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Ecological Distribution and Seasonality of Darkling Beetles (*Coleoptera: Tenebrionidae*) in the Western Region of Abu Dhabi, UAE

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Abstract: Invertebrate survey conducted to establish species knowledge to assess habitat and diversity of ground dwelling invertebrates in proposed Houbara bustard *Chlamydotis undulata macqueenii* release sites of the Western Region of Abu Dhabi Emirate. The specific invertebrate species diet of Houbara Bustard in this region is poorly known and this study helps to understand those needs for attempts restore Houbara Bustard populations in the wild. Pitfall traps were used to study the diversity and seasonal abundance of invertebrates, especially ground dwelling darkling beetles (Tenebrionidae) at five desert sites in the Western Region of Abu Dhabi Emirate from March 2009 to February 2010. Traps were checked monthly and analysis was done based on the total catch of Tenebrionids from all study sites. The most abundant were Tenebrionid specimens. From all sites a total of 5720 Tenebrionid beetles were trapped, representing 15 species. The most dominant were *Adesmia stoeckleini rasalkhaymana*, *Prionotheca coronata*, *Erodius octacostatus*, *Blap skollari kollari, Pimelia arabica, Pimelia arabica emiri, Apentanodesarabica* and *Paraplatyopepopovi.* The species *P. coronata*, *P. arabica, Mesostena puncticollis, A. arabica* and *P. popovi* were found in all sites while species *A. stoeckleini rasalkhaymana* was confined to Site I. Number of Tenebrionids trapped in winter and midsummer were low, they reached peak in the spring when the weather was moderate and plant diversity highest. The appearance and disappearance of the beetles were strongly linked with seasonal changes.

Key words: Diversity · Seasonality · Darkling Beetles · Pitfall Trapping · *Prionotheca coronata*

INTRODUCTION

Beetles play significant roles in most ecosystems [1]. Prominent epigeal examples are the Tenebrionids that play a relatively major role in tropical and subtropical dry-lands, more so with increasing aridity [2]. Since the inventorying of biodiversity is the first step in any conservation programme, an invertebrate survey was conducted to establish a basis for species level knowledge of specified invertebrate groups on specific habitat types in the Western Region of Abu Dhabi Emirate. The greater portion of the United Arab Emirates is a desert, with large, rolling sand dunes and the overall climate falls within true xeric and arid climates which are sub-tropical. One of the most active forms of wildlife in the Arabian Desert is beetles, which are able to survive in the sweltering heat of the sand dunes [3]. Among the ground dwelling invertebrates, Tenebrionids are relatively abundant, large, cursorily, readily captured in pitfall traps and the most easily identified.Communities of these beetles integrate factors such as the availability of detritus, plant cover and various soil characteristics like moisture, hardness and grain-size composition. Therefore, Tenebrionids are considered as sensitive indicators of biodiversity change due to habitat loss and degradation [4]. Desert Tenebrionids may generally be described as rather slow moving, black, flightless beetles. Adults and larvae are considered as detritivorous [5], although adults have been observed feeding upon carrion [6] and dung [7] and some larvae are root-feeders [8]. Tenebrionids may play an important role in detritus cycling in ecosystems [9]. Long-term monitoring programme of their population can provide valuable insights into how environmental changes affect organisms [10]. The aim of the study is to establish species knowledge to assess habitat and diversity of ground dwelling invertebrates in proposed Houbara release sites of Western Region of Abu Dhabi Emirate.

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MATERIALS AND METHODS

Study Area: This study was carried out at five different desert sites at the Western Region of Abu Dhabi Emirate (interdune gravel plains (Site I), sand sheets with low dunes (Site II), area of white sand sheets (Site III), sand dunes (Site IV) and sand and gravel mixed dune habitat (Site V) that situated approximately 180 km North-West of Abu Dhabi Island. Sites were selected based on the type of micro habitat to understand the diversity, distribution, abundance and seasonality of ground dwelling invertebrate species.

Site I and Site II: Site I and II (N23.97783 E054.14168 and N23.94631 E054.19688) are located approximately 50 km from Al Marzoum, on Abu Dhabi -Sila Road, The site I is a unique gravel plain area with a little vegetation, mainly dominated by one plant species- the foetid saltwort *Salsola imbricata*, which is a leaf succulent perennial halophyte from the family Chenopodiaceae. The soil substrate is sandy-gravelly and mixed with gravels and very little organic matter. Surrounding areas of the Site I have interdunal plains on which area of coastal flats (locally known as Sabkhas) are seen with no vegetation. Site II is characterized by sand sheets and dunes in which shrubs of white saxaul *Haloxylon persicum* and a common perennial shrub of the Arabian deserts *Haloxylon salicornicum* are seen. Other major shrubs observed in this area are Cyperus *Cyperus conglomerates* and bean caper *Zygophyllum qatarense* [11]. The soil substrate is of fine silt with sand without gravel. Signs of camel grazing are also generally found in this area. Insect galls were observed on two plant species *H. persicum* and *H. salicornicum*.

Site III: Site III (N23.90550 E053.92321) is near Al Hilwha which is 15 km from Abu Al Abyad exit on Abu Dhabi - Sila Road. This site is characterized by sand sheets and sand dunes which are exposed to strong winds year round. The soil substrate is comprised of fine sand and no gravels or organic matter is present, sand is whiter compared to other sites. The vegetation of this habitat is dominated by *Z. qatarense* and *H. salicornicum*. Other plant species include *C. conglomeratus* and *Dipterygium glaucum*.

Site IVand Site V: Site IV and V (N23.95226 E053.56308 and N23.94268 E053.58252) are located approximately 13 km from Mirfa roundabout on Abu Dhabi -Sila Road. The soil substrate is sandy and the habitat type is mostly sand sheets and dunes dominated mainly by *H. salicornicum*. The vegetation showed signs of camel grazing. Another plant species observed in this site is *C. conglomeratus.* Site IV and V are close to each other with approximate distance of 2 km. The soil substrate is more or less the same as Site IV except that the texture of the sand is slightly different; here sand is mixed with small amount of gravel. The major plant species noted from the site are *H. salicornicum*, *C. conglomerates* and *D. glaucum*.

Methods: The pitfall trap is an adaptation by the ecologist of a common hunting technique originally described by Barber [12], which continues to be amongst the most widely employed sampling methods for ground-dwelling macro-invertebrate. It is the use of a pit in the ground into which an animal falls and cannot escape [13]. Pitfall traps were baited with Apple Cedar Vinegar (ACV) to attract insects. ACV is a type of vinegar made by the fermentation of apples or cider which contains a substance called acetic acid which gives strong smell.In the current study, beetles were collected mainly by setting pitfall traps on five distinct habitat sites (I, II, III, IV & V) of Abu Dhabi Western Region over a period of 12 months. Twenty pitfall traps were placed approximately 1 to 2 m apart in an area of 40/40 meter at each site. They were constructed using small plastic buckets (17 cm length and 17 cm in diameter). The traps were buried with rims flush with the soil surface. No efforts were made to keep wind-blown sand and debris, or rainwater entering the traps. Pitfall traps were emptied monthly and beetles were counted.

Species Identification: Collected invertebrate specimens were preserved; dried, pinned and kept in the invertebrate reference collection of Environment Agency -Abu Dhabi (EAD). Voucher specimens (insect specimens collected from study sites and preserved for future references) were identified to species level by comparing with identified specimens [14]. Later trapped specimens were compared with direct observation in the field.

RESULTS

In the current study, we compare the invertebrate diversity especially the abundance, seasonality and peak appearance of dominant ground dwelling beetle species in the desert habitats. A total of 5720Tenebrionid beetles were captured which belongs to 15 species. The other invertebrate species (Scorpions, spiders, camel spiders and insect orders like Hymenoptera, Diptera, Isoptera,

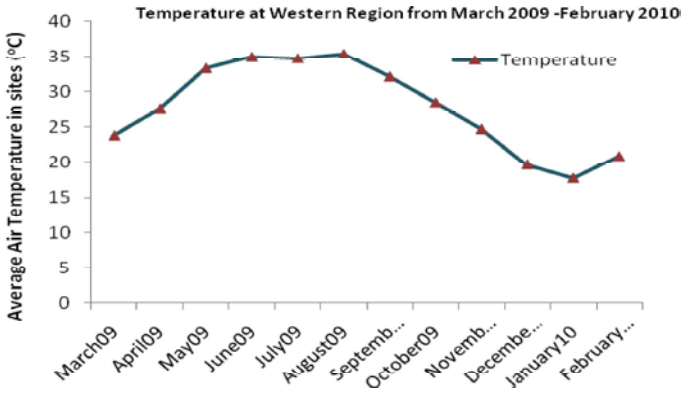

Fig. 1: Monthly average recorded temperatures in five sites from March 2009 to February 2010

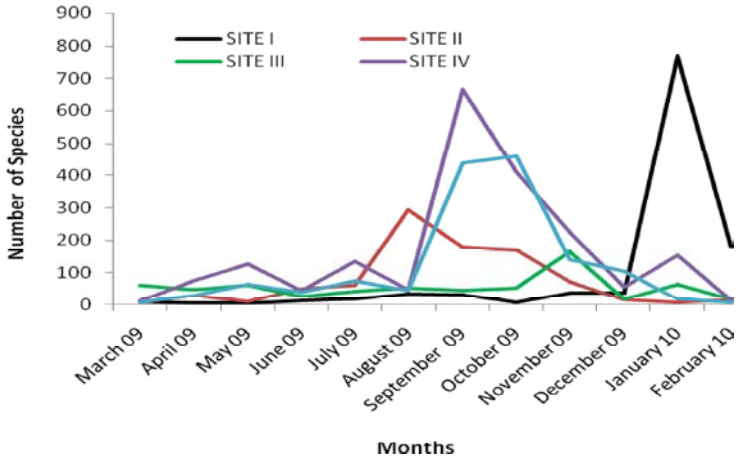

Fig. 2: Seasonal abundance of major beetle species at the four study sites in the Western Region from March 2009 to February 2010

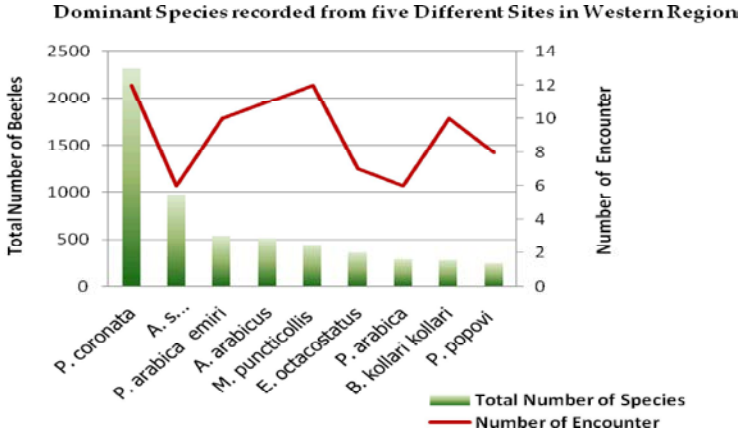

Fig. 3: Capture frequencies of most abundant species at five different sites in Western Region

Lepidoptera, Heteroptera and Odonata) recorded for the base line information. The study area has an arid desert climate with irregular rainfall, typically between zero to 0.1mm/annum. The mean annual rainfall recorded was about 0.1 mm during the study period. Maximum temperature observed was around 35.34°C and a minimum temperature observed was 17.68°C (Fig. 1) during the same period. The total number of invertebrates, dominant species and seasonal patterns in the number of beetles at the five different study sites are presented in Figures (2 & 3) and Table 1.

Table 1: Total number, dominance and percent of distribution of Tenebrionid Beetles

Species	Abundance	% Distribution Site 1	Site II	Site III	Site IV	Site V	Dominance (%)	Appearance (Peak)
Adesmiastoeckleinirasa lkhaymana	975	87.9	0.0	0.00	0.00	0.00	17.05	Dec -April (Jan)
Apentanodesarabica	565	0.8	26.9	18.3	7.2	5.5	9.8	Feb - Dec (Aug)
Blapskollarikollari	299	0.0	0.4	22.6	8.5	0.8	5.2	Sept-May (Jan)
Erodiusoctacostatus	229	0.0	6.1	0.3	5.4	5.4	4.0	Feb-Aug (April)
Erodiusrubalkhalianus	26	0.0	6.1	4.2	0.0	0.0	0.4	March - April
Mesostenapuncticollis	417	4.2	9.9	0.7	8.8	8.7	7.2	Jan-Dec (Sept)
Microderamarginatade serticola	8	0.0	0.2	0.1	0.2	0.0	0.1	July
Paraplatyopepopovi	244	0.0	2.2	0.7	4.1	10.9	4.2	Jul-Dec (Oct)
Pimeliaarabica	824	3.5	8.1	51.7	7.2	22.2	14.4	Sept-Jan (Oct)
Pimeliaarabicaemiri	24	0.0	0.4	0.0	0.0	1.5	0.4	March -Jan (Oct)
Prionothecacoronata	2028	1.8	44.3	0.1	56.2	43.8	35.4	Mar-Feb (Sept)
Scelosodisbesnardi	14	0.0	0.0	0.5	0.2	0.4	0.2	Oct-Nov
Tentyrinapalmerithomasi	43	0.0	0.9	0.3	1.4	0.3	0.7	(Aug)
Tentyrinapunctipes	2	0.000	0.00	0.178	0.05	0.00	0.03	(Aug)
Trachydermaphilistina	22	1.5	0.0	0.0	0.2	0.0	0.3	(Sept & Dec)

* Dominance = species abundance/total number of Tenebrionid beetle (5720) x 100.

%Distribution= species abundance per site/species abundance x100

Site 1: Altogether 1142 individuals were collected from Site I in pitfall traps. The most abundant species were identified as coleopteran beetles of the family Tenebrionidae, represented by 1109 specimens, belonging to 8 species: *Adesmia stoeckleini rasalkhaymana*, *P. arabica*, *Trachyderma philistina*, *M. puncticollis*, *P. coronata*, *A.arabica, Ammocleonus aschabadensis* and *P. popovi.* The most abundant were *Adesmia stoeckleini rasalkhaymana, M. puncticollis*, *P. arabica* and *P. coronata*. These four species were observed as the most dominant in terms of their density and seasonal occurrence in the year. Among these four dominant species, the density and abundance of the species *A. stoeckleinii rasalkhaymana* was observed to be higher than the other three species. This species appeared from December to February and with its peak appearance occurred in January. This species is characterized by high rate mobility during daytime and found to be associated with the plant species *S. imbricata*. Other species like *T. philistina*, *P. coronata*, *A. arabica* and *P. popovi* were observed infrequently at the site.

Site II: Altogether 940 specimens were collected from Site II that belong to 11 species of beetles: *Apentanodes arabica, Blaps kollari kollari, E. octacostatus*, *Erodius rubalkhalianus, M. puncticollis*, *P. arabica*, *P. arabicaemiri*, *P. coronata*, *P. popovi, T. palmeri thomasi* and *Microdera marginata deserticola* belonging to the Tenebrionidae family. Six species were found to be dominant at Site II in terms of their numbers and seasonal occurrence during the 12 months survey period. Theseare *P. coronata*, *A. arabica*, *M. puncticollis*, *P. arabica*, *E. octacostatus* and *P. popovi*. Among the six species observed, species *P. coronata* was the most abundant species in Site II. This species was recorded from April to February and their peak appearance was in October. *A. arabica* stood next in terms of abundance in Site II. The other five species were observed infrequently at this site during the same period. *M. marginata deserticola* and *E. rubalkhalianus* are the two species observed low in abundance and encounter less during one year survey period. They have been recorded from site II only for 1 or 2 months in a year. The most dominant species *P. coronata* is a very common Tenebrionid species with high seasonal abundance and was observed from the Site I as well.

Site III: A total number of 674 specimens were collected from Site III in pitfall traps that include 13 species of beetles i.e. *A. arabica*, *B. kollari kollari*, *E. octacostatus*, *E. rubalkhalianus*, *M. puncticollis*, *M. marginata deserticola*, *P. arabica*, *P. arabica emiri, P. coronata*, *P. popovi*, *T. palmeri*, *T. puncticeps* and *Scelosodis besnardi.* Six species were observed to be dominant at Site III which includes: *P. coronata*, *E. octacostatus*, *B. kollari kollari*, *P. arabica*, *A. arabica* and *M. puncticollis*. *P. coronata* was the most dominant species observed in terms of abundance and encountered during the study period from March 2009 to February 2010 with a peak appearance in November. The appearance of *E. octacostatus* was observed from the month of March to July and the peak appearance noted

in the month of May. The species *B.kollarikollari* and *P. arabica* were not recorded at the site from March to October and were only recorded from November to February. Some of the beetles were encountered infrequently such as *M. marginata deserticola*, *T. palmeri thomasi*, *T. puncticeps*, *T. philistina* and *S. besnardi.*

Site IV: A total of 1847 specimens were collected from Site IV in pitfall traps during the study period from March 2009 to February 2010. Fifteen species of beetles which include *A. arabica*, *B. kollari*, *E.octacostatus*, *M. puncticollis*, *M. marginata deserticola*, *P. arabica*, *P. arabica emiri, P. coronata*, *Paraplatyope popovi*, *T. palmeri*, *T. puncticeps*, *S. besnardi* and *Z. magneauxi.* As in the Site II and Site III, the beetle species *P. coronata* was observed as the major species in terms of number and encounter during the one year survey period. Among 15 species, 8 species were identified to be dominant in terms of their encounter and seasonal occurrence during the study period from March 2009 to February 2010. The abundance of *P. coronata* was found to be higher than the other seven species during the entire study period and it appeared from April to January with a peak appearance in September. *A. arabica* is the second frequently encountered species from site IV.

Site V: Altogether 1430 specimens were collected from Site V in pitfall traps from March 2009 to February 2010 includes 13 species of beetles *A. arabica*, *A. buettikeri*, *Ammogiton omanicum, Blaps kollari kollari*, *E. octacostatus*, *M. puncticollis*, *M. marginata deserticola*, *P. arabica*, *P. arabicaemiri, P. coronata*, *P. popovi*, *Scarites guineensis* and *S. besnardi*. Eight dominant species were observed at Site V including *P. coronata*, *E. octacostatus*, *B. kollari kollari*, *P. arabica P. arabica emiri, P. popovi* and *A. arabica*. *P. coronata* was found to be the most abundant species at Site V in terms of number and times of encounter. The appearance of this species has been noted during the study period except on February with a peak appearance in September. *P. arabica* was noted to be the second most abundant species at Site V with a peak appearance in November.

Diversity and abundance in Site IV was found to be higher compared to the rest of the studied sites. The number of beetles trapped was low during the months of March, April, May, June and July and it increased sharply during the months of August, September, October and November except for Site I, where the peak was in the months of December, January and February. The number of beetles trapped was positively correlated with rainfall during these months in Site I where the soil was dry in rest of the months of the year.

The distribution of the most abundant species varied in the different sites. *P. coronata*, *M. puncticollis*, *P. arabica*, *A. arabica*, *P. popovi* were found in all study sites of the Western Region, while, *A. stoeckleini rasalkhaymana* was observed from Site I only. *S. besnardi* was the least observed species from Site III, Site IV and Site V and its appearance was observed only in these sites during the month of October and November. *P. coronata* was observed as the most abundant species in terms of density and encounter in all the sites except Site I where the abundant species was *A. stoeckleini rasalkhaymana*. Number of *P. coronata* captured was highest between October and November whilst numbers *A. stoeckleini rasalkhaymana* captured was highest between January and February.

DISCUSSION

Attributes such as bare ground, vegetation cover, vegetation density and site aspect slope may influence an insect's incidence and abundance in unexpectedly subtle ways. Climatic conditions in the study area were extremely hot throughout most of the year. The total amount of rainfall was less than 0.1 mm in the year. Tenebrionids avoid harsh weather in various ways such as burying themselves underground to avoid the sand's extremely high temperatures emerging periodically each day [15]. Many Tenebrionids also secrete a layer of wax that coats the exoskeleton, reflecting some of the sun's radiation and protecting beetles from water loss, abrasion and micro- organisms [16]. Most Tenebrionid beetles trapped in this study were shiny and this may be connected with solar reflection [13]. Furthermore, most of the beetles were strictly nocturnal and avoided the heat of the day [17, 18]. The peak of abundance occurred in the spring, when the weather was moderate and plant diversity highest. Most beetles disappeared during summer and winter, when the temperature was intolerable. The reason for the relatively less number during this period may be due to the comparatively less flora present in that time in these areas [13]. During these periods, the cycle is continued by larval stages in the soil where conditions are more favourable. Furthermore, the larvae obtain their food and water from the roots of desert plants and this ensures the successful development during hottest months [13]. Evidence of tolerance and hardiness was afforded by the fact that most trapped beetles remained alive for a week in the traps without food and water [19].

Some species were found at all the sites but a few species were strictly confined to particular areas. *P. coronata*, *P. arabica, M. puncticollis, A. arabica* and *P. popovi* were found in all sites. This indicates that these species are capable of existing in a wide range of habitats [13]. *A. stoeckleini rasalkhaymana*were confined to Site I, which were mostly captured in traps close to plant species *Salsola imbricata* and this might be correlated with the plant characteristics. *S. imbricata* is a leaf succulent perennial halophyte which has thick fleshy leaves and stems that can store water and might be used as food plant for beetles [20].

The number of beetles trapped in any habitat is well correlated not only with species abundance but also with activity [21]. *A. stoeckleini rasalkhaymana*, *P. coronata*, *E. octacostatus*, *B. kollari*, *P. arabica, P. arabica emiri, A. arabica, P. popovi* were dominant species observed from the study sites in terms of abundance and encounter, characterized by a high rate of mobility. On the other hand, the least abundant species such as *Zophis* sp*, Paraplatyope* sp. and *T. philistina* were least active and, therefore, their capture rate was low.

In the current study five species of Tenebrionid beetles were observed dominant from the study sites in terms of abundance and encounter, characterized by a high rate of mobility of which *Pimelia* sp. and *Blaps* sp. were widely eaten by Houbara bustard in Saudi Arabia [22]. Faecal analysis studies on Houbara Bustard (*Chlamydotis* (*undulata*) *macqueenii*) diet showed that invertebrates constitute a major portion of its diet which represents mainly Tenebrionids, Scarabaeidae, Carabids, Curculionids, Meloids, Formicidae, Isoptera, Arachnids (scorpions, spiders) and Solifugae (camel spider) mainly of the Genus *Galeodes* [23]. Some of the Tenebrionid beetles species observed in the Western Region sites include the diet of Houbara and hence this habitat can be considered important in connection with the Houbara conservation programmes. *Pimelia* spp was reported to form part of the Houbara diet [22] which was found in all the study sites from September to December, therefore, these sites can be considered for Houbara release and conservation in future.

CONCLUSION

The pitfall traps have been considered as a reliable method for beetles and a long -term trapping is required to understand the biodiversity, community composition and activity of different species in different seasons. The numbers of Tenebrionid beetles trapped in winter and midsummer were low and reached peak in spring. Pitfall trapping and population responses make Tenebrionids a convenient and suitable taxon to track environmental conditions over long periods of time. Some of the Tenebrionid beetles species observed in the Western Region sites include the diet of Houbara and hence this habitat can be considered for Houbara release and conservation in future.

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