A COMPREHENSIVE ENHANCEMENT IN FINDING DIVERSITY SEASONAL VARIATION IN DUNG BEETLE FAUNA IN AND AROUND ALIGARGH, UTTAR PRADESH, INDIA.

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ABSTRACT

Five pitfall traps baited with 150–200 g of fresh cattle dung were installed for 24 h at weekly intervals. A total of 991 dung beetles from 11 genera, 31 species and three subfamilies was obtained. The community was dominated by Oniticellus spinipes individuals by 32.3%. Ten species appeared only once during the collection period and species composition and dominance changed throughout the period. The overall pattern we detected in the organization of the dung beetle community is that the species richness, abundance and diversity rise in September and the 2nd week of October. The dung beetle community was found to be affected by season.

Species diversity and abundance of scarabaeoid dung beetles (Coleoptera) attracted to fresh cow dung were studied in three habitats of New Jersey: Hutcheson Memorial Forest (HMF) disturbed field, HMF old growth forest, and Rutgers University Bovine Farm. Over a one year period, baited pitfall traps yielded a total of 15,206 beetles representing at least 26 species. Onthophagus hecate was a dominant species in all three sites, accounting for 55.1% of all individuals collected. Onthophagus pennsylvanicus and Copris minutus were present in high numbers in the field, comprising 25.1% and 3.8%, respectively, of specimens collected in that habitat, while O. orpheus and C. minutus were numerous in the forest (20.8% and 13.3%, respectively). Two introduced species, Aphodius lividus (68.5%) and O. taurus (9.6%), were the most numerous species on the farm. Nine species accounted for more than 96% of all scarabaeoid dung beetles collected during the year-long study. The majority of the beetles were collected during the warmer months (May-September), with general peaks appearing to be correlated with temperature. A total of five introduced species were collected: five in the farm site, two in the field site, but none in the forest; 80% of the individuals collected on the farm were introduced.

1.0 INTRODUCTION

The productivity of grazed ecosystems depends on the recycling of dung in which dung beetles play an important role. The activity of these insects is crucial to dung decomposition and they thereby enhance primary productivity. Studies in temperate and tropical areas have demonstrated the role of scarabaeid dung beetles in the recycling of the animal excreta. Scarabaeid dung beetles. The ephemeral character of their trophic resource affects the abundance of dung beetles but especially the possibilities of coexistence of many species in the same locality.

Most dung beetles are attracted to fresh herbivore and omnivore dung, and almost all Scarabaeidae and Geotrupidae species have developed complex nesting behaviour that enhance dung utilization and secures a food supply for their offspring. Most of Aphodiidae species do not show nesting behaviour and oviposit in a mass of dung, where their larvae are exposed to competition and predation. Their lower sensitivity to soil characteristics and lower energy requirements permit Aphodiidae to be active where conditions are colder and competition is less, both at high latitudes and high altitudes where other groups are rare. Larval development in the dung pats obliges most Aphodiidae species to be active either when conditions are wet or cold, when diggers are less abundant.

In Northern Europe, communities of coprophagous beetles are dominated by Aphodiidae. Wassmer showed that the temporal dimension is an important factor structuring communities of dungbeetles in Central Europe. In the north Mediterranean regions, these communities are more diverse. In these areas, species differ in their use of the trophic resources, which limits the degree of interspecific competition. Several studies describe the local dung beetle communities at temperate latitudes; in Northern Europe; Southern Europe and North America.

Dung beetle communities are well-studied in the French Mediterranean area, Spain, but until now not in Tunisia. In the majority of the investigations, phenology proved to be one of the most important factors structuring dung beetle assemblages. Season was the most important factor determining niche separation in dung beetle guilds in temperate conditions. Temporal separation of species can also be facilitated by the existence of several trophic guilds. In this context, the purposes of the present paper were to:

(i) study the seasonal pattern in the composition of Tunisian dung beetle assemblages in a sub-arid bioclimate;

(ii) quantify the temporal distribution and local coexistence within and between the Tunisian guilds of dung beetles over a one year period and

(iii) discuss and compare the local composition and structure and their temporal variation with that recorded in other studies from Mediterranean and temperate areas.

Altitude is a variable that is frequently related to changes in the species richness and composition of assemblage. The altitudinal variation in dung beetles has been studied at several locations in Europe, Mexico, and Southeast Asi. As for other insect groups, the number of species generally diminishes with increasing altitude and there is an altitudinal replacement between the two main groups of dung beetles, similar to that which takes place along latitude both for European and North American dung beetle assemblages.

2.0 LITERATURE REVIEW

Valiathan MS and Thatte U (2010) Modulatory influence of Andrographis paniculata crude extract on cytochrome P450 (CYP) enzymes was performed by administration of the crude extract of Andrographis paniculata to ICR male mice.

Bodeker G, Bhat KKS, Burley J and Vantomme P (1997) Andrographolide is the main diterpenoid lactone contained in the leaves of Andrographis paniculata. The Hildebrand solubility parameter concept was not able to predict the extraction of andrographolide using polar organic solvents.

Hammer KA, Carson CF and Riley TV (1999) The aim of the present study was to enhance the germination rate of Andrographis paniculata seeds which have a very low germination rate under normal conditions. The seeds were soaked in different hormonal solutions i.e. GA (10 ppm), IAA(10 ppm), IBA (10 ppm), Kinetin (10 ppm), GA+Kintetin (10 ppm), IAA+Kintetin (10 ppm) and IBA+Kintetin (10 ppm), and 50°C hot water at three treatment times (5, 10 and 15 min) before placing in Petri plates. The seeds of A. paniculata treated in hot water for 5 min showed maximum germination percentage of 93%. Analysis of variance indicated that both hormonal and hot water treatments had a significant effect on seed germination and final germination percentage. The results showed that hormonal treatments are not useful methods for breaking the seeds dormancy.

Ncube NS, Afolayan AJ and Okoh AI (2008) Many transient receptor potential (TRP) channels are activated or blocked by various compounds found in plants; two prominent examples include the activation of TRPV1 channels by capsaicin and the activation of TRPM8 channels by menthol. We sought to identify additional plant compounds that are active on other types of TRP channels. We screened a library of extracts from 50 Chinese herbal plants using a calcium-imaging assay to find compounds active on TRPV3 and TRPV4 channels. An extract from the plant Andrographis paniculata potently activated TRPV4 channels. The extract was fractionated further, and the active compound was identified as bisandrographolide A (BAA).

Hostettmann K (1999) To find out the active principles against ethanol-induced toxicity in mice, Andrographis paniculata Nees. (Ap) was chosen and isolated andrographolide (ANDRO) and arabinogalactan proteins (AGPs). ANDRO was detected by HPTLC, FTIR and quantified by HPLC (10 mg/g of Ap powder). AGPs was detected by β-glucosyl Yariv staining of SDS-PAGE gel, FTIR and quantified by single radial gel diffusion assay with β-glucosyl Yariv reagent (0.5 mg/g Ap powder).

Valdiani A, Kadir MA, Tan SG, Talei D, Abdullah MP and Nikzad S (1999) An exotic earthworm, Eudrilus eugeniae (Kinberg), was used to prepare coirpith based compost. This vermicomposted coirpith was amended with alkaline soil from an industrial site and compared with coirpith composted with EM (effective microorganisms) as a growth medium for the medicinal plant, Andrographis paniculata(Burm.f.) wall.ex.Nees, in field plots. Significant plant growth was attained when the same compost was amended with garden soil. The present results suggest vermicomposted coirpith could be helpful for the reclamation of soils from industrial sites for the cultivation of A. paniculata in a small scale nursery.

3.0 METHODOLOGY

Field sites

A survey of coprophagous Scarabaeoidea was conducted in Aligarh. The RUBF consists of a 2-hectare farm which, on average, holds approximately 45 cows. During the year, the cows were herded from one arena to another within this area. These cows are fed a combination of corn silage, Timothy hay and wet brewer's grain. Pilot studies conducted at the University farm suggested that the abundance of beetles found in pitfalls by the open pasture was equivalent to the number of individuals collected by the barn. The tract includes a number of adjoining 1-ha abandoned fields of known-age. The soils at HMF belong to the Penn soil series, derived from the Triassic red shale of the Brunswick Formation and there are only slight variations in soil texture, drainage, and depth among the sites (Ugolini, 1964). In addition, there are no significant differences in chemical composition, mineralization potential, soil structure, soil texture, or organic matter between the fields of different ages. The climate of the area includes mild winters with subtropical summers (Biel, 1958) and about 124 cm of annual rainfall. Average annual temperature is 11.48C with monthly means ranging from 1.38C to 248C.

Collection of beetles

Dung baited pitfall traps were used according Each trap consisted of a 2.5 qt. plastic container, 15 cm in diameter and 16 cm deep, buried to its rim in the soil. Insects falling into the traps were killed by water during the warmer months (June–November, and March–May), and a 1:4 ratio of antifreeze/water during the colder months (December– February). The bait consisted of 225–250 g of cow dung wrapped in cheesecloth, tied with a 20 cm piece of polypropylene twine, and hung from a 13 mm square piece of hardware cloth placed on the top of the bucket. Plywood tiles were nailed into the ground above each trap in order to discourage rainwater flooding.

Five traps were put at intervals of 18 m on each transect line that ran for 72 m (15 to 16 m intervals were used in the forest due to natural barriers and accessibility) in each of the three locations: 1) HMF disturbed field (40830.0289N, 74833.8359W), 2) HMF old growth forest (40829.7539N, 74833.8529W), and 3) RUBF (40828.5429N, 74826.2639W). Although similar studies have used ;9 m, and 20 m intervals, 18 m intervals were chosen in this study due to the size of the disturbed field (;110 m in length).

Field and forest pitfall traps were positioned in their sites parallel to each other, with forest pitfall #3 positioned next to a trail. Farm traps were placed along the fence of the bovine farm and a maintenance road. Trap–1 was closest to the barn and trap–5 was adjacent to a; 100 year old forest containing red and white oak as well as sweetgum. Collections were made once a week from May, 2017 to May, 2019. Beetles were collected in 15 Ziploc bags labeled forest 1–5, field 1–5, and farm 1–5, and were brought back to the lab for preservation in vials containing 80% alcohol.

Specimens collected during June and July were pinned. All specimens were counted and identified at a later date. Voucher specimens are in Prices' personal reference collection, and have been deposited at the Rutgers University Insect Museum and the National Museum of Natural History, Washington, DC. Books and papers that were helpful in identifying the species.

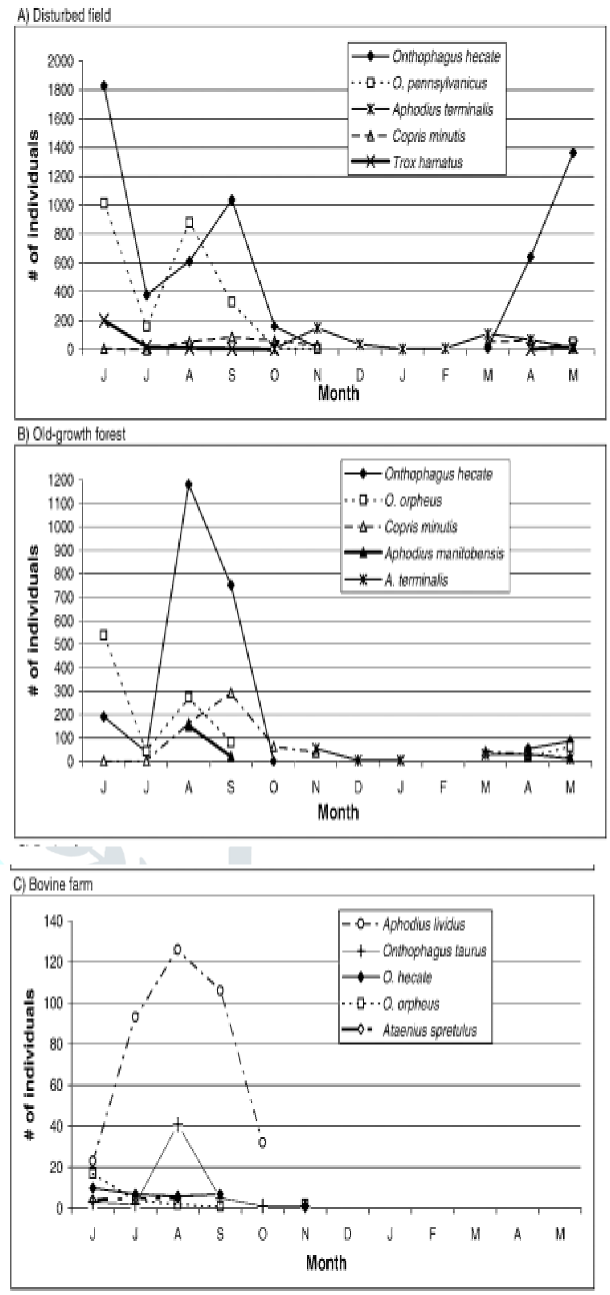
Alpha diversity

In the absence of general agreement on the most appropriate matrices of biodiversity, several non-parametric indices were selected to measure species richness and diversity. The following are explained in detail where formulas for each appear. Species richness was determined using Margalef's and Menhinick's indices. Both indices use a combination of S (the number of species recorded) and N (the total number of individuals summed over all S species). One advantage of these indices is the simplicity of the calculation, in addition to providing an instantly comprehensible expression of diversity.

Other indices used include the Shannon index (an information theory index), Simpson's index, McIntosh's index, and Berger-Parker index, of which the last three are generally referred to as dominance measures. Shannon index takes into account the evenness of the abundance of species and assumes that individuals are randomly sampled from an 'infinitely large' population, while Simpson's index is less sensitive to species richness and more sensitive to the most abundant species.

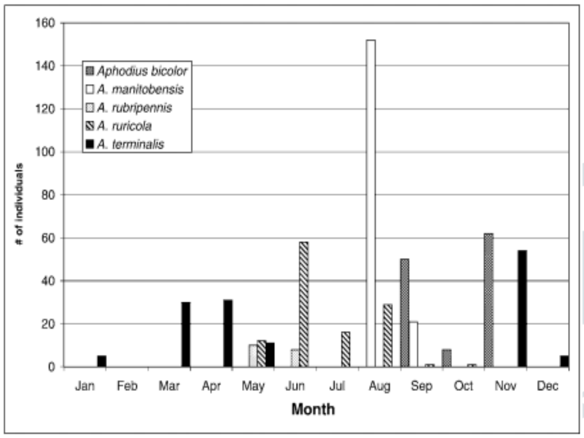
4.0 RESULTS

A total of 15,206 beetles were collected from the HMF disturbed field, HMF old-growth forest and RUBF (Table 1). Approximately twice as many individuals were collected in the field site as in the forest site, with many fewer still collected from the farm site. Onthophagus hecate, accounting for 55.1% of the total individuals collected, was a dominant species in all three sites. Onthophagus pennsylvanicus and Copris minutis were the second and third most abundant species collected in the field site (Fig. 1A; Table 1), while O. orpheus and Copris minutis were the second and third most abundant species collected in the forest site.



Graph Five most abundant dung beetle species collected at each site. A. Disturbed field site. Scale: 0 to 2,000. B. Old-growth forest site. Scale: 0 to 1,200. C. Bovine farm site. Scale: 0 to 140. Collection started 30 May 2002 and was complete 30 May 2019.

Aphodius lividus, an imported species, was found to be the most abundant species collected in the farm site, accounting for 68.47% of the total individuals caught on the farm (Fig. 1C; Table 1). The general diversity of each site is shown in Table 2. With the exception of Menhinick's index, which estimates the farm to have the highest diversity, all of the diversity indices estimate the forest to have the highest diversity over all. All indices are in agreement that the field site has the lowest diversity. In addition, all of the dominance indices estimate the forest to have the lowest degree of dominance, and therefore the highest evenness of scarabs.



Graph Seasonality of five most abundant Aphodius species in the forest.

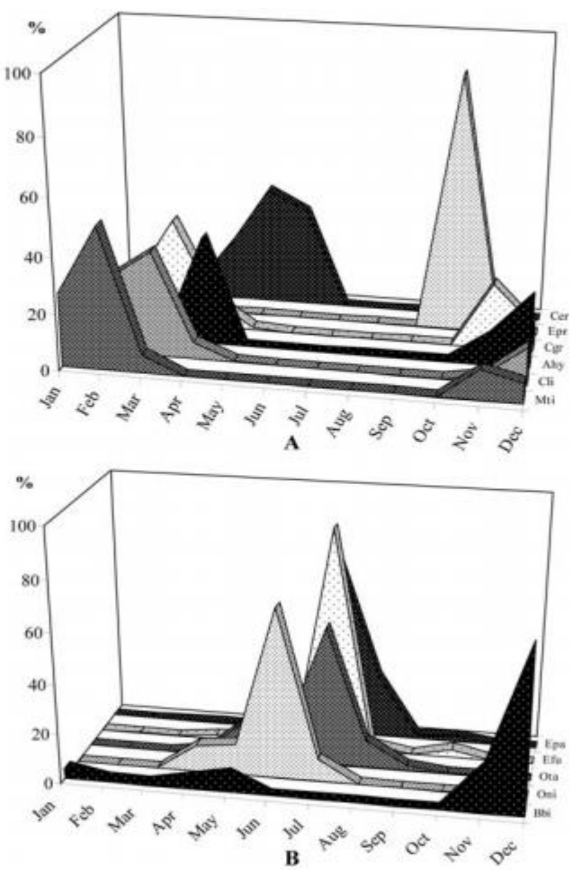
Ninety-three percent of the total individuals in all three sites were collected during the months of June–September 2018 and, April and May 2019. Aphodius terminalis, a winter species, was collected from October to May; it was the main species collected during the winter months, and the only one collected in December and January (with the exception of one Trox specimen). Aphodius species in the forest site demonstrated a clear seasonal pattern as follows: A. rubripennis collected in May and June, A. ruricola collected from May to October, A. manitobensis collected in August and September, A. bicolor collected from September to November, and A. terminalis collected from October to May.

Abiotic factors examined in this study include temperature and precipitation over the entire year. The total annual precipitation for June 2018 to June 2019 was 134.8 cm verses an average of 123.9 cm for the previous 30 years (1971–2000). Temperature had a significant effect on the abundance of beetles collected each month in the farm site. None of the sites showed a significant correlation with precipitation. A total of five introduced species were collected among the three sites; five in the farm site, two in the field site and none in the forest.

In the farm site, 80% of the total individuals collected were introduced species. Introduced species in the field only accounted for 0.10% of the individuals collected. Additional families of Coleoptera collected included; Staphylinidae, Carabidae, Silphidae, Coccinellidae, Chrysomelidae, Curculionidae, Elateridae, Histeridae, Lampyridae, Byrrhidae, Hydrophilidae, and Mordellidae. Individuals of the family Silphidae (Coleoptera) were collected throughout the summer, with high abundances in July and August.

We collected a total of 2,018 dung beetles across 39 species, distributed among 15 genera. The December collection had the highest species richness, with 34 species (1,706 individuals). February and April collections yielded 15 and 16 species (143 and 169 individuals, respectively). Six species were shared among all sample periods, and no species was sampled only in February. Three species were found only in April (Table 1). Canthon histrio, Onthophagus aff. Hirculus, and Deltochilum verruciferum were the most abundant species, representing together >61% of the samples. We found no effects of plant species richness and abundance on the dung beetle community (a- and b-diversity, and abundance). Scarabaeinae a-diversity and abundance were higher in December, and did not differ between February and April (, while b-diversity among plots was lowest in December.

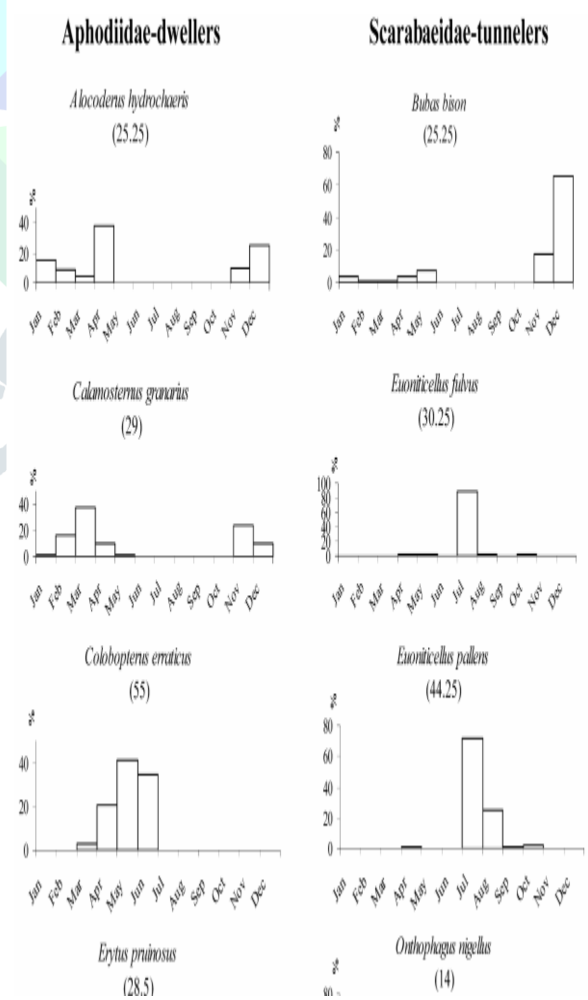
The decomposition of b-diversity revealed that the relative importance of nestedness and species turnover varies between pairs of sample periods. Nestedness was the main process between December and February, while turnover was more important between February and April. Between December and April, the two processes were equally important for structuring dung beetle communities.



Graph Seasonal segregation of species of Aphodiidaedwellers (A) and Scarabaeidae-tunnelers (B). X-ordinate: time (month); Y-ordinate: abundant species (no. > 10/trap/year); Z-ordinate: relative percentage (%) based on mean abundance. For abbreviations of species names

Species composition of assemblage

The pooled sample for the trapping period (January– December 2019) included 4,965 beetles belonging to 37 species: 19 Aphodiidae-dwellers (52.63%), 14 Scarabaeidae-tunnelers (36.84%), one Scarabaeidae-roller (2.63%) and three Geotrupidae-tunnelers (7.89%) (Table 1). Aphodiidae-dwellers were active throughout most of the year, except during the driest period (June to September), with two exceptions, Colobopterus erraticus was active in June and Anomius castaneus in September. Scarabaeidae-tunnelers showed a major peak of activity of species and individuals in spring-summer (May to August). The Geotrupidae-tunnelers activity showed two peaks, a high one in spring and a low one in autumn.



Graph Seasonal occurrence of the 11 most abundant scarabeid species (> 10 ind./trap/year). Ordinate: relative percentages (%) based on mean abundance. Below each species (in brackets): total no. of individuals

5.0 CONCLUSION

Our results make it possible to conclude that the coexistence of dung beetles in ephemeral and patchy habitats in a variable environment can be explained partly by differences in species life-history traits and separation in time. The seasonal changes in activity of the guilds can be interpreted as the result of a long-term co evolution of species resulting in a widening of niches, which reduces competition. The seasonal distribution of species may result from a relatively constant level of trophic resource during the year. Local coexistence and differences in phenology in dung beetles communities may reflect past competitive interaction, as mentioned.

The coexistence of species is based on a complex seasonal segregation within and between guilds. If St and Sr together monopolize most of the resource (due to their numbers and size), Ad species have to be active in other periods of the year when competition is less severe as strong and Scarabaeidae are scarce.

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