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Biological cycle and populations dynamics of bean weevil Bruchus rufimanus (Coleoptera: Bruchinae) on two parcels: Vicia faba major (Seville) and Vicia faba minor (Field bean) in the region of Haizer (Bouira, Algeria)

Siham Hamani[1], Ferroudja Medjdoub-Bensaad[2]

Department of Biology/ Faculty of Biological and Agricultural Sciences,
University Mouloud Mammeri Tizi Ouzou 15000, Algeria.

Abstract: ***The broad bean weevil Bruchus rufimanus, its development cycle involves an annual generation (monovoltin). Its life cycle dependes strictly on its host plant. The objective of this study is to know in successive steps, the conditions of the colonization of the broad bean crops by this bioagressor in the area of Haizer (Bouira), in order to provide the key to better combat this pest adapted to the conditions of our agricultural systems. The colonization of the two broad bean plots by this beetle coincides with the full flowering. The egg-laying period ranged from 28 days for Seville variety, and 35 days for Faba bean variety. It varies depending on weather conditions. Oviposition occurs on all pods whatever their stage of growth. Larval development takes place during the ripening pods. It is carried out in four larval stages L1, L2, L3 and L4 and pupae. The complete development cycle of the weevil from egg laying until the emergence of the first adult takes about 4 months and 16 days for parcel Seville variety and 4 months and 18 days for the parcel variety Field bean variety.***

Keywords: Vicia faba major, Vicia faba minor, Bruchus rufimanus, bioecology of the weevil, development cycle, Bouira.

1. Introduction

Distributed worldwide, the legume family is very diverse, it includes about 19,000 species (Roland, 2002). The subfamily Papilionoideae contains the essential species (14,000) compared to those of Mimosoideae and Caesalpinoideae.

The subfamily Papilionoideae gathers the most important species grown economically like soy, beans, peas, peanuts, chickpea and field bean (Lazrek Ben- Friha -2008).

According Gepts *et al.* (2005) in 2004, more than 300 million tons of grain legumes were performed on 190 million hectares (or 13% of the total cultivated area, including arable land and permanent crops).

According Lazrek Ben-Friha (2008), legumes allow both to enrich the soil with organic matter and nitrogen fertilizers to save the operation of a natural process. They provide significant benefits to farming systems and the environment due to the possibility of symbiotic nitrogen fixation (Kaur *et al*., 2012).

According Hanafy *et al*. (2005), bean (*Vicia faba* L.) is the grain legume grown mainly for dry grains for human consumption and animal feed in many developed countries

and developing countries especially in West Asia and in North Africa.

In Algeria the bean is exposed to stresses of biotic order including weeds, fungal and viral diseases and pests such as insects (Maatougui, 1996).

Among the pests from the bean, we quote the pea leaf weevil *Sitona lineatus*, black aphid *Aphis fabae* and bean weevil *Bruchus rufimanus* (Boh).

The species of the genus are Bruchus phytophagous insects that colonize crops at the flowering stage of their host plant and breed on green pods. This kind includes about 300 species spread throughout the Eurasian region and America.

Weevil of *Bruchus rufimanus* bean develops at the expense of Vicia legume seeds. This cosmopolitan insect attacks legume crops in Europe, North Africa, the Middle East and the United States (HUIGNARD et al., 2011).

Bruchus rufimanus is one of the most damaging pests of bean and field bean. The larvae cause quantitative and qualitative changes in reserves contained in the seeds and reduce their ability to germinate (Gain 1978).

The response window is quite narrow because insecticides available today are effective only on adults weevils. It is necessary to intervene dice the appearance of the first pods for testing by Cailliez (2005) showed once again that adults lay at that time.

Given the scale of the damage caused by the bean weevil and to the importance of the culture of the bean, and to develop a strategy against this bioagressor, it is necessary to know its bioecology in the conditions of our agricultural systems, including population dynamics and the conditions of its reproductive diapause.

2. Materials and methods

Our tests are conducted in open fields in the town of Haizer during the 2012/2013 agricultural companion. It is located 11 km north-east of Bouira, 609 meters above sea level, it has the geographical coordinates 36 ° 23 '49 "North, 3 ° 59' 57 " East. During our studies we followed the phenology of the host plant *V. faba* since the vegetative cycle until the fruit. The sampling unit is the stem. We conducted our experiment in a completely randomized design, namely 10 feet by plot with a single stem by foot, distributed and marked in a straight line from right to left, to monitor their growth. Flowering and fruiting are observed on both sides of the ten stems randomly selected. Capturing adult is done manually at the apex, pods, flowers and leaves once a week. Harvested weevils are then counted and sexed in the laboratory using a binocular microscope. To follow the post-embryonic development *B. rufimanus* in the field and in the laboratory during the agricultural year 2012-2013, we randomly selected each week on two parcels of study Seville and Field Bean variety, 10 low stratum pods (old pods) and 10 cloves high stratum (young pods) of 10 rods, located on different feet in order to have a representative sample from spawning to harvesting the beans. Sampled pods are returned to the laboratory to measure their size with a ruler and count the eggs on their pericarp and larvae in seed using a binocular microscope. Once the pods have completed their ripening on both plots, the study followed on stored seeds. The latter are dissected with a scalpel, larvae of different stages L1 to L4, pupae and imagos are observed and counted under a binocular microscope.

3. Results

3.1Temporal variations of the number of inflorescences produced by the two varieties

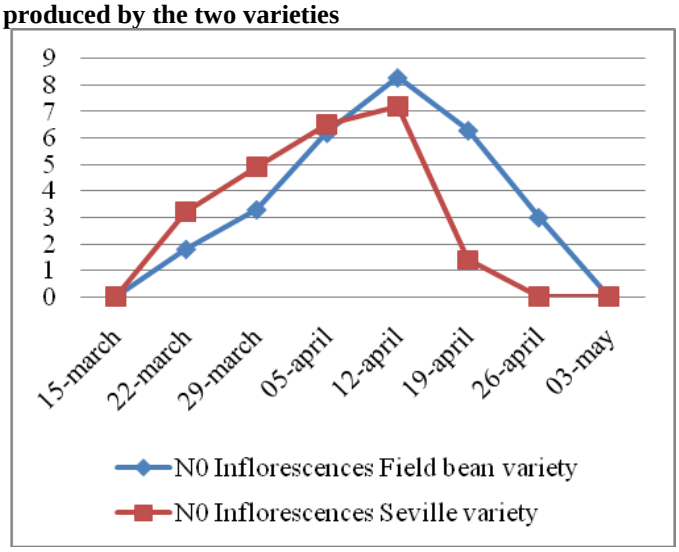


Figure 1: Temporal variations of the number of inflorescences produced by the two varieties

Flowering spans about five weeks and six weeks for Seville and Field bean, respectively. It begins about March 22th for the two varieties and vanishes about April 26th and 3th May of that year, respectively for *Vicia faba* major and *Vicia faba* minor.

Full bloom reaches about 12th April for the two varieties, it is 8.3 ± 1.25 inflorescences for Faba bean variety and 7.2 ± 1.13 inflorescences for Seville variety.

3.2 Temporal evolution of the average number of pods floor of both varieties

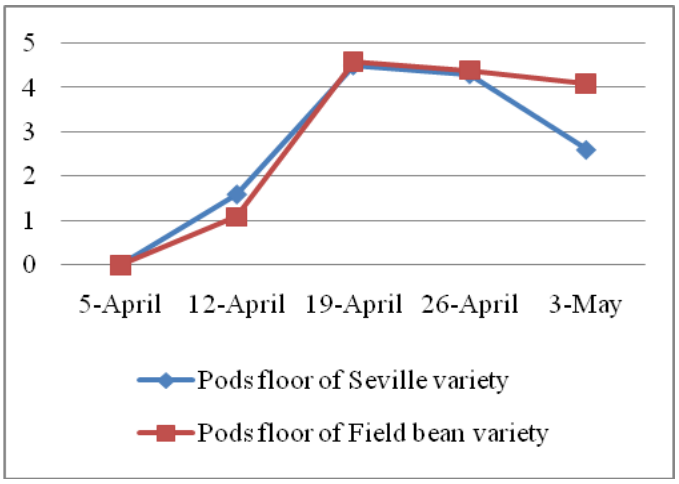


Figure 2: Temporal evolution of mean number of pods floor of both varieties

From the figure, fruiting is noted on April 12th, three weeks after flowering of the host plant, where we note a number of 1.6 ± 1.71 floors per rod to Seville and 1.1 ± 0, 99 floors per rod for Field bean. The average number of floors pods gradually increases to reach a maximum which is of the order of 4.5 ± 1.50 floors per rod and 4.6 ± 1.50 floors per rod in April 19th for the Seville and Field bean respectively.

After this date, this number starts decreased to a value of 2.6 ± 1.07 floor per rod for Seville and 4.1 ± 1.66 floor per rod for Field bean. This decrease is due to the fall of young pods and attacks by pests such as black aphids that make the pods puny.

4. Study of weevil's adult density and their activities

4.1Parcel of Seville variety

The arrival of the adult weevil was noted late on 12th April. The total number captured on that date is only 09 individuals (7 males and 02 females); males are the first to arrive (figure 3). The colonization of weevils coincides with the full bloom (April 12th), when the photoperiod was of 11:1h LD and the mean temperature reached 17. 6° C.

The peak of captured adult is observed on April 19th with 14 individuals (9 males and 5 females), this is explained by the rise in temperature with 18.3 ° C, the lack of rainfall (0mm) and calm wind (0.9m / s), which promotes their displacement.

The number of adults captured remains high with 11 individuals marked on April 26th, despite the high rate of moisture on that date which is 89 %. The high rate of humidity did not influence the number of adults captured, as they fled in leaf cones.

From 3th May, the number of captured weevil's decreases to scarcity, which corresponds to the end cycle of the plant shown by the absence of flowers, heralding the end of the imaginal or reproductive activity this pest. Indeed, it is noted a predominance of males, representing 68.29 % of a total of 41 individuals captured during the study period.

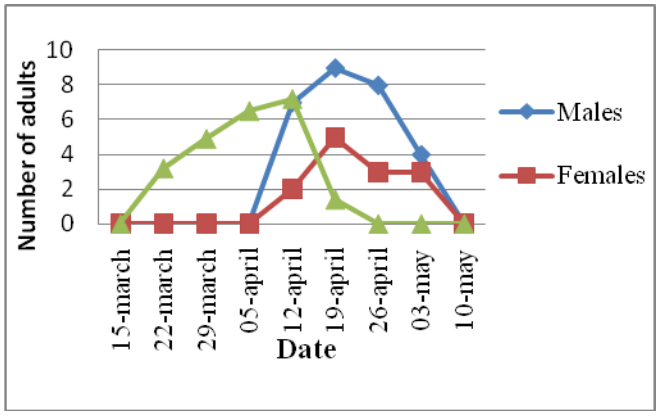
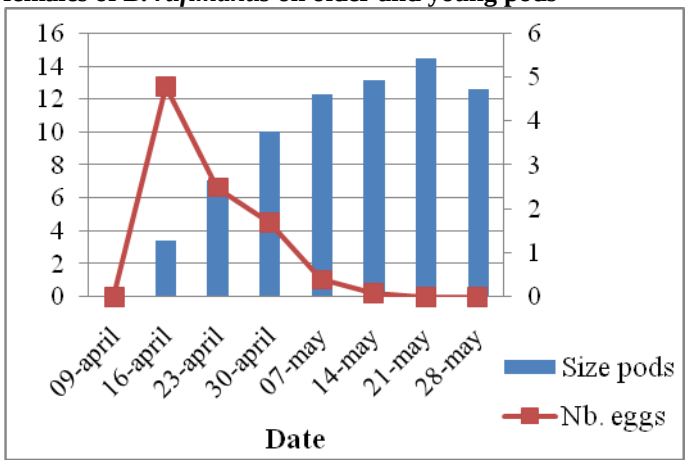
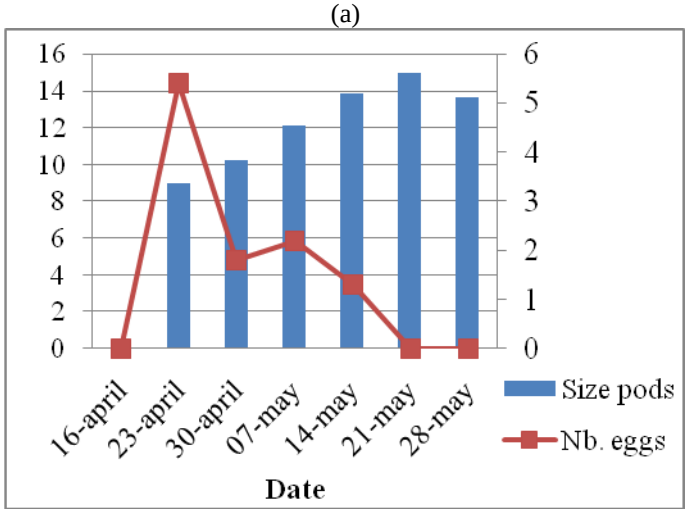


Figure 3: Temporal evolution of mean number of adults of *B. rufimanus* captured as a function of mean number of inflorescences *Vicia faba* in plot of Seville variety.

4.1.1Temporal evolution of mean number of laid eggs by females of *B. rufimanus* on older and young pods



(a)



(b)

Figure 4: Mean number of laid eggs by females of *B. rufimanus* on older (a) and younge pods (b) of *Vicia faba* in plot of Seville variety.

Oviposition by females of *B. rufimanus* started as soon as they arrived in the parcel in April 16th on older pods and in April 23th on young pods, with respectively 4.8 ± 2.89 eggs / pods and 5.4 ± 3.89 eggs / pods that correspond to the peak.

4.2 Parcel of Field bean variety

The emergence of adults of *B. rufimanus* in the plot of Field bean variety coincides with the plot to variety Seville, noted on April 12th, where we caught that day a total of 16 individuals; 12 females and 4 males, with a mean daily temperature of 17.6 ° C (figure 5). This date coincides with the period of full bloom, which is 8.3 ± 1.25 per inflorescence by stem. From May 10th, we observed a total absence of adults in the plot. Moreover, we note that since the beginning of the colonization of land by adults of *B. rufimanus* , both sexes are present with a frequency of females higher than of males.

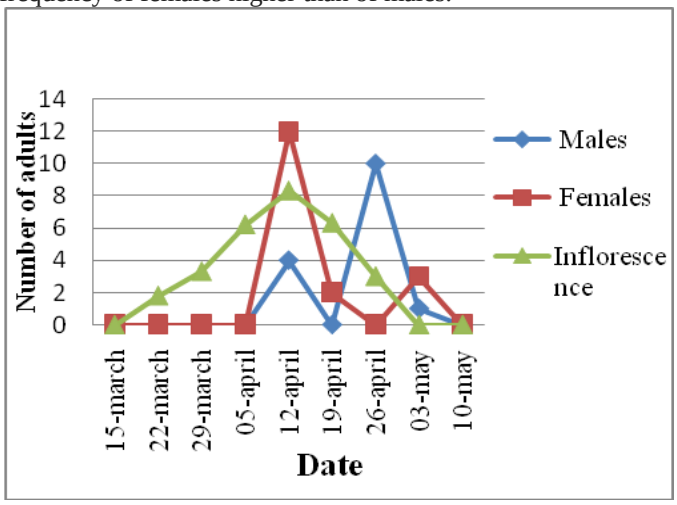
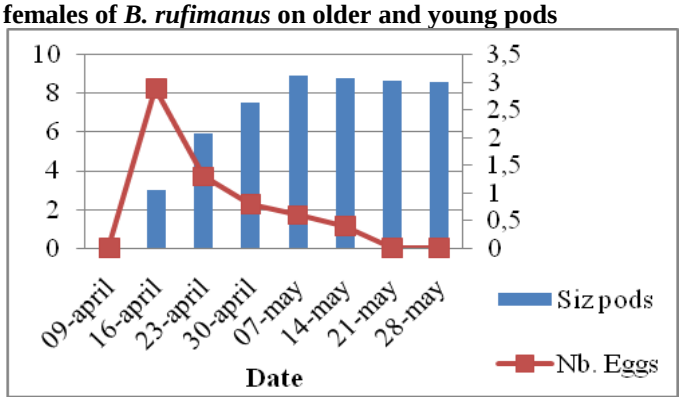
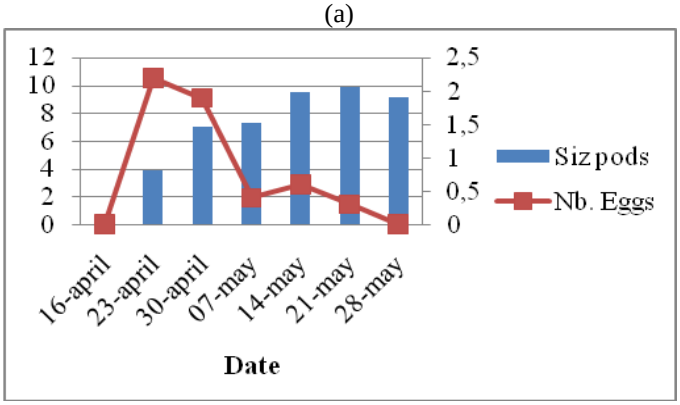


Figure 5: Temporal evolution of mean number of adults of *B. rufimanus* captured as a function of mean number of inflorescences *Vicia faba* in plot of Field bean variety.

4.2.1Temporal evolution of mean number of laid eggs by females of *B. rufimanus* on older and young pods



(a)



(b)

Figure 6.:Mean number of laid eggs by females of *B. rufimanus* on older (a) and younger pods (b) of *Vicia faba* in plot of Field bean variety.

The pods of high strata are formed during the last week of April (one week after pod of the lower stratum) . Their length to the onset was 3.85 ± 0,80 cm , it increases to reached a maximum of 9.87 ± 1,62cm towards the end of May and down slightly to 9.12 to ± 1,81cm at harvest.

An average length of 2.97 ± 0,68cm is recorded on older pods training on 16 April. The size of these pods gradually increases to a peak 8.95 ± 1,48cm the first week of May and slightly decreases to reach 8.57 ± 1,43cm .Spawning occurs on the pods dice appear April 23 for young pods and 16 April for older pods which corresponds to the peak of eggs laid for the two strata , respectively 2.2 ± 1,61oeufs by pods and 2.9 ± 2.13 eggs per pod deposited on 100% and 90% of sampled pods. The wind speed during the period of oviposition varies between 2.1 and 1.4 m / s, while the day time temperature is between 17.9 ° C and 15.7 ° C.

From the third week of May , the adults of the bean weevil are no longer found in the plot. Indeed there is lack of food resources, discouraging them from staying in the plots.

4.3Interpretation

According to the results, the arrival of the first weevils coincides with the blooming of *Vicia faba* in both varieties. Our observations are similar with those found by Mezani (2011) on two varieties of bean namely Seville and Muchaniel.

During our observations on field in the plot of Seville variety, we captured 41 adults with a predominance of males at 68.29%. On the other hand, the number of adults captured in the plot to Field bean variety is 32 individuals, with a slight predominance of females with 53.12%. Our results corroborate those of Mezani (2011) in the variety Seville, on which adults of *B. rufimanus* have high activity compared to others (Aguadulce, Muchaniel and Field Bean).

The activity of laying is spread over a period of 28 days for the variety Seville from 16th April to 14th May and 35 days for Field bean variety from April 16th to May 21th. Medjdoub-Bensaad (2007) indicates that the period of spawning varies from year to year depending on the region; it is spread over a period of 1 month to 2 months and a half and broadly covers the period of growth of the pods.

Females of *B. rufimanus* show no preference lay between elderly and young pods in two varieties (Seville and Field Bean). Our observations are consistent with those of Mezani (2011) for the 4 varieties of the bean and different from those of Medjdoub-Bensaad (2007) which indicate that the female prefer to lay on older pods that young pods as early pods more exposed and are therefore more eggs.

In the plot variety Seville oviposition lasted about 28 days with 95 eggs are deposited on older pods and 107 eggs are laid on young pods, these values are not significantly different ($F = 1.17$, $df = 16$, $p = 0.41$).

In the plot variety Field bean, egg laying is spread on five weeks where we have recorded a total of 114 eggs. Fischer test shows that the average number of laid eggs on early pod (elderly) and late pod (young) was not significant ($F = 1.25$, $df = 16$, $p = 0.38$).

5. Development cycle of the bean weevil

To follow the post-embryonic development and embryo of *B.rufimanus* in the field and the laboratory during the agricultural year 2012-2013 (figure 07), we randomly selected each week on two parcels of study variety of Seville and Field Bean, 10 low stratum pods (older pods) and 10 high stratum (young pods) of 10 rods, located on different feet to a representative sample from spawning to harvesting the beans. Once the pods have completed their ripening on both plots, the study followed on stored seeds (100 seeds).

Figure 07: Biological cycle of *Bruchus rufimanus* in two parcels of studies (Original 2013)

5.1 Interpretation

Weevil bean uses the host plant for its reproduction, its development, dissemination and as overwintering sites (Dupont, 1990).

Oviposition began on April 16 on the two plots, including the laying period spans about 28 days for the parcel to variety Seville and one month and 5 days for the parcel to Faba bean variety. Boughdad (1994) estimates that embryonic development is between 5 to 20 days depending on the date of laying.

The duration of the incubation of eggs after spawning also vary from year to year depending on weather conditions and in the regions. It is 11 days for Field bean variety and 5 days for the Seville. According Cambell (1920), the incubation of eggs of *B. rufimanus* lasts 9-8 days with an average of 13 days.

The first larval develop in green seeds in the field. Their presence spans 42 days on the plot of Seville variety and 49 days on the plot of Field bean variety. Mezani (2011) notes that the duration of the presence of the first larval stage takes place over 31 days on the variety Aguadulce and Seville, 29 days on the Muchaniel variety and shorter duration of their stay is 15 days on Field bean variety.

The development of the second larval stage is carried out with a small amount in the green pods and continues in dry seeds. Lardjane-Hamiti (2009) reports that the second stage larvae change into green seeds, with a small proportion and continue in dry seeds.

The third larval stage grows exclusively in the dry seeds, the duration lasts 77 days on plot of Seville variety and 84 days on the plot of Field bean variety. Our results are similar to those of Lardjane-Hamiti (2009) indicates that the development of L3 larval stage occurs between 70 and 77 days.

The duration of the fourth larval stage ranges between 91 and 98 days. This is the stage that lasts the longest. Our results differ from those observed by Medjedoub-Bensadd (2007) and Mezani (2011), but similar to Lardjane-Hamiti (2009) which is a significant spreading of this stage between 70 and 98 days.

6. Conclusion

To plan a good program against the bean weevil *Bruchus rufimanus* submitted to environmental and Mediterranean conditions, it is interesting to carry out a detailed ecological study, which limits the location and density of the pest in different habitats.

Bruchus rufimanus, its development cycle involves an annual generation, which begins in the field with the arrival of adults from the overwintering sites that depends on environmental factors; the most important would be the rise in temperature, wind and increase in the length of days.

Colonization of adults coincides with the blooming of the two plots of Seville and Field Bean noted on 12 April. The inflorescence is a source of food for the weevils and acts as a determining factor in the population dynamics of *B. rufimanus*. Towards the end of flowering the number of adults begins to decline, as and as we approach the maturity of pods.

We found that females of *B. rufimanus* show no preference as to the age of pods seen that Fischer statistical analysis revealed no significant difference in egg laying on older pods or young pods and, for both varieties Seville and Field Bean.

After the issuance of eggs by female of *B. rufimanus* on pods of *V. faba* and after embryonic development, the hatched larvae enter into the pericarp of the young pod formation and runs parallel with the evolution of the seed. This larva undergoes various molts until reaching adulthood. The entire development cycle (from egg laying until the emergence of the imago) is spread over 4 months and 16 days for the parcel to variety Seville and 4 months and 18 days for the parcel to Field bean variety.

Protection bean fields against *B. rufimanus* are a daily challenge. Thus, the farmer must apply protection methods compatible with their financial and technical resources. It is for this reason that the problem of post-harvest losses can not be solved, not by a unique method of struggle, but by combining different effective methods recognized.

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