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Biology of faba bean beetle {*Bruchidius incarnatus* (Boh)}under conditions of Northern State, Sudan

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Abstract

The mating duration of the small faba bean beetle (*Bruchidius incarnatus* Boh.) was very short, with a mean of 25 seconds. Number of eggs laid and egg hatching dropped with time. The highest number of eggs laid in summer, while the lowest was in the winter. The length of the oviposition period and the egg incubation period varied during the various months of the year. The adult longevity was also affected by temperature., and also the developmental period of larvae and pupae. The number of generations was affected by temperature and also the generation period, which was short during the summer season and long in the winter. The insect produced nine generations per year (eight generations in the summer and one generation in the winter).

Keywords: mating; hatching; Longevity; fecundity and generations.

Introduction

Faba bean (*Vicia faba* L.) belongs to the family Leguminosae. It is the most important legume crop and it is grown as an irrigated winter crop mainly in the northern part of Sudan (Northern State and Nile River State) and at higher elevation of Jebel-Marra (Salih, 1995 and Salih *et al*., 1995).

Faba bean (*V. faba* L.) is one of the earliest domesticated food legumes in the world and it is a much appreciated food legume in the Middle-East, the Mediterranean region, China and Ethiopia. The crop has a wide range of uses: as feed of poultry, the human consumption and as a lignocellulosic biomass to produce bioethanol and biogas. In addition, the crop contributes to soil fertility through biological nitrogen fixation. Faba bean crop is valued and considered a cash crop in Egypt and Sudan (Muehlbauer and Tullu1997; Duc and Marget, 2002; Khan *et al*., 2003 and Petersson *et al*., 2007).

In store, faba bean seeds are subject to attack by many coleopterous insects of the family Bruchidae such as *B. incarnatus* (Boh) which is an important pest of faba bean in Egypt and Sudan (Siddig, 1981; Cardona *et al*., 1985 and Ragaa, 2003).

The damage caused by insects of store products can take many forms. The attack on the endosperm results in a loss of weight, a reduction in the seed ability to germinate, a reduction in the nutrients and deterioration of their quality. Ultimately, the specific gravity of seed decreases, lowering the market value of the product (Ragaa, 2003).

The Laboratory experiments were carried out with the main objectives of biological studies which include adult behaviour, mating and oviposition, fecundity and multiplication during the various months of the year, life cycle, generation period and number of generations per year.

Materials and Methods

The Laboratory experiments were conducted for the years 2014/2015 at Dongola- Northern State- Sudan- located within latitude 16° and 22° N and longitude 20° and 32° E (Mukhtar *et al.,* (2013).

For rearing and culture techniques: the original stock culture of *B. incarnatus* was derived from a stock culture maintained on faba bean at Dongola, Sudan at room temperature since 2014. Ten pairs of adults were introduced to 2 kg kilner jars furnished with 2 kg of faba bean (Beladi variety). The faba bean used in the culture was from the 2013/2014 season that was initially fumigated in storage in Dongola with phostoxin. Every three months the culture was renewed maintaining the adults emerging from the same lot to prevent crowding and mould growth.

Only during the winter months when the temperature was low, it was necessary to place the cultures in an incubator maintained at 30°c.

Temperature and R.H. were continuously recorded using a thermohygrograph.

To study the biological of *B. incarnatus* on faba bean which includes adult behaviour and oviposition, fecundity and multiplication during the various months of the year, life cycle and number of generations per year**,** adults were sexed and separated as soon as they emerged from seeds. They were then paired as one female and one male and put in 9 cm plastic Petri-dishes each containing ten seeds of faba bean (Beladi variety) and the behaviour of the adult was observed.This treatment was replicated four times. The time duration between release and mating was recorded and also the duration of copulation and number of times was recorded. The female was observed till it died and if the male died first it was replaced by another male of the same age. In addition to the above observations on mating, the number of eggs laid by the female every day was counted; the seeds with eggs on were removed and replaced by an equivalent number of seeds.

Thus it was possible from this experiment to record the adult behaviour and mating and oviposition.

To study the fecundity and multiplication during the various months of the year one pair of freshly emerged adults as described above was allowed to oviposit in 9 cm covered plastic petri-dishes each furnished with 15 seeds of faba bean (Beladi variety). Every day, the eggs laid were counted. Seeds with eggs on were removed and replaced by an equivalent number of seeds. The experiment was replicated four times. At the end of the females life span the total number of eggs laid, oviposition period, longevity of female and male and progeny / female in different months was calculated. This experiment was repeated every month of the year for the full duration of twelve months.

To study the life cycle (development from egg to adult emergence) freshly emerged adults (female and male) were kept for oviposition in 9 cm covered plastic Petri-dish furnished with 15 seeds. Next day the seeds with eggs on were removed and all eggs except one were then removed by scraping away with a seaker. The single egg on the seed was then observed under the binocular for hatching and subsequently till the adult emerged (egg incupation period).

The above batches of eggs were used to study larval and pupal development periods by close observation under the binocular and the day each egg hatched was recorded. Also the seeds were then observed until the larvae prepared the adult emergence window. Then the larval and pupal period was determined. The experiment was then repeated once during every month of the year. The same seeds and batches of eggs described above were used to observe for adult emergence. Prior to emergence the adult would come close to the surface which was easy to tell by the window darkening.

The number of generations produced for the whole year was observed on faba bean from June 2014 to May 2015. Five pairs of freshly emerged adults were introduced into petri dishes containing 30 grams of seeds each. Four petri-dishes were prepared. Adults were kept in these petri-dishes until the last adult (introduced ones) died. The seeds were then observed for emergence of new adults.

Five pairs of freshly emerged adults were then taken from these petri-dishes and introduced onto a fresh lot of seeds and the whole process was repeated until the end of the year. At the end, the number of generations produced and the length of generation period were calculated.

All the experiments were arranged in a randomized complete block design (RCBD) with four replications. Analysis of variance (ANOVA) was carried out on data obtained using the statistical analysis system (SAS) computer package for SAS Institute Inc., 1990, to detect significant effects among the treatments and populations compared. Mean squares for treatments or populations were calculated. Simple statistics including mean, standard error and coefficient of variation (C.V %) were also calculated. The collected data were subjected to standard procedures of statistical analysis. The procedure described by Gomez and Gomez (1984) was used to estimate analysis of variance.

Results and Discussin

The adults were observed to mate as soon as they emerged from the seed. The mating duration is short and lasts on average for only 24.9 seconds (range 20-30 seconds) and varies significantly from pair to an other (Table 1).

Table 1: Observed period of mating

Pair number	Period in seconds
1	20 c
2	25 b
3	25 b
4	29 a
5	20 c
6	25 b
7	20 c
8	25 b
9	30 a
10	30 a
Mean	24.9
CV%	8.55
SE ±	0.67

Means with the same letters in the same column are not significantly different at 5% level of probability to Duncan's Multiple Range Test (DMRT).

The pre-oviposition period of *B. incarnatus* is only a few hours. The female was observed to start laying its eggs in the same day it emerged from the seed. This fact referred that adults are fully sexually mature after emerge. Similar results were found by Ahmed (1987).

The number of eggs laid by female dropped sharply with the time and the most of the total number of eggs/female was laid in the first three days after emergence (Figure 1). These results are in line with those obtained by Ahmed (1987).

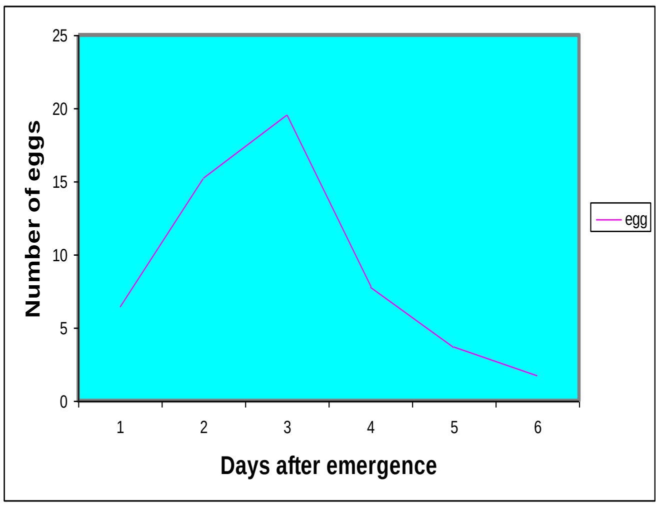

Fig. 1: Egg laying of mated female of *B. incarnatus* under laboratory conditions of temperature and humidity

Egg hatching similarly dropped with the time, the maximum mean percentage egg hatch (77.00%) was on the second day, while the minimum mean percentage egg hatching (5.00%) was on the sixth day. Mean percentage egg hatch of *B. incarnatus* per day for six days was 51.01% (Table 2).

Table 2: Mean percentage egg hatch of *B. incarnatus* per day

Days	Mean percentage egg hatch per day
1	75.00
2	77.00
3	62.00
4	54.00
5	33.10
6	5.00
Mean	51.01

During the various months of the year the mean number of eggs laid by the female on faba bean (Beladi variety) is shown in table (3). In April it is obvious that the highest number of eggs laid (8.90) followed by October (7.90) and May (7.00), while in

December (3.00) and January (4.90) the lowest number of eggs was laid (Table 3).

The length of the oviposition period was found to be much affected by temperature and varied during the various months of the year as show in Table (3). During June and September months (summer season) this period was found to be as short as 3.1 days, this period extended to a maximum with a mean value of 9.00 days where temperature dropped to (21°c) in January (winter season) as show in Table (3). These results are in line with the findings of Hashim (2005) who indicated that the oviposition period of *B. incarnatus* in the winter season was long compared to the summer season.

The mean number of progeny per female varies greatly with temperature and humidity. The progeny per female was significantly lower in the winter months (November to February) than summer months (March-October) as shown in Table (3). The highest mean progeny / female (6.00) was achieved on April while the lowest mean progeny / female (1.00) was achieved on November (Table 3). These results may be attribute that both fecundity and survival from eggs to the adult stage are adversely affected by low temperature.

The adult longevity was also found to be much affected by temperature. Longevity of the adult especially the female was shown to have increased significantly during the winter months (Table 3). Longevity during the winter cold months (November to February) was significantly higher than all other months where the temperature was hot (March to October), this is more obvious in the case of the adult female. Male longevity was however less obvious probably as show in (Table 3). On the male longevity the effect of temperature was however less obvious probably because males lived shorter than the females. The maximum mean longevity of female was 18 days on December and the minimum mean longevity of it was 4.30 days on September while the maximum mean longevity of male was 9.50 days on January and the minimum mean longevity of it was 4.10 days on September as presented in Table (3). The increase in adult longevity with drop in temperature in the winter months is in agreement with findings of Ahmed (1998) who showed that adult longevity increased in the winter season compared to the summer season.

Table 3: Fecundity and multiplication of *B. incarnatus* on faba bean Beladi during the months (March 2014- February 2015)

Months	Mean number of eggs laid by female	**Mean oviposition period in days**	Mean progeny per female	**Mean longevity of female (days)**	**Mean longevity of male (days)**
March	6.90 c	4.10 cd	4.90 b	6.00 d	5.00 de
April	8.90 a	4.30 c	6.00 a	6.00 d	5.50 d
May	7.00 c	3.60 cd	5.00 b	4.60 e	4.70 de
June	6.70 cde	3.10 d	4.80 bc	4.70 e	4.80 de
July	6.60 cde	3.80 cd	5.60 ab	5.10 de	4.40 e
August	6.80 cd	4.00 cd	5.00 b	4.90 e	4.60 de
September	6.00 de	3.10 d	4.00 cd	4.30 e	4.10 e
October	7.90 b	3.60 cd	5.40 ab	5.00 de	4.50 e
November	5.90 e	3.60 cd	1.00 g	13.30 c	7.80 b
December	3.00 g	5.30 b	2.00 f	18.00 a	7.80 b
January	4.90 f	9.00 a	3.00 e	16.40 b	9.50 a
February	5.00 f	6.00 b	3.90 d	13.00 c	6.80 c
CV%	13.88	22.19	21.43	12.74	15.91
SE ±	0.15	0.17	0.15	0.46	0.17

Means with the same letters in the same column are not significantly different at 5% level of probability to Duncan's Multiple Range Test (DMRT).

Temperature was found to be the most important factor affecting all attributes of the pest. The variation in the length of the egg incubation period is shown in table (4) which clearly shows that the egg incubation period was lengthened with drop in temperatures. The longest egg incubation period (19 days) was observed during January which was also the coldest of the winter months while the minimum egg incubation period (4.20 days) was achieved on August (Table 4). The increase of mean egg incubation period during the winter months, compared to the summer months is comparable to the result of Bushara *et al*., (1982) and Ahmed (1987) who reported that the incubation period increased during the winter months compared to the summer months.

The larval and pupal development period was calculated from the date of hatching to the date of adult emergence as shown in Table (4). The total larval and pupal development period was also lengthened by drop in temperature (winter season)). The maximum mean development period of larval and pupal (111.50 days) was in November while the minimum (20.00 days) was in October (Table 4). Similar results were found by Mariam (1987) and Muaz (2006) who stated that the developmental period of larva and pupa of *B. incarnatus* was short in the summer months compared to the winter months.

The adult emergence period was found to be variable and it is much affected by the prevailing conditions of temperature and humidity (Table 4). In the winter months the emergence period was short while in the summer months it was high. The highest emergence period (16.90 day) was found on March while the lowest emergence period (9.10 days) was recorded on June (Table 4). It has previously been illustrated that fecundity was lowest during the winter months and highest in April. April is the harvest time of all legumes such as faba bean in the Northern State and River Nile State and it is the time when crops are brought for storage. Hence with an abundance of the host a high fecundity rate, coupled with comparatively short developmental period should enable the pest to achieve its maximum rate of increase.

The effect of temperature drop during winter season on the development of the insect may explain the disappearance of the pest from stores during that season. As a typical store pest *B. incarnatus* breeds and reproduces in store. Naturally the pests abundance reaches its maximum during the summer months when infestation of the stored faba bean is at highest. The succession of generations under laboratory conditions was found to be much affected by temperature (Table 4). During the summer season the generation period was short, ranging between 27.10 and 31.00 days, while in the winter months this period was long (121 days). One generation was produced in the winter months while 8 generations were produced in the other months of the year or in the summer season. (Table 4). These results are in line with that obtained by Mariam (1987) while they were not similar to those found by Muaz (2006) and Zobida (2007) who reported that *B. incarnatus* produces only seven generations in a year on faba bean. This variation in the number of generations of *B. incarnatus* per year can be attributed to the effect of prevailing conditions of temperature and humidity.

Table 4: Developmental period, emergence period and generation period of *B. incarnatus* on faba bean Beladi during the months (March 2014- February 2015)

Months	Egg incubation period	Larval and pupal development period	Emergence period	Generation period
March	4.90 e	35.50 d	16.90 a	31.00 b
April	4.80 e	24.60 e	10.90 d	30.50 bc
May	4.40 e	24.10 e	12.10 c	28.60 d
June	4.50 e	23.40 e	9.10 e	29.10 d
July	4.40 e	24.70 e	10.10 d	27.10 e
August	4.20 e	25.00 e	13.90 b	30.00 c
September	4.60 e	22.00 e	11.90 c	29.00 d
October	7.40 d	20.00 e	10.90 d	30.20 bc
November	10.60 c	111.50 a	10.50 d	121.00 a
December	13.60 b	81.70 b		
January	19.00 a	43.20 c		
February	13.80 b	27.90 e		
CV%	12.04	20.33	7.15	2.35
SE ±	0.45	2.60	0.25	3.05

Means with the same letters in the same column are not significantly different at 5% level of probability to Duncan's Multiple Range Test (DMRT).

Recommendations

As indicated in the study, the infestation by *B. incarnatus* (Boh) reaches its highest in stores during the summer months. Accordingly, it can be recommended that, the control of this pest should be done early in the summer season.

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إحيائية خنفساء الفول الصغيرة {*Bruchidius incarnatus* (Boh)}
تحت ظروف الولاية الشمالية – السودان

مختار عبدالعزيز محمد عثمان و آمال عبدالحليم نصر خيري

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المستخلص:

فترة التزاوج للحشرات البالغة من خنفساء الفول المصري الصغيرة كانت قصيرة بمتوسط 25 ثانية. عدد البيض الموضوع قل بزيادة الوقت، وكذلك فقس البيض. أعلي عدد لوضع البيض كان في الصيف بينما أدناه كان فى الشتاء. طول فترة التبويض وفترة حضانة البيض تفاوتت خلال الأشهر المختلفة للسنة. طول عمر البالغ تأثر أيضاً بالحرارة وكذلك فترة التطور لليرقة والعذراء. عدد الأجيال تأثر بالحرارة وكذلك فترة الجيل، حيث كانت قصيرة خلال فصل الصيف، وطويلة فى الشتاء. انتجت الحشرة تسعة أجيال فى السنة (ثمانية أجيال فى الصيف وجيل واحد فى الشتاء).