# Biology and Dispersal of the Watermelon Bug *Coridius viduatus* (F.) Heteroptera: Dinidoridae on Different CucurbitCrops, in North Darfur State, Sudan.


## ABSTRACT

The watermelon bug, *Coridius_viduatus* (F.) is a real threat to watermelon *Citrulluslanatus*(Thunb.)_in western Sudan, where over 80% of the population relies economically on agriculture. In order to overcome this constraint, a study was carried out at University ofAlfashir, North Darfur State, to investigate biology, food preference and dispersal of watermelon bug. A survey was conducted on season (2013/~~20~~14) to determine the movement and dispersal of the watermelon bug in the area around Alfashir._Biology of the bug was studied under laboratory conditions, preoviposition, oviposition, incubation and post oviposition periods were calculated. Food preference and non-preference by the bugtofour watermelon varieties and tow cucurbit ones were also evaluated; afield experiment was conducted, a randomized complete block design was used. The field survey results indicated that there was a regular movement from plant shelters, mountain crevices and soil cracks to the field crop and back again to aestivation sites._Results showed that the bugs preferred improved watermelon varieties (Crimson, Sugar baby and Congo) to the local watermelon variety (Saphinga), the different life cycle stages of the bug were determined. The bug aestivation shelters were determined, local watermelon –varieties could be cultivated however further work should be done to improve their productivity.



**Key words:*Citrulluslanatus, Coridius vidiuatus* (F.) watermelon- bug,Cucurbitaceae, dispersal, preference.**




## 1. INTRODUCTION

The watermelon ,*Citrullus lanatus* (Thunb.) is originated in Africa and has been cultivated for more than 4000 years in the drier parts of the continent and throughout India and parts of Asia. It was grown in an area 3.2 million ha and the total production was 89.1 million tons in 2010 [1]. It is used as desert fruit and thirst quencherand in the very dry parts of Africa, it is consumed by both man and his animals as a source for water. The roasted seeds are popular as food in some areas, especially in west Africa and southern China and they contain a semi- drying oil [2].Watermelon is a warm season crop and can be cultivated year round_in the tropics, the most producing countries are China(70,000,000 tons), Turkey (4,044,144 tons), Iran(3,800,000 tons), Brazil (2,079,547 tons) and Egypt (1,874,710 tons), worldwide production of watermelon was 95,211,432 tons in season 2012, watermelon contain about 92% water and 6% sugar by weight, it is a source of vitamin C [3].

There are several insects causing damage on watermelon such as watermelon –beetles, aphids, flies, ants, etc. However, the most serious one is the Black watermelon bug *Coridius viduatus* (F.) (Heteroptera:_Dinidoridae).The genus Coridius includes this species is currently replacing the old genus Aspongopus, in the Sudan watermelon is considered to be an important economic food crop both for man and his animals and is widely grown in Kordofan, Darfur, Kassala, Khartoum, Blue Nile, and white Nile States [4][5].There exist, in the far northern parts of the Darfur Region, wild local cucurbits varieties including

watermelon. The environmental conditions were suitable for watermelon bug to develop, hide and rest along the study area. Long ago event of drought phenomenon had enforced many local farmers to leave for Libya to improve their living standards, when returned back home, they brought with them, large quantities of improved watermelon seeds ( Charleston, Congo, Sugar baby and Crimeson).Consequently the pest found it possible to develop, multiply and increases its population density to high levels. Therefore the grown populations have invaded the traditional water melon growing areas in the sandy clay soils of Maliet, Elseyah, Elkoma,Mudo, El-leytani, FazaGuddom and emigrated to attack the plant grown in valleys together with other insect pests *Aphis gossypii, Hensoepilachna elatrii, Aulchophora africana*, *Dacus ciliatus*, *Dacaus dorsalis*, *Dacus vertebratus, Palpita indica* and *Epicauta aethiops***.** On the other hand some species are notorious insect pests feed on cucurbits, attack leaves, stems and fruits. Heavily infested plants wilt and finally die. In this regard melon bug is the most important insect pest in western Sudan[6] it is also found in almost all African, Arabian countries, Iran and Turkey. Nymphs and adults are gregarious, those from one egg cluster feed close together, and transmit bacterial and viral diseases. Watermelon bug *C. vidautus* seriously attacks the watermelon crops, in Northern Kordofan and Darfur states. This crop is considered as most important one, since it is used as a source for drinking water because of water shortage in that area during the summer months. Also the residues of the fruits are used as animal feed, and its seeds serve as source of income to the farmer [7]. The population of the insect was very big and the damage caused is really high. On the other side, in the remote territories of Sudan, oil from the bug *Coridius viduatus* is extracted and used as sweet oil without any poisons effect. This oil corresponds in its main content with the most of animal oils[8].It has been investigated that watermelon bugoil is used as food and medicine in dermatological diseases due to its antibacterial effect[9].Biofuel production from this insect was reported in this country as well. Hundred grams of watermelon fruits contains 92.6g moisture, 0.5g protein, 0.2g fat and 4.6g carbohydrates; [10]added that the whole watermelon seed contains moisture (4.94), fat (25.87), protein (18.96), ash (2.31), fiber (39.84) and carbohydrate (8.38) g.Watermelon production in the Sudan facing many problems including diseases, pests attack, rain fluctuation and farmers lack of experience [11] [12].

the eggs laid in clusters in lower surface of the leaves, the dark brown eggs are laid in groups about 1cm across on the lower surface of the leaf or in long rows along stems or veins, The female lays about 300-500 eggs in masses of dark colour,[4] [13] [14], [15][16] Young nymphs of the melon bug range in ~~colour~~color from, pale-brown to reddish black depending on their age. The newly hatched nymphs are found near the eggs cluster, Nymphs of the last instars reassemble the adult in colour and appearance but without fully developed wings. They are often seen feeding on the host in great numbers [5][15].The incubation period is (7-8) days, hatchability is (95-100%), eggs hatch to give Nymphs, there are five nymphal instars with a period of (42-45) days to give adult bugs, there are two generations per year[13][17].

Heavy infestation generally occur during the winter season, the bugs concentrate for aestivation, after massing in shady,low lying places [18],The bug seriously reduces the cropvigour and productivity. The objectives of this study are to investigate the biologyof the bug under laboratory conditions, food preference and dispersal of watermelon bug.

## 2. MATERIAL AND METHODS:

### 2.1 Field Survey:

Geographical survey was conducted in selected secured Localitiesviz. Alfashir, Dar Alslam, Kelimendo, Wada and some other rural areas around Al-Fashir city; the capital of North Darfur State Latitude 13° 37' 40.55" N, Longitude25° 20' 57.70"E.The survey took place on

winter, summer and autumn (October-2013, March-2014 and August-2014).The objectives of this survey were to determine the sheltering sites and the nature of the watermelon bug movement. These areas are characterized by poor dry Savannah and sandy soils predominate as well as scattered shrubs and trees where water melon is grown at wide scales for both, fruits and seeds.

### 2.2. Watermelon Bug Food Preference and Non- Preference on Different Watermelon and Cucurbit Varieties in North Darfur State:

An experiment was conducted at the demonstration farm of Al-Fashir University; the objective of this experiment was to study food preference and non-preference of melon bug. An area of 740 $m^2$was divided into 18 plots (4×5m)each contain three mustabasone meter width and 3meters length, A randomized complete block design was used, 6 treatments (varieties) were replicated 3 times. Seeds of four watermelon varieties, (three are genetically improved, i.e. Crimeson, Congo, Sugar baby and one local watermelon_Safinga) and towpumpkin varieties (genetically improved Ananas, and local Harshayia) were sown in a complete randomized block design and replicated three times, in the first week of July, 2014 with the onset of rainfall .Cultural practices were followed as recommended, Observations were recorded on weekly bases intervals and six counts were obtained.

### 2.3 Biological studies:

#### 2.3.1Life cycle:

Formatted: No underline

After survey that carried out in the study areas around Al-Fashir in season 2013 – 2014, insects' stock culture has initially been established from eggs deposited by female watermelon bugs.

Mature adult melon bugs were collected by hands early in the mornings and late evenings during late November and early December 2013,from Sarafayia, Magdoob and Umgidaibo areas around Al-Fashir.The bugs were put in transportable wooden cage and carried to the main laboratory of the Faculty of Environmental Sciences and Natural Resources then transferred into a mass rearing box measures (20x25x30cm), the bottom side was covered with a hard wood, the 4sides were coveredwith fine mesh, the top side was covered with a movable door to facilitate insect inspection. Adults were daily fed with fresh food, small leaves, stems, growing shoots of water melon; laboratory reared progeny of the overwintering adults were remain alive and continue egg layingon the wooden cages floor on leave under sides and cage corners.

–Eggs lay in clusters, rows or singly were left to incubate at room temperature (37±2.6°C). After eggs hatchingthe first nymphs transferred into plastic containers, sorted out and uniform ages kept in groups, each group was composed of 5nymph instars as one unit of similar ages and kept in separate cages, Ibrahim metallic cage, the number of cages were 10. The total number of the first instars amounted (50) nymphs and were fed with foods (watermelon leaves, stems, young growing shoots, young fruits), and replaced every 24hours by fresh succulent food. However, after hatching, the first, second , third, fourth and fifth instar stages up to adult emergency were summed up in days. Ibrahim cage was designed by makinguse of local materials as described below.

#### 2.3.1.1 Ibrahim cage description.

Formatted: No underline

It was designed by making use of some local material to study the life cycle of melon bug.It composed of empty cylindrical perfume container (Mahlabia), its height was 8_cm and the diameter was 8.4cm with 4windows (Holes) their length was 5.9cm, the width was 4.6cm to

allow smooth ventilation, the inner walls were lined all through with fine sieve/mesh to hinder escaping of nymphs and permit close watch over,as well as enabling the nymphs to cling onto during resting and food sucking periods and molting process. However, nymphs remain in tight contact with food most of the time. The bottom of cage was mulched with filter paper where food was placed and the top of the cage covered with a piece of cloth made of cotton and fixed with a rubber band. It services as protective cover and allows ventilation. This cage was used for bug groups rearing at arrange of 5 nymphs per cage [10].

## 3. RESULTS AND DISCUSSION:

### 3.1 Field Survey

The results of the filed survey that took place on winter, summer and autumn (October-2013,March-2014 and August-2014) in the study areas. It had been found that the most important sheltering plants for the black watermelon bug *Coridius vidautus* were Remta (*Eragrostis aspera*), Argassy (*Chrozophora brocchiana*), Eyear (*Momordica balsamina*), Dura (*Sorghum bicolor)*,Mrahabaeb (*Cymbopogon giganteus*), Gdgad (*Gloriosa superba*), Tontob (*Capparis sepiaria*), Hashab (*Acacia Senegal*), Laout (*Acacia nubica*), Gedaem (*Grewia villosa*), Khbaesh (*Haemanthus multiflorus*), Sider (*Ziziphus spina-cristi*) and Osher (*Calotropis procera*). The black watermelon bugs were found hiding between the leaves of these plants; in addition to mountain crevices and soil cracks. Adult melon bugs undergo the dry season in aestivation. [7]Mentioned that black watermelon bug shelter plants were Sodom apple *Calotropis procera*, Neem *Azadirachta indica* and some *Acacia* spp. He added that the main sheltering plant was date palm *Phoenix dactylifera* at the Northern State, Sudan.

It was also noted that melon bugs prefer cucurbit crops specially the watermelon. Adults and nymphs suck the juice of the main stems, leaves and the developing fruits, heavily infested plants shed their leaves and young fruits. The bug attacked other crops like Dura *Sorghum bicolor* and pearl millet *Pennissetum gluacum*; these crops act as a source of infestation.

During this survey many observations were recorded; before sunset the bugs moved to the upper parts of the host plant for a while then returned to the lower parts at night. Numbers of bugs were bigger in the sheltering plants around the watermelon fields and reached up to 3000 bugs. They were found at the lower part of trees, shrubs, and weeds (mentioned above) in clusters.

The results showed that the bug was found in great number in valley flows under Hills and traditional stores in the villages. It could be argued that from these observations the black watermelon bug *Coridius viduatus* passed the off season hiding under these plants, trees, shrubs in summer and start to migrate to attack field crops sorghum and pearl millet during autumn. Its population increases toward the end of the rainy season and attack watermelon and other cucurbit crops in winter (October to March), then back to aestivation sites in late March. Generally we can mention that there was a regular movement started during early August from plant shelters, mountain crevices and soil cracks to the field crops especially watermelon and back again to aestivation sites during summer.

### 3.2. Biological Studies:

Studies on the life cycle of the black watermelon bug *Coridius viduatus* (Fabricius) were conducted in the Entomology laboratory of the Faculty of Environmental Sciences and Natural Resources, University of Alfashir, under room temperature in season (2013-2014). Eggs were found laid on the leaves, stem and growing shoots of watermelon and arranged in clusters. The results showed that, the black watermelon bug endures incomplete metamorphosis and passed through five nymph instars. This result was in the same line with[7] [15][22]. The different developmental tages during the course of the bug life span were described as follows:

#### 3.2.1Pre oviposition period:

The mean preoviposition period of the mated female was 5.70± 2.53 day. This period ranged from 2 to 9 days (Table 1).

**Table 1.The number of eggs laid by a female, preoviposition, oviposition, post oviposition periods and life span of the black watermelon bug *Coridius viduatus* in days reared under laboratory conditions.**

| No. | Total number of eggs Laid/Female | Pre oviposition period | Oviposition Period | Post oviposition period | Life span of female | Life span of male |
|---|---|---|---|---|---|---|
| 1 | 160 | 9 | 45 | 5 | 59 | 30 |
| 2 | 210 | 3 | 45 | 7 | 55 | 29 |
| 3 | 265 | 5 | 29 | 7 | 41 | 27 |
| 4 | 419 | 6 | 43 | 6 | 55 | 30 |
| 5 | 519 | 2 | 39 | 4 | 39 | 25 |
| 6 | 315 | 6 | 55 | 3 | 53 | 23 |
| 7 | 220 | 9 | 50 | 5 | 64 | 29 |
| 8 | 251 | 7 | 41 | 6 | 54 | 27 |
| 9 | 361 | 8 | 52 | 3 | 63 | 28 |
| 10 | 215 | 2 | 57 | 5 | 64 | 30 |
| **Mean** | 293.50 | 5.70 | 45.6 | 5.1 | 54.70 | 27.80 |
| **Range** | 160-519 | 2-9 | 29-57 | 3-7 | 39-64 | 23-30 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **SE±** | 105.16 | 2.53 | 8.34 | 1.37 | 8.36 | 2.23 |

### 3.2.2 Oviposition period and fecundity:

It was found that the egg is small in size;_cylindrical in shape when newly laid it was green in colour and gradually changed to reddish-brown just before hatching. The eggs either laid singly in rows along the running stems of watermelon shoot or eggs lay in clusters glued to each other along the running stem forming a straight bead like structure, frequently eggs were laid on the lower surface of the leaves of watermelon. However, during the course of this study, few eggs were laid on the cloth pieces that covered the oviposition cage.

The mean oviposition period of watermelon bug reared under laboratory conditions was 45.60±8.43 days ranged from 29 to 57 days. The Maximum number of eggs laid by female was 519 and minimum was 160 eggs. The mean of eggs laid/female was 293.50±105.16 (Table 1), this results are in accordance with [17] [18]. The maximum number of eggs laid by a female was during the third week from the beginning of egg laying.

### 3.2.2 Postoviposition period:

Post oviposition period varied from one female to another, the mean post oviposition period was 5.10±1.37 days ranged from3 to 7 days. The duration of total life span for female and male were 54.78± 8.36 and 27.80± 2.23 respectively (Table1).

### 3.2.3 Hatchability%:

The mean hatchability was 92.50±7.16,

$.Hachability\% = \frac{emerged\ nymphs}{total\ eggs\ laid} X100$ (Table 2). This result coincides with the same that mentioned by [11]

**Table 2. Incubation period in days and hatchability % of watermelon bug *Coridius viduatus* reared under laboratory conditions.**

| Serial No. | Egg laying Date | Hatching date | No. of egg laid | No. of egg hatched | incubation period | Hatchability% |
|---|---|---|---|---|---|---|
| 1 | 27-11 | 7-12 | 20 | 18 | 10 | 90 |
| 2- | 27-11 | 7-12 | 20 | 19 | 10 | 95 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3- | 27-11 | 7-12 | 20 | 20 | 10 | 100 |
| 4- | 27-11 | 7-12 | 20 | 16 | 10 | 80 |
| 5- | 27-11 | 10-12 | 20 | 20 | 13 | 100 |
| 6- | 28-11 | 10-12 | 20 | 20 | 12 | 100 |
| 7- | 29-11 | 9-12 | 20 | 16 | 10 | 80 |
| 8- | 29-11 | 8-12 | 20 | 19 | 9 | 95 |
| 9- | 30-11 | 7-12 | 20 | 19 | 7 | 95 |
| 10- | 30-11 | 11-12 | 20 | 18 | 11 | 90 |
| Range | - | - | - | 16-20 | 7-13 | 80-100 |
| Mean | - | - | 20 | 18.5 | 10.20 | 92.50 |
| SE± | - | - | 0.00 | 1.43 | 1.54 | 7.16 |

### 3.2.4. First nymph instar

The first nymph instar emerged by pushing the eggshell, small in size, reddish brown to black. Nymph's head, antennae and thorax changed to black after few minutes from hatching, while the abdomen was orange in colour and appeared flat in shape. It moves slowly searching for food and shelter. The mean duration of this nymph instar was (7.40±0.49) days and ranged from 6 to 8 days. The other four nymph instars each had unique characters and showed different duration period, the mean total nymph instars is 51.6±2.42 (Table 3).

### 3.2.5. Second nymph instar

The body of this nymph stage is generally flat, with orange colour abdomen, creamy thorax and dark brown thoracic appendages. The head and its appendages were also dark brown. The mean duration of this stage was (11.3±1.10) days. This nymph moved quickly searching for food and shelter (Table 3).

### 3.2.6. Third nymph instar

The body shape of this nymph instar is oval in shape, creamy in colour with two creamy traverse stripes in the dorsal sides, the nymph head, antennae and thorax were dark brown. The mean duration and range of this nymph instar were found to be (6.1±0.7)days, 5to 7 days respectively (Table 3).

### 3.2.7. Fourth nymph instar

The structure of this nymph was featured out, the abdomen become flattened with brown colour interrupted with creamy stripes along each of body sides. The mean duration period was (12.7±1.79) days and the range was10 to 15 days (Table 3).

### *3.2.8. Fifth nymph instar*

This stage is nearly similar to the fourth nymph instars in shape and colour. The main duration period took (14.1±0.83) days, ranged from 13 to15 days (Table 3).

**Table 3. The durations of nymph developmental stages of the melon bug *Coridius viduatus* (Fabricius)in days under laboratory conditions.**

| No | First instar | Second instar | Third instar | Fourth instar | Fifth instar | Total nymph days |
|---|---|---|---|---|---|---|
| 1 | 7 | 10 | 6 | 10 | 13 | 46 |
| 2 | 7 | 12 | 6 | 10 | 15 | 50 |
| 3 | 8 | 11 | 6 | 11 | 15 | 51 |
| 4 | 7 | 11 | 7 | 12 | 13 | 50 |
| 5 | 8 | 12 | 7 | 13 | 13 | 53 |
| 6 | 8 | 13 | 5 | 13 | 14 | 53 |
| 7 | 8 | 13 | 6 | 14 | 14 | 55 |
| 8 | 7 | 10 | 6 | 14 | 15 | 52 |
| 9 | 7 | 10 | 7 | 15 | 15 | 54 |
| 10 | 7 | 11 | 5 | 15 | 14 | 52 |
| **mean** | 7.4 | 11.3 | 6.1 | 12.7 | 14.1 | 51.6 |
| **range** | 7-8 | 10-13 | 5-7 | 10-15 | 13-15 | 46-55 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **SE±** | 0.49 | 1.10 | 0.70 | 1.79 | 0.83 | 2.42 |

247

248 **3.3. Food preference and non-preference:**

249 There was a significant difference between the improved watermelon variety Crimson and the
250 local watermelon variety Saphinga, It worth mentioning that the bugs were strongly attracted
251 to the improved watermelon varieties Crimson (78%), Sugar baby(72%) and Congo (69%).A
252 significant difference between Ananas and Harshyia cucurbit varieties was found, the local
253 varietieswere least preferred by the bug (Table 4).DISCUSSION

254 **Table 4. Mean percentages of food preference of watermelon bug *Coridius**
255 ***vidautus*on different watermelon and pumpkin varieties.**

| Variety | Mean % |
|---|---|
| Crimson | 78 |
| Sugar baby | 72 |
| Congo | 69 |
| Ananas | 64 |
| Saphinga | 61 |
| Harshyia | 49 |
| Mean | 67.3 |
| SE*± | 5.7 |
| C.V** | 8.4 |
| LSD*** | 11.77 |

256 *SE = Standard error

257 **C.V = Coefficient of variation

258 ***LSD = Least Significant Difference

259

## 4. CONCLUSION

The bug aestivation shelters were determined. A regular movement of the watermelon bug was discovered from aestivation and sheltering site mainly shrubs and trees in addition to mountain crevices and soil cracks, so control measures may consider this in future. Different developmental stages were investigated. Local watermelon varieties could be cultivated as they were less preferred by the bug, however further work should be done to improve their productivity.

## References:


1. Tarla S,Yetiir H, Tarla G. Black Watermelon Bug *Coridius viduatus* (F.)(Heteroptera: Dinidoridae) in Hatay Region of Turkey.Journal of Basic and Applied Sciences. 2013; 9:31-35.

2. Cobly LS.An Introductionto theBotony of Tropical Crops; 1979.

3. Satyagopal K, Sushil SN, Jeyakumar P, Shankar G, Sharma OP, et al.AESA based IPM package for Watermelon. National Institute of Plant Health Management, Rajendranagar, Hyderabad 500 030; 2014.

4. Pollard DG.A note on the biology of *Calideaduodecciumpunctata*(Fabr.) in the Sudan. Entomological Section Research Division, Min. of Agric., Sudan; 1955.

5. Schumeterer H. Pests of crops in Northeast and central Africa. Gustav Fisher Stuttgart; 1969.

6. Mustafa NEM, Mariod AA, Matthaus B. Antibacterial Activity of the *Aspongopus viduatus* (Melon bug) oil.J Food Safety.2008; 28:577-86.

7. MohammedSalih, MHM. Studies on the biology, morphology and host range of the melon bug *Coridius viduatus* (Fabricius) (Hemiptera: Dinidoridae) in the Northern State.M.Sc. thesis U. of Kordofan. Sudan; 2008.

8. Tauscher B, Muller M, Schildkecht H.Composition and toxicology of oil extracts (edible oil) from *Aspongopus viduatus*. Chem MikrobiolTechnol Lebensm. 1981; 7: 87-92.

9. Mariod AA, Matthaus B, Abdelwahab SI. Fatty Acids, Tocopherols of *Aspongopus viduatus* (melon bug) oil during different Maturity stages. IntJ Nat Prod Pharm Sci. 2011; 2(1): 20-27

10. Ibrahim IA. Studies on Life tables, Ecology and Efficiency of the aphidophagouscoccinellid*Cheilomenesvicina* (Muls). (Coccinellidae :Coleoptera). M. Sc. thesis, University of Khartoum; 1988.

11. Guddoura E. Insects and disease. Attacking cucurbits .PPD Bull. No.1. plant protection Deportment .The Ministry of Agriculture, Sudan; (1972).

12. Dabrowski ZT, Alsaffar, AA, Abdurrahman, AA. Integrated pest management on vegetable crops in the Sudan. Development and implementation strategy. 1994; ICIPE Science press,Nairobi, Kenya David, A. Riger: .24-32.

13. Mohammed AO. Studies on the Biology, Ecology and Possible control measures of the melon bug *Coridius viduatus* (Fabricus) (Heteroptera: Dinidoridae). M.Sc. thesis Faculty of Natural Resources, University of Kordofan, Sudan; 2003.

14. AhmedAI. Studies on the ecology and control of the melon bug *coridius viduatus* (Fabricius)(Heteroptera: Dinidoridae), M.Sc. Thesis, Faculty of Natural Resources, University of Kordofan, Sudan; 2004.

15. Adra, A1. Biological, Ecological, and Morphological studies on the melon bug *Coridius viduatus* (Fabricius )Hemiptera, Dinidoridae on watermelon in North Kordofan State M.Sc. thesis Faculty of Natural Resources University of Kordofan, Sudan; 2005.

16. Abdalla MI. Ecology, Biology, Behaviour and control of the melon bug, *Aspongopus viduatus* (Fabricius) (Hemiptera: Dinidoridae ) . Ph.D. thesis, University of Khartoum; 2010.

17. Gulbarga SM. Pests status, ecology and control. Plant protection deportment annual report, Ministry of agriculture, Khartoum ,Sudan:2002.

18. Anonymous . G.TZ project, ISVFF. Tech. pamphlet No (4/1000) April, 1992, No.(5,6,7and 8/15000 may, 1992). Khartoum- Sudan. Press Cairo; (in Arabic language).