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ORIGINAL ARTICLE

Insects Associated with *Jatropha curcas* Linn. in Dry Land: A Case Study at El Rawakeeb, West Omdurman, Sudan

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Abstract

Diversity of insects associated with *Jatropha curcas* was studied at El Rawakeeb Dry-land Research Station, which lies within the semiarid zone of Sudan. Insects were studied under a practical work of *Jatropha* cultivation, where their ecological and functional roles were evaluated. About 36 out of 108 quadrates were chosen as permanent sampling plots in a Randomized Complete Block Design. The Statistics (8) software was applied for data analysis. Insects were collected during the period November 2015 - February 2016. Butterfly netting, beating and hand picking methods were used to collect insects. Air and soil temperature, soil moisture and wind speed were measured throughout the sampling period. Simpson's Diversity Index and Pearson Correlation Coefficient were used to measure the diversity index and evaluate climatic impact on insect diversity, respectively. A total of 1777 insects was collected and identified into 8 orders, 14 families and about 19 species. These include orders: Orthoptera (*Schistocerca gregaria*), Isoptera (*Psammotermes hybostoma*), Hemiptera (*Calidea dregii*), Neuroptera, Coleoptera (*Trogoderma hispida, Prionotheca coronata* and *Pimelia grandis*), Lepidoptera (*Belenois aurota*), Diptera (*Musca domestica, Chrysomya marginalis* and *C. putoria*), Hymenoptera (*Apis mellifera, Formica rufa, Camponotus rufoglaucus, C. sericeus, Cataglyphis abyssinicus, C. auratus, Monomorium salomonis, Tapinolepis simulans* and *Pachycondyl sennaarensis*). Insects' relative abundance and dominance showed that individual number of Hymenoptera has the highest values of all collected insect orders (27.40% and 0.7481, respectively), whereas, individual number of Orthoptera revealed the lowest values (0.56% and 0.0154, respectively). High diversity index was obtained for the insects collected (0.90). A positive linear correlation was shown between air and soil temperature and individuals of Orthoptera, Isoptera, Neuroptera and Hymenoptera, whereas, negative linear correlation was found between wind speed, soil moisture content and these orders. These results could be ascribed to shelter and food provided by *J. curcas* to these insects. Diversity of insects could be attributed to the functional role of the insects as pollinators and plant pests.

Keywords: Diversity index, insect order, dominance, abundance.

Introduction

The development of the bio-energy system has attracted considerable public, commercial and scientific attention as a potential solution for the global climate and energy crisis (King *et al*., 2009). The genus *Jatropha*, belongs to the family Euphorbiaceae, is considered a potential biofuel producing plant (Edrisi *et al*., 2015). Among this genus the species *curcas*, which is a shrub or small tree native to Central America and the Caribbean region, is widely distributed in many western and central African countries.

Botanically, *J. curcas* grows up to 20' tall with spreading branches, and has yellow-green flowers and large heart-shaped (pale) green leaves, arranged alternately. The inflorescence is formed in the leaf axel; flowers are formed terminally and individually, with female flowers usually slightly larger. Pollination is carried out by pollinators to male - and female plants. The seeds are of about 2½ cm long, and mature when the fruit changes from green to yellow (Shanker and Dhyani, 2006).

Besides its potentiality as a biofuel plant, *J. curcas* is also known to possess several biologically active properties, e.g., insecticidal, fungicidal and anti-cancer (Heller, 1996, and Gudeta, 2016). Additionally, it is usually used as a hedge to protect crops and soil against animals and wind or hydrous erosion (Henning, 2008). It also improves soil organic matter through adding leaf litter (Dieye *et al.,* 2016).

In Sudan, *J. curcas* is found in a number of States e.g., Khartoum, Kassala and Kordofan (Renner, 2007). Diversities of insects (both pests and non pests) are associated with most of these plants (Abdoul Habou *et al*., 2014). In spite of *J. curcas* bio-active properties, certain groups of insects feed on this plant are known to withstand or tolerate its toxicant effects. Such insect groups could either be defoliators, visitors, predators of other species or pollinators. *Jatropha curcas* was introduced in El Rawakeeb area during the last decade as a monoculture to study its economic (biofuel production) and ecological (wind break) potentiality.

The objective of this study was to establish an inventory of insects associated with *J. curcas* in an arid environment, and to clarify their ecological and functional roles.

Materials and Methods

A study area

The present study was carried out at El Rawakeeb Dry-land Research Station, west Omdurman, Khartoum State. The area coordinates (15°2' - 15°36' N & 32° 0'-32°10' E) lies within the semiarid zone of the dry land in the country. The soil of El Rawakeeb is a sandy clay loam alkaline, which is poor in nitrogen and carbon, moderate in bicarbonate and potassium, and rich in sodium, calcium and chloride contents, where the land use system is an agropastural. The main vegetational cover consists primarily of species of Scurb belt (*Acacia tortilis-Maerua crassifolia*). However, some other climatic features of the area (Elhag *et al.,* 2006) were listed as follows:

Seasons	R.H.%	Wind m/s	Solar W/m²	Temperatture(°C)	
				Soil	Air
March – June	0.1425	3.075	283	32.33	35.95
July-October	0.355	2.7	199.75	33.93	37.525
Nov. – February	0.26	3.05	180.4	24.3	30.15

Insect collection methods

Field catches were collected twice a month during the period November 2015 to February 2016. Insects were randomly collected from 36 *J. curcas* trees. Sampling was carried out during the above mentioned period using the methods of collection and preservation described by Gibb and Oesto (2006). These methods are as follows:

a. **Hand collection:** Using forceps, insects were picked from leaves, flowers, fruits, stems, branches and surface soil surrounding the trees. Specimens collected were then preserved in jars

containing 70% ethyl alcohol for identification.

b. **Butterfly net:** This method was used to collect aerial insects, feeding or resting on the top of the tree.
c. **Beating:** Insects were collected by beating *Jatropha* plants with a stick while holding a cloth sheet under the area being beaten. The insects were then picked up by hand or with forceps and treated as above.

Statistical analysis

Data were analyzed by comparing means using Duncan's Multiple Range test, at 0.5 level. The Pearson Correlation Coefficient was used to evaluate the effect of climatic factors on the diversity of insects associated with *J. curcas*, using statistical program 8 (Statistix 8 software). The value of this coefficient ranges between + 1 and -1. A positive value means having a positive linear correlation, while a negative value means a negative linear correlation, whereas zero means no correlation between values.

Results

Insect classification

Application of the three collection methods resulted in a collection of 1777 insects belonging to 8 orders, 14 families and about 19 species. These include orders: Orthoptera (*Schistocerca gregaria*), Isoptera (*Psammotermes hybostoma*), Hemiptera (*Calidea dregii*), Neuroptera, Coleoptera (*Trogoderma hispida, Prionotheca coronata* and *Pimelia grandis*), Lepidoptera (*Belenois aurota*), Diptera (*Musca domestica, Chrysomya marginalis* and *C. putoria)*, Hymenoptera (*Apis mellifera, Formica rufa, Camponotus rufoglaucus, C. sericeus, Cataglyphis abyssinicus, C. auratus, Monomorium salomonis, Tapinolepis simulans* and *Pachycondyl sennaarensis*), as shown in table 1 and 2.

Table 1. Systematic list of insects associated with *Jatropha curcas* collected from El Rawakeeb Dry-land Research Station, during the period November 2015 - February 2016.

Order	Family	Genus	Species	Binomial name
Orthoptera	Acrididae	*Schistocerca*	*gregaria*	*Schistocerca gregaria*
Isoptera	Rhinotermitidae	*Psammotermes*	*hybostoma*	*Psammotermes hybostoma*
Hemiptera	Scutelleridae	*Calidea*	*dregii*	*Calidea dregii*
Neuroptera	Chrysopidae	*Chrysoperla*	-	*Chrysoperla* sp.
Coleoptera	Dermestidae	*Trogoderma*	*hispida*	*Trogoderma hispida*
	Scarabaeidae	*Scarabaeus*	-	*Scarabaeus* sp.
	Tenebrionidae	*Prionotheca*	*coronata*	*Prionotheca coronata*
		Pimelia	*grandis*	*Pimelia grandis*
Lepidoptera	*Pieridae*	*Belenois*	*aurota*	*Belenois aurota*
Diptera	Muscidae	*Musca*	*domestica*	*Musca domestica*
	Calliphoridae	*Chrysomya*	*marginalis*	*Chrysomya marginalis*
			putoria	*C. putoria*
	Bombyliidae	*Exoprosopa*	-	*Exoprosopa* sp.
Hymenoptera	Apidae	*Apis*	*mellifera*	*Apis mellifera*
	Formicidae	*Formica*	*rufa*	*Formica rufa*
		Camponotus	*rufoglaucus*	*Camponotus rufoglaucu*
			sericeus	*C. sericeus*
		Cataglyphis	*abyssinicus,*	*Cataglyphis abyssinicus*
			auratus	*C. auratus*
		Monomorium	*salomonis*	*Monomorium salomonis*
		Tapinolepis	*simulans*	*Tapinolepis simulans*
		Pachycondyl	*sennaarensis*	*Pachycondyl sennaarensis*

Table 2. ANOVA table for insects associated with *Jatropha curcas* collected from ElRawakeeb Dry-land Research Station, during the period November 2015 - February 2016.

Source of variation	DF	SS	MS	F	P
Orders	7	76.76	10.9657	4.19	0.000**
Error	1728	4524.34	2.6183		
Total summation	1735	4601.10			

- Significant difference at p=0.05

Insect numerical variation:

The mean numbers of the insects collected were compared. Results shown in tables 2 and 3 indicated significant differences among them. Table 3 specified that a significant difference was found between the mean number of order Hymenoptera and all other orders except order Lepidoptera. Also, a significant difference was found between the mean number of order Orthoptera and each of the other orders; Hemiptera, Isoptera, Diptera and Coleoptera. Likewise, a significant difference was observed between the mean number of the order Diptera and the orders, Orthoptera and Hymenoptera ($p \geq 0.05$). Insignificant difference was noticed between the mean number of orders, Orthoptera, Neuroptera and Coleoptera.

Insect relative abundance and dominance:

Insects collected throughout the study period were identified into 8 orders. Order Hymenoptera was found to be the most prevalent among the other orders. It represents 27.4% of the total catch followed by the orders Lepidoptera (18.40%), Isoptera (14.07%) and each of Hemiptera and Diptera (12.64 & 12.77%), respectively. Orders Neuroptera and Orthoptera were found to be the least abundant among the encountered insect orders, where they represent only 4.57% and 0.56%, respectively (Table 4).

Insect diversity

The Simpson Diversity Index was applied to measure insect diversity at El Rawakeeb dry land during the period November 2015 - February 2016. The value of the diversity index is 0.90 as measured at the species level, as shown in table 5.

Table 3. Mean number of insects associated with *Jatropha curcas* collected from El Rawakeeb Dry-land Research Station, during the period November 2015- February 2016.

Orders	Individual Mean No.
Orthoptera	0.0154 d
Isoptera	0.3840 bc
Hemiptera	0.3441 bc
Neuroptera	0.1244 cd
Coleoptera	0.2627 bcd
Lepidoptera	0.5054 ab
Diptera	0.3487 bc
Hymenoptera	0.7481 a

*Means with the same letter (s) are not significantly different according to Duncan's Multiple Range Test.

Table 4. Individual number and abundance of insects associated with *Jatropha curcas* collected from El -Rawakeeb Dry-land Research Station, during the period November 2015 - February 2016.

Orders	Numbers	Relative abundance %
Orthoptera	10	00.56
Isoptera	250	14.07
Hemiptera	224	12.64
Neuroptera	81	04.57
Coleoptera	171	09.62
Lepidoptera	327	18.40
Diptera	227	12.77
Hymenoptera	487	27.40
Total	1777	100

Table 5. Simpson Diversity Index calculated for insects associated with *Jatropha curcas* collected from El Rawakeeb Dry-land Research Station, during the period November 2015 - February 2016.

Species	n	n-1	n(n-1)
gregaria	10	9	90
hybostoma	250	249	62,250
*dregi**i***	224	223	49,952
hispida	35	34	1190
coronata	56	55	3080
grandis	68	67	4556
aurota	171	170	29070
domestica	164	163	26732
marginalis	15	14	210
putoria	33	32	1056
mellifera	10	9	90
rufa	48	47	2256
rufoglaucu	195	194	37830
sericeus	38	37	1406
abyssinicus	37	36	1332
auratus	30	29	870
salomonis	36	35	1260
simulans	44	43	1892
sennaarensis	49	48	2352
N	1513		227474

D=1- ∑n (n-1)/N(N- 1) = 1- 0.0994354046237721= 0.9005645953762279
Simpson Diversity Index (D) = 0.90

Impact of climate on insects:

Pearson Correlation Coefficient was used to evaluate the impact of some climatic factors on insects associated with *J. curcas*. Table 6 shows a positive linear correlation between soil and air temperature and individual numbers of the orders Orthoptera, Isoptera, Neuroptera and Hymenotera. A negative linear correlation was observed between these orders, soil moisture and wind speed. A negative linear correlation was observed between soil temperature, moisture and wind speed and the individuals of the orders Hemiptera and Coleoptera. The results also, indicate a negative linear correlation between the individuals of Lepidoptera and average air temperatures and soil moisture content, and a positive one with soil temperatures and wind speed. There is also a positive linear correlation between the individuals of Diptera and air temperature and soil moisture, and a negative one with the soil temperature and wind speed.

Discussion

Application of three collection methods in this research resulted in a total of 1777 insects identified into 8 orders, 14 families and 19 species. Terren *et al.* (2012) and Datinon *et al.* (2013), reported most of these insect groups in an inventory study of insects associated with *J. curcas*. Accordingly, some of the detected insects are phytophagous and

Table 6. Pearson Correlation Coefficient for the effect of some climatic factors on the diversity of insects associated with *Jatropha curcas* collected from El Rawakeeb Dry-land Research Station, during the period November 2015 - February 2016.

Insect orders	Climatic factors			
	Air temperature (°C)	Soil temperature (°C)	Soil moisture (%/gm)	Wind speed (m/se)
Orthoptera	0.1542	0.1519	- 0.0324	- 0.0275
Isoptera	0.2873	0.0392	- 0.0721	- 0.0506
Hemiptera	- 0.1190	- 0.2312	- 0.0231	- 0.0419
Neuroptera	0.3658	0.1524	- 0.0984	- 0.0717
Coleoptera	- 0.2248	- 0.0351	- 0.0445	- 0.0890
Lepidoptera	- 0.1369	0.1458	- 0.0968	0.3922
Diptera	0.0351	- 0.0963	0.0593	- 0.0735
Hymenoptera	0.1829	0.0468	- 0.0643	- 0.0655

were reported as *Jatropha* main pests e.g., *Calidea dregii* (Hemiptera: Scutelleridae), while some others were recorded as soil pests including *Psammotermes hybostoma* (Isoptera: Rhinotermitidae) which burrow through the roots and stem causing extensive tunneling and finally complete damage to plant (Rao *et al*., 2011). Also, other groups of insects associated with *J. curcas* were described as plant pollinators. These include, *Exoprosopa* sp. (Diptera: Bombyliidae) and *Apis mellifera* (Hymenoptera: Apidae) in addition to some ant species. Ants were the most abundant floral visitors that carry pollen loads; and thus responsible for most of the successful pollen transport (Luo *et al*., 2012, and Scampavia, 2016).

Comparison of the mean number of the collected insects was found to show significant differences among the detected orders. They showed the hymenopteran, lepidoptern, isopteran, dipteran and hemipteran species as the highest groups, in a descending numerical ranking. Orders Neuroptera and Orthoptera were found to be the least abundant among the encountered insect orders. Such results were attributed to the time of collection, which coincided with flowering period of the plant (i.e. winter). During this period pollinators (e.g., *Apis mellifera* and species of the genus *Exoprosopa*) were found in appreciable numbers. Similar results were obtained by Gubitz *et al*. (1999) and Sabi-Sabi and Nacro (2016). According to Salman and Saud (2015), living organisms are believed to be dominant when their percentage exceeds 70%, abundant when the range is between 69- 40% and rare at 39 -10%. Thus, it is evident that 5 orders were found in relatively higher numbers than the other remaining orders.

The Simpson Diversity Index was applied to measure insect diversity at El Rawakeeb Dry-land Research Station during the study period (November 2015 - February 2016). The value of the diversity index is 0.90 as measured at the species level. This result could be ascribed to the effect of the plant where it may provide suitable sheltering and breeding habitat for insects, which in turn encourage a variety of species to colonize the plant zone. Similar observations and conclusions were attained by Uddin *et al.* (2012) and Usha and John (2015), who studied insects associated with *J. curcas* in Nigeria. A diversity of insects associated with *J. curcas* was also observed by Terren *et al*. (2012).

The impact of air temperature, soil temperature and moisture and the prevailing wind speed were assessed. The results showed the presence of either positive or negative linear correlations between these factors and the insect orders. This shows that the temperature has different effects on the diversity of insects and their distribution, in addition to its impact on the insect biology, feeding ability and reproduction. Insects responded differently to changing climatic factors (Regniere *et al*., 2012).

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