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EFFECT OF SOME CLIMATIC FACTOR ON DIVERSITY OF CUCURBITS INSECT PESTS AT SHENDI AREA, SUDAN

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Abstract: Cucurbits are important economic crops grown in Sudan for local consumption and export. They are subjected to pest attack especially insect infestation that causes significant economic loss. The present study aims to identify cucurbits insect pests, illustrate their diversity and evaluate the impact of climate on them. A general survey was carried out to collect insect pests infesting three major cucurbits: snake cucumber (*Cucumis melo* var. *Flexuosus*), pumpkin (*Cucurbita pepo* L.) and watermelon (*Citrullus lanatus* Thunb.), which were grown at three study sites; (Al-Shagalwa, Gandato and Hosh-Bannaga) in the River Nile state, Sudan Direct collection and butterfly netting methods were used to collect insect pests, whereas, Simpson Diversity Index and Pearson correlation coefficient were used to examine insect pests diversity and correlation to climatic factors, respectively. A total of 4585 specimens of cucurbit insect pests from the three locations were collected and identified into 6 orders, 10 families and 11 species, including 5 major cucurbits insect pests species: *Chnootriba elaterii* (Rossi), *Bemisia tabaci* (Gennadius), *Aphis gossypii* (Glover), *Thrips tabaci* (Lindeman) and *Caliothrips sudanensis* (Bagn. and Can.). These insect were noticed to dominate Al-Shagalwa, followed by Hosh-Bannaga and lastly Gandato. The Al-Shagalwa area is famous for its biodiversity and crop rotation. High Simpson Diversity Index value was recorded in each study site. Pearson correlation coefficient showed a negative correlation between temperature and mean number of each of *C. elaterii* or *B. tabaci* in the three study sites. A negative correlation between temperature and mean number of *T. tabaci* infesting snake cucumber was noticed at Gandato site only. A positive correlation between temperature and mean number of *T. tabaci*, or *C. sudanensis* infesting snake cucumber at Hosh-Bannaga and Al-Shagalwa sites. A positive correlation between relative humidity and mean number of insect infesting cucurbits grown in the three sites.

Keywords: Cucurbits, Insect pests, Diversity, Dominance, Sudan.

Introduction:

Cucurbits seeds, leaves, roots, flowers and fruits are consumed as food or fodder. They contain vitamins, carbohydrates, minerals and carotenoid pigments thus sustain high energy and provide antioxidant, anti-diabetic, anti-inflammatory and purgative properties to human (Rolnik and Olas, 2020). In Sudan; cucurbits cultivated include snake cucumber (*Cucumis*

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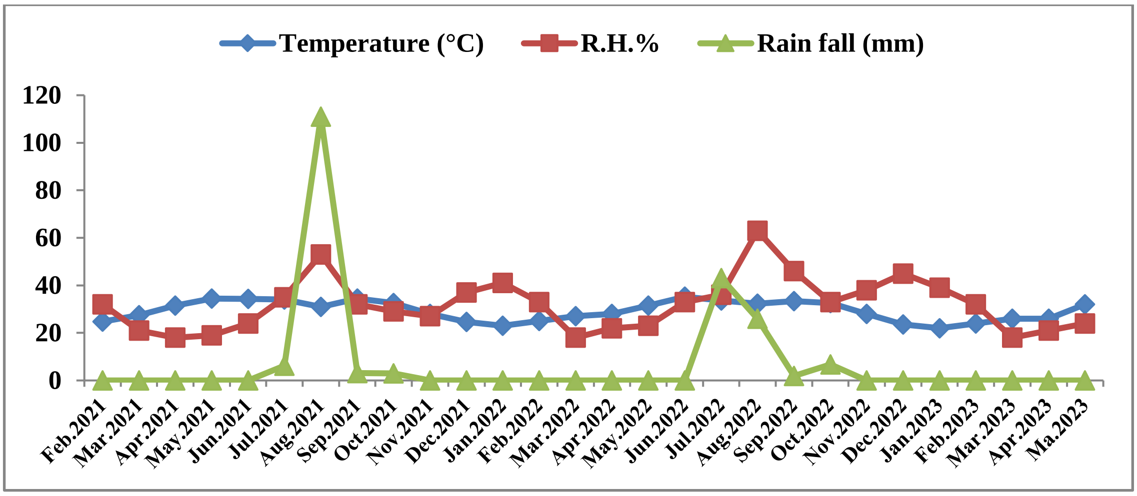
melo var. *Flexuosus*), pumpkin (*Cucurbita pepo* L.), sweet melon (*Cucumis melo* L.) and watermelon (*Citrullus lanatus* Thunb.). According to Subina (2019), cucurbits are attacked by insect pests affecting their performance and production including blister beetles (Meloidae), two-spotted beetles (*Adalia bipunctata*), twelve-spotted melon beetles (*Chnootriba elaterii*), red pumpkin beetle (*Aulacophora foveicollis*) and cucurbit stink bug (*Cordius janus*). These insects can affect cucurbits directly by inducing defoliation, roots or flowers damages or indirectly by transmitting bacterial, fungal and viral diseases. Field and laboratory investigations were carried out to study cucurbits insect pests in term of biology, biodiversity and temporal fluctuations in the River Nile State / Sudan.

Materials and Methods

Study sites

The three study sites are located at (latitude 17°N: longitude 23°E), within the semi-arid zone of Sudan which is characterized by a hot summer and a cold dry winter. Winter season ranges from December to March with minimum temperature of 10°C, while the summer is characterized by maximum temperature of 45°C extended from March up to mid-July and the annual rainfall ranges between 50-100 mm/y (Elamin, 2017). The natural vegetation is represented by *Acacia* trees, shrubs and some annuals. The land use system is agricultural where surface and rain fed irrigation are used to grow various field and horticultural plants on these sites (Allaeldien, 2020).



Mean monthly air temperature (°C), relative humidity (R.H. %) and rain fall (mm), during the study period (Feb. 2021 - May.2023) at Shendi area (Source Shendi meteorological station).

Insect pest collection and preservation

The experiment of insect pest associated with cucurbits grown on Hosh-Bannaga, Gandato and Al-Shagalwa was carried out during the study period (February to December 2021), following the methods of collection and preservation described by Satti and Bilal, (2012). These methods include direct collection and Butterfly netting methods. Insect specimens obtained were grouped according to their body thickness, where, insects of tiny smooth specimens were preserved in 70% ethyl alcohol and other insects were placed into killing jars and were then kept in insect box for further identification.

Ecological assessment of cucurbits insect pests

Ecological parameters were applied to assess variations of insect pest associated with the three selected cucurbits according to Ghani and Maalik, (2020). These parameters include dominance, Pearson correlation coefficient and Simpson's Diversity Index.

Identification of cucurbits insect pests

Insect pests obtained were preliminary checked in Plant Protection Department in River Nile State, Shendi and then transferred to the National Insect Collection Museum at the Agricultural Research Corporation (ARC), Wad Medani, Sudan.

Results:

Collection of the encountered insect pests

A total of 4585 insect pests individuals associated with cucurbits grown on the three study sites were collected and classified into 6 orders, 10 families and 11 species as explained in table (1).

Ecological assessment of cucurbits insect pests

Relative abundance of the encountered insect pests orders

Insect pests relative abundance indicated that most of the identified insect pests belong to Hemiptera followed by Coleoptera, whereas, least number belong the four other orders as shown in Figure (1). The relative abundance rank or Wittker plot was used to rank the obtained orders according to the log value of their representative values. Results shown in

Figure (2), showed that the rank follow the order Hemiptera, Coleoptera, Diptera and all other orders. Five of these insect pests were selected as major cucurbit insect pests throughout the study due to their relative abundance in the study area and they are preferred as preys for *C. carnea*. These pests are *C. elaterii*, *B. tabaci*, *A. gossypii*, *T. tabaci* and *C. sudanensis*.

Table1. Taxonomic list of insect pests associated with cucurbit plants in the study sites, during the study period (February 2021 to May 2023).

Scientific name	**Family**	**Order**	**Common name**
Aulacophora foveicollis (Lucas)	Chrysomelidae	Coleptera	Red melon beetle
Chnootriba elaterii (Rossi)	Coccinellidae	Coleptera	Melon ladybird beetle
Dacus ciliatus (loew)	Tephritidae	Diptera	Lesser pumpkin fly
Aphis gossypii (Glover)	Aphididae	Hemiptera	Melon aphid
Bemisia tabaci (Gennadius)	Aleyrodidae	Hemiptera	Silver whitefly
Acanthocephala curvipes (Fabricius)	Coreidae	Hemiptera	Giant coreid bug
Coridius viduatus (Fabricius)	Dinidoridae	Hemiptera	Black watermelon bug
Gryllotalpa gryllotalpa (Linnaeus)	Gryllotalpidae	Orthoptera	Mole cricket
Thrips tabaci (Lindeman)	Thripidae	Thysanoptera	Cotton thrips
Caliothrips sudanensis (Bagn. and Can.)	Thripidae	Thysanoptera	Dark cotton leaf thrips

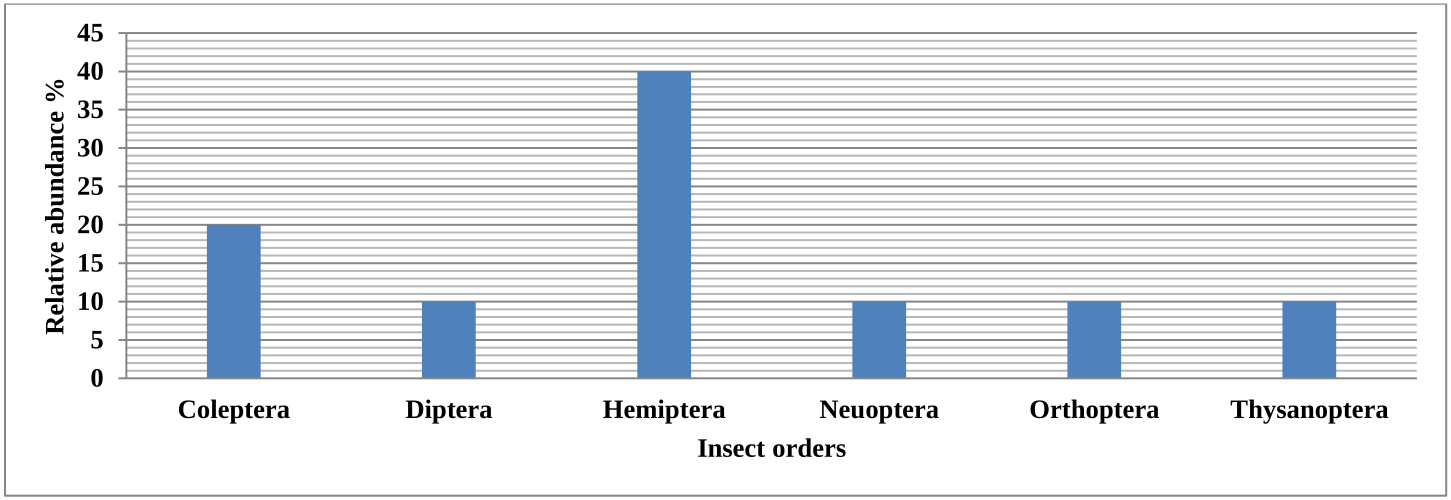


Figure 1. Relative abundance (%) of insect pests collected from the cucurbit plants grown on the study sites, during the study period (February 2021 to May 2023).

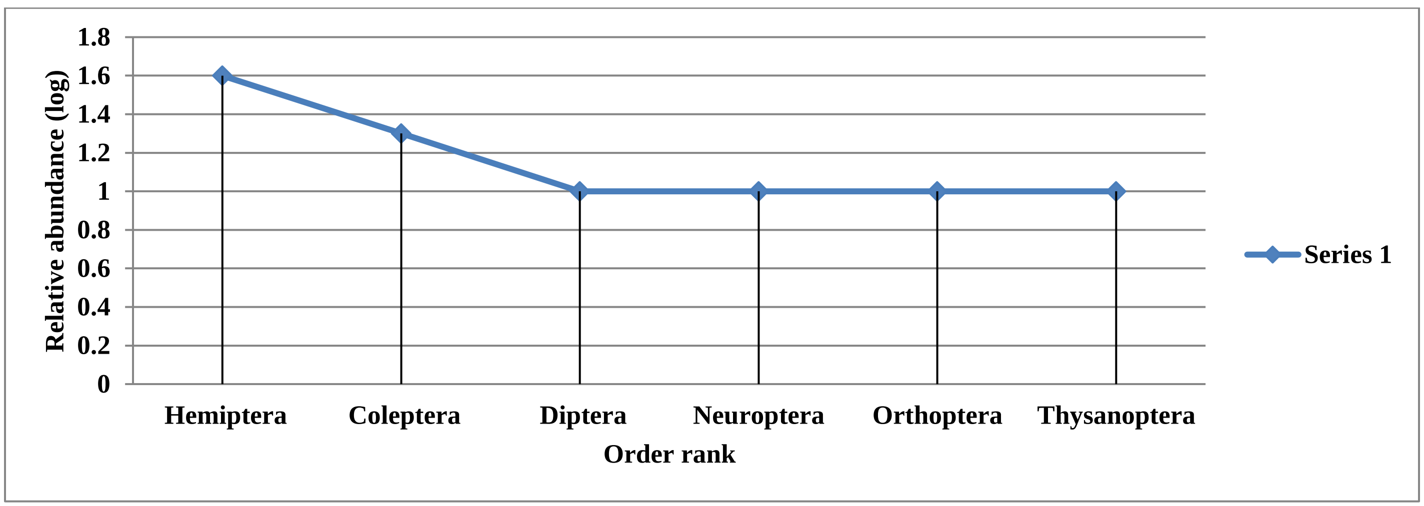


Figure 2. Insect pests abundance curve rank (Whittaker plot).

Dominances of insect pests in the three study sites

The dominance of the five insect pests associated with cucurbits grown on the three study sites was calculated and the obtained results are shown in figure (3) below, that the five insect pests dominated at Al-Shagalwa followed by Hosh-Bannaga, whereas, least relative dominance appeared in Gandato site, Figure (3).

Simpson diversity index for the encountered insect pests

Simpson Diversity Index was calculated for the encountered insect pests recorded from the three study sites. Results in table (2) illustrated that the SDI value for insect pests collected from the three study sites were 0.82, 0.69 and 0.79 for Hosh-Bannaga, Gandato and Al-Shagalwa, respectively. These values designated high diversity for insect pests in each of the three sites.

Pearson correlation coefficient

Pearson correlation coefficient (r) was applied to evaluate the effect of temperature and relative humidity on the insect pests collected during the study period (February 2021 to May 2023) from Hosh-Bannaga, Gandato and Al-Shagalwa and the obtained results are shown in table (3). At Hosh-Bannaga, weak negative linear correlations were revealed between temperature values and individual numbers of *C. elaterii* or *B. tabaci*, (r= -.038 and -.450), respectively. Also, a positive linear correlation occurred between temperature values and individual numbers of *A. gossypii*, *T. tabaci* and *C. sudanensis*, (r= 015, .218 and .488), respectively. Similarly; the relative humidity was found to affect insect collected from Hosh-Bannaga differently where a weak positive correlation are noticed between relative humidity and individual numbers of *C elaterii*, *A. gossypii* or *T. tabaci*, (r = .002, .342 and .011), respectively. A weak negative correlation is found between relative humidity and individual numbers of *C. sudanensis*, (r= -.081). High positive significant correlation is noticed between relative humidity values and individual numbers of *B. tabaci*, (r= .737*, p= 0.05, table3).

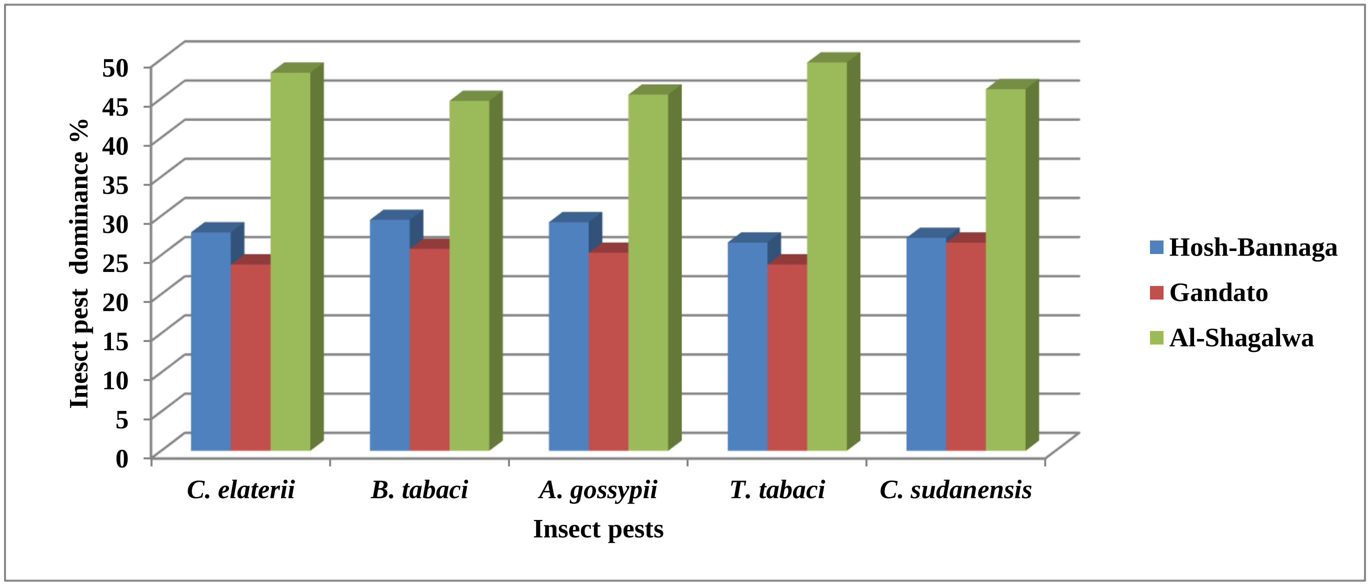


Figure 3. Dominance of insect pests collected from the three study sites.

Table 2. Simpson Diversity Index as calculated for the insect species collected from the three study sites.

Simpson' diversity index for insects collected from Hosh-Bannaga study site			
Insect species	n	(n-1)	n (n-1)
C. elaterii	275	274	75350
B. tabaci	276	275	75900
A. gossypii	344	343	59292
T. tabaci	248	247	61256
C. sudanensis	205	204	41820
Total	N= 1348 ∑N(N-1) = 1348(1348-1) = 1348*1347 = 1815756		∑n (n-1) = 313618
D = 1- (Σn (ni-1) / N(N-1))	D= 1- (313618/1815756 = 0.1727203434822741) D= 1- (0.1727203434822741= 0.8272796565177259)		
Simpson' diversity index for insects collected from Gandato study site			
Insect species	n	(n-1)	n (n-1)
C. elaterii	233	232	54056
B. tabaci	242	241	58322
A. gossypii	298	297	88506
T. tabaci	222	221	49062
C. sudanensis	233	232	54056
Total	N= 995 ∑N(N-1) = 995(995-1) = 995*994 = 989030		∑n (n-1) = 304002
D = 1- (Σn (ni-1) / N(N-1))	D= 1- (3304002/989030 = 1- 0.308309077817105) D= 1- (0.308309077817105 = 0.691690922182895)		
Simpson' diversity index for insects collected from Al-Shagalwa study site			
Insect species	n	(n-1)	n (n-1)
C. elaterii	476	475	226100
B. tabaci	419	218	175142
A. gossypii	537	536	287832
T. tabaci	461	460	212060
C. sudanensis	349	348	121452
Total	N= 2242 ∑N(N-1) = 2242(2242-1) = 2242*2241 = 5024322		∑n (n-1) = 1022586
D = 1- (Σn (ni-1) / N(N-1))	D= 1- (1022586/5024322 = 1- 0.2035271624708767) D= 1- (0.2035271624708767= 0.7964728375291233)		

Table3. Pearson correlation coefficient for impact of temperature and relative humidity on insect species collected from the three study site, during the study period (February 2021 to May 2023).

Hosh-Bannaga study site		
Insect species	**Temperature**	**Relative humidity**
C. elaterii	-.038	.002
B. tabaci	-.450	.737*
A. gossypii	.015	.342
T. tabaci	.218	.011
C. sudanensis	.488	-.081
Gandato study site		
Insect species	**Temperature**	**Relative humidity**
C. elaterii	-.236	.001
B. tabaci	-.119	.949**
A. gossypii	-.085	.505
T. tabaci	-.033	-.093
C. sudanensis	.368	.029
Al-Shagalwa study site		
Insect species	**Temperature**	**Relative humidity**
C. elaterii	-.306	.004
B. tabaci	-.306	.004
A. gossypii	.008	.119
T. tabaci	.033	.829
C. sudanensis	.063	.381
*. Correlation is significant at the 0.05 level (2-tailed).		

At Gandato site, there were weak negative linear correlations between temperature values and individual numbers of *C. elaterii*, *B. tabaci*, *A. gossypii* and *T. tabaci*, (r = -.236, -.119, -.085 and -.033, table-3), respectively, whereas, a positive linear correlation occurred between temperature values and individual numbers of *C. sudanensis*, (r = .368). Weak linear correlations were observed between relative humidity and individual number of *C elaterii* and *C. sudanensis*. Very high significant positive correlation was noticed between relative humidity and individual number of *B. tabaci*, (r = .949**, p = .01), while moderate one was realized for *A. gossypii*, (r = .505).

At Al-Shagalwa site, there was weak negative linear correlations between temperature values and individual numbers of all insect pests except for *C. sudanensis*, where a weak positive one was observed (r= .036, table-3). Weak linear correlations were also observed between relative humidity and individual number of all examined insect pests except those of *T. tabaci*, where, a very high positive correlation is noticed between relative humidity and individual number of *C. sudanensis* (r = .829).

Discussion:

General survey of cucurbits insect pests

A total of 4585 insect specimens associated with cucurbits grown on Hosh-Bannaga, Gandato and Al-Shagalwa were collected and classified into 6 orders, 10 families and 11 species. This could be due to the ability of cucurbits to harbor several insect pests by providing them with food and shelter. Similar observations were attained by Parolin *et al*., (2012), Chen *et al*., (2014), Mahgoub and Satti, (2017) and Odewole, (2018), who stated that plant species can provide food, shelter and breeding sites for insects which can increase their diversity and on the other hand they might be as a harbor of predatory natural enemies.

Relative abundance of the encountered insect pest orders

Insect pests relative abundance indicated that most of the identified insect pests were shown to belong to order Hemiptera followed by order Coleoptera, whereas, least number of the collected insects were found to belong the 4 other orders and the relative abundance rank or Wittker plot showed that the rank follow the order Hemiptera, Coleoptera, all of Diptera, Hemiptera, Neuroptera, Orthoptera and Thysanoptera. This could be ascribed to the presence of dense vegetation which provides food and shelter for feeding these insects. Similar observations were given by John, (2011), who correlated insect diversity to vegetation cover; the findings indicated that five species of the encountered insect pests represented major cucurbits' pests and recommended as preferred food for *C. carnea*. These pests were *C. elaterii*, *B. tabaci*, *A. gossypii*, *T. tabaci* and *C. sudanensis*. Mohamed *et al*., (2019), indicated that the most important insect pests infested cucurbits in Sudan include whitefly, greenfly, leaf miner, cucurbit stink bug, spotted beetle, red pumpkin beetle and cucurbit fruit worm. Choudhary *et al*., (2018) and Ofuya *et al*., (2023) recorded these insects species as major cucurbits insects prey for *C. carnea* in Rajasthan and Nigeria, respectively.

Dominances of insect pests collected from the three study sites

The dominance of the insect pests' orders associated with cucurbits dominated Al-Shagalwa followed by Hosh-Bannaga, whereas, least relative dominance appeared in Gandato study sites site. This could be ascribed to the variations in site characteristics which may favor dominance of certain groups more than other sites. Savopoulou-Soultani *et al*., (2012), gave some accounts on effect of a biotic factor on insect's dominance and abundance.

Simpson diversity index for the encountered insect pests

High values of Simpson Diversity Index were obtained for the insect pests collected from Hosh-Bannaga, Gandato and Al-Shagalwa study sites. These results could be attributed to the ability of insect pests to adapt to a wide variety of environmental and plant conditions such morphological features of cucurbits that facilitate their movement between adjacent plants and spatial distribution in addition to the cucurbits stands closeness to the ground which help in reproduction of pests as soil is critical for pupation. Similar conclusions were attained by Berenbaum, (2017), who insect biodiversity and later by Nage *et al*., (2023), showed that the diversity of insect species vary depending on biotic and a biotic factors, type of food, and geography of the ecosystem.

Pearson correlation coefficient

Pearson correlation coefficient was measured to correlate temperature to insect population. Results indicated weak negative linear correlations between temperature values and individual numbers of *C. elaterii* or *B. tabaci* and positive linear correlation individual numbers of *A. gossypii*, *T. tabaci* and *C. sudanensis* in Hosh-Bannaga. Weak negative correlation was observed between temperature and individual numbers of *C. elaterii*, *B. tabaci*, *A. gossypii* and *T. tabaci*, whereas, positive one was found for *C. sudanensis* in Gandato. In Al-Shagalwa, temperature values indicated negative linear correlations to individual numbers of *C. elaterii*, *B. tabaci*, *A. gossypii* and *T. tabaci* but weak positive to *C. sudanensis*. These results could be ascribed to the impact of temperature on insect life cycles, reproductive patterns and changes in ecological distribution. Curnutte *et al*., (2014), reported that temperature affected insect morphology such as body size. Biber-Freudenberger *et al*., (2016), generalized those insects as temperature variables proliferate and fluctuate differently with temperature. These observations are in conformity with the findings of Saha *et al*., (2018), who indicated varied positive and negative impact of temperature on six species of cucurbits. Karar *et al*., (2021), 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. Pearson correlation coefficients calculated for the impact of relative humidity on cucurbits insect pest on the three study sites revealed positive correlation between relative humidity and individual numbers of *C. elaterii*, *A. gossypii* or *T. tabaci*, negative one for *C. sudanensis*, and high positive significant *B. tabaci* in Hosh-Bannaga, in Gandato weak linear correlations between relative humidity and individual numbers of *C. elaterii* and *C. sudanensis*. Very high significant positive correlation between relative humidity and individual numbers of *B. tabaci*, whereas, moderate one was realized for *A. gossypii*. Weak linear correlations between relative humidity and individual numbers of *C. elaterii*, *B. tabaci*, *A. gossypii and C. sudanensis* and very high positive correlation was noticed for *T. tabaci* in Al-Shagalwa. Rahman *et al*., (2015), depicted positive impact of relative humidity on some cucurbit insect pest studied under field conditions. Solanki *et al*., (2023), indicated that the relative humidity had positive association with cucurbits insect pest when they studied the dynamics of cucumber major in sect pests in India.

Conclusion:

A general field survey was carried out in the River Nile state to collect and identify cucurbits insect pests. A total of 4585 insect specimen were obtained and identified into different orders including *C. elaterii*, *B. tabaci*, *A. gossypii*, *T. tabaci* and *C. sudanensis* as major cucurbit insect pests. Individual numbers of these orders showed significant variations in terms of relative abundance, dominance and diversity indices.

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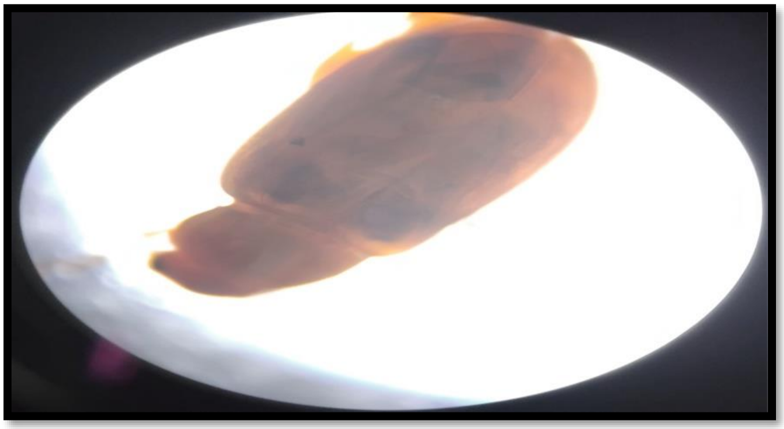

Plate (1). *Aulacophora foveicollis* (Lucas).

Plate (2). *Chnootriba elaterii* (Rossi).

Plate (3). *Dacus ciliatus* (loew).

Plate (4). *Aphis gossypii* (Glover).

Plate (5). *Bemisia tabaci* (Gennadius).

Plate (6). *Acanthocephala curvipes* (Fabricius).

Plate (7). *Coridius viduatus* (Fabricius).

Plate (8). *Thrips tabaci* (Lindeman).

Plate (9). *Caliothrips sudanensis* (Bagn. and Can.).