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

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The watermelon bug, *Coridius viduatus* (F.) is a real threat to watermelon *Citrullus lanatus* (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 of Alfashir, North Darfur State, to investigate biology, food preference and dispersal of watermelon bug. A survey was conducted on season (2013/2014) 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 bug to four watermelon varieties and tow cucurbit ones were also evaluated; a

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field 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.

Keywords: Citrullus lanatus; Coridius viduatus (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 quencher and 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 [4], 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 [5,6]. 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. Therefore the grown populations have invaded the traditional water melon growing areas in the sandy clay soils and emigrated to attack the plant grown in valleys. Heavily infested plants wilt and finally die. In this regard melon bug is the most important insect pest in western Sudan [7] 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. 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. It has been investigated that watermelon bug oil 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 92.6 g moisture, 0.5 g protein, 0.2 g fat and 4.6 g carbohydrates; whole watermelon seed contains moisture (4.94), fat (25.87), protein (18.96), ash (2.31), fiber (39.84) and carbohydrate (8.38) g [10].

the eggs laid in clusters in lower surface of the leaves, the dark brown eggs are laid in groups about 1 cm 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 [5,13,14,15,16]. Young nymphs of the melon bug range in colour 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 [6]. 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 crop vigour and productivity. Some studies were carried in Sudan talked biology, ecology,

biocontrol and integrated management of the watermelon bug in different ecological zones and even under different cropping systems [19] but meager or absent studies about the movement or dispersal of the bug from host plants to the aestivation sites. The objectives of this study are to investigate the biology of the bug under laboratory conditions, food preference and dispersal of watermelon bug.

2. MATERIALS AND METHODS

2.1 Field Survey

A survey was conducted in selected secured Localities viz. Alfashir, Dar Alsalam, Kelimendo, Wada and some other rural areas around Al-Fashir city; the capital of North Darfur State Latitude 13° 37' 40.55" N, Longitude 25° 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. The numbers of the pest were calculated during summer season to identify the sheltering sites and the pest density.

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 (4×5 m) each contain three mustabas one meter width and 3meters length, a completely randomized 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 tow pumpkin varieties (genetically improved Ananas, and local Harshayia) were sown in a randomized complete 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. Analysis of variance was done and the least significant difference (LSD) at 0.05 was calculated.

2.3 Biological Studies

2.3.1 Life cycle

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 (20x25x30 cm), the bottom side was covered with a hard wood, the 4 sides were covered with 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 laying on the wooden cages floor on leave under sides and cage corners [10].

Eggs lay in clusters, rows or singly were left to incubate at room temperature (37±2.6°C). After eggs hatching the first nymphs transferred into plastic containers, sorted out and uniform ages kept in groups, each group was composed of 5 nymph 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 24 hours 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 making use of local materials as described below.

2.3.1.1 Ibrahim cage description

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 8.4 cm with 4windows (Holes) their length

was 5.9 cm, the width was 4.6 cm 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 viduatus* 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. These shelters differ from that reported in Northern State, Sudan where the black watermelon bug shelter on Sodom apple *Calotropis procera*, Neem *Azadirachta indica* and some *Acacia* spp. But the main sheltering plant was date palm *Phoenix dactylifera* [8] Watermelon bug *C. viduatus* 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.

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 huge in the sheltering plants around the watermelon fields and reached up to 3000 bugs per tree. 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 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 the same observation reported later [20]. 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 many investigators [8,15,16]. The different developmental stages during the course of the bug life span were described as follows:

3.2.1 Pre 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) [19,8].

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 [8,18] and it differ [19]. The maximum number of eggs laid by a female was during the third week from the beginning of egg laying.

3.2.3 Postoviposition period

Post oviposition period varied from one female to another, the mean post oviposition period was 5.10±1.37 days ranged from 3 to 7 days this result in the same line with other investigator [8]. The duration of total life span for female and male were 54.78± 8.36 and 27.80± 2.23 respectively (Table 1).

3.2.4 Hatchability%

The mean hatchability was 92.50±7.16,

$Hachability\% = \frac{emergednymphs}{totaleggslaid} X100$ (Table 2). This result coincides with the same that mentioned by [11] also indicates the high fecundity of the pest.

3.2.5 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 this finding coincides with other workers [8,19]. 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).

3.2.6 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 and the result reported by Mahgoub et al. [19]. This nymph moved quickly searching for food and shelter (Table 3).

3.2.7 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, 5 to 7 days respectively (Table 3), this results in agreement with other workers [7,19].

3.2.8 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) this result slightly differ from [19] this may be due to differences in the climate conditions.

3.2.9 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) these developmental stages came as reported by Mahgoub et al. [19] and slightly differ from [8].

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

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	Forth instar	Fifth instar	Total nymph days
1	7	10	6	10	13	46
2	7	12	6	10	13	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

3.3 Food Preference and Non-preference

There was a significant difference between the improved watermelon variety Crimson, sugar baby and the local watermelon variety Saphinga, It worth mentioning that the bugs were strongly attracted to the improved watermelon varieties Crimson (78%), Sugar baby (72%) and to lesser extent to Congo (69%). A significant difference between Ananas and Harshyia cucurbit varieties was found, the local varieties to determine the sheltering sites and the nature of the watermelon bug movement were least preferred by the bug (Table 4) the bug preferred the imported improved varieties which may be more susceptible than the local varieties.

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

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

**SE = Standard error; **C.V = Coefficient of variation; ***LSD = Least Significant Difference*

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 and tolerance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

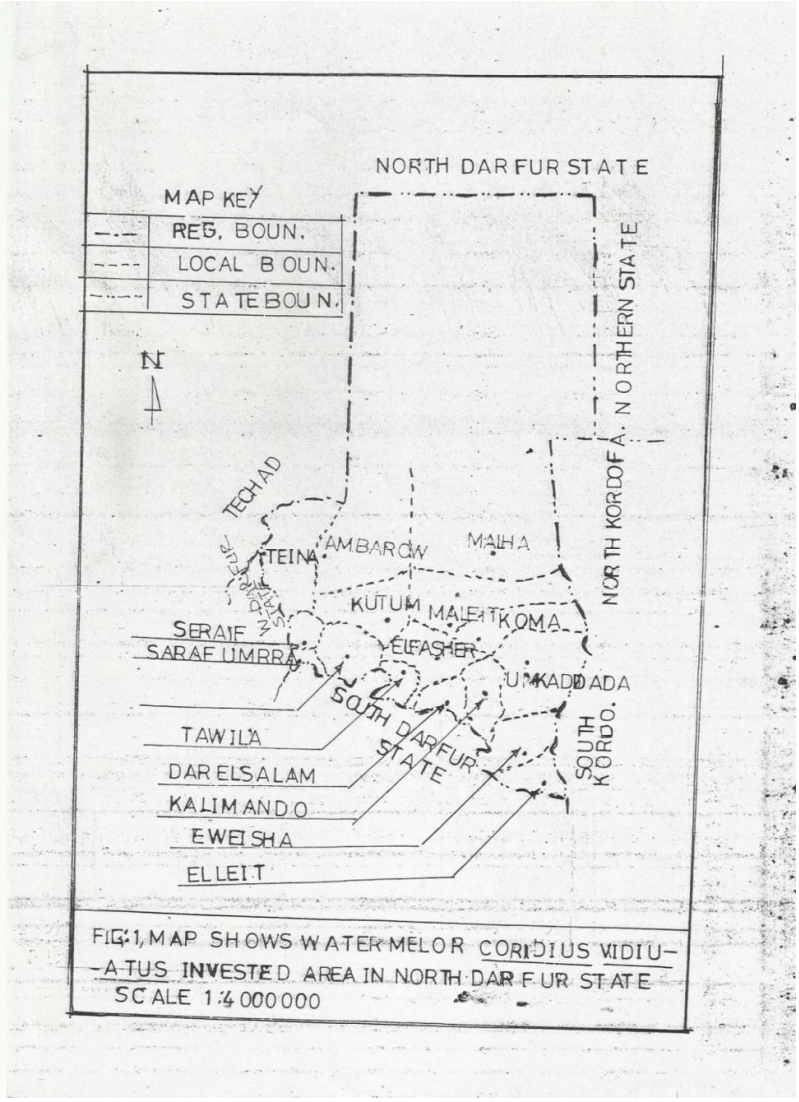

Fig. 1. Watermelon study area North Darfur State- Sudan

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