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## Rainfall seasonality and guild composition of scarabaeinae dung beetles in a forest in South Western Ghats

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### Abstract

Effects of rainfall seasonality on functional and temporal guild composition of scarabaeinae beetles in a forest in South Western Ghats was studied. Dung baited pitfall traps were used to collect the beetles in the northeast monsoon, summer and southwest monsoon seasons. For each collection efforts trap contents were collected at 12.00 h intervals to separate the diurnal and nocturnal collections. Tunneler guild dominated the three seasons. Heavy rains prevailing in the southwest monsoon negatively affected the roller and dweller guild. Nocturnal guild dominated the three seasons and availability of food at night seemed to be the factor that influenced the temporal guild abundance rather than rainfall seasonality.

**Keywords:** Rainfall seasonality, forest, South Western Ghats, functional guild, temporal guild

### 1. Introduction

Scarabaeinae beetles are predominantly dung feeding beetles that are important components of the terrestrial ecosystems. They provide numerous ecosystem services such as enhance soil fertility through nutrient recycling <sup>[1-3]</sup>, promote seed dispersal and forest regeneration <sup>[4]</sup>, increase soil aeration and porosity <sup>[2]</sup>; and control population of disease causing pests and parasites living in dung <sup>[5-6]</sup>. They are considered as biological indicators as their community attributes are affected by changes in biotic and abiotic factors of the environments such as vegetation <sup>[7]</sup> mammal abundance <sup>[8-9]</sup>, temperature <sup>[10-12]</sup>, rainfall <sup>[13-17]</sup> and soil types <sup>[18]</sup>.

Food used by most Scarabaeinae in both larval and adult stages is the excrement of mammals and competition for this ephemeral food within and between species is intense <sup>[19]</sup>. To avoid competition for this scarce resource, dung beetles use different strategy to relocate dung for feeding and breeding based on which they are classified into three functional guilds; they are Paracoprids or tunnelers, telecoprids or rollers and endocoprids or dwellers <sup>[20]</sup>. Tunnelers dig a more or less vertical tunnel below the dung pad and transport dung into the bottom of the burrow; to be used for adult feeding or breeding. Rollers make balls of dung, a transportable resource unit, rolls it for a shorter or longer distance before burying it at a suitable spot. Dwellers eat their way through the dung and most species deposit their eggs in dung pads without constructing any kind of nest or chamber <sup>[20]</sup>. Some adult tunnelers and rollers feed directly in dung pads, but many others feed on their relocated dung reserves <sup>[20]</sup>. Studies on functional guild composition of dung beetles in a habitat is important since the ecosystem services performed by dung beetles in a habitat depends on the functional guild composition of these beetles in the habitat. Studies have shown that absence of large tunnelers from a habitat results in an approximate 75% reduction in dung removal in the habitat <sup>[21]</sup>.

To avoid competition, dung beetles also restrict their activity to a particular time of day <sup>[22-24]</sup>. Temporal activity differentiates dung beetles into diurnal beetles that are active during the day, nocturnal beetles that are active during the night, crepuscular species that are active during day and dusk, and others that are active both during day and night <sup>[25-28]</sup>. Temporal differentiation is particularly important in tropical forests where high rates of exploitation of carrion and dung occur especially because the resource is presumably limited <sup>[29-31]</sup> and success of any dung beetle species is determined by their early arrival at the resource <sup>[32]</sup>.

The South Western Ghats in the Indian subcontinent is a biodiversity hotspot, extraordinarily rich in biodiversity and endemism and is at the same time threatened with destruction due to various human pressures <sup>[33]</sup>. South Western Ghats influences the climate of Kerala state, a strip of land running almost in North-South direction and situated between the Arabian Sea on

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the West and the ranges of Western Ghats and Nilgiri Hills on the East, both mountain ranges running parallel to each other. The Kerala state including the South Western Ghats mountain ranges experiences three main seasons, the hot summer season (March–May), southwest monsoon season (June–September), and northeast monsoon season (October–February) [34]. Southwest monsoon season contributes 67.9%, the northeast monsoon season contributes 18.1% and the premonsoon or the hot summer season contributes 14.0% to the annual rainfall of the Kerala state [35].

In the present study, rainfall seasonality on the functional and temporal guild composition of dung beetles in a forest in South Western Ghats was studied. Studies on the effects of rainfall seasonality on functional and temporal guild composition of dung beetles in the ecosystems of Western Ghats is scanty. Such studies are important to help understand how changes in rainfall pattern and intensity in the region can disrupt the normal guild composition of dung beetles in these forests and consequently affect the ecosystem functions provided by these beetles.

## 2. Materials and Methods

### 2.1 Study site

The study was carried out in Kaikatty in Nelliampathi, located at 100° 31' N and 76° 40' E, at an elevation of 960 msl in the South Western Ghats region. The temperature of the region varies between 15°C–30°C and annual rainfall exceeds 3000 mm [36]. The vegetation in the study site is characterized by west coast semi-evergreen forest [37]. 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 [38]. Beetles were collected on a seasonal basis in May (summer season), September (southwest monsoon season) and December (northeast monsoon season) 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). Collected beetles were preserved in 70% alcohol overnight and later identified to species level using taxonomic keys and by verifying with type specimens available in the coleoptera collections of St. Joseph's College, Devagiri, Calicut. Species were sorted into the three functional guilds namely; tunnelers (paracoprids), rollers (telecoprids) and dwellers (endocoprids) [20], species were also designated based on their activity pattern into the three temporal guilds namely; nocturnal, diurnal and generalist species (active during day and night) [39].

### 2.3 Analysis

The data was not normally distributed so non-parametric statistics Kruskal-Wallis test was used to test the significant levels of variation in functional and temporal guild abundance within and between the three seasons. Differences with a p-value <0.05 were compared using Mann-Whitney Test.

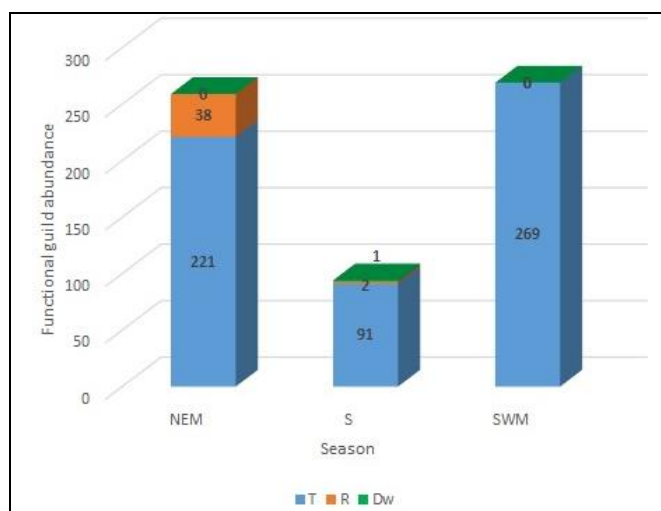
## 3. Results and Discussion

Tunnelers dominated the northeast monsoon (NEM), summer

(S) and southwest monsoon seasons (SWM), with 15 species (85.33% of total abundance) in NEM, seven species (96.81% of total abundance) in S and ten species (100% of total abundance) in SWM season. Rollers were the second most abundant guild, represented by one species (14.67% of total abundance) in NEM, two species (2.13% of total abundance) in S and none in SWM. Dwellers were represented by one species in S (1.06% of total abundance) and none in NEM and SWM (Fig. 1; Fig. 3; Table 1). Functional guild abundance did not vary significantly in NEM and S but varied significantly in SWM (Table 2). Functional guild abundance varied significantly between seasons for tunnelers and rollers but not for dwellers (Table 2).

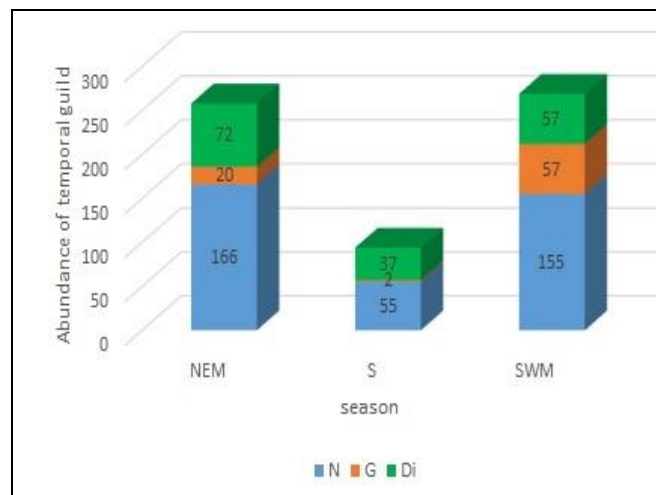
**Table 1:** Functional guild (FG: T=tunneler, Dw=dweller, R=roller) and temporal guild (Di=diurnal; N=nocturnal; G=generalist) abundance of dung beetles in Northeast monsoon (NEM) Summer (S), Southwest monsoon (SWM) seasons in a forest habitat in Nelliampathi in South Western Ghats during the 2007–2008 study period.

| Species                          | FG | TG | NEM | S  | SWM |
|----------------------------------|----|----|-----|----|-----|
| <i>Catharsius molossus</i>       | T  | N  | 0   | 0  | 1   |
| <i>Copris repertus</i>           | T  | N  | 4   | 13 | 11  |
| <i>Onthophagus ampicoma</i>      | T  | G  | 1   | 0  | 0   |
| <i>Onthophagus andrewesi</i>     | T  | Di | 8   | 0  | 0   |
| <i>Onthophagus bronzeus</i>      | T  | G  | 6   | 1  | 22  |
| <i>Onthophagus castetsi</i>      | T  | N  | 8   | 1  | 7   |
| <i>Onthophagus cavia</i>         | T  | G  | 1   | 0  | 0   |
| <i>Onthophagus centricornis</i>  | T  |    | 1   | 0  | 0   |
| <i>Onthophagus ensifer</i>       | T  | Di | 3   | 0  | 0   |
| <i>Onthophagus favrei</i>        | T  | G  | 2   | 0  | 0   |
| <i>Onthophagus furcillifer</i>   | T  | Di | 61  | 37 | 57  |
| <i>Onthophagus insignicollis</i> | T  | G  | 1   | 0  | 0   |
| <i>Onthophagus laevis</i>        | T  | G  | 0   | 0  | 18  |
| <i>Onthophagus manipurensis</i>  | T  | G  | 2   | 0  | 17  |
| <i>Onthophagus pacificus</i>     | T  | N  | 100 | 32 | 103 |
| <i>Onthophagus turbatus</i>      | T  | N  | 11  | 1  | 4   |
| <i>Onthophagus vladimiri</i>     | T  | G  | 7   | 0  | 0   |
| <i>Paracopris cribratus</i>      | T  | N  | 5   | 6  | 29  |
| <i>Paragymnopleurus sinuatus</i> | R  |    | 0   | 1  | 0   |
| <i>Sisyphus araneolus</i>        | R  | N  | 38  | 1  | 0   |
| <i>Tibiodrepanus setosus</i>     | Dw | G  | 0   | 1  | 0   |

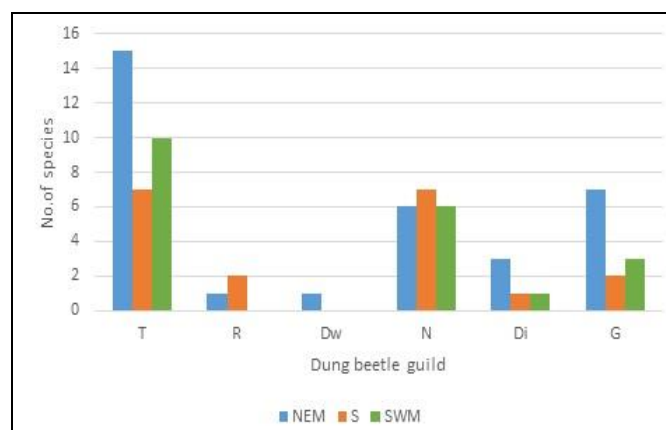


**Fig 1:** Functional guild (T=tunneler, R=roller, Dw=dweller) abundance of dung beetles in northeast monsoon (NEM), summer (S) and southwest monsoon (SWM) seasons in Nelliampathi forest during 2007–2008 study period.

Dominance of tunnelers in the three seasons as observed in the present study was also observed in earlier studies in the forest habitats of the South Western Ghats region [40]. The superior competitive nature of tunnelers in utilizing the dung resource [41, 23] contributed to their success and dominance in the three seasonal collections. Low abundance of tunnelers in summer could be attributed to the lack of rainfall, high solar radiation, and low humidity prevailing in the Nelliampathi forests during this season. These conditions affect the availability of food resources as herbivorous mammals migrate out of the forest due to drying up of understory vegetation [39, 16]. Dry weather conditions also limit reproduction and increases larval mortality [42, 13, 41]. Lack of rainfall in the summer also makes the soil hard to dig [43]. Absence of roller and dweller beetles in the SWM season could be attributed to the heavy rains in the season that can especially affect roller and dweller species as dung remains in a fluid state during the season or is washed away due to the heavy rains and this makes dung ball rolling and dwelling a difficult task for the beetles. This had led to the absence of roller *Sisyphus araneolus* and dweller *Tibiodrepanus setosus* in the southwest monsoon season. The low abundance of the superior competitors such as tunnelers and rollers for dung resource in the summer season favored the presence of dweller *T. setosus* in the unfavorable summer season [41]. The rarity of dwellers in the region is related to the low presence of undisturbed dung pads in the Nelliampathi forests as it is quickly used up by the activity of tunnelers and rollers. Nocturnal guild dominated the three seasons. Nocturnal guild dominated NEM with six species (64.34% of total abundance), S with seven species (58.51% of total abundance) and SWM with six species (57.62% of total abundance). Diurnal guild was represented by three species (27.91% of total abundance) in NEM, one species (39.36% of total abundance) in S and one species (21.19% of total abundance) in SWM. Generalist guild was represented by seven species (7.75% of total abundance) in NEM, two species (2.13% of total abundance) in S and three species (21.19% of total abundance) in SWM (Fig. 2; Fig. 3; Table 1). Temporal guild abundance varied significantly in NEM, S and SWM (Table 2). Nocturnal and generalist guild abundance showed significant variation between seasons but diurnal guild abundance did not vary between seasons (Table 2).



**Fig 2:** Temporal guild (N=nocturnal, G=generalist, Di=diurnal) abundance of dung beetles in northeast monsoon (NEM), summer (S) and southwest monsoon (SWM) seasons in Nelliampathi forest during 2007-2008 study period.



**Fig 3:** Functional guild (T=tunneler, R=roller, Dw=dweller) and temporal guild (N=nocturnal, G=generalist, Di=diurnal) species richness in Nelliampathi forest in northeast monsoon (NEM), summer (S) and southwest monsoon season during 2007-2008 study period.

**Table 2:** Statistical analysis of seasonal variation in abundance between functional and temporal guild in a forest habitat in Nelliampathi, Southwestern Ghats during 2007-2008 study period (T=tunneler, R=roller, Dw=dweller; N=nocturnal, Di=diurnal, G=generalist; NEM=northeast monsoon, S=summer, SWM=southwest monsoon).

| Parameters                        | Kruskal-Wallis Test |    |      | Mann-Whitney Test (P value) |       |         |
|-----------------------------------|---------------------|----|------|-----------------------------|-------|---------|
|                                   | H                   | df | p    | T-R                         | R-Dw  | T-Dw    |
| Functional guild abundance in NEM | 4.801               | 2  | .091 | *                           | *     | *       |
| Functional guild abundance in S   | 0.646               | 2  | .724 | *                           | *     | *       |
| Functional guild abundance in SWM | 16.86               | 2  | .000 | .001                        | *     | .016    |
|                                   | H                   | df | p    | NEM-S                       | S-SWM | SWM-NEM |
| Abundance of tunnelers            | 28.6                | 2  | .000 | .000                        | .000  | .162    |
| Abundance of rollers              | 6.412               | 2  | .041 | .165                        | .152  | .019    |
| Abundance of dwellers             | 2                   | 2  | 0.36 | *                           | *     | *       |
|                                   | H                   | df | p    | N-Di                        | Di-G  | N-G     |
| Temporal guild abundance in NEM   | 13.929              | 2  | .001 | .404                        | .000  | .004    |
| Temporal guild abundance in S     | 21.891              | 2  | .000 | .696                        | .000  | .000    |
| Temporal guild abundance in SWM   | 8.636               | 2  | .013 | .343                        | .240  | .003    |
|                                   | H                   | df | p    | NEM-S                       | S-SWM | NEM-SWM |
| Abundance of nocturnal guild      | 10.602              | 2  | .005 | .006                        | .002  | .784    |
| Abundance of diurnal guild        | 4.688               | 2  | .096 | *                           | *     | *       |
| Abundance of generalist           | 25.393              | 2  | .000 | .001                        | .000  | .024    |

Dung beetles generally show abundance peak at dusk and around midday [44-49]. Diurnal species were more numerous than nocturnal species in several studies [50, 51, 48, 52, 26] but equal or higher numbers of nocturnal species existed in other forests [53, 45, 54-56]. Nocturnal species represented by tunnelers and rollers dominated the assemblage during NEM, S and SWM seasons in Nelliampathi forests. They were more speciose and abundant. High availability of dung at the end of a feeding day could be the reason for the high abundance of nocturnal guild [51]. Though rollers are frequently diurnal with their abundance peak at midday when the high temperatures enable them to perform their energetically costly rolling behavior at greater speed [23, 57], in the present study the roller *Sisyphus araneolus* was nocturnal. This presumably may be related to the availability of food at night and the warm temperatures prevailing in the S and NEM seasons in these forests that enabled their rolling behavior. Large beetles are nocturnal to avoid high diurnal temperatures which may elevate their body temperature to lethal levels [14]. Similar observations were made in the present study with the large tunnelers such as *Paracopris cribratus*, *Copris repertus* and *Catharsius molossus* all being nocturnal. Such large bodied, nocturnal species with specific requirements of soil temperature and compaction were found to be more sensitive to anthropogenic changes [58] and can be negatively impacted by the anthropogenic activities occurring in the study region. High abundance of diurnal beetle, *Onthophagus furcillifer* in the three seasons led to diurnal guild showing no seasonal preference, while nocturnal and generalist guild showed low abundance in the unfavourable summer season. *O. furcillifer* is a common species in the forests of South Western Ghats and well adapted to survive in the three seasons [16, 40]. The low abundance of generalist species in the forests of Nelliampathi indicates that restricting foraging activity to a particular time of day seem to favour the dung beetles in these forests.

In conclusion, high rainfall of SWM negatively affected the roller and dweller guild, while tunneler guild dominated the three seasons. Nocturnal guild dominated the three seasons and availability of food at night appeared to be the factor that influenced the temporal guild abundance rather than rainfall seasonality.

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