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DIVERSITY OF ARTHROPODS IN HAFIER DOKA RESERVE FOREST, SUDAN

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Abstract

Sudan has suffered natural drought cycles during the last decades. These cycles coupled with human interventions resulted in desertification. The major impacts of desertification on natural resources can be assumed up in the following: Socio-economic livelihoods, decline of land productivity, food production shortage, and resource based Conflict, decline in environmental quality decline of rangelands and loss of biodiversity.
Arthropods are considered as main components of desert eco-system. They gain this importance via their close association with desert flora .They depend on flora for feeding and shelter. Despite the vital role of arthropods in desert eco-system, they receive little attention by many ecologists in Sudan. Diversity of arthropods was studied in Hafeir Doka forest reserve Southern Khartoum. The study was conducted to evaluate the diversity of arthropods in the reserve forest as well as to through some light on the impact of reserve areas on biodiversity of encountered arthropod. The area of the study was divided into 4 sites according to their topography, these sites were: Hilly, Sandy dune, valley and flat land sites. The study included identification and quantification of arthropods from the four sites. Beating sheet, butter fly net and hand sorting methods were used to collect arthropods. A total of 5639 arthropods identified into 2 classes (Insecta and Arachnida), 18 orders, and 31 families. Statistical analysis showed that members of class Insecta were dominated the class Arachnida in all sites. Within the class Insecta, members of the order Hymenoptera were prevailed members of the other orders followed by members of the orders Coleopteran and Diptera, while members the orders Pseudoscorpionida and Acari were found to be the least represented taxa of the total collected arthropods. Simpson's Diversity Index (SDI) calculated for the total arthropods catch was high (= 0.2). These results could be ascribed to the ability of members of the class Insecta to colonize, proliferate and withstand different environmental conditions. Whereas, the

high (SDI) value could reflects the importance of reserve areas to conserve arthropods diversity.

Keywords: Desertification, arthropods diversity, reserve forest, Insecta, Arachnida

Introduction

Biodiversity as a term is defined as “the variability among living organisms from all sources including terrestrial (above and below ground), marine and other aquatic ecosystems and the ecological complexes of which they are part. This concept covers the diversity of genes, species and ecosystems. The values of biodiversity include: contribution to environmental protection, such as protection of water sources, keeping food sources through cycles of elements in addition to keeping a balance and addressing climate events such as fires, natural cycles of drought and floods. Also, biodiversity provide scientific and social benefits such as providing areas of education, training and research and areas for tourism and recreation, Food and Agriculture Organization of the United Nations, FAO, 2003).

Sudan is characterized by ample natural resources such as water, farmland, forestry, livestock, fisheries and minerals. The natural resources represented in animal and plant species are considered a natural wealth of high economic value. These resources can be reinvested back on the individual and community well- being upon wise use, taking into account their development and sustainable use. The conflict over natural resources is one of the most important recent challenges facing the world generally, and the developing countries, particularly in African; taking into consideration the population growth coupled with declining resources and growing demand. This situation has resulted in the depletion of these resources. Sudan is characterized by multiple natural environments, including: desert, semi - desert, savannah, flood areas and mountain environments, which produce a unique biodiversity, Zinta and MacDonald (2012).

According to Nour El Dayem (2008), biodiversity monitoring began in Sudan before independence, where 3132 of flowering plant species , 106 species of the Nile fish, 265 species of mammals , 938 species of birds and two species of amphibians and many insects and other arthropods were identified. Several combined factors accelerating the rate of loss of these species including: the lack of environmental awareness on the importance of biodiversity, the human using the living organisms as unlimited sources, in addition to the absence of institutional and legislative authority that regulate the exploitation of natural resources and protection. Also disasters such as floods, fires and drought cycles accelerate the loss of many species. As a result of deterioration of biodiversity; ecological belts shifted to the south. The repeated cycles of drought and desertification have forced the living forms organisms to migrate to the moist south .The same conditions forced farmers to farm in the bottom of the valleys to sustain their livelihoods.

Arthropods are important components of ecosystems occupying vital positions in food as decomposers, parasitoids and pollinators. Arthropods are highly diverse and live in nearly every habitat on Earth. Trillions of them are alive at any one time. Class Insecta alone may have 5-30 million species (Erwin, 1982; Novotny *et al*., 2002). Their high diversity, small body size, high reproductive capacity, makes them suitable for monitoring environmental changes. (Weaver, 1995, Desert arthropods are affected by environmental factors such as habitat conditions, and plant cover (Gitler, *et al* 1997).

Soil arthropods are usually affected directly and/or in directly by changes in their local environment including biotic and abiotic factors. The direct effects of abiotic factors include biological and physiological disturbances, while indirect ones include changes in habitat properties, Mopper *et al*.2004).

Studies on arthropods diversity have gained attention in recent years, due to rapid of species with increasing environmental degradation. Awareness of the dangers of species loss has been translated into environmental convention aiming at conservation and sustain of biodiversity (IUBS, 1992) as well as national ones (Baldwin, *et al* 1992).

In Sudan information of arthropods diversity is limited; few groups have been identified in addition to the frequent loss of diversity. Desert arthropods are affected by environmental factors such as habitat conditions, and plant cover (Seely,1989).

Despite the vital role of arthropods in desert ecosystem they receive little attention by many ecologists in Sudan .Information regarding the diversity of arthropods are limited; few groups have been identified in addition to the frequent loss of diversity. The null hypothesis of this study is that there is no difference in arthropods diversity between the study sites selected at Hafier Doka reserve forest, Sudan. The objectives of the study include evaluating diversity of arthropods in relation to habitat characteristics in a desert reserve forest. It also meant to throw some light on the ecological relation between arthropods taxa as well as their ecological roles in maintain desert ecosystem future.

Material and Method

Study area:

Hafeir Doka forest is located Southern Western Khartoum State, About 40 km, near Khartoum International New Air Port, Sudan. The area occupies about 1.2 hectares ,between longitudes ″32º 24" 23’ ‟ and ″32º 13" 23’‟ E and latitudes″15º 31" 06 ‟and ″15 º 11" 09’ N’‟, Fig.(1) .

.It thus lies within the tropical semi arid region of the Sudan. Its climate is characterized by short rainy season that extends between (July – October) with high evaporation potential and low relative humidity values indicating the general aridity of the area. Air temperature values fluctuated and show marked rise in May and drop in July and October due to the incidence of rains. The soil is generally sandy clay loam textured, ELHag *et al* (1994).

Plant cover in the reserve

The natural plant cover is mainly composed of *Acacia seyal* species since it lies within the *Maerua crassifolia* - *Acacia tortlis* belt, Harrison and Jackson (1958).

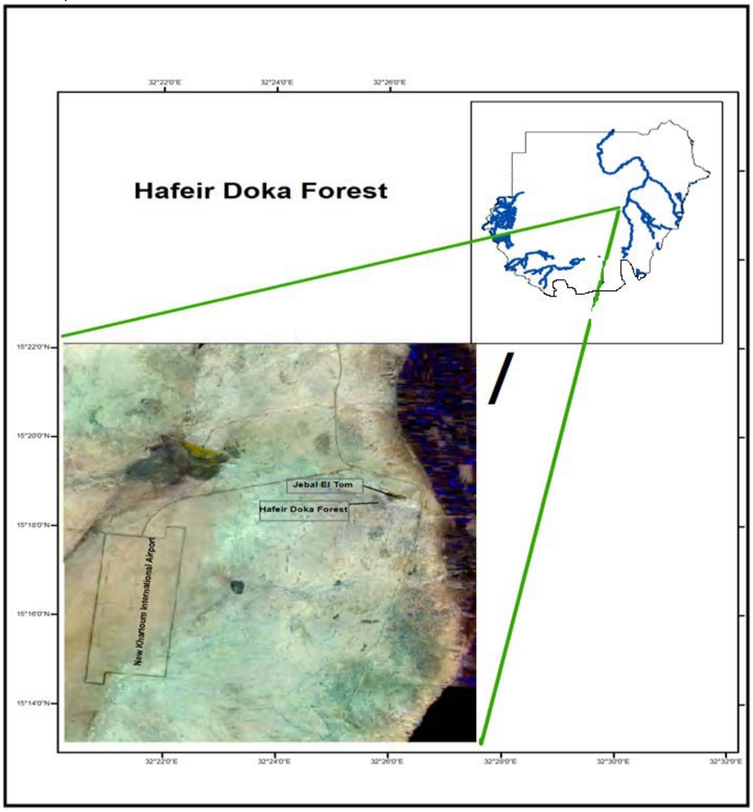


Fig. (1): Location map of Hafeir Doka reserve forest (source, Remote Sensing Authority,2013).

Methods

Experimental sites

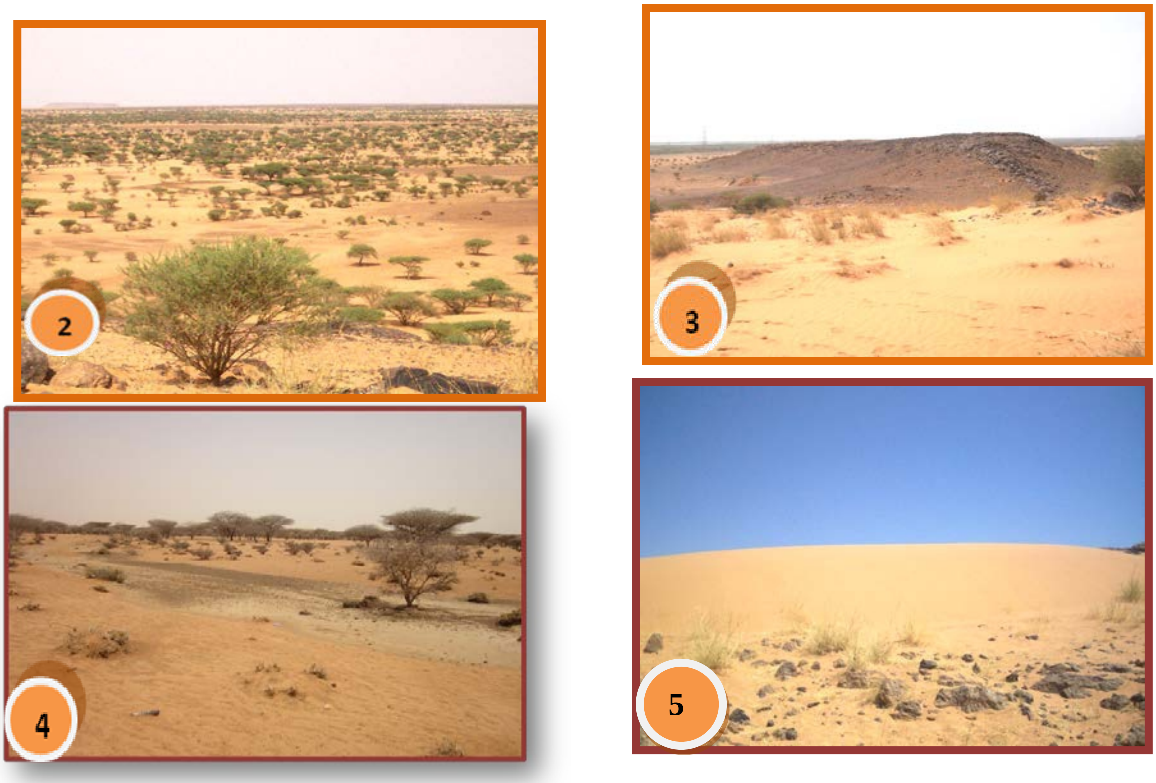
The area of the study was sub divided into four experimental sites according to their topography. The elevation of each site was measured using the Global Positioning (GPS), these sites were:

Control site: elevated 411 m above the sea level and covered with Acacia sp. trees of moderate distribution and considered as control site, (Fig.2).

Hill site: elevated 429 m above sea level and covered by stones and gravels, (Fig.3).

Wadi site: elevated 406 m below sea level and characterized by clay soil and vegetated with Acacia sp. trees of high density, (Fig.4).

Sand dune site: elevated 422 m above the sea level and completely formed of sand with low vegetation cover, (Fig.5)**.**



Figures 2-5. Study sites at Hafeir Doka reserve forest. 2. Control site 3. Hilly site. 4. Wadi site 5. Sand dune site.

Methods

Characterization of the study sites

The four study sites were analyzed for some of their physico-chemical properties using Atomic Absorption Buck scientific VGP 210 made in USA 200. Additionally, topography of all study sites was measured using the Geographical Position System (GPS) Garmin 12.

Arthropods collection

Arthropods were periodically collected using three standard methods as described by Gibb and Oseto,(2010). These methods include:

1-Beating sheet method

This method was used to collect arthropods by beating the *Acacia sp.* plants with a stick while holding a beating a 2x1 feet square sheet under the area being beaten, (Fig. 6). The faunal taxa on the plant fallen onto the sheet were then picked up by hand or with forceps and preserved into 70% ethanol.

Fig. (6): Beating sheet method applied to collect arthropods mat Hafeir Doka Reserve Forest, Sudan.

2-Butterfly netting

A collecting aerial butterfly net composed of net bag made of fine meshed white cloth attached to a wire hoop and affixed to a wooden pole was used to catch flying arthropods fauna associated with the trees, (Fig. 7). Encountered fauna were preserved in 70% ethanol for further identification.

Fig. (7): Butterfly net method applied to collect arthropods at Hafeir Doka Reserve Forest, Sudan**.**

3-Hand collecting method

It is a basic method done by simply collecting arthropods fauna with collectors' hands and putting them into glass jars, (Fig.8). Forceps were used to assist in collecting arthropods. Encountered specimens were then preserved in 70% ethanol for further identification.

Fig. (8): Hand collecting method applied to collect arthropods at Hafeir Doka Reserve Forest, Sudan.

Calculation of Diversity Index

Simpson's diversity index was calculated using the following formula:

$$D = \frac{\Sigma n(n-1)}{N(N-1)}$$

D= Diversity index
n = the total number of organisms of a particular species
N = the total number of organisms of all species

Statistical analysis

Data obtained was statistically analyzed and compared using Analysis Of Variance (ANOVA).

Results and Discussion

Characteristics of the study sites

Topography: A topographic feature at the four study sites in term of elevation was measured. Result given in Fig. 9 indicated that the hilly site is the highest site followed by sand dune one as compared to the control. The lowest elevated site among all study sites is shown to be the Wadi site. Such elevation variability may induce changes in habitat characteristics and consequently affect arthropods diversity. Brown (1988) illustrated that many scientists have linked biodiversity to topographical and temporal patterns of habitat diversity. Coblentz and Riitter , (2005), concluded that spatial distribution of topography plays an important role in the distribution of biodiversity. They added that the large elevation gradient have resulted in stacked biotic communities in which species with broadly similar climatic preferences sort themselves along the elevation gradient where the blend of temperature and aridity best supports them.

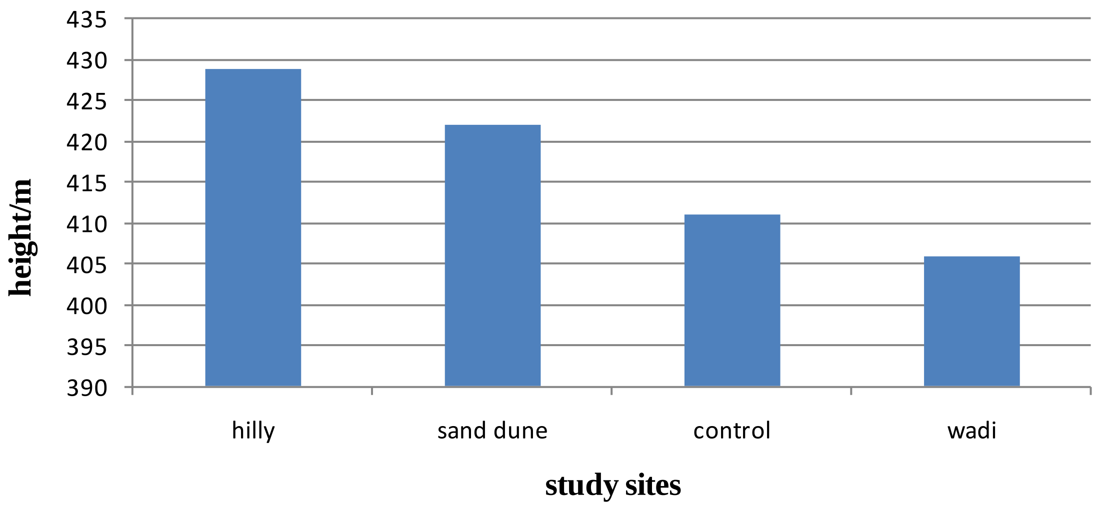


Fig.9: Topograhpy of study sites at Hafeir Doka reserve forest

Soil properties: Study sites were analyzed for some of their physico-chemical properties. Results shown in Table (1) indicated that the control site is classified as: Sandy loam non-saline, non – sodic, neutral and of low Ca, Mg and Na contents. The Hilly site is described as: Loamy sand, non-saline, non – sodic, neutral and of low Ca, Mg and Na contents. Moreover, the Wadi is found to be Sand clay loam, non-saline, non – sodic, neutral and of low Ca, Mg and Na contents. The sandy dune site is shown to be Sandy loam non-saline, non – sodic, neutral and of low Ca, Mg and Na contents. Table (1). It is evident that the Hilly, Wadi and Sand dune sites are different in soil texture and almost similar in chemical properties. This result indicated that variation in habitat characteristics might affect their arthropods community. Chacoff and Aizen, (2005) claimed that arthropods communities at the landscape or local scale may be affected by landscape structure. Soil physicochemical properties, habitat structure dictate the abiotic environmental conditions at a location that in turn affect arthropods communities, (Byrne, 2007)

Table (1): Physic-chemical properties of the study sites at Hafeir Doka Reserve Forest

Soil properties	**Study sites**			
	Hilly	Wadi	**Sand dune**	**Control**
Soil physics				
Sand	54.733 C	66.067 B	78.733 A	74.733 A
Silt	27.773 A	10.107 B	4.773 C	7.440 BC
Clay	17.493 B	23.827 A	16.493 B	17.827 B
Soil chemistry				
SAT	23.333 B	25.000 B	29.833 A	25.000 B
EC	0.5533 AB	0.3013 B	0.6343 A	0.6570 A
SAR	0.7000 A	0.5667 A	0.3967 A	0.4133 A
pH	6.7367 A	6.8933 A	6.9933 A	7.1567 A
Ca	0.2033 A	0.2533 A	0.1067 A	0.1300 A
Mg	0.7867 A	1.3533 A	0.4500 A	0.5733 A
Na	0.5000 A	0.3600 AB	0.1867 B	0.2233 B

- Means with same letter do not significantly differ; otherwise they do according to Duncan's multiple range tests.

Identification of Arthropods

Arthropods collections revealed 5639 taxa identified into 2 classes (Insecta and Arachnida), 18 orders, and 31 families as shown in Table (2) and Appendix 1. Members of class Insecta dominated the other class Arachnid (92% and 8% respectively) of the total arthropods' collection, Fig. (10).This mode of dominance might be due to the ability of insects to proliferate under varied habitat conditions. Insects' morphology; including small boy size enables them to have permitted exploitation of habitat and food resources at a microscopic scale. Insects can take shelter from adverse conditions in microsites too small for larger organisms, Crawford (1979). Moreover, having an exoskeleton provides protection against predation and desiccation or water-logging and innumerable points of muscle attachment for flexibility. Also, insects' metamorphosis permits partitioning of habitats and resources among life stages. Immature and adult insects can differ dramatically in form and function and thereby live in different habitats and feed on different resources; reducing intraspecific competition, Schowalter, (2006).

Table (2): Systematic list of arthropods collected from different habitats at Hafeir Doka reserve forest, Sudan.

Class	Order (s)	Family (ies)
Arachnida	Pseudoscorpionida	Un identified
	Scorpionida	Un identified
	Acari	Ixodidae
	Araneae	Eresidae
		Salticidae
		Philodromidae
		Lycosidae
Insecta	Embioptera	Un identified
	Thysanura	Lepismidae
	Odonata	Un identified
	Phasmida	Phasmatidae
	Isoptera	Rhinotermitidae
	Orthoptera	Acrididae
		Crycantherdium
	Dictyoptera	Mantidae
	Hemiptera	Lygaedae
		Largidae
		Pentatomidae
	Neuroptera	Myrmeleontidae
	Coleoptera	Tenebrionidae
		Curculionidae
		Buprestidae
		Elatridae
		Scarabidae
	Diptera	Muscidae
		Chaliphoridae
		Tabanidae
	Lepidoptera	Paplionidae
	Hymenoptera	Formicidae
		Apidae
		Pompilidae
		Chrysididae

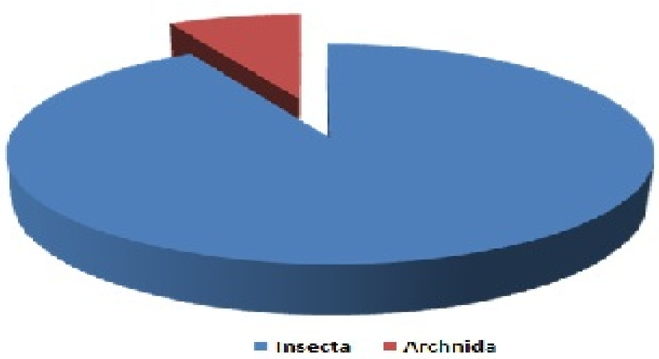


Fig. (10): Dominance of arthropods collected from Hafier Doka reserve forest

Comparison of arthropods' abundance between study sites

Figure (10) showed arthropods fauna encountered in each study site. It illustrated that higher arthropods' abundance was noticed within the Wadi site (38.4%), followed by Hilly and Sand dune sites (16.7%, 14.8%) respectively as compared to the control site (30.1%). Variations in arthropods abundance between the study sites could be attributed to the impact of habitat characterizations in terms of vegetation cover's density and diversity, climatic and other edaphic factors. Abdallah *et al***,** (2010), who studied the ecology of Hafeir Doka reserve forest; claimed that the forest shows significant variations in floral diversity as well as topographic variations. Impact of habitat characterization on arthropods abundance was formerly recognized by **Romoser** and Stoffolano (1998). Mclntyre *et al* (2001) indicated that arthropod community structure is affected by habitat structure and land use, and because they play key roles in nutrient cycling, organic matter decomposition, pollination, and soil aeration; the spatial heterogeneity of ecosystems therefore may affect their role in ecosystem functioning.

Topography also added to the effect of habitat characteristics on arthropods abundance, Ettema and Wardle, (2002). Moreover, their distribution is often very restricted, with many species responding in a very fine spatial and temporal scale to habitat Cardoso *et al*., (2010).

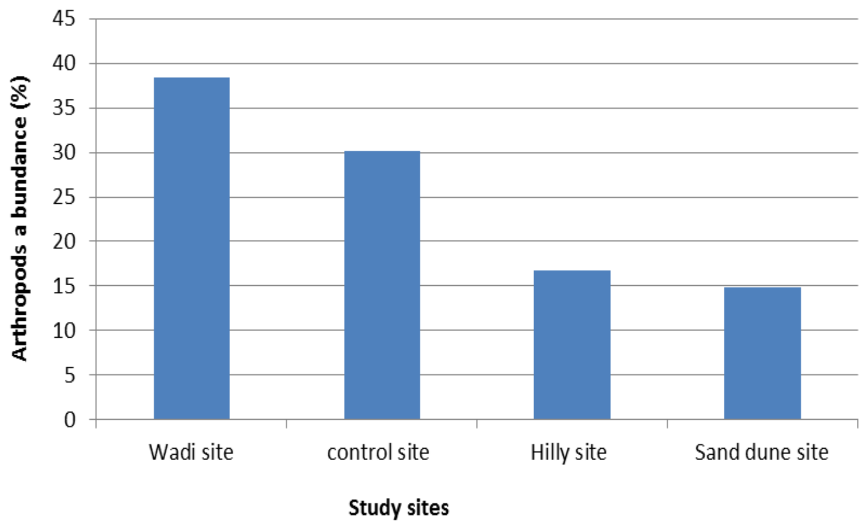


Fig.11: Abundance of arthropods collected from Hafeir Doka Reserve Forest

Diversity of arthropods at order level

Arthropods fauna collected during the study period were classified and compared at order levels. Results indicated that members of order of Hymenoptera were highly represented followed by members of orders Coleoptera and Diptera of all orders, Fig.(12) . These results could be ascribed to the feeding habit of Hymenoptera as phyto-phagous insects. Most of Coleoptera insects are stem borers and some are ground beetles which have modification to avoid heat stress and this agree with findings of Ghabbour (1999).Also most of the Diptera insects are highly adapted and have a great variety of life styles where some are agricultural pests and most depend on plants as shelter. Uys *et a*l (2009) were in conformity with these findings.

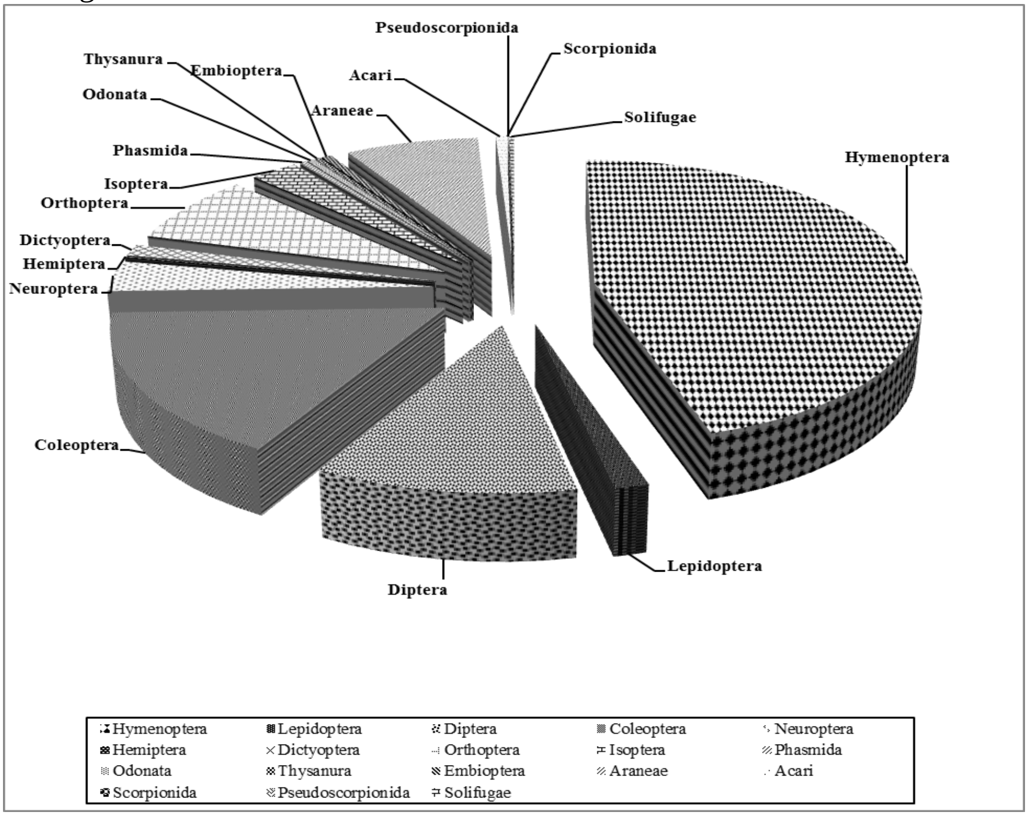


Fig 12: Individual arthropods' number as collected from Hafier Doka reserve forest, Sudan.

Diversity of arthropods within the study sites

Arthropods collected from the four sites showed variation in terms of number of orders, individual and diversity (D) as shown in Table (3). The Table indicated that numbers of orders, individuals and Simpson's index of diversity of the Wadi site exceeded those collected from the other three sites

Table (3) : Number of orders, individuals, and Sampson´s diversity index as compared for

Location	No. of Orders	No. of individual	Diversity
Control	16	1700	0.2
Wadi site	16	2163	0.1
Hilly site	13	944	0.4
Sand dune	12	832	0.4

Arthropods collected from the four sites

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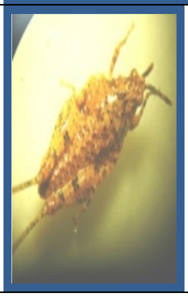
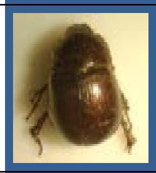
Appendix 1: Some photos of arthropods collected from Hafeir Doka reserve forest, Sudan.

Order	Specimen
Pseudoscorpionida	
Acari	
Araneae	
Thysanura	
Phasmida	
Orthoptera	

Dictyoptera	
Hemiptera	
Coleoptera	
Hymenoptera