



An Ecological Assessment of Insect Diversity at Rawakeeb Semi-Arid Land in Sudan

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Abstract

Sudan boasts diverse ecological zones with unique biodiversity. Some of these zones were subjected to degradation due to climate change and human intervention. Several attempts and sometimes serious efforts have been made to mitigate such degradation, including the formulation of legislative rules to regulate their use and the development of pilot projects to adopt and recommend appropriate conservation methods. Insects are considered as main components of the ecosystem biodiversity. They gain this importance via their vital role in providing ecological processes that sustain ecosystems such as nutrient cycling, plant growth and productivity, and soil and water conservation. Despite their vital role, they receive little attention from many ecologists in Sudan. Thus, this paper was aimed to undertake an ecological assessment for the insect fauna at Rawakeeb semi-arid land (lat. 15° 2' & 15° 36' N, long. 32° 0' & 32° 10' E). A general survey was done to collect insects using direct and butterfly netting collection methods. The ecological assessment was carried out by classifying encountered insects and identifying their biodiversity value using the Simpson Diversity Index and counting the relative abundance of the insect species. The impact of the prevailing climatic conditions of soil and air temperatures and relative humidity on insect was evaluated using Pearson's correlation coefficient.

Results: Obtained indicated the collection of 672 insect specimens identified into 6 orders, 8 families, and 9 species. Insect orders included Hemiptera, Blattodea, Coleoptera, Orthoptera, Diptera, and Bacillidae. The encountered insects showed a high diversity index of 0.87. The relative abundance value of the collected insect specimens varied from 22.32% in *Microtermes* sp, 10.42 % in *Spilostethus* sp, and 1.48 % in *Clonaria aegyptiaca*. Pearson correlation coefficient values indicated positive correlations of all insect species to soil and air temperature and relative humidity. These results could be ascribed to the suitability of the prevailing climatic and other habitat conditions for the proliferation of the encountered insects.

Keywords: Sudan; Semiarid; Insects; Biodiversity; Relative Abundance

Introduction

Sudan ecological zones include arid, semi-arid, low and high rainfall savannah, mountain and coastal zones with their unique biodiversity. It is known as one of the most countries affected by climate change and its consequences represented in high temperature values, erratic rain fall, repeated drought cycles and socio economic effects, Abdellatif, et al. [1]. Several attempts were done to mitigate these consequences including strengthening legislative rule for natural resources use, improving water management technologies, adoption of climate resilient crops, and empower environmental awareness on environmental and biological resources use and conservation, Khalid, et al. [2]. Among these biological resources; insects represented an important group of animal resources that contribute significantly to the functioning of their ecosystem. They play key role in keeping ecosystem balance through their role in nutrient cycling via decomposition process, crop production as pollinators and natural enemies for other insect plant pest Verma, et al. [3]. Their ecological function are greatly affected by their population density and abundance which in turn are factors of the prevailing climatic conditions, Knopetal [4].

Despite the benefits; insects are subjected to threats leading to its extension. These threats result from habitat change due from human intervention which may lead to reduction in insect diversity, abundance and eventually insect extension, Hausmann, et al. [5]. Monitoring insect diversity in Sudan began before independence in 1956; since then, intensive field surveys have been conducted to cover all ecological zones of the country. It began when Welcome Tropical Research Laboratories in Khartoum has carried out a national insect collection and identification efforts in 1902. Although this national insect collection concentrates on insect species of agricultural and medical importance, it is considered as one of the largest and oldest insect collections in Africa. During these surveys; they came to identify 15

orders, 248 families and over 4000 species, Abdellatif, et al. [6]. Recently field surveys were carried out in Sudan semi dry land by the National Center for Research in collaboration with the Insect Collection unit in the Agricultural Research Corporation during the period (2019-2024). During these surveys X orders, X families and X species were identified. The present study gives an account on insects diversity as collected from El Rawakeeb dry land ecosystem. The objectives include identification of insect fauna and determine their functional groups to throw some light on the ecological role that could be played by them.

Materials and Methods

Study Area

Rawakeeb semi arid land (15°-2' and 15°-36-N. and longitudes 32°-0' and 32°-10' E), lies within the tropical semi-arid region of the Sudan, and its climate is characterized by a short rainy season (July- October) with peak in August (Figure 1). According to Abdellatif, et al. [7] the average rainfall is 100-180mm and the evaporation potential was 1800mm, and thus the relative humidity is low. The summer season usually extends for a long period with a maximum temperature of 43.0°C during May (Figure 2). The soil temperature is lower than the ambient temperature throughout the year. The geological formation of the area is mainly basement complex overlain by superficial deposits of the Nubian Sandstone. The soil is generally characterized by sandy texture, poor organic nitrogen and carbon, moderate bicarbonate and potassium and high sodium, calcium and chloride contents. The natural vegetation of Rawakeeb area is composed mainly of *Acacia* spp. (e.g., *Vachellia tortilis*) and different grasses (e.g., *Aristida* spp.). This natural vegetation is replaced in the cultivated sites by some cereals, e.g., Sorghum color and few legumes, e.g., *Cajanus cajan*. The system of land use is mainly pastoral except in low land where traditional agriculture is practiced.

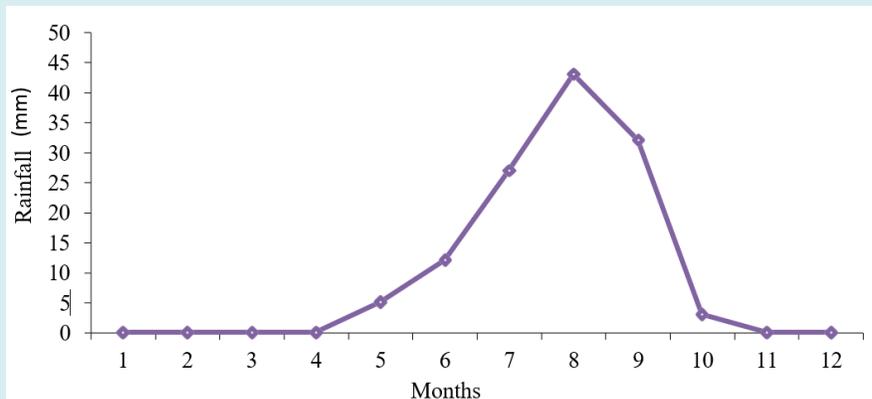


Figure 1: Mean monthly rain fall in Khartoum State during the survey period (source ENDRI2022).

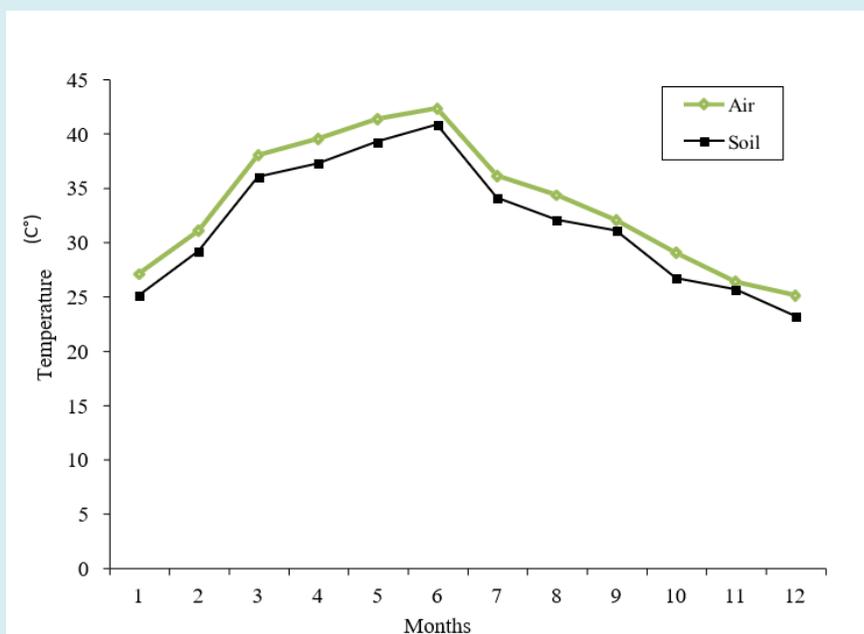


Figure 2: Mean monthly air and soil temperature as recorded at Rawakeeb soil during the survey period (source: ENDDRI2022).

Methods

Insects were Collected Using the Following Methods

Insects specimens were collected and preserved as described by Sattiand, et al. [8]. The semethods include direct collection and Butter fly netting methods. Insect specimens obtained were grouped according to their body thickness, where, insects of tiny smooth bodies were preserved in 70% ethyl alcohol and other insects were placed into killing jars and were then kept in insect box for further identification.

Insects classification:

Insect specimens obtained were classified and functionally grouped in Insect Museum at the Agricultural Research Corporation (ARC), Wad Medani, Sudan.

Ecological assessment Relative abundance

According to Hubbell [9], the relative abundance is calculated using the following formula:

Relative Abundance (%) = $\frac{Isi}{\sum Nsi} \times 100$ Where:

Isi = Total Number of individual spp.

$\sum Nsi$ = Total Number of species population.

The relative abundance was graphically represented using a rank abundance curve or Whittaker plot which ranks the species according to their value of their relative abundance in log values Simpson' diversity index.

Simpson's Diversity Index (SDI), as mentioned by Krebs [10]. was calculated by the following formula:

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

Where:

n : The number of organisms that belong to species. N : The total number of organisms.

The value of Dranges between 0 and 1. With this index , 1 represents infinite diversity and 0, no diversity, i.e. high D scores indicates high diversity.

Pearson Correlation Coefficient

The Pearson correlation measures the strength of the linear relationship between two variables. It has a value between -1 to 1, with a value of -1 meaning a total negative linear correlation, 0 being no correlation, and + 1 meaning a totalpositive correlation.

Results

Identification of Insects Collected from Rawakeeb

A total of 672 insect specimens which comprised 9 species, 8 families and 6 orders were collected from Rawakeeb semiarid land during the study period as shown

in Table 1. In term of insect dominance; order Hemiptera accounted for the largest number of individual (222) thus making up 33.04% of the entire insect collection (Table 2).

Hemiptera was represented by three families Aphididae (96), Lygaeidae, (70) and Lygaeidae (56). Hemiptera is followed by Blattodea which accounted for a total of

(150)22.32% and distributed in one family Termitidae (Table 2). Diptera and Bacillidae showed the least individual number of (66and10) 9.82 and 1.48% of the total catch respectively. The remaining taxonomic group of insects occurred in twoorders: Coleoptera113 (16.82%) and Orthoptera 111 (16.52 %), (Table 2).

Scientificname	Family	Order	Commonname
<i>Microtermes sp</i>	Termitidae	Blattodea	Termites
<i>Ahid sp.</i>	Aphididae	Hemiptera	Greenandblack flies
<i>Spilostethus sp</i>	Lygaeidae	Hemiptera	Seedbug
<i>Lygaeus sp</i>	Lygaeidae	Hemiptera	Blackandredbugs
<i>Chrotogonus sp</i>	Acrididae	Orthoptera	Grasshoppers
<i>Epicauta sp</i>	Meliodae	Coleoptera	Blisterbeetle
<i>Prionotheacoronata</i>	Teneberionidae	Coleoptera	Darklingbeetle
<i>Bactrocera sp</i>	Tephritidae	Diptera	Fruit fly
<i>Clonaria aegyptiaca</i> (Gray, 1835)	Phasmatoidea	Bacillidae	Stickinsects

Table 1: Taxonomiclist of insects collected from Rawakeeb semi aridland.

Insect species	Family	Order	Individual number/ species	Individual number/ order	Individual number% per order
<i>Microtermes sp</i>	Termitidae	Blattodea	150	150	22.32
<i>Ahid sp.</i>	Aphididae	Hemiptera	96		
<i>Spilostethus sp</i>	Lygaeidae	Hemiptera	70	222	
<i>Lygaeus sp</i>	Lygaeidae	Hemiptera	56		
<i>Chrotogonus sp</i>	Acrididae	Orthoptera	111	111	16.52
<i>Epicauta sp</i>	Meliodae	Coleoptera	86		16.82
<i>Prionothea coronata</i>	Teneberionidae	Coleoptera	27	113	
<i>Bactrocera sp</i>	Tephritidae	Diptera	66	66	9.82
<i>Clonaria aegyptiaca</i> (Gray, 1835)	Phasmatoidea	Bacillidae	10	10	1.48

Table 2: Dominance of insects collected from Rawakeeb semi aridland.

Relative Abundance of the Encountered Insects Species

Figure 3, illustrated that *Microtermes sp*, has the largest abundance of all insect species collected of (150) 22.32%, followed by *Chrotogonus sp* (111) 16.52%, but least abundant species were exhibited in *Clonaria aegyptiaca* (10), 1.48%. The other species are represented in different percentages

as shown in Figure 3. The relative abundance rank or Wittker plotused to rank the obtained species according to the log value of their representative numbers and the results are shown in Table 3 and Figure 4. The figure shows that the sespecies are arranged in descending order as follows: decreasing order of *Microtermes sp* >*Chrotogonus sp* > *Ahid sp* >*Epicauta sp* >*Spilostethus sp*>*Bactrocera sp*>*Lygaeus sp*>*Prionothea coronata*>*Clonaria aegyptiaca*.

Insect Species	Insect Number	% of Total Count	log
<i>Microtermes</i> sp	150	22.32	2.17
<i>Chrotogonus</i> sp	111	16.52	2.05
<i>Ahid</i> sp.	96	14.28	1.98
<i>Epicauta</i> sp	86	12.79	1.9
<i>Spilostethus</i> sp	70	10.43	1.85
<i>Bactrocera</i> sp	66	9.82	1.82
<i>Lygaeus</i> sp	56	8.33	1.74
<i>Prionothea coronata</i>	27	4.03	1.43
<i>Clonaria aegyptiaca</i>	10	1.48	1
Total	672	100%	

Table 3: Relative abundance of the encountered insects species.

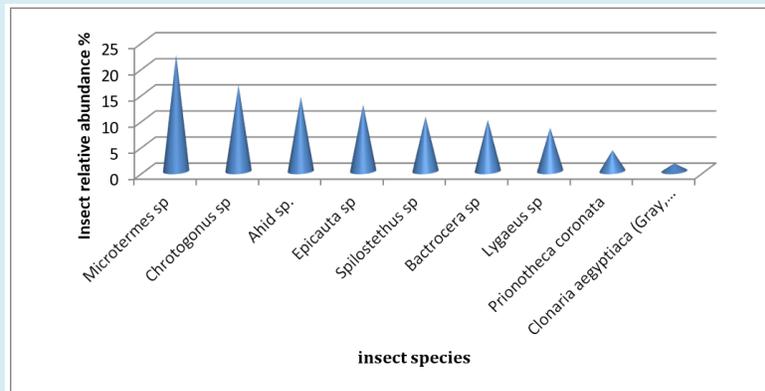


Figure 3: Relative abundance(%) of insects species collected from Rawakeeb semi aridland.

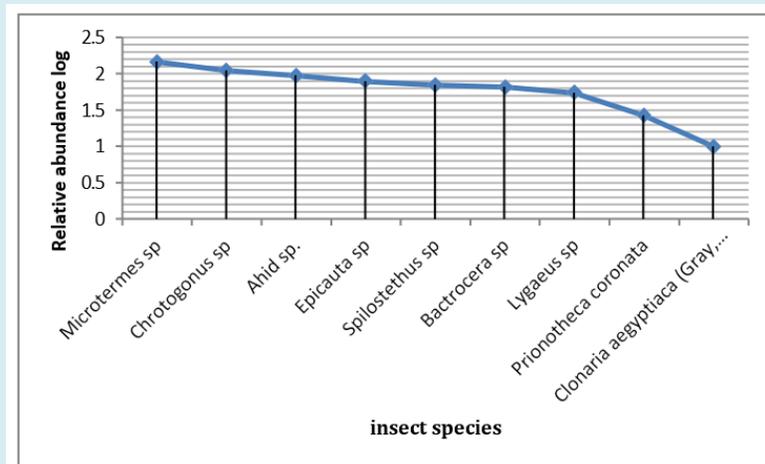


Figure 4: Insects species abundance curve rank (Whittakerplot).

Diversity of Insects Collected from Rawakeeb

that $D = 0.8672601305798027$.

High Simpson Diversity Index (D) is obtained for the encountered insects as given in Table 4. This table indicated

Insectspecies	N	(n-1)	n(n-1)
<i>Microtermes</i> sp	150	149	22350
<i>Ahid</i> sp.	96	95	9120
<i>Bactrocera</i> sp	66	65	4290
<i>Prionotheccoronata</i>	27	26	702
<i>Spilostethus</i> sp	70	69	702
<i>Lygaeus</i> sp	56	55	3080
<i>Chrotogonus</i> sp	111	110	12210
<i>Epicauta</i> sp	86	85	7310
<i>Clonaria aegyptiaca</i>	10	9	90
Total	$N=672 \sum N(N-1)=672(672-1)=1672*671=450912$		$\sum n(n-1)= 59854$
$D=1- (\sum n(n-1)/N(N-1))$	$D=1-0.1327398694201973=0.8672601305798027$		

Table 4: Simpson' diversity index for insects collected from Rawakeeb dry land.

Effect of Temperature and Relative Humidity on Insects

Pearson correlation coefficient was calculated for the effect of temperature and relative humidity values on insects species collected from Rawakeeb land. Results indicated a positive high linear correlation of soil and air temperature on *Microtermes* sp (1.00 and 0.989 respectively) and also *Epicauta* sp (0.900**, 1.00 respectively). Weak positive

linear correlation to soil or air temperature were observed regarding *Spilostethus* sp, *Bactrocera* sp, *Lygaeus* sp, *Prionothecca coronata*, *Clonaria aegyptiaca* (Table 5). High positive linear correlation was observed between relative humidity and individual numbers of *Lygaeus* sp or *Clonaria aegyptiaca* (1.00, 0.890** respectively). Table 5 also, showed moderate to weak positive linear correlations of relative humidity to the remaining insect species.

Insect species	Soil Temperature (°C)	Air Temperature (°C)	Relative Humidity(%)
<i>Microtermes</i> sp	1	.989**	0.226
<i>Chrotogonus</i> sp	0.471	0	0.479
<i>Ahid</i> sp.	0	1	0.531
<i>Epicauta</i> sp	0.900**	1	0.201
<i>Spilostethus</i> sp	0.163	0.274	0.369
<i>Bactrocera</i> sp	0.222	0.24	0.368
<i>Lygaeus</i> sp	0.226	0.201	1
<i>Prionothea coronata</i>	0.22	0.275	0.36
<i>Clonaria aegyptiaca</i>	0.357	0.279	0.890**

Table 5: Pearson correlation coefficient for impact of temperature and relative humidity on insect species collected from Rawakeeb semi dry land.

Discussion

Insects Collected from Rawakeeb

At order level; the order Hemiptera dominated the entire insect collection followed by order Blattodea whereas, the order Bacillidae showed least dominance. Hemiptera are major classified as phytophagous and potential plant pest, despite some others are predators and used as a biological control agent.

This mode of dominance could be ascribed to the habitat characteristic that may suit some insect proliferation and reproduction more than others. Hemiptera is followed by Blattodea that live in a wide variety of habitats and feed as omnivores or detritivores. Coleoptera and Orthoptera showed intermediate dominance within the entire insect collection. Coleoptera are found in aquatic or terrestrial habitats and feed on wide range of diet. Likewise, Orthoptera are cosmopolitan and are phytophagous. Alzahrani, et al [11] reported insect abundance and diversity in an arid ecosystem Kingdom Saudi Arabia. They correlate their findings to insect functional group and habitat characteristics that favored insect feeding habit and reproduction giving that insects resembling any other each biota might significantly proliferate in a habitat that provides required life needs. At species level; the greatest collected specimen are *Microtermes* sp followed by *Chrotogonus* sp but least number of insect specimens are found to be *Clonaria aegyptiaca*. *Microtermes* sp dominance might be due to the availability of food source and suitability of some a biotic factor e.g. soil moisture. Pratiknyo, et al. [12], related abundance and distribution of *Microtermes* to environmental factors *Clonaria aegyptiaca*.

Diversity of Rawakeeb Insects

The encountered insect fauna showed high diversity index. This could be ascribed to the suitability of Rawakeeb as a habitat for insect proliferation expressed in provision of food, shelter and reproductive conditions. It may also reflect the ability of insect species to adapt to prevailing ecological conditions and can withstand changing conditions of climate or habitat disturbances. Landmann, et al. [13], specified that insect diversity correlated to their habitat diversity and its suitability for insect reproduction and proliferation.

Relative Abundance of the Encountered Insects Orders

The relative abundance of the encountered insects belong to the order Hemiptera followed Blattodea, Coleoptera, Orthoptera Diptera and least Bacillidae and followed the same rank according to Wittker plot rank. Kumar, et al. [14] reported that certain insects exhibit greater abundance due to their extended evolutionary history, which allows them to diversify and adapt to a broader array of ecological niches. Furthermore, elements such as size, reproductive potential, and the capacity to utilize various food sources enhance the success of specific species. Environmental factors, including temperature, humidity, and the availability of food, are also vital in influencing which insects prosper in a given region.

Effect of Temperature and Relative Humidity on Insects

The study analyzed the relationship between temperature, relative humidity, and insect populations in Rawakeeb, revealing varying correlations. *Microtermes* sp. and *Epicauta* sp. exhibited a strong positive linear relationship with both soil and air temperature. In contrast, *Spilostethus* sp., *Bactrocera* sp., *Lygaeus* sp., *Prionothea coronata*, and *Clonaria aegyptiaca* showed a weak positive

correlation with temperature. A strong positive linear correlation was found between relative humidity and the number of *Lygaeus* sp. and *Clonaria aegyptiaca*, while other insect species showed moderate to weak positive correlations with relative humidity. The key finding showed high positive correlation of *Microtermes* sp. and *Epicauta* sp. with both soil and air temperature. Weak positive correlation of *Spilostethus* sp., *Bactrocera* sp., *Lygaeus* sp., *Prototheca coronata*, and *Clonaria aegyptiaca* with soil and air temperature. The relative Humidity indicted high positive correlation in *Lygaeus* sp. and *Clonaria aegyptiaca*. Moderate to weak positive correlation to other insects species. Fluctuations in temperature can affect various physiological processes, including metabolism, respiration, immunity, and reproduction, ultimately influencing insect behavior, distribution, and population dynamics. Biber-Freudenberger, et al. [15], generalized those insects as temperature variables proliferate and fluctuate differently with temperature. These observations are in conformity with the findings of Saha, et al. [16] who indicated varied positive and negative impact of temperature on six species of *cucurbits* Karar, et al. [17], indicated that temperature is one of the most critical environmental factors influencing rate of insect growth and development, colonization, distribution, abundance, behavior, life history and fitness. Specific relative humidity preferences vary among insect species, with some preferring low humidity for survival and reproduction, while others thrive in higher humidity Jaworski, et al. [18,19].

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