seasons in a forest habitat in Nelliampathi in South Western Ghats during the 2007-2008 study period.

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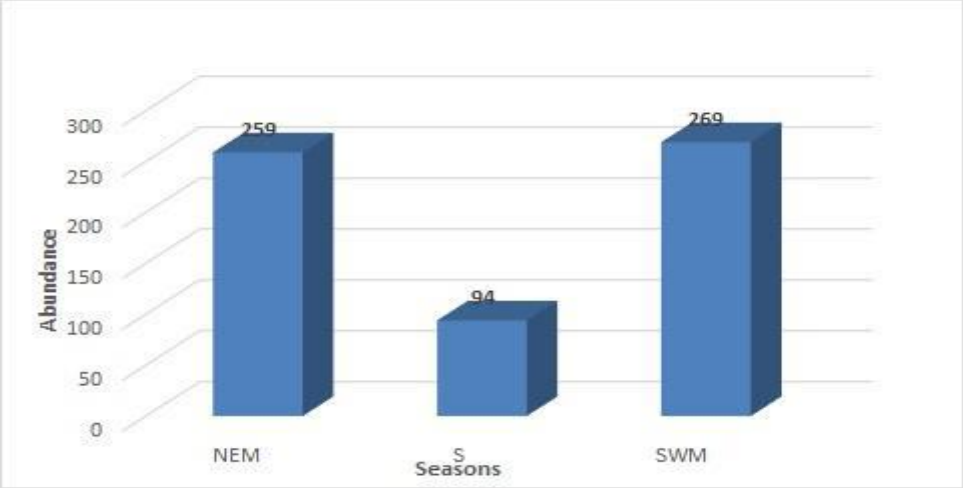

Fig. 3: Dung beetle abundance in the northeast monsoon (NEM), summer (S) and southwest monsoon (SWM) seasons in a forest habitat in Nelliampathi in South Western Ghats during the 2007-2008 study period.

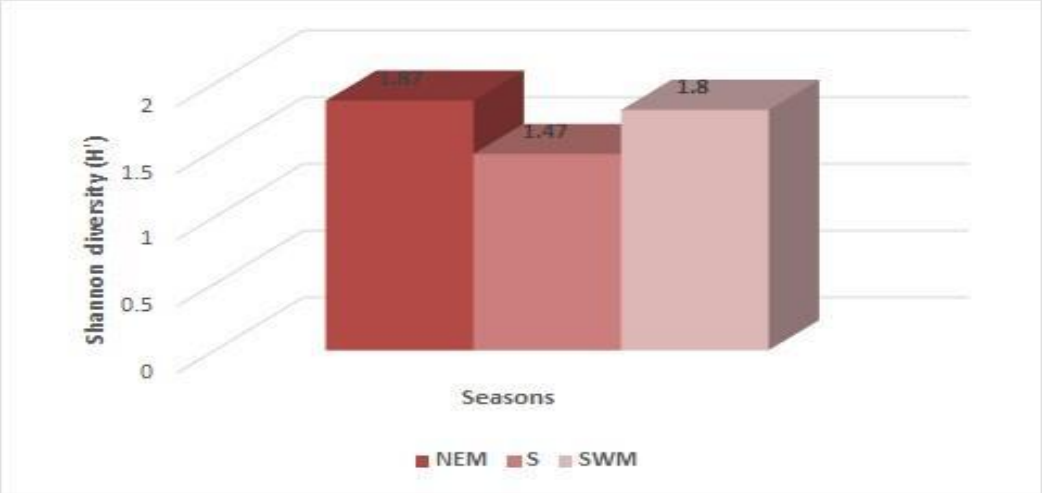

Fig. 4: Shannon diversity (H') values of dung beetles in the northeast monsoon (NEM), summer (S) and southwest monsoon (SWM) seasons in a forest habitat in Nelliampathi in South Western Ghats during the 2007-2008 study period.

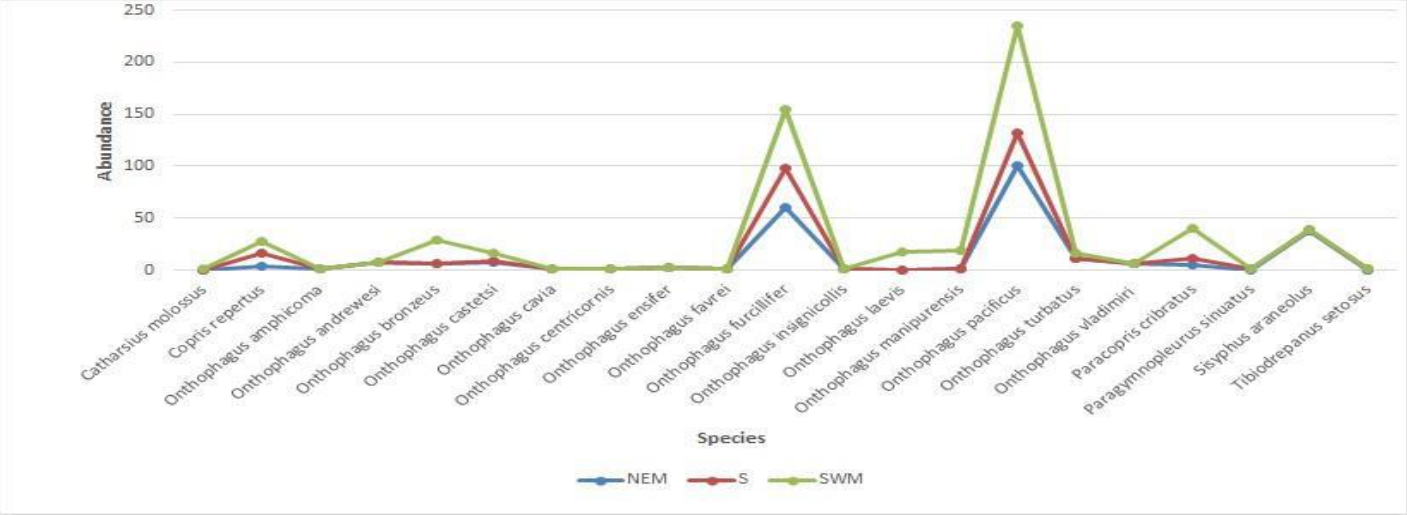

Fig. 5: Seasonal abundance of dung beetle species in a forest habitat in Nelliampathi in South Western Ghats during the 2007-2008 study period (NEM =northeast monsoon, S= summer, SWM=southwest monsoon).